Battery Tester and Charger

c u r a t i o ®

A P L - 4

Operating Instructions

Contents

1 ! Caution !   ! Please read !

⇒ **Read these operating instructions carefully. Damages that occur due to handling errors or because the instructions of the manual were disregarded, will terminate any warranty claims. We are not liable for consequential damages.**

⇒ **Before opening the device, please unplug the power cable and disconnect all batteries.**

⇒ **Caution! The heat sink and the transformer may be hot!**

⇒ **The charging device must be set up in a way that ensures proper ventilation through the ventilation flaps and the removal of warm air.**

⇒ **Protect the device from humidity.**

⇒ **Before installing a battery block to the *curatio* please verify all programmed values such as battery type, number of cells and current. Incorrect programming of these values could lead to destruction of the battery or in the worst case to explosion or fire.**

⇒ **APL-4 with external memory: plug in the charging adapter first, then tighten the screws of the 15-pin plug and then install the battery. Before unplugging the external charging adapter, first take the battery out of the battery adapter and then unplug the charging adapter.**

⇒ **If battery cells, which were purchased and used as single units instead of block units, are supposed to be installed in the *curatio* device, ensure that each cell is in the same charging condition and has the same cell capacity. This means that the cells need to be selected. Different charging conditions of battery cells could damage the cells during charging and discharging and will most probably make it impossible to recognize the correct end of the charging procedure.**

⇒ **If an error occurs – e.g. if both the red and the green LED indicator blink simultaneously – do not connect any new batteries.**

⇒ **Always connect minus and plus poles of a battery at the same channel.**

⇒ **Do not connect voltages larger than 24V to the charging connector.**

2   Technical Specifications

According to the design of the charger device, the batteries are connected either via two 4-mm safety plugs or a 15-pin D-connector. The APL-4 is protected against incorrect polarization during the connection process.

For the 15-pin design, the discharging/charging program for the battery is saved in an external EEPROM. When changing the plug or the battery adapter respectively, the program that was saved in the EEPROM is loaded into the *curatio* APL-4 and runs as soon as the battery is connected.

When loading Nickel-Cadmium (NiCd) batteries and Nickel-Metal-Hydride (NiMH) batteries you can choose either "reverse pulse" charging current or continuous charging current. The end of charging is recognized via –Delta/V.

Serial interface 9600 bps, 7 data bits, even parity, 1 stop bit, 9-pin D-connector.

Maximum charging voltage: 22.0 Volt.

The following battery types can be discharged and charged: NiCd and NiMH batteries with 1 to 12 cells, Lithium-Ion (Li-Ion) batteries and Polymer batteries with 1 to 5 cells and lead batteries with 1 to 9 cells.

Maximum discharging and charging current for each channel is 2.0A. Discharging and charging currents can be set individually in 5mA intervals, from 10mA to 2.0A. Total charging power: 8.0A.

Mains supply: 100 - 240VAC 50/60Hz 200VA.

Power supply switch with inlet connector for non-heating apparatus and fuse are found on the rear of the device.

Mains fuse: 3,15/inert 250V

Power cable with connector for non-heating apparatus, 1.5 m

Measurements: 350mm x 290mm x 110mm (WxLxH)

Weight: 5.9 kg

curatio is a Latin word meaning maintenance and care.

3   Introduction

The product *curatio* APL-4 is a universal charging and discharging device, controlled by microprocessors.

The *curatio* is controlled via four push keys. The Parameters are displayed via an illuminated LCD with 16 x 2 characters. Two LED's per channel are reserved for the indication of operation.

For the *curatio* APL-4 the charging/discharging program for the batteries is saved by 4mm safety plugs with no-volt protection, within the charging device.

For the APL-4 with a 15-pin D-plug to connect the batteries, the discharging and charging program for the batteries is saved in an EEPROM of the 15-pin D-connector or the external battery adapter. When changing the plug or the battery adapter respectively, the program that was saved in the EEPROM of the plug is loaded into the *curatio* APL-4, and runs as soon as the batteries are connected.

For each battery type a specific charging procedure is used which will disconnect the battery when it becomes fully charged. Correct programming of the device will prevent overloading of the battery blocks.

Charging and discharging currents can be set individually from 10mA to 2.0A in 5mA intervals.

All four channels can be operated simultaneously, each with a different battery program.

During charging and discharging the battery capacity is measured. The measured values are shown on the display and can be printed via the serial interface.

If an ideal capacity for a battery is programmed, the report "Battery OK/faulty" is displayed.

Batteries can be checked for self-discharging (one hour to 200 days).

It is possible to automatically switch to "Trickle Charge" after the battery is "Charged".

For batteries which suffer from capacity loss (memory effect), you can program the operation "Forming". During this operation, the battery is discharged and charged multiple times. For batteries with memory effect the capacity values are improved with each operation.

The *curatio* automatically recognizes when a battery is connected, and executes the programmed operation accordingly.

The battery blocks can remain connected when the device is switched off. The device will not be damaged. The internal resistance value of the *curatio* is approximately 50kOhm.

Using the PC software "*curatio*WIN3", the *curatio* APL-4 can be programmed via a personal computer. The batteries are managed via a database. The battery data are displayed on the PC monitor numerically and graphically.

4   Switching on the Battery Tester and Charger

Use the power switch to switch the *curatio* on and off.

After switching the *curatio* on , the following message will be displayed for approximately 2 seconds:

b		d		s			G	m	b	H					
A	P	L	-	4		V		x	.	x	x			G	x

V x.xx stands for the software release number, G x stands for the GAL version.
(During operation the release number can be displayed by constantly holding down the key "-".)

After that the *curatio* carries out a self-test .

After switching the *curatio* on for the first time, after changing the EPROM (depending on the release number), or after data loss in the EEPROM a basic setting is loaded (Nickel-Cadmium battery, charge with 200mA).

After repeatedly switching the *curatio* on and off, the values programmed at that time are used for further operation.

After the charger is switched on, the CPU, the EEPROM and the hardware are tested and possible errors are displayed. The LED's are switched on for a short time. After the device is switched on and during the self-test the ventilator inside of the charger is running.

If no error is reported, the following message is shown on the display window:

S	e	l	f		t	e	s	t		O	K				

The programmed operation will not be executed immediately, if a battery was connected before the device was switched on. The operation will start automatically after approximately 30 minutes, the reason being, that a voltage failure that occured shortly before the charging operation is finished, might not be recognized. The battery could be overcharged.

Installing a new EPROM version will – depending on the release number – lead to the display message "New EEPROM loaded" and to the message that parameters are loaded. If the message "New EEPROM loaded" is shown, the control parameters, the currents and the voltage have to be adjust. This message can be deleted by pressing the key " Anzeige/Zurück ".

Caution! Do not connect a battery block until the control parameters are adjust!

Each time the device is switched on, the following display message will appear, if the parameters were not adjust:

P	a	r	a	m	e	t	e	r							
A	d	j	u	s	t		!	!	!	!					

If a malfunction occurs during the operation, the channel is switched off and the message "WATCHDOG RESET" is shown. After this message has been shown for approximately 30 seconds, the operation is continued as programmed, just as if the device had been switched on . This message can be deleted by pressing the key "Anzeige/Zurück".

5   Programming

For the *curatio* APL-4 with 4mm safety plugs inside the charging device, the discharging and charging program for batteries is saved in an EEPROM, with no-volt protection.

For the APL-4 with a 15-pin D-plug for battery connection, the discharging/charging program for the batteries is saved in the 15-pin D-plug or or the external battery adapter. When changing the plug or the battery adapter respectively, the program that was saved in the EEPROM of the plug is loaded into the *curatio* APL-4 and runs as soon as the battery is connected.

When using the battery adapter with the 15-pin D-plug the *curatio* does not need to be re-programmed when changing the adapter. The battery program that is saved in the plug will be automatically executed.

Programming the *curatio* APL-4:

Use the keys "+" and "-" to choose the desired channel (A 1 to 4).

Use the key "Programmieren" to retrieve the programming mode. When in the programming mode, use the key " Programmieren " to jump to the next programming step. The keys "+" and "-" will change the values.
Use the key "Anzeige/Zurück" to terminate the programming mode. Earlier changes in the programming mode will not be included.

By pressing the key " Programmieren " the display will show the following message:

P	r	o	g	r	a	m	m	i	n	g	:				

The message "Programming" will be shown in the first display line as long the key " Programmieren " is being held. Then the Cursor will blink in the second display line. During this programming step the battery type is programmed. The second display line will show the current battery type that is being programmed. Select the desired battery type by hitting the keys "+" or "-".

By pressing the key "+" the battery types will be displayed successively as follows:
Nickel-Cadmium, Nickel-Metal-Hydride, Lithium-Ion (Polymer), Lead battery, set voltage.

A	1		B	a	t	t	e	r	y		T	y	p		
N	i	c	k	e	l	-	C	a	d	m	i	u	m		

Using the operation "set voltage" the individual final charging or discharging voltage can be entered. During the operation the battery is charged with a continuous charging current.

After choosing the desired battery type, press the key " Programmieren " again.
Now the desired operation can be programmed.

A	1		M	o	d	e	:								
C	h	a	r	.	-	D	c	g	.	-	C	h	a	r	.

By pressing the key "+" the operations will be displayed successively as follows:
Charge, Discharge, Discharge-Charge, Char.-Dcg.-Char., Conditionin, Disch--Char xx Day, Keys set mode.

"Charging" means that the battery is charged only. **"Discharging"** means that the battery is discharged only**. " Char.-Dcg.-Char."** will charge the battery, discharge it and then charge it again. **" Conditioning"** will execute the operation "Discharge-charge" multiple times. **" Disch-Char xx Day"**

will discharge the battery and then charge it again. The battery will be discharged and charged according to the number of days programmed. In between those programmed days, trickle charge is carried out.

When you choose **" Keys set mode",** the desired operation is executed via keys after the connection of a battery block to the APL-4. If " Keys set mode " was programmed, the next entry is the number of cycles for the operation "Conditioning".

After a battery block has been charged and all programmed operations are finished, trickle charge is carried out automatically. The end of the operation is indicated via display and the LED "End of program".

If you chose the operation " Conditioning ", the display will show the following message after you hit the key "Programmieren" once more:

A	1		M	o	d	e	:								
C	o	n	d	i	t	i	o	n	i	n		A	u	t	o

Choose the keys "+" or "-" to program the number of charging or discharging cycles.
It is possible to choose two to six discharging or charging cycles, or set the value to "Auto". After each discharging operation, the operation "Auto" will compare the measured capacity with the previously measured capacity. If the new value is a minimum of 2 % greater, the discharging operation will be repeated. If the new value is smaller than 2 %, the operation will be terminated after the new charging operation has begun and will be switched to trickle charge. The function "Auto" will discharge and charge the battery at least twice. There is no limitation to the number of cycles.

The next step will program the number of cells.

The first display line will show the nominal voltage of the chosen battery type. The second display line will show the number of cells. Example: Nickel-Cadmium battery with a nominal voltage of 1.2V per cell and a default of six cells:

A	1		B	a	t	t	.				7	.	2	V	
C	e	l	l	s						6					

Use the key " Programmieren" to get to the next step.

If the operation "Set voltage" was chosen earlier (when the battery type was requested), the display will ask you to enter the voltage values now. In this case the number of cells cannot be programmed. If the program was set on charging only, the final charging voltage has to be entered. If the battery only needs to be discharged, the final discharging voltage has to be entered. If the battery is supposed to be discharged and charged, both final discharging and charging voltages have to be entered. The smallest programmable value for voltages is 0.9V; the maximum value is 22.0V. Enter the values in 10mV steps. Pressing the key " Programmieren" will save the programmed values and take you to the next step.

A	1		C	h	a	r	g	e							
v	o	l	t	a	g	e		1	5	.	0	3	0	V	

A	1		D	i	s	c	h	a	r	g	e				
v	o	l	t	a	g	e			6	.	1	2	0	V	

The next step will program the charging current.

A	1		C	h	a	r	g	e	c	u	r	r	e	n	t
			1	.	2	0	0	A							

Enter the desired charging current in 5mA intervals with the keys "+" and "-".

The next program step will program the discharging current.

A	1		D	i	s	c	h	a	r	g	e		c	u	r	r
			2	.	2	0	0	A								

The discharging current should correlate with the current used for operating the battery.

Now the nominal capacity can be entered.

A	1		B	a	t	t	.		c	a	p	a	c	i	t	y
P	r	o	g	.		-			N	o		+		Y	e	s

Pressing the key "-" will skip the entering of the capacity value. Use the key "+" to enter the battery capacity.

A	1		B	a	t	t	.		C	a	p	a	c	i	t	y
							3	.	5	0	0	A	h			

Use the keys "+" or "-" to enter battery capacity values between 10mAh and 40Ah.

Pressing the key „Programmieren" will allow you to set the percentage of capacity for the message "battery OK/faulty".

A	1		m	i	n	.		c	a	p	a	c	i	t	y	
B	a	t	t	e	r	y			O	K				8	0	%

Use the keys "+" or '-" to enter the percentage for the message "Battery OK/faulty".

After a battery is discharged, the capacity that was measured while it was discharged is compared to the programmed nominal capacity. Depending on the set percentage the battery is displayed as OK or faulty. After the programming is finished the LED "End of program" also shows the battery condition. A blinking LED indicates a faulty battery. A constantly illuminated LED shows that the condition of the battery is OK.

Use the key "Programmieren" to jump to the display message, which will prompt you for the self-discharging test of the battery.

A	1		S	e	l	f	-	d	i	s	c	h	g	r	.	
t	e	s	t			-			N	o		+	+	Y	e	s

Hit the key "-" to skip entering data. Hit the key "+" to enter the period after which self-discharging is tested.

A	1				P	r	o	g	r	a	m	m	l	n	g	
-		D	a	y	s				+		H	o	u	r	s	

Hit the key "-" to enter how long it is until the test is executed in days, and hit the key "+" to enter how long it is in hours.

A	1		T	e	s	t		s	e	l	f		d	c	.
a	f	t	.			2	0		h	o	u	r	(	s	)

The keys "+" and "-" enable the setting of a period of 1 to 200 hours and 1 to 200 days respectively.

If the test is programmed for the measurement of **self-discharging** of the battery, the display will show the time left before the operation will be executed. When the programmed time has expired, the battery is discharged and charged again. During the discharging operation, the measured capacities before and after the programmed time are compared. The difference is shown as the self-discharging value of the battery. Any small discharge of the battery as a result of the internal resistance of the adapter is taken into consideration when calculating the values of the self-discharging operation.

Hitting the key "Programmieren" will offer you the option of selecting the extended programming mode.

A	1		E	x	t	.		p	r	o	g	r	a	m	
m	o	d	e				-	N	o		+		Y	e	s

The key "+" will select the extended programming mode. The key "-" or "Programmieren" will not select the extended programming mode.

The extended programming mode is described in the next chapter.

When all the steps are programmed, the following message is displayed:

D	a	t	a		s	a	v	e							
w	i	t	h			P	r	o	g	r	a	m	m		

Hitting the key "Programmieren" will save the programmed values in the EEPROM. These values are not lost when the device is switched off. The key "Anzeige/Zurück" will remove the changes and preserve the old values. The display will show the current operation condition of the channel. The device is in basic position.

After you hit the key „Programmieren", the display will briefly show the following message.

D	a	t	a		i	n		E	E	P	R	O	M		
s	a	v	e	d											

Then the current operation condition of the channel is shown. If the battery type, the operation or the number of cells have been changed compared to the basic settings, the *curatio* will operate as if the battery block had been disconnected and newly installed. The running charging operation is terminated and the newly programmed operation is executed. If only the charging or discharging current was modified, the new current is adjusted to the new value and the running charging or discharging operation will not be interrupted.

Caution! When a battery has almost finished charging , it may become overloaded as the end of charging is not always recognized exactly.
Risk of fire! Risk of Explosion!

In the programming mode a rapid adjustment of values can be achieved by permanently pushing the keys "+" or "-" .

The key "Anzeige/Zurück" will end the programming mode. The old values are preserved and the currently running charging or discharging operations are not influenced.

The programming mode will automatically terminated when no key is hit for more than 60 seconds. The old programmed values will be preserved and the current charging or discharging operations will not be influenced.

5.1 Extended Programming Mode

In the extended programming mode, first the condition for "End of Charging" by loading via I/U characteristic is entered.

A	1		C	h	a	r	g	e		e	n	d		I	/	U
															5	%

If the end of charging is determined via the I/U characteristic (by reducing the charging current), e.g. for lead batteries, the end of charging occurs when the charging current is down to a predetermined percentage of the programmed charging current. The basic setting for this value is 5 %. At a programmed charging current of 1.0A the end of charging would occur at a charging current of 50mA, should the percentage be set at 5 %.

Use the keys "+" and "-" to set a value between 1 % and 50 %. If you increase the percentage, the capacity that is loaded into the battery will increase. Decreased percentage will also lead to increased charging times.

Hit the key „Programmieren" to jump to the next step.

In this programming step it is possible to set the type of the charging current for Nickel-Cadmium batteries and for Nickel-Metal-Hydride batteries. For these batteries, you can choose "Charging with or without reverse pulse". When choosing "Charging without reverse pulse" the batteries are loaded with continuous current.

Hit the key "Programmieren" to jump to the next step.

A	1		D	i	s	c	h	a	r	g	e			
c	u	r	r	e	n	t		o	n					

Use the keys "+" and "-" to switch between "Measure discharge with current on" and "Measure discharge current off".
For the programmed value "Measure discharge with current on ", the battery voltage is measured while the discharging current is flowing.
For the programmed value "Measure discharge current off ", the battery voltage is measured during discharging breaks, when no discharging current is flowing. In this mode, the battery is discharged for approximately 10 seconds, then there is a charging break of approximately 1 second, during which the battery voltage is measured.

The next programming step the charging mode for lead batteries can be set. "Mode 1" will charge a lead battery with a charging voltage of 2.3V per cell. Charging time is limited to a maximum of 24 hours. Trickle charge is also executed with 2.3 V per cell. "Mode 2" will charge a lead battery with a charging voltage of 2.4V per cell. Charging time is limited to a maximum of 12 hours. Trickle charge is executed with 2.3V per cell.

The next programming step will set the charging mode for Lithium-Ion and Polymer batteries. "Mode 1" will charge the battery with a charging voltage of 4.1V per cell. "Mode 2" will charge the battery with a charging voltage of 4.2V. Charging time is limited to a maximum of 24 hours. Trickle charge is executed with the set charging voltage.

6   Charging Currents (Tips for Programming the Currents)

Most simple charging devices charge batteries with a charging current of C/10 of the battery capacity. For example, a battery with a capacity of 300mAh would be charged with a charging current of 30mA.

It is possiblie to charge most batteries with a larger current than C/10, using the switch-off method of the *curatio* Battery Testers and Chargers.

We recommend a charging current of C/3 for these batteries. A battery with 600mAh would thus be charged with 200mA.

Sometimes batteries can be charged with currents of 1C or higher. Charging currents that are set too high could lead to increased self-discharge.

The following batteries should not be charged with currents higher than C/10, even with our charging devices.

BOS areas: Bosch Stick Battery 12.0V 300mAh, 9V blocks.

New charging devices, which are included in the orders of battery-operated devices, sometimes also load with larger charging currents than C/10. Those charging currents can be set at the *curatio* Battery Tester and Charger devices as well.

The discharging current should match the current for battery operation.

7   External Program Memory

For the APL-4 with external memory: Always plug in the adapter and tighten its screws first, only <u>then</u> insert the battery.

After connection, the external memory displays the message "No charging adapter", and the battery program that was loaded into the external memory will only run when a key on the device is pushed, or when a battery is being inserted or when the personal computer sends a battery program.

8   LED Functions

APL – 1	Green LED "End of program"
End of program and **battery OK**	on
End of program and **battery faulty**	blinking

APL – 4	Red LED	Green LED
No battery connected	off	off
Battery is being **discharged**	blinking	off
Battery is being **charged**	on	off
End of program and **battery OK**	off	on
End of program and **battery faulty**	off	blinking
Trickle charge is being carried out	on	on
Charger error or battery program error	blinking	blinking

9   Mode Word Table

Mode word 1. position: 1   Nickel-Cadmium battery
                        2   Nickel-Metal-Hydride battery
                        3   Lithium-Ion battery (Polymer battery)
                        4   Lead battery
                        5   Free programming of final discharging and charging voltage

Mode word 2. position: 1   Charge only
                        2   Discharge only
                        3   Discharge - Charge
                        4   Charge – Discharge - Charge
                        5   Multiple Discharge - Charge(Forming)
                        6   Discharge – Charge every xx days
                        7   Start key operation after connection of battery

Example:
M23   (**2**)- A Nickel Metal Hydride battery is   (**3**)- discharged and then charged.

10   Test Program

Programmed values can be tested as follows:
Hit the key „Programmieren" to get into the programming mode and to choose the next value. When the display message "Save values – program key" appears at the end of the programming mode, hit the key „Anzeige/Zurück". That terminates the programming mode without affecting the connected battery. If the key „Programmieren" is hit accidentally, the display will show the message "Values saved in EEPROM". If there have been no changes of any of the values in the programming mode, the connected battery will not be affected.

Please do not hit the keys ""+" or "-" during the test operation. The key „Anzeige/Zurück" will terminate the programming mode any time. Using the key „Anzeige/Zurück" will dismiss changes.

11   Setup Program

Hitting the keys „Anzeige/Zurück" and "-" simultaneously, calls up the setup program.

11.1 Display Language

The first setting in the setup program is the display language. You can choose either German or English. The display shows the language selected. Use the keys "+" or "-" to switch between languages. The key „Programmieren" will save the selected language.

12   Block Programming

The programming can be blocked to stop unauthorized persons from changing the programmed values in the *curatio*.

After switching on the mains voltage (at the end of the self-test), the *curatio* checks if the key „Programmieren" is activated. If it is activated at the end of the self-test, the LCD displays the message "Programming" on the first display line. On the second display line "unblocked" or "blocked" is shown. Using the key „Anzeige/Zurück", you can choose between "Block programming" or "Unblock programming". Hitting the key „Programmieren" will activate this setting. If programming is blocked, the programming mode can be retrieved during operation by hitting the key „Programmieren", and the values can be changed. The changed values cannot be saved at the end of the programming mode and thus they cannot be executed. The display will show the message "Block programming".

You can select blocked or unblocked programming for each channel individually. Use the keys "+" or "-" to select the desired channel.

If you use an external program memory, the unblocking or blocking of the programming is set within the external memory. This means, that the programming for each external memory can be individually set on "block" or "unblock".

13   Battery Types

Nickel-Cadmium battery. This battery type is recognized using the –Delta-U method. When the battery is fully charged, the battery voltage decreases. The *curatio* then recognizes the end of charging using the –Delta/v method. Discharging takes place up to 0.9V per cell. The Battery voltage is always measured under load. You can choose between charging with a "reverse pulse" charging current or with a continuous charging current. The setting can be entered in the extended programming mode. When loading with "reverse pulse" the battery is loaded for approximately 9.5 seconds. Then there is a charging break consisting of a short-term discharging impulse and measurement of the battery voltage. Trickle charge is executed every six hours. One cell correlates to a nominal voltage of 1.2V. For a battery with 7.2V you have to enter "6" when asked for the number of cells .

Nickel-Metal-Hydride battery. The same procedure applies as for Nickel-Cadmium batteries.

Lithium-Ion and Polymer batteries. Lithium-Ion and Polymer batteries are charged with a continuous charging current . The charging takes place via an I/U characteristic. First, the battery is charged with the programmed current; as soon as the battery voltage reaches the final charging voltage of 4.1V (mode 1) or 4.2V (mode 2) per cell, the charging current is reduced. The charging current is reduced according to the charging voltage so that the cell voltage is not exceeded. Discharging takes place up to a cell voltage of 2.7V. One cell correlates to a nominal voltage of 3.6V. For a battery with 7.2V you have to enter "2" when asked for the number of cells . Trickle charge is executed every six hours.

> **Caution! Lithium-Ion and Polymer batteries are very sensitive to overcharging.**
> **Maximum charging voltage per cell: 4.2V. Risk of fire! Risk of Explosion!**

Lead Battery. Lead batteries are charged with continuous charging current. The charging takes places via an I/U characteristic. First, the battery is charged with the programmed current;.as soon as the battery reaches the final charging voltage, the charging current is reduced to ensure that the maximum cell voltage of 2.3V (mode1) or 2.4V (mode 2) per cell is not exceeded. Discharging takes place up to a cell voltage of 1.8V. One cell correlates to a nominal voltage of 2.0V. For a battery with 12V you have to enter "6" when asked for the number of cells. Trickle charging is executed every six hours.

(Mode 1 and 2 for Li-Ion and Lead batteries see chapter "Extended Programming Mode")

Set Voltage. Charging takes place with a continuous charging current via I/U characteristics. First, the battery is charged with the programmed current; as soon as the battery voltage reaches the programmed final charging voltage, the charging current is reduced. The charging current is reduced to ensure that the programmed final charging voltage is not exceeded. Discharging takes place up to the programmed final discharging current. Trickle charge is executed every six hours.

Regarding charging and discharging currents, the operation "Set voltage" is the same as with Lead batteries. The only difference is the additional entry of individual final charging and discharging voltages.

General Information

When the end of charging is determined via the I/U characteristic (by reducing the charging current), e.g. for lead batteries, the end of charging occurs when the charging current is down to a predetermined percentage of the programmed charging current. The basic setting for this value is 5 %. This value can be changed in the extended programming mode. The smallest possible value for the charging current is 10mA.

After 24 hours, charging will be terminated (safety disconnection). In addition, if the battery voltage does not increase during a period of several hours, the charging operation will be terminated. The maximum charging time for trickle charge is six hours.

During the discharging and charging operation the according capacity values are recorded and saved in the internal memory. The latest measured values for discharging and charging are shown on the display. Further values can be printed via the serial interface.

13.1 Batteries with EX Protection and Integrated Electronics

Most batteries with EX protection, e.g. the Motorola GP900 EX, can be discharged and charged with the *curatio* APL-4. Depending on the design of the protective electronics, the discharging and charging operations need to be adjusted by using the **"Extended programming mode"** of the APL-4 device.
The GP900 EX must be charged with a continuous charging current (no reverse pulse charging). Discharging can be measured "with load". It may be necessary to discharge some batteries "without load" during voltage measurement.

Not every battery with integrated charging electronics can be charged with the *curatio* APL-4.

14   Connecting Battery Blocks

If incorrect polarization occurs when connecting the batteries, the display shows a corresponding message. The charging device is protected against incorrect polarization.

Always connect minus und plus poles of a battery at the same channel.

If the battery has been connected correctly, the *curatio* recognizes the installed battery and automatically starts the programmed charging operation.

Battery blocks with integrated charging circuits can only be connected under reserve.

After the battery is connected, the first display line will show the programmed operation "M13" in coded form, the number of cells and the battery voltage. The second display line will show "Charging", "Dischrg." or "Tric.chrg." for trickle charge as well as the actual current.

Charging:

A	1	M	1	3			5	C			6	,	4	0	V
C	h	a	r	g	e						1	,	0	0	0	A

Discharging:

A	1	M	1	3			5	C			4	,	8	0	V
D	i	s	c	h	a	r	g	e		0	,	8	0	0	A

Trickle (Standby) charge:

A	1	M	1	3			5	C			6	,	9	0	V
S	t	b	.		c	h	a	r	.		0	,	5	0	0	A

If "**OP via keys"**" has been programmed, then the desired operation has to be started using a key after installing the battery. The display will show help texts for the key functions.

The operations "discharge/charge" will be executed automatically when no keys are hit for approximately one minute.

Key functions: „↑" Battery charge only,   „↓↑" Battery discharge/charge,   „♡ " Battery Forming.

The key "DISPLAY" will enable you to switch between the values for time and measured capacity. The first display line will show the channel number, the programmed mode and the time in minutes for the current operation. When using trickle charge the time of the trickle charge is shown. The second display line shows the currently measured discharged "D" and the loaded capacity "C" in Ah. The displayed capacity values are not changed by the trickle charge. No capacity is measured when trickle charge is taking place.

The following display shows a Nickel-Cadmium battery that is charged, then discharged and charged again. A capacity of 1.200Ah was measured during 120 minutes while the battery was discharged. While it was charged, a capacity of 1.454Ah was measured.

A	1	M	1	3			5	C			1	0	m	i	n
D		1	.	2	0	0	C		1	.	4	5	4	A	h

The cursor will blink on "D" during discharging, on "C" during charging and on "min." when trickle charge is being executed.

When the programmed operation is fully completed, an appropriate message appears on the display.

Mode 13 finished, battery charged:

A	1	M	1	3			5	C			6	,	4	0	V
B	a	t	t	e	r	y		c	h	a	r	g	e	d	

Mode 12 finished, battery discharged:

A	1	M	1	2			5	C			4	,	8	0	V
B	a	t	t	e	r	y		d	I	s	c	h	a	r	e

When the process is finished, the condition "Charged" or "Discharged" is shown on the display and via the LED "End of program". If a nominal capacity was programmed for the battery, the LED blinks if a faulty battery has been detected. The battery is OK when the LED is illuminated permanently.

If a nominal capacity for the battery was programmed for the current operation, once the capacity values are shown and the key „Anzeige/Zurück" is pressed once more, the measured percentage value of the battery will be displayed.

B	a	t	t	.		O	K						9	0	%
m	e	d	i	u	m			c	a	p	a	c	l	t	y

The display will then show the time until the self-discharging test is due to start, if this has been pro-grammed earlier. If the value for self-discharging has been measured already, it will also be dis-played.

If repeated discharging and charging after xx days was programmed, the amount of time until the next discharging operation is due will be displayed.

15 Recognizing a Faulty Battery

The *curatio* APL-4 will test the connected battery for its condition. After the battery has been charged and the program is finished, the battery voltage is tested. If the battery voltage is too low, the following message is displayed:

B	a	t	t	.		f	a	u	l	t	y				
V	o	l	t	a	g	e			t	o	o		l	o	w

The error message "Voltage too low" may also be displayed when a wrong number of cells is programmed.

After the fault is recognized no more operations, such as trickle charge, repeated discharging/charging or the self-discharging test, are executed. The green LED starts blinking.

After discharging the battery, the discharging capacity is compared to the programmed nominal capacity and the battery is displayed as OK or faulty according to the programmed percentage. After the program is finished the green LED also shows the battery condition. The LED blinks when the battery is faulty. The LED is illuminated permanently if the battery is OK.

16 Monitoring Features and Error Messages

A "WATCHDOG" constantly monitors the program sequences of the *curatio*. If, for example, a program error occurs because of very high electrostatic discharging, the currents are terminated and the program is interrupted. The following message is displayed:

S	e	l	f		t	e	s	t					
W	a	t	c	h	d	o	g		r	e	s	e	t

This message is displayed for 30 seconds. The key „Anzeige/Zurück" will delete this message and the operation can be continued as if the device has just been switched on.

Error messages can be deleted with the key „Anzeige/Zurück".

The temperature of the heat sink is monitored as well. If the temperature gets too high, the discharging and charging operations are interrupted and a message is displayed. As soon as the temperature has dropped, the discharging and charging operations are automatically continued.

17 Tuning of Voltages, Control Parameters and Currents

In order to balance component tolerances and to receive exact measurement values, the voltages, control parameters and currents need to be tuned. Only the exact setting of all parameters can ensure secure discharging and charging of a battery block.

The control parameters determine how the charging current acts when the charging voltage is turned on. An incorrectly set control parameter can cause the message "Over current" to appear, or the programmed charging current is reached too slowly.

The adapter is delivered with tuned voltages, control parameters and currents.

A new tuning has to be carried out when the message "New EEPROM" loaded is shown.

Tuning should be carried out with a battery block that has 9 or 10 cells. The battery block must endure a charging current of 1.0A. **The tuning can only be carried out, when the battery type is set to Nickel-Cadmium or Nickel-Metal-Hydride**.

If the values measured by the *curatio* and the actual values are far apart from each other, the EEPROM should be loaded with the basic settings before starting the tuning operation. The basic settings are loaded by hitting the keys "+" and "-" simultaneously during the switching on process, until the message "New EEPROM loaded" appears. Delete this message by hitting the key "DISPLAY", and then start the tuning operation.

Calling up the tuning program

When the device is switched on, a self-test is being executed. At the end of this self-test the keys are being prompted. At this point the keys „Anzeige/Zurück" and „Programmieren" need to be hit at the same time. The display shows the message "Tune control parameters". Releasing the keys takes the *curatio* to the tuning program for the voltage value.

To carry out the voltage tuning, connect the battery block to the *curatio* and install a voltage measurement device parallel to the battery block. The voltage shown on the display of the charging device has to exactly match the voltage of the voltage measurement device. The keys "+" and "-" will adjust the displayed voltage.

The key „Programmieren" will take you to the function "Tune shunt". This mode will tune the internal resistance of the adapter and the specific resistance.
The *curatio* will switch on a charging current of approximately 1.0A. As soon as the charging current of 1.0A is reached, the voltage can be adjusted by hitting the keys "+" or "-".

Voltage tuning has to be executed very precisely.
False voltage tuning can lead to battery overload.

Voltage measurement must take place directly at the charging device.

To tune the control parameters hit the key „Programmieren". If a battery block is connected, the *curatio* tunes its control parameters automatically. First, the control parameters for the charging current are determined, then the value for the discharging current. After the tuning is successful the display will show the message "Executed". If the control parameters cannot be determined within a set time, the display will show the message "Failure". After connecting the battery, the 100 % value is being counted up until the target current of 10mA is reached.

With the key „Programmieren" you can switch between the tuning of the control parameters, the tuning of the charging and discharging currents and the tuning of the battery voltage.

To tune the current you need to install a current measuring device to the battery using a series connection. Switch to "Tune charging" or "Tune discharging" by hitting the key „Programmieren". Tuning will take place with a current of approximately 2000mA. In the next step 200mA The current displayed on the charging device has to match the current of the measuring device as precisely as possible. The keys "+" and
 "-" will adjust the displayed current.

The key „Anzeige/Zurück" will take you to the next channel.

Hitting the keys „Anzeige/Zurück" and „Programmieren" simultaneously will end the tuning program.

Calling up the tuning program will reset error bits that may have been set.

During the tuning operation, a test for end of charging cannot be executed. The battery should only be connected during the tuning operation. The battery must be suitable for a discharging/charging current of 1.0A. Protect the battery from overcharging during the tuning operation of the function "charging".

Immediately disconnect the battery from the charging device when the measurement and the tuning are finished.

18   Safety Tips for the Operation of the Charger

The charging cable for the batteries should be as short as possible, but have a large cross-section. When connecting the charging cable to the battery, make sure that the contacting is ok and that there is not much transition resistance.

For the connection of battery blocks, we recommend charging cables with safety plugs. If you do not use safety plugs, connect the cables to the adapter first and then to the battery. Risk of short-circuit!
During the charging operation of a battery, do not change either the operation or the charging current. Changing these values can cause premature termination or overcharging of the battery.

Batteries with large internal resistance should not be discharged with high currents. Due to the voltage drop at the internal resistance, the battery voltage drops quickly and the *curatio* recognizes the battery as discharged. The measured capacity is then lower than the actual battery capacity.

If battery cells, which were purchased and used as single units instead of block units, are supposed to be installed at the *curatio* device, you need to ensure that each cell is in **the same charging condition and has the same cell capacity.** This means that the cells need to be selected. Different charging conditions of battery cells can damage the cells during charging and discharging and will most probably make it impossible to recognize the correct end of the charging procedure.

Risk of fire! Risk of explosion!

19 Description of the Serial Interface

9-pole D-pin strip;   Transfer format 9600 bps, 7 data bits, even parity, 1 stop bit,

Pin assignment   Pin 2   RXD   to *curatio*
                       Pin 3   TXD   from *curatio*
                       Pin 4   DTR   from *curatio*
                       Pin 8   CTS   to *curatio*
                       Pin 5   GND

When sending the measured values to a printer, pin 8 is used as busy wire.
"+V" sends data; "-V" does not send data. With "-V" the display will indicate briefly that the printer is not ready.

19.1 Pin Assignment of the *curatio* Serial Connection Cable <--> PC

Fem.Connector   9 pole   25 pole

Pin   2   2
                      3   3
                      5   7

Fem.Connector   9 pole   9 pole

Pin   2   3
                      3   2
                      5   5

20 Printing of the Battery Data as Table or Label

The measurement values that were recorded during charging and discharging can be printed either as a table or as self-adhesive labels that adhere to the battery block.

It is possible to print the measurement values on most needle printers that offer a serial or parallel interface. To connect the *curatio* to a printer with parallel interface, you will need a special cable that includes the interface. The printing operation is started manually using the keypad of the *curatio*. The values are saved in the *curatio* until a new battery block is connected or the device is switched off.

Set the data channel to be printed by hitting the keys "+" or "-" at the *curatio* APL-4.

The printing program is retrieved by hitting the keys „Anzeige/Zurück" and "+" simultaneously. The display will show the following message:

M	e	a	s	u	r	e	m	e	n	t	s				
s	e	n	d		t	o		p	r	i	n	t	e	r	

Once the keys are released you are asked in which format you wish to print.

C	h	a	r	t				P	r	e	s	s		+
L	a	b	e	l				P	r	e	s	s		-

If the key "+" is hit, the data is printed in chart format.
If the key "-" is hit, the data is printed in label format.
If either the key „Anzeige/Zurück" or „Programmieren" is hit, the printing program is terminated.

If the printer is not ready for operation, the display will show the following message:

P	r	i	n	t	e	r		n	o	t				
r	e	a	d	y										

If the printer is not ready for operation within 5 seconds, the printer program is terminated.

During the printing operation the following message is displayed:

M	e	a	s	u	r	e	m	e	n	t	s			
s	e	n	d		t	o		p	r	i	n	t	e	r

Printing in chart format

All recorded values for the battery can be printed.

```
********  b d s  GmbH       APL-x ********

Mode 13
Batt.No.  _____  Date _____

Charge    1.500A   0.571Ah   21 min   6.871V
Discharge 0.500A   1.425Ah  177 min   4.499V

Charge    1.500A   1.805Ah   82 min   6.889V

End mode
Batt. OK    95% of  1.500Ah nominal capacity
```

Printing in label format

A label showing the last two cycles is being printed.
Please use self-adhesive computer labels with the format 88.9 x 35.7 mm.
(HERMA Computeretiketten Nr. 8060)

```
****  b d s  GmbH      curatio ****
Mode 13
Batt.No._____  Date _____
Discharge 0.500A   1.425Ah   4.499V
Charge    1.500A   1.805Ah   6.889V
End mode        Batt. OK
 95% of  1.500Ah Nominal capacity
```

21 PC Software "*curatio*WIN3" for Windows

- Recording and managing battery data and programs in one single database.

- Graphical displaying of discharge and charge characteristics, or recording measured accumulated values, such as battery capacity, charging currents, battery voltage, etc.

- Programming and controlling all functions of the *curatio* APL-1 + APL-4 Battery Tester and Charger devices using the program "*curatio*WIN3".

- Printing discharge and charge characteristics, measured accumulated values and programmed values. Additional function to enter and print text (e.g. customer information).

System requirements

Available up to Windows 95 or Windows NT

Installing the program "*curatio*WIN3"

For Windows: Insert the "*curatio*WIN3" CD in your CD drive. Choose Start->Run and select "SETUP.EXE" from the CD.

The setup program will write new system data into your computer files. If this data is newer than the existing data, the computer must be restarted during installation and "SETUP.EXE" must be run again.

Working with the program "*curatio*WIN3"

After installing the program "*curatio*WIN3" and having started it for the first time, all basic settings, such as language, COM port and the battery charger that is used (APL-1 or APL-4), need to be entered. These entries are only necessary for the first program start. Later those settings can be changed in the program itself under "settings". The release number of the program *curatio*WIN3 is shown in the headline of the program window.

Window "Main Selection":

When the program "*curatio*WIN3" starts, the APL-4 requests the battery program and the battery measurement values from the charger that may have already been entered, and displays them. If there is no charger connected, a message to that effect is displayed. The footer in the window "program" will show the condition of the charger channels. The charging device *curatio* APL-1 offers one active window, the *curatio* APL-4 four windows.

By clicking the mouse on "battery" in the footer or by using the key sequence Shift + F1 (F2,F3,F4) the selected battery is brought into the foreground of the window "program". The battery and program data for the chosen channel can then be edited and printed.

Window "Program":
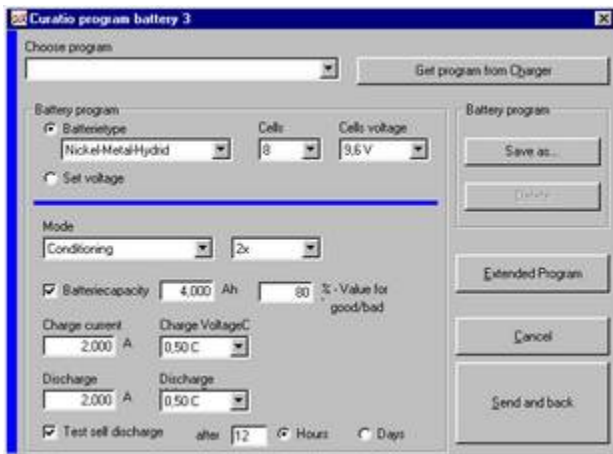
In the window "program", all parameters for discharging and charging the battery can be set and then sent to the *curatio* APL1/4.

If a battery is connected to the *curatio*, sending a battery program will cause the operation to restart.

The battery programs can be saved with "Save as" on the personal computer. Use the function "Choose battery program" to load a saved program and click on "Send and back" to send the program to the charger.

Use the option **"Extended programming mode"** to set more parameters.

"Block programming" blocks programming via the charger keys. The charger program can only be changed via the personal computer.

"Charging mode" is used for setting the charging process for Nickel-Cadmium and Nickel-Metal-Hydride batteries.

If "Measure discharging with load" is chosen, the battery voltage is measured while the discharging current is flowing. If "Measure discharging without load" is chosen, the battery voltage is measured during charging breaks, when no charging current is flowing.

"Mode 1" charges a lead battery with a charging voltage of 2.3V per cell. The charging time is limited to a maximum of 24 hours. Trickle charge is also executed with 2.3V per cell.

"Mode 2" charges a lead battery with a charging voltage of 2.4V per cell. The charging time is limited to a maximum of 12 hours. Trickle charge is executed with 2.3V per cell.

"Mode 1" charges a Li-Ion or a Polymer battery with a charging voltage of 4.1V per cell.
"Mode 2" charges the battery with a charging voltage of 4.2V per cell. The charging time is limited to a maximum of 24 hours. Trickle charge is executed with the corresponding charging voltage.

The conditions for "End of charging" when charging via I/U characteristics can be entered in the extended programming mode as well. If the end of charging is determined via the I/U characteristic (by reducing the charging current), e.g. for lead batteries, the end of charging occurs when the charging current is down to a predetermined percentage of the programmed charging current. The basic setting for this value is 5 %. At a programmed charging current of 1.0A the end of charging would occur at a charging current of 50mA, should the percentage be set at 5.

The function **"Measurement values"** in the window "Main selection" enables the recording of the *curatio* APL-4 measurement values.
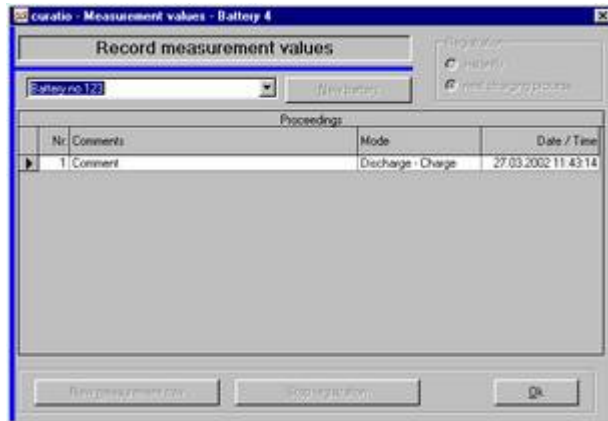
You can either enter a new battery or a new series of measurement values to an existing battery.

The battery data (either since a new series of measurement values was entered or all measurement values since the program start) can be recorded and saved, while a charging or discharging operation is running.
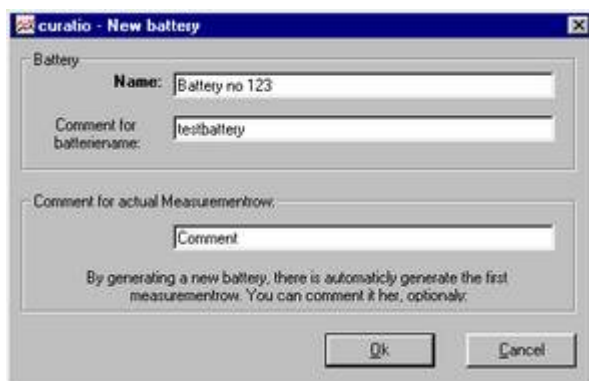
In order to enter a new battery you need to select a name for it.

You can add a comment to the name of the battery. These comments are displayed when the cursor is pointed to the battery name.

You can add a comment to each series of measurements of a battery as well. The comment is displayed in the comment window of the window "main selection" during operation. It is also displayed in the comment windows of "Record measurement values" and "Manage measurement values".

The series of measurements is closed as soon as the program ends or the battery is disconnected. All data, which was recorded during the discharging and charging operations, is saved in this series of measurements. The values after the self-discharging test and the repeated discharging and charging every xx days are saved as well. Measurements that were sent during trickle charge are not saved.

The function "Print" in the window "Main selection" enables the program to print the measurement values and the battery program in a non-graphical form.

In addition, you can edit and print a comment.

If you print the graphs, you can add a comment as well.

The function "Diagram" in the window "Main selection" shows all recorded measurement values graphically.

A single series of measurement values can be displayed graphically by double-clicking the data in the fields "Measurement values after charging" or "Measurement values after discharging".
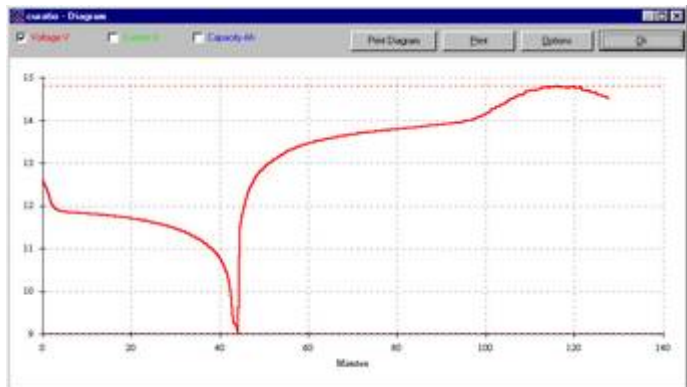
The window "Diagram" displays the following values graphically: battery voltage, currents and capacity.

When the diagram is called up, first only the battery voltage is displayed. Click the boxes in the header to select the graphics of the values voltage, currents and capacity.

Choosing the function "Print" makes it possible to print the diagram, the accumulated values and the battery program.
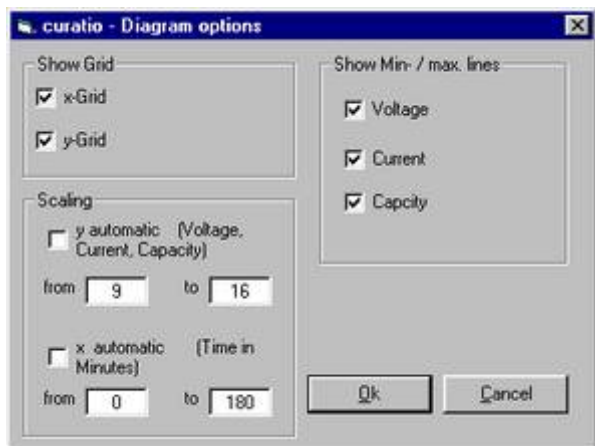
Use the function "Settings" to select different diagram options.

The grid for the x- and the y-axis can be turned on or off.

You can resize the x-coordinates (Time in minutes) and the y-coordinates (Voltage, current, capacity) by adjusting the "from-to" values.

The lines for minimum and maximum values as well as the x and y lines can be turned on or off.

Manage measurement values
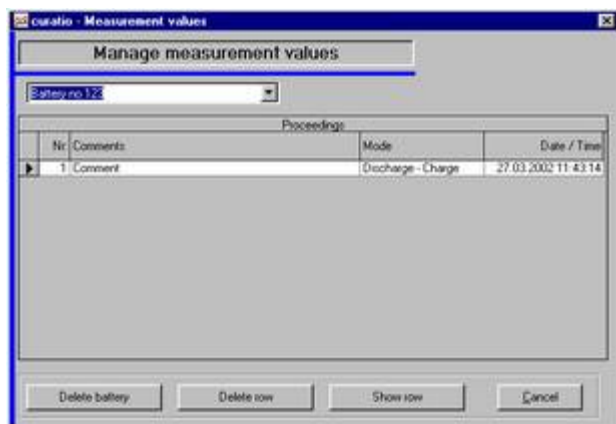
You can display and print recorded battery data using the function "Edit" and "Manage measurement values" in the window "Main Selection".

In this window, single series of measurements for one battery or total data of a battery can be deleted.

Database

The battery programs and the recorded measurement values are saved and managed in a database. Do not make any changes to the database (files ending with *.mdb).

The database "curuser.mdb" can be compressed via the function "Edit" -> "Compress Database" ". After compressing this database the program *curatio*WIN3 will need to be restarted. Please save all measurement values prior to this operation.

Tips:

You can close and open all windows that are not being used, without any effect on data recording and without any data loss.

The software sometimes uses standard Windows messages. These messages tend to stop programs that are running in the background, which means that current recordings cannot be completed. Do not just leave the standard Windows messages on your monitor, but click on the button OK (Example: "Print to standard printer OK Reset").

22   Index