Schambeck SFD GmbH

Solvent Delivery System

S 2100

User Manual
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Appendix 1  AUXILLIARY FUNCTION
Appendix 2  REMOTE CONTROL
2. Standard Accessories

A. Solvent Delivery System S 2100 in Stainless Steel

1 pc. Solvent Delivery System S 2100
1 pc. Operation manual
1 pc. Power cord
2 pc. Fuses
1 pc. Wrench 1/4" x 5/16"
1 pc. Wrench SW 13 x 12
1 pc. Allen wrench 3 mm
1 pc. Allen wrench 2.5 mm
2 pc. Fittings with ferrules
1 pc. Plastic syringe
1 pc. PTFE tubing 1.6 x 3.2 mm i.d. for the pump suction capillary tube
1 pc. Stainless steel capillary (0.25 x 1.6 mm)

B. Solvent Delivery System S 2100 in PEEK

1 pc. Solvent Delivery System S 2100
1 pc. Operation manual
1 pc. Power cord
2 pc. Fuses
1 pc. Wrench 1/4" x 5/16"
1 pc. Wrench SW 13 x 12
1 pc. Allen wrench 3 mm
1 pc. Allen wrench 2.5 mm
2 pc. Hexagon fittings, PEEK
2 pc. Double cone, PEEK
1 pc. Plastic syringe
1 pc. PTFE tubing 1.6 x 3.2 mm i.d. for the pump suction capillary tube
1 pc. PEEK tubing 0.25 x 1.59 mm

C. Solvent Delivery System S 2100 with Reagent Organizer S 7131

additionally to the above stated items:
1 pc. Reagent Organizer S 7131
4 pcs. Eluent glas bottles, 1 l, each with 4 integrated valves with tubing
4 pcs. PTFE capillaries for the eluent supply

D. Solvent Delivery System S 2100 with integrated Vacuum Degasser

additionally to the above stated items:
4 pcs. Teflon capillaries (1.6 x 3.2 mm; 1.5 m long)
    with fittings and ferrules
3. Safety Instructions

The manufacturer, Schambeck SFD GmbH, does not warrant for any defects or damage resulting from incorrect operation and maintenance, non-observance of the manual's instructions and negligence during installation.

Before putting the instrument into operation, read carefully the manual and should there be any further questions, please get in contact with your supplier.

3.1. General Electrical Hazards

1. Check actual line voltage to confirm that the set voltage (on the rear side; voltage selector and fuse carrier) of the instrument is correct.

2. Before changing the instrument's voltage or before changing defective fuses, disconnect the instrument from all power sources.

3. The instrument has to be plugged into grounded wall sockets only

4. This instrument can be used only with other instruments which comply with the general safety regulations.

3.2. General Precautions

1. In order to avoid any damages, perform periodic leak checks on all installed supply lines.

2. The instrument is only allowed to be used for applications with specifications described in this manual.

3. For flammable and/or toxic solvent, follow a regulated approved waste disposal program. Never dispose of such products through the municipal sewage system.

4. The instrument is suitable for operation between 10 °C and 35 °C surrounding temperature.
4. Technical Specification

Dialogue: selectable English/German language

Control: through integrated processor (Montorola 68000)

Communication: RS 232 interface and interface for system control (remote control)
8 integrated Reed relays: inject marker and/or remote control of external components

Flow rate: with the micro pump head 0.01 - 2.00 ml/min
with the analytical pump head 0.05 - 10.0 ml/min
with the semi-preparative pump head 0.20 - 40.0 ml/min
Pump heads available in stainless steel, PEEK or Titan

Pulsation: less than 1%

Pressure: selectable on the display in Bar, Mpa or psi
max. pressure: up to 40 Mpa (400 bar) equivalent to 6000 psi

Display: large LCD display

Compressibility: Programmable 0.7 - 1.00 for compressibility correction

Operation mode: - programmable flow rate
- programmable run time: 0 - 999.9 min
- programmable flow after the run time for continuously flushing of the system with reduced flowrate
- programmable start delay time 1 - 999 sec.
- programmable stop delay time 1 - 999 sec
- programmable pressure control
  min. pressure
  max. pressure
  purge pressure

Quaternary Gradient Mixing:

Gradient: Quaternary low pressure mixing

Programmable steps: 0.1%

Mixing Cycle: programmable 1 - 99 seconds

Operation: manual with constant mixing rate
 automatic with time programming
Program storage: up to 20 gradient programs can be stored

Program sequence: chaining of existing programs in any sequence

Gradient profile display: graphic display of gradient profile selectable for A, B, C, and D

Diagnostic: storage of a pressure profile and display of irregularities during unattended operation
- short term pressure drop
- short term pressure increase
- unnormal constant pressure increase

RELAY SWITCHING
Function: free programmable 8 relay settings
programmable switching on-off or pulsed operation with programmable pulse duration

VACUUM DEGASSER OPTION:
Degasser: Built-in four channel vacuum degasser
Degassing Method: with applied vacuum, dissolved gases are continuously removed through a semi permeable membrane
Flow Rate: max. 10 ml/min for each degassing channel
Efficiency: 0.5 ppm oxygen at 0.5 ml/min
Applied Materials: All parts coming in contact with the solvent are made of PTFE or PEEK
Volume per each channel: about 8 ml
Power supply: 230 / 110 Vac 50 / 60 Hz
Fuses: for 230 Vac: 2 pcs. 1.0 AT-fuses
for 110 Vac: 2 pcs. 2.0 AT-fuses
Dimensions: 310 x 210 x 450 mm
Weight: approx. 16 kg
5. GENERAL DESCRIPTION

The Pump S 2100 is an extraordinarily flexible dosing system. It also can be used for applications where under high pressure, fluids have to be dosed exactly and almost pulsation-free. To ensure low pulsation, the pump's mechanism is designed with short-piston stroke technology and only two check valves.

According to the stream of eluent which is required, the built-in pump head is easily replaced with another pump head.

Three different pump heads are available and meet nearly every application where low flow rates and high pressures are required.

1. Micro pump-head: 0.01 - 2.00 ml/min
2. Analytical pump-head. 0.05 - 9.95 ml/min
3. Semi preparative pump-head: 0.2 - 40 ml/min

All these pump heads are available in different materials depending on the application. They can be made in stainless steel, PEEK or titanium.

With the help of the integrated micro processor, the composition and/or the flow rate of the eluent can be automatically changed, according to the requirements. The low gradient mixing of up to 4 eluents is done with the help of the 4 integrated 2-way solenoid valves. The gradient mixing steps are programmable with 0.1 % steps for each eluent A, B, C and D. With the programmable mixing sequence of the valves, the solvent mixing and the baseline can be optimized. In addition, suitable stored solvent programs can be activated for sample sequences with different samples. Analysis programs/analysis sequences are set via the large graphical display. According to the GLP regulations, a log book monitoring for various wear and tear parts and for diagnostic parameters (pressure irregularities and pressure runs) is integrated.
5.1 Functioning

The solvent delivery system S 2100 combines the dual piston technique with its advantage of low pulsation and reliable operation. The mechanism is designed with short piston stroke technology and only two check valves. This results in the low pulsation of a dual piston pump combined with the reliability of a single piston pump. Difficulties with solvent delivery systems, caused mainly by malfunctioning of the valves are reduced.

The delivery piston of the standard analytical unit works with a 2 mm stroke length, the compensation piston with 1 mm. The nearly pulse less solvent delivery of the S 2100 results from the high stroke frequency and the use of the compensation piston. The two pistons are contra rotated installed.

**Function diagram of the pump**

1. Dampening part of the pump
2. Plunger sealing
3. Camshaft
4. Pump piston
5. Inlet for back-valve flushing
6. First valve ball
7. Second valve ball
8. Outlet of back-valve flushing
9. Pressure sensor
10. Pump outlet
11. Microprocessor
12. D.C. Motor
13. Tachogenerator
While the delivery piston pushes the solvent volume out, the compensation piston, located on the pressure side, collects half of the volume. During return movement of the delivery piston, the collected volume is pumped from the compensation piston. The microprocessor controlled speed regulation leads to a highly stable speed of the d.c. motor. Contrary to standard regulators, the microprocessor is able to correct continuously the compressibility of the eluents through a computerized program. This results in a constant volume delivery throughout the entire delivery range.

The microprocessor technology also offers the possibility to handle the programming, application and controlling of an instrument in a simple manner. Through the alphanumeric display the instrument parameters are shown in clear letters. The user can easily control or change the data. To simplify operation, the function keys are kept at a minimum.

According to the individual modes, the following parameters can be programmed: constant flow in ml/min, constant pressure in MPa, minimum pressure level, maximum pressure limit, maximum flow, compressibility factor, maximum run time, delay time, programmable start delay time and stop delay time. The pump is equipped with a built-in diagnostic system. This continuously controls the following parameters: power failure, program memory, maximum and minimum pressure levels, maximum flow and the power supply. Illogical data, entered by the operator will be ignored by the processor's logic control and signalized.
5.2. Front Side of the SOLVENT DELIVERY SYSTEM S2100

All parts necessary for the operation of the system are positioned at the front.

Via the large LC display all functions can be controlled at any time. The integrated keyboard makes it possible to program the pump via the menu for nearly all analytical applications. On the right side of the pump, the important pump components like pump head, relief valve etc. are positioned. These are hidden by a magnetically closed door.

Front Side of the S 2100

1. Keyboard
2. Large graphical LC Display
3. Function Keys
4. Pump Head
5. Drain capillary relief valve
6. Relief Valve
7. Eluent Outlet
8. Connection for the Eluents
9. Door
5.2.2. Description of the Operation Panel

The programming and control of the pump S 2100 is done by a stepwise dialog using different menus. With the function keys F1 - F5, positioned below the display, different menus/functions can be selected directly depending on the actual menu. With the numeric keys, values are entered.

1. MENU key: With this function key, it is possible to select the main menu at any time.
2. DELETE key: Deletes the actual value
3. SELECT key: For selecting variable settings in the individual programs
4. CURSOR keys: For selecting the programmable fields described in the screen menus
5. NUMERIC KEYS (0-9): Used for numeric values
6. ENTER key: Used for entering the values
7. START key: Starts the automatic processing
8. STOP key: Stops the automatic processing, HOLD (pressing stop key once): the system runs, the clock stops STOP (pressing stop key twice): the system stops completely
9. Function keys and display: the actual function of the keys is displayed. These are dependent on the menu selected
5.2.3. **Pump Components positioned at the front**

Opening the magnetically closed door reveals the important parts of the pump:

1. Solvent connection block
2. Suction valve housing
3. Pump head
4. Purge valve
5. Venting screw
6. Drain capillary purge valve
7. Solvent outlet
8. Connecting capillary pressure sensor
9. Pressure valve housing
10. Connecting capillary damping piston
11. Mounting screws
**Pump Head (3)**

the pump head can be completely removed with the integrated pistons. For this loosen the connections for the pressure sensor (8) and solvent inlet capillary. Remove the four mounting screws (11) and the pump head can be pulled out.

**Relief Valve (4)**

used for a fast solvent change or for flushing the pump head to remove any air. The purge/relief valve can be opened by rotating the knob (5) counter-clockwise and clockwise respectively; after opening the valve, the eluent leaves through the drain capillary (6) due to gravity or with sucking on with the help of a syringe, connected to the capillary. Depending on the location of the pump, the eluent can be directed directly into a drain reservoir or via a teflon capillary directly into the main drain.

**Pressure Sensor**

The sensor (micro bourdon-tube type) is positioned behind the relief valve in the inner part of the pump. It has not only zero dead volume but also only an inside volume of 20 ìl. The pressure transfer is done through the inside connection to the relief valve.

**Eluent Inlet Valve (2)**

the inlet valve and the connecting capillary for the solvent is positioned on the lower part of the pump head.

**Eluent Outlet Valve (9)**

the pressure check valve is positioned on the upper part of the pump head and is connected through a capillary (10) to the damping piston. The eluent delivered from the delivery plunger streams into the second plunger space and therefore is directly connected with the pressure sensor and the relief valve.
5.3. Sectional view of the system

After removing all screws, the top cover can be lifted. All parts of the solvent delivery system are then accessible.

1. Eluent inlet
2. Pump Head
3. Valve Unit
4. PC-boards for System Control
5. Large graphical display
6. Four Channel Vacuum Degassing System (optional)
7. Signal in- and outputs
8. Transformer
9. Power Supply
10. Pump motor
5. 4. Description Rear Panel

At the rear side of the pump, the communication part is installed, like the serial communication port RS 232C, Interface for the operation with a PC and an additional connection for the remote control of external components. Due to these connection possibilities, the pump can be integrated into totally different analysis systems.

1. Sub-D connector (25pins) **AUX. FUNCTIONS** for the control of external components.
2. Sub-D connector (15pins) **REMOTE CONTROL** for system control
3. RS 232 C
4. Sub-D connector (9pins) **RS 232C** for digital signal transfer
5. Serial interface input for RS 232 signals (not in use)
6. Master switch
7. Power supply
8. Voltage selector and fuse carrier

*REMOTE CONTROL: The functions printed at the rear panel for remote control are not correct.

Corrected functions:

1 Free
2 Error relay N.C.
3 GND
4 GND
5 Start
6 Run relay COM
7 Error relay COM
8 GND
9 Free
10 Run relay N.C.
11 GND
12 GND
13 Hold skip
14 Run Relay N.O.
15 Error relay N.O.
6. SETTING UP FOR OPERATION

Before connecting the pump to the mains, check the voltage shown on the typed plate. This voltage should be identical with the voltage of the existing power source. If the voltage is correct, connect the instrument with the enclosed power cord. If necessary, the voltage has to be changed accordingly:

![Voltage Selector](image)

For resetting the voltage, pull the voltage selector out, turn 180° and push connector back. When the voltage selector is pulled out, also the two fuses (either 0.5 A for 220V or 1.0A 110V) can be replaced if necessary.

Connect the 4 pcs. PTFE capillaries (1.6 i.d. x 3.2 mm o.d.) to the solvent connection block (1). Connect the relief valve outlet (7) to the injection valve and/or autosampler with the enclosed stainless steel/PEEK capillary. Then the pump can be switched on. Connect the enclosed syringe to the outlet capillary of the relief valve.

**NOTE:**
During the final quality control the pump is tested with propanol. When setting up for operation and later when changing solvents, care must be taken to ensure solvent miscibility to avoid malfunctioning of the check valves. When changing immiscible solvents e.g. methanol-hexane, the pump should be flushed with an intermediate solvent that is miscible with both, e.g. chloroform. For the basic version of the system without integrated degassing unit, the solvents should be degassed carefully before use, as air bubbles within the pump head will create an unstable delivery of solvents by the pump. The most effective way of degassing is by bubbling helium through the solvent. Storing the solvents at 0.5 to 1 bar after degassing, a steady flow from the pump will be ensured. Under these conditions the solvents will be delivered to the pump inlet better than by gravity alone. Sucking of eluents by the pump may create air bubbles in the tubing. If helium is not available, heating of the solvent and stirring, as well as ultrasonic treatment are also very well tested methods for solvent degassing. Many problems associated with the analytical systems arise from insufficiently degassed solvents.
6.1. Priming the Pump

Always, before putting the pump into operation, all of the in- and outlet capillaries have to be filled bubble-free with the solvent. To do so, connect the enclosed plastic syringe to the outlet (6) of the relief valve. Display the menu for the manual operation (MAIN MENU - MANUAL OPERATION (1)).

During isocratic operation, the valves for the single channels (A, B, C and D) are switched one after another and after opening the relief valve (5) by one turn counter-clockwise, the eluent is sucked on (approx. 10 ml solvent). This should be done until the solvent is supplied without any air bubbles. For the version with the integrated degasser, approx. 20 ml solvent has to be sucked on. Afterwards, remove the syringe and activate the PURGE key (F3) approx. 20 ml solvent.

Close the relief valve (clockwise) and the pump is ready for operation. Above described priming of the pump with the help of a syringe will only work as long as the whole system is closed, e.g. the capillary tube between the pump head and the sample injection valve has to be in place and is not leaking.

In case air bubbles remain in the pump head (pressure drifting during operation), open the purge valve and activate the Purge function key several times. With a pressure of approx. 1 - 2 bar, air-bubbles will dissolve slowly in the eluent and are flushed out of the pump head.

NOTE: Only activate the PURGE function when the relief valve is in the open position!
7. Description of the Individual Screen Menus

All screens have an uniform design.

The upper part of the screen displays the actual values

- the flow rate of the solvent
- the pressure of the solvent
- the operation mode (manual, internal or external)
- the mode of running (Run, Stop, Hold)
- below the status remarks, (eventual) errors are described in abbreviations.

In the middle part of the screen all parameters, important for the operation of the system, can be adjusted. For that purpose the function keys and numeric keys at the front panel must be used. The positions for entering the values can be selected either via arrow key of the operation panel or directly entered using the numeric keys and the ENTER key. Change of values can be done by using the numeric keys or by pressing the selection keys.

In the lower part the names of the sub-menus available for the displayed screen are shown. They can be entered by pressing the appropriate function buttons.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATUS</strong></td>
<td></td>
<td>(M)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRAD. GRAPH</td>
<td>PRESS. GRAPH</td>
<td>DIAG. REPORT</td>
</tr>
</tbody>
</table>


7.1. MAIN MENU

This menu can be displayed at any time by pressing the function button 'MENU' at the front panel. From the main menu, the single programs can be selected with the cursor key and pressing the ENTER key or typing the number 0 to 6.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>VER 1.03</td>
<td>19-07.1999</td>
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</table>

**INTERNAL CONTROL**

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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANUAL</td>
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<td>OPERATION</td>
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<tr>
<td>ANALYSIS</td>
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<td>SEQUENCE</td>
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<tr>
<td>GRADIENT</td>
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<tr>
<td>PROGRAM</td>
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<tr>
<td>DIAGNOSTIC</td>
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<tr>
<td>SETUP</td>
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<tr>
<td>PRESSURE</td>
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<tr>
<td>PROFILE</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>STATUS</th>
<th>MODE</th>
<th>MENU</th>
<th>INTERN/</th>
<th>PURGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/P/S</td>
<td></td>
<td>LOCK</td>
<td>EXTERN</td>
<td></td>
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</tr>
</tbody>
</table>
0 STATUS

Status display

1 MANUAL OPERATION

In this menu all functions can be operated manually

2 ANALYSIS SEQUENCE

Single programs which are already stored can be chained and repeated.

3 GRADIENT PROGRAM

The solvent's composition consisting of up to four different eluents can be set.

4 DIAGNOSTIC

All parameters documented for GLP can be displayed.

5 INSTRUMENT SETUP

All parameters for the configuration of the instrument can be adjusted.

6 PRESSURE PROFILE

For checking the pressure during the analysis, the pressure profile of single runs can be recorded and can be used as a reference profile.

Function keys:

These function keys do have different functions depending on the menu selected. With the function keys F1 - F5 additional information can be displayed or submenus can be selected directly.

F1 STATUS

The STATUS menu can be entered

F2 MODE M/P/S

The mode of the system can be set:

M-manual program: the system can be controlled by using the keys at the front panel

P-single program: the system runs according to the installed program

S-program sequence: the system runs according to a program sequence

F3 MENU LOCK

The menu can be locked with a security code

F4 INTERN/EXTERN

The system can be controlled internally or externally via remote control.

F5 PURGE

For flushing the system the purge key can be pressed.

Only activate the PURGE function when the relief valve is in the open position!
7.1.1. Main Menu Lock

To protect all menus and settings against any manipulations, the system can be locked with a special legitimation code. After entering the code in the special menu accessible from the MAIN MENU and pressing **F3 (Main Menu/Lock)** no changes can be done. Only after unlocking the system, the submenus can be entered and parameters can be changed.

With the cursor key 'V', the field where the legitimation code has to be entered can be reached.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAIN MENU / LOCK</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEGITIMATION CODE</td>
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<tr>
<td></td>
<td></td>
<td>MAIN MENU</td>
</tr>
</tbody>
</table>

The keyboard can be locked by typing the **code 23456** and pressing the ENTER key.

**F3   MAIN MENU**  The main menu can be entered. All submenus are locked, except the status menu.
7.1.2. Main Menu Unlock

Before any changes can be done, the keyboard has to be unlocked. Press the function key F3 (MAIN MENU/UNLOCK). Use the cursor key 'V' and enter the same legitimating code (23456).

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/Min</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAIN MENU / UNLOCK</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LEGITIMATION CODE

Now the system will be unlocked and accessible again.

**Function keys:**

F3 MAIN MENU display of the main menu
7.2. STATUS Display

After pressing the F1 key or the '0' key the status of the system is displayed. All parameters important for the analysis are shown. We recommend that this menu is displayed during operation.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/Min</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M)</td>
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</tbody>
</table>

**STATUS FLOW**

- SINGLE
- TIME: 13:15
- PROGRAM
- DATE: 20-07-99

- PROG. NO.: 0
- TOTAL TIME: 0 SEC
- STEP NO.: 1 / 10
- STEP TIME: 2 / 4000 SEC
- SEQUENCE: 0 / 0
- CYCLE: 0 / 0
- FUNCTION: 0 / 0
- GRADIENT: 80.0 %A  5.0 %B  3.0 %C  12.0 %D

<table>
<thead>
<tr>
<th>GRAD. GRAPH</th>
<th>PRESS GRAPH</th>
<th>DIAG. REPORT</th>
<th>FLOW/ FUNCT.</th>
<th>PURGE</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>
FLOW: display of the actual flow rate

SINGLE PROGRAM: The mode of operation is shown
- Single Program: the system is controlled by a stored program
- Program Sequence: the system can run a complete sequence, programmed and stored in a submenu.
- Manual Program: the system can be run manually.

PROG. NO.: Shows the number of the actual program

TOTAL TIME: Displays the total runtime of the system

STEP NO.: The actual step and the total no. of steps is shown.

STEP TIME: The time since the beginning of the step and the total time of the actual step is shown.

SEQUENCE: The actual sequence and in case of chaining the total number of sequences are shown.

FUNCTION: the active relays are shown

CYCLE: The actual run and the total numbers of cycles are shown.

GRADIENTS: The actual composition of the gradient delivered at the moment is shown.

Function keys:

F1 GRAD GRAPH Shows graphically the composition of the eluent.

F2 PRESS. GRAPH Display of the pressure run.
This is only possible, if this has been programmed in the menu PRESSURE PROFILE

F3 DIAG. REPORT Displays any pressure irregularities

F4 FLOW/FUNCT. Switching to the menu STATUS FUNCTION, the programmed switching functions are displayed

F5 PURGE Pressing this button, the system is flushed with the eluent.

Pressing the START key, single programs can be skipped. The actual step is displayed.
7.2.1. Submenu: Gradient Graphic

This submenu is entered by pressing the function key **F1** in the STATUS Menu and displays the diagram of the gradient. The complete curve of the gradient during the analysis run and also of the single solvents can be displayed.

![Gradient Graphic Diagram](image)

FLOW: 1.50 ML/MIN  PRESS: 125.0 BAR  MODE STOP

<table>
<thead>
<tr>
<th>GRADIENT GRAPHIC</th>
<th>(ABCD)</th>
<th>PROG.NO.: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 %</td>
<td>0 %</td>
<td></td>
</tr>
<tr>
<td>ZEIT: 0</td>
<td>127 SEC</td>
<td>3600 SEC</td>
</tr>
<tr>
<td>A %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>127 SEC</td>
<td>3600 SEC</td>
<td></td>
</tr>
<tr>
<td>GRAD. ABCD</td>
<td>GRAD. A</td>
<td>GRAD. B</td>
</tr>
<tr>
<td>GRAD. B</td>
<td>GRAD. C</td>
<td>GRAD. D</td>
</tr>
</tbody>
</table>

The X-axis shows the percentage of the single component A, B, C and D the eluent is consisting of. The Y-axis shows the time of the total run. The actual composition of the eluent is shown by the vertical mark in the graphic.

**Function keys:**

**F1**  **GRAD ABCD**  The percentage of each component A, B, C, and D of the eluent are displayed in one graphic.

**F2-F5**  **GRAD A - GRAD D**  Each single component of the eluent is shown in a separate diagram.

Pressing the START key, single programs can be skipped. The actual step is displayed.

The STATUS menu can be displayed by pressing the MENU key.
### 7.2.2. Submenu: Pressure Graphic

This submenu is displayed after pressing the function key **F2** in the STATUS Menu. Especially with analysis where constant operation conditions are required, the pressure profile is of the utmost importance. During the analysis, the actual pressure can be compared to an already programmed pressure profile. For the reference pressure profile, the parameters have to be set in the submenu **PRESSURE PROFILE** (**Main Menu and [6]**).

During the analyses, the actual status is displayed by a vertical line on the reference diagram. The pressure difference of the actual pressure run is shown in numerical values.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE</th>
<th>STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRESSURE</strong></td>
<td>(BASE LINE)</td>
<td>PROG.NO.: 4</td>
<td></td>
</tr>
</tbody>
</table>

![Pressure Profile Graph](image)

**STATUS**  | **REDRAW** | **+ERROR** | **-ERROR**

| RECORDING | T = 127 SEC | T = 3600 SEC | 400 | BAR | 0 | 0 | 0 |
PROG. NO.: Number of the reference profile used for comparing the actual pressure run

The mode of the profile is displayed below the diagram:

RECORDING displayed before the analyses is started (the data acquisition has been activated in the menu PRESSURE PROFILE)

PART The data recording is not finished yet

COMPLETE The recording process is finished

EMPTY No reference diagram is stored

Below the diagram, also the actual run time and the total run time are displayed

Function keys:
F1 STATUS display or the STATUS menu

F3 REDRAW the stored reference diagram is redrawn

F4 +ERROR displayed when the pressure exceeds the max. pressure level

F5 -ERROR displayed when the pressure remains under the min. pressure level

NOTE
In case of an error message caused by pressure irregularities (PRS-AN), the message has to be first deleted before starting the next analyses.
- go to STATUS Menu
- press the F3 function key (DIAG. REPORT)
- press the F2 function key (CLEAR ERROR)
Afterwards, the next analyses can be started.

Pressing the START key, single programs can be skipped. The actual step is displayed.

The STATUS menu can be displayed by pressing the MENU key.
7.2.3. Submenu Diagnostic Report

The submenu is displayed after pressing the function key F3 in the STATUS Menu.
This menu is listing pressure values during a single run or a sequence which exceed or remain under the set pressure values.
The programming of the min. and max. pressure values and the duration of the irregularities have to be programmed in the menu PRESSURE PROFILE (Main Menu and [6])

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnostic Report</strong></td>
<td>(ANALYSIS PRESS. ERROR )</td>
<td></td>
</tr>
<tr>
<td>NO.: ERROR TIME</td>
<td>ANALYSES W/O</td>
<td>COMMENT ARE</td>
</tr>
<tr>
<td>2 + 21.4</td>
<td></td>
<td>O.K.!</td>
</tr>
<tr>
<td>5 - 33.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 + 41.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 + 55.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-PRESSURE TOO LOW
+PRESSURE TOO HIGH

<table>
<thead>
<tr>
<th>STATUS</th>
<th>CLEAR ERRORS</th>
<th>+ERROR 0 SEC</th>
<th>-ERROR 0 SEC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**NO.:** Number of analyses where pressure irregularities happened

**ERROR** Describes the type of error:
+ the programmed max. pressure is exceeded
- the pressure remained under the programmed min. pressure

**TIME** shows the time, when the irregularities happened

**Function keys:**

**F1 STATUS** Display of STATUS menu

**F2 CLEAR ERRORS** Deletes the listed errors

**F4 + ERROR 0 SEC** counting meter; the duration (in sec.) are registered. If the pressure exceeding remains for a certain period of time, the pressure irregularity will be listed. If the pressure goes below the max. pressure within the programmed period of time, the counting meter will be reset and no error is listed.

**F5 - ERROR 0 SEC** counting meter; has the same function as F4, but for pressure remaining under the programmed min. pressure.

**NOTE:**
In case of any errors listed, these have to be deleted before starting renewed operation

The pump is equipped with a safety control to avoid any damage caused by a leakage. In case the duration of pressure irregularities (min. or max. pressure value) are longer than the programmed threshold value (entered in the menu PUMP SETUP), the pump switches off.

**Attention**
After initializing the instrument, various parameters are entered automatically for the self testing procedure. These parameters have to be deleted first before operation.
7.2.4. Submenu FLOW FUNCTION

The submenu is displayed after pressing the function key \textbf{F4} in the STATUS Menu.

The instrument is equipped with 8 relays with which the integrated micro processor can control an analyses system. The programming is done in the menu \textbf{PROG. FUNCTION} (Main menu, [4] and F3).

The display FLOW FUNCTION shows all important parameters of the actual analysis during operation.

\begin{tabular}{|l|l|l|}
\hline
FLOW: 1.50 ML/MIN & PRESS: 125.0 BAR & MODE STOP (M) \\
\hline
\textbf{STATUS FUNCTION} & SINGLE & \\
 DATE: 20-07-99 & TIME: PROGRAM & \\
 PROG. NO.: 0 & \\
 TOTAL TIME: 0 SEC & \\
 STEP NO.: 1 / 10 & \\
 STEP TIME: 2 / 4000 SEC & \\
 SEQUENCE: 0 / 0 & \\
 CYCLE: 0 / 0 & \\
 FUNCTION: ----------- & \\
 GRADIENT: 80.0 %A 5.0 %B 3.0 %C 12.0 %D & \\
\hline
\end{tabular}

The description of the individual functions can be found under STATUS FLOW (chapter 7.2). With the function key F4 (FLOW/FUNCT.), the menu can be switched between STATUS FLOW and STATUS FUNCTION.
For maintenance or testing purposes or for special applications, the system must be run manually.

**7.3. MANUAL OPERATION**

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE (M)</th>
<th>STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MANUAL OPERATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME:</td>
<td>18 MIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLOW RATE RUN:</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLOW RAMP UP:</td>
<td>0.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESS. FAIL MIN.:</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESS. FAIL MIN.:</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RELAY FUNCTIONS:</td>
<td>1 - 3 - 5 - 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIX. SPEED:</td>
<td>2.0 SEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMPR. FACTOR:</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TIME:** programming of the analysis time

**FLOW RATE** programming of the flow rate during the analyses (ml/min.)

**END:** programming of the flow rate of the eluent after finishing the analyses.

The mode of the pump is displayed in the top right corner:

**IDLE** the pump delivers with the programmed flow rate (END)

**STOP** the pump stopped; (value entered under END: 0)
FLOW RAMP* programmable start and stop delay time which protects and therefore prolongs column's durability as a careful pressure increase and decrease onto the column is possible.

UP: programming of the flow rate ramp (ml/sec) before starting the analyses. The flow rate of the pump will increase linearly from 0 to the set flow rate during the time ramp entered. After reaching the programmed flow rate, the analyses will start.

DOWN programming of the flow rate ramp (ml/sec). The flow rate of the pump will be linearly decreased from the working flow rate down to zero during the time ramp entered. This will avoid a sudden pressure drop.

** The displayed measures (ml/min.) are not correct. The time ramps are programmed in ml/sec.**

PRESS. FAIL: If the pressure exceeds and/or drops under the programmed pressure values (minimum or maximum value) for a certain period of time (programmed in the menu PUMP SETUP) the pump stops automatically.

MIN Value for min. pressure
MAX Value for max. pressure

ISOCR. X: The mode of the system can be adjusted by pressing the SELECT buttons. Each single eluent can be delivered. In ISOCR. mode after pressing the SELECT button, the corresponding valve opens and the single eluent will be delivered.

or GRAD. X: The gradient can be adjusted for manual use of the instrument. Due to the SELECT button, the gradient for the different solutions can be selected. If a gradient is chosen, the concentrations of all the other components can be set and the concentration of the selected gradient will be calculated automatically.

RELAY FUNCTIONS: Here, up to eight integrated relays can be manually activated

MIXING SPEED: For preparing the mixture of the gradient, the valves open in the frequency which is adjusted here. In some cases, depending on the flow rate (pressure pulsation), the signal shows a typical pulsation. To avoid this disturbance the mixing speed should be adjusted (0,1 - 99 sec.)

COMPR. FACTOR Especially organic eluents can be compressed by the high pressure of the pump during delivery. For an accurate flow rate the system needs a factor which can be set here. (refer to Compressibility; chapter 8)

Function keys:
F1 STATUS The STATUS of the system is shown
F5 PURGE The system will be flushed with the eluent (in general this will be the max. flow rate)
7.4. ANALYSIS SEQUENCE

The different single programs can be chained, repeated and combined in sequences. Up to 14 different steps can be stored.

<table>
<thead>
<tr>
<th>COUNT</th>
<th>PROGR. / NAME</th>
<th>COUNT</th>
<th>PROGR. / NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 4 PROG# 4#</td>
<td>8</td>
<td>0 1 PROG# 1#</td>
</tr>
<tr>
<td>2</td>
<td>3 2 PROG# 2#</td>
<td>9</td>
<td>0 1 PROG# 1#</td>
</tr>
<tr>
<td>3</td>
<td>5 3 PROG# 3#</td>
<td>10</td>
<td>0 1 PROG# 1#</td>
</tr>
<tr>
<td>4</td>
<td>0 1 PROG# 1#</td>
<td>11</td>
<td>0 1 PROG# 1#</td>
</tr>
<tr>
<td>5</td>
<td>0 1 PROG# 1#</td>
<td>12</td>
<td>0 1 PROG# 1#</td>
</tr>
<tr>
<td>6</td>
<td>0 1 PROG# 1#</td>
<td>13</td>
<td>0 5 PROG# 5#</td>
</tr>
<tr>
<td>7</td>
<td>0 2 PROG# 2#</td>
<td>14</td>
<td>0 3 PROG# 3#</td>
</tr>
</tbody>
</table>

MAX. SEQUENCE: Here, the number of the last step has to be entered to which the sequence program should be processed automatically.

COUNT: Here, the number of repetitions of the single steps must be set. If the number 0 is set, the sequence is stopped at that point.

PROG./NAME Here, the number and name of the single program which is to be chained must be set.

Function keys:

F1 STATUS The STATUS menu can be entered.

F5 PURGE The system is flushed with the max. flow rate
7.5. ANALYSIS PROGRAM

In this menu the programming of the gradients is done. In more than 100 steps the flow with max. and min. pressure can be set. With the relay function, the relays can be switched in pulse or permanent mode.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS.: 125.0 BAR</th>
<th>MODE (M)</th>
<th>STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANALYSIS PROGRAM</td>
<td>SINGLE PROGRAM NO.: 1</td>
<td>EDIT PROGRAM NO: 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STEPS FLOW: 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRADIENT: GRAD A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEAD: ANALYT:</td>
<td>STEPS FUNCT.: 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMPR: FACTOR: 1.00</td>
<td>MIX. SPEED: 6 SEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAMP UP: 1.00 ML/MIN (MAX.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAMP DOWN: 1.00 ML/MIN (MAX.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.-MIN: 0 BAR</td>
<td>FUN.# 1 2 3 4 5 6 7 8</td>
<td>P S P S S S S</td>
<td></td>
</tr>
<tr>
<td>P.-MAX: 100 BAR</td>
<td>(STATIC/PULS):</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FUNCTION:

<table>
<thead>
<tr>
<th>STATUS</th>
<th>PROG./FLOW</th>
<th>PROG./GLOBAL</th>
<th>CLEAR</th>
<th>INSERT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROG./GLOBAL</td>
<td>CLEAR</td>
<td>INSERT</td>
<td>STEP</td>
<td>STEP</td>
</tr>
</tbody>
</table>

SINGLE PROGRAM NO Shows the actual program which will be activated after pressing the START key

EDIT PROGRAM NO Shows the number of a different program which can be edited while the other program is running

ISOCR./GRADIENT With the SELECT buttons, the mode can be adjusted. ISOCR. mode; each single eluent can be delivered GRADIENT mode; after selecting a gradient, the concentrations of all the other components can be set and the concentration of the selected gradient will be calculated automatically.

STEPS FLOW number of programming steps entered in the submenu PROG. FLOW

HEAD ANALYT./MICRO/PREP: Shows, which pump head is installed
In the menu PUMP CONFIGURATION the parameters for the appropriate pump head are entered

STEPS FUNCT. number of relay functions, programmed in the submenu PROG. FUNCTION

COMPR. FACT. Especially organic eluents can be compressed by the high pressure of the pump during delivery. For an accurate flow rate the system needs a factor which can be set here. (refer to Compressibility; chapter 8)
FLOW RAMP* programmable start and stop delay time which protects and therefore prolongs column's durability as a careful pressure increase and decrease onto the column is possible.

UP: programming of the flow rate ramp (ml/sec) before starting the analyses. The flow rate of the pump will increase linearly from 0 to the set flow rate during the time ramp entered. After reaching the programmed flow rate, the analyses will start

DOWN programming of the flow rate ramp (ml/sec). The flow rate of the pump will be linearly decreased from the working flow rate down to zero during the time ramp entered. This will avoid a sudden pressure drop.

** The displayed measures (ml/min.) are not correct. The time ramps are programmed in ml/sec.**

PRESS. FAIL: If the pressure exceeds and/or drops under the programmed pressure values (minimum or maximum value) for a certain period of time (programmed in the menu PUMP CONFIGURATION) the pump stops automatically.

P.-Min. Value for min. pressure
P.-Max. Value for max. pressure

FUNCTION (Static/Pulse) The 8 installed relays make a remote control of external instruments (photometer or additional pumps) possible. Pressing the arrow keys and the SELECT key, each relay can be set on pulse mode or as a static signal.

Function keys:

F1 STATUS The STATUS menu is displayed
F2 PROGRAM FLOW For programming the composition of the solvent
F3 PROGRAM FUNCTION For programming automatically HOLD periods and relay functions
F4 CLEAR PROGRAM Deletes the active program
7.5.1. ANALYSIS PROGRAM; Submenu PROG./FLOW

This menu is used for programming the composition of the solvent. In this submenu, entered with pressing the F2 key in the ANALYSIS PROGRAM MENU, up to 25 programs with more than 100 steps each can be created.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS.: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M)</td>
</tr>
</tbody>
</table>

**ANALYSIS PROGRAM**

<table>
<thead>
<tr>
<th>NO</th>
<th>SEC</th>
<th>ML/MIN</th>
<th>GR:A%</th>
<th>GR:B%</th>
<th>GR:C%</th>
<th>GR:D%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.50</td>
<td>100.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>4.0</td>
<td>0.0</td>
<td>20.0</td>
<td>10.0</td>
<td>20.0</td>
<td>50.0</td>
</tr>
<tr>
<td>2</td>
<td>21.0</td>
<td>1.25</td>
<td>50.0</td>
<td>20.0</td>
<td>15.0</td>
<td>25.0</td>
</tr>
<tr>
<td>3</td>
<td>34.0</td>
<td>1.25</td>
<td>30.0</td>
<td>10.0</td>
<td>20.0</td>
<td>40.0</td>
</tr>
<tr>
<td>4</td>
<td>50.0</td>
<td>1.25</td>
<td>20.0</td>
<td>30.0</td>
<td>32.0</td>
<td>18.0</td>
</tr>
<tr>
<td>5</td>
<td>0.1</td>
<td>1.25</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>6</td>
<td>10.0</td>
<td>1.25</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**STATUS**

<table>
<thead>
<tr>
<th>SINGLE PROGRAM NO.: 1</th>
<th>EDIT PROGRAM NO: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROG./ FLOW</td>
<td>PROG./ GLOBAL</td>
</tr>
<tr>
<td>CLEAR STEP</td>
<td>INSERT STEP</td>
</tr>
</tbody>
</table>
**SINGLE PROGRAM NO**  
Shows the actual program which will be activated after pressing the START key.

**EDIT PROGRAM NO**  
Shows the number of a different program which can be edited while the other program is running.

**NO.**  
The number of the programming step

**SEC**  
The duration of this step in seconds. During this time, the mixing ratio changes linearly until reaching the programmed value. A gradient change in steps can be achieved by programming between the eluent change 0.1 min. In the next program step, the duration of the constant delivery of the programmed mixing ratio has to be entered.

**ML/MIN**  
The flow rate of the eluent

**Gr.A% (B,C,D)**  
For programming the single eluents in VOL%. A selected choice of the gradient makes the programming process easier, as the selected gradient will be calculated automatically.

**ISOCRAT A% (B,C,D)**  
For the selection of the single eluent in VOL%.

**Function keys:**

**F1 STATUS**  
The STATUS menu is shown

**F2 PROG./GLOBAL**  
Switches between the menu of the actual analysis program (7.5.) and the submenu for programming

**F3 PROG./FUNCT.**  
Switches to the menu PROG/FUNCT. for programming the relay functions (7.5.2.)

**F4 CLEAR STEPS**  
Single programming steps can be selected and deleted by pressing the F4 function key

**F5 INSERT STEPS**  
To save time, a selected program step can be copied with the function key F5
7.5.2. ANALYSIS PROGRAM; Submenu PROG./FUNCT.

In this submenu, the relay functions and hold functions for the analysis program can be entered. The submenu is displayed by pressing the F3 function key or in the submenu PROG./FLOW by pressing the submenu PROG./FUNCT. [F3].

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS.: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M)</td>
</tr>
</tbody>
</table>

**ANALYSIS PROGRAM**

SINGLE PROGRAM NO.: 1
EDIT PROGRAM NO: 2

<table>
<thead>
<tr>
<th>NO</th>
<th>SEC</th>
<th>HOLD</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
<th>F6</th>
<th>F7</th>
<th>F8</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NO</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>7</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
<td>YES</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7.0</td>
<td>NO</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>7</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>11.8</td>
<td>NO</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>24.8</td>
<td>NO</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>30.0</td>
<td>NO</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

**STATUS**

<table>
<thead>
<tr>
<th></th>
<th>PROG./FLOW</th>
<th>PROG./GLOBAL</th>
<th>CLEAR STEP</th>
<th>INSERT STEP</th>
</tr>
</thead>
</table>

Page 38 of 63
<table>
<thead>
<tr>
<th><strong>SINGLE PROGRAM NO</strong></th>
<th>Shows the actual program which will be activated after pressing the START key.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EDIT PROGRAM NO.</strong></td>
<td>Shows the number of a different program which can be edited while the other program is running</td>
</tr>
<tr>
<td><strong>NO.</strong></td>
<td>The number of the step with the described parameters</td>
</tr>
<tr>
<td><strong>SEC.</strong></td>
<td>The time when the programmed event will start</td>
</tr>
<tr>
<td><strong>HOLD</strong></td>
<td>YES/NO after a programmed start time (e.g. 0.1 min.), the pump will stop (YES) until pressing the START key or through an external start signal. For automatic processing, the HOLD function has to be deactivated (NO).</td>
</tr>
<tr>
<td><strong>F1 - F8</strong></td>
<td>Number of the active relay; Slash: inactive relay</td>
</tr>
</tbody>
</table>

**Function keys**

<table>
<thead>
<tr>
<th><strong>F1</strong></th>
<th><strong>STATUS</strong></th>
<th>The STATUS menu is shown</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F2</strong></td>
<td><strong>PROG./FLOW</strong></td>
<td>Switches to the menu PROG./FLOW for programming the gradient composition (7.5.1.)</td>
</tr>
<tr>
<td><strong>F3</strong></td>
<td><strong>PROG./GLOBAL</strong></td>
<td>Switches between the menu of the actual analysis program (7.5) and the submenu for programming</td>
</tr>
<tr>
<td><strong>F4</strong></td>
<td><strong>CLEAR STEPS</strong></td>
<td>Single programming steps can be selected and deleted by pressing the F4 function key</td>
</tr>
<tr>
<td><strong>F5</strong></td>
<td><strong>INSERT STEPS</strong></td>
<td>To save time, a selected program step can be copied with the function key F5</td>
</tr>
</tbody>
</table>
7.6. DIAGNOSTIC PROGRAM

This menu shows the most important parameters of the system necessary for GLP and for fast checks in case of malfunctioning. The menu displays the important power supplies of the single PC boards, the actual vacuum (optionally) and the operating hours of various wear and tear parts.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M)</td>
</tr>
</tbody>
</table>

**DIAGNOSTIC PROGRAM (GLP)**

<table>
<thead>
<tr>
<th>VACUUM:</th>
<th>-889 mBAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1: 5.14 U2: 15.3 U3: -15.4 U4: 24.9 U5: 33.5</td>
<td></td>
</tr>
<tr>
<td>INLET CHECK VALVE:</td>
<td>785 h OPERATING TIME</td>
</tr>
<tr>
<td>DELIVERY PISTON:</td>
<td>785 h</td>
</tr>
<tr>
<td>DAMPING PISTON:</td>
<td>1082 h</td>
</tr>
<tr>
<td>PISTON SEAL:</td>
<td>762 h</td>
</tr>
<tr>
<td>SECONDARY SEAL:</td>
<td>897 h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STATUS</th>
<th>H/S</th>
<th>CLEAR TIMER</th>
<th>CONFIRM</th>
</tr>
</thead>
</table>

**VACUUM:** The present vacuum applied on the eluent is shown (only with built-in vacuum degasser option)

**U1, U2, U3, U4:** Various controlled power supplies for the PC-boards

**INLET CHECK VALVE**

**DELIVERY PISTON**

**DAMPING PISTON**

**PISTON SEAL**

**SECONDARY SEAL** counting meter for the operating hours of the individual part.

**Function keys:**

**F1 STATUS** The STATUS menu is displayed

**F2 H/S** Using this button the runtime can be displayed in seconds and/or hours

**F4 CLEAR TIMER** If any of the parts are replaced and the timer must be set to zero again, this can be done by pressing this button.

**F5 CONFIRM** After setting the timer back to zero, this has to be confirmed with the F5 function key.
7.7. PUMP SETUP

In this menu all parameters for setting up the pump can be entered.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M)</td>
</tr>
</tbody>
</table>

**PUMP SETUP**

|------------------------|---------------------|--------------------------|-------------------------|-----------------|-------------------|-----------------|-------------------|------------------------|---------|

**DATE/ TIME**

The date (refer to 7.9) and time can be set, selecting the number to be changed, -with the arrow key- and is replaced by typing the correct number. The new numbers must be confirmed with the ENTER key.

**CONTROL MODE**

The system can be controlled internally by its built-in microprocessor or externally with a separate PC. The mode can be changed using the SELECT key.

- **INTERNAL** control through internal microprocessor
- **EXTERNAL (Remote Control)** control through external signals (FLAGS)
- **SERIEL** after connecting the pump to a RS232 interface, the system can be controlled via a data software

**PUMP HEAD**

For selecting the pump head in use. After exchanging the pump head, the appropriate pump head must be selected with the SELECT key. In addition, the head constant in the Menu PUMP CONFIGURATION has to be changed.

**PURGE PRESS MAX.**

For some applications the purge pressure should be limited. Here the maximum pressure can be set.

**VACUUM DEGASSER (OPTIONAL)**

The built-in vacuum degasser can be switched on or off, pressing the SELECT button.
TIME BASE  The time base can be selected by pressing the SELECT button.  
Alternatives:  1 SEC, 0.1 MIN, 1 MIN

PRESSURE UNITS  The pressure unit can be selected by pressing the SELECT button.  
Alternatives: BAR, MPA, PSI

MIXING SPEED  The mixing speed of the built-in valves can be adjusted. In some cases the 
frequency of opening and closing the valves and the pump frequency 
can  cause problems. The baseline shows a typical pulsation.  
After changing the mixing speed (from 0.1 - 99 sec) the pulsation can be 
avoided.

RELAY PULSE  The pulse duration of the signal relays can be set (1-99 sec) by typing the 
new number.

PRESS. FAIL:  In case of pressure irregularities over a certain period of time, the 
pump will switch off to avoid any damage caused by leakage.  
MIN.: period in case of minimum pressure failure (0-999 sec).  
MAX.: period in case of maximum pressure failure (0-999 sec).

NOTE: It is strongly recommended to set the Max. Pressure Failure to 0 Sec.

Function keys:

F1  STATUS  The STATUS menu is displayed

F2  PUMP CONFIGURATION  The menu for configuration (head constant, motor, 
span etc.) can be entered

F3  DIALOGUE GERMAN  The dialogue language can be selected by pressing 
the SELECT button (GERMAN / ENGLISH)
7.7.1. PUMP CONFIGURATION

In this submenu the settings for the different pump heads are programmed. Before changing the values, a note of the old values should be made and if necessary, the manufacturer of the pump should be contacted.

After an initializing process (should be only done on manufacturer's approval) or after exchanging the pump head, the head constant and Motor zero value should be checked and if necessary, changed.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M)</td>
</tr>
<tr>
<td>PUMP CONFIGURATION</td>
<td>LEGITIMATION: 0</td>
<td></td>
</tr>
<tr>
<td>HEAD CONSTANT:</td>
<td>3.00</td>
<td>MOTOR ZERO: 10</td>
</tr>
<tr>
<td>3.00</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>HEAD PARAMETER</td>
<td>SPAN</td>
<td>FLOW</td>
</tr>
<tr>
<td>MICRO:</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td>1.00</td>
<td>ML/MIN</td>
<td></td>
</tr>
<tr>
<td>ANALYT:</td>
<td>1.00</td>
<td>10.00</td>
</tr>
<tr>
<td>1.00</td>
<td>ML/MIN</td>
<td></td>
</tr>
<tr>
<td>PREP:</td>
<td>1.00</td>
<td>40.00</td>
</tr>
<tr>
<td>1.00</td>
<td>ML/MIN</td>
<td></td>
</tr>
<tr>
<td>STATUS</td>
<td>PUMP SETUP</td>
<td>MOTOR ZERO</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ATTENTION!!!!! Settings in this menu should be changed only on request.

LEGITIMATION Enter the legitimating code (123)

HEAD CONSTANT The head constant of the pump head delivered with the pump can be found in the inside of the system. After removing the pump's cover, a label is fixed on the left sided mounting plate (used for the processor boards). There the head constant and the motor zero value are recorded. After the initializing process, the displayed head constant and motor zero value has to be checked and in case of discrepancies, changed.

After exchanging the pump head (analytical, micro, prep. version), in general the following head constancies are used:

**Stainless steel version:**
- analytical: head constant 3.00
- micro: head constant 0.80
- preparative: head constant 5.00

**PEEK version:**
- analytical: head constant 1.25
- further head constancies on request.
MOTOR ZERO

Motor value of the pump motor.
Each pump has a different motor value. The exact value is recorded in the inside of the system (refer to Head Constant). The displayed value should be identical to the listed value.

The following values for PARAMETER, SPAN and FLOW should be checked and if necessary, corrected.

<table>
<thead>
<tr>
<th>Head</th>
<th>MICRO</th>
<th>PARAMETER:</th>
<th>SPAN:</th>
<th>FLOW:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.00</td>
<td>1.00</td>
<td>4.00 ML/MIN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANALYT.</th>
<th>PARAMETER:</th>
<th>SPAN:</th>
<th>FLOW:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00</td>
<td>1.00</td>
<td>10.00 ML/MIN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PREP.</th>
<th>PARAMETER:</th>
<th>SPAN:</th>
<th>FLOW:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00</td>
<td>1.00</td>
<td>40.0 ML/MIN</td>
</tr>
</tbody>
</table>

Function keys:

F1 STATUS The STATUS MENU is displayed
F2 PUMP SETUP Switching to the PUMP SETUP menu for programming
F3 MOTOR ZERO For adjusting the starting output of the motor (changes only on manufacturer's approval)
7.8. PRESSURE PROFILE

If the column's packing material changes during the analyses, unexplainable drifts or peaks are the result. For comparing the pressure profiles, a reference profile should be monitored before starting the analysis sequence. For programming the profile parameters, the menu PRESSURE PROFILE has to be used.

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M)</td>
</tr>
</tbody>
</table>

**PRESSURE PROFILE**

<table>
<thead>
<tr>
<th>PROGRAM NO. FOR BASE LINE:</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>USE PRESSURE PROFILE:</td>
<td>NO</td>
</tr>
<tr>
<td>OVERPRESSURE:</td>
<td>1% FOR 15 SEC</td>
</tr>
<tr>
<td>UNDERPRESSURE:</td>
<td>1% FOR 15 SEC</td>
</tr>
<tr>
<td>PROFILE RECORDED:</td>
<td>15:32 12-07-99</td>
</tr>
<tr>
<td>STATUS:</td>
<td>PART</td>
</tr>
<tr>
<td>PROGRAM:</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STATUS</th>
<th>CLEAR PROFILE</th>
<th>NEW PROFILE</th>
</tr>
</thead>
</table>

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PROGRAM NO. FOR BASE LINE
The no. of the analyses program is selected where this reference pressure profile should be applied to

USE PRESSURE PROFILE
YES/NO
After recording the reference profile, it is up to the operator if he wants to use the profile for comparison of other analysis sequences or not.

OVERPRESSURE
programming of the max. pressure [%] and the duration of the max. pressure [sec.] until the overpressure is registered as error.

UNDERPRESSURE
programming of the min. pressure [%] and the duration of the min. pressure [sec.] until the under pressure is registered as error.

PROFILE RECORDED
Date and time of the reference profile monitored

STATUS
EMPTY no reference profile is stored
COMPLETE the reference profile can be used for comparison
PART displayed while the reference profile is monitored

PROGRAM
No. of program where the reference profile was recorded.

Function keys:

F1 STATUS The STATUS MENU is displayed
F3 CLEAR PROFILE Deletes a recorded pressure profile
F4 NEW PROFILE Activates a new profile recording process. The monitoring will start, when the pump starts and is displayed in the menu STATUS-PRESSURE GRAPHIC.
7.9. Setting Time and Date

For changing the date and time of the instrument, the menu PUMP SETUP (Main Menu and Pos. 5) has to be activated

<table>
<thead>
<tr>
<th>FLOW: 1.50 ML/MIN</th>
<th>PRESS: 125.0 BAR</th>
<th>MODE</th>
<th>STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(M)</td>
</tr>
<tr>
<td><strong>PUMP SETUP</strong></td>
<td></td>
<td>TIME: 11:49</td>
<td>DATE: 20-7-99</td>
</tr>
<tr>
<td>CONTROL MODE:</td>
<td>INTERNAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUMP HEAD:</td>
<td>ANALYT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PURGE PRESS MAX:</td>
<td>100 BAR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VACUUM DEGASSER:</td>
<td>YES/NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME BASE:</td>
<td>1 SEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESSURE UNIT:</td>
<td>BAR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIX. SPEED:</td>
<td>6 SEC</td>
<td>RELAY PULSE: 7 SEC</td>
<td></td>
</tr>
<tr>
<td>PRESS. FAIL MIN:</td>
<td>55 SEC</td>
<td>MAX: 0 SEC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>STATUS</strong></td>
<td>PUMP CONFIG.</td>
<td>DIALOGUE GERMAN</td>
<td></td>
</tr>
</tbody>
</table>

**Setting the Time:**

With the arrow key, go to DATE and change the date requested (day-month-year). This has to be confirmed with the ENTER key

**Setting the Time:**

Also with the arrow key, go to TIME and change the hour/minutes as requested. Confirm with the ENTER key.
8. Compressibility

A general problem for constant flow delivery with piston pumps is the compressibility of the solvents under pressure. Any liquid shows a specific volume elasticity. If the liquid is influenced by pressure changes $dp$, the volume will change by $dV$. The volume $V$ will become the same as before, if the pressure will be reduced to the original value again. The dimension of the change in volume is the compressibility.

This can be shown as:

$$\text{Compressibility} = \frac{\text{relative change of the volume}}{\text{the necessary pressure change}}$$

Therefore:

$$K = \frac{-1}{V} \frac{dV}{dp}$$

The constant volume delivery can be seen as a stepwise displacing of liquid out of the pump head. The dimension for the volume delivery is the amount of piston volume during a period of time. But this is only correct as long as the delivery is done without any added pressure. As soon as the liquid delivery has to be done against a back pressure, a specific amount of the piston volume has to be used for compressing the liquid first, before the delivery can start.

This can be described by the following diagram:

![Diagram showing constant volume delivery with piston pumps.](image)

$V_1 =$ suction volume  
$V_2 =$ delivery volume  
$p_1 =$ suction pressure  
$p_2 =$ suction pressure  

A to B means suction of liquid during pressure $p_1$  
B to C means compressing the liquid from $p_1$ to $p_2$
C to D means delivery against pressure p2
D to A means changing from delivery to suction

The compressibility will affect the constant of the liquid delivery depending on the pressure. To overcome this problem, the S 2100 pump is using a calculation program to correct the pressure depending change of the flow rate. This calculation program corrects the compressibility as well as the always existing leaking rate of the check valves, in relation to the actual pressure. The processor is checking the back pressure every 0.1 seconds and corrects accordingly the piston speed.

The calculation program is using the liquid with the smallest compressibility - water - for the factor 1.

As different organic solvents are showing a different compressibility, the processor needs this information for the most accurate delivery rate.

This information can be added through the compressibility factor in the programming dialog.

As water has been normalized for the factor 1, all the others have to be below 1.

The following table is showing the factors of the mostly used solvents.

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Compressibility factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>1</td>
</tr>
<tr>
<td>methanol</td>
<td>0.63</td>
</tr>
<tr>
<td>ethanol</td>
<td>0.74</td>
</tr>
<tr>
<td>propanol</td>
<td>0.72</td>
</tr>
<tr>
<td>butanol</td>
<td>0.75</td>
</tr>
<tr>
<td>acetonitril</td>
<td>0.68</td>
</tr>
<tr>
<td>chloroform</td>
<td>0.58</td>
</tr>
<tr>
<td>methanol/water 1:1</td>
<td>0.79</td>
</tr>
<tr>
<td>ethanol/water 1:1</td>
<td>0.88</td>
</tr>
<tr>
<td>ethanol/water 3:1</td>
<td>0.79</td>
</tr>
<tr>
<td>buffer solutions</td>
<td>1</td>
</tr>
</tbody>
</table>
For solvent mixtures of different organic solvents, the constant can be calculated by adding the constants of the different solvents in relation to their percentage in the mixture.

For example: 50 % H2O / 20 % methanol / 30 % acetonitril

\[
F = 0.5 \ F (\text{H2O}) + 0.2 \ F (\text{methanol}) + 0.3 \ F (\text{acetonitril})
\]

\[
F = 0.5 \times 1 + 0.2 \times 0.63 + 0.3 \times 0.68
\]

\[
F = 0.5 + 0.126 + 0.204
\]

\[
F = 0.83
\]

For other solvents with an unknown factor, an average factor of 0.7 can be used. The difference from the correct delivery rate won't be higher than 5%. If this accuracy is good enough, a medium factor of 0.7 for all organic solvents and 1 for water can be used.
9. Service and Maintenance

The need of maintenance is limited to the mechanic of the pump. It is recommended to oil all the mechanic moving parts, as bearings and slide plates with sewing machine oil.

9.1. Trouble Shooting

<table>
<thead>
<tr>
<th>Fault</th>
<th>Cause</th>
<th>Elimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>No flow</td>
<td>no solvent</td>
<td>check the level of the reservoir</td>
</tr>
<tr>
<td>No pressure</td>
<td>gas bubbles in the</td>
<td>flush the inlet tubing and the pump head by activating the purge function</td>
</tr>
<tr>
<td></td>
<td>inlet tubing or pump head</td>
<td></td>
</tr>
<tr>
<td></td>
<td>solvent line interrupted</td>
<td>check the solvent inlet tube and the solvent filter, clean or exchange the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tube or the filter</td>
</tr>
<tr>
<td></td>
<td>pump is not running</td>
<td>check the fuses on rear panel check the main connections check the display</td>
</tr>
<tr>
<td></td>
<td></td>
<td>concerning error messages check if a start delay time is programmed</td>
</tr>
<tr>
<td></td>
<td>failure of the check valves</td>
<td>clean the check valve by using an ultrasonic bath, or exchange the check</td>
</tr>
<tr>
<td></td>
<td></td>
<td>valves</td>
</tr>
<tr>
<td></td>
<td>broken piston</td>
<td>exchange the piston</td>
</tr>
<tr>
<td>Problem Description</td>
<td>Possible Solutions</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------</td>
<td></td>
</tr>
</tbody>
</table>
| **Pressure fluctuation** | - gas bubbles in the pump head: flush the pump head with purge function
- leak in the chromatography system: exchange or fasten the leaking parts
- faulty check valve: clean the check valves by using an ultrasonic bath or replace the check valve
- piston seal leaking: exchange the piston seal
- immiscible solvents in the pump: use an intermediate solvent which mixes with both solvents |
| **pump runs but doesn't build-up pressure** | - failure of the check valves: activate purge function or clean the valves by using an ultrasonic bath, or exchange the valves
- leak in the chromatography system: change or correct the leaking part |
9.2. Exchange and Repair of the Pump Head

9.2.1. Exchange of the Pump Head

- disconnect the capillary tube (4.1) between the pump head and the relief valve
- remove the solvent suction tubing (4.2)
- loosen the four hollow screws (4.4), and remove the head

Pump head

The assembling of the head is done in the opposite sequence.

The pump heads are indicated by the characters stated on the pump head:

  a for the analytical head
  m for the micro head
  p for the preparative head
9.2.2. Pump Head Assembly

The following diagram shows all the components of the dismantled pump head:

**Pump Head assembly**
1. Pump head body
2. Piston sealing ring
3. Piston guide with piston back flushing
4. Secondary sealing ring
5. Centering disk
6. Pressure spring
7. Ceramic piston assembly
8. Guide bearing
9. Mounting plate
10. Hollow screw
11. Check valve cartridge
12. Suction valve housing
13. Peek ferrule 1/8"
14. Thrust bolt
15. Outlet valve housing (pressure)
16. Capillary tube for connecting the damping piston
17. Hollow screws M4 x 45
18. Relief valve block
19. Venting screw
20. Sealing ring relief valve
21. Capillary for connecting relief valve and pump head
22. Drain capillary from relief valve block
23. Solvent outlet
24. Pressure sensor
Cross-cut of pump head's piston

1. Pump head body
2. Piston sealing ring (mini flange)
3. Piston guide with piston back flushing
4. Secondary sealing ring
5. Centering disk
6. Pressure spring
7. Ceramic piston assembly
8. Guide bearing

9.2.3. Piston back flushing

When using saliferous eluents, a growth of salt crystals behind the piston ring on the sapphire piston is possible. Under unfavorable working conditions, these salt crystals can lead to a higher wearing of the piston ring.

Generally, it is sufficient to rinse the rinsing chamber (between piston ring and secondary sealing ring) with distilling water once a week. The water remaining in the rinsing chamber stops the crystallization of salt crystals. Therefore; the lower capillary tubes should be connected together with a PTFE tubing so that the water remains in the rinsing chamber.

The rinsing of the chamber should be done with the plastic syringe delivered with the pump.
9.2.4. Change of parts subject to wear

As the piston and piston rings are constantly in use, a natural process of wearing takes place dependent on the flow rate, operation pressure as well as on solvents used. As these variables have a different influence on the wearing no statement concerning durability of the parts subject to wear can be made. When a change of piston sealing rings is necessary, the surface of the pistons have to be checked, too. If the surface shows small grooves in longitudinal direction, it is absolutely necessary to change these pistons too, as this damaged surface will lead to a higher wearing of the sealing rings.

9.2.4.1 Change of piston ring

- Loosen the two hollow screws (10) for removing the mounting plate (9)
- take off the guide bearing, piston assembly, pressure springs and centering discs
- pull out the piston guide
- pull out very carefully the piston rings with the help of a tweezers
- insert completely the new sealing rings into the opening (flange upwards); the small spring has to show in direction of the pump head
- insert upwards the piston guide with the secondary sealing ring (white)
- put the ceramic piston into the guide bearing, insert the spring with the centering disks in the piston and place the whole unit on the piston guide.
- put the mounting plate on top and fasten it with the hollow screws (10)
- push down completely both pistons by hand for several times in order to check if the pistons were jammed during the process of assembling.
9.2.5. Replacing the pump valves

The valves are constructed as cylindrical cartridges. On the top and bottom of these cartridges are Peek sealing rings mounted. These sealing rings have to ensure that the solvent will not bypass the check valve. Both valves, on the high and on the low pressure side of the pump, are identical and therefore can be used for both sides of the pump. Place the cartridge in the valve housing and fasten first by hand and then turn another half of a turn by using a SW13 spanner. If the pump is not delivering the correct flow rate, the valve housing might not be tightened enough. Before tighter fastening, make sure that the pump was carefully flushed.

9.2.5.1. Cleaning the Valve Cartridges

Generally, the check valve cartridges don't wear. However, a deposit of dirt in the valve can influence the function. In this case, only a limited improvement will be achieved when cleaning the fully assembled valve cartridge. The more dependable method is to dismantle the valve for cleaning.

Attention: In order to avoid any loss of valve parts, it is recommendable, to use a small container for the process of dismantling.

- pull out both of the sealing disks (5) (in case, the careful usage of a knife is possible)
- push out very carefully the valve contents
- clean the valve parts depending on their degree of dirtiness either with a washing bottle or with an ultrasonic bath
- insert first the sealing disc which is next to the ring marker
- then insert the sapphire seat with the rough side showing downwards in the valve bearing (it is absolutely necessary that the polished side shows in the direction of the ruby ball)
- place the ruby ball in the deeper side of the check guide made of ceramic and put both into the bearing. The ball has to show in the direction of the the sapphire seat
- press the second sealing disk on top.

After assembling, check the functioning of the valve by blowing air through it. It is possible to blow the air from this side of the ring marker through the valve and it should lock when blowing the other direction.
Valve cartridge assembly

1. Valve bearing with ring marker
2. Sapphire seat
3. Ruby ball
4. Check guide made of ceramic
5. Peek sealing disk

Cross-cut of valve cartridge

1. Valve bearing
2. Sapphire seat
3. Ruby ball
4. Check guide made of ceramic
5. Peek sealing disk
**Appendix 1:**

**AUXILLIARY FUNCTION**

25 Pin Connections of the Interface

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<th>Function 1 N.O.</th>
<th>Function 1 COM</th>
<th>Function 2 N.O.</th>
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<th>Function 4 N.O.</th>
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<th>Function 6 COM</th>
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N.O.: normally open
N.C.: normally closed
COM: common
Appendix 2

REMOTE CONTROL
15 Pin Connections of the Interface

Free 1 ○ ○ 9 Free
Error relay N.C. 2 ○ ○ 10 Run Relay N.C.
GND 3 ○ ○ 11 GND
GND 4 ○ ○ 12 GND
Start 5 ○ ○ 13 Hold skip
Run Relay COM 6 ○ ○ 14 Run Relay COM
Error relay COM 7 ○ ○ 15 Error relay COM
GND 8 ○ ○

N.O.: normally open
N.C.: normally closed
COM: common
## 9. Spare parts

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### B. Pump head analytical (steel)

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<td>5</td>
<td>20 20 039</td>
</tr>
<tr>
<td>Pump head body</td>
<td>5.1</td>
<td>26 01 068</td>
</tr>
<tr>
<td>Piston sealing ring</td>
<td>5.2</td>
<td>24 10 015</td>
</tr>
<tr>
<td>Piston guide</td>
<td>5.3</td>
<td>26 01 032</td>
</tr>
<tr>
<td>Secondary sealing ring</td>
<td>5.4</td>
<td>24 10 016</td>
</tr>
<tr>
<td>Centering disk</td>
<td>5.5</td>
<td>26 01 033</td>
</tr>
<tr>
<td>Pressure spring</td>
<td>5.6</td>
<td>25 50 005</td>
</tr>
<tr>
<td>Sapphire piston assembly</td>
<td>5.7</td>
<td>20 20 018</td>
</tr>
<tr>
<td>Guide bearing</td>
<td>5.8</td>
<td>20 20 033</td>
</tr>
<tr>
<td>Mounting plate</td>
<td>5.9</td>
<td>25 01 047</td>
</tr>
<tr>
<td>Hollow screw M 3 x 8</td>
<td>5.10</td>
<td>25 20 005</td>
</tr>
<tr>
<td>Check valve cartridge</td>
<td>5.11</td>
<td>20 30 001</td>
</tr>
<tr>
<td>Suction valve housing</td>
<td>5.12</td>
<td>26 01 038</td>
</tr>
<tr>
<td>Peek ferrule</td>
<td>5.13</td>
<td>26 01 035</td>
</tr>
<tr>
<td>Thrust bolt, PVDF</td>
<td>5.14</td>
<td>26 01 069</td>
</tr>
<tr>
<td>Outlet valve housing</td>
<td>5.15</td>
<td>26 01 039</td>
</tr>
<tr>
<td>Capillary tube for connecting the damping piston</td>
<td>5.16</td>
<td>21 90 059</td>
</tr>
<tr>
<td>Capillary for connecting relief valve with pump head</td>
<td>5.21</td>
<td>21 90 054</td>
</tr>
</tbody>
</table>
D. **Pump head preparative (steel)**
only parts which differ from table B:
- Pump head complete: Fig. 4, 20 20 042
- Pump head body: Fig. 5.1, 26 01 069
- Piston sealing ring: Fig. 5.2, 24 10 018
- Piston guide: Fig. 5.3, 26 01 043
- Secondary sealing ring: Fig. 5.4, 24 10 019
- Centering disk: Fig. 5.5, 26 01 044
- Sapphire piston assembly: Fig. 5.7, 20 20 020

E. **Pump head preparative (Peek)**
only parts which differ from table C:
- Pump head complete: Fig. 4, 20 20 043
- Pump head body: Fig. 5.1, 26 01 070
- Piston sealing ring: Fig. 5.2, 24 10 018
- Piston guide: Fig. 5.3, 26 01 043
- Secondary sealing ring: Fig. 5.4, 24 10 019
- Centering disk: Fig. 5.5, 26 01 044
- Sapphire piston assembly: Fig. 5.7, 20 20 020

F. **Pump head micro (steel)**
only parts which differ from table B:
- Pump head complete: Fig. 4, 20 20 040
- Pump head body: Fig. 5.1, 25 01 070
- Piston sealing ring: Fig. 5.2, 24 10 020
- Piston guide: Fig. 5.3, 26 01 047
- Secondary sealing ring: Fig. 5.4, 24 10 021
- Centering disk: Fig. 5.5, 26 01 048
- Sapphire piston assembly: Fig. 5.7, 20 20 019

G. **Pump head micro (Peek)**
only parts which differ from table C:
- Pump head complete: Fig. 4, 20 20 041
- Pump head body: Fig. 5.1, 26 01 071
- Piston sealing ring: Fig. 5.2, 24 10 020
- Piston guide: Fig. 5.3, 26 01 047
- Secondary sealing ring: Fig. 5.4, 24 10 021
- Centering disk: Fig. 5.5, 26 01 048
- Sapphire piston assembly: Fig. 5.7, 20 20 019

H. **Valve cartridge**
- Valve bearing: Fig. 7.1/6.1, 25 01 056
- Sapphire seat: Fig. 7.2/6.2, 40 20 003
- Ruby ball: Fig. 7.3/6.3, 40 21 002
- Check guide made of ceramic: Fig. 7.4/6.4, 40 22 001
- Peek sealing disk: Fig. 7.5/6.5, 26 01 024