Anton Paar

Measure,
what is measurable,
and make measurable
that which is not.

Galileo Galilei (1564–1642)

Instruction Manual

DMA 4000

Density / Specific Gravity / Concentration Meter

Software Version: 1.203

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Contents

1 Introduction

Thank you for buying the DMA 4000 density/specific gravity/concentration meter for liquids.

The DMA 4000 is based on a highly accurate and patented U-tube oscillator, with highest accuracy in wide viscosity and temperature ranges.

In addition to the U-tube oscillator, a unique reference oscillator provides extraordinary long-term stability and makes adjustments at temperatures other than 20 °C virtually unnecessary.

Two integrated Pt 100 platinum thermometers provide highly accurate temperature control and are traceable to national standards.

To perform a measurement, select one of 3 individual measuring methods and fill the sample into the measuring cell. The results are automatically converted into concentration, specific gravity or other density-related units using the built-in conversion tables and functions.

The density results, including sample name, are available on the programmable fluorescent display, as a printout or stored in the data memory.

For fully automatic measurements, the DMA 4000 can be connected to the sample changer SP-1m or SP-3m.

2 Safety Instructions

- This manual does not claim to address all of the safety issues associated with the use of the DMA 4000 and/or samples. It is the responsibility of the user to establish health and safety practices and determine the applicability of regulatory limitations prior to use.
- Before using the DMA 4000 read this manual completely.
- **Anton Paar** GmbH only warrants the proper functioning of the DMA 4000 if no unauthorized adjustments have been made to mechanical parts, electronic parts and software, and the following points are adhered to.
- Follow all hints, warnings and instructions in the manual to ensure the correct and safe functioning of the DMA 4000.
- Do not use the DMA 4000 for any purpose other than described in the manual. **Anton Paar** GmbH is not liable for damages caused by incorrect handling of the DMA 4000.
- Do not use any accessories other than those supplied or approved by **Anton Paar** GmbH.
- The installation procedure should only be carried out by authorized personnel who are familiar with the installation instructions.
- Do not operate the DMA 4000 if a malfunction is suspected. The DMA 4000 must not be operated under conditions where damages, injuries or loss of life cannot be excluded.
- The DMA 4000 is **not** an explosion-proof instrument and therefore must not be operated in areas where there is a risk of explosion.
- Service and/or maintenance procedures which involve removing outside covers and working with the power on may only be performed by authorized service personnel.
- Ensure that all operators are fully trained in the correct use of this instrument and its safe operation.
- Due to the nature of the measurement, the measuring results not only depend on the correct use and functioning of the DMA 4000, but may also be influenced by other factors. We therefore advise that the analysis results are plausibility tested before consequential actions are taken.
- Repair and service procedures may only be carried out by authorized personnel or by **Anton Paar** GmbH.
- Follow the precautions below for the handling and of inflammable samples and cleaning materials:
  - Do not store inflammable material near the DMA 4000.

- Do not leave sample containers uncovered.
- Clean all spillages immediately.
- Ensure that the DMA 4000 is located in a sufficiently ventilated area, free from inflammable gases and vapors.
- Connect the DMA 4000 to mains power via a safety switch located a safe distance from the instrument. In an emergency, turn off the power using this switch. Do not use the DMA 4000 power switch.
- Keep a fire extinguisher at hand.
- Do not leave the DMA 4000 unattended while in use.

Do not touch areas marked with this sign while the power is turned on.

3 Symbols in the Manual

The following symbols are used in the manual:

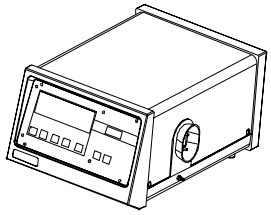
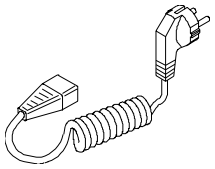
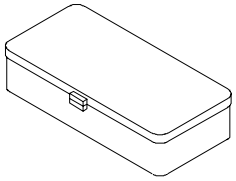
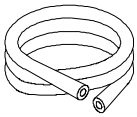
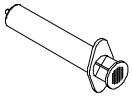
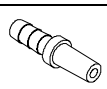
Important:
The "Important" sign indicates a **hazard to the equipment**.
It calls attention to an operating procedure, practice, etc. which, if not correctly performed or adhered to, could result in **damage or destruction** of the instrument or parts of it.
Do not proceed beyond an "Important" sign until the indicated conditions are fully understood and met.

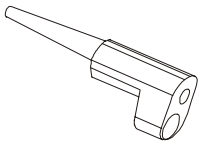
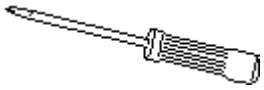
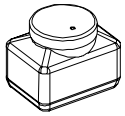
Hint:
The "Hint" sign calls attention to any **additional information** which might be of use to the operator.

4 Supplied Items

Hints:

- The DMA 4000 has been tested and packed carefully before shipment. However, damage may occur during transport.
- If the DMA 4000 or a supplied item has been damaged during transport, contact the transport firm as well as your local Anton Paar representative. Keep the packing material for examination by the transport firm or an insurance representative.
- If a part is missing, please contact your Anton Paar representative.

Delivered	Delivered pcs.	Item *Spare part cat.no.*
	1	DMA 4000 *Cat.no.: 2698*
	1	Instruction manual *English: Cat.no.: 9263 / 1pc.* *German: Cat.no.: 9262 / 1pc.* *French: Cat.no.: 13665 / 1pc.*
	1	Main power cable *Euro: Cat.no.: 65146 or* *GB: Cat.no.: 61865 or* *US: Cat.no.: 52656*
	1	Accessory kit *Cat.no.: 70248*
	1	Silicone hose, 3 x 5 mm *Cat.no.: 50814 / 2m*
	7	Syringe 2 ml Luer *Cat.no.: 51974 / 1pc.*
	3	Adapter Luer cone *Cat.no.: 63863 / 1pc.*

Delivered	Delivered pcs.	Item *Spare part cat.no.*
	2	Male Luer plug *Cat.no.: 63865 / 1pc.*
	2	Injection adapter Luer *Cat.no.: 12225 / 1pc.*
	1	Screwdriver PH-0x40 *Cat.no.: 75030 / 1pc.*
	1	Waste vessel *Cat.no.: 6210 / 1pc.*
	1	Density standard "Ultra pure water", 5 x 10 ml *Cat.no.: 78169*

5 Putting into Operation

Hint:

- The DMA 4000 does not require any special installation conditions. The installation conditions should correspond to conditions in a typical laboratory.
- However, to guarantee temperature stability, do not place the DMA 4000
  - near a heater
  - near an air conditioner
  - in direct sunlight.

Important:

A powerful built-in cooling fan dissipates heat through the bottom and rear of the DMA 4000. Care must therefore be taken that the airflow is not blocked.

Preparing the DMA 4000 for the first start-up

1. Take two injection adapters Luer from the accessory box.

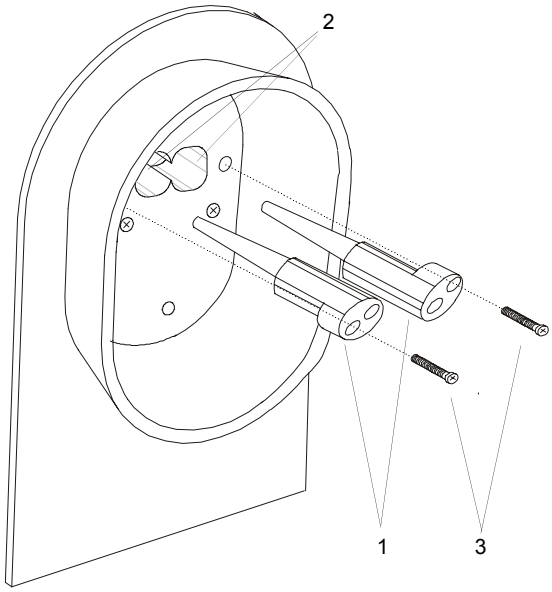


Fig. 5 - 1 Mounting the injection adapters Luer

2. Carefully insert the injection adapters Luer (1) into the openings (2) of the filling device until the tips of the adapters reach the openings of the measuring cell.

3. With moderate force, push the adapters towards the measuring cell.

4. Insert the screws (3) into the bore holes of the adapters and tighten the screws until some resistance against further turning can be felt.

Important:
Do not screw in the screws (3) too tightly. The gap between the holding plate and the adapter (1) where the thread of the screw (3) becomes visible has to be 3 to 4 mm (approx. 1/8"). If the screws are screwed in too tightly, the measuring cell may be damaged.

5. Check the connection of the injection adapters to the measuring cell for leak tightness:

   - Close one adapter tightly with a finger.
   - Fill air under moderate pressure through the other adapter using a 2 ml plastic syringe from the accessory box.
   - Release the plunger of the syringe.
   - If the connections are leak tight, the plunger of the syringe will be slowly pushed back by the pressure in the measuring cell.
   - If the connections are leaking, no pressure was built up in the measuring cell and the plunger will not move. Repeat steps 2 to 5.

6. Cut a piece approx. 250 mm long from the silicone hose contained in the accessory box.

7. Attach the silicone hose to the air pump outlet (see Fig. 5 - 2).

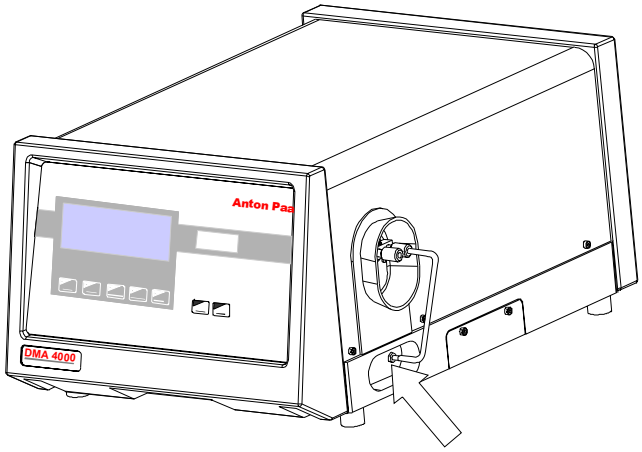


Fig. 5 - 2 Attaching the silicone hose to the airpump outlet

8. Attach an adapter Luer cone (accessory box) to the other end of the silicone hose (see Fig. 5 - 3).

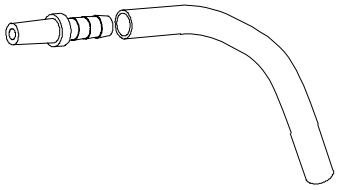


Fig. 5 - 3 Attaching the adapter Luer cone to the hose

9. If a printer is used, plug the interface cable into the COM 1 connector at the rear of the DMA 4000.

10. Check the operating voltage.

Important:
- Before switching the DMA 4000 on, make sure that the correct line voltage is available (AC 85 to 260 V, 48 to 62 Hz). If large voltage fluctuations are to be expected, the use of a constant voltage source (UPS) is recommended.
- The nonfused earth conductor of the power cord (or power inlet) has to be connected to earth.

11. Connect the power inlet of the DMA 4000 to the mains using the power cord.

12. Turn on the DMA 4000 using the "POWER" switch at the rear of the DMA 4000. After the start-up procedure, the cell light of the DMA 4000 is lit continuously.

Hints:
- **After turning the power on, the DMA 4000 needs approx. 20 minutes for attemperating and a further 5 to 10 minutes for internal temperature adjustments.** During this time "AT" is displayed.
- If the desired measuring temperature is already set, do not touch any key during this time as this will considerably increase the waiting period.
- In case of high air humidity or low measuring temperatures, see Appendix A.

13. As soon as the attemperating to 20 °C is finished, perform a density check measurement as described below.

Important:
The DMA 4000 is factory adjusted and the following control measurement should be performed to check if the adjustment is still valid after transport.

14. Press the "MENU" key and select "density check" in the main menu with the "↑" and "↓" keys. Select "start check". The message "fill standard: E" is displayed. (The factory default is 0.9982 for water at 20 °C. It is possible to enter any value for the density check in the menu "instrument setting", "density check", "reference value". See also chapter 8.5)

15. Place the supplied waste vessel below the rear adapter and connect the adapter to the waste vessel with an appropriate hose (from the accessory box).

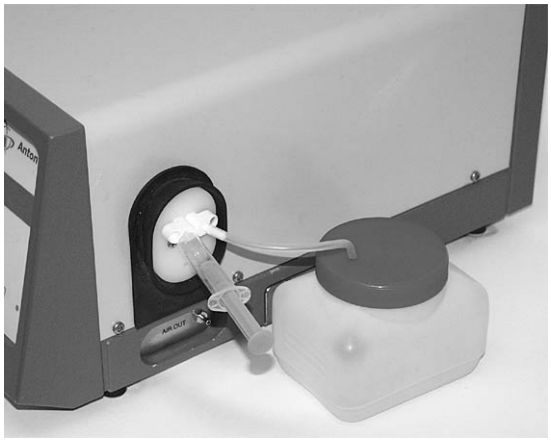


Fig. 5 - 4 Positioning the waste vessel

16. Open one bottle of the supplied liquid density standards (ultra pure water) and immediately introduce the liquid density standard into the measuring cell of the DMA 4000. Use the supplied syringes and ensure that there are no air bubbles in the substance. Press "E".

17. During the density check, the actual cell temperature and "checking..." is displayed.

18. When the measurement is finished, the deviation between the measured value and the reference value is displayed. Depending on the deviation between the measured and the reference value, "OK" or "NOK" is displayed. Press the "E" key to save the density check in the memory of the DMA 4000.

    - If the density check is "OK", the instrument is ready for routine measurements.
    - If the density check is "NOK", clean the measuring cell properly (see chapter 10) and repeat the density check from step 15.

Hint:
The density of (ultra pure) water is 0.99820 g/cm^3 at 20 °C.

- If the result is still "NOK", an air/water adjustment at 20 °C must be performed (see chapter 8.3.1).

Hint:
The "density check" function can also be used when performing routine measurements in order to check the validity of the adjustment. Other density calibration liquids or standardized samples can also be used.

6 Functional Components

6.1 Display

After turning on the DMA 4000, a self-test procedure and initialization of the instrument is carried out (approx. 25 seconds) and then the following display is shown:

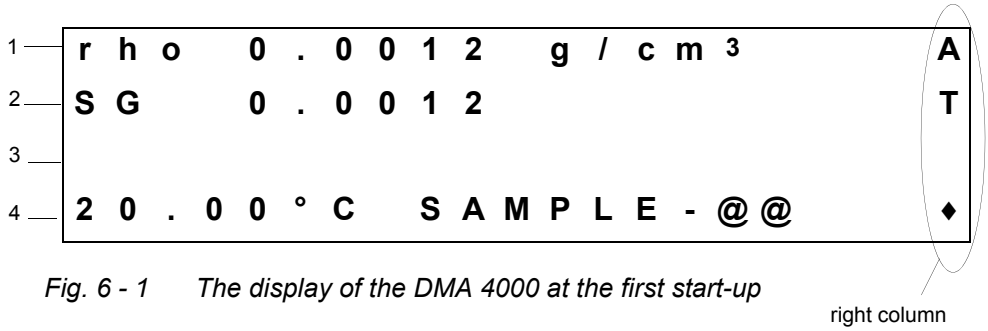


Fig. 6 - 1 The display of the DMA 4000 at the first start-up

1 1st line: Density of the sample.

2 2nd line (example): Specific gravity.

3 3rd line (example): Empty row.

4 4th line: Measuring cell temperature and sample name (@... spacer for the sample number).

Right column: Status of the measurement and activity (see chapter 6.1.1).

Hint:
- The display in the second and third line can be changed in the menu "method settings", "display assignment", "line2/line3".
- The first line always shows the density.
- The fourth line always shows the actual cell temperature and the sample name.
- Certain menus are only available in the unlocked mode (see chapter 11.1.1).

6.1.1 Status of the Measurement

A short explanation of the abbreviations in the right column is also shown by pressing the "HELP" key twice (see chapter 11.4).

OK	(equilibrium)	The measurement is stable and has reached equilibrium. The measurement will not be frozen or printed automatically.
AT	(attemperating)	Attemperating of the sample is in progress.
PD	(predetermination)	Determination of the measuring result before "OK" is reached (faster).
DP	(damping measurement)	First harmonic oscillation of the U-tube.
MF	(measurement frozen)	The measurement is frozen. This status is displayed, when the measurement is valid after pressing the "START" key.
AP	(air pump on)	The air pump is switched on.
TO	(time out)	Is displayed after 10 minutes if no valid measurement is possible (e.g. due to bubbles in the measuring cell).

If a sample changer SP-1m or SP-3m is connected and activated, the following status messages may be displayed:

SF	(sampler filling)	Either the sample is filled into the DMA 4000 or the magazine moves to the zero position or to the next vial.
SC	(sampler clean)	Only for the SP-3m: The SP-3m performs a rinsing and drying cycle.
SW	(sampler waiting)	Press the "START" key on the sample changer to start e.g. a density check.
SE	(sampler error)	A problem concerning the sample changer has occurred (see Appendix A of the SP-1m/SP-3m instruction manual).

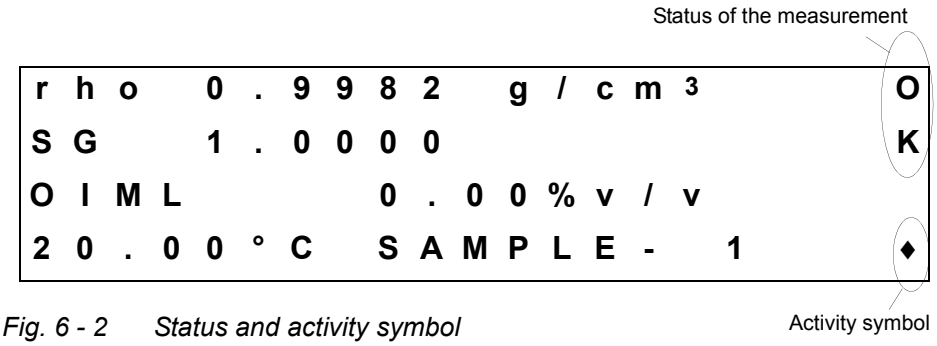
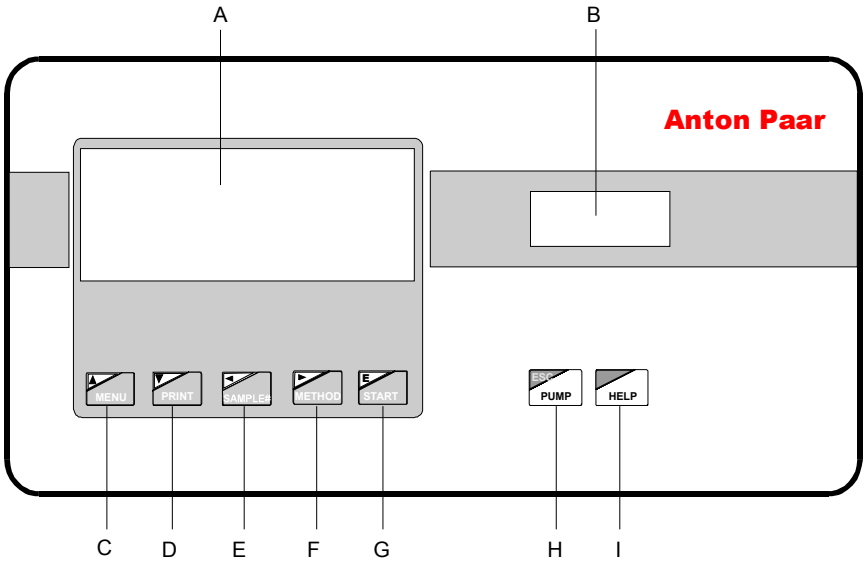


Fig. 6 - 2 Status and activity symbol

6.1.2 Activity Symbols

+	(measurement)	The measurement is started by pressing the "START" key.
●	(measurement valid after "START")	The symbol flashes when a measurement is valid after pressing the "START" key.
♦	(instrument active)	The symbol flashes as long as the instrument is active.
!	(general hint)	Press the "HELP" key to obtain more information when the exclamation mark is displayed.

6.2 Keypad



A Vacuum fluorescent display 4 lines, 20 signs

B Inspection window for the measuring cell

C "UP" / **MENU** key: Selects menus for settings and configurations. Access to the full menu can be restricted by password. (see chapter 11.1.1)

D "DOWN" / **PRINT** key: Starts a printout of the actual measuring result.

E "LEFT" / **SAMPLE#** key: Keys in a sample text and/or number.

F "RIGHT" / **METHOD** key: Selects a measuring method. (see chapter 7.4)

G "ENTER" / **START** key: Starts a measuring procedure with a defined beginning and end. The automatic measuring procedure includes waiting for the measurement to be stable, printing the results, storing them in the memory and increasing the sample number.
If a sample changer SP-1m/SP-3m is connected and activated, the "START" key of the DMA 4000 is deactivated. Use instead the "START" key on the sample changer.

H "ESC" / **PUMP** key: In the measuring mode: For switching the air pump on and off.
In the menu mode: For moving one menu level higher.

I **HELP** key: Can be pressed up to 4 times to browse through the 4 help screens.(see chapter 11.4)

Hint:
Except for the "HELP" key, all the keys on the keypad of the DMA 4000 have two different functions.

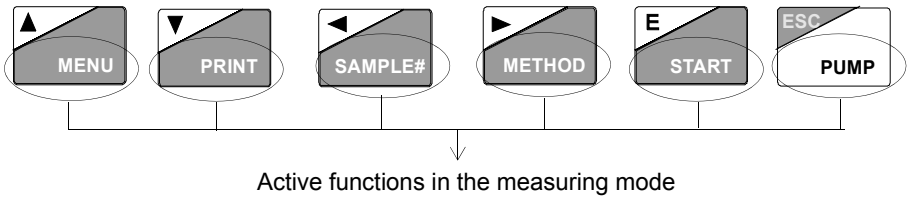


Fig. 6 - 3 Measuring mode: Key functions

These functions are active in the measuring mode when the measuring window is displayed.
Example of a measuring window:

```
rho 1.0982 g/cm³          M
conc      23.84 °Brix     F
Takt   19.99 °C           •
20.00 °C  SAMPLE-  1      ♦
```

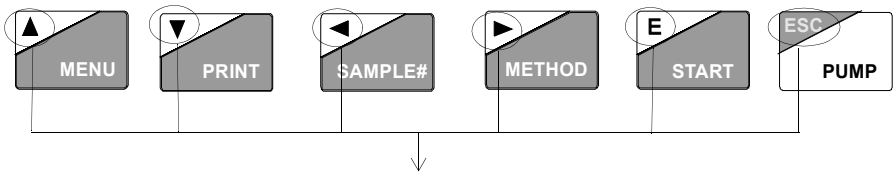


Fig. 6 - 4 Menu mode: Key functions

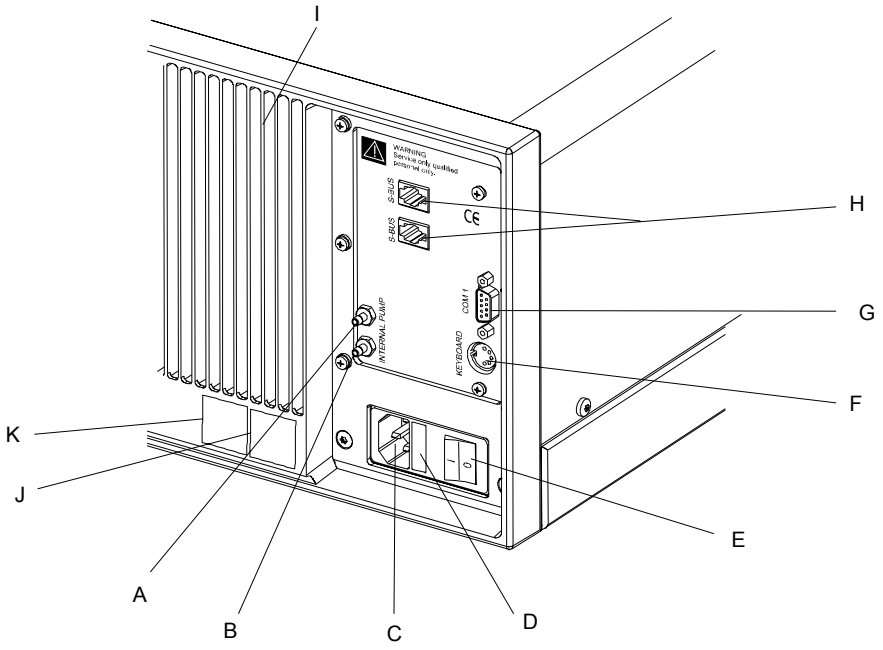
These functions are active in the menu mode. Pressing the "MENU" key once in the measuring mode sets the DMA 4000 to the menu mode.

```
                          P
                          D

measuring  window         ♦
```

Fig. 6 - 5 Display after pressing the "MENU" key once. The menu mode is active.

6.3 Rear View



A "DRY AIR PUMP" nozzle for connecting the desiccator (see Appendix A)
B "DRY AIR INTERNAL" nozzle for supplying the interior of the DMA 4000 with dry air in order to prevent humidity condensation on the cell block at low measuring temperatures (see Appendix A)
C Power inlet
D Fuse holder
E Power switch
F Keyboard/bar code reader interface
G Interface (COM 1) for a PC or printer
H S-BUS interfaces for connecting a sample changer SP-1m or SP-3m
I Cooling fins
J Technical data shield
K Type plate

7 General Settings

Hints:

- To access all menus, the DMA 4000 must be set to the "unlocked" mode. The actual status of the DMA 4000 is displayed after pressing the "HELP" key twice (see chapter 11.4).
- To change to the "unlocked" mode, change to the menu "unlock", type in the password for the unlocked mode and confirm with "E". The default password is "4000".
- For more information on navigating through the menu of the DMA 4000, see chapter 11.1.2).

7.1 Setting Date and Time

- The DMA 4000 must be set to the "unlocked" mode.
- Date and time are set in the "instrument setting", "set date and time" menu.
- Type in the date and time.
- Confirm with "E".

7.2 Defining a Method

- A method consists of a temperature unit, measuring temperature, display assignment, printer and memory configuration, all stored under a unique method name.
- The 3 methods of the DMA 4000 are factory preset and cover the most common measuring tasks. Every method can be individually changed, adapted or renamed.
- To activate a method, press the "METHOD" key and select a method from the list with the "↑" and "↓" keys. Confirm with "E".
- To rename the method, change to the menu "method settings", "edit method name" and type in up to 15 signs for the method name (when a keyboard is connected) or use the "↑", "↓", "←" and "→" keys.
- To change or adapt the method, follow chapters 7.3 to 7.4 in the given order.

7.3 Setting the Temperature

- The DMA 4000 must be set to the "unlocked" mode.
- The temperature units, degrees Celsius or Fahrenheit, are set in the menu "method settings", "set temp. unit".

- The temperature is set in the menu "method settings", "set temperature" (see chapter 11.2.5). Change the digit with the "←" and "→" keys. Change the value with the "↑" and "↓" keys. Confirm with "E". For specified measuring temperatures, see Appendix B.

7.4 Selecting the Output Data for the Display, Printer and Memory

Hint:
- For the following steps, the DMA 4000 must be set to the "unlocked" mode.
- Change to the menu "unlock" and type in the password. Confirm with "E".
- The default password is "4000" (see chapter 11.1.1).

7.4.1 Output Data for the Display

It is only possible to change the output for the second and the third line. The first line always shows the true density. The fourth line always shows the current temperature of the measuring cell and the sample name.

Hint:
- For the following steps, also refer to the menu tree in the appendix.
- For more information on navigating through the menu of the DMA 4000, refer to chapter 11.1.2.

1. Press the "METHOD" key and select the method which should be changed or adapted from the list with the "↑" and "↓" keys. Confirm with "E".

```
                                M
measuring window                F
method                          •
M3-BRIX                         ♦
```

2. Press the "MENU" key and change to the menu "method settings", "display assignment" and select "line2" with the "↑" and "↓" keys.

```
                                P
method settings                 D
display assignment
line2                           ♦
```

3. Press the "E" key and the **current** setting of "line2" is displayed, e.g. "conc. (°Brix)" out of the main group "extr./sugar tables".

```
display assignment      P
line2                   D
extr./sugar tables
conc. (°Brix)           ♦
```

4. Press the "ESC" key to move one menu level higher and select the desired main group with the "↑" and "↓" keys.
   Available main groups are: ethanol tables; extr./sugar tables; acid/base tables; system + temp.; density meas.; user functions.

```
method settings         P
display assignment      D
line2
ethanol tables          ♦
```

5. Press the "E" key and select the desired table or item of the main group with the "↑" and "↓" keys, e.g. "OIML (%w/w)" from the main group "ethanol tables":

```
display assignment      P
line2                   D
ethanol tables
OIML (%w/w)             ♦
```

6. Press the "E" key to store the setting for line2.

7. Press the "ESC" key twice and confirm the question "SAVE all changes?" with the "E" key.

```
SAVE all changes?       P
CAUTION: datamemory     D
will be erased!
↑ No              Yes E ♦
```

Hint:
After changing the method name, temperature unit, temperature or the display assignment of a method, the stored measurements of the activated method will be erased!

8. Press the "ESC" key to change back to the menu "measuring window". After pressing the "E" key, the question **"↑No LOCK? Yes E"** is displayed. Press the "↑" key to keep the DMA 4000 in the "unlocked" mode.

Hint:
To change the setting for the third line, repeat the steps 2 to 8 and select "line3" with the "↑" and "↓" keys at step 3.

A separate display assignment can be defined for each of the 3 methods.

7.4.2 Output Data for the Printer and Memory

The selected settings for line2 and line3 in the menu "method settings", "display assignment" also include the "data memory" and printout of the DMA 4000. This means that no separate settings for the data memory and printout can be carried out.

Depending on the settings for line2 and line3 in the menu "method settings", "display assignment", the measuring results are stored in the data memory and printed after pressing the "START" key.

Up to 48 measurements can be stored in the DMA 4000. The 49th measurement overwrites the oldest measurement, independent of the activated method.

Hint:
After changing the method name, temperature unit, temperature or the display assignment of a method, the stored measurements of the activated method will be erased!

Example for a display and a corresponding printout:

rho 0.9972 g/cm^3	M
OIML 0.52 %w/w	F
IUPAC 0.65 %v/v	•
20.00 °C SAMPLE- 1	♦

2002 02 15 10:55
rho 0.9972 g/cm3
OIML 0.52 %w/w
IUPAC0.65 %v/v
Tset 20.00 C
SAMPLE 1
- - - - - - - - - - - - - - - - - -

7.5 Data Memory

7.5.1 Display of a Stored Measurement

To display a stored measurement, change to the menu "data memory", "browser". A stored measurement can be selected with the "↑" key. Pressing the "←" and "→" keys displays the different data of a measurement step by step in the 4th line of the display:

```
                                        P
data  memory                            D
browser
2002  02  15  10:55          fp ♦
```

The data are displayed in the 4th line in a given order (browse by pressing the "→" key):

Date and time	(e.g. 2002 02 15 10:55 fp)
Sample name	(e.g. SAMPLE 1)
Density	(e.g. rho 0.9972 g/cm^3)
Data of line2	(e.g. OIML 0.52 %w/w)
Data of line3	(e.g. IUPAC 0.65 %v/v)
Tset	(e.g. 20 °C)

If no measurement is stored in the data memory, the message "no new data" is displayed.

7.5.2 Printout of a Stored Measurement

1. Select the desired measurement in the menu "data memory", "browser" with the "↑" key.
2. Use the "←" and "→" key to move to the line where the date and time and **"fP"** are displayed.

```
                                        P
data  memory                            D
browser
2002  02  18  13:36          fP ♦
```

3. Set "fP" to "fp" with the "↓" key and confirm with the "E" key.

4. Press the "↓" key to change to the menu "data memory", "print" and confirm with the "E" key.

Hint:
Repeat step 1 to 4 for each stored measurement which should be printed out.

5. Now all stored measurements of the activated method with the status "fp" will be printed.

   Printout of a stored measurement:

   2002 02 18 14:03
   method: M3-BRIX
   sample: SAMPLE 2
   measurement finished: yes
   fetched by host: no
   rho 0.9942 g/cm3
   SGapp 0.9960
   SG 0.9960
   Tset 20.00 C

   Up to 48 measurements can be stored in the DMA 4000.

7.6 Settings for the Sample Changer

The menu "SP-1m" or "SP-3m" will only be displayed if a sample changer SP-1m or SP-3m is connected and switched on.

Select the menu "SP-1m", "parameter" or "SP-1m", "parameter" to enter the control parameters according to the instruction manual for the sample changer SP-1m/SP-3m.

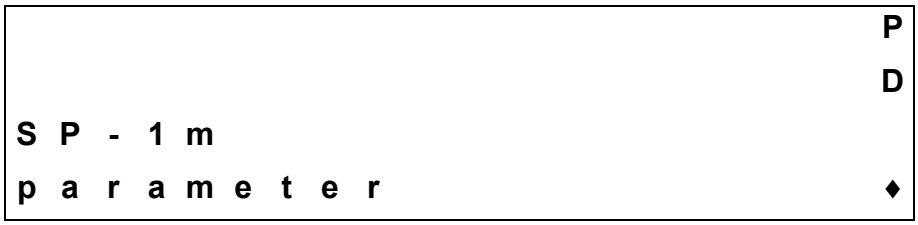


Fig. 7 - 6 Menu "parameter" to enter the control parameter for the sample changer

8 Checking Procedure, Adjustment and Calibration

8.1 Definitions

Adjustment of the density meter

- The process of bringing the instrument into a state suitable for use by setting or adjusting the density instrument constants.
- The adjustment of the DMA 4000 is performed with air and bi-distilled water.

Calibration of a density meter

- A set of operations that establishes the relationship between the reference density value of standards and the corresponding density reading of the instrument.
- Calibrations are performed to determine the deviation of the displayed density values from the reference values of density standards.

8.2 Checking Procedure before Measurement

- Before each series of measurements, check the validity of the adjustment using degassed, bi-distilled water. An inaccurate adjustment can be recognized by a deviation of the density reading of water from the true density at the measuring temperature (see density tables, Appendix D).
- The following procedure should be performed at least once every day.

Checking the adjustment with degassed, bi-distilled water

1. Boil **freshly** bi-distilled water for several minutes to remove dissolved air.
2. Fill a clean glass flask full with the boiled water and cover it.
3. Wait until the water has cooled down to approx. measuring temperature.
4. Slowly fill the dry and clean measuring cell with the degassed, bi-distilled water, checking for bubbles through the inspection window.
5. Press the "START" key and wait until the status of the DMA 4000 is "MF" and the density is displayed in the first line.
6. Compare the displayed value with the corresponding value in the density table in appendix E.
7. • If the compared values agree within ± 0.0001 g/cm^3, measurements can be performed after drying the measuring cell.

- If the displayed density value deviates more than ± 0.0001 g/cm^3 from the corresponding table value, clean and dry the measuring cell and fill it again with degassed, bi-distilled water.
- If the displayed density value still deviates more than ± 0.0001 g/cm^3 from the corresponding table value, carry out a new adjustment (see chapter 8.3).

8.3 Adjustment

- An adjustment has to be performed if deviations between the displayed values and the reference values of density standards consistently exceed the specifications of the DMA 4000 or the specifications of the standard.
- Air and bi-distilled, freshly degassed water are used for an adjustment.
- The density values of water and dry air at specific atmospheric pressures are stored in the memory of the DMA 4000 for the complete temperature range.
- The factory setting allows density measurements in the entire temperature range, even though the adjustment is only performed at 20 °C.
- If measurements at different temperatures indicate deviations between the displayed values of the DMA 4000 and the reference values of density standards, an air and water adjustment for the whole temperature range is necessary (see chapter 8.3.2).
- It is not recommended and does not improve the performance of the DMA 4000 to adjust if calibrations with proper density standards indicate no deviations from the reference values.

8.3.1 Adjustment with Air and Water at 20 °C

Hint:
- For the following steps, the DMA 4000 must be set to the "unlocked" mode.
- Change to the menu "unlock" and type in the password. Confirm with "E".
- The default password is "4000" (see chapter 11.1.1).

- Normal adjustment is performed using dry air (see Appendix A) and bi-distilled, freshly degassed water at 20 °C.
- The complete adjustment procedure takes 5 to 10 minutes if the DMA 4000 is at 20 °C before the adjustment procedure is started.

Adjustment procedure at 20 °C

1. Before the adjustment, thoroughly clean and dry the measuring cell (see chapter 10).

2. Press the "MENU" key and select the menu "adjustments", "dens. (air, water)" using the "↑", "↓" and "E" keys.

Hint:
If the DMA 4000 is set to any other temperature, it will automatically be switched to 20 °C when the adjustment procedure is started.

3. Enter the current air pressure or confirm the already entered value (default: 1013.25 hPa) with the "E" key.

Hints:
- For air adjustment, the current air pressure must be entered as this influences the air density.
- The density values of water and air at a specific atmospheric pressure for the complete temperature range are stored in the memory of the DMA 4000.
- If the current on-site barometric pressure is not available, enter the average air pressure (depending on the altitude) according to table 8.1.

Table 8.1: Altitude and air pressure

Altitude above sea level		**Air pressure**
[m]	**[ft]**	**[mbar]**
0	0	1013
400	1312	966
800	2625	921
1200	3937	877
1600	5249	835
2000	6562	795
2400	7874	756
2800	9186	719
3200	10499	683
3600	11811	649

4. Start the adjustment by pressing the "E" key.

5. Wait until the air adjustment is finished. During the air adjustment the actual cell temperature and "air" are displayed.

Hints:
- The adjustment can be aborted by pressing the "←" key.
- If the error message "time-out error" is displayed, abort the adjustment with the "←" key, clean and dry the measuring cell carefully and repeat the adjustment (Refer also to Appendix F).

6. Fill the measuring cell with bi-distilled, freshly degassed water, checking for bubbles through the inspection window (See also chapter 8.2).

7. Start the water adjustment by pressing the "E" key.

8. Wait until the water adjustment is finished. During the water adjustment the actual cell temperature and "water" are displayed.

9. After the water adjustment, the message "dev. KBg: xx.xxExx" is displayed. This is the deviation of the density coefficient "KBg" compared to the density coefficient "KBg" of the previous adjustment. After confirming with the "E" key, the question "↑ No save? Yes E" is displayed. The adjustment is saved by pressing the "E" key and the adjustment data are stored in the memory.

Hint:
By selecting "↑", the message "aborted" is displayed and the adjustment data are **not** stored.
The adjustment has to be repeated, preferably after a thorough cleaning procedure (see chapter 10).

Hint:
If the deviation to the previous KBg value exceeds $1x10^{-3}$ g/cm^3, the error message "adjustment error" is displayed. Press the "E" key to display the deviation of the "KBg" value. After pressing the "E" key again, the question "↑ No save? Yes E" is displayed. The adjustment can be saved or aborted.

10. The adjustment data can be printed if a printer is connected and activated. To start the printout, change to the menu "adjustments", "print data", "dens. (air, water)" and confirm with the "E" key.

11. Make a note of the "Qair" and "QH2O" value in the adjustment report (Appendix E).
    The "Qair" and "QH2O" values can be printed out in the menu "adjustments", "print data", "dens. (air, water)".
    If no printer is connected, the Q values can be displayed in the menu "adjustments", "view data", "dens. (air, water)".

8.3.2 Adjustment with Air and Water for the Entire Temperature Range (Full Range Adjustment)

Hint:
- For the following steps, the DMA 4000 must be set to the "unlocked" mode.
- Change to the menu "unlock" and type in the password. Confirm with "E".
- The default password is "4000" (see chapter 11.1.1).

- If measurements at different temperatures indicate deviations between the displayed values on the DMA 4000 and reference values of density standards, then an air and water adjustment for the whole temperature range is necessary. Dry air (Appendix A) and bi-distilled, freshly degassed water are used.

- The adjustment procedure is performed as follows:

  - Air adjustment at 30 °C (T1)
  - Air adjustment at 45 °C (T2)
  - Water adjustment at 45 °C (T2)
  - Water adjustment at 30 °C (T1).

- The air and water adjustment for the entire temperature range takes approx. 1 hour.

Full range adjustment procedure:

1. Perform an air and water adjustment at 20 °C (see chapter 8.3.1).

2. Thoroughly clean and dry the measuring cell (see chapter 10).

3. Press the "Menu" key and select the menu "adjustments" and "dens. (temp. range)" using the "↑", "↓" and "E" keys.

4. Start the full range adjustment by pressing the "E" key.

Hints:
- The adjustment can be aborted by pressing the "←" key.
- If the error message "time-out error" or "adjustment error" is displayed, abort the adjustment with the "←" key, clean and dry the measuring cell carefully and repeat the adjustment (Refer also to Appendix F).

Hints:
- For air adjustment, the current air pressure must be entered as this influences the air density.
- The density values of water and air at a specific atmospheric pressure for the complete temperature range are stored in the memory of the DMA 4000.
- If the current on-site barometric pressure is not available, enter the average air pressure (depending on the altitude) according to table 8.1 in chapter 8.3.1.

5. The temperature of the measuring cell is automatically set to 30 °C and the air adjustment is performed.

6. After the air adjustment at 30 °C is finished, the temperature of the measuring cell is automatically switched to 45 °C and an air adjustment at 45 °C is performed.

7. Wait until the air adjustment is finished.

8. Degas bi-distilled water by boiling it and let it cool down to approx. 45 to 50 °C. Inject the water into the measuring cell of the DMA 4000 and check that the cell is free of any bubbles (See also chapter 8.2).

9. Start the water adjustment by pressing the "OK" key.

10. The cell temperature is automatically set to 45 °C and the water adjustment is performed.

11. After the water adjustment at 45 °C is finished, the temperature of the measuring cell is automatically switched to 30 °C and a water adjustment at 30 °C is performed.

12. Wait until the water adjustment is finished.

13. The adjustment is saved by selecting "E" after the question "↑ No save? Yes E" is displayed. The adjustment data are stored and can be printed if a printer is connected and activated.

    Selecting "↑" discards the adjustment. The message "aborted" is displayed and the adjustment data are not stored. The adjustment has to be repeated, preferably after a thorough cleaning procedure (see chapter 10).

14. To start the printout, change to the menu "adjustments", "print data", "dens. (air, water)" and confirm with the "E" key.

8.4 Calibration

- Calibrations are checking procedures which are carried out using certified liquid density standards.

- The displayed density value on the DMA 4000 is compared to the reference value indicated in the calibration certificate of the liquid density standard in order to check and document the accuracy of the method.

- The physical properties (density, viscosity) of the liquid density standards should be similar to the physical properties of the samples.

- The frequency of calibrations with certified liquid density standards depends on the requirements and the user's judgement. Recommendation: 1 to 2 calibrations per year.

- Notes on the liquid density standards supplied with the DMA 4000:

  - Five small bottles containing ultra pure water (density standard) and the corresponding calibration certificate are supplied with the DMA 4000.
  - The density of the ultra pure water is given at different temperatures with an uncertainty of 0.00001 g/cm^3 at a confidence level of 95 %.
  - The listed densities are valid for the time at which the liquids were filled.
  - The calibration liquids should be stored in a cool and dark place.
  - The calibration liquids must be used immediately and only once after the bottle has been opened.

Calibration procedure

1. Perform a checking procedure with water and carry out an adjustment at 20 °C (see chapter 8.3.1), if necessary.
2. Thoroughly clean and dry the measuring cell (see chapter 10).
3. Immediately after opening the bottle, inject the liquid density standard **without any bubbles** into the measuring cell of the DMA 4000.
4. After the measurement is finished, print the result (density at given temperature).
5. Document the calibration procedure in a calibration protocol, which contains the operator's name, date, place, description of the calibration procedure, results and the calibration certificate of the liquid density standard.

8.5 Density Check

The "density check" function allows you to check the validity of the factory adjustment after transport and the validity of the your own adjustments for routine measurements.

To check the factory adjustment, degassed and bi-distilled water is used as the calibration fluid.

To check your own adjustments for routine measurements, different density calibration fluids or standardized samples can be used.

Performing the density check

Hint:
- For the following steps, the DMA 4000 must be set to the "unlocked" mode.
- Change to the menu "unlock" and type in the password. Confirm with "E".
- The default password is "4000" (see chapter 11.1.1).

1. Type in the acceptable deviation in the menu "instrument setting", "density check", "max.dens.dev.", e.g. 0.0001 g/cm^3, and confirm with "E" (The factory setting is 0.0001 g/cm^3).

Hint:
The lowest deviation which can be entered is 0.0001 g/cm^3.

```
instrument setting          P
density check               D
max.dens.dev.
  0.0001 g/cm³              ♦
```

2. Enter the density value of the calibration fluid in the menu "instrument setting", "density check", "reference value", e.g. "0.9982 g/cm³" for ultra pure water and confirm with "E" (The factory setting is 0.9982 g/cm³).

```
instrument setting          P
density check               D
reference value
rho 0.9982 g/cm³            ♦
```

Hint:
- A memory function can be activated in the menu "instrument setting", "density check", "check interval". Depending on the setting of the "check interval" a flashing punctuation mark in the lower right of the measuring window reminds you to perform a new density check.
- The check interval time is between 1 and 365 days. (The factory setting is 30 days.)
- Entering "000" days deactivates the memory function.

3. Press the "ESC" key twice to return to the main menu. Select "density check" with the "↑" and "↓" keys.

4. Confirm twice with the "E" key and fill the calibration fluid in the clean measuring cell. Check that the cell is free of any bubbles. Confirm with the "E" key. During the density check, the actual cell temperature and "checking..." are displayed.

Hint:
The density check can be aborted by pressing the "←" key.

```
                            A
density check               T
start check
19.98 °C  checking...       ♦
```

5. Wait until the measurement is finished.

6. • If the measured density is within the maximum deviation, the display shows the deviation to the entered density value and "OK".

• If the measured density is outside the maximum deviation, the display shows the deviation to the entered density value and "NOK".

• In each case the deviation compared to the set density is shown on the display.

7. Pressing the "E" key saves the density check to the data memory of the DMA 4000.

8. Up to 64 density checks can be stored with date, time, deviation and status. All stored density checks can be printed out in the menu "density check", "print check".

   Example of a printout:

```
DMA 4000 443265
number,date,dev.,status
1,2002 01 21 11:37  ,-0.00005 g/cm3,OK
2,2002 02 21 11:44  ,+0.00015 g/cm3,NOK
3,2002 03 21 11:11  ,-0.00001 g/cm3,OK
4,2002 04 21 11:15  ,+0.00019 g/cm3,NOK
```

9 Measurement

Hint:
The DMA 4000 automatically corrects the influence of viscosity on the measured density.

1. Activate the required method using the "METHOD" key.

- A method consists of a temperature unit, measuring temperature, display, printer and memory configuration, all stored under a unique method name.
- Method "DENSITY" and a measuring temperature of 20 °C are factory default settings.
- 2 more preset methods (display, memory, printout) are already stored in the DMA 4000, covering the most common measuring tasks. Each of these methods can easily be altered, renamed and adapted according to your needs (see chapter 7.4).

List of methods:

- **M1-DENSITY:**
  Measurement of true density and specific gravity. This method is suitable for highly accurate measurements of the true density of liquids.
- **M2-PETRO:**
  Measurement of true density, API density in kg/cm^3 and API number for the product group B ("fuel, heat. oil -B") converted to the reference temperature of 15 °C.
- **M3-BRIX:**
  Measurement of true density, Brix concentration at 20 °C and apparent density. This method is suitable for the measurement of soft drinks and other samples containing sugar.

2. Ensure that the measuring cell is clean and dry.

3. Fill the sample into the measuring cell.

Important:

- Before filling any sample into the DMA 4000,
  - make sure that **all wetted parts**, made of PTFE (injection adapters, adapters) and borosilicate glass (measuring cell), **are resistant** to the sample. Borosilicate glass is not resistant to samples containing hydrofluoric acid, even in traces.
  - work out a proper cleaning procedure for the measuring cell (see chapter 10).
  - If a sample changer SP-1m/SP-3m is connected, check the resistance of the wetted parts (see instruction manual SP-1m/SP-3m).
- Samples with a moderate tendency to corrode borosilicate glass i.e. strong alkali solutions (e.g. caustic soda) can still be measured with the DMA 4000.
  - However, take care to remove such samples immediately after measurement and rinse the measuring cell properly.
  - Check the validity of the adjustment more frequently than generally recommended. Perform a new adjustment, if necessary.
  - The measuring temperature for strong alkali solutions should not be higher than 20 °C. Higher temperatures dramatically increase the speed of corrosion.

Hints:

- The sample has to be homogeneous and free of gas bubbles.
- Suspensions or emulsions may tend to separate in the measuring cell, giving incorrect results. Such samples should remain in the measuring cell only briefly. It is therefore recommended to pre-thermostat them before filling. It may help to put spacers below the left legs of the DMA 4000, thus putting it at an angle to counterbalance the separation force generated by the oscillation of the measuring cell.
- A sample temperature similar to the measuring temperature reduces the measuring time.
- If the DMA 4000 is in the 1st harmonic oscillation (high-pitched sound), do not fill the sample as this might create bubbles during the filling procedure. Wait until the high-pitched sound (approx. 10 seconds) can no longer be heard or press the "MENU" key before filling.
- If the sample to be measured tends to form bubbles, introduce the sample at a temperature higher than the measuring temperature. Another remedy may be to put the density meter at an angle by means of proper spacers below the right side of the DMA 4000 to allow the bubbles to escape, due to buoyancy.
- The message "osc. unstable" is displayed every time the DMA 4000 is in the 1st harmonic oscillation phase (high-pitched sound, status "DP"). After a few seconds, this message disappears and the measurement is not influenced (The message is displayed after pressing the "HELP" key when the "!" sign appears).
  If the message "osc. unstable" does not disappear, the DMA 4000 reaches the status "TO" (time out). The measuring cell must be filled again (free of bubbles).

There are several **options for filling the samples** into the measuring cell:

A. By syringe with Luer tip, see Fig. 9 - 1

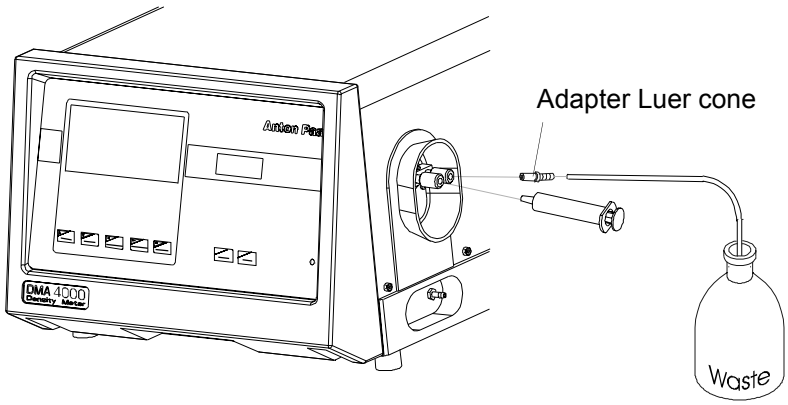


Fig. 9 - 1 Filling the DMA 4000 by syringe

Hints:

- Make sure that there is a waste bottle at the outlet of the measuring cell.
- Never fill the samples without the injection adapters (see chapter 5) in order to avoid glass breakage of the measuring cell.
- Attach the syringe to the injection adapter and push the plunger of the syringe slowly and continuously until a drop emerges from the other nozzle.
- The proper filling of the measuring cell can be observed through the inspection window. Take care that the entire measuring cell is filled with sample. A sample amount of approx. 1.5 ml is required.
- Leave the syringe in the filling position in order to prevent sample leakage.

B. By gravity, using a funnel and a hose at the inlet and a hose with a valve (e.g. a clamp to block a flexible hose) at the outlet.

C. Automatically, using the Anton Paar **sample changer SP-1m or SP-3m**

D. Semiautomatically, using a **peristaltic pump**

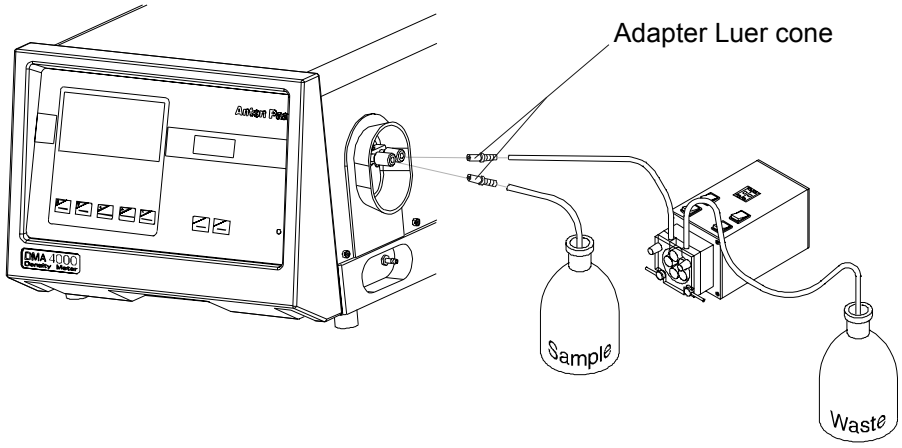


Fig. 9 - 2 Filling the DMA 4000 using a peristaltic pump

Hints:
- Use two adapters Luer cone for the hose connections.
- Make sure that there is a waste bottle at the outlet of the peristaltic pump.
- A flow rate of 10 to 25 ml per minute is recommended for filling the sample.
- Make sure that the pump hose is resistant to all samples and cleaning liquids.
- Turn off the pump after filling a proper amount of sample.

4. Ensure that there are no gas bubbles in the measuring cell.

5. Start the measurement by pressing the "START" key. The "+" symbol is displayed on the right side of the display and the sample number is increased. As soon as the measurement is valid the "•" symbol starts to flash and the measurement is "frozen" (status "MF"-measurement frozen). The measurement is automatically stored in the data memory of the DMA 4000. To start the next measurement, press the "START" key again.

```
rho   0.9982  g/cm³          M
SG    1.0000                 F
                             •
20.00°C  SAMPLE-  1          ♦
```

Fig. 9 - 3 A "frozen" measurement after pressing the "START" key

Hint:
- A measurement can be aborted by pressing the "START" key again. The "+" symbol disappears.
- To end the status "MF" (measurement frozen), press the "START" key twice. The DMA 4000 measures continuously. Without pressing the "START" key the instrument attemperates automatically (status "AT"-attemperating) until the status "OK" is reached and the measurement is stable. This measurement is **not** stored in the data memory and **not** printed automatically.

```
rho   0.9982  g/cm³          O
SG    1.0000                 K

20.00°C  SAMPLE-  1          ♦
```

Fig. 9 - 4 Stable measurement after attemperating

6. Print your measuring results.

A. Automatic printout and data storage

- Press "SAMPLE#" key and define a sample name and/or a sample number.
- Press the "START" key. The measuring results are printed and stored automatically as soon as measurement has reached "MF" (measurement frozen).

B. Manual printout

A manual printout is possible at any time:

- Press the "Sample#" key to define a sample name and/or sample number.
- Press the "START" key twice. The DMA 4000 leaves the "MF" status and starts to attemperate. Wait until the status "OK" is reached.
- Print the measuring results by pressing the "PRINT" key.
- **Examples for DMA 4000 printouts:**

```
2002 02 18 11:48
rho 0.9982 g/cm3
SGapp 1.0000
SG 1.0000
Tset  20.00  C
SAMPLE -  1
---------------------------
2002 02 18 12:20
rho 0.9940 g/cm3
SGapp 0.9958
SG 0.9958
Tset  20.00  C
SAMPLE -  2
---------------------------
```

C. Printout of stored data

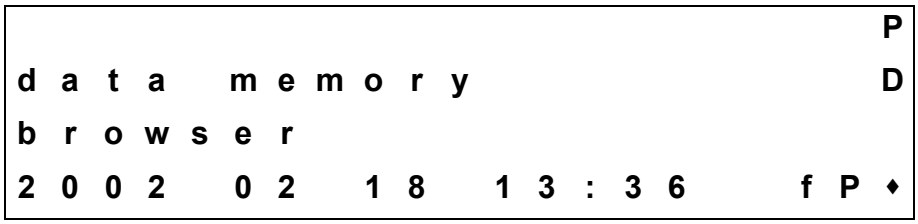
Stored and already printed out data can be reset for repeated printouts:

Hint:
- All the different data of a stored measurement (date and time, sample name, density, data line2, data line3 and Tset) are only displayed in the fourth line of the display.
- To browse the data, use the "←" and "→" keys.
- To browse the stored measurements, use the "↑" key.

a) Select the desired measurement in the menu "data memory", "browser" with the "↑" key.

b) Use the "←" and "→" keys to move to the line where the date and time and

"fP" are displayed.



c) Set "fP" to "fp" with the "↓" key and confirm with the "E" key.

d) Press the "↓" key to change to the menu "data memory", "print" and confirm with the "E" key.:

Hint:
Repeat step a to d for each stored measurement to be printed out.

e) Now all stored measurements with the status "fp" will be printed.

Printout of a stored measurement:

```
2002 02 18 14:03
method: M3-BRIX
sample: SAMPLE  2
measurement finished: yes
fetched by host: no
rho 0.9942 g/cm3
SGapp 0.9960
SG 0.9960
Tset 20.00 C
----------------------------------------
```

Up to 48 measurements can be stored in the DMA 4000.

7. Fill in the next sample or clean and dry the measuring cell between measurements if necessary (see chapter 10).

Hints:
- Clean and dry the measuring cell after each measurement if dissimilar samples are to be measured. For similar samples, replace the previous sample with a sufficient amount (10 ml or more) of the new sample.
- Do not leave samples in the measuring cell longer than absolutely necessary. Replace the sample with proper solvent and clean and dry the measuring cell as soon as possible (see chapter 10).

10 Cleaning and Drying the Measuring Cell

Hint:
Cleaning should be performed with 2 cleaning liquids. Cleaning liquid 1 dissolves and removes residues, cleaning liquid 2 removes cleaning liquid 1 and is easily evaporated by a stream of dry air.

1. Fill the measuring cell with cleaning liquid 1 using a syringe with Luer tip, and move the plunger of the syringe in and out several times. This creates gas bubbles which improve the cleaning action. Instead of a syringe, any other suitable device i.e. a peristaltic pump can be used.

Hints:
- Find a suitable cleaning liquid 1 before carrying out the first measurement.
- Cleaning liquid 1 should dissolve residues in the measuring cell.
- Cleaning liquid 1 must be selected so that no chemical reactions with the sample and cleaning liquid 2 are to be expected.
- For water-soluble residues water can be used.

Important:
Do not use highly concentrated alcohol as cleaning liquid 1 for proteins, sugar or similar organic residues because insoluble precipitates may form in the measuring cell.

2. Remove cleaning liquid 1 from the measuring cell.

3. Rinse the measuring cell with cleaning liquid 2 repeatedly using a syringe with Luer tip and move the plunger of the syringe in and out several times.

Hints:
- Cleaning liquid 2 should be volatile at the measuring temperature.
- Cleaning liquid 2 must be selected so that no chemical reactions with cleaning liquid 1 are to be expected.

4. Remove cleaning liquid 2 from the measuring cell.

5. Attach the air hose (see chapter 5) to the injection adapter.

Hint:
Check that the air humidity does not exceed the limits given in Appendix A and use a desiccator if necessary.

6. Turn on the air pump using the "PUMP" key. "AP" is displayed to indicate that the air pump is in operation.

Hint:
The "ESC/PUMP" key has two different functions. The "PUMP" function is only active when the measuring window is displayed. Otherwise, the air pump cannot be turned on or off because the "ESC" function of the key is active.

7. Let dry air blow through the measuring cell for approx. 10 minutes. If the automatic switch off function for the air pump is activated, the air pump will stop after the preset time.

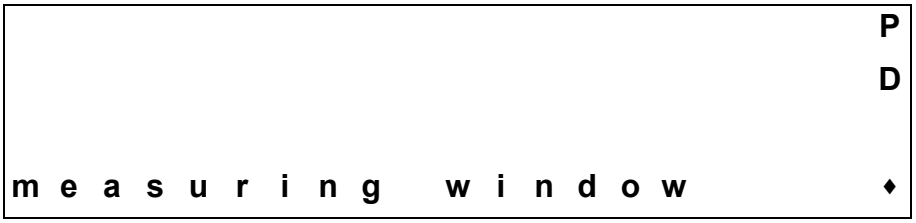
   - To switch off the air pump automatically, change to the menu "instrument setting", "air pump time" and type in the desired time.
   - 10 minutes are recommended, "00 minutes" deactivates the automatic switch off function. (The factory setting is "10 minutes".)

8. Turn off the air pump (by pressing the "PUMP" key) if it has not automatically switched off.

9. Remove the air hose from the injection adapter.

11 Operation

11.1 Menu Operation



11.1.1 Locked and Unlocked Mode

Parts of the menu structure of the DMA 4000 are password protected. Therefore, different menus are available in the locked and the unlocked mode.

Menus	Mode	
	locked	unlocked
measuring window	x	x
density check	x	x
unlock	x	x
adjustments		x
method settings		x
instrument setting		x
user functions		x
data memory	x	x
verify		x

Hint:
If a sample changer SP-1m or SP-3m is connected and activated, the menu SP-1m or SP-3m is only available in the unlocked mode.

The current mode of the DMA 4000 is displayed by pressing the "HELP" key twice (see chapter 11.4).

To change from the locked mode to the unlocked mode, change to the menu "unlock", type in the password and confirm with "E". The default password is "4000".

To define a new password, change to "instrument setting", "change password" and type in the desired password (max. 18 characters).

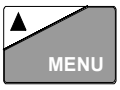
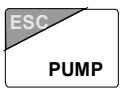
Hint:
- Each time the DMA 4000 is switched on, it is set to the locked mode.
- If the DMA 4000 is set to the unlocked mode, the question "↑ No LOCK? Yes E" is displayed each time you change from the menu mode to the measuring window.
- If the DMA 4000 is set to the unlocked mode and the menu mode is active, "↑ No LOCK? Yes E" is displayed, if no key is pushed for two minutes.
- The DMA 4000 keeps in the "unlocked" mode, if in the menu "instrument setting", "change password" blanks are typed in as password.

11.1.2 Using the Keys on the Keypad

Hints:
- Except for the "HELP" key, all the keys on the keypad have two different functions:
  - If the measuring window is displayed, the functions "MENU", "PRINT", "SAMPLE#", "METHOD", "START" and "PUMP" are active.
  - In the menu mode (after pressing the "MENU" key) the functions "↑", "↓", "←", "→", "E" and "ESC" are active.
  - The "HELP" key is always active (see chapter 11.4).

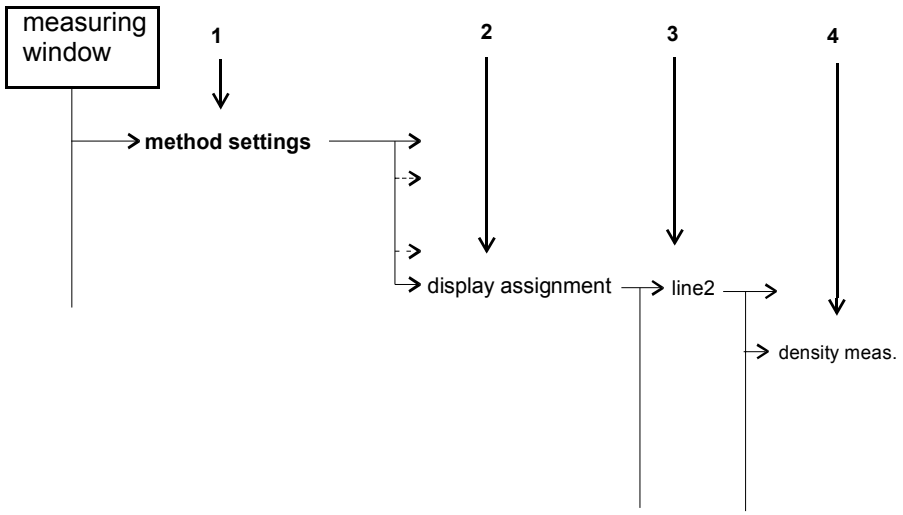
11.1.2.1 Functions for navigation through the menu

The following key functions are active after pressing the "MENU" key once (menu mode).

 	"↑" and "↓":	• To select a menu item (e.g. density check, unlock, adjustments... in the main menu). • To decrease or increase the numerical value of a digit and to select letters and numbers.
	"←":	• To stop a printout, to abort an adjustment or density check. • To browse the values of a stored measurement in the menu "browser". • To select a menu item.
	"→":	• To browse the values of a stored measurement in the menu "browser". • To select a menu item.
	"E":	• To move one menu level lower or enter a selected menu (e.g. from the main menu to the menu "density check"). • The "E" key is also used to confirm inputs, settings and queries.
	"ESC":	• To move one menu level higher (e.g. from the menu "method settings", "edit method name", to the menu "measuring window").

Hint:
Each step through the menu is displayed from line 1 to line 4.

1	method settings	P
2	display assignment	D
3	line2	
4	density meas.	♦



Browsing the menu

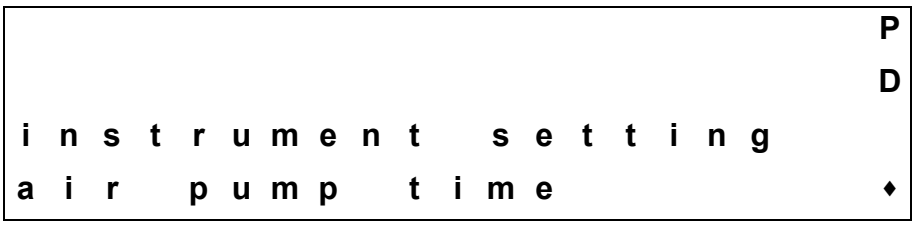
Example: Setting the air pump time (see also the menu tree in the Appendix).

1. Pressing the "MENU" key sets the DMA 4000 to the menu mode.

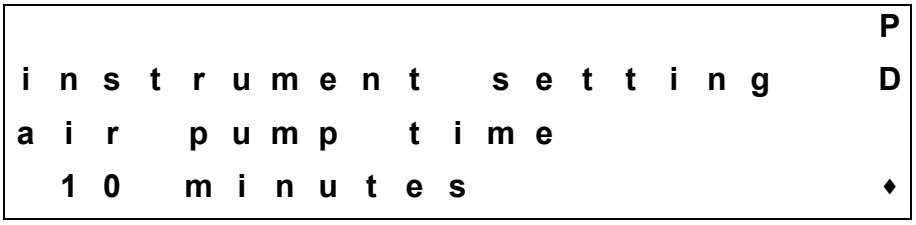
		P
		D
	measuring window	♦

2. Using the "↑" and "↓" keys, the different menus of the main menu will be displayed step by step in the fourth line of the display. For this example, the menu "instrument setting" should be selected.

3. By pressing the "E" key, the DMA 4000 moves one menu level lower. With the "↑" and "↓" keys, the menu "air pump time" can be chosen.

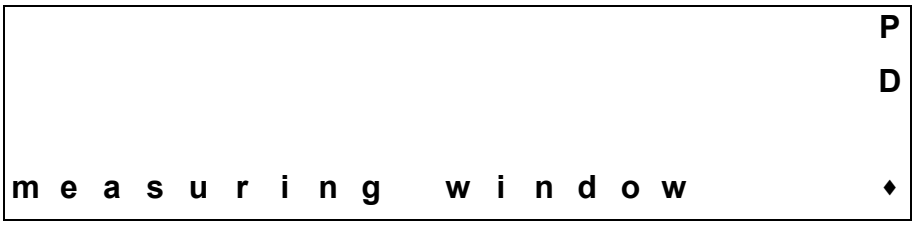


4. After pressing the "E" key, the desired air pump time can be entered. Pressing the "←" and "→" keys changes the digit, pressing the "↑" and "↓" keys changes the value of a digit.



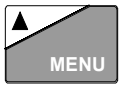
5. After confirming with the "E" key, the value is saved in the memory of the DMA 4000.

6. By pressing the "ESC" key twice, the DMA 4000 moves two levels higher to the menu "measuring window".



7. After pressing the "E" key, the measuring window will be displayed. When the status of the DMA 4000 is "unlocked", the question "↑ No LOCK? Yes E" will be displayed. Pressing the "↑" key keeps the DMA 4000 "unlocked", pressing the "E" key locks the DMA 4000 (see chapter 11.1.1).

11.1.2.2 Functions for measuring



MENU: To change from the measuring window to the menu mode.

Hint:
It is not possible to access the menu level of the DMA 4000 during a started measurement procedure ("+" symbol is displayed). The message "measuring..." will be displayed when the "MENU" key is pressed. To access the menu level, the measurement must be interrupted by pressing the "START" key again.

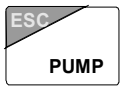
PRINT: To print the current measurement when a printer is connected (see chapter 9).

SAMPLE#: To enter a sample name with or without a number (see chapter 11.3). Up to 18 signs can be entered.

METHOD: To select one of the three stored methods (M1-DENSITY, M2-PETRO and M3-BRIX).

START: To start a measurement after filling a sample.
A cross "+" in the display indicates a started measurement.
If a measurement is aborted by pressing the "START" key again, the "+" symbol disappears.

Hint:
If a sample changer SP-1m/SP-3m is connected and activated, the "START" key on the DMA 4000 is deactivated. Use the "START" key on the sample changer instead.



PUMP: To activate the air pump for drying the measuring cell (see chapter 10).

HELP: Can be pressed up to four times to obtain informations about key functions, the software version, status of the DMA 4000 and date of adjustments (see chapter 11.4).

11.1.3 Using an External Keyboard (Optional)

Connect a standard PC keyboard to the keyboard connector (PC/AT interface) at the rear of the DMA 4000. If necessary, use an adapter plug (e.g. from PS/2 interface to PC/AT interface). This connector can also be used to plug in a bar code reader for sample ID. Simultaneous operation of keyboard and bar code reader is possible using adapters.

- The "↑", "↓", "←", "→", "ESC" and "Enter" keys on the keyboard have the same function as on the DMA 4000 keypad.
- Delete characters with "SPACE".

11.2 Menu Structure and Description

Hints:
- For a summary of all functions, see the menu tree in the Appendix. Menus which are only available in the "unlocked" mode are marked with a "*".

11.2.1 "measuring window"

After pressing the "E" key, the DMA 4000 moves to the measuring mode and the measuring window is displayed (for an example, see Fig. 11 - 1).

```
rho  1.3034  g/cm³          M
conc        62.85  °Brix    F
rhoapp+ 1.3024  g/cm³        •
20.00 °C  SAMPLE- 1          ♦
```

Fig. 11 - 1 Measuring window

If the DMA 4000 is in the unlocked mode, the question "↑No LOCK? Yes E" is displayed.

11.2.2 "density check"

→ **density check**	
→ **start check**	This function is used either to check the validity of the factory adjustment after transport or to check the validity of your own adjustments for routine measurements.
→ **print check**	Print the density check history. Up to 64 density checks can be stored (see chapter 8.5).

11.2.3 "unlock"

→ **unlock**	Key in the password to unlock the DMA 4000. The default password is "4000" (see chapter 11.1.1).

11.2.4 "adjustments*"

→ **dens. (air, water)**	Adjustment at 20 °C using air and water. For a detailed description, see chapter 8.3.1.
→ **dens. (temp. range)**	Air and water adjustment over the whole temperature range, for a detailed description see chapter 8.3.2.
→ **print data**	
→ **dens. (air, water)**	Printout of the latest density adjustment data.
→ **temperature sensors**	Printout of the latest adjustment data of the temperature sensors.
→ **adjustment history**	Printout of the most recent density and temperature sensors adjustment data.
→ **density**	Printout of up to 50 stored "dens. (air, water)" and "dens. (temp. range)" adjustments.
→ **temperature sensors**	Printout of up to 14 stored "temperature sensors" adjustments.
→ **view data**	All adjustment data of temperature and density sensors for all types of adjustment can be displayed for service and documentation purposes.
→ **dens. (air / water)**	The density coefficients used for calculating the density from the period of oscillation are displayed.

→ **Q air**	
→ **Q H2O**	
→ **air pressure**	Air pressure entered for the adjustment.
→ **KAo**	
→ **KBo**	
→ **KAg**	
→ **KBg**	
→ **KCo**	
→ **KCg**	
→ **dens. (temp. range)**	The density coefficients used for calculating the density from the period of oscillation are displayed.
→ **TKA1o**	
→ **TKA2o**	
→ **TKB1o**	
→ **TKB2o**	
→ **TKA1g**	
→ **TKA2g**	
→ **TKB1g**	
→ **TKB2g**	
→ **temperature sensors**	The sensor data of both built-in Pt 100 temperature sensors are displayed.
→ **R-block**	Resistance at 0 °C.
→ **R-cell**	Resistance at 0 °C
→ **a**	Linear constant.
→ **b**	Quadratic constant.
→ **act. factory adj.**	This function can be used to re-activate the original factory adjustment. With this, the present adjustment data are replaced by the factory adjustment data.

11.2.5 "method settings*"

→ **method settings**

- → **edit method name** — Issue or change an individual name for the activated method.
- → **set temp. unit**
  - → **°C** — The temperature unit is degrees Celsius.
  - → **°F** — The temperature unit is degrees Fahrenheit.
- → **set temperature** — Any temperature from 10 to 60 °C or 50 to 140 °F.
- → **display assignment** — Different customer functions can be selected for line2 and line3.
  - → **line2**
    - → **system + temp.**
      - → **date + time** — Date and time.
      - → **method name** — Method name.
      - → **serial number** — Serial number of the DMA 4000.
      - → **sample name** — Sample name and/or number entered via "Sample#" key or a bar code reader (See chapter 11.3).
      - → **empty row** — Empty line on the display and no line on the printer.
      - → **Q** — Quotient of the current measured period of oscillation of the U-tube divided by the actual period of oscillation of the reference oscillator. Q is used internally by the DMA 4000 to calculate the density using the adjustment coefficients.
      - → **actual cell temp.** — The temperature in the measuring cell measured by the Pt 100 measuring sensor.
      - → **set cell temp.** — The set temperature.
    - → **density meas.**
      - → **density** — Density value after viscosity correction.
      - → **apparent density** — Apparent density.
      - → **SG** — Specific gravity: The density divided by the density of water at a specified temperature.
      - →**apparent (SG)** — Apparent specific gravity: The apparent density divided by the apparent density of water at a specified temperature. Apparent density is the weight in air (not mass!) divided by the volume.

→ **user functions**	User polynomials, tables limits and API functions can be selected.
→ **polynomial**	Polynomial formulas to calculate density-related values.
→ **user table**	A user-specified table for converting density to concentration or any other related value.
→ **high/low limits**	Supervision of one selected measuring result.
→ **API gravity**	API number.
→ **API SG**	API specific gravity.
→ **API kg/m^3**	API density in kg/m^3.
→ **API g/cm^3**	API density in g/cm^3.
→ **ethanol tables**	A variety of tables are available for the determination of the alcohol concentration of alcohol/water mixtures using density. The range of all tables is 0 to 100 % ethanol. A density change of 1x 10^{-4} g/cm^3 corresponds to a concentration change of approx. 0.07 %.
→ **OIML (%w/w)**	Alcohol concentration in percentage by weight according to the International Alcoholometric Tables issued by the International Organisation of Legal Metrology (OIML), temperature according to ITS 68, based on true density at 20 °C.
→ **OIML (%v/v)**	Alcohol concentration in percentage by volume according to the International Alcoholometric Tables issued by the International Organisation of Legal Metrology (OIML), temperature according to ITS 68, based on true density at 20 °C.
→ **OIML-ITS90 (%w/w)**	Alcohol concentration in percentage by weight according to the International Alcoholometric Tables issued by the International Organisation of Legal Metrology (OIML), temperature according to ITS 90, based on true density at 20 °C.

→ **OIML-ITS90 (%v/v)**	Alcohol concentration in percentage by volume according to the International Alcoholometric Tables issued by the International Organisation of Legal Metrology (OIML), temperature according to ITS 90, based on true density at 20 °C.
→ **IUPAC (%w/w)**	Alcohol concentration in percentage by weight according to the International Union of Pure and Applied Chemistry, based on true density at 20 °C. The measuring temperature **must** be 20 °C (68 °F).
→ **IUPAC (%v/v)**	Alcohol concentration in percentage by volume according to the International Union of Pure and Applied Chemistry, based on true density at 20 °C.The measuring temperature **must** be 20 °C (68 °F).
→**KAEMPF(%w/w)**	Alcohol concentration in percentage by weight according to W. KAEMPF, based on true density at 20 °C.
→**KAEMPF (%v/v)**	Alcohol concentration in percentage by volume according to W. KAEMPF, based on true density at 20 °C.
→ **AOAC 60°F (%v/v)**	Alcohol concentration in percentage by volume at 15.56 °C (60 °F) according to the AOAC Tables, based on true density at 20 °C. The measuring temperature **must** be 20 °C (68 °F).
→ **Proof 60°F**	Alcohol concentration in Proof degrees at 15.56 °C (60 °F), based on true density at 20 °C.
→ **HM C&E (%v/v)**	Alcohol concentration in percentage by volume according to the HM C&E Table at 20 °C.
→**HM C&E (%w/w)**	Alcohol concentration in percentage by weight according to the HM C&E Table at 20 °C.
→ **extr./sugar tables**	2 tables for the determination of the saccharose/extract concentration of sugar in water using density are available. The range of both tables is 0 to 100 %. A density change of 1E-4 g/cm^3 corresponds to a concentration change of approx. 0.02 %.

→ **conc. (°Brix)**	Saccharose concentration in percentage by weight according to NBS Table 113, based on true density at 20 °C.
→ **conc. (°Plato)**	Extract concentration according to the Plato table, based on true density at 20 °C.
→ **Baume (°Baume)**	Concentration unit according to the given formulae below, based on specific gravity at set temperature (t). • For liquids heavier than water: °Be = (145 x SGt/t - 145) / SGt/t • For liquids lighter than water: °Be = (140 - 130 x SGt/t) / SGt/t
→ **acid/base tables**	A variety of acid/base concentration equations are stored in the DMA 4000, many more are available on request.
→ **HCl**	Aqueous hydrochloric acid concentration in percentage by weight according to the CRC Handbook of Chemistry and Physics, based on true density at 20 °C, range 0 to 40 %. Accuracy approx. 0.02 %.
→ **NaOH**	Aqueous sodium hydroxide concentration in percentage by weight according to Landolt-Boernstein, based on true density at 20 °C, range 0 to 50 %. Accuracy approx. 0.04 %.
→ **H3PO4**	Aqueous phosphoric acid concentration in percentage by weight according to Landolt-Boernstein, based on true density at 20 °C, range 0 to 100 %. Accuracy approx. 0.06 %.
→ **HNO3**	Aqueous nitric acid concentration in percentage by weight according to Landolt-Boernstein, based on true density at 20 °C, range 0 to 100 %. Accuracy approx. 0.07%
→ **H2SO4**	Aqueous sulfuric acid concentration in percentage by weight according to the CRC Handbook of Chemistry and Physics, based on true density at 20 °C, range 0 to 94 %. Accuracy approx. 0.05 %.
→ **line3**	As for line2.

11.2.6 "instrument setting*"

→ **instrument setting**

→ **density check**	Input of the following parameters:
→ **max. dens. dev.**	Max. deviation (lowest possible entered value: 0.0001 g/cm^3).
→ **reference value**	Density of the calibration fluid.
→ **check interval**	Check interval (1 to 365 days). Default setting: 30 days. Entering "000" days deactivates the memory function (see chapter 8.5).
→ **display timeout**	Screen- saving mode after a preset time of 1 to 99 minutes. Default setting: 20 minutes.
→ **interface setting**	If the DMA 4000 is connected to a PC or a printer via COM1, the interface has to be adjusted depending on the software/printer used for the data transfer (see Appendix B).
→ **baudrate**	Bits/second.
→ **1200**	
→ **2400**	
→ **4800**	
→ **9600**	
→ **19200**	
→ **format**	
→ **E71**	**E**ven **7** data bits **1** stop bit.
→ **O71**	**O**dd **7** data bits **1** stop bit.
→ **E81**	**E**ven **8** data bits **1** stop bit.
→ **handshake**	
→ **none**	
→ **softw. (Xon/Xoff)**	
→ **hardware (RTS/CTS)**	
→ **line delimeter**	The line delimiter separates each data string from the next.
→ **<CR><LF>**	Carriage return and line feed after each data string.
→ **<CR>**	Carriage return after each data string.
→ **<LF>**	Line feed after each data string.
→ **<LF><CR>**	Line feed and carriage return after each data string.

→ **data delimeter**	The data delimiter separates each data within a string from the next.
→ **; semicolon**	
→ **→ tabulator**	
→ **, comma**	
→ **/ fwd. slash**	
→ **host mode**	To select if a printer or PC is connected to the COM1 interface.
→ **PRINTER**	
→ **PC**	
→ **set date and time**	Using this menu, the local date and time can be set.
→ **change password**	Change a password for the unlocked mode.
→ **air pump time**	The air pump is switched off automatically after the specified time. Entering "00 minutes" deactivates the automatic switch off.
→ **external keyboard (optional)**	To define the connected keyboard type. The factory setting is "us".
→ **german**	
→ **us**	
→ **start update**	A new software version can be loaded from the computer to the DMA 4000 via serial interface COM1. Detailed information is supplied with the software.

11.2.7 "user functions*"

- One user-specific polynomial and one user-specific table per method can be defined to calculate density-related values.
- One high/low limits function per method is available for supervising measuring results. Depending on the measuring results and on the specified limits, "too low/OK/too high" will be reported.

→ **user functions**

→ **polynomial**	Polynomial formulas are provided to calculate density-related values. Polynomial formula: Output = A0 + A1 x (density) + A2 x $(density)^2$ + A3 x $(density)^3$ + A4 x $(density)^4$ The coefficients A0 to A4 can be calculated from density/concentration data.
→ **name**	Name of the polynomial, maximum of 18 characters.
→ **coefficients**	A maximum of 5 coefficients can be entered (A0 to A4).
→ **A0**	Input of coefficient A0.
→ **A1**	Input of coefficient A1.
→ **A2**	Input of coefficient A2 .
→ **A3**	Input of coefficient A3.
→ **A4**	Input of coefficient A4.
→ **output format**	"|" ……Spacer for math. sign + or – "@" … Spacer for a number 0 to 9 "." ….. Spacer for a decimal point "E" …..Spacer for an exponent
→ **print**	Printout of the polynomial name, format and all coefficients.
→ **user table**	User-specific tables linking density to concentration or any other related value can be individually set up (1 per method).
→ **settings**	
→ **table name**	Name of the table, maximum of 18 characters.
→ **output**	"|" ……Spacer for math. sign + or – "@" … Spacer for a number 0 to 9 "." ….. Spacer for a decimal point "E" …..Spacer for an exponent

→ **edit table**	The table data are entered in sets of pairs. A maximum of 100 data pairs can be entered in one table. The data pairs have to be entered in ascending order beginning with the lowest density value.
→ **print**	Printout of the table name, format and all data pairs.
→ **high/low limit**	Supervision of one selected measuring result. The high/low limits are factory preset to 0.9983 g/cm^3 and 0.9981 g/cm^3. The preset limits can be changed according to your preference. The message "limits: invalid" is displayed, when there is no measuring result to supervise.
→ **name**	Name of the limits, maximum of 15 characters.
→ **input value**	Select the measuring result to be supervised from the displayed listing.
→ **upper limit**	Defines the upper limit
→ **lower limit**	Defines the lower limit
→ **print**	Printout of the limit name, input value upper and lower limit.
→ **API function**	The API functions automatically convert the density values of petroleum samples measured at any temperature to the respective readings at the reference temperature 15 °C or 60 °F, according to ASTM D1250-80 and DIN 51757. Additionally, the same API functions are available for a reference temperature of 20 °C according to the "IP Petroleum Measurement Paper No. 3, 1988". The samples are divided into the groups crude oil (group A), fuel to heating oil (group B) and lubricants (group D).
→ **product group**	Selection of the product group.
→ **crude oil –A**	Group A: crude oil -A
→ **fuel, heat. Oil –B**	Group B: fuel to heating oil -B
→ **lubricating oil –D**	Group D: lubricating oil -D
→ **reference temp.**	Conversion to selected temperature.
→ **15 °C**	Conversion at measuring temperature to 15 °C.

→ **60 °F**	Conversion at measuring temperature to 60 °F.
→ **20 °C**	Conversion at measuring temperature to 20 °C.
→ **print**	Printout of the product group and reference temp.

11.2.8 "data memory"

→ **browser**	Display of the stored data. Browse through the stored measurements using the "↑" key when the sample name is on the display. A stored measurement contains the following values: • date, time • sample name • density • data set in line2 • data set in line3 • set temperature To browse the values use the "←" and "→" keys. Only stored data of the activated method will be displayed. Up to 48 measurements can be stored in the data memory. The latest measurement overwrites the oldest measurement independent of the activated method. To leave the menu press the "E" key.
→ **print**	Printout of all the stored data of the activated method. To print out a stored measurement several times, refer to chapter 9, "Printout of stored data". The information "fetched by host:yes/no" shows whether the displayed stored data have been transmitted to a PC.

11.2.9 "SP-1m*"

- The menu "SP-1m" is only available if a sample changer SP-1m is connected and activated.
- If an SP-1m is connected, the measurement is started by pressing the "START" key on the SP-1m. The "START" key of the DMA 4000 is deactivated.

→ **SP-1m**	To edit the control parameter for the sample changer SP-1m.
→ **parameter**	A 7-digit number controls the filling procedure (refer to the SP-1m instruction manual).

11.2.10 "SP-3m*"

- The menu "SP-3m" is only available if a sample changer SP-3m is connected and activated.
- If an SP-3m is connected, the measurement is started by pressing the "START" key on the SP-3m. The "START" key of the DMA 4000 is deactivated

→ **SP-3m**	To edit the control parameter for the sample changer SP-3m.
→ **parameter**	A 7-digit number controls the filling procedure (refer to the SP-3m instruction manual).
→ **double filling**	The sample can be measured once or twice from each vial.
→ **no**	The sample from each vial is measured once.
→ **yes**	The sample from each vial is measured twice.

11.2.11 "verify*"

- The DMA 4000 can be used to calculate concentrations and other density-related results from manually entered density values using the built-in customer functions, tables or polynomials.
- Select the user function which should be observed in the menu "method settings", "display assignment" at line2. Then enter the required input value in the menu "verify". Press "E" to perform the calculation.
- Only the item selected in the menu "method settings", "display assignment" at "line2" is available. Tables, formulas or functions not selected in "method settings", "display assignment", "line2" cannot be used for customer function verification.
- If API functions or SG functions are selected, enter the required measuring temperature.

Hint:
To verify an API function, end the status "MF" by pressing the "START" key twice.

- If results cannot be calculated, "----------" appears on the display (out of range).

11.3 Sample#

For sample identification, a sample number before or after a sample name can be entered. Up to 18 signs for the sample name can be printed and up to 11 signs are displayed.

The spacer for a number can be entered as the "@" symbol. If only one "@" is entered, the number increases to a maximum of 9. By using "@@" the number increases to a maximum of 99. When the highest possible number is reached, it will be automatically reset to 1. If the sample name is changed, the number can be reset to 1 by pressing the "↓" key.

The sample number can also be entered via the keys on the keypad, a PC keyboard (optional) or a bar code reader (optional).

After pressing the "START" key on the DMA 4000, the sample name and/or the sample number will be displayed.The sample number will be increased automatically.

If a sample changer SP-1m or SP-3m is connected and activated, the sample position in the magazine can be transferred to the DMA 4000 for sample identification by keying in two "@" after the sample name.

11.4 The HELP Key

For further information about key functions, the software version, status of the DMA 4000 and date of adjustment, press the "HELP" key up to 4 times.

1. Press the "HELP" key once:

Explanation of the keys:

```
↑ menu  ↓ print
← set samplename
→ select method
E start new meas.
```

2. Press the "HELP" key two times:

Status of the DMA 4000:

Software version →	DMA4000 V:1.200
Actual date and time →	2002 01 15 15:45
Status of the measurement →	MF-meas. frozen
Current mode of the DMA 4000 →	unlocked

3. Press the "HELP" key three times:

Additional informations:

Date and time of the factory adjustment, serial number →	2002 01 17 565911
Number of times switched on →	ON: 146 x 0 i
Operation hours →	1926 hours
Connected peripheral equipment →	no sampler

4. Press the "HELP" key four times:

Date of adjustments:

Date of last density check →	2002 02 15 16:13	DC
Date of last air and water adjustment →	2002 02 13 10:02	AW
Date of last temp. range adjustment →	2002 02 14 09:31	TR
Date of last temperature sensor adjustment →	2002 01 24 13:52	TS

Hints:

- To get more information when the call sign appears instead of the "instrument active" symbol ("♦"), press the "HELP" key once.
- Either by pressing the "E" key or automatically after 20 seconds, the DMA 4000 returns to the measuring window.

Appendix A: Operation at High Air Humidity and/or Low Measuring Temperatures

If the ambient air contains humidity and the measuring temperature is lower than the ambient temperature, condensation may occur in the measuring cell and measuring cell block. Condensation in the measuring cell causes adjustment and measurement errors. Condensation in the measuring cell block damages the electronics.

The higher the difference between the set measuring temperature and ambient temperature and the higher the air humidity, the easier condensation occurs.

Preventing condensation in the measuring cell

To prevent condensation in the measuring cell, use a drying cartridge connected to the "DRY AIR PUMP" nozzle at the rear of the DMA 4000. The drying cartridge provides dry air for a thoroughly drying of the measuring cell (see chapter 10).

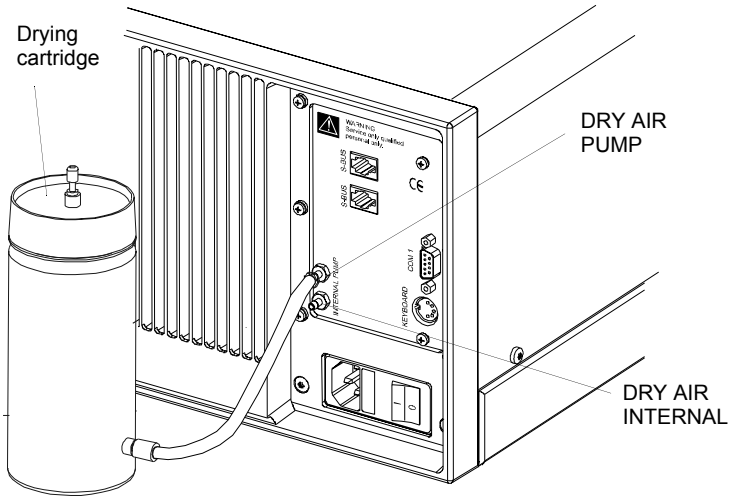


Fig. A - 1 Connections for supplying dry air

Important:
Never connect hoses containing liquids or moist gases to the "DRY AIR PUMP" nozzle as this may lead to condensations in the measuring cell and subsequently to measurement and adjustment errors.

For a measuring temperature of 20 °C, a drying cartridge must be used under the following conditions:

Ambient temperature	Relative air humidity (RH)
20 °C	> 70%
25 °C	> 50%
30 °C	> 38%

The drying cartridge contains beaded ruby gel, a non-toxic drying agent. When active, the color of the drying agent is red. Ruby gel which has absorbed liquid turns orange.

Moist ruby gel can be regenerated:

Pour the ruby gel into a glass bowl and blow hot, dry air (max. 130°C) through it for approx. 5 hours or place it in a laboratory oven for a few hours (or over night) until it is red again.

Important:
Do not use higher drying temperatures than 130°C, otherwise the indicator function of the ruby gel is spoiled.

Preventing condensation in the measuring cell block

To prevent condensation in the measuring cell block, connect a dry air supply to the "DRY AIR INTERNAL" nozzle at the rear of the DMA 4000 (see Fig. A - 1).

Important:
Never connect hoses containing liquids or moist gases to the "DRY AIR INTERNAL" nozzle as this may lead to damage of the electronics.

The dry air supply must be used additionally to the drying cartridge, if the measuring temperature is more than 5°C lower than the ambient temperature.

Following specifications of the applied air are required:

- 0.2 to 0.3 bar (2.9 to 4.4 psi)
- Class 5 from ISO 8573-1
- Max. particle size: 40 µm
- Max. pressure dew point: +7°C (44.6 °F)
- Max. oil content: 25 mg/m^3

Appendix B: Technical Data

Measuring range:	0 to 3 g/cm^3
Repeatability, s.d.:	
Density:	5 x 10^{-5} g/cm^3
Temperature:	0.02 °C
Measuring temperature:	+15 to +50 °C (+59 to +122 °F)
Pressure range:	0 to 10 bars (0 to 150 psi)
Environmental conditions (EN 61010):	Indoor use only
Ambient temperature:	+15 to +35 °C (+59 to +95 °F)
Air humidity:	10 to 90 % relative humidity, non-condensing
Pollution degree:	2
Overvoltage category:	II
Amount of sample in the measuring cell:	Approx. 1ml
Typical measuring time per sample:	approx. 40 seconds
Sample throughput:	10 to 40/hour
Dimensions (L x W x H):	440 x 315 x 220 mm
Weight:	approx. 20 kg
Power:	50 VA; mains voltage according to the technical data shield on the rear of the DMA 4000
Fuses:	Glass tube fuses 5 x 20 mm; DIN 41662; 230 V, T 800 mA

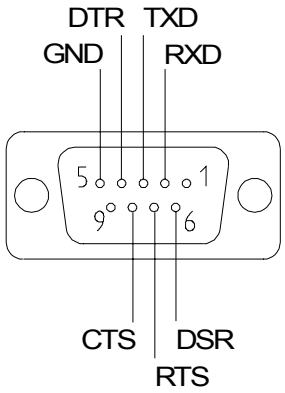
Important:
All interfaces are designed to comply with SELV (Separated Extra Low Voltage) requirements according to EN 60950. Interfaces which do not comply to SELV requirements must not be connected.

Computer/printer interface (COM1):

- RS 232 C
- 1200 to 19200 baud
- 1 stop bit
- 7 or 8 data bits
- no, odd or even parity
- hardware, software or no handshake

Factory default settings:

baud rate:	9600
format:	E71
handshake:	Hardware (RTS/CTS)
line delimiter:	<CR><LF>
data delimiter:	; (semicolon)
host mode:	PRINTER



RXD receive data
TXD transmit data
DTR data terminal ready
GND signal ground (connected to earth)
DSR data set ready
RTS request to send
CTS clear to send

Keyboard interface: PC/AT interface

Appendix C: Wetted Parts

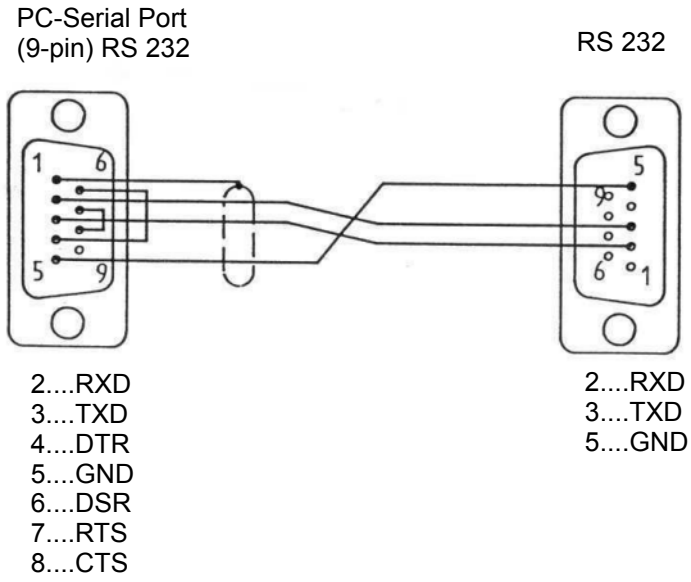
The following materials are in contact with the sample and the cleaning agents:

Material	**Part**
Borosilicate glass	Measuring cell
PTFE	Filling adapter

Appendix D: Commands for Communication between PC and DMA 4000

- Via the interface COM1, data stored in the memory can be transferred to a PC. In addition a limited remote control of the DMA 4000 is possible (e.g. changing temperature or changing measurement settings).
- Connect COM1 on the DMA 4000 and the RS 232 C interface at the PC, using a proper interface cable (see Appendix B).
- Synchronize the interface settings of the DMA 4000 and the PC (see chapter 11.2.6).
- The communication can be tested using a simple interface program, e.g. Windows Terminal, Procomm or Hyper Terminal.
- Commands consisting of several words can be entered with or without blanks (e.g. "get data ↵" or "getdata↵").
- Each set of measuring results transferred by "getdata↵" will be marked (see chapter 11.2.8) in the memory with "fetched by host: yes/no" and in the printout with "fetched by host: yes".
- If a sample changer SP-1m or SP-3m is connected and activated, a measurement cannot be started, continued or aborted via PC.
- For data communication software please contact your local distributor or Anton Paar GmbH.

Interface cable DMA 4000 - PC:



PC command	DMA 4000 response	Comments
$ 4000↵	unlocked	The DMA 4000 is set to the "unlocked" mode.
$ locked↵	locked	The DMA 4000 is set to the "locked" mode.

PC command	DMA 4000 response	Comments
help↵	Currently Available Commands: GetData,GetDataHead, GetDataUnit,GetId, GetMethodName, GetRawData,ResetData, SelectMethod, abort, continue, finished, help, start,	If the command "help" is sent from the PC, the DMA 4000 responds with a list of available commands.
GetData↵	no new data available 2001 06 06,10:45, SAMPLE 1,1,20.00, 0.9911,0.00, 0.0000,valid	No new data available. Transfer of the first available measuring result.
GetDataHead↵	date, time, samplenumber, ready, actual cell temperature, density, conc. (Brix), apparent density, condition	This is the response, if conc. °Brix and apparent density are selected in "method settings", "display assignment".
GetDataUnit↵	YYYY MM DD,hh:mm,,,,C, g/cm3,Brix, g/cm3,	The unit of the selected items is transferred, separated by the selected delimiter.
GetId↵	serial number: 443074, DMA4000 V:1.200	Serial number of the DMA 4000, Softwareversion.
GetMethodName↵	M3-BRIX	Name of the activated method.
GetRawData↵	Q,20.01,20.00,SAMPLE 1	Q, actual cell temperature, set cell temperature, sample name
ResetData↵	reset data successful	Resets read data to the "not fetched" status, e.g. for a second data transfer (see chapter 11.2.8).
SelectMethod 1↵	M1-DENSITY number out of range	Method 1 is activated. This is the response if a number 4 or higher has been entered.
abort ↵	measurement aborted measurement not started measurement not aborted	This aborts the started measurement. No measurement was started. Response if an SP-1m or SP-3m sample changer is connected. A measurement cannot be aborted by remote control.

PC command	DMA 4000 response	Comments
continue ↵	measurement continued	The measurement is continued.
	measurement not finished	The previous measurement has not been finished.
	measurement not started	Response if an SP-1m or SP-3m sample changer is connected. A measurement cannot be continued by remote control.
finished ↵	measurement not finished	A measurement is already under progress.
	measurement not started	A measurement has not been started.
	measurement finished	A measurement has been finished.
start ↵	measurement started	Remote start of the measurement
	measurement already started	A measurement has already been started.
	measurement not started	Response if an SP-1m or SP-3m sample changer is connected. A measurement cannot be started by remote control.

Appendix E: Density Tables

Density of Dry Air

At the temperature t in [°C] and the pressure p in [mbar] or [hPa], the density r of air in [g/cm³] is calculated using the following formula[1]:

$$\rho = \frac{0.0012930}{1 + 0.00367 \times t} x \frac{p}{1013.25}$$

The numbers are valid for a CO_2 content in air of 0.03 % by volume; the numbers change by ±1/19000 for every change in CO_2 volume content of ±0.0001.

Density of Dry Air[2] (10 °C to +60 °C)

Composition of dry air in [v/v]: 78.110 % N_2; 20.938 % O_2; 0.916 % Ar; 0.033 % CO_2; 0.002 % Ne

Meas. temp. in °C	Density in g/cm³ at the pressure in mbar (=hPa)							
	900	920	940	960	980	1000	1013.25	1050
10	0.001108	0.001132	0.001157	0.001182	0.001206	0.001231	0.001247	0.001293
15	0.001088	0.001113	0.001137	0.001161	0.001185	0.001210	0.001226	0.001270
20	0.001070	0.001094	0.001117	0.001141	0.001165	0.001189	0.001205	0.001248
25	0.001052	0.001075	0.001099	0.001122	0.001145	0.001169	0.001184	0.001227
30	0.001035	0.001058	0.001081	0.001104	0.001127	0.001150	0.001165	0.001207
35	0.001018	0.001040	0.001063	0.001086	0.001108	0.001131	0.001146	0.001187
40	0.001001	0.001024	0.001046	0.001068	0.001090	0.001113	0.001127	0.001168
45	0.000986	0.001008	0.001029	0.001051	0.001073	0.001095	0.001110	0.001150
50	0.000970	0.000992	0.001014	0.001035	0.001057	0.001078	0.001093	0.001132
55	0.000956	0.000977	0.000998	0.001019	0.001041	0.001062	0.001076	0.001115
60	0.000941	0.000962	0.000983	0.001004	0.001025	0.001046	0.001060	0.001098

1. Literature: Kohlrausch: Praktische Physik, Bd. 3, Tafeln, 22. Auflage (1968), pg. 39, B.G Teubner Stuttgart.
2. Literature: Excerpt from Tab. 3, DIN 51 757 (04.1994): Prüfung von Mineralöl und verwandten Stoffen. Bestimmung der Dichte. p. 11.

Density of Water (10 °C to 60 °C)

t°C	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
10	0.999699	0.999691	0.999682	0.999672	0.999663	0.999654	0.999644	0.999635	0.999625	0.999615
11	0.999605	0.999595	0.999584	0.999574	0.999563	0.999553	0.999542	0.999531	0.999520	0.999508
12	0.999497	0.999486	0.999474	0.999462	0.999450	0.999438	0.999426	0.999414	0.999402	0.999389
13	0.999377	0.999364	0.999351	0.999338	0.999325	0.999312	0.999299	0.999285	0.999271	0.999258
14	0.999244	0.999230	0.999216	0.999202	0.999187	0.999173	0.999158	0.999144	0.999129	0.999114
15	0.999099	0.999084	0.999069	0.999053	0.999038	0.999022	0.999006	0.998991	0.998975	0.998959
16	0.998942	0.998926	0.998910	0.998893	0.998876	0.998860	0.998843	0.998826	0.998809	0.998792
17	0.998774	0.998757	0.998739	0.998722	0.998704	0.998686	0.998668	0.998650	0.998632	0.998613
18	0.998595	0.998576	0.998558	0.998539	0.998520	0.998501	0.998482	0.998463	0.998443	0.998424
19	0.998404	0.998385	0.998365	0.998345	0.998325	0.998305	0.998285	0.998265	0.998244	0.998224
20	0.998203	0.998182	0.998162	0.998141	0.998120	0.998099	0.998077	0.998056	0.998035	0.998013
21	0.997991	0.997970	0.997948	0.997926	0.997904	0.997882	0.997859	0.997837	0.997815	0.997792
22	0.997769	0.997747	0.997724	0.997701	0.997678	0.997654	0.997631	0.997608	0.997584	0.997561
23	0.997537	0.997513	0.997490	0.997466	0.997442	0.997417	0.997393	0.997369	0.997344	0.997320
24	0.997295	0.997270	0.997246	0.997221	0.997196	0.997170	0.997145	0.997120	0.997094	0.997069
25	0.997043	0.997018	0.996992	0.996966	0.996940	0.996914	0.996888	0.996861	0.996835	0.996809
26	0.996782	0.996755	0.996729	0.996702	0.996675	0.996648	0.996621	0.996594	0.996566	0.996539
27	0.996511	0.996484	0.996456	0.996428	0.996401	0.996373	0.996345	0.996316	0.996288	0.996260
28	0.996232	0.996203	0.996174	0.996146	0.996117	0.996088	0.996059	0.996030	0.996001	0.995972
29	0.995943	0.995913	0.995884	0.995854	0.995825	0.995795	0.995765	0.995735	0.995705	0.995675
30	0.995645	0.995615	0.995584	0.995554	0.995523	0.995493	0.995462	0.995431	0.995401	0.995370
31	0.995339	0.995307	0.995276	0.995245	0.995214	0.995182	0.995151	0.995119	0.995087	0.995056
32	0.995024	0.994992	0.994960	0.994928	0.994895	0.994863	0.994831	0.994798	0.994766	0.994733
33	0.994700	0.994667	0.994635	0.994602	0.994569	0.994535	0.994502	0.994469	0.994436	0.994402
34	0.994369	0.994335	0.994301	0.994268	0.994234	0.994200	0.994166	0.994132	0.994097	0.994063
35	0.994029	0.993994	0.993960	0.993925	0.993891	0.993856	0.993821	0.993786	0.993751	0.993716
36	0.993681	0.993646	0.993610	0.993575	0.993540	0.993504	0.993469	0.993433	0.993397	0.993361
37	0.993325	0.993289	0.993253	0.993217	0.993181	0.993144	0.993108	0.993072	0.993035	0.992998
38	0.992962	0.992925	0.992888	0.992851	0.992814	0.992777	0.992740	0.992703	0.992665	0.992628
39	0.992591	0.992553	0.992515	0.992478	0.992440	0.992402	0.992364	0.992326	0.992288	0.992250
40	0.992212	0.992174	0.992135	0.992097	0.992058	0.992020	0.991981	0.991942	0.991904	0.991865
41	0.991826	0.991787	0.991748	0.991708	0.991669	0.991630	0.991590	0.991551	0.991511	0.991472
42	0.991432	0.991392	0.991353	0.991313	0.991273	0.991233	0.991193	0.991152	0.991112	0.991072
43	0.991031	0.990991	0.990950	0.990910	0.990869	0.990828	0.990787	0.990747	0.990706	0.990665
44	0.990623	0.990582	0.990541	0.990500	0.990458	0.990417	0.990375	0.990334	0.990292	0.990250

t°C	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
45	0.990208	0.990166	0.990125	0.990083	0.990040	0.989998	0.989956	0.989914	0.989871	0.989829
46	0.989786	0.989744	0.989701	0.989658	0.989616	0.989573	0.989530	0.989487	0.989444	0.989401
47	0.989358	0.989314	0.989271	0.989228	0.989184	0.989141	0.989097	0.989053	0.989010	0.988966
48	0.988922	0.988878	0.988834	0.988790	0.988746	0.988701	0.988657	0.988613	0.988568	0.988524
49	0.988479	0.988435	0.988390	0.988345	0.988301	0.988256	0.988211	0.988166	0.988121	0.988076
50	0.988030	0.987985	0.987940	0.987894	0.987849	0.987803	0.987758	0.987712	0.987666	0.987621
51	0.987575	0.987529	0.987483	0.987437	0.987391	0.987345	0.987298	0.987252	0.987206	0.987159
52	0.987113	0.987066	0.987020	0.986973	0.986926	0.986879	0.986832	0.986785	0.986738	0.986691
53	0.986644	0.986597	0.986550	0.986502	0.986455	0.986408	0.986360	0.986313	0.986265	0.986217
54	0.986169	0.986122	0.986074	0.986026	0.985978	0.985930	0.985881	0.985833	0.985785	0.985737
55	0.985688	0.985640	0.985591	0.985543	0.985494	0.985445	0.985397	0.985348	0.985299	0.985250
56	0.985201	0.985152	0.985103	0.985054	0.985004	0.984955	0.984906	0.984856	0.984807	0.984757
57	0.984707	0.984658	0.984608	0.984558	0.984508	0.984458	0.984408	0.984358	0.984308	0.984258
58	0.984208	0.984158	0.984107	0.984057	0.984006	0.983956	0.983905	0.983855	0.983804	0.983753
59	0.983702	0.983651	0.983601	0.983550	0.983498	0.983447	0.983396	0.983345	0.983294	0.983242
60	0.983191	0.983139	0.983088	0.983036	0.982985	0.982933	0.982881	0.982829	0.982777	0.982725

Literature: Spieweck, F. & Bettin, H.: Review: Solid and liquid density determination. Technisches Messen 59 (1992), pp. 285-292.

Appendix F: Possible Adjustment Errors, Adjustment Report

Cause	Correction
Direct sunlight on the DMA 4000.	Make sure that the DMA 4000 is not exposed to direct sunlight.
The measuring cell is not clean.	Make sure that the measuring cell is perfectly cleaned before adjustment.
The measuring cell was not perfectly dry before air adjustment. There are drops of liquid or humidity condensation in the measuring cell (check through the window).	• Clean the measuring cell again according to chapter 10 and dry it carefully. • If condensation is still visible through the visual control of the measuring cell, then the atmospheric humidity is too high. Connect a drying cartridge (desiccator) to the "DRY AIR PUMP" nozzle (see Appendix A).
There are gas bubbles in the measuring cell.	• Slowly inject the adjustment liquid into the measuring cell. • The temperature of the adjustment liquid must be equal to or slightly above the measuring temperature.
"timeout error": No valid density value can be measured.	• Make sure there are no gas bubbles in the measuring cell. • The measuring cell is not sufficiently dry before adjustment. • Clean the measuring cell according to chapter 10 and dry it carefully.
"adjustment error": The deviation of the determined density coefficient "KBg" exceeds $1x10^{-3}$ g/cm^3 compared to the previous adjustment.	• Make sure there are no gas bubbles in the measuring cell. • Clean the measuring cell according to chapter 10 and dry it carefully. • Check that the correct value for the air pressure is typed in.

Adjustment Report

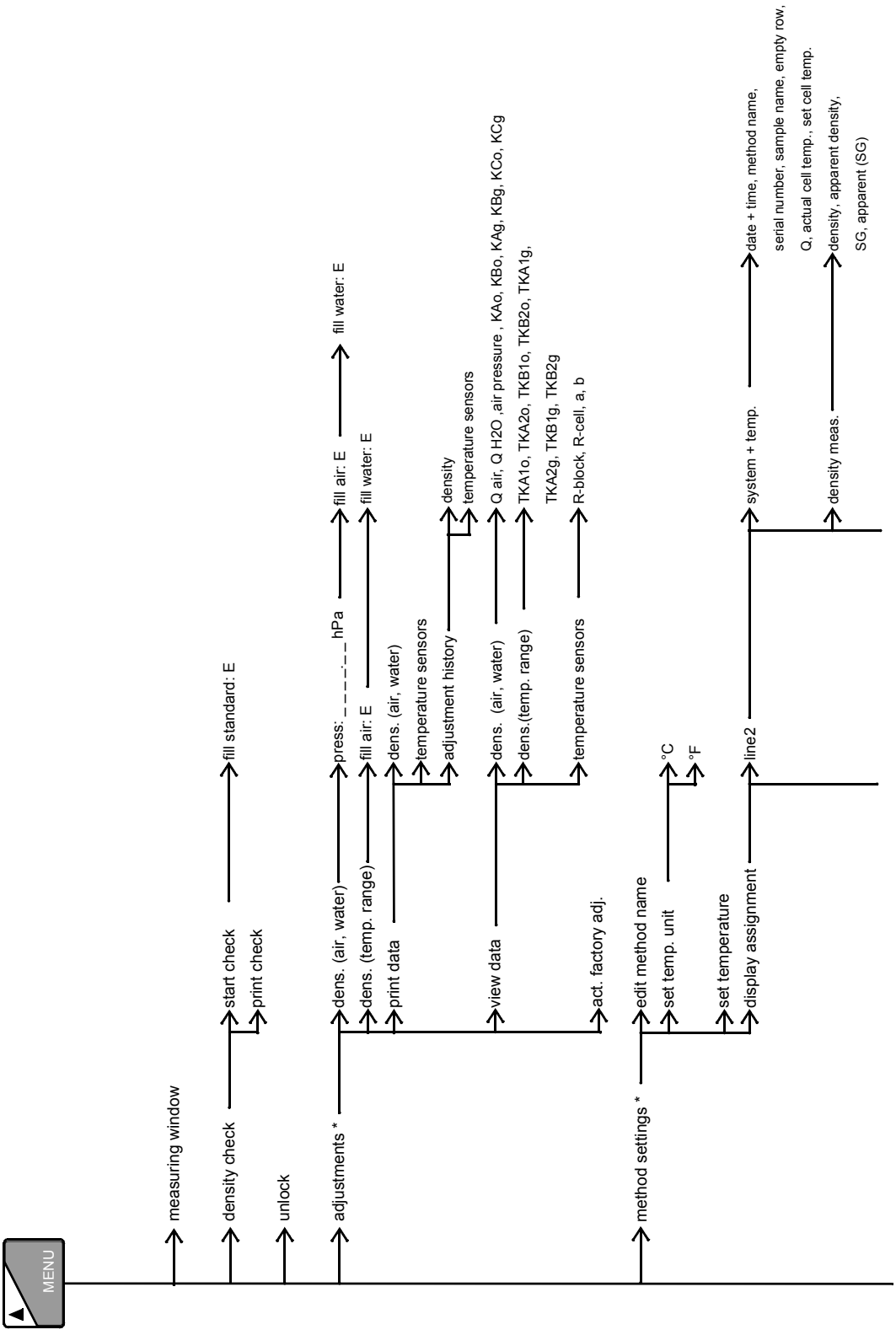
Serial number of the DMA 4000:

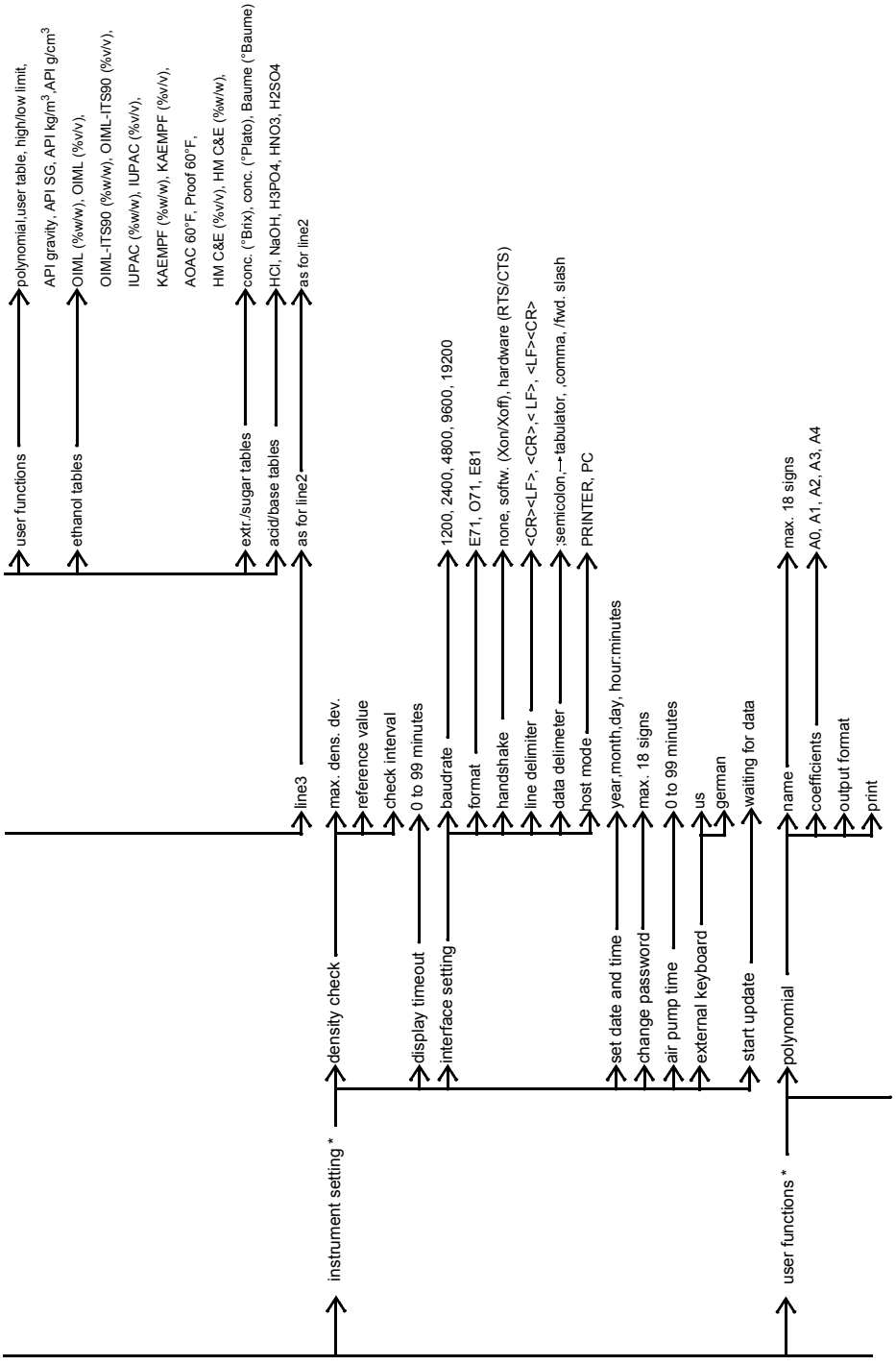
Date	Temperature	Period Q		Apparatus Constants				Signature
		Air	Water	KAo	KBo	KAg	KBg	

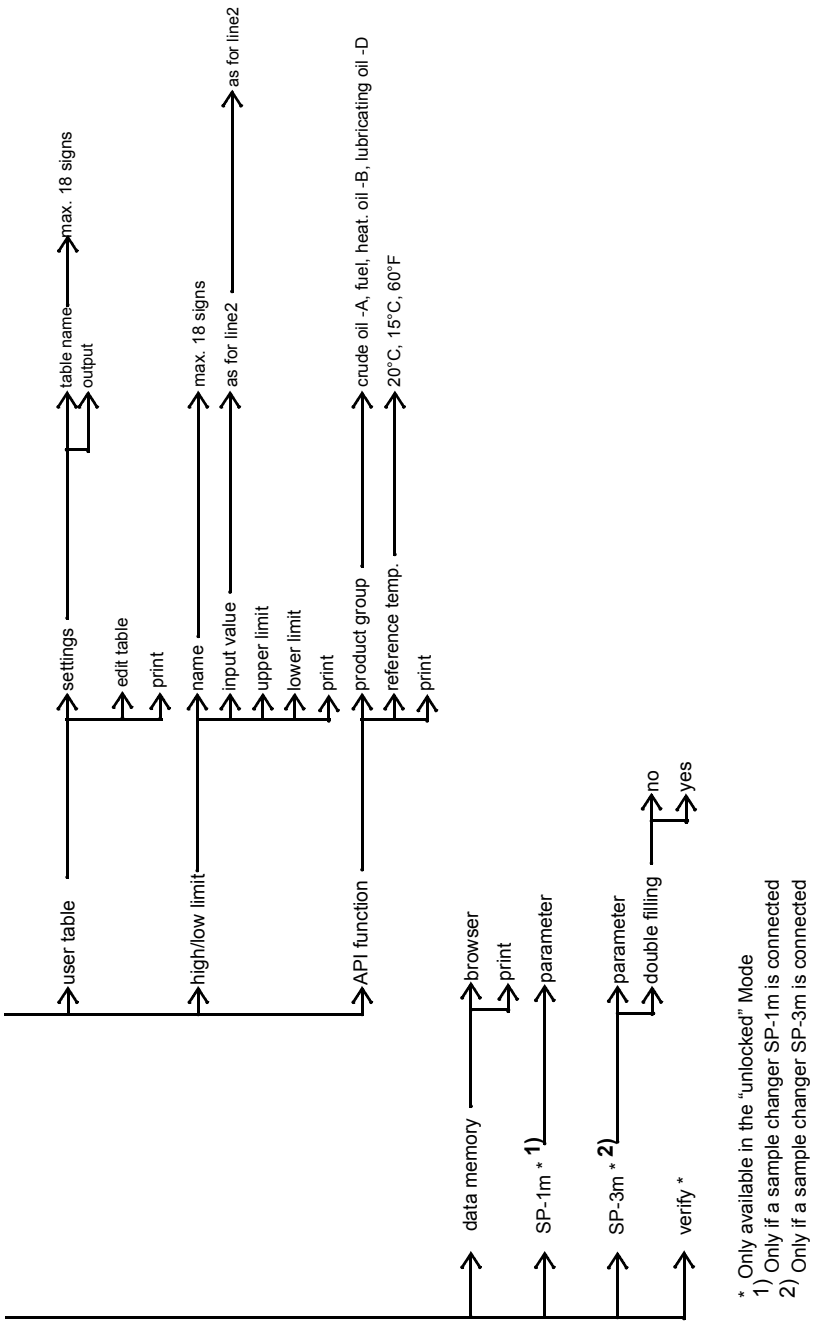
Appendix G: Software Versions

Software version	Date of release	Document number	Comments
V1.000	29.04.2002	B87IB02A	First software release.
V1.100	22.07.2002	B87IB02B	• API g/cm^3. • Measurement frozen after "START". • Time out. • German software version.
V1.200	29.11.2002	B87IB02C	• Supports filling with sample changer SP-1m or SP-3m.
V1.202	17.03.2003	B87IB02D	• Software failure: loss of data from the density check history and adjustment history when backdating the system clock is eliminated. • Optional saving of adjustments with too high deviation of KBg values.
V1.203	29.09.2004	B87IB02E B87IB02F	• Extended limits for raw data measurement. • Problems with editing customer table corrected. • Problems with display of method-specific customer functions corrected.

Appendix H: Menu Tree




user functions
polynomial,user table, high/low limit,
API gravity, API SG, API kg/m³,API g/cm³
ethanol tables
OIML (%w/w), OIML (%v/v),
OIML-ITS90 (%w/w), OIML-ITS90 (%v/v),
IUPAC (%w/w), IUPAC (%v/v),
KAEMPF (%w/w), KAEMPF (%v/v),
AOAC 60°F, Proof 60°F,
HM C&E (%v/v), HM C&E (%w/w),
extr./sugar tables
conc. (°Brix), conc. (°Plato), Baume (°Baume)
acid/base tables
HCl, NaOH, H3PO4, HNO3, H2SO4
as for line2
as for line2
line3
instrument setting *
density check
max. dens. dev.
reference value
check interval
display timeout
0 to 99 minutes
interface setting
baudrate
1200, 2400, 4800, 9600, 19200
format
E71, O71, E81
handshake
none, softw. (Xon/Xoff), hardware (RTS/CTS)
line delimiter
<CR><LF>, <CR>, <LF>, <LF><CR>
data delimeter
;semicolon,→tabulator, ,comma, /fwd. slash
host mode
PRINTER, PC
set date and time
year,month,day, hour:minutes
change password
max. 18 signs
air pump time
0 to 99 minutes
external keyboard
us
german
start update
waiting for data
user functions *
polynomial
name
max. 18 signs
coefficients
A0, A1, A2, A3, A4
output format
print


user table
settings
table name
max. 18 signs
output
edit table
print
high/low limit
name
max. 18 signs
input value
as for line2
upper limit
lower limit
print
API function
product group
crude oil -A, fuel, heat. oil -B, lubricating oil -D
reference temp.
20°C, 15°C, 60°F
print
data memory
browser
print
SP-1m * 1)
parameter
SP-3m * 2)
parameter
double filling
no
yes
verify *
* Only available in the "unlocked" Mode
1) Only if a sample changer SP-1m is connected
2) Only if a sample changer SP-3m is connected

Index

S

T

U

V

W