

PAL SYSTEM
Ingenious sample handling



The new Generation PAL RSI and PAL RTC



A close-up photograph of a laboratory instrument, likely a PAL System, with a person's hand in a blue nitrile glove interacting with it. The instrument is white and has a small screen and a tray of sample wells. The background is a blurred laboratory with windows and other equipment.

PAL System's new generation of sample preparation and handling instruments.



The PAL System is one of the most widely used and successful sample preparation and handling platforms.

40'000 systems worldwide are proof of its reliability and flexibility. Each PAL leaving the factory has passed a 24h specification test.

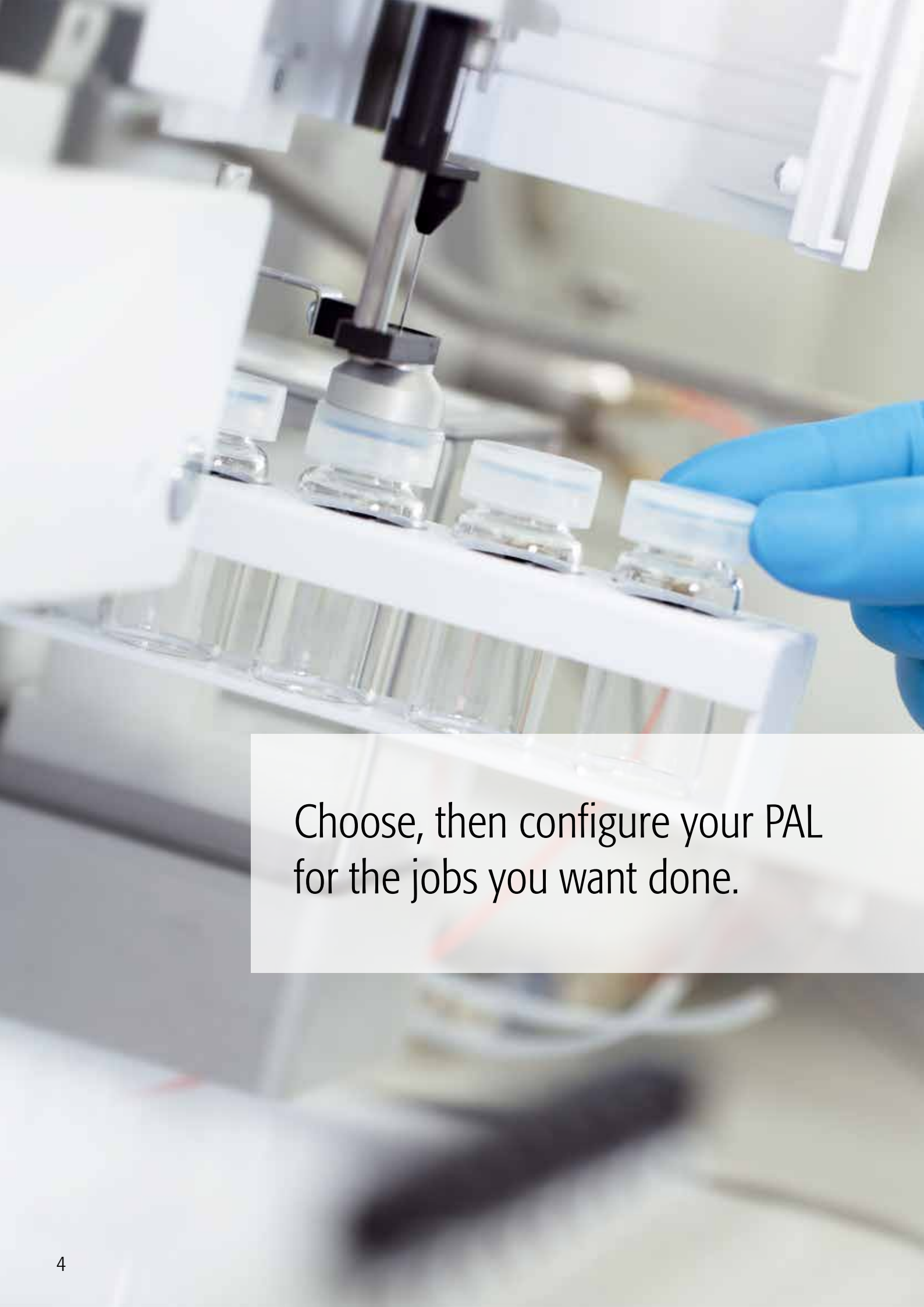
The PAL's mechanical precision and robustness form the basis for precise and accurate handling of gaseous and liquid samples.

Headspace, SPME or Liquid? Why not all three? PAL Systems can be adapted or extended to meet almost any requirement. Numerous options allow to increase sample capacity, add injection or switching valves or modules for sample preparation.

Ingeniously reliable
flexible
productive

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Choose, then configure your PAL
for the jobs you want done.



PAL RTC Highest Productivity

The PAL RTC with Robotic Tool Change is the logical (r)evolution of the successful PAL-xt product line. It is a robotic platform for the efficient and safe automation of most sample preparation steps.

The robotic change of tools enables unattended 24/7 operation, even for multistep workflows and thereby greatly increases the productivity of labs. At the same time process safety is optimized since all operations become traceable.

PAL RSI Workhorse for Sample Prep

The RSI is the robust workhorse for analytical labs. It is the cost effective solution for labs in need of robustness and uncompromising performance.

The PAL RSI is a safe investment: if your requirements grow an upgrade to the full RTC functionality is possible and gives access to complete workflow automation.

PAL Sample Control Software for Efficient Operation of PAL RTC & RSI

The latest generation of PALs can all be controlled by the user friendly PAL Sample Control software. It interfaces seamlessly with many common CDS and MS-data systems (e.g. AB Sciex Analyst, Agilent Chemstation, Masshunter oder Thermo Scientific Xcalibur). With a few clicks you can import or generate sample lists and start the data acquisition. Or you can quickly set up workflows to eliminate tedious manual operations. PAL Sample Control allows overlapping of time consuming steps. This increases sample throughput greatly and boosts productivity.

The PAL RSI is the reliable and flexible workhorse for today's analytical labs.



PAL RSI with extended x-axis for LC/MS

Ingeniously reliable.

Laboratories work under time pressure and often with a tremendous workload. The reliability of hardware and software should not be something the user has to worry about. Reliability is just expected from every tool.

That is exactly what the PAL RSI was designed for. It is a tool that you can rely on. 40.000 PAL systems worldwide are proof of this. Every PAL RSI leaving our factory has passed a 24 h robustness test.

The PAL RSI defines the industry standard for intelligent sample preparation and is the most flexible system on the market.



PAL RSI with standard x-axis for GC & GC/MS

The RSI is a flexible tool. Its open and modular architecture makes it the most versatile system on the market. Tools can be exchanged readily within minutes.

PAL customers working with GC love the possibility to use liquid, headspace or SPME sampling on the same system. LC customers use the PAL because of its huge sample capacity, the range of syringes and valves available.

Only some of the numerous options available for the PAL are listed below:

- 42, 74 or 109cm (17, 29 or 43 inches) work space
- Liquid, gas, headspace, SPME sampling
- Syringes from 1 μ L-10mL
- Sample capacity max. 1296 2mL vials or 24 MTPs, temperature-controlled if required
- Up to 6 valve drives with 4 injection valves
- Wash and solvent stations
- Vortexer
- Agitator
- Dilutor
- LC/MS Tool

For more details see pages 12 - 17

The PAL RTC is all about increasing productivity.



PAL RTC with extended x-axis for LC/MS

Automation is the way to increase productivity and (process) safety in the laboratory. Transferring repetitive or dangerous manual tasks to a robot improves safety. The possibility to run the instrument 24h/day increases throughput, especially for long sample preparations.

The PAL RTC was developed to maximize productivity in analytical and clinical labs. Robotic Tool Change (RTC) brings sample preparation to a higher level. Every process requires a number of different tools for best performance, e.g. a 10 μ L syringe for the accurate addition of small volumes followed by the dilution with a 1 mL syringe. Robotic Tool Change allows to switch between different tools automatically.

This additional versatility in combination with the large number of available tools enable the design of tailored automation processes.

Robotic Tool Change takes productivity to a new level.



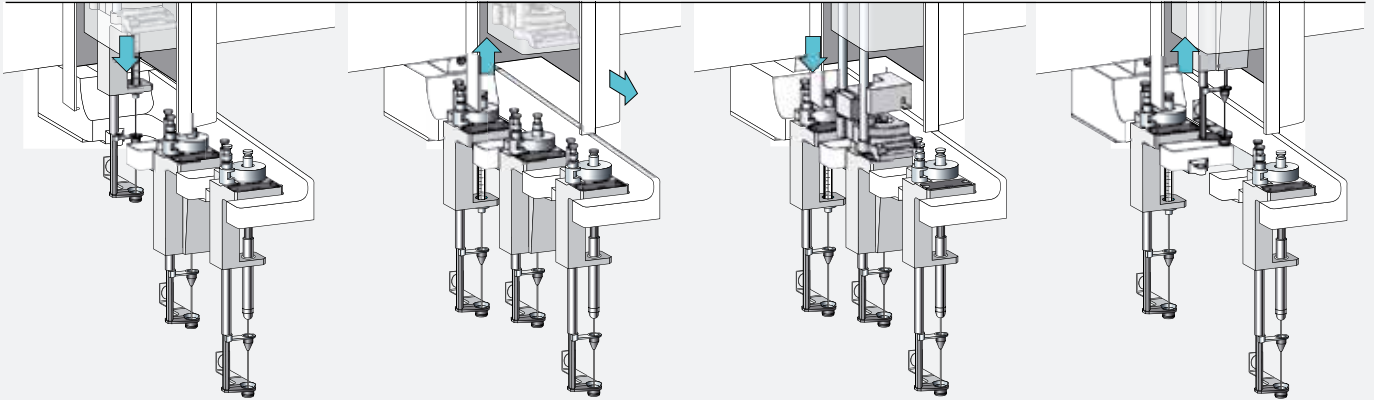
PAL RTC with standard x-axis for GC & GC/MS

Ingeniously productive.

- Automatic selection of the syringe with optimal accuracy for adding standards or preparing serial dilutions
- On the fly switching between a syringe tool for the addition of an internal standard and the LC/MS Tool for subsequent analysis
- Possibility to permanently configure several workflows on one system for a walk-up prep station, e.g. Liquid/Liquid Extraction and Solid Phase Extraction (SPE)
- Automated optimization of methods e.g. by selecting the most suitable Solid Phase Micro Extraction (SPME) fiber from an array of 4 different ones
- Derivatization reactions performed without manual intervention for productivity, protection against hazardous chemicals and process safety
- Automation of labor intensive manual workflows like protein digestion

For detailed examples of workflows see p.20.

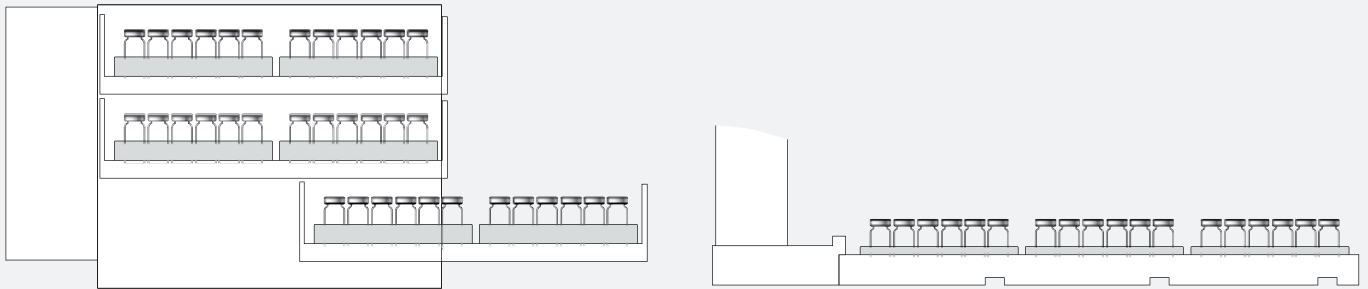
Innovative Features giving real Benefits.



Robotic Tool Change (PAL RTC only) for productivity

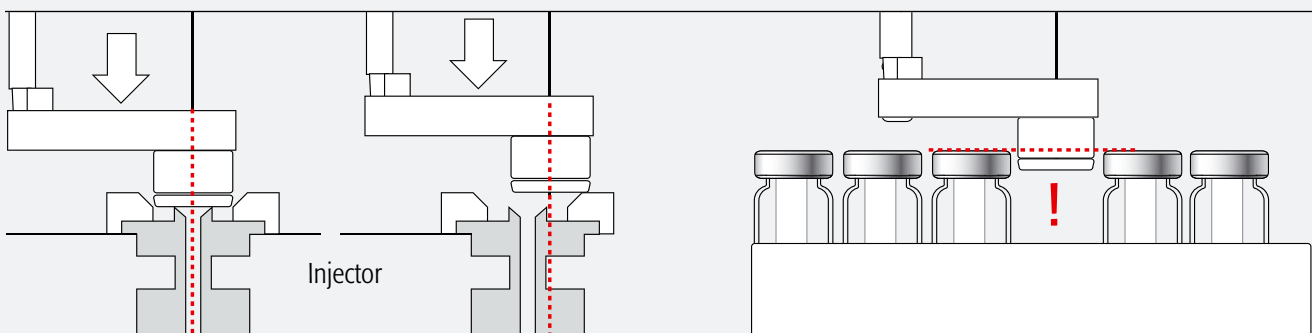
The unique Park Station enables the Robotic Tool Change.

- With different syringes available always the ideal one can be selected, for instance one syringe is reserved for standard addition to minimize carryover while 2 others are used for dilution steps.
- The RTC speeds up SPME method development by allowing automatic sampling of different types of SPME fibers.
- The PAL RTC identifies type of tool and its position automatically.



Increased Vial Capacity

- 162 x 2mL or 60 x 10mL or 20mL vials/tray holder, other vial types and microtiter plates can be handled.
- With temperature controlled stacks a maximum of 9216 samples out of 24 MTPs can be handled.
- Cooled Stack with position control.



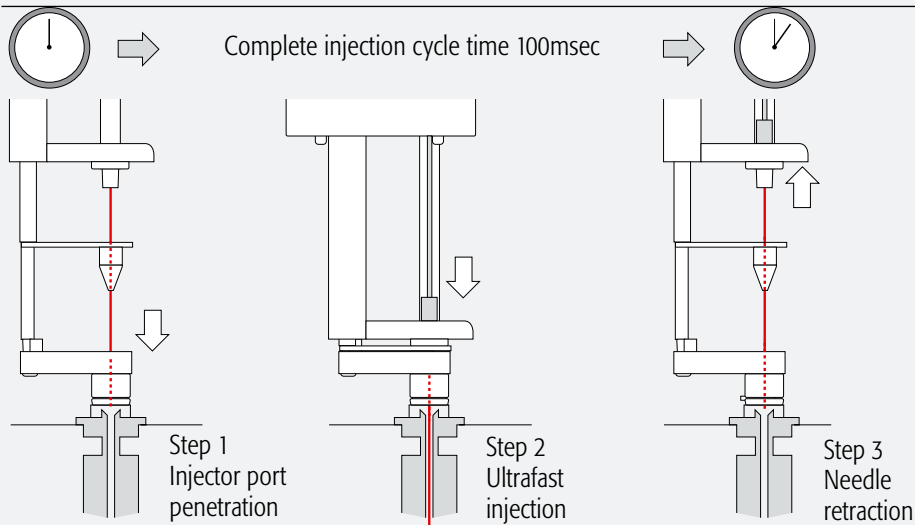
correct position

wrong position detected

Missing vial detected

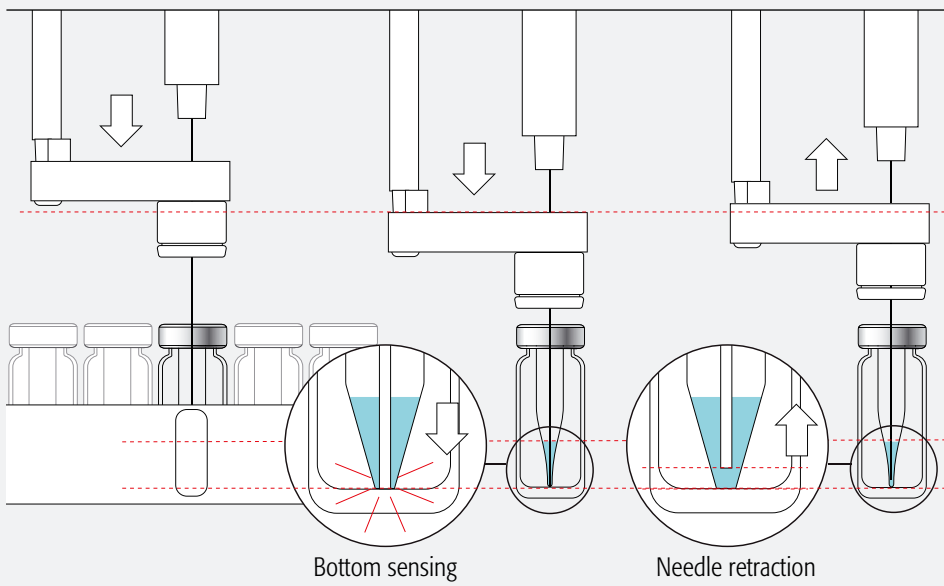
Process safety

Position detection means process safety. Missing vials or the correct position of the injector are detected and traced. Position detection for the temperature controlled stack ensures that the drawer is in the correct position (open / closed) and the temperature is monitored.



Discrimination free Injection

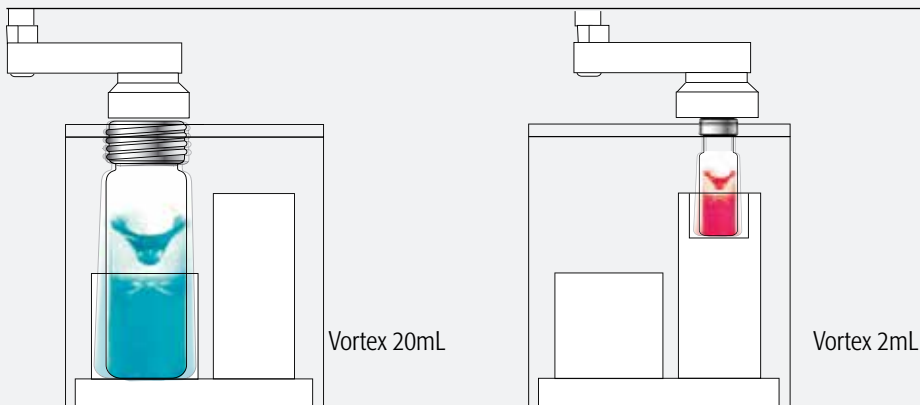
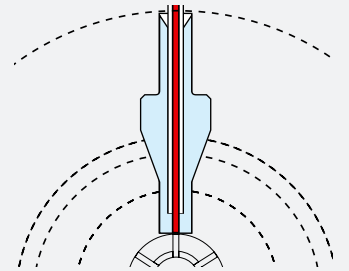
Ultrafast injections down to 100 ms reduce discrimination in GC down to $C_{40}/C_{20} > 0.98$.



Minimized carryover and reproducible injection of minute sample volumes


Bottom sensing makes sure that small volumes can be injected out of a few μL of sample (e.g. $3 \times 1 \mu\text{L}$ out of $5 \mu\text{L}$).

With Constant Force Technology the PAL detects the correct position of the needle in the specially designed needle seal. Potential carryover is avoided.



Efficient Mixing

The vortex mixer is indispensable for serial dilutions or extraction steps. Supported vial sizes are 2, 10 and 20mL.



For every analytical method
the right tools and modules, tailor
the PAL that suits your needs.

Park Station (RTC only)

The unique Park Station allows a robotic tool change (syringes with different volumes or different tool types) for advanced sample preparation, liquid handling (dilutions), derivatization steps or any other time consuming repetitive step. The additional versatility in combination with the increased volume range are significant benefits and allow the realization of flexible tailor-made automation processes.

- Park Station for up to three injection tools
- Installation of up to 2 Park Stations on one PAL RTC
- Process safety through tool recognition and position control
- Designed for automated screening of method conditions with multiple tools



Park Station with Liquid, SPME and Headspace tools

Liquid Syringe Tool

- Supports 57mm or 85mm syringe needle lengths
- Syringes available:
 - 1.2 μ L / 5 μ L / 10 μ L / 100 μ L with D7 tool
 - 250 μ L / 500 μ L / 1'000 μ L with D8 tool
 - 5'000 μ L / 10'000 μ L with D18 tool

Headspace Tool

- Three different syringe types available:
 - 1mL / 2.5mL / 5mL (with corresponding tools)
- Syringe temperature 40°C up to 150°C in 1°C steps
- Syringe flush with inert gas flow through X-Y-Z rail
- Magnetic vial transport for 2mL, 10mL and 20mL vials

SPME Tool

- SPME Fiber Conditioning Module (separate module)
- New SPME holder for increased fiber protection
- Compatible with a variety of SPME fibers
- Easy fiber exchange by hand
- For 10mm or 20mm fiber length



Liquid Syringe Tool (LS Tool)

Headspace Tool (HS Tool)

SPME Tool

LC/MS Tool

- The special design minimizes carryover even for the most sensitive detectors
- Enables special injection techniques like sandwiching a sample between air gaps for accurate small volume injections
- Flow control guarantees bubble-free solvent delivery
- Position detection for zero dead volume positioning of syringe needle in the injector port



LC/MS Tool

SPME Fiber Conditioning Module

- For the conditioning of SPME fibers prior to sample collection
- Temperature range up to 350°C
- Purge gas connection for more efficiency
- Additional port for a replacement fiber



Vortex Mixer Module

For efficient mixing (dilution / extraction).

- Standard vial sizes: 2mL / 10mL / 20mL
- 1 additional slot for custom specific vials
- Provides efficient mixing with up to 2000rpm



Agitator Module

For the incubation and agitation of samples.

- 6 positions for 20mL vials
- Temperature range 40-200°C
- Agitation speed 250-750rpm
- Optional adapters for 2mL or 10mL vials



Barcode Reader Module

This unique Barcode Reader allows PAL RSI and PAL RTC to read the barcode labels on 2mL, 10mL and 20mL vials regardless of the orientation on the vials. Therefore it ensures highest process safety and traceability.

- Reads horizontal 1D barcodes
- Two scanners allow identification of vials irrespective of position of the barcode
- Works with 2mL / 10mL / 20mL vials



Peltier Stack 2DW Module

For the storage of two racks or plates under defined temperature conditions between 4°C and 40°C. Allows to use transparent standard vials with light sensitive compounds. Position detection (drawers open/close) for additional process safety.

Capacity:

- 2x MTP (Multi Titer Plate)
- or 2x DW (Deep Well Plate)
- or 2x VT15 (15 x 10mL)
- or 2x VT 54 (54 x 2mL)
- or 2x VT70 (70 x 1mL)
- or combinations



Peltier Stack 6DW Module

For the storage of six racks or plates under defined temperature conditions between 4°C and 40°C. Allows to use transparent standard vials with light sensitive compounds. Position detection (drawers open/close) for additional process safety.

Capacity:

- 6x MTP (Multi Titer Plate)
- or 6x DW (Deep Well Plate)
- or 6x VT15 (15 x 10mL)
- or 6x VT54 (54 x 2mL)
- or 6x VT70 (70 x 1mL)
- or combinations



Valve Drive Module

Universal Valve Drive for applications like sample injection, column switching for online LC-LC/MS or online SPE-LC/MS, Multiplexing, column selection and many more.

- Valve Drive supports VICI/Valco and Rheodyne valve types
- Injection port bottom sensing minimizes carryover
- Constant Force Technology to reduce dead volume during injection process
- UHPLC/HPLC: up to 50% faster switching times for optimum system performance and prolonged column life time
- Stackable design to reduce the space required
- Huge flexibility to arrange multiple valve solutions
- The Fast Wash Module is also stackable below a Valve Drive



Two Injection Valves and two Selector Valves. Staggered injection configuration reduces space required.

Fast Wash Module

- Cleans syringes of gauges 19 to 26
- Integrated pumps for active wash solvent delivery
- Supports two different wash solvents (aqueous and organic)
- Reduces wash solvent consumption by automatic flow adjustments
- Can be mounted underneath Valve Drives to minimize required space



Standard Wash Module

Wash Module for low volume injections:

- 4x 10mL wash solvent vials
- 1x 10mL waste vial
- Optional Waste Port Adapter to connect a tube to a waste bottle



Large Wash Module

Wash Module for large volume injections:

- 2 x 100mL solvent container (glass) with septum cap
- Waste port with tubing olive to connect waste bottle



Solvent Module

For large solvent demands, e.g. for the addition of larger volumes of solvents or serial dilutions:

- 3 x 100mL solvent container (glass) with septum cap



Dilutor Module & Tool

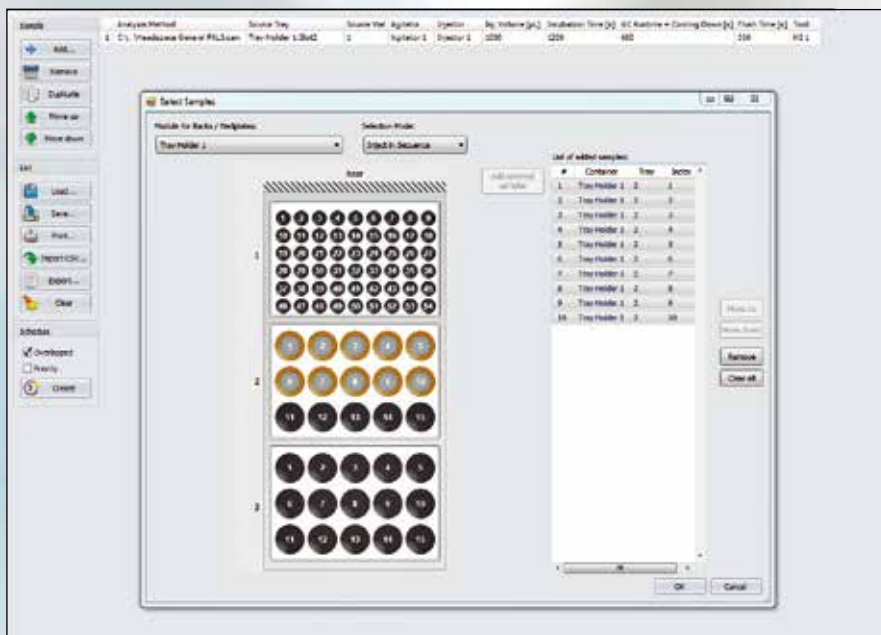
- For the efficient and accurate addition of larger amounts of liquids
- 100 μ L, 1mL, 5mL & 10mL dispensing syringes available
- Optional selector valves allow dispensing of up to 5 different liquids



For more information about PAL Tools and Modules please visit our website



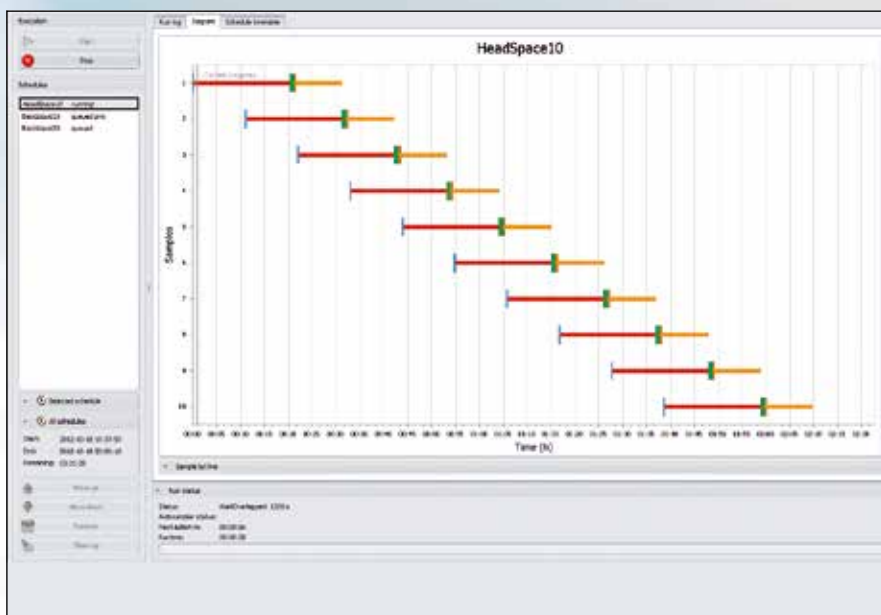
www.palsystem.com



Easy to use

Creation or import of sample lists is done with a few clicks.

With one more click sample preparation and data acquisition are started.



Productivity

PAL Sample Control optimizes productivity by overlapping individual steps. In many cases runtimes of sequences can be cut to 1/3 or less compared to a sequential procedure.

Task	Description	Name	Value	Visible
1. Inject	Put sample in Autosampler	Enabled	True	<input checked="" type="checkbox"/>
2. WaitOverlapped	Wait generation	Runtime	15	<input checked="" type="checkbox"/>
3. Injection	Get sample and inject	RepeatRuntime	False	<input checked="" type="checkbox"/>
4. Transport	Put sample back to initial position	SkipTaskInFailure		<input checked="" type="checkbox"/>
5. MoveToHome		Wait	1000%	<input checked="" type="checkbox"/>
6. FlushSyringe		Source	%START%-%VOLUME%	<input checked="" type="checkbox"/>
7. WaitOverlapped	Wait for GC to be ready for the next injection	Debounce		<input checked="" type="checkbox"/>
		DebounceTime	%START%-%VOLUME%	<input checked="" type="checkbox"/>
		DebounceInTime	False	<input checked="" type="checkbox"/>

Powerful Method Editor

A powerful yet easy to use tool to generate custom methods is included.



PAL Sample Control

Easy to use routine software

PAL Sample Control software is the user-friendly tool for the daily routine jobs. With a few clicks sample lists are generated or imported. Now PAL Sample Control starts the operation and the data acquisition. Since PAL Sample Control interfaces seamlessly with most of the major chromatographic or MS data systems only one sample list has to be handled. Different user levels ensure process safety.

Productivity

PAL Sample Control allows overlapping of time consuming steps. It optimizes automatically the timing of various steps in a sample preparation process and generates a schedule that minimizes the runtimes of sequences. This increases sample throughput greatly and boosts productivity.

Powerful Method Editor

While PAL Sample Control is straightforward to use in the daily operations it is also a powerful tool for the generation of tailored methods. A set of tested methods that comes with every system (e.g. headspace injection, partial loop liquid injection etc.) can be used as templates and optimized or tailored for specific workflows. Furthermore a large number of building blocks (tasks) for method development are part of the software. These building blocks make it easy to generate new methods, even for complex workflows.

PAL Sample Control is shipped with every PAL RTC or PAL RSI.

Supported CDS and MS-Data Systems

- Analyst
- ChemStation LC/GC/MSD
- Chromcard
- ChromPerfect
- ChromQuest
- Clarity
- Empower 2
- EZChrom
- MassHunter for GC/ MS
- Master Lab
- QuanLab
- Xcalibur

Ingenious Productivity Application Examples.

The workflows on these pages were realized with PAL Sample Control. The overlapping option boosts productivity.

For instance the required time to process 10 protein digestion samples is reduced from 1800min (serial) to 240 min (excl. LC/MS time).

Protein digestion with different enzymes (most often trypsin) is the daily bread for many proteomics labs. For reproducible results, e.g. for quantitation studies, it is of utmost importance to strictly follow the protocol.

This multistep workflow has been automated on PALs with excellent results in terms of yield and reproducibility.

Automated Digestion of Proteins

Wash storage solution

▼ Add 50 μ L MeCN/10mM Tris

▼ Vortex 10sec.

▼ Remove supernatant

▼ Add 50 μ L DTT 100 mM (Reduction)

▼ Incubate 30min, 50°C

▶ Next sample

▼ Remove supernatant

▼ Add 50 μ L DTT 100 mM (Alkylation)

▼ Incubate 30min, 40°C

▼ Remove supernatant

▼ Add 50 μ L 10mM Tris

▼ Vortex 10sec.

▼ Incubate 15min, RT

▼ Remove supernatant

▼ Add 50 μ L MeCN

▼ Vortex 10sec.

▼ Incubate 15min, RT

▼ Blow down MeCN

▼ Add 20 μ L trypsin

▼ Add 10 μ L protease

▼ Incubate 60 min, 50°C (Digestion)

▼ Transfer supernatant to LC vial

▼ Add 20 μ L formic acid 20%

Sample READY Start analytical run

Derivatization: Trans-esterification of Fatty Acids for GC/MS analysis

Start Trans-esterification

▼ Add ISTD

▼ Add NaOMe

▼ Vortex vial

▼ Wait (Derivatization time)

▼ Add heptane

▼ Vortex vial

▼ Add citrate

▼ Vortex vial

▼ Inject sample

Start analytical run

End derivatization

Start Trans-esterification
of next sample

The trans-esterification of fatty acids to generate the corresponding methyl esters (FAME) is a very common and at the same time tedious procedure. Its automation increases productivity and prevents exposure of humans to hazardous chemicals.

Automated Solid Phase Extraction (SPE) and filtration for PAL RTC/RSI with ITSP.

A wide variety of materials allows the selective clean-up of samples for further analysis.

Condition cartridge

▼ Transfer sample to cartridge

▼ Wash sample/cartridge

▼ Remove wash solvent

▼ Elute sample

▼ Inject eluted sample

Start analytical run

Start SPE of next sample

Get filter cartridge

▼ Aspirate sample through filter cartridge

▼ Discard empty cartridge

▼ Dispense sample into MTP

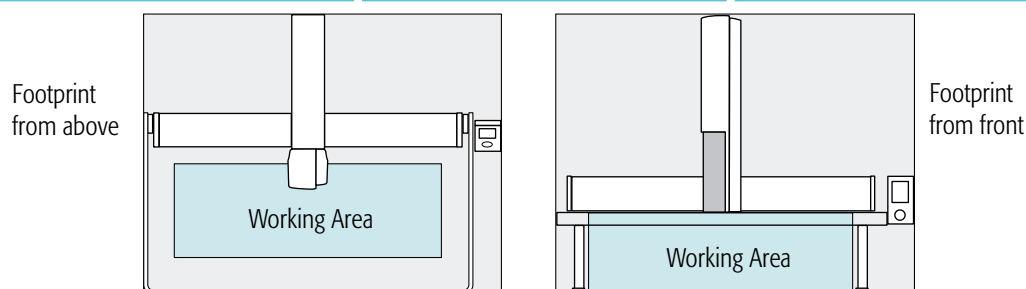
▼ Inject sample

Start analytical run

Start filtration of next sample

Dimensions

	PAL RSI compact x-axis length	PAL RTC & RSI standard x-axis length	PAL RTC & RSI xtended x-axis length
Working Space	Width: 420mm (16.8 inches) Depth: 255mm (10.0 inches) Height: 420mm (16.8 inches)	Width: 735mm (28.9 inches) Depth: 255mm (10.0 inches) Height: 420mm (16.8 inches)	Width: 1090mm (43.0 inches) Depth: 255mm (10.0 inches) Height: 420mm (16.8 inches)
Footprint Instrument dimensions with standard legs	Width: 600mm (24.0 inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)	Width: 915 mm (36.6 inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)	Width: 1270mm (50.8 inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)



Sample Capacity	2 Tray Holders Up to 420 1mL vials 324 2mL vials 90 10/20mL vials 6 MT/DW plates	4 Tray Holders Up to 840 1mL vials 648 2mL vials 180 10/20mL vials 12 MT/DW plates	6 Tray Holders Up to 1260 1mL vials 972 2mL vials 270 10/20mL vials 18 MT/DW plates
Sample Capacity Temperature Controlled (4-40°C)	1 Peltier Stack Up to (with 6DW) 420 1mL vials 324 2mL vials 90 10mL vials 6 MT/DW plates	Max. 3 Peltier Stacks Up to (with 6DW) 1260 1mL vials 972 2mL vials 270 10mL vials 18 MT/DW plates	Max. 4 Peltier Stacks Up to (with 6DW) 1680 1mL vials 1296 2mL vials 360 10mL vials 24 MT/DW plates 9216 samples (with 384 well MTPs)

Supported Injection Techniques PAL RTC & RSI

Tool	Ranges/Tools
Liquid Injection GC / LC	1.2µL / 5µL / 10µL / 100µL with D7 tool 250µL / 500µL / 1'000µL with D8 tool 5'000µL / 10'000µL with D18 tool
Headspace Injection	1mL / 2.5mL / 5mL, with corresponding tools
Solid Phase Micro Extraction (SPME)	SPME tool holds commercially available fibers
Multiple Headspace Extraction (MHE)	MHE tool for 10 and 20mL vials

Available Modules

Agitator Module	Temperature controlled agitation, 40-200°C, 250-750rpm
Barcode Reader Module	Reads 1D barcodes on 2, 10, 20mL vials
Dilutor Module	Fast and accurate dispensing of larger volumes of up to 5 different liquids
Fast Wash Module	Efficient cleaning of syringes / needles (gauge 19-26) with 2 different solvents
Large Wash Module	2 x 100mL solvent container and waste port for cleaning of syringes / needles
Multiple Headspace Extraction Module	Tool & holder for MHE
Peltier Stack Modules (2DW, 6DW)	Temperature controlled storage 4-40°C for a range vials and multititerplates
Solvent Module	3 x 100mL solvent container for the addition of larger volumes of liquids
SPME Fiber Conditioning Module	Conditioning of SPME fibers, up to 350°C, optional purge gas connection
Standard Wash Module	4 x 10mL solvent vial, 1 x 10mL waste vial
Valve Drive Module	For Rheodyne or Valco injection & switching valves
Vortex Mixer Module	Efficient mixing for 2, 10, 20mL vials

LC Application Specifications

Type	Specifications	Comment
Injection volume	0.1-10000 μ L	Depending on syringe
Liquid injection, repeatability (gravimetric)	Full loop < 0.1% RSD Partial loop < 0.15% RSD	20 μ L loop, 4 x overfill 10 μ L in 20 μ L loop
Liquid injection, linearity (gravimetric)	R > 0.9999	20, 40, 60, 80, 100 μ L, n=3 each level
Liquid injection from small sample volume	3 injections 1 μ L out of 5 μ L	With bottom sense option and conical 150 μ L vial
Carryover	< 30 ppm	With LC/MS Tool, blank measured after injection of Cl-Hexidine 0.6mg/mL

GC Application Specifications

Type	Specifications	Comment
Injection volume	0.1-10000 μ L	Depending on Syringe
GC liquid injection, repeatability	< 0.60 % RSD	Alkanes C14,C15,C16, 1 μ L, split mode
GC liquid injection, linearity (gravimetric)	R > 0.9999	20, 40, 60, 80, 100 μ L, n=3 each level
GC head space injection, repeatability	< 1.00 % RSD	Iso-octan, 10 μ L in 20 mL vial, 500 μ L injection
GC needle discrimination	C40/C20 > 0.98	Restek Florida Mix 1 μ L, 100ms fast split/splitless injection

PAL SYSTEM

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For more information on the RTC and RSI visit:

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