



## Printing History

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The PAL System may be operated with another level of firmware. Details of the current level are given with the leaflet "Firmware Overview" which is placed in the front of this binder.

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## Safety Information

### Declaration of Conformity

See Declaration of Conformity sheet enclosed with the instrument

### General Considerations



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.

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.

When you use the PAL System, follow the generally accepted procedures for quality control and methods development.

When you use the PAL System in the field of chromatographic analysis and you observe a change in the retention of a particular compound, in the resolution between two compounds, or in peak shape, immediately determine the reason for the changes. Until you determine the cause of a change, do not rely on the separation results.

## Electrical Hazards

Every analytical instrument has specific hazards, so be sure to read and comply with the following precautions. They will help ensure the safe, long-term use of your PAL System.

The Installation Category (Over voltage Category) for this instrument is Level II. The Level II Category pertains to equipment that receives its electrical power from the local level, such as an electrical wall outlet.

Only use fuses of the type and current rating specified. Do not use repaired fuses and do not short-circuit the fuse holder.



The supplied power cord must be inserted into a power outlet with a protective earth contact (ground). When using an extension cord, make sure that the cord also has an earth contact.



Do not change the external or internal grounding connections. Tampering with or disconnecting these connections could endanger you and/or damage the PAL System.

The instrument is properly grounded in accordance with these regulations when shipped. You do not need to make any changes to the electrical connections or the instrument's chassis to ensure safe operation.



The combination of a PAL System with a LC/MS System does require the safety measure as described by the LC/MS System manufacturer. Detailed instructions for the safety grounding on the LC/MS system are outlined in the corresponding operating/installation manual.

CTC Analytics recommends to use a grounding cable connected on one side at the Injection Valve, Loop or any other suitable direct metallic contact and the other side at an appropriate grounding point at the LC/MS System. This supplementary grounding measure will support the safety strategy of the LC/MS System manufacturer.



Do not turn the instrument on if you suspect that it has incurred any kind of electrical damage. Instead disconnect the power cord and contact a CTC Analytics representative for a product evaluation. Do not attempt to use the instrument until it has been evaluated. Electrical damage may have occurred if the PAL System shows visible signs of damage, exposure to any liquids or has been transported under severe stress.

Damage can also result if the instrument is stored for prolonged periods under unfavorable conditions (e.g. subjected to heat, water, etc.).



In any case disconnect the power cord(s) from the power supply or from the different power supplies if optional devices are installed before attempting any type of maintenance.

Capacitors inside the instrument may still be charged even if the instrument is turned off.



To avoid damaging electrical parts, do not disconnect an electrical assembly while power is applied to the PAL system. Once the power is turned off, wait approximately 30 seconds before you disconnect an assembly.

The instrument includes a number of integrated circuits. These circuits may be damaged if exposed to excessive line voltage fluctuations and/or power surges.



Never try to repair or replace any components of the instrument that is not described in this manual without the assistance of a CTC Analytics representative.

There are no operator-serviceable or replaceable parts inside the power supply(ies) or in the PAL System. If a power supply is not functioning, contact a CTC Analytics representative.



The power supply for the PAL Instrument has the symbols 1/0 on the label for the power switch to switch ON/OFF.

Any additional power supply for other devices like, Cooled Stack or a Valve Module shows the symbols as shown below on the label for the power switch:



Power ON



Power OFF

The symbols shall warn the user that in a emergency case more than one power supply has to be turned OFF or more than one power cord has to be pulled from power supply or from the wall outlet to shut down the complete PAL System.

If the basic PAL System is installed, than a single power supply is installed only. Turning OFF the power supply or pulling this single power cord in an emergency case will stop the complete PAL System.

It is important that the power supply (ies) are in a location where the power ON and OFF switch is accessible and easy to operate, and where it is possible to unplug the AC power cord from the power supply/wall outlet in case of emergency.

## Other Hazards



To avoid injury during PAL System operation, keep your hands away from the syringe.



Do not operate the PAL System without the safety shield. The safety shield must be installed for safe operation.



To avoid injury, observe safe laboratory practice when you handle solvents, change tubing, or operate the PAL System. Know the physical and chemical properties of the solvents you use. See the Material Safety Sheets from the manufacturer for the solvents in use.



Use caution when working with any polymer tubing under pressure:

- Always wear eye protection when near pressurized polymer tubing.
- Do not use polymer tubing that has been severely stressed or kinked.
- Do not use polymer tubing, in particular not PEEK or Tefzel tubing, with Tetrahydrofuran (THF), Dimethylsulfoxid (DMSO), chlorinated organic solvents, concentrated mineral acids, such as Nitric, Phosphoric or Sulfuric acids, or any related compounds to above listings.

## Lithium battery















An onboard lithium battery buffers the electronic memories, when the instrument is turned off. Replace it only with the same or equivalent type recommended by the equipment manufacturer.

Battery: Panasonic VL 2330, soldered directly on the electronic board.

Discharged lithium batteries shall be disposed off locally according to national waste disposal regulations for batteries.

There are no operator-serviceable parts on the electronic boards.  
If an electronic board fails, contact a CTC Analytics representative.

Commonly Used Symbols

	Caution or refer to User Manual
	Caution, Risk of Needle-Stick Puncture
	Caution, Hot Surface or High Temperature
	Direct Current
	Alternating Current
	Protective Conductor Terminal, Ground
	Fuse
	Electrical Power ON. Used with Main PAL Power Supply.
	Electrical Power OFF. Used with Main PAL Power Supply.
	Electrical Power ON for Only Part of the System. Used with Optional Device(s)
	Electrical Power OFF for Only Part of the System. Used with Optional Device(s)
	Caution, Risk of Electrical shock (high voltage)





## Combi PAL Operating Manual

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## How to Use this Manual

The manual is divided into three major sections:

**Combi PAL Operating Instructions Section A**

**Combi PAL Description and Installation Section B**

**Appendices**

The "Combi PAL Operating instructions" in section A are intended for infrequent PAL users or new users that are experienced in using automated systems to perform existing analytical methods.

**note !**

**The Combi PAL must be installed and set up properly before the Operating Instructions in Section A can be used**

Users who are installing a Combi PAL system, Combi PAL accessories or who need to adjust an installed system should consult "Combi PAL Description and Installation" in Section B.

The Appendices provide useful information such as the Software Flow Chart, Definition of Terms, Injection Cycle parameter descriptions or the Combi PAL Accessories guide.

## A. Combi PAL Operating Instructions

### 1. Using the Control Terminal

The following procedures present the key steps required to set up and process multiple groups of samples with the Combi PAL. It is intended to provide an overview for new users and a reminder for infrequent users. The Combi PAL and all accessories should be installed and Objects defined correctly. A Syringe of the type called for in any Method to be used should also be installed.

Figure 1 illustrates the PAL Control Terminal and the conventions used to enter, edit, and view information.

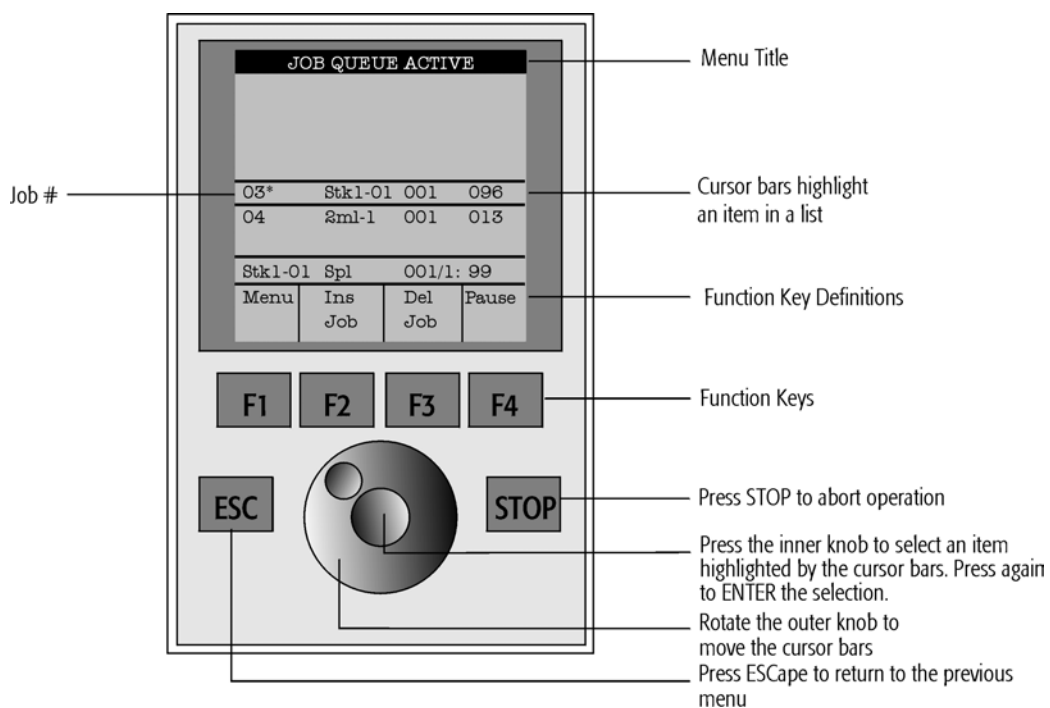


Figure 1. PAL Control Terminal and Conventions

## 1.1 Menu Screens

Different menu screens are displayed depending on the Combi PAL operating state and the particular function being accessed by the operator. All menu screens have the same basic format. The menu title is displayed at the top of the screen. A list of items is displayed below the title. The date and time or a status is shown in the highlighted area above the Function key labels on the bottom of the screen.

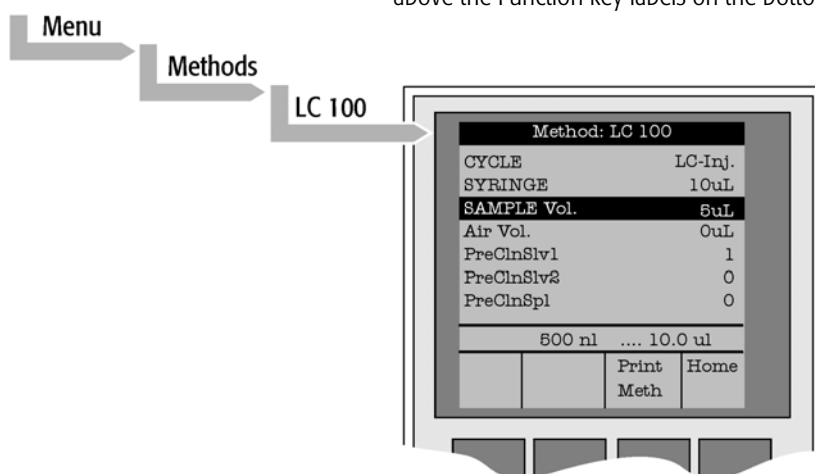


Figure 2. Accessing a Method Screen

## 1.2 Function Keys

Options for a particular menu are assigned to the corresponding function keys (**F1**, **F2**, **F3** and **F4**) directly below each function key label.

Pressing the function key defined as **Home** will always return to the Job Queue menu.

## 1.3 ESCape and STOP Keys

Press the **ESC**ape key to return to the previous menu. Press the **STOP** key to abort the current Cycle, Job, or Job Queue.

## 1.4 Scroll Knob and ENTER Button

Rotate the outer knob to scroll through items in a menu list. To select a highlighted item press the central knob (ENTER button). Then use the outer knob to scroll through available options for that item or to change a numeric value. Then press the inner knob again to **ENTER** the displayed option. The inner knob is also used for other operations that require an **ENTER** operation to continue or complete an operation.

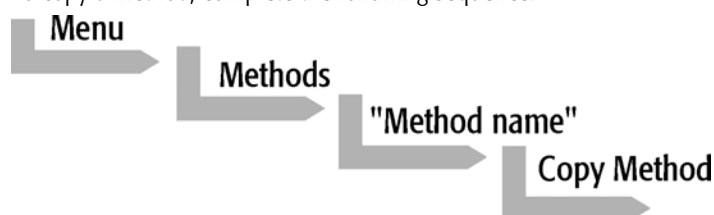
## 2. Methods

### 2.1 Creating Methods

Methods can be defined by the user and assigned names up to eight characters in length. Methods can be created, copied, edited, and viewed from the menu Methods. Methods can be viewed (but not edited) from the Job Queue menus.

Methods are created by either copying an existing Method or creating a new Method.

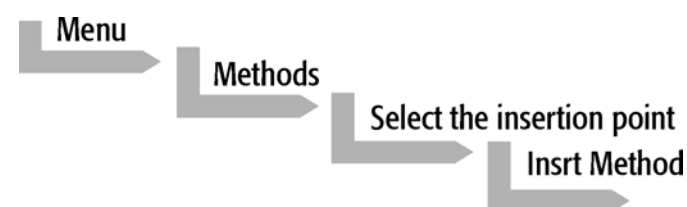
- 1 To copy a Method, complete the following sequence:



- 2 You will be prompted to enter a name for the new Method.

Use the scroll knob and the left-right arrow function keys (F2 and F3) to select among alphanumeric characters and spaces. Press the ENTER function key (F4) to accept the name.

- 1 To create a new Method, complete the following steps:



- 2 Assign and enter a new Method name as above.

After a copy of the Method has been created, the Method parameters will be displayed and can be edited. The Cycle and Syringe entries cannot be changed.

- 3 If the Method is new (i.e. added), select and enter a Cycle that is appropriate for the application.
- 4 Select the specific Syringe to be used by the Method.

**note !**

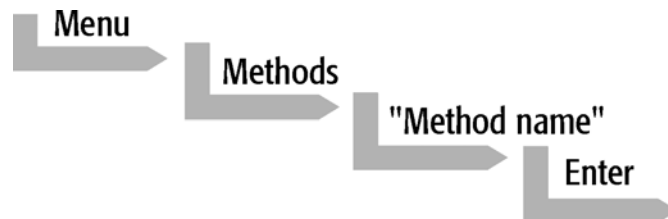
Once a Method has been created and saved, the Cycle and Syringe can not be changed. To use a different Cycle or Syringe, a new Method must be created.

- 5 Assign Parameter values according to the application requirements. Consult Appendix C Combi PAL "Cycle Parameters" for details of the specific items.

## 2.2 Edit / View Methods

Method parameters (excluding Cycle and Syringe) can be viewed and changed from the Method menu as follows:

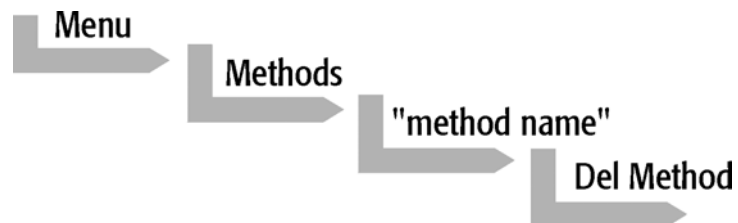
- 1 Complete the following menu selections:



- 2 Scroll to and select the Parameter to be changed. Assign the new value and press the ENTER key.
- 3 Exit from Parameter List by pressing either the Home function key (F4) to return to the top-level Job Queue menu or the ESCape key to return to the previous menu.
- 4 Method contents may be viewed from the Job Queue displays by selecting the desired Job, pressing ENTER, and the View Method function key.

## 2.3 Delete Methods

Methods can be deleted from the Method menu. Methods in use by an active Job cannot be deleted. Complete the following menu selections to delete a Method.





### 3. Job and Job Queue

#### 3.1 Building and Starting a Job Queue

- 1 Power up the Combi PAL. The JOB QUEUE screen is displayed.

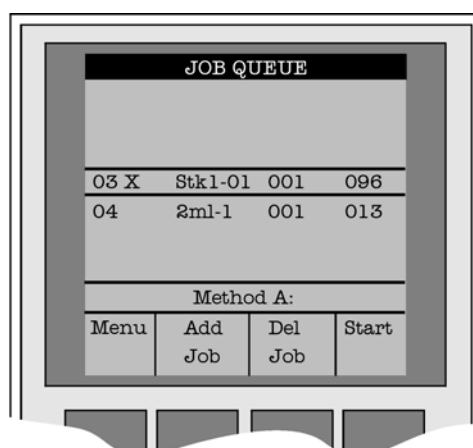


Figure 3. Example Job Queue Screen

- 2 Load a sample Tray onto an available location in a Tray Holder. Note the corresponding Tray name.

**note !**

If a sample Tray contains 10ml sample vials and the "HS-Inj" cycle is used insert the supplied adapters into the Agitator sample positions.

- 3 Add a new Job for the Tray. Press the **Add Job** key to bring up the default Job.
- 4 For TRAY select the Tray Name (e.g. Tray1) that corresponds to the location of the Tray that was just loaded.
- 5 Enter the **First** and **Last** sample number for this Job.
- 6 Select and enter the sample processing **Method** for this Job.
- 7 Press the **Home** function key (**F4**) to return to the JOB QUEUE screen.
- 8 To add additional samples to be processed repeat steps 2 - 7.
- 9 If necessary, replace and/or clean the Syringe (liquid versions only). Press the Menu key to see the available options for changing (**F1 Change Syringe**) and cleaning (**F2 Clean Syringe**). To completely remove air bubbles, the Syringe should be primed manually. (See chapter 8.2, page 31, "Syringe priming")



- 10 If only one Job will be processed, select that Job with the scroll knob. Press **Start** key. In the dialog box "**Select Job(s) to Process**" select one of the following options:
  - **All** (Entire Job Queue starting from the top)
  - **Selected** (Job selected with the cursor bars)
  - **Resume** (Continue with the next Job after the aborted one)

### 3.2 Aborting a Job Queue

- 1 Press **STOP**
- 2 Select one of the available options (**Continue**, **Sample**, **Job**, or **Job Queue**).

Select **Continue** to resume processing with the current sample.

Select **Sample** if there is a problem with only the current sample. Processing will resume with the next sample.

Select **Job** to abort processing of all samples in the current Job. Processing will resume with the next Job. The aborted Job is marked with an **X**.

Select **Job Queue** to abort processing of all Jobs. The JOB QUEUE screen will be displayed. The aborted Job is marked with an **X**.

### 3.3 Restarting an aborted Job Queue

- 1 Press the **START** key.
- 2 Select the option **Resume**. The job after the last one marked as aborted will be started.

## 4. Utility Functions

**Utility functions**, selectable from the **Menu** screen, provide quick access to checking operations and parameters that may need to be changed. These functions are available for the actual Syringe, Trays, Injectors, and the Wash Station. They allow access to key functions without having to set up and execute a Method and Job.

**note !**

If an item is used in the sample processing cycle, the appropriate Utility value will be overwritten by the Method value.

### 4.1 Syringe

By pressing a Function Key the following functions are available:

Function Key	Description
F1 Chang Syr	The syringe is moved to a position, where the syringe assembly can be completely lowered to facilitate removal of the syringe adapter. The syringe can then be removed from the adapter and replaced. A prompt will be displayed to specify the new syringe. The syringe must be installed before pressing <b>Enter</b> . (see Chapter 8 "Syringes")
F2 Clean Syr	This Function is used to clean or prime the syringe prior use. After selcting <b>F2</b> either Wash1 or Wash2 can be selected.
F3 Set Pos	Set Pos is used to define the Chang Syr position.
F4 HOME	The Injection Unit moves to it's HOME position and the Job Queue Menu is displayed.

The following Syringe Parameters may be changed by selecting the particular item:

Item	Description
Actual Id	Indicates the Identification number (ID) of the currently inserted syringe. If the syringe detection system is set to manual the extension "man" is displayed. This value can not be changed.
Fill Volume	This parameter serves to control the filling of the syringe. It may happen that air bubbles remain below the plunger after the first pull up. If the plunger is moved up and down several times (see Fill Strokes), these air bubbles are worked out. With this operation the syringe can be completely filled even when using very small sample volumes.
Fill Strokes	Number of Fill Strokes. All Fill Strokes, except the last one, use the selected Fill Volume. If the selected Sample Volume is higher than the Fill Volume, the Sample Volume is used for all Fill Strokes. If zero is selected the plunger is pulled up only once using the Sample Volume value.
Pullup Del	Using this item a delay time between sample pullup and ejection while filling the syringe can be selected. The same delay time is used after the last plunger pullup until the syringe needle is moved out of the sample vial. It is only used if more than one Fill Stroke is selected. This feature is especially useful for handling viscous fluids or syringe sizes >25µl.
Fill Speed	Speed of plunger movement used in all syringe filling operations.
Eject Speed	Speed of plunger movement used in all syringe eject operations except sample injection.
Inject Speed	Speed of plunger movement for sample injection.
Standby Temp*	Sets the temperature for a heated syringe during standby mode. (e.g. before or after a Job/JobQueue is processed)
Actual Temp *	Indicates the actual syringe temperature
Plunger Pos	Plunger position during Chang Syr operation. The syringe plunger is moved to a position where the syringe can be removed and replaced. The value may be changed for different types of syringes.

\* Available for heated syringes only.

## 4.2 Tray

After selecting the particular Tray to be accessed, the following Functions are available:

Function Key	Description
F1 Start Agi *	F1 starts the spinning motion of the agitator. It may be used to test the agitator function or to optimize the spinning speed for particular applications.
F3 Movto nnn	This function serves as a quick check to determine if the XYZ coordinates are defined correctly for the selected Tray. To use this utility the selected Tray including the sample vials must be present. After pressing "Movto 001" the Injection Unit moves to sample position no.1. This procedure can be repeated for the last sample position in the first row and the last sample position.
F4 HOME	The Injection Unit moves to it's HOME position and the Job Queue Menu is displayed.

\* Available for Agitator only.

The following Tray Parameters may be changed by selecting the particular item:

Item	Description
Needle Penetr	Needle penetration depth into the sample vial. The needle penetration depth for the selected Tray may be changed by entering the desired value.
Tray Type	The Tray Type which is selected for the Tray is shown. If the Tray enables the use of different Tray Types it can be changed at this position.
Standby Temp*	Sets the temperature for the Agitator during standby mode. (e.g. before or after a Job/JobQueue is processed)
Actual Temp *	Indicates the actual agitator temperature.
Speed *	Sets the agitator spinning speed. Usually it has to be set as high as possible, but not too high so the liquid does not move up to the septum. Check the correct speed by inserting a spacer below the vial inside the agitator so the liquid level is visible. Try different speeds and monitor the liquid level.
Agi On Time *	Sets the time how long the agitator is spinning in one direction.
Agi Off Time *	Sets the time how long the agitator stops before it reverses spinning direction. If this value is set to 0, only the clockwise direction with no interrupts will be used.

\* Available for Agitator only

## 4.3 Injector

After selecting the particular Injector to be accessed, the following Functions are available:

Function Key	Description
F3 Movto Inj	The Injection Unit moves to the selected Injector position. The Injectors GC-Inj1, Waste, Waste2 and Flush may be accessed. By selecting the Parameter "Needle Penetr" on the same screen the Injector Needle Penetration value may be checked or changed.
F4 HOME	The Injection Unit moves to its HOME position and the Job Queue Menu is displayed.

The following Injector Parameter may be changed by selecting the particular item:

Item	Description
Needle Penetr	By selecting the Parameter "Needle Penetr" the Injector Needle Penetration value may be checked and/or changed. To ensure reproducible sample injections and minimize carryover it is critical that the needle penetration depth is set accurately.



#### 4.4 Wash Station

After selecting the specific Wash Station, the following functions are available:

Function Key	Description
F3 Movto Wash	The Injection Unit moves to the selected Wash Station port. By selecting the Parameter "Needle Penetr" on the same screen the Wash Station Needle Penetration value may be checked or changed.
F4 HOME	The Injection Unit moves to it's HOME position and the Job Queue Menu is displayed.

The following Wash Station Parameter may be changed by selecting the particular item:

Item	Description
Needle Penetr	By selecting the Parameter "Needle Penetr" the Wash Station Needle Penetration value may be checked and/or changed.

## B. Combi PAL Description and Installation

### 5. General System Overview

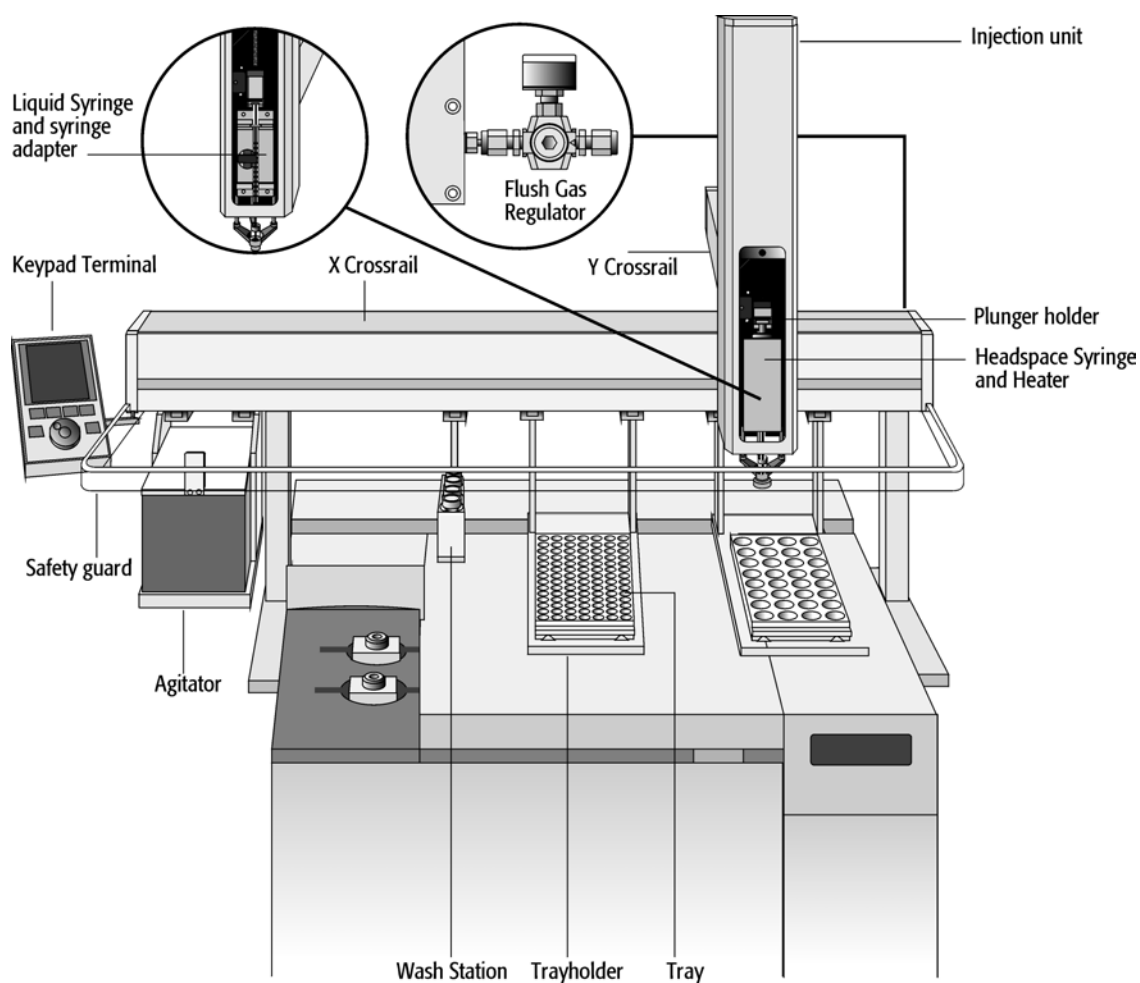


Figure 4. Combi PAL Major System Components

The standard Combi PAL includes the following hardware:

- 1 X Y Crossrail
- 1 Injection Unit
- 1 Flush gas regulator
- 1 Trayholder/Tray for 1ml / 2ml vials
- 1 Trayholder/Tray for 10ml / 20ml vials
- 1 Syringe kit for liquid injections
- 1 Syringe kit for heated syringes
- 1 Heated 6 position agitator
- 1 Wash station for 2 different solvents
- 1 GC mounting kit (optional)



## 5.1 Specifications

<b>Sample capacity</b>	98 x 2ml vials per Tray 200 x 1ml vials per Tray 32 x 10ml / 20ml vials per Tray (up to 2 Trays may be configured)
<b>Thermostatted Sample Tray</b>	Optional, 4°C – 70°C
<b>Liquid injection range</b>	1µl - 10µl with standard 10µl syringe down to 0.2 - 1.4µl with Sandwich technique or optional 1.2µl syringe up to 50 - 500µl with optional 500µl syringe
<b>Headspace injection range</b>	250 - 2500µl with standard 2.5ml heated syringe down to 100µl with optional 1.0ml heated syringe up to 5000µl with optional 5.0ml heated syringe
<b>Heated syringe temperature</b>	35°C - 150°C selectable in 1°C increments
<b>Incubator oven</b>	6 heated vial positions for 2 / 10 / 20ml vials temperature range 35°C - 200°C, selectable in 1°C increments orbital interval shaking, speed 250 - 750rpm
<b>Replicate injections</b>	1 - 99 from one vial
<b>Minimum sample volume</b>	1µl from 3µl sample in 1ml tapered micro vial in liquid injection mode
<b>Precision</b>	Typically < 0.5% RSD of peak area from 1µl - 10µl Typically < 1.0% RSD of peak area from 0.1µl - 1µl
<b>Carryover</b>	Typically < 0.05%



## Electrical Specifications

Parameter	Requirement
Protection Class <sup>a</sup>	Class I
Over Voltage Category <sup>b</sup>	Category II
Pollution Degree <sup>c</sup>	2
Moisture Protection <sup>d</sup>	Normal (IPX0)

**a: Protection Class I:**

Protection class describes the insulating scheme used in the instrument to protect the user 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 plug.

**b: Over Voltage Category II:**

Over Voltage category II pertains to instruments that receive their electrical power from a local level such as an electrical wall outlet.

**c: Pollution Degree2:**

This is a measure of pollution on electrical circuits that may produce a reduction of the dielectric strength or surface resistivity.

Degree 2 refers to normally only non-conductive pollution.

Occasionally, however, a temporary conductivity caused by condensation must be expected.

**d: Moisture Protection:**

Normal (IPX0) – IPX0 means that there is NO Ingress Protection against any type of dripping or sprayed water. The X is a place holder to identify protection against dust if applicable.





## Electrical Specifications (Continued)

Parameter	Requirements
<b>PAL System</b>	
Voltage	36 VDC
Current	3.2 A
Fuse	T6.3 A/250 V
<b>PAL System Power Supply</b>	
Input Line Voltage	Grounded AC, 100 to 240 V
Input Line Frequency	50/60 Hz
Input Power	4 A
Output Voltage	36 VDC
Output Current	4.16 A

## Physical Specifications

Parameter	Requirements
<b>Combi PAL Systems</b>	
Height	648 mm (25.5 in.)
Depth	385 mm (14.1 in.)
Width	828 mm (32.6 in.)
Weight	10 kg (22 lbs) without accessories

## Operating and Environmental Requirements

Parameter	Requirements
Operating Temperature Range	4 to 40 °C (39 to 104 °F)
Maximum Relative Humidity	75%, non-condensing
Bench Space	At least 16 cm (6 in.) at the rear. Access to power switch(es) and power cord(s). Clean, level and smooth surface. Solid bench plate.
Vibration	Negligible
Static electricity	Negligible

## 6. Installation

### 6.1 Unpacking the Components

A Combi PAL system is shipped in one box. The box contains the X/Y Crossrail assembly, the Injection Unit, the heated Agitator, the Keypad Terminal, GC mounting kit (optional), connecting Cables, Power supply, (heated) Syringe Kits, Trayholders, Trays, Wash Station assembly, Safety Guard and miscellaneous parts.

- 1 Open the box and first remove the accessory boxes and the Injection Unit before attempting to remove the X/Y Crossrail assembly.
- 2 Remove any loose foam packing around the X/Y Crossrail. Carefully lift the X/Y Crossrail and remove it from the box. Hold the Y Crossrail in place as the assembly is removed from the box. Set the X/Y Crossrail assembly on a bench.
- 3 Unpack the remaining small boxes and any other accessories.
- 4 When placing the Combi PAL onto a GC, make sure that no objects will interfere with either the Y Crossrail or Injection Unit throughout the entire range of potential movements.

### 6.2 Assembling the Combi PAL

**note !**

During headspace operation, the syringe is cleaned after each injection with inert, clean gas (e.g. N<sub>2</sub> or He). Therefore, a 1/8 inch gas supply line must be available close to the Combi PAL.

- 1 First mount the correct GC mounting kit onto the GC.
  - 2 Loosen the two mounting clamp Torx screws of the vertical legs.
  - 3 Place the X/Y Crossrail on top and fit the mounting kit legs into the groove in the X-Crossrail. Be sure that the clamps fit completely into the grooves. Alternately tighten the two Torx screws until the legs are firmly in place.
- 1 Double check if the legs claws are correctly attached to the X-Crossrail (see Figure 5).

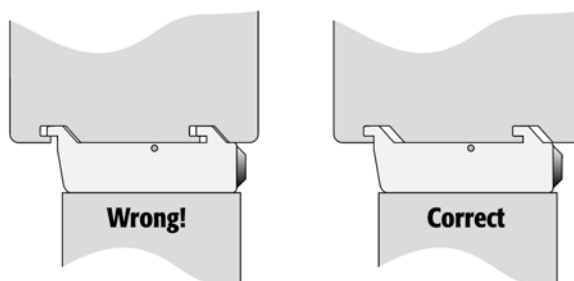


Figure 5. Attachment of Mounting Claws

## Installing the Injection Unit

**note !**

Installation of the Injection Unit should be done carefully. When installing it for the first time, have someone hold it in place while the mounting screws are inserted (see Figure 8).

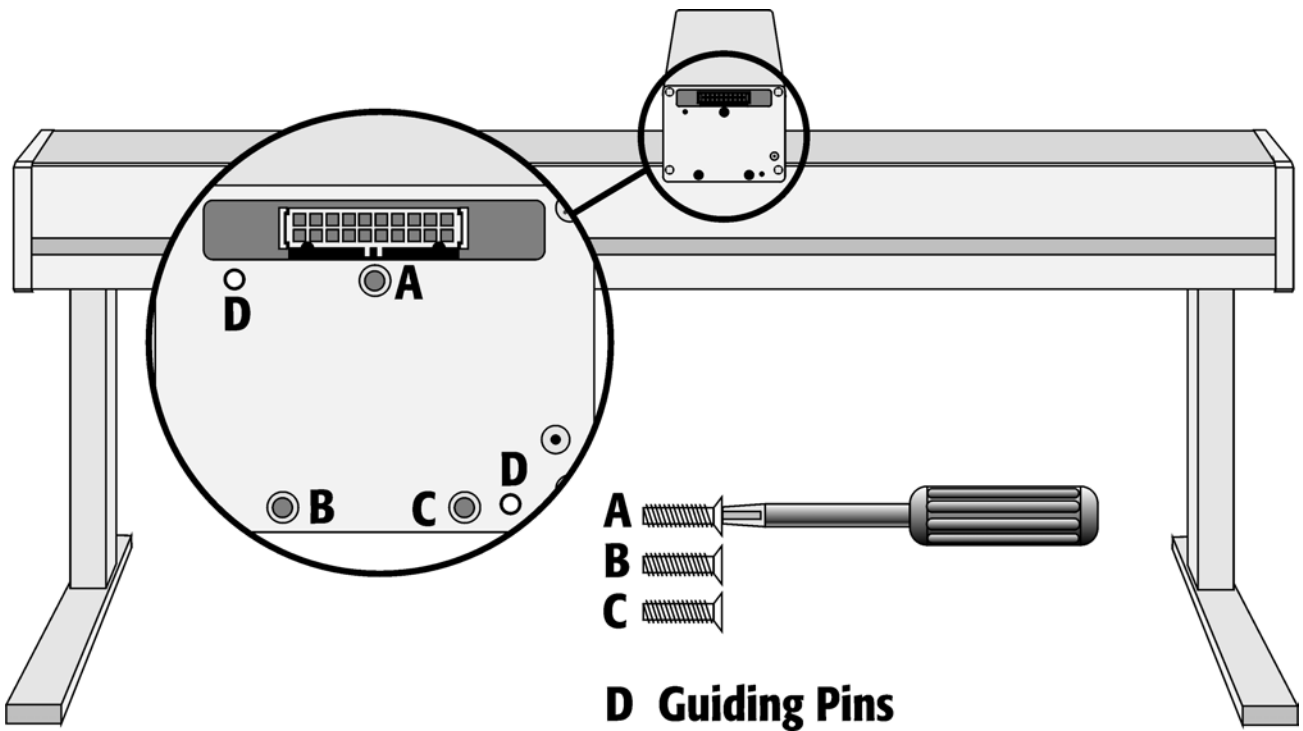


Figure 6. Attaching the PAL Injection Unit

- 1 Remove the 3 Torx mounting screws **A**, **B** and **C** that will be used to fix the Injection Unit to the Y Crossrail.

- 2 Connect the flat ribbon cable **A** protruding from the front end of the Y Crossrail to the corresponding connector on the Injection Unit (see Figure 7).

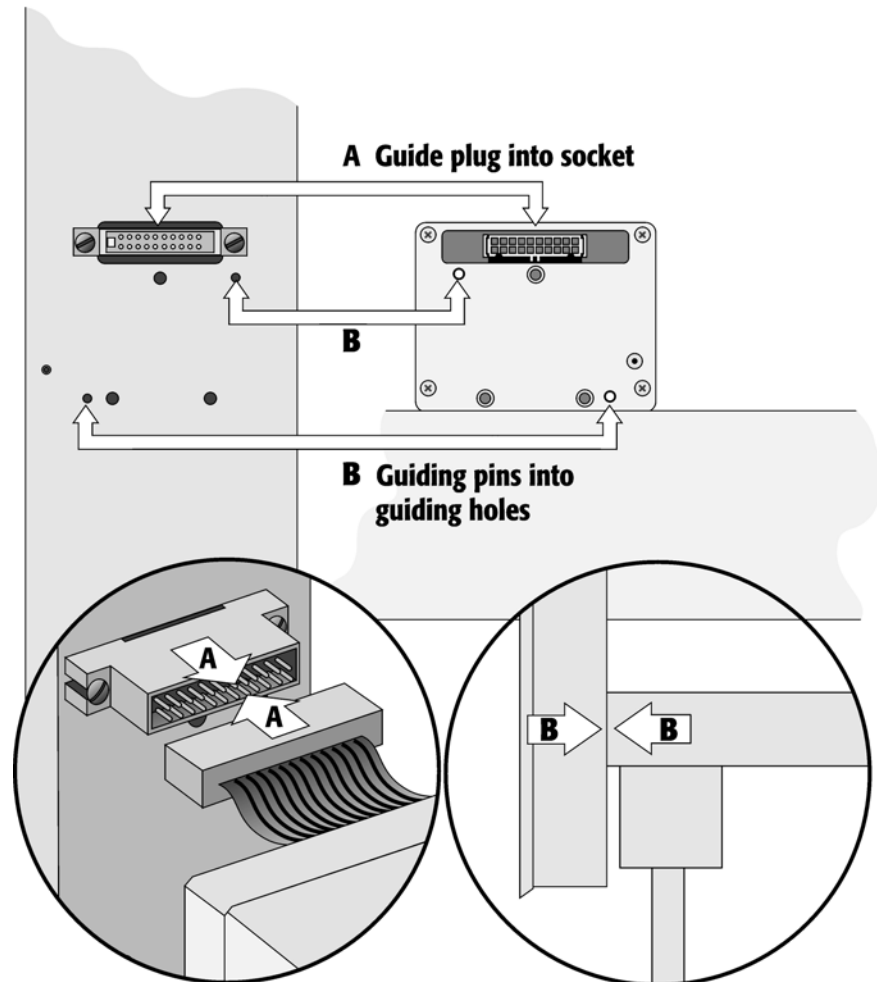


Figure 7. Connecting the Injection Unit Flat Cable

- 3 Hold the Injection Unit in place against the Y Crossrail. Make sure the two locating pins on the Y Crossrail fit into the two guiding pin holes on the Injection Unit.

- 4 Place one of the screws onto the end of the supplied Torx driver. Slide the clear plastic cover on the Injection Unit all the way to the top. Locate the three large holes in the black anodized frame attached to the Z Crossrail inside the Injection Unit. Slide the frame upwards until the top hole is centered on the top threaded hole in the end of the Y Crossrail. Insert and securely tighten the Torx screw **A** (see Figure 8).

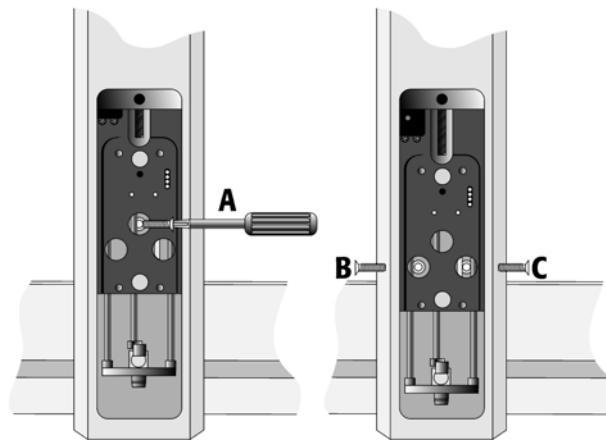


Figure 8. Inserting the Injection Unit Mounting Torx Screws

- 5 Install the two remaining Torx screws **B**, **C** in the left and right mounting holes, respectively. It may be necessary to move the elastic cord slightly to the left to insert the Torx screw **C** into the right-hand hole.

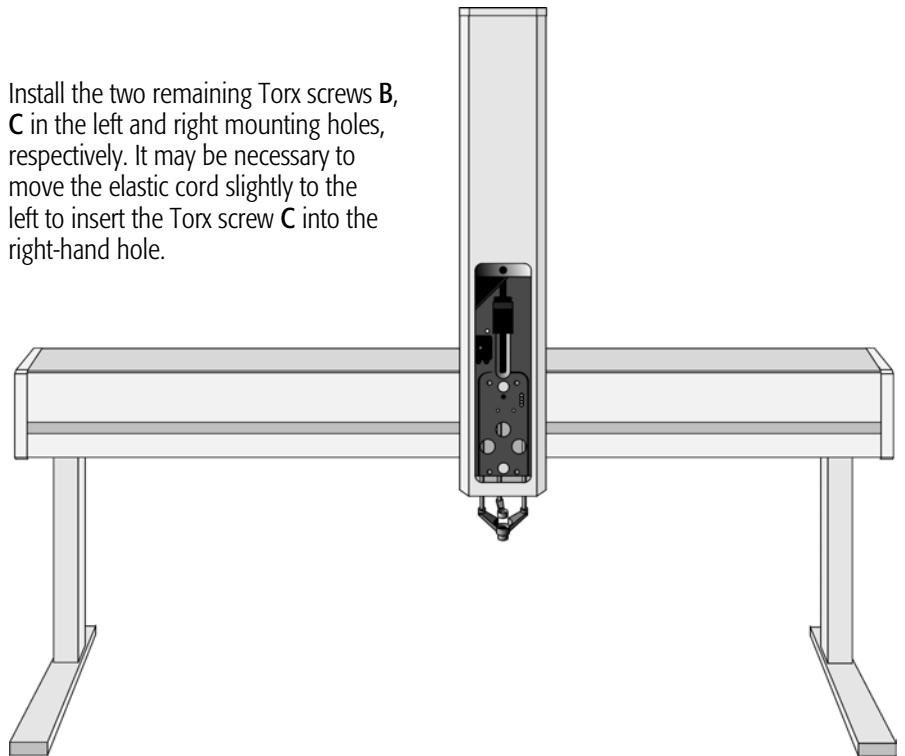


Figure 9. Combi PAL with Injection Unit and standalone supports

## Installing the Keypad Terminal

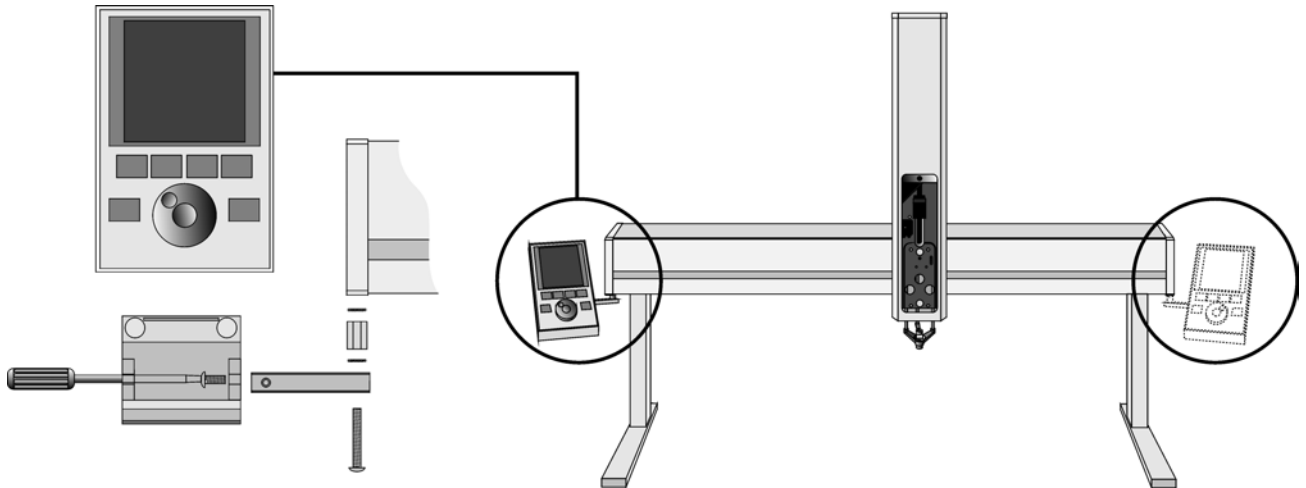


Figure 10. Installing Keypad Terminal

- 1 Install the Safety Shield on the left and right sides to the outside of the X-Axis. Use the provided longer thumbscrew on the side where you plan to install the keypad.
- 2 Install the Keypad mounting bracket on either the right or left side of the X Crossrail.
- 3 Connect one end of the white coiled cable (Part SS8J-700) to the Keypad and the other end to the **SER3** interface jack on the rear side of the X Crossrail.
- 4 Place the Keypad terminal onto it's mounting bracket.

## Installing the Power Supply

- 1 Locate the power supply, the DC power cable (Part RS3M-2000), and the AC power cable.
- 2 Set the power supply switch to the **OFF** position.
- 3 Connect one end of the DC power cable to the power supply and the other end to the **POWER** connector at the rear side of the X-Crossrail.
- 4 Connect the female end of the AC power cable to the power supply. Then connect the male end to an AC power outlet.

**note !**

Before proceeding with the remaining steps, switch OFF power to the PAL System.

## Installing the Flush Gas Regulator

- 1 Attach the OUT-side of the supplied Regulator at rear right hand side of the Combi PAL. (see Figure 11)
- 2 Connect a 1/8 inch clean gas supply line at the IN-side of the Regulator. Use an isolated gas line to avoid any pressure drops on other equipment. (e.g. GC)
- 3 Adjust the pressure of the gas supply source to 1.0-1.5 bar.
- 4 Adjust the Combi PAL Gas Regulator to approx. 0.5 bar.

**note !**

Higher pressure than 0.5 bar will not result in higher flow rates through the heated syringe.

- 5 Check the installed Flush Gas Regulator connections for leaks.
- 6 Verify the Flush Gas Pressure again during the flush period of a Headspace Cycle.

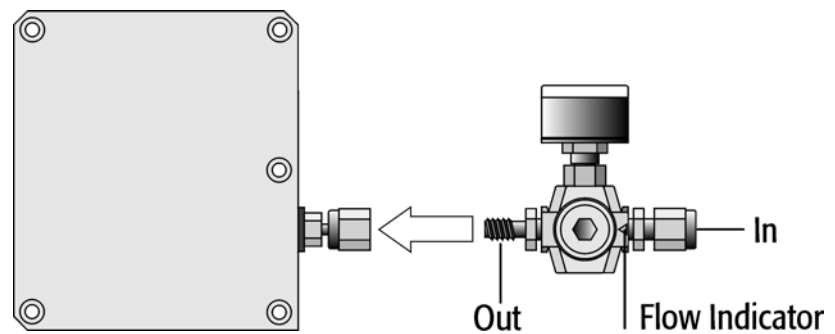


Figure 11. Installing the Flush Gas Regulator

## Installing the Wash Station

- 1 Attach the Wash Station assembly to the X-Crossrail

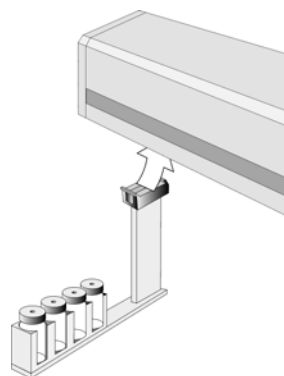


Figure 12. Installing the Wash Station

## Installing the Agitator

- 1 Loosen the two Torx screws on the two Agitator mounting brackets.

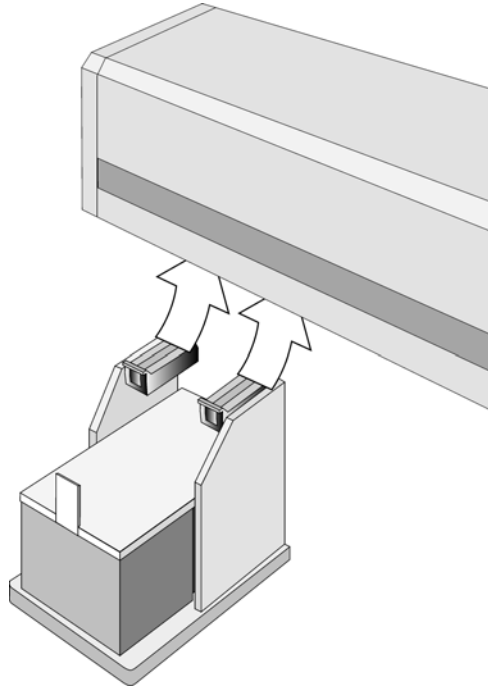


Figure 13. Installing the Agitator

- 2 Attach the Agitator to the left or right end of the X-Crossrail. Install it with the mounting clamp teeth fitting into the grooves on the bottom of the X-Crossrail.
- 3 Be sure that the clamps fit completely into the grooves. Alternately tighten the two Torx screws until the two mounting clamps are firmly in place.
- 4 Double check if the Agitator clamps are correctly attached to the X Crossrail (see Figure 5, page 18).
- 5 Connect the supplied Agitator control cable from **AUX1** to the connector on the rear side of the Agitator.



## Installing a Trayholder

- 1 Loosen the two Torx screws on the two mounting clamps located on top of the Trayholder legs.

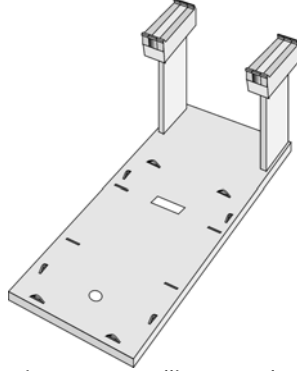


Figure 14. Installing a Trayholder

- 2 Install the Trayholder with the mounting clamp teeth fitting into the grooves on the bottom of the X Crossrail.
- 3 Be sure that the clamps fit completely into the grooves. Alternately tighten the two torx screws until the two mounting clamps are firmly in place.
- 4 Double check if the two Trayholder clamps are correctly attached to the X Crossrail.

### 6.3 Electrical connections

Before defining the Combi PAL object positions, make sure the Agitator and Keypad Terminal are correctly connected to the Combi PAL X-axis rear side.(see Figure 15)

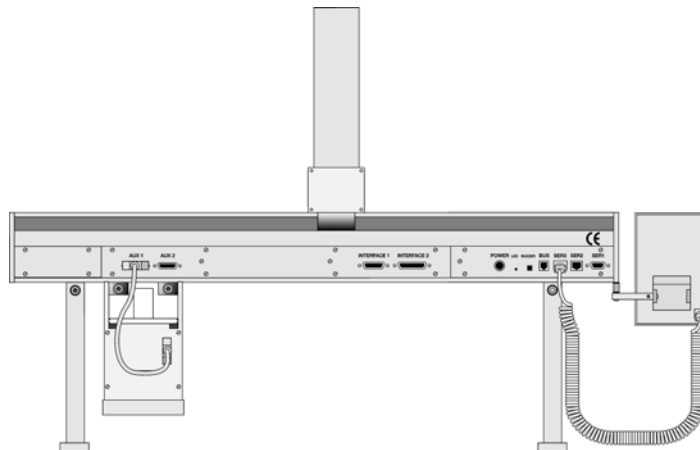


Figure 15. Electrical Connections

**note !**

Always switch OFF the PAL power supply before connecting or disconnecting any Combi PAL accessories cable !

## 7. Combi PAL Object Positions

### 7.1 Defining Object Positions

**note !**

Remove the Syringe Adapter from the Injection Unit before performing the following steps.

The objective is to define the Reference Positions for all Combi PAL Objects. Make sure the Trayholder(s), Agitator and Wash Station are properly mounted to the PAL X-Crossrail. The following description is an example how to teach the Reference Position for a Trayholder. The described procedure is **common** to all Combi PAL Objects.

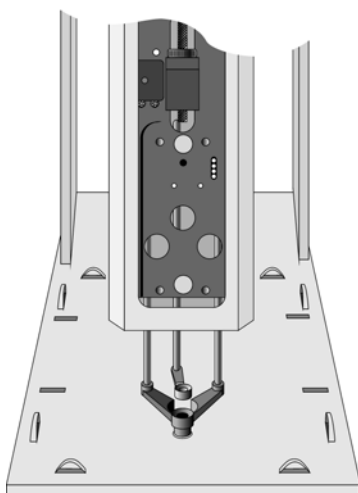
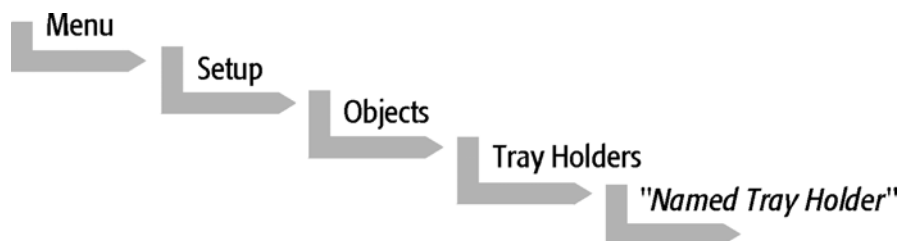


Fig. 16 Object Reference Position

For Trayholder, the **Reference Position** is a hole (slightly larger than the lower needle guide) in the base plate of the Holder. The lower needle guide should be centered in the hole with the bottom of the needle guide flush with the bottom of the base plate (see Fig. 16).

- 1 Switch ON the PAL power supply.
- 2 Observe the Keypad display. The model name Combi PAL will be displayed along the software version number. The Job Queue menu screen will then be displayed.
- 3 When the "Job Queue" menu is displayed, complete the following sequence (common to all objects):



where "Named Tray Holder" represents a predefined Trayholder (e.g. THldr1).

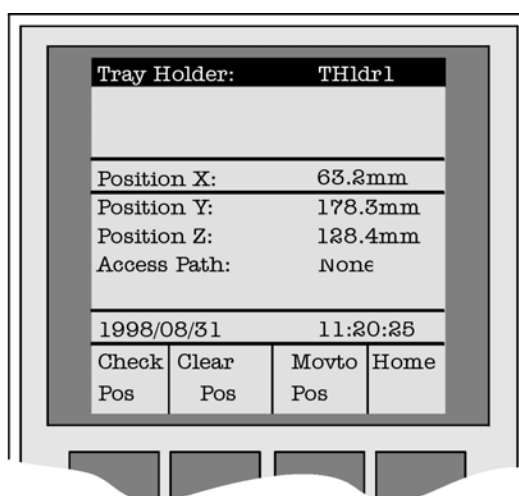


Figure 17. Menu Screen Object Trayholder

- 4 After selecting "Named Tray Holder", the **X Y Z** positions associated with the object will be displayed (see Figure 17).
- 5 Highlight the item **Position X:** with the cursor bars and press ENTER. The Injection Unit will move to the previous defined X-axis position.
- 6 Rotate the outer knob to adjust the X- axis position to the Trayholder **Reference Position** (see Figure 18, page 28).
- 7 Press the inner knob to ENTER the **Position X** value.
- 8 Repeat steps 5-7 for **Position Y** and **Position Z**.
- 9 Press the **F3** button "**Moveto Zero**". The Injection Unit will move to the **HOME** position.
- 10 Verify the defined **X Y Z Positions** by pressing **F1 "Check Pos"**.

## 7.2 Description of Object Positions

### Trayholder (e.g. THldr1)

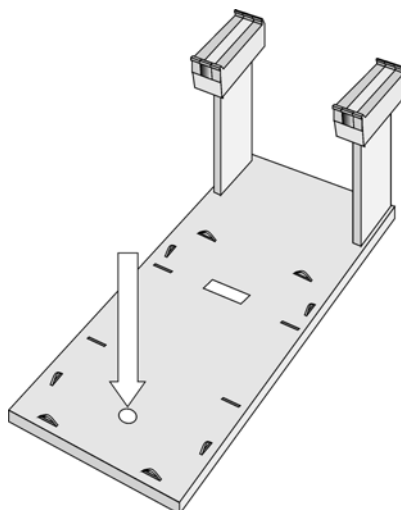


Figure 18. Trayholder Reference Position

For Trayholder, the **Reference Position** is a hole in the base plate of the Holder. The lower needle guide should be centered in the hole with the bottom of the needle guide flush with the bottom of the base plate.

### Wash Station (e.g. Wash1 or Wash2)

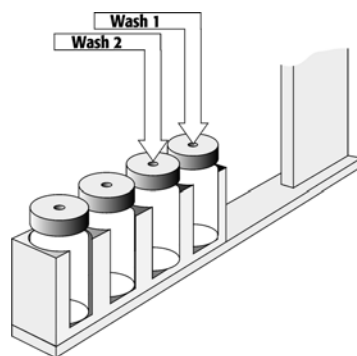


Figure 19. Wash Station Reference Position

For the Wash Station the reference positions are the two holes in the wash vial caps (see Figure 19, Wash1 and Wash2). The lower needle guide should be centered in these holes with the bottom of the lower needle guide lightly touching the surface of the caps.

**note !**

The Waste positions represent an "Injector" within the PAL software. It is defined in the Object class "Injectors" (see Figure 20, page 29).

### Injectors (e.g. Waste / Waste2 or GC Inj1)

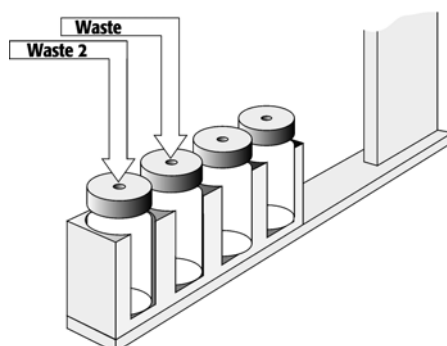


Figure 20. Waste / Waste2 Reference Position

For **Waste / Waste2** the reference positions are the two holes in the wash vial caps (see Figure 20). The lower needle guide should be centered in these holes with the bottom of the lower needle guide lightly touching the surface of the caps.

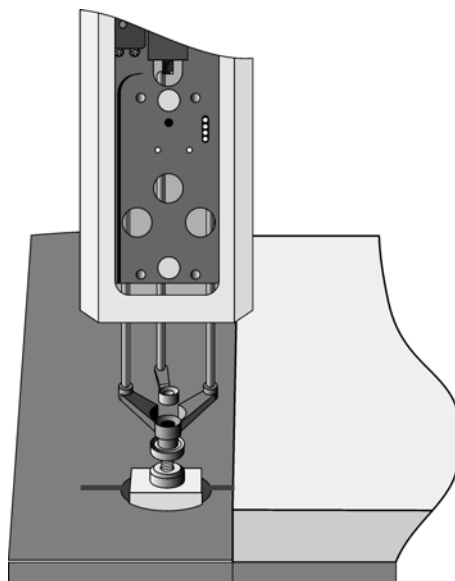


Figure 21. GC Inj1 Reference Position

For the GC Inj1 (GC Inj2) the reference position is the appropriate GC Injection port. The lower needle guide should be centered on the port with the bottom of the lower needle guide lightly touching its surface.

## Agitator

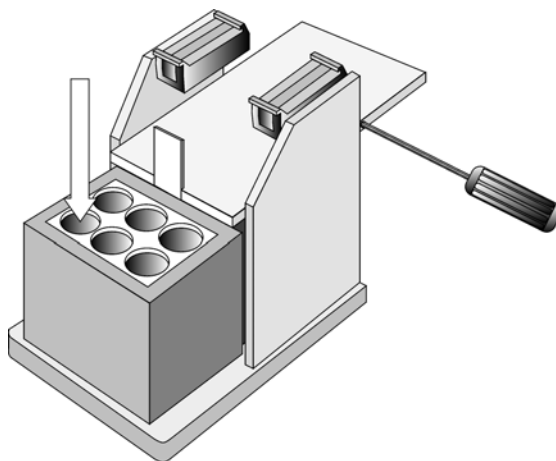
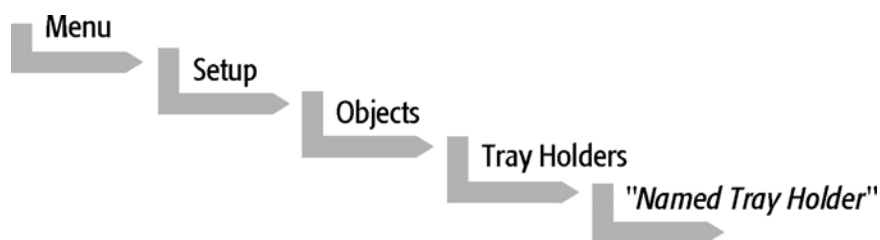


Figure 22. Agitator Reference Position

The Agitator **Reference Position** is located as indicated in Figure 22. To define the position complete the following steps:

- 1 When the "Job Queue" menu is displayed complete the following sequence:



- 2 Select "AgiHldr" and scroll to **Access Path / Restore Path**.
- 3 If the Agitator is located on the left side choose **AgiOpnL / AgiClsL**  
If the Agitator is located on the right side choose **AgiOpnR / AgiClsR**  
**The steps 2+3 are only needed for Firmware level 2.2.0 or lower.**
- 4 Open the white Agitator cover manually and block it with a screwdriver (see Figure 22).
- 5 Insert a 20ml vial in sample position no. 1 (see Figure 22)
- 6 Attach the red vial transport ring to the lower needle guide (see Figure 25, page 33).
- 7 Define the **X Y Z** positions common to all objects as described in chapter 7.1.  
The **Reference Position** is located at the hole in the vial steel cap. The lower needle guide should be centered to the vial cap and should touch the cap.
- 8 Remove the screwdriver and close the Agitator cover.

**note !**

**note !**

**After all positions have been set perform a backup of the existing configuration (see Chapter 10, page 36, PAL Loader Program).**

## 8. Syringes

### 8.1 Selecting Syringes

The standard Combi PAL is shipped with two syringe kits:

1 PAL SyrGC10 $\mu$ l	Kit GC Syringe 10 $\mu$ l for Combi PAL, consisting of: 1 pc syringe adapter 1 pc plunger holder 2 pc syringe SYRC L10-26S-AS
1 PAL SyrHS2.5ml	Kit HS Syringe 2.5ml for Combi PAL, consisting of: 1 pc syringe heater 1 pc plunger holder 2 pc syringe SYRC HS2.5-23-5

The supplied syringe kits cover the standard liquid and headspace GC injection ranges. However, certain applications may require different syringe sizes. Consult **Appendix F** "Combi PAL Accessories" for details.

### 8.2 Syringe Priming (for liquid syringe types only)

It is critical that syringes be primed before beginning sample preparation. Prime the syringe by using the Utility function "**Clean Syr**". For fixed needle syringes, priming may also be achieved by using an adequate number of filling strokes in a Combi PAL Method. Gas-tight syringes must be primed manually. Remove the plunger and fill the syringe from the top of the barrel until solvent either overflows or forms a "bead" at the top of the syringe. Then insert the plunger.

### 8.3 Installing a Syringe for Liquid Injections

- 1 Select Menu and press **F1/Chang Syr**. The Injection Unit will move to a location that will facilitate installation of the syringe.
- 2 Place the blue plunger holder into the injection unit.
- 3 Place the syringe in the appropriate syringe adapter. Pull the plunger out to approximately 20% of its length (see Figure 23).

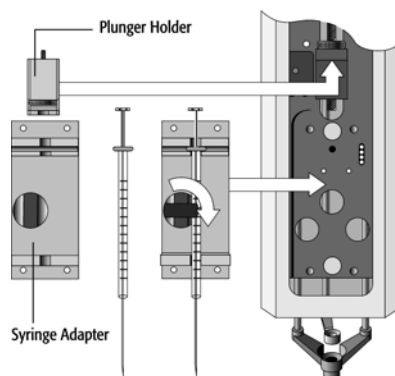


Figure 23. Syringe and Syringe adapter for Liquid Injections

- 4 If necessary, loosen the plunger retaining screw in the plunger holder.
- 5 Move the syringe, installed in the syringe adapter, partially into the Injection Unit. Guide the needle first into the upper needle guide and then into the lower needle guide (see Figure 24)
- 6 Place the plunger button into the plunger holder. Allow the syringe adapter to "dick" into place by magnetic force, against the syringe carrier.
- 7 Tighten the plunger retaining screw against the plunger button.
- 8 Press "**Home**".  
The plunger moves down until it hits the mechanical stop. This position is stored as the syringes zero volume position. Then the Injection Unit returns to the **HOME** position.

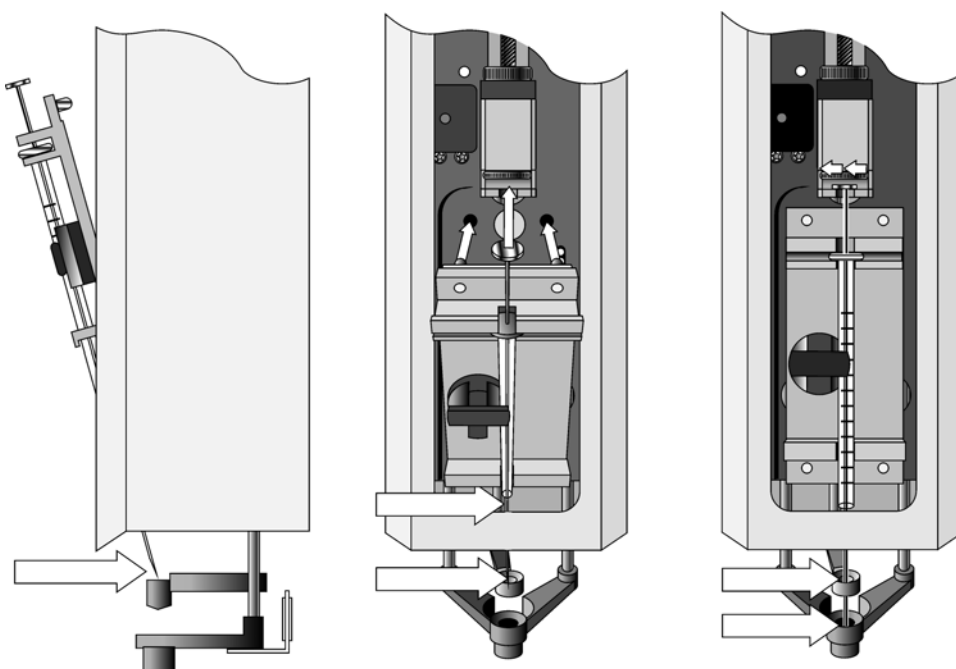


Figure 24. Installing and Removing a Syringe for Liquid Injections

#### 8.4 Removing a Syringe for Liquid Injections

- 1 Select "Menu" and press **F1/Chang Syr**. The Injection Unit will move to a location that will facilitate removal of the syringe.
- 2 Loosen the plunger retaining screw. Move the plunger slightly out of the plunger holder.
- 3 Pull the syringe adapter out and then carefully up to remove the syringe adapter with the syringe from the Injection Unit.



## 8.5 Installing a Syringe for Headspace Injections

- 1 Select Menu and press **F1/Chang Syr**. The Injection Unit will move to a location that will facilitate installation of the syringe.
- 2 Place the red plunger holder into the injection unit.
- 3 Place the syringe in the appropriate heated syringe adapter. Pull the black plunger out to approximately 20% of it's length. (see Figure 25)

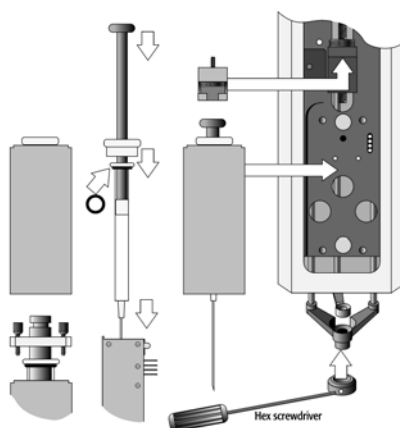


Figure 25. Headspace syringe and heated syringe adapter

- 4 If necessary, loosen the plunger retaining screw in the red plunger holder.
- 5 Move the syringe, installed in the heated syringe adapter, partially into the Injection Unit. Guide the needle first into the upper needle guide and then into the lower needle guide (see Figure 26).
- 6 Place the black plunger button into the red plunger holder. Press the syringe adapter against the syringe carrier until it sits flush on the carrier.

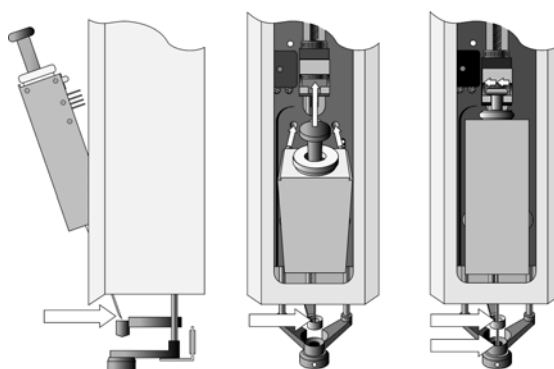


Figure 26. Installing and Removing a Headspace Syringe

- 7 Tighten the plunger retaining screw against the plunger button.
- 8 Press "Home".  
The plunger moves down until it hits the mechanical stop. This position is stored as the syringes zero volume position. Then the Injection Unit returns to the **HOME** position.

### 8.6 Removing a Syringe for Headspace Injections

- 1 Select "Menu" and press **F1/Chang Syr**. The Injection Unit will move to a location that will facilitate removal of the heated syringe adapter.
- 2 Loosen the red plunger retaining screw. Move the black plunger slightly out of the red plunger holder.
- 3 Pull the syringe adapter out and then carefully up to remove the syringe adapter with the syringe from the Injection Unit.

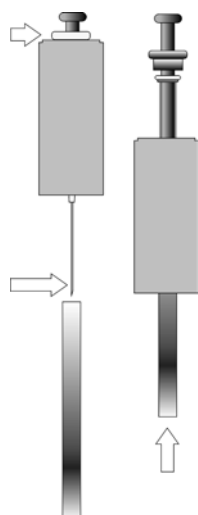


Figure 27. Removing a Headspace Syringe from the heated Syringe Adapter

- 4 Unscrew the white plastic retainer
- 5 Place the supplied gray plastic tube over the needle.
- 6 Using the gray plastic tube, push the Headspace Syringe through the heated Syringe Adapter.

#### note !

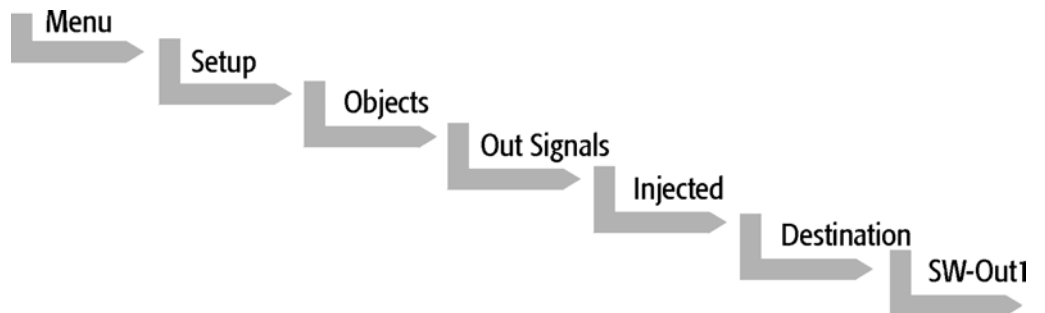
Gastight Headspace syringes have very tight plungers when new. After a short operating time at elevated temperature, the plunger cap adjusts its diameter. Should the syringe be used later at lower temperatures the risk for leakage exists. The Teflon cap never expands at lower temperatures. Therefore, a particular Headspace syringe should always be used at the same or higher temperatures.

## 9. Interfacing the Combi PAL to Other Devices

### 9.1 Synchronization and Output Signals

Synchronization Signals (**Sync Signals**) are inputs that tell the Combi PAL when to wait or proceed with a sample-processing step. Output Signals (**Out Signals**) are sent from the PAL to external devices to indicate status or completion of particular processing steps. These signals are classified as Objects. Physical Events (e.g.TTL-In1) are also Objects and may be assigned to named signals. PAL Cycles require that certain signals such as "**Start**", "**Inject**", and "**Injected**" be defined. See Table below for the PAL Events and signal assignments associated with the standard PAL "**GC-Inj**", "**HS-Inj**" and "**GC-Dual**" cycles.

To assign a physical Event (e.g. SW-Out 1) to an existing signal Object ("Injected") complete the following menu selections:



PAL's are shipped with all Cycle events pre-defined as shown in the table below. If a different physical signal needs to be used, then it will be necessary to assign a new Event to the signal Object.

If a signal is to be ignored, then it's corresponding Event must be set to "**Immediat**".

Standard Assignment for Combi PAL Injection Cycles	Description	Default Events	INTERFACE1 Pin #
Start (Sync Signal)	Start a cycle (Input from GC or data system)	TTL-In1	7 8(GND)
Start2 (Sync Signal)	Continue the cycle "GC-Dual" for the second sample	Immediat (Ignore)	
Inject (Sync Signal)	Inject READY to INJECT	Immediat (Ignore)	
Inject2 (Sync Signal)	Inject the second sample for "GC-Dual" cycle	Immediat (Ignore)	
Injected (Out Signal)	Is activated at the moment when the sample has been injected	SW-Out1	3 4
Injectd2 (Out Signal)	Is activated at the moment when the second sample has been injected	Off	
Running (Out Signal)	Active as long as the Job Queue is being processed and the PAL is not in an error state	Off	



## 10. PAL Loader Program

The following procedures require a PC with Windows 95/98/NT/2000 and XP Operating System, the supplied PAL Loader program (Version 1.1 or higher), the supplied gray cable (Part RS9B-3000), and the correct version of the PAL firmware to be loaded.

### 10.1 Backing Up the PAL Control Program

**note !**

The following procedure should be performed after the installation of a new PAL System is completed. Furthermore, periodically System backups ensures that an updated configuration of the PAL is available any time.

Recommended practice is to create the following directory structure to store PAL firmware updates and backups:

Directory Path	Contents
C:\Program Files\PAL\Loader\Backup\	Full backup files of current and previous PAL configurations; includes firmware and parameter settings; maintained for archival purposes
C:\Program Files\PAL\Loader\Update\	Extracted "Update" files in Loader format (*.sss); may include firmware only or firmware and parameter settings

- 1 Shut off power to the PAL and the computer. Connect the supplied gray cable between the PAL (**SER1**) and a PC serial port.
- 2 Switch on power to the PAL. When the PAL Job Menu is displayed, start up the computer.
- 3 Double-click the PAL Loader icon, the PAL Loader screen appears (see Figure 28).



Figure 28 PAL Loader menu screen

- 4 Click the **"Backup"** button. A dialog box entitled **"Backup Target Memory"** will be displayed. The path (storage location) and file name to be assigned to the new backup will be shown. A customized path and/or filename may be entered (see Figure 29).

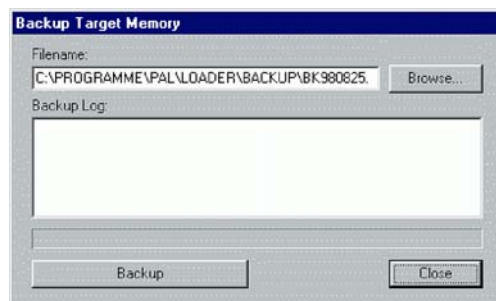


Fig. 29 PAL Loader Backup Target Memory

- 5 Click the **"Backup"** button.



- 6 Backup will proceed and information on the backed up components will be displayed in the "Backup Log:" window. The process will take several minutes. The message "**Backup of Target Memory succeeded**" indicates a successful backup.
- 7 Click the "**Close**" button to exit the "**Backup**" dialog box. Click the "**Start PAL**" button to terminate control by the Loader program. On the Keypad terminal, the Job Queue screen is displayed.
- 8 Disconnect the RS-232 cable from the PAL.

## 10.2 Reloading a Backup

**note !**

**This operation can potentially overwrite existing parameter settings. Methods created by the user will be overwritten.**

The firmware file to be loaded must reside on the PC hard drive. The file cannot be loaded from a floppy drive. A full update (including parameter settings) will not fit on a single floppy diskette in the PAL Loader format. It must be transferred to the PC hard drive in compressed (\*.zip) format and extracted into the "\*.sss" file, which is the PAL Loader format.

Complete the following steps to reload a PAL backup:

- 1 Shut off power to the PAL and the computer. Connect the gray cable between the PAL (**SER1**) and a PC serial port.
- 2 Switch on power to the PAL. When the PAL Job Menu is displayed, start up the computer.
- 3 Double-click the PAL Loader icon, the PAL Loader screen appears.
- 4 Click the "**Update**" button.
- 6 Click the "**Browse**" button and select the appropriate .sss backup file.
- 7 Click the "**Open**" button. The "**Update Flash Memory**" window will be displayed. The path and filename for the update file will be shown in the "Filename:" entry box.
- 8 Click the "**Update**" button to load the new firmware. The process will take several minutes. If the update is successfully completed the message "**Update of target memory succeeded**" will be displayed.
- 9 Click the "**Close**" button to exit the "**Backup**" dialog box. Click the "**Start PAL**" button to terminate control by the Loader program. On the Keypad terminal, the Job Queue screen is displayed.
- 10 Disconnect the RS-232 cable from the PAL.

## 11. Troubleshooting

**note !**

The Combi PAL represents always one of several components in a chromatography system. The following Troubleshooting Guide is limited to the Combi PAL only.

Symptom or Error Message	Possible Cause	Recommended Action
No or very low detector signal is observed.	Clogged syringe.	Remove syringe and aspirate/dispense liquid manually. Clean syringe.
	Bent needle.	Inspect and/or change syringe.
	No sample liquid is injected.	Check and/or adjust Needle Penetration into sample vial (see chapter 4.2).
	Sample volume too low.	Increase sample volume.
Syringe does not fill properly.	Air bubbles below Syringe plunger. It may happen that air bubbles remain below the plunger after the first pull up. If the plunger is moved up and down several times, these air bubbles are worked out.	Increase method parameter "Fill Strokes".
Sample peaks/responses are not reproducible.	Dirty syringe.	Increase Pst Cln Slv1/Slv2 values in method. Use PreClnSlv1/Slv2 and PreClnSpl.
	Syringe pressure differences.	Increase Pullup Delay value.
	Vacuum created in sample vial.	Reduce sample volume in sample vial.
	High volatile solvent.	Use gastight syringe and sample tray cooling.
	Not properly crimped vials.	Check vial cap by attempting to rotate by hand. Loose caps may cause selective loss of lighter components from sample. Adjust crimping tool correctly.
Excessive carryover between samples.	Dirty syringe.	Increase Pst Inj Slv1/Slv2 values in method. Use PreClnSlv1/Slv2 and PreClnSpl.
	Inappropriate wash solvent(s).	Use appropriate wash solvent(s).
	Wash Solvent and Waste vial septa too tight.	Check if the syringe fills completely when washing. If several cleaning cycles are programmed and many samples are processed vacuum in the Wash Solvent vials and overpressure in the Waste vials may build up. Cut away a segment of the Solvent and Waste septa to assure equalization of pressure.
Unexplained collisions of the Injection Unit.	Object(s) not defined correctly.	Define Object(s) correctly (see 7.1 Defining Object Positions).
Error Message "Object Not Detected".	Incorrect Z value for the affected Object (e.g. GC Inj1, THldr1 or Agitator).	Redefine Z value for the affected Object (see chapter 7.1 PAL Object positions).
Error Message "Invalid Motor Status Motor Aux1".	Agitator not connected.	Switch OFF PAL and check connection between PAL and Agitator.
	Agitator Connection cable.	Change connection cable.
	MOTIO Board defective.	Replace MOTIO Board.
<b>Headspace specific Symptoms</b>		
Sample peaks/responses are not reproducible.	Dirty syringe.	Increase method value "Syr Flushing" Set method value "Syringe Temp" 10°C above "Incubat Temp"
	Syringe pressure differences.	Increase Pullup delay value
	Vacuum created in sample vial.	Reduce sample volume
	Not properly crimped vials.	Check vial cap by attempting to rotate by hand. Loose caps may cause selective loss of lighter components from sample. Adjust crimping tool correctly.
	No or too low Syringe Flush gas pressure	Check pressure at flush gas regulator (0.5 bar) during Syringe Flushing period. Check gas flow at syringe needle tip.



Excessive carryover between samples.	Dirty syringe.	Increase method value "Syr Flushing" Set method value "Syringe Temp" 10°C above "Incubat Temp"
	No or too low Syringe Flush gas pressure.	Check pressure at flush gas regulator (0.5 bar) during Syringe Flushing period. Check gas flow at syringe needle tip.
Unexplained chromatographic peaks.	Dirty flush gas.	Check flush gas for impurities.

## 12. Replacing Parts

### 12.1 MOTIO Board

- 1 Follow the sequence shown in Figure 30 to detach and release the MOTIO board from its position inside the X Crossrail.
- 2 Carefully pull the two flat cable connectors upwards to free from the board.
- 3 Install the replacement board in the reverse order.

**note !**

After reconnecting the two flat cables to the board ensure that the cables are folded flat and can be slid inside the cross-rail without damage.

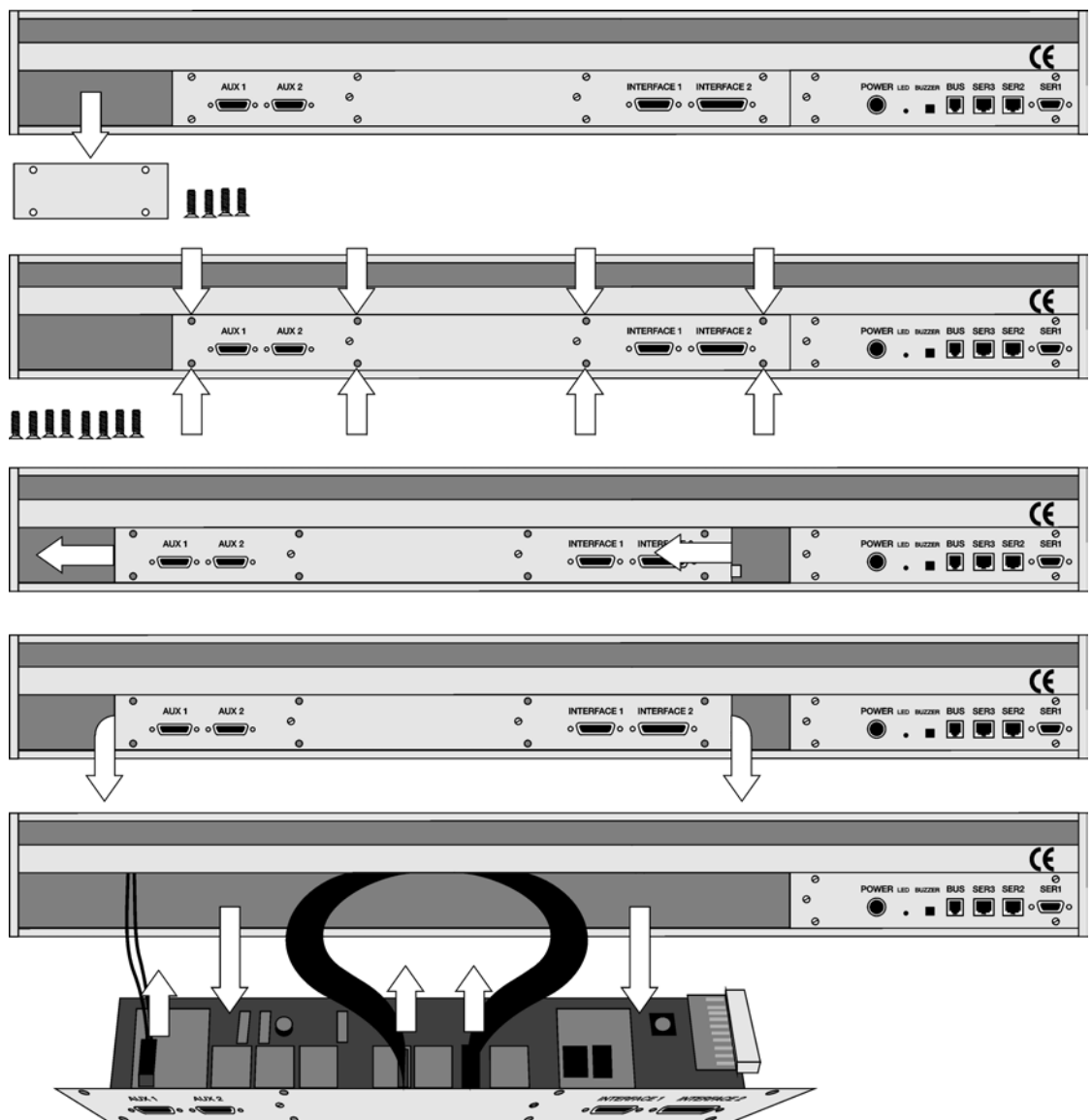


Figure 30 Replacing MOTIO Board



## 12.2 CPU Board

- 1 Remove the right end cover of the Crossrail (facing the rear of the chassis).
- 2 Slide the CPU board out and towards the right end of the Crossrail. This is necessary because the CPU board mates on its left side with a connector on the MOTIO board.
- 3 Install the replacement board in the reverse order

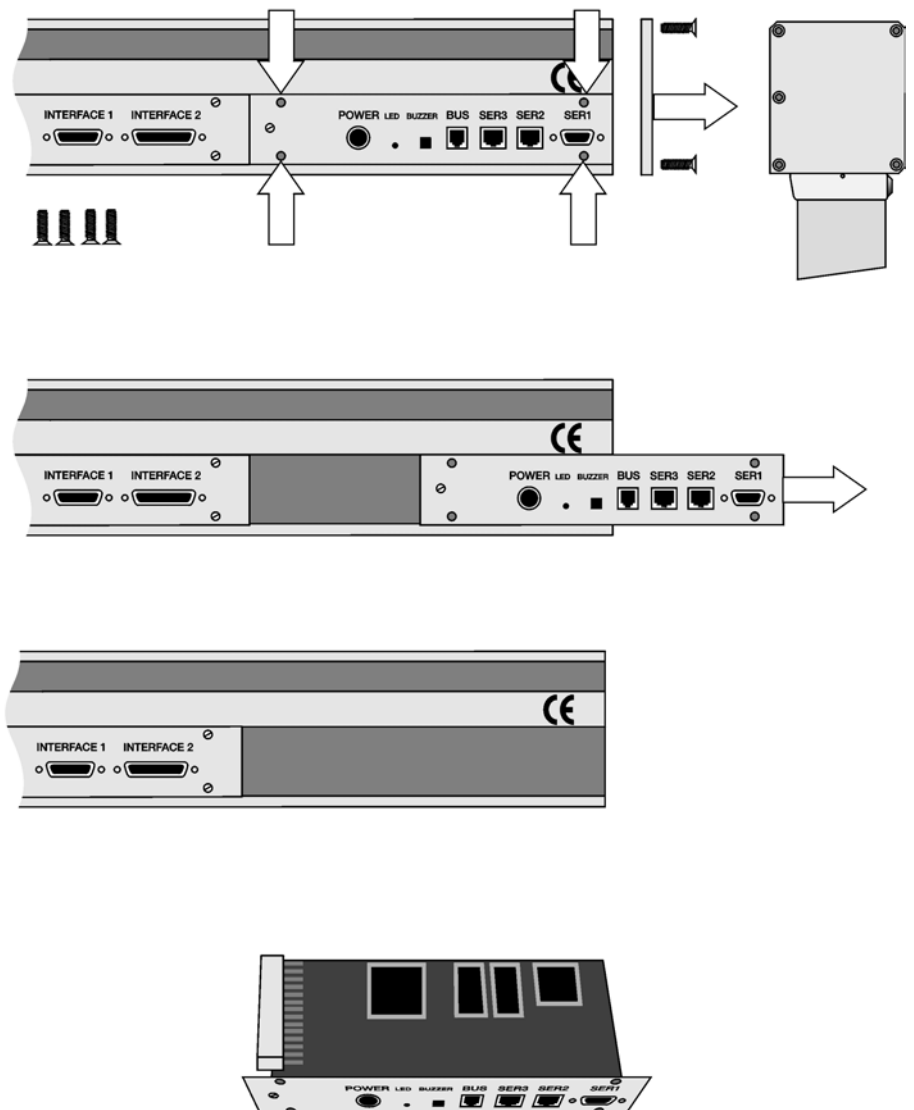


Figure 31 Replacing CPU Board



### 12.3 Agitator

Follow the sequence of steps shown in chapter 6.2, page 18, Assembling the Combi PAL.

### 12.4 Injection Unit

Follow the sequence of steps shown in chapter 6.2, page 18, Assembling the Combi PAL.

### 12.5 Wash Station

Follow the sequence of steps shown in chapter 6.2, page 18, Assembling the Combi PAL.

### 13. Maintaining the PAL System

Regularly performing maintenance helps ensure accuracy and precision of the PAL System. Suggested intervals for maintenance procedures to ensure uninterrupted operation are given below.

If you use the system heavily (for example, nights and weekends), or if you use aggressive solvents, you may need to perform the maintenance procedure more frequently.

Maintenance Step	Interval
Clean the outside of the instrument. Use only a soft lint-free paper or cloth dampened with mild soap and water.	Weekly or as needed
Clean Instrument, syringe and surfaces	Weekly or as needed.
Replace the syringe plunger	<p>Syringe Plunger for a liquid syringe (Metal Plunger sealing against glass) should be cleaned on a regular base with an aqueous Alcohol solution. Be aware that this plunger type should not be used for samples with a high amount of matrices, clinical or residue analysis. A Teflon plunger would be more suitable.</p> <p>Syringe Plunger for a gas tight syringe (Teflon tip) has to be replaced on a regular base. The interval is highly dependent on the application, throughput, quality of sample solution (particles, etc.) washing solvent. It is advisable to check the tightness of the plunger on a regular base to gain the experience with the own application.</p>
Wash and Waste Solvent reservoirs	<p>Weekly or as needed. Replace the Septum as well to avoid carry over.</p>

The other steps are described in the "Preventative Maintenance Procedure". Specific kits for the GC or the HPLC techniques are available. The kits include the parts which shall be changed annually.  
PM Kit1 for HPLC and PM Kit2 for GC technique.

**note !**

There are no operator-serviceable or replaceable parts inside the power supply(ies) or the PAL System. In case of any failure, contact a representative of CTC Analytics.



## A. Definition of Terms

<b>Job Queue</b>	A Job Queue is a list of sample processing Jobs. Jobs are executed in the order displayed on the JOB QUEUE menu screens. New Jobs may be added to the queue while samples are being processed.
<b>Job</b>	A Job contains the information needed by the PAL to process multiple samples by the same processing steps. The elements of a Job are a Method and a Tray that defines the location of the samples to be processed. For identification Jobs are automatically numbered from 01 to 99 and then restarting with 01 when they are added to the Job Queue.
<b>Cycle</b>	A Cycle consist of the specific operations necessary to process one sample. The Cycle operations are repeated for each sample within a Job. Cycles are designed for specific applications. The Standard Combi PAL Cycles are named GC-Inj , HS-Inj and GC-Dual.
<b>Method</b>	A Method defines how the samples are processed. The elements of a Method are a Cycle, a Syringe and a Parameter List. Methods have names with up to 8 characters and can be edited, copied, and deleted.
<b>Method Parameters</b>	Method Parameters are associated with the Cycle operations. User-assigned Parameter values define how a processing operation is performed. A zero Parameter value will disable a Cycle operation. Cycle parameters are application-specific.
<b>Object</b>	Objects are data structures describing the properties of physical modules. Certain modules (e.g. an Agitator) require several objects.
<b>Trayholder</b>	A Trayholder can hold one or more Trays. Each Trayholder has a reference position (X, Y, Z co-ordinates) that defines it's location.
<b>Agitator</b>	The Agitator is a particular type of Trayholder, that is designed to heat and shake up to 6 headspace vials at the same time.
<b>Tray</b>	A Tray that holds multiple samples. Trays are defined by designating the Tray Type (see below) and the Trayholder. Tray names are used to identify the sample source within a PAL Job.
<b>Tray Type</b>	A Tray Type defines the pattern and sampling sequence of sample locations within a Tray. Standard Tray Types include Trays that hold 1, 2, 10, and 20 ml vials.



## B. Conventions of Naming

This section recommends standard naming conventions for Combi PAL Trays, Tray Types, and Tray holders. Following these conventions will allow Combi PAL's to be pre-configured for certain applications, will simplify software backups and application development, and will improve technical support and training.

Tray Type	Tray Description
VT200	Vial Tray, 200 positions (10 x 20) for 7mm micro-vials, 1.0ml
VT98	Vial Tray, 98 positions (7 x 14) for 12mm vials, 2.0ml
VT78	Vial Tray, 78 positions (6 x 13) for 7mm micro-vials, 1.0ml (opposite side of 98 positions Tray)
VT32-10	Vial Tray, 32 positions (4 x 8) for 23mm headspace vials, 10ml
VT32-20	Vial Tray, 32 positions (4 x 8) for 23mm headspace vials, 20ml



## C. Combi PAL Injection Cycles

### 1. Combi PAL "GC-Inj" Cycle

No.	Processing Step	Method Parameter	Object (Class)	Used Object Value
1	Reference X, Y, Z axis and syringe plunger		(System)	Start Ref = ON
2	Wait for Start signal		Start (Sync Signals)	
3	Read Barcode if enabled		TRAY (Tray Type)	Barcode • None
4	Clean syringe with solvent from Wash1 selected number of times	Pre Cln Slv1	SYRINGE (Syringes) Wash1 (Wash Stations) Waste (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr
5	Clean syringe with solvent from Wash2 selected number of times	Pre Cln Slv2	SYRINGE (Syringes) Wash2 (Wash Stations) Waste2 (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr
6	Rinse syringe with sample selected number of times	Pre Cln Spl Sample Volume Fill Volume Fill Speed Pullup Delay	SYRINGE (Syringes) TRAY (Tray Type) Waste (Injectors)	Eject Speed Needle Penetr Needle Penetr
7	Fill syringe with sample using several filling strokes; aspirate air outside of vial if Air Volume = 0	Sample Volume Air Volume Fill Volume Fill Speed Fill Strokes Pullup Del	SYRINGE (Syringes) TRAY (Tray Type)	Eject Speed Overfill Needle Penetr
8	Wait for Inject signal		Inject (Sync Signals)	
9	Move to Injector	Inject to		
10	Drive needle to penetration depth	Inject to	(Injectors) Motor Z (Motors)	Needle Penetr Inj Penetr Spd
11	Delay	Pre Inj Del		
12	Activate Injected signal		Injected (Out Signals)	Pulse Time
13	Activate Injectd+ signal		Injectd+ (Out Signal)	Pulse Time
14	Dispense syringe contents into GC Injector	Inject Speed		
15	Delay	Pst Inj Del		
16	Retract needle from injector		Motor Z (Motors)	Inj Penetr Spd
17	Clean syringe with solvent from Wash1 selected number of times	Pst Cln Slv1	SYRINGE (Syringes) Wash1 (Wash Stations) Waste (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr
18	Clean syringe with solvent from Wash2 selected number of times	Pst Cln Slv2	SYRINGE (Syringes) Wash2 (Wash Stations) Waste2 (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr
19	Move to Home position		Home (Positions)	



## "GC-Inj" Cycle Parameter Description

Parameter	Description
CYCLE	GC-Inj
SYRINGE	Selected syringe
Sample Volume	Selected sample volume
Air Volume	Volume aspirated after the syringe needle is moved out of the sample liquid
Pre Cln Slv1	Pre injection syringe wash strokes with Solvent 1
Pre Cln Slv2	Pre injection syringe wash strokes with Solvent 2
Pre Cln Spl	Pre injection syringe wash strokes with Sample
Fill Volume	Fill Volume used for all Filling strokes except the last one
Fill Speed	Speed of plunger movement used in all syringe filling operations
Fill Strokes	Number of Fill Strokes
Pullup Del	Delay time between sample pullup and ejection
Inject to	Selected Injector
Inject Speed	Speed of plunger movement used during sample injection
Pre Inj Del	Delay time prior sample injection
Pst Inj Del	Delay time after sample injection
Pst Cln Slv1	Post injection syringe wash strokes with Solvent 1
Pst Cln Slv2	Post injection syringe wash strokes with Solvent 2



## 2. Combi PAL "HS-Inj" Cycle

No.	Processing Step	Method Parameter	Object (Class)	Used Object Value
1	Wait for Start signal (This is only checked at the job start)		Start (Sync Signals)	
2	Wait for Agitator Temperature	Incubat Temp	Agitator (Trays)	
3	Wait for Syringe Temperature	Syringe Temp	SYRINGE (Syringes)	
4	Transfer sample vial from Tray to Agitator		TRAY (Tray Type) Agitator (Tray Type)	Transport Mode Transport Mode
5	Move to Flush position		Flush (Injectors)	Needle Penetr
6	Activate Agitator	Agi Speed Agi On Time Agi Off Time	Agitator (Trays)	
7	Wait for Incubation timer	Incubat Time		
8	Fill syringe with sample using several filling strokes	Sample Volume Fill Speed Fill Strokes Pullup Del	SYRINGE (Syringes) Agitator (Trays)	Eject Speed Overfill Needle Penetr
9	Move to Injector	Inject to	(Injectors)	
10	Wait for Inject signal		Inject (Sync Signals)	
11	Drive needle to penetration depth	Inject to	(Injectors) Motor Z (Motors)	Needle Penetr Inj Penet Spd
12	Delay before injection	Pre Inj Del		
13	Dispense syringe contents into Injector	Inject Speed		
14	Activate Injected signal		Injected (Out Signals)	Pulse Time
15	Activate Injectd+ signal		Injectd+ (Out Signal)	Pulse Time
16	Delay after injection	Pst Inj Del		
17	Retract needle from injector		Motor Z (Motors)	Inj Penet Spd
18	Transfer sample vial from Agitator to Tray		Agitator (Tray Type) TRAY (Tray Type)	Transport Mode Transport Mode
19	Move syringe to Flush position (Move to Home position and skip remaining steps if Syr Flushing = 0)		Flush (Injectors)	Needle Penetr
20	Move plunger to open flush inlet and activate syringe flush valve		SYRINGE (Syringes)	Fill Speed
21	Delay	Syr Flushing		
22	Close syringe flush valve			





## "HS-Inj" Cycle Parameter Description

Parameter	Description
CYCLE	HS-Inj
SYRINGE	Selected syringe
Sample Volume	Sample volume
Incubat Temp	Temperature during incubation time
Incubat Time	Incubation time
Agi Speed	Agitator speed during incubation time
Agi On Time	On interval time during incubation time
Agi Off Time	Off interval time during incubation time
Syringe Temp	Syringe temperature
Fill Speed	Speed of plunger movement used in all syringe filling operations
Pullup Del	Delay time between sample pullup and ejection
Inject to	Selected Injector
Inject Speed	Speed of plunger movement used during sample injection
Pre Inj Del	Delay time prior sample injection
Syr Flushing	Syringe flush time
GC-Runtime	GC-Runtime (calculated from GC ready to GC ready)

### 3. Combi PAL "GC-Dual" Cycle

No.	Processing Step	Method Parameter	Object (Class)	Used Object Value
1	Reference X, Y, Z axis and syringe plunger		(System)	Start Ref = ON
2	Wait for Start signal		Start (Sync Signals)	
3	Read Barcode if enabled		TRAY (Tray Type)	Barcode • None
4	Clean syringe with solvent from Wash1 selected number of times	Pre Cln Slv1	SYRINGE (Syringes) Wash1 (Wash Stations) Waste (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr
5	Clean syringe with solvent from Wash2 selected number of times	Pre Cln Slv2	SYRINGE (Syringes) Wash2 (Wash Stations) Waste2 (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr
6	Rinse syringe with sample selected number of times	Pre Cln Spl Sample Volume Fill Volume Fill Speed Pullup Delay	SYRINGE (Syringes) TRAY (Tray Type) Waste (Injectors)	Eject Speed Needle Penetr Needle Penetr
7	Fill syringe with sample using several filling strokes; aspirate air outside of vial if Air Volume = 0	1. Sample Vol 1. Air Vol Fill Volume Fill Speed Fill Strokes Pullup Del	SYRINGE (Syringes) TRAY (Tray Type)	Eject Speed Overfill Needle Penetr
8	Wait for Inject signal		Inject (Sync Signals)	
9	Move to Injector	1. Inject to		
10	Drive needle to penetration depth	1. Inject to	(Injectors) Motor Z (Motors)	Needle Penetr Inj Penet Spd
11	Delay	Pre Inj Del		
12	Activate Injected signal		Injected (Out Signals)	Pulse Time
13	Activate Injectd+ signal		Injectd+ (Out Signal)	Pulse Time
14	Dispense syringe contents into first GC Injector	Inject Speed		
15	Delay	Pst Inj Del		
16	Retract needle from injector		Motor Z (Motors)	Inj Penet Spd
17	Clean syringe with solvent from Wash1 selected number of times	Int Cln Slv1	SYRINGE (Syringes) Wash1 (Wash Stations) Waste (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr
18	Clean syringe with solvent from Wash2 selected number of times	Int Cln Slv2	SYRINGE (Syringes) Wash2 (Wash Stations) Waste2 (Injectors)	Fill Speed Eject Speed Needle Penetr Clean Volume Needle Penetr



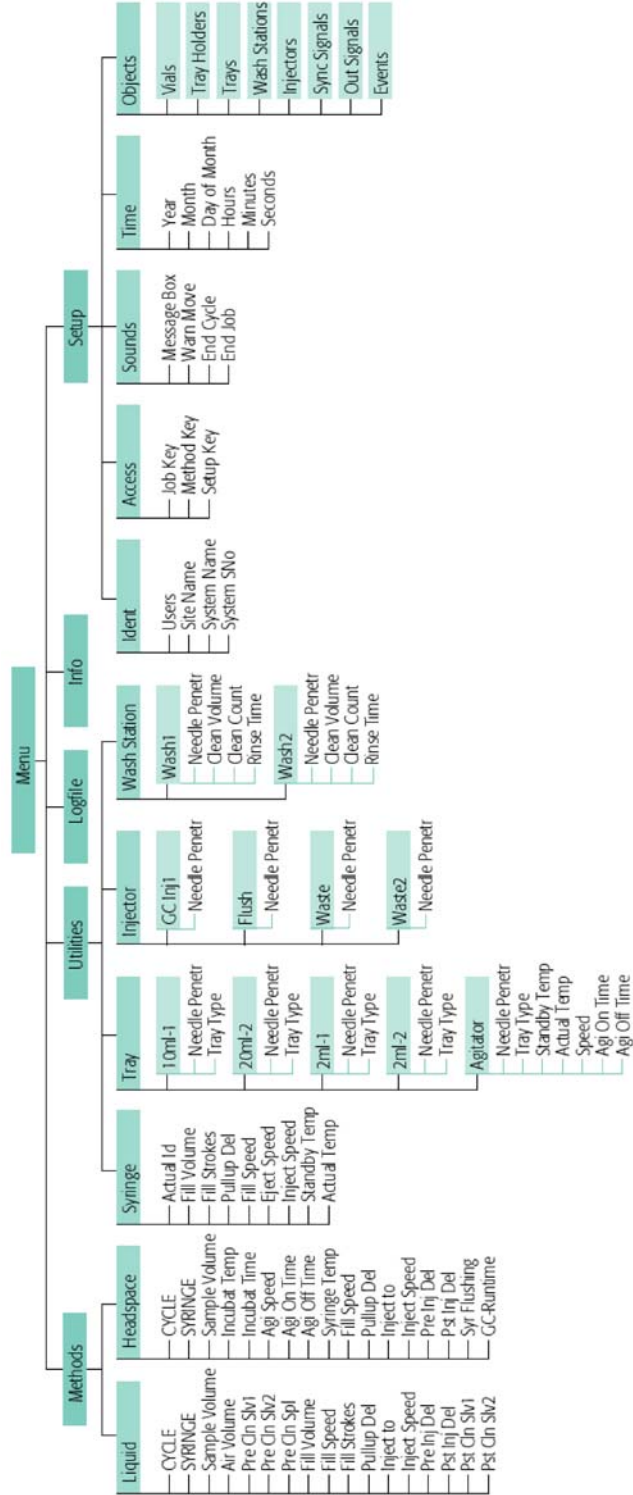
19	Fill syringe with sample from job's sample number incremented by 2. Sample Offs using several filling strokes; aspirate air outside of vial if Air Volume = 0	2. Sample Offs 2. Sample Vol 2. Air Vol Fill Volume Fill Speed Fill Strokes Pullup Del	SYRINGE (Syringes) TRAY (Tray Type)	Eject Speed Overfill Needle Penetr
20	Wait for Inject2 signal		Inject2 (Sync Signals)	
21	Move to second GC Injector	2. Inject to		
22	Wait for time since first injection	Inj Time Diff		
223	Drive needle to penetration depth	2. Inject to	(Injectors) Motor Z (Motors)	Needle Penetr Inj Penet Spd
24	Delay	Pre Inj Del		
25	Activate Injectd2 signal		Injectd2 (Out Signals)	Pulse Time
26	Dispense syringe contents into second GC Injector	Inject Speed		
27	Delay	Pst Inj Del		
28	Retract needle from injector		Motor Z (Motors)	Inj Penet Spd
29	Clean syringe and needle with solvent 1	Pst Cln Slv1	SYRINGE (Syringes) Wash1 (Wash Stations) Waste (Injectors)	Fill Speed Eject Speed Needle Penetr Needle Penetr
30	Clean syringe and needle with solvent 2	Pst Cln Slv2	SYRINGE (Syringes) Wash2 (Wash Stations) Waste2 (Injectors)	Fill Speed Eject Speed Needle Penetr Needle Penetr
31	Move to Home position		Home (Positions)	

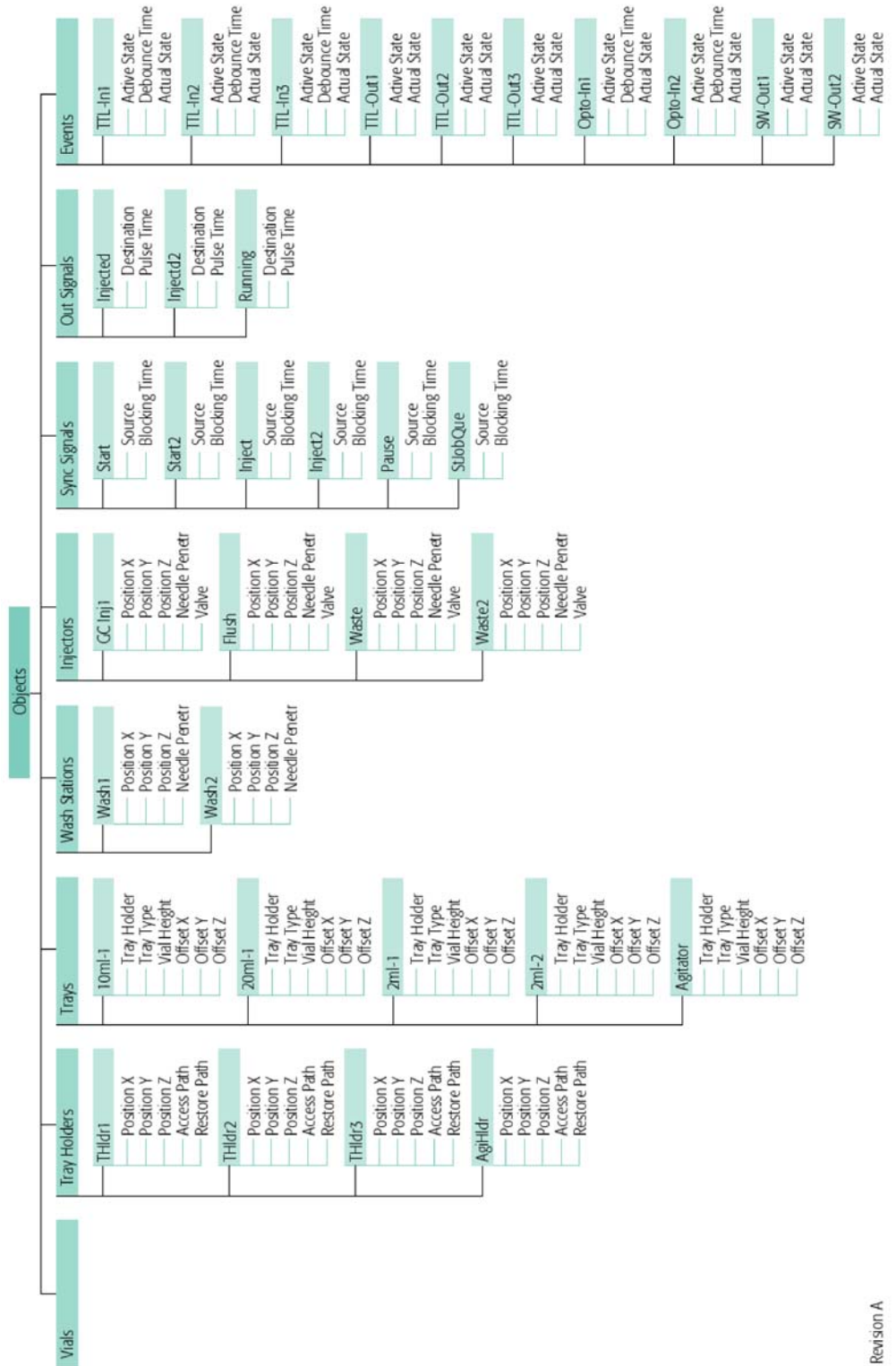


## "GC-Dual" Cycle Parameter Description

Parameter	Description
CYCLE	GC-Dual
SYRINGE	Selected syringe
1. Sample Vol	Sample volume for first injection
1. Air Vol	Volume aspirated after the syringe needle is moved out of the sample liquid
1. Inject to	Injector used for first injection
Inj Time Diff	Time difference between first and second injection
2. Sample Offs	Offset from first sample number to second sample number
2. Sample Vol	Sample volume for first injection
2. Air Vol	Volume aspirated after the syringe needle is moved out of the sample liquid
2. Inject to	Injector used for second injection
Pre Cln Slv1	Wash cycles with Wash1 before first sample is aspirated
Pre Cln Slv2	Wash cycles with Wash2 before first sample is aspirated
Pre Cln Spl	Rinse cycles with sample before first sample is aspirated
Int Cln Slv1	Wash cycles with Wash1 before second sample is aspirated
Int Cln Slv2	Wash cycles with Wash2 before second sample is aspirated
Pst Cln Slv1	Wash cycles with Wash1 after second sample is aspirated
Pst Cln Slv2	Wash cycles with Wash2 after second sample is aspirated
Fill Volume	Fill Volume used for all Filling strokes except the last one
Fill Speed	Speed of plunger movement used to aspirate sample
Fill Strokes	Number of filling strokes
Pullup Del	Delay time between sample pullup and ejection
Inject Speed	Speed of plunger movement used during sample injection
Pre Inj Del	Delay time before sample injection
Pst Inj Del	Delay time after sample injection

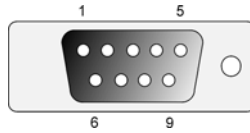
### D. Software Flow Chart





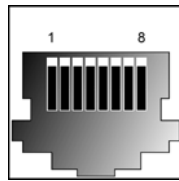
## E. External Connector

### Connector SER1

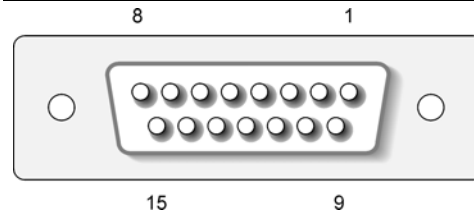


Pin	Signal Name
1	DCD
2	RXD
3	TXD
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

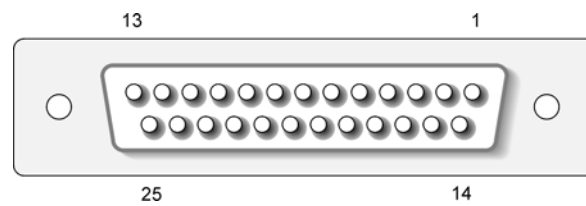
### Connector SER2 / SER3



Pin	Signal Name
1	GND
2	RXD
3	TXD
4	RTS
5	CTS
6	+5V
7	reserved
8	reserved

**Connector INTERFACE 1**


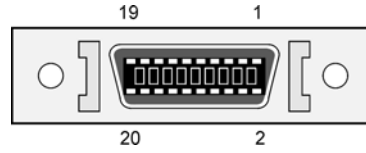
Pin	Signal Name
1	Pwr-Out1 +
2	Pwr-Out2 +
3	SW-Out NO
4	SW-Out1 COM
5	SW-Out2 NO
6	Opto-In1 +
7	TTL-In1
8	GND
9	Pwr-Out1 -
10	Pwr-Out2 -
11	TTL-In2
12	SW-Out2 COM
13	TTL-In3
14	Opto-In1 -
15	+5V

**Connector INTERFACE 2**


Pin	Signal Name
1	TTL-In1
2	TTL-In2
3	TTL-In3
4	TTL-Out1
5	TTL-Out2
6	TTL-Out3
7	Opto-In1 +
8	Opto-In2 +
9	SW-Out1 NO
10	SW-Out2 NO
11	Pwr-Out1 +
12	Pwr-Out2 +
13	+5V
14-19	GND
20	Opto-In1 -
21	Opto-In2 -
22	SW-Out1 COM
23	SW-Out2 COM
24	Pwr-Out1 -
25	Pwr-Out2 -



**Connector AUX1 / AUX2**



Pin	Signal Name
1,3	Motor A1
2,4	Motor A2
5,7	Motor B1
6,8	Motor B2
10,16,18	GND
11	Temp +
12	Temp -
13	Sens
14	+5V
15,17	Heater
19,20	36V