Patrick

... the Particle Counter

Operating Instructions

Rev. 1.8 EN • November 29, 2012

TKZ L3160-00-76.00EN

Contents

Illustrations

1. Safety

1.1. General Safety and Warning Hints

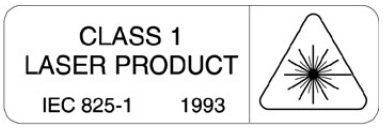
ATTENTION – Dangerous electrical voltage

- Do not cut, damage or modify the connection wire and do not place items on it.
- Never touch the device with wet or moist hands.
- Only connect the device to suited power sources (see technical data).
- Unplug the mains cord during a thunderstorm.
- Unplug the mains cord when detecting a smell or smoke, or if the cord is damaged.
- Assure a proper grounding of your plant. Measuring errors may be caused by improper grounding.

1.2. Laser Safety Advice

WARNING – Class 1 laser contained

- Never remove covers or housings. Otherwise laser light may come out what can lead to injuries of your eyes.
- The device contains a laser sensor classified as “Class 1 Product” acc. to 21 CFR, sub-chapter J, of the Health and Safety Act of 1968, when it is used as described in this manual. This manual does not contain information on implemented parts, maintenance and repair may only be executed by qualified personnel.
- This device has been evaluated and tested according to EN61010-1:1993, IEC 825-1:1993 and other norms (e.g. ISO 4406, ISO 6149-2).
- A label indicating the laser class according to 21 CFR is attached to the device. This must be present and readable at all time. Damaged or unreadable labels must be replaced immediately.



1.3. Hints for the Use of the Particle Counter

Handle the device carefully

- Never expose the device to excessive heat or moisture, obtain the technical data.
- Do not store the device a humid or dusty location or at temperature below the freezing point.
- Never dip the device into water or other liquids. Never let liquid come into the device.
- Never open the device.
- Do not use the device after it has fallen down or if the casing is damaged.
- Avoid strong magnetic fields. Keep the device away from electric motos or other devices that generate electro-magnetic fields. These may cause malfunctions and influence measured values.
- Avoid the condensation of water. If water has condensed, you should acclimate the device before switching it on. Otherwise it may be damaged.

2. Introduction

Do not loose claims

The information and hints in this section are important. By non-observance you may loose possible warranty claims.

2.1. Range of Validity

The manual on hand is valid for particle counters named "Patrick". It adresses to the operator of this instrument, that means the person, who works with the instrument. The manual is not a technical manual. Please contact our service staff for questions, that exceed the contents of this manual.

2.2. Copyright

The device and this manual are protected on copyright. Manufacture without license will be prosecuted by law. All rights reserved on this manual, even the reproduction and/or duplication in any thinkable form, e.g. by photocopying, printing, on any data recording media or translated. Reproduction of this manual is only permitted with a written approval of Hydrotechnik GmbH.

The technical state by the time of delivery of instrument and manual is decisive, if no other information is given. Technical changes without special announcements are reserved. Earlier manuals are no longer valid.

The general conditions of sale and delivery of Hydrotechnik GmbH are valid.

2.3. Limitation of Liability

We guarantee the faultless functioning of our product in accordance with our advertising, the product information edited by Hydrotechnik GmbH and this manual. Further product features are not guaranteed. We take no liability for the economy and faultless function if the product is used for a different purpose than that, described in the chapter „Use as agreed“.

Compensation claims are generally impossible, except if intention or culpable negligence by Hydrotechnik GmbH is proved, or if assured product features are not provided. If the product is used in environments, for which it is not suited or which do not represent the technical standard, we are not responsible for the consequences.

We are not responsible for damages at installations and systems in the surroundings of the product, which are caused by a fault of the product or an error in this manual.

We are not responsible for the violation of patents and/or other rights of third persons outside the Federal Republic of Germany.

We are not liable for damages, which result from improper operation according to this manual. We are not liable for missed profit and for consecuting damages due to non regardance of safety advice and warning hints. We don’t accept liability for damages which result from the use of accessoires which are not delivered and/or approved by Hydrotechnik GmbH.

The products of Hydrotechnik GmbH are designed for a long life. They represent the standard of technique and science and were checked on all functions individually before delivery. The electrical and mechanical construction corresponds to the current norms and regulations. Hydrotechnik GmbH is doing product and market research for the further development and permanent improvement of their products.

In case of faults and/or technical trouble please contact the Hydrotechnik GmbH service staff. We assure that suitable measures will be taken immediately. Hydrotechnik GmbH guarantee regulations are valid, which we will send to you on demand.

2.4. Use as Agreed

The device ***Patrick*** is an optical particle monitor that may be used for the monitoring of fluid cleanliness. It works according to the light extinction principle and detects particles and other contaminants in the fluid. The measured values are calculated into purity classes according to ISO4406:99 or SAE AS4059E and then shown on the display.

You may read the measuring data via a serial interface and transfer them to a measuring instrument or a computer. The connection to the fluid system is achieved by two Minimess® test points of the 1620 screw series.

Any other use of this device is regarded as improper use. Please contact our service staff if you have questions or want to use the device for another purpose. We will be always glad to help you.

2.5. Warranty Regulations

In accordance to our warranty regulations we guarantee the condition without defects for this measuring instrument for a duration of six months. Wearing parts and storage batteries are excepted from this warranty. The warranty is spoiled if repair work or interventions are executed by unauthorized persons.

Within the warranty period we repair damage or defects which are caused by a manufacturing fault. We only accept warranty claims if they are reported to us immediately after their discovery, but latest six months after delivery. The warranty benefit is by our choice through repair of defective parts or replacement by intact parts.

Send your instrument with an invoice copy or delivery note copy to Hydrotechnik. The adress is mentioned at the end of this manual.

2.6. Obligations to the Customer

The operating authority of this product has to assure, that only persons who

- know the regulations on working safety and accident prevention
- have been instructed in the operation of this product
- have read and understood this manual

can operate this product. Persons who operate this instrument are obliged to

- obey all regulations on working safety and accident prevention
- read this manual completely, especially the safety instructions in the first chapter.

2.7. Authorized Staff

Persons are authorized if they have a professional education, technical experience, knowledge of the important norms and regulations and if they are able to estimate their duties and recognize possible danger at an early time.

Operator of the instrument

Persons are authorized if they are trained in the operation of the instrument and have read and understood this manual completely.

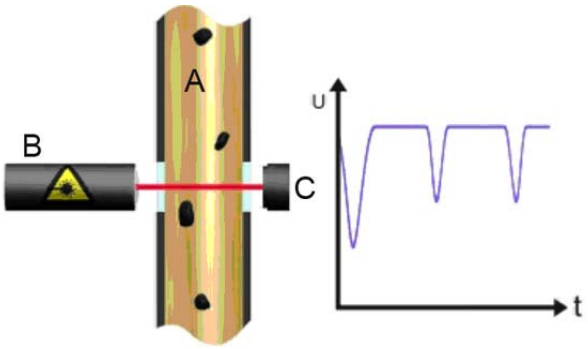
Personell for installation and maintenance

Persons are authorized if they are trained in all aspects of the instrument and have read and understood this manual completely.

3. Description of the Device

3.1. Qualities

The device ***Patrick*** is an optical particle monitor working according to the light-extinction principle:



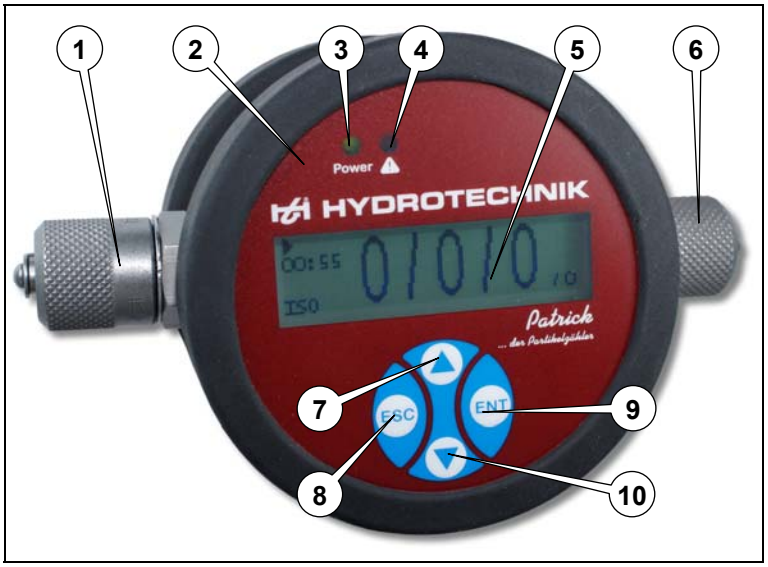
Pic. 1 Functional principle

The device comprises a through-flown measuring cell (A), a laser (B) and a photo cell (C). The laser shines through the measuring cell and impacts the photo cell. If a particle flows through the laser beam, the intensity reflected by the photo cell is reduced. The larger the particle, the more the reflection will be reduced.

You may use Patrick to monitor the contamination level and the purity trend of fluids. There may be differences in the absolute accuracy to particle counters calibrated according to ISO 11171:99, but this difference is smaller than one ordinal number. Changes are display with very high accuracy. By the continuous purity monitoring you can detect changes within a machine very quickly. This allows you to initiate measures to avoid further contaminations and damage to the machine.

The purity class display can be switched to ISO4406:99 or SAE AS4059E. The device also measures the temperature, not in the liquid but on the electronic switchboard (measuring range -20 … 100 °C). The device is equipped with an operating counter, the values will still be available after a power loss. After each interruption, the counter will restart at the last saved time value before the interruption.

3.2. Components of the Device



1	*Fluid inlet*
2	*Rotatable panel*
3	*Indicator „Power“*
4	*Indicator „Alarm“*
5	*Display*
6	*Fluid outlet*
7	*Key „Up“*
8	*Key „Escape“*
9	*Key „Enter“*
10	*Key „Down*

Pic. 2 Front view

Fluid inlet/outlet (1) (6)

The device is equipped with two Minimess® test points of the 1620 screw series. Normally two Minimess® hoses will be connected here to connect Patrick to the fluid system.

Display (2) (5)

The front panel may be rotated by 190° to allow a horizontal orientation of the display in any mounting situation. The bw-display shows the last calculated purity classes and the time to the next measurement, or the remaining measuring duration.

Indicator „Power“ (3)

Operating voltage is present if the indicator is lit green.

Indicator “Alarm” (4)

This is lit red if an alarm is present. You may program two alarms, please see the information in the respective chapter of this manual.

Keys (7) ... (10)

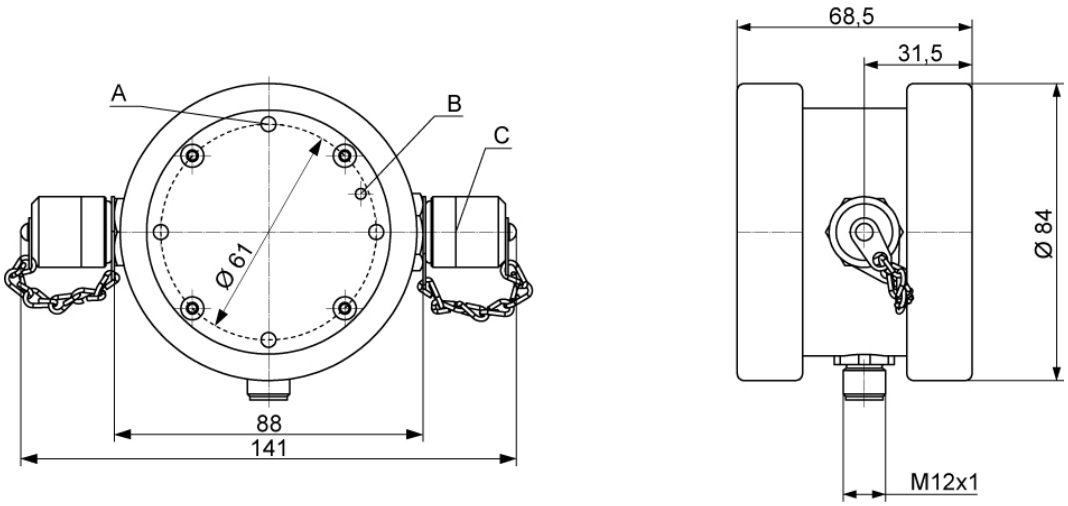
The complete operation and programming is done with four keys:

▲	opens the main menu; moves the highlighting bar upward; increases a value
▼	opens the main menu; moves the highlighting bar down; lowers a value
ENT	selects menu items and opens submenus; confirms entries; jumps to the next digit
ESC	returns to the higher menu level; leaves the main menu; cancels entries

3.3. Technical Data

Operating conditions	
allowed operation pressure	420 bar (dynamic)
environmental temperature	-20 ... 80 °C
humidity	0 … 95 %
Storage conditions	
environmental temperature	-20 ... 85 °C
humidity	0 … 95 %
Fluids	
allowed fluids	mineral- and esther fluids, polyalfaolefines
fluid temperature	-20 ... 80 °C
fluid connectors	2x ¼“ Minimess® 1620
allowed volume flow rate	50 … 400 ml/min
Moistened materials	high-grade steel, sapphire, copper
Sealing material	NBR
Power supply	9 … 36 V DC
Power consumption	max. 300 mA
Current outputs	4 … 20 mA
Interfaces	RS 232, CANopen
Alarm contact	potential-free contact
Electrical connector	8-pole plug M12 x 1
Measuring range acc. to ISO 4406:99	0 … 24 (ordinal number)
Calibrated measuring range	10 … 22 (ordinal number)
Measuring accuracy	± 1.0 (ordinal number)

3.4. Dimensional Drawing



Pic. 3 Dimensions and mounting possibilities

A: four mounting points M5 x 5.5
B: ventilation hole with pressure compensation element
C: 2x Minimess® test point 1620, 2103-01-18.00N

4. Installation and Start-up

4.1. Installation Location

Please observe these hints when choosing an installation location:

- Connect Patrick with a T-branch to a bypass pressure line.
- The flow direction is arbitrary.
- There should be constant pressure conditions at the installation location. The pressure may vary, but there may not be pressure peaks or large alternations.
- It is recommended to choose a control line, otherwise you may also choose the filter or cooling loop.
- The volume flow rate should be constant between 50 and 400 ml/min.
- Flow control or pressure reduction should be installed after the particle counter since such installations may cause particles or air bubbles that may cause wrong measurements.
- If a pump is required to produce the required volume flow rate, it should be low-pulsating and be installed in front of the particle counter. Otherwise bubbles could be generated on the suction side what would lead to wrong measurements.

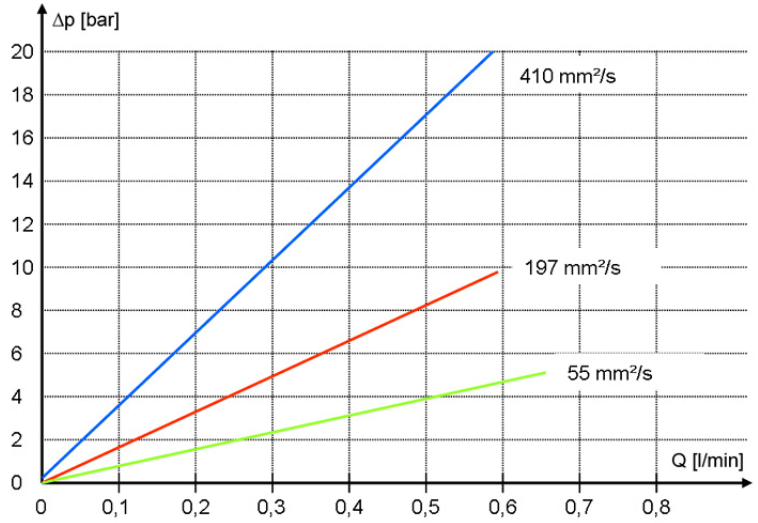
4.2. Installation

Please observe these hints before starting the installation:

- Assure that the display can be read easily after installation. It is rotatable by 190° to ease the selection of a installation location.
- The shorter, the better is valid for connection hoses. If the hoses get too long, larger particles may deposit.
- It must be assured especially for higher viscosities and the use of Minimess® hoses that the pressure is high enough to set a volume flow rate between 50 and 400 ml/min.
- Assure a bubble-free fluid. Bubbles in the fluid result in very high ordinal numbers in different size classes. Such bubbles cannot be visible to the naked eye.

Estimation of the required pressure level

Obtain the deltaP of the particle counter dependant to the fluid viscosity:



Pic. 4 Δp-Q-curve for different viscosities

This diagram allows you to estimate the required pressure level for the required volume flow rate of 50 to 400 ml/min.

Installation

Now you may install Patrick:

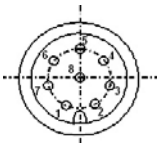
1. Identify the installation location corresponding to the stipulated criteria.
2. Connect two fluid lines to the Minimess® test points.
3. Mount the particle counter using the mounting points at the rearside of the device.

4.3. Elektrical Connection

The device may be installed by qualified staff, only. Obtain the national and international regulations for the installation of electrical plants and install the power supply in accordance to EN50178, SELV, PELV, VDE0100-410/A1. Use the Hydrotechnik power pack 8812-00-00.36 together with the Y-distributor 8808-50-01.03.

Cut-off the mains power and then connect the device as follows:

Pin assignment of sensor connector

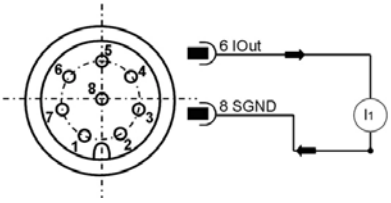


1	$+U_B$
2	GND
3	TxD; CAN-L
4	RxD; CAN-H
5	Digital input
6	IOUT1
7	Open Collector, Alarm OUT
8	SGND
	Casing / shield

Pic. 5 Pin assignment viewed from top to the sensor connector

The allowed operating voltage is between 9 and 36 VDC. Use shielded sensor wires, only. You may only use suited connectors and wires to achieve protection class IP67. The tightening torque of the connector is 0.1 Nm.

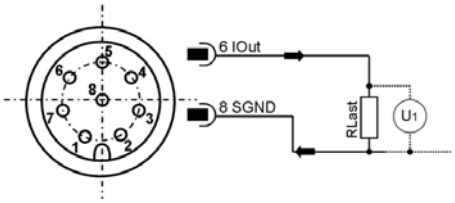
Analog current outputs** (4 ... 20 mA) **– Measurement without load resistor



Pic. 6 Measurement of the analog 4 … 20 mA output without load resistor

Use a suited measuring instrument, the assignment of the current value to the measurand will be explained below.

Analog current outputs** (4 ... 20 mA) **– Measurement with load resistor



Pic. 7 Measurement of the analog 4 … 20 mA output with load resistor

A load resistor must be connected to each output to measure the current of both analog current outputs. Dependant on the supply voltage, the load resistor should be between 250 and 2,600 Ω. Use a volt meter to measure the voltage dropped over the respective resistor.

Use the formula shown in section 4.4 on page 12 to calculate the purity class from the measured voltages.

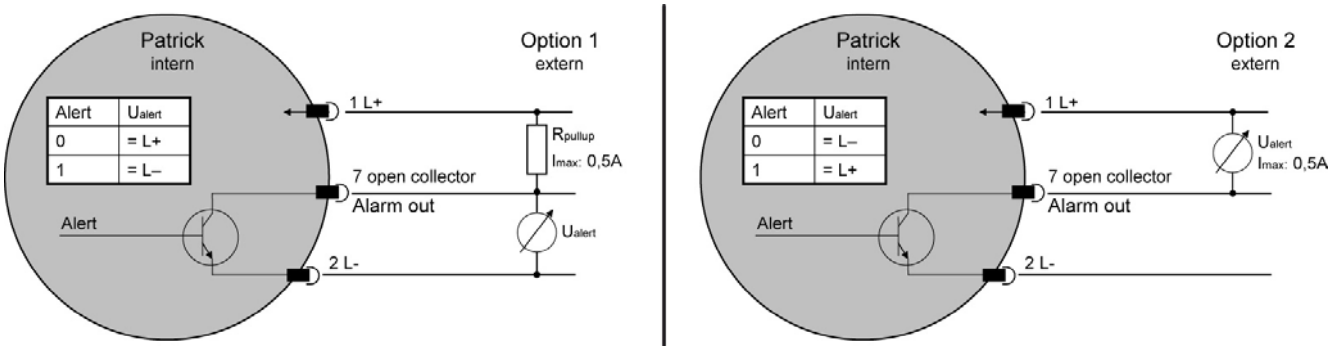
Calculation of the required load resistor

The load resistor cannot be chosen arbitrary. It must be adapted to the sensor supply voltage. Either use the following formula to calculate the required resistor, or use a value shown in the table:

Formula	U_V in V	R_{max} in Ω
$R_{Max} = \frac{U - 2V}{20mA} - 100\Omega$	9	250
	12	400
	18	600
	24	1,000
	30	1,300

4.4. Switching output

The switching output is not short-circuit protected and has no over-current or over-temperature protection. The maximum switching voltage is 36 VDC.



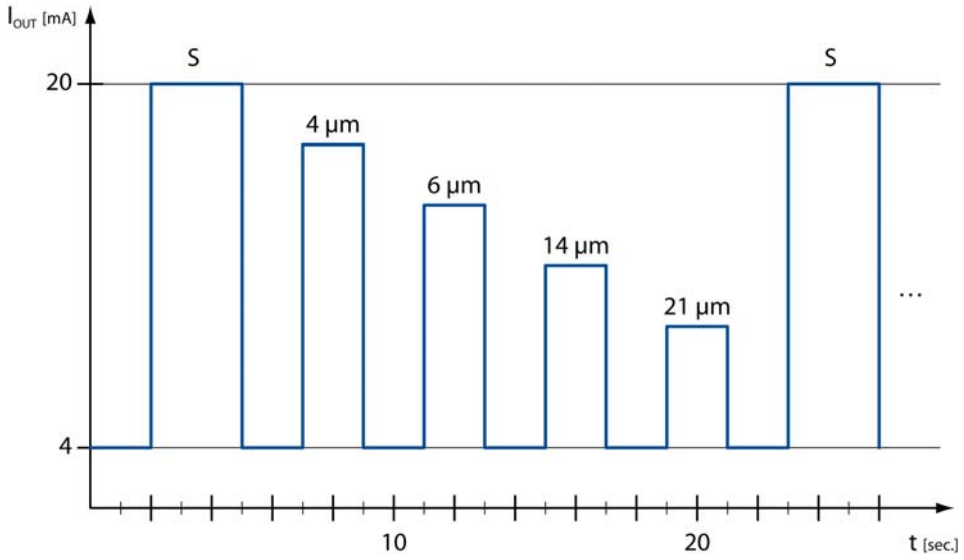
Pic. 8 Switching output

4.5. Calibration (reference value of the current output)

The current range covers ordinal numbers accoring to ISO 4406:99 from 0 … 32. A current value of 4 mA corresponds to the ordinal number „Zero“, 20 mA to the ordinal number „26“.Normally only ordinal numbers between 4 and 24 are used for display. Use this formula to calculate the ordinal number of the purity class from the measured current:

Formula	I_{OUT} in mA	Result	Ordinal No
$OZ = \frac{26}{(20-4)[mA]} \times x[mA] - \frac{26}{4}$	6	3.25	3
	10	9.75	10
	14	16.25	16

4.6. Sequential Data Output



Pic. 9 Sequence when transmitting all parameters subsequently

After a starting sequence (S), the measured values for the different size classes are transmitted subsequently. After a pause the next cycle starts with the transmission of the starting sequence.

4.7. Start-up

The particle counter will immediately start to measure and will display the first measuring results after approximately one minute.

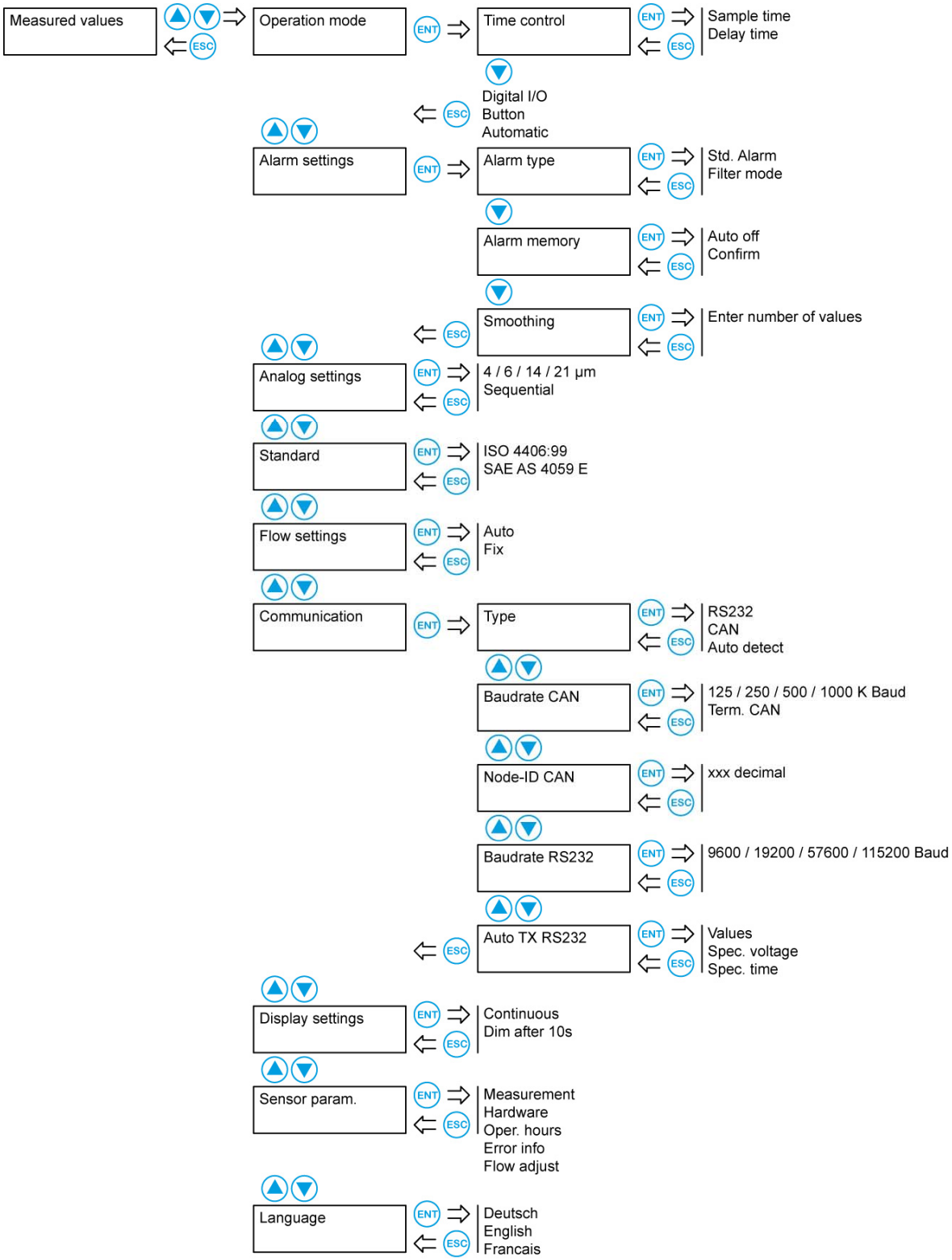
5. Operation of the Particle Counter

5.1. Navigation in the Menu

The operation keys are occupied as follows:

▲	opens the main menu; moves the highlighting bar upward; increases a value
▼	opens the main menu; moves the highlighting bar down; lowers a value
ENT	selects menu items and opens submenus; confirms entries; jumps to the next digit
ESC	returns to the higher menu level; leaves the main menu; cancels entries

5.2. Menu Tree



5.2.1. Select operation mode

Observe the minimal measuring duration

Do not use a measuring duration of less than 30 seconds. The particle counter needs more time to detect all particles accurately. The cleaner the oil, the longer the measuring duration. ISO 4406:99 purity levels of 15 and better should be re-measured after 120 seconds, latest.

Patrick can be used in three operation modes that can be selected in the menu:

Time controlled meas.	Patrick works with the set sample time and a delay time between the measurements; example: one minute sample time and four minutes delay time produce a measuring result each five minutes; in fact this will take some seconds more, because the laser is re-focussed at the beginning of each measurement; press ENT again while the option “Time control” is enabled and highlighted to set sample and delay time:
Sample time	press ENT to start the entry; arrows are displayed at the first digit; press ▲ ▼ to set the first digit; press ENT to jump to the next digit; set all digits of the sample time, confirm with ENT and press ESC
Delay time	set the desired delay time like described for the sample time
Digital I/O	the measurement continues until a signal is present at the input; the digital input is active when connected with GND; then a current will be present of I = (U – 1.1 V) / 5,600 Ω with U = supply voltage
Button	press the ENT key to start and end a measurement
Automatic	Patrick continues measuring until sufficient values for statistically confirmed measuring results are available; these will be displayed; measurement starts again after a pause time

5.2.2. Set alarms

Alarm type

First select the alarm type:

Std. Alarm	the alarm is triggered as soon as a set threshold is exceeded at a channel
Filter mode	used to supervise a cleaning; the alarm is triggered after all channels have been fallen below a defined threshold

Press ENT to activate the desired alarm type and then press ENT again to display the set threshold values:

```
STD. ALARM
  0 / 0 / 0 / 0
```

Press ENT to start the entry. Arrows will be displayed at the first „Zero“. Press ▲ ▼ to set the first alarm threshold. Press ENT to jump to the next class. Repeat this procedure to set the thresholds for all classes. If a class shall be neglected, the value should be set to “Zero”.

The thresholds set for the standard alarm will be used for the filter mode, too. And vice versa.

Alarm memory

Here you select the reaction of Patrick in case of an alarm. This can either be disabled automatically (set to „Auto off“) or remain active until confirmed by the operator.

Smoothing

Here you may set an average calculation preventing alarms for a single extreme value. Open the function and set the desired number of values used to calculate the average.

5.2.3. Analog settings

Here you may select which data shall be transferred to the analog output:

4 / 6 / 14 / 21	select the class which measured value shall be transferred via the analog output; it is a linear output in full ordinal numbers (4 mA equals to ordinal number “zero”, 20 mA to ordinal number “26”); the maximum burden depends on the supply voltage (R_{max} = ((U – 2 V) / 20 mA) – 100 Ω)
Sequential	the measured values of all classes are transferred sequentially (see section 4.6 on page 13)

5.2.4. Select standard

Choose the purity display in accordance to ISO 4406:00 or SAE AS4059E. Please be aware for SAE that the size classes 38 and 70 µm will not be evaluated in separate channels, but together with size class 21.

5.2.5. Flow settings

Patrick measures the volume flow rate together with particle size and number to calculate the concentration. This is done when the option „Auto“ is selected (recommended flow rate: 100 ... 400 ml/min).

Since each measurement has a certain inaccuracy you may set a known volume flow rate. This will be used to calculate the concentration. Select the option “Fix” and then press ENT, again:

```
Fix
   050 ml/min
```

Press ENT to start the entry. Arrows will be displayed at the first digit. Press ▲ ▼ to set the first digit. Press ENT to jump to the next digit and repeat the procedure to set the volume flow rate.

5.2.6. Communication settings

Here you define the configuration of the digital interface.

Select interface type

RS 232	data output via the RS 232 interface
CAN	data output via CAN bus
AutoDetect	the connected recipient will be detected automatically and the data output will be set to the required format

Baudrate CAN

Select the data transmission speed of the CAN interface. The selected speed must be identic with that of the connected CAN bus, otherwise communication will be impossible.

50 / 125 / …	select the speed in kBaud
Term. CAN	switches an 120 Ω resistor to terminate the CAN line; this option should be set at any time

Node-ID CAN

Here you may display the set node ID of the particle counter. This will be required to address the CAN commands and assign the CAN signals correctly.

Baudrate RS 232

Select the data transmission speed of the RS 232 interface. The selected speed must be identic with that of your system, otherwise communication will be impossible.

Auto TX RS 232

Here you may choose the data that shall be transmitted via the digital interface. You may transmit the current measured values, and the voltage and time values of the particle counter. You may transmit one, two or all three values.

5.2.7. Display settings

As a standard the display illumination is switched off after ten seconds („Dim after 10x“), but you may also switch it on permanently („Continuous“).

5.2.8. Sensor parameter

Here you may view several parameters of the particle counter:

Measurement	shows the recent measurements of the size classes and a volume flow rate index; press ▼ to toggle the display between the size classes
Hardware	shows several measured values of the system electronics; press ▼ to show more parameters
Oper. hours	shows the number of operation hours of sensor and laser
Error info	shows a list of all error messages and alarms; press ▲ ▼ to scroll through all information messages
Flow adjust	shows the volume flow rate level; if the bar is between L and H, the volume flow rate is ok; if the bar fills the complete diagram, or is invisible, and H/L blinks, the flow rate is too high/low and must be adjusted The display limits (bar chart) are between L = 100 ml/min and H= 400 ml/min. The L (low) starts flashing, if the volume flow rate falls below 100 ml/min. Patrick continues measuring correctly down to the minimal flow rate of 50 ml/min.

5.2.9. Language

Select one of the available languages.

6. Communication settings

6.1. Serial interface configuration

Patrick can be readout and configured via the serial interface. You will need a PC and an installed terminal software to do this.

Connect Patrick to an available COM port of the computer. A suited communication cable for the serial connection between sensor and PC/control can be ordered from Hydrotechnik. If the computer does not have a COM port, you may use a serial interface card or an USB-serial-converter.

6.1.1. Interface parameters

- Baud rate: 9600 / 57600
- Data bits: 8
- Parity: none
- Stop bits: 1
- Flow control: none

6.1.2. Command list: read commands

Cmd	Meaning	Return format
RVal[↵]	read current measured values with checksum (CRC)	$Time:%.4f[h];ISO4µm:%i[-];ISO6µm:%i[-];ISO14µm:%i[-]; ISO21µm:%i[-];SAE4µm:%i[-];SAE6µm:%i[-];SAE14µm:%i[-]; SAE21µm:%i[-];Conc4µm:%.2f[p/ml];Conc6µm:%.2f[p/ml]; Conc14µm:%.2f[p/ml];Conc21µm:%.2f[p/ml];FIndex:%i[-]; Mtime:%i[s];Status:0x0000; 0x0000;0x0000;0x0000;CRC:x
RMemS[CR]	read number of recordable data sets	MemS: xxxx[CR][LF]
RMemU[CR]	read number of recorded data sets	MemU: xxxx[CR][LF]
RMem[↵]	read all recorded measured values	Time [h]; T [°C]; P [-];P40 [-];PTG [1/K];… [CR][LF] x.xxx;x.xxxx;x.xxxx;x.xxxx; x.xxxx;... [CR][LF]
RID[↵]	read identification with checksum (CRC)	Hydrotechnik;Patrick;SN:xxxxxx-xxx; SW:xx.xx.xx;CRC:x 1)
RCon[↵]	read current configuration	Smode:%i;Fmode:%i;Analog:%i;Amode:%i;Alarm4:%i;Alarm6:%i;Alarm 14:%i;Alarm21:%i;(Mtime:%i[s];Htime:%i[s])

Please contact our customer support if you need a complete list with all commands.

6.2. USB communication

Patrick can be readout via an USB interface. You will need a PC with the installed software **HYDRO***com* 6. Connect Patrick to an USB interface of your computer. A suited RS 232 – USB converter cable is available from Hydrotechnik. Please obtain the hints in the **HYDRO***com* 6 online help for more information.

6.3. CAN

Patrick can be embedded into existing bus systems that comply with the CANopen standard. Please refer to corresponding technical or school books for more information on CAN and CANopen.

CANopen Object Dictionary

The table contains the communication-related part of the object dictionary of the particle counter. With a few exceptions, the possible settings correspond to the CANopen standard as described in „DS-301“.

Communication profile						
Idx	**SIdx**	**Name**	**Type**	**Attr.**	**Standard**	**Remarks**
1000h	0	device type	unsigned 32	ro	194h	sensor, see DS404
1001h	0	error list	unsigned 8	ro	00h	obligatory, see DS301
1017h	0	heartbeat time	unsigned 16	rw	1388h	heartbeat time in ms, range: 0 ... 65535
1018h		identity object	record	ro		
	0	number of entries	unsigned 8	ro	04h	largest sub index
	1	manufacturer ID	unsigned 32	ro	000001C0h	000001C0h
	2	product code	unsigned 32	ro	12D5C74Ch	12D5C74Ch
	3	version number	unsigned 32	ro	1000	device specific
	4	serial number	unsigned 32	ro		device specific
1800h		transmit PDO1 parameters	record			
	0	number of entries	unsigned 8	ro	05h	largest sub index
	1	COB-ID	unsigned 32	rw	180h +NodeID	COB-ID used by PDO, range: 181h ... 1FFh, may be changed when switched off (bit 30 must be set always, means no TPDO triggered to RTR)
	2	transmission type	unsigned 8	rw	FFh	cyclic + synchronous, asynchronous; values: 1 … 240, 254, 255
	5	event timing	unsigned 16	rw	1F4h	event time in ms for asynchronous TPDO1, value must be multiple of 50 and max 12700
1801h		transmit PDO2 parameters	record			
	0	number of entries	unsigned 8	ro	05h	largest sub index
	1	COB-ID	unsigned 32	rw	280h +NodeID	COB-ID used by PDO, range: 281h … 2FFh, may be changed when switched off (bit 30 must be set always, means no TPDO triggered to RTR)
	2	transmission type	unsigned 8	rw	FFh	cyclic + synchronous, asynchronous; values: 1 … 240, 254, 255
	5	event timing	unsigned 16	rw	1F4h	event time in ms for asynchronous TPDO2 range: 0 ... 65000
1802h		transmit PDO3 parameters	record			
	0	number of entries	unsigned 8	ro	05h	largest sub index
	1	COB-ID	unsigned 32	rw	380h+NodeI D	COB-ID used by PDO, range: 381h … 3FFh, may be changed when switched off (bit 30 must be set always, means no TPDO triggered to RTR)
	2	transmission type	unsigned 8	rw	FFh	cyclic + synchronous, asynchronous; values: 1 … 240, 254, 255
	5	event timing	unsigned 16	rw	1F4h	event time in ms for asynchronous TPDO3 range: 0 ... 65000
1A00h		TPDO1 mapping parameters	record			
	0	number of entries	unsigned 8	ro	05h	largest sub index
	1	PDO mapping for first application object to be mapped	unsigned 32	co	20000220h	operation hours time stamp of measurement, 4 byte
	2	PDO mapping for second application object to be mapped	unsigned 32	co	20010108h	ISO4µm, 1 byte in 2001h, sub 01
	3	PDO mapping for third application object to be mapped	unsigned 32	co	20010208h	ISO6µm, 1 Byte im 2001h, sub 02
	4	PDO mapping for fourth application object to be mapped	unsigned 33	co	20010308h	ISO14µm, 1 Byte im 2001h, sub 03
	5	PDO mapping for fifth application object to be mapped	unsigned 32	co	20010408h	ISO21µm, 1 Byte im 2001h, sub 04
1A01h		TPDO2 mapping parameters	record			
	0	number of entries	unsigned 8	ro	05h	largest sub index
	1	PDO mapping for first application object to be mapped	unsigned 32	co	20000220h	operation hours time stamp of measurement, 4 byte
	2	PDO mapping for second application object to be mapped	unsigned 32	co	20020108h	SAE4µm, 1 byte in 2002h, sub 01
	3	PDO mapping for third application object to be mapped	unsigned 32	co	20020208h	SAE6µm, 1 byte in 2002h, sub 02
	4	PDO mapping for fourth application object to be mapped	unsigned 33	co	20020308h	SAE14µm, 1 byte in 2002h, sub 03

	5	PDO mapping for fifth application object to be mapped	unsigned 32	co	20020408h	SAE21µm, 1 byte in 2002h, sub 04
1A02h		TPDO3 mapping parameters	record			
	0	number of entries	unsigned 8	ro	05h	largest sub index
	1	PDO mapping for first application object to be mapped	unsigned 32	co	20000120h	operation hours time stamp of measurement, 4 byte
	2	PDO mapping for second application object to be mapped	unsigned 32	co	20030108h	oil condition bits, 1 byte
	3	PDO mapping for third application object to be mapped	unsigned 32	co	20030708h	measuring bits, 1 byte
	4	PDO mapping for fourth application object to be mapped	unsigned 32	co	20030808h	sensor status bits, 1 byte
	5	PDO mapping for fifth application object to be mapped	unsigned 32	co	20040008h	temperature, 1 byte
2000h		time related sensor parameters	record			
	0	number of entries	unsigned 8	ro	02h	largest sub index
	1	operation hours counter[1]	unsigned 32	ro		sensor operation time in seconds
	2	operation hour time stamp of measurement[1]	unsigned 32	ro		time stamp of last measurement
2001h		ISO measurement	record			
	0	number of entries	unsigned 8	ro	04h	largest sub index
	1	ISO4µm[1]	unsigned 8	ro		
	2	ISO6µm[1]	unsigned 8	ro		
	3	ISO14µm[1]	unsigned 8	ro		
	4	ISO21µm[1]	unsigned 8	ro		
2002h		SAE measurement	record			
	0	number of entries	unsigned 8	ro	04h	largest sub index
	1	SAE4µm[1]	unsigned 8	ro		offset of two to display 000, 00 and 0, valid for all classes: 0 = SAE 000 1 = SAE 00 2 = SAE 0 3 = SAE 1 4 = SAE 2 …
	2	SAE6µm[1]	unsigned 8	ro		
	3	SAE14µm[1]	unsigned 8	ro		
	4	SAE21µm[1]	unsigned 8	ro		
2003h		condition monitoring bit field	array			
	0	number of entries	unsigned 8	ro	08h	largest sub index
	1	oil-specific bits[1]	unsigned 8	ro		0 = conc.limit exceeded (C >= ISO 23) 1 = high flow rate (F > 400) 2 = low flow rate (F < 50) 3 = measured values not plausible (air ...) ISO (i+1) >= ISO(i)
	2	reserved	unsigned 8	ro		
	3	reserved	unsigned 8	ro		
	4	reserved	unsigned 8	ro		
	5	reserved	unsigned 8	ro		
	6	reserved	unsigned 8	ro		
	7	measurement information[1]	unsigned 8	ro		0 = measurement in progress 1 = auto measuring mode 2 = I/O measuring mode 3 = manual measuring mode 4 = alarm mode filter / standard
	8	sensor alarm[1]	unsigned 8	ro		0 = laser voltage high (I > 2,8 mA) 1 = laser voltage low (I < 1 mA) 2 = photo voltage high (U > 4V) 3 = photo voltage low (U < 4V) 4 = temperature high (T > 80°C) 5 = temperature low (T < -20°C)
2004h	0	sensor temperature[1]	signed 8	ro		oil temperature in °C
2005h	0	flow rate index	unsigned 16	ro		flow rate index (0 … 400)
2020h		command	unsigned 8	wo		1 = start measurement 2 = stop measurement

2030h		measurement settings	record			
	0	number of entries	unsigned 8	ro	2h	largest sub index
	1	measuring time	unsigned 32	rw		measuring time in s
	2	idle time	unsigned 32	rw		time between two measurements
2031h		start settings	record			
	0	number of entries	unsigned 8	ro	1h	largest sub index
	1	start mode	unsigned 16	rw	0h	0 = network with NMT master (Init => PreOp => Start_Remote_Node => operational) >0 = network without NMT master (Init => operational)
2100h		control functions read memory	record			
	0	number of entries	unsigned 8	ro	3h	largest sub index
	1	history memory size	unsigned 32	ro	device-specific	memory size in data sets
	2	used history memory	unsigned 32	ro		occupied data sets in memory (corresponds to the write pointer internally)
	3	read pointer, data set	unsigned 32	rw		auto-incremental read pointer to a data set to read history memory; between 0 and the current write pointer
2101h	0	read memory starts segemented SDO data upload	unsigned 16	ro		suited pointer must be set before reading (with 2100sub3), data set size returned after reading, this initiates a standardized "segmented SDO upload"; obtain: change toggle bit at each data set and set corresponding bit at end of complete transmission
1: mapped on PDO						

7. Troubleshooting

No communication at COM port or current outputs < 4 mA	
cable not connected properly	conenct supply and communication cords properly
operation voltage outside range	run sensor in the range 9 … 36 VDC
No serial communication	
faulty interface configuration	check whether interface parameters (9600, 8,1, N, N) are set correctly in Patrick and PC
wrong COM port	check and correct the COM port
faulty notation of sensor commands	check notation, obtain small and capital letters
NumLock key disabled	enable the NumLock key
wrong or defective cable	only use Hydrotechnik cables
Identic values in all size classes	
air in the oil	connect Patrick at pressure side; increase distance to the pump
Fault measurement of analog current outputs	
wrong parameter emitted	correct the value assignments to the current outputs
Laser voltage high / photo voltage low	
air in the oil	connect Patrick at pressure side; increase distance to the pump
measuring cell dirty	clean the particle counter with clean oil or solvent, e.g. isopropanole