

A nanoparticle dosimeter for easy workplace exposure monitoring



Partector 2

Aerosol Dosimeter

Operation Manual

English

April 2021



Document information

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Related device versions: v 1.0

Related firmware versions: \geq 212

Older firmware may not offer all features
described in this manual

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Abbreviations

DC	Diffusion charging, diffusion charger
HV	High voltage
LED	Light-emitting diode
LDSA	Lung deposited surface area
N	Number concentration
d	Average particle diameter
S	Total surface area
PM0.3	Mass of particles smaller than 0.3 μm
μSD	Micro secure digital memory card

Safety information

General notes and warnings

This operation manual must be read completely before using the Partector 2. Incorrect use or handling and any consequences arising from this may damage the device or endanger personnel.

The manufacturer declines all liability resulting from incorrect use and handling.

Safety notes

Never operate the instrument at condensing conditions.

Do not blow into the instrument.

Do not open the Partector 2 as you may damage it.



The Partector 2 is a sensitive instrument made for measuring nanoparticles. Sampling too much coarse dust will eventually lead to deteriorating instrument performance. Use a cyclone when measuring in environments where large numbers of microparticles might be present.

Do not operate the Partector 2 in an explosive atmosphere or in the presence of flammable gases or fumes.

Have your instrument recalibrated once a year.

Use only the original USB power supply and USB cable.

Instrument specifications

Measurements and accuracy

Measured values:	LDSA	Lung deposited surface area
	N	Number concentration
	d	Average particle diameter
	S	Total surface area
	PM0.3	Particle mass (<0.3 μm)
Concentration ranges:	LDSA	0 - 12'000 $\mu\text{m}^2/\text{cm}^3$
	N	0 - 10 ⁶ pt/cm ³
	S	0 - 50'000 $\mu\text{m}^2/\text{cm}^3$
	PM0.3	0 - 1'000 $\mu\text{g}/\text{m}^3$
Particle size range:		20 – 150 nm (fixed deposition voltage) 10 – 300 nm (adaptive deposition voltage)
Typical accuracy:	LDSA	$\pm 30\%$ or $\pm 3 \mu\text{m}^2/\text{cm}^3$
	N	$\pm 30\%$ or $\pm 1000 \text{ pt}/\text{cm}^3$
	d	$\pm 30\%$ or $\pm 10 \text{ nm}$
	S	$\pm 30\%$ or $\pm 15 \mu\text{m}^2/\text{cm}^3$
	PM0.3	$\pm 50\%$ or $\pm 0.3 \mu\text{g}/\text{m}^3$
Noise floor:		$\sim 0.5 \mu\text{m}^2/\text{cm}^3$ in particle-free air (LDSA)
Time resolution:		1 s
Response Time:		2/4/8/16 s, user-adjustable

The measurement uncertainty of the Partector 2 is largely determined by the unknown shape of the particle size distribution. It is calibrated for lognormal particle size distributions with a geometric standard deviation of 1.9, which is a reasonable assumption for many environments.

Note: if you measure particles of only a specific diameter (monodisperse particles), the Partector 2 diameter determination will be inaccurate, as will number, surface and mass determination. Contact naneos if you want to use the device for monodisperse particles.

Technical specifications

Inlet flow:	0.5 l/min
Operating Temperature:	0 – 40 °C
Storage Temperature:	-10 – 50 °C
Relative Humidity:	10 % to 90%, non-condensing
Operating height:	0 - 3000m above sea level
Battery:	Rechargeable Li-Ion, 12Wh
Battery lifetime:	~ 24h (with a new battery; aging will occur; low power mode enabled, ~20h with silent pump)
Battery Charging:	via USB, 5V / 1.5A
Data storage:	µSD-card
PC Interface:	USB/serial by virtual COM-Port Serial port adapter for SD card available
BT wireless range:	3 - 30 m, depending on obstacles
Noise:	~ 35dB in 1m distance (standard pump) inaudible (silent pump)
Dimensions:	8.8 x 14.2 x 3.4 cm
Weight:	420 g (410 g with silent pump)
Pollution degree:	2, or with cyclone at inlet 3.

Checking the shipment contents

When unpacking the device, verify that you have received the following items. If any of the components are missing or damaged, contact naneos.

Type	Items
Standard	Partector 2 device
	USB cable, 1.2m
	μSD-card 8 GB
	μSD/SD-card adapter or μSD/USB-adapter
	Carrying sleeve
	USB charger
	12 cm Tygon tubing
	Peli case

Storage and transport

To avoid damage during storage and transport, please use original packaging.

Avoid locations with high/low temperatures and high humid conditions or places that can get wet.

Do not store the device with an empty battery.

Do not store the device in direct sunlight.

For longer storage, mount the protection cap.

Getting started

Instrument description

The Partector 2 is a hand-held, battery powered instrument to measure the lung deposited surface area (LDSA), the number concentration and the average particle diameter of nanoparticles. It displays the measured data on a graphical display and stores it on a μ SD card. A user-defined LDSA alarm level can be set. If the alarm level is exceeded, the instrument's internal buzzer is turned on to produce an audible warning. The device can communicate with Android smartphones that support BT low energy.

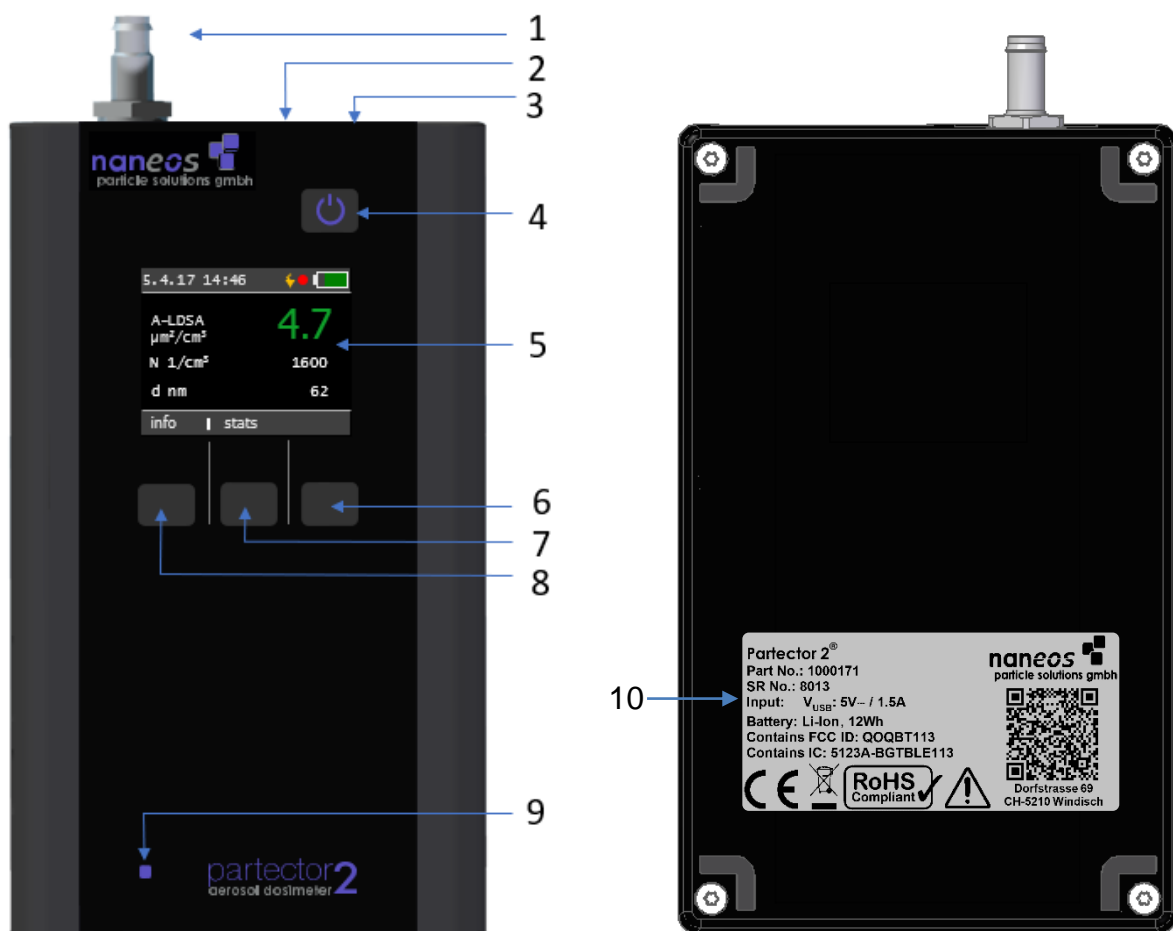


Figure 1: Partector 2 main parts

- | | | | | | |
|---|--------------------|---|-----------------|----|--------------|
| 1 | aerosol inlet | 5 | display | 9 | charge LED |
| 2 | USB Port | 6 | right soft key | 10 | serial plate |
| 3 | μ SD card slot | 7 | middle soft key | | |
| 4 | power button | 8 | left soft key | | |

Aerosol inlet and outlet

The aerosol inlet is located at the top of the instrument. The internal pump provides a regulated air flow of about 0.5 l/min. The standard aerosol inlet has a 6-mm barb for tubing connection and contains a coarse wire mesh to keep coarse dirt and small insects out of the instrument.

The air exits the device via the slits in the right-hand side of the housing. Note that the air is not filtered internally, so do not connect the instrument to hazardous nanoparticle sources!

Tubing

When using the Partector 2 with tubing make sure **not to use conductive silicone tubing**. It releases silanes which lead to rapid fouling of the Partector's corona wire. We recommend using PVC tubing instead – a nice flexible version is Tygon S3 E-3603, a sample of which is included in the Partector 2 case. If in doubt about using tubing, please contact us. In any case, tubing should only be as long as necessary to prevent particle losses in the tubing.

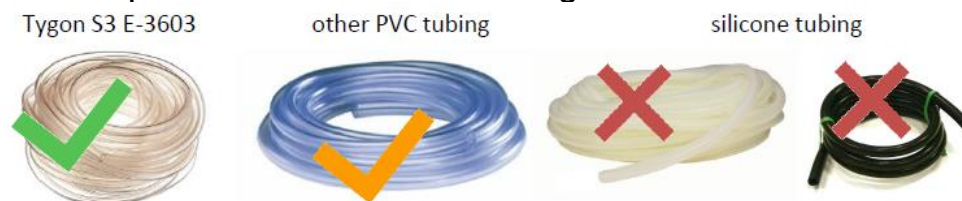


Figure 2: different tubing options

Supplying power

To charge the Partector 2 or to operate it for periods longer than the battery lifetime, connect the Partector 2 USB port to a PC, Laptop or to a USB-charger or to a mobile power bank to charge the device.

While charging, the blue charge LED on the front panel lights up. When the Partector 2 is fully charged, the LED turns off.

The Partector 2 supports fast charging (1.5A charging current). For optimum charging, use the original USB power supply and USB cable. Some PC's and USB power supplies only provide 0.5A charging current, which will prolong the charging duration.

Turning the device on and off

To switch on the device, press the power button. To turn it off, press and hold the power button for two seconds and release it when the goodbye message appears.

Insert / remove μ SD-card

To store data on the microSD-card, insert it in the Partector 2 as shown in Figure 3 till it snaps in.

To remove the μ SD-card, press on the inserted card which will force the release. To insert the card in your SD-card slot on a PC you need to insert the card first in the μ SD/SD-card adapter or μ SD/USB adapter provided.



Figure 3: micro-SD card slot

Recording measurements on the μ SD-card

If a μ SD-card is inserted in the Partector 2 before startup, the device automatically starts recording on the μ SD-card when the device is turned on. It automatically generates a filename depending on start date, time and device serial. For more information about this, read the “Partector 2 data file” section.

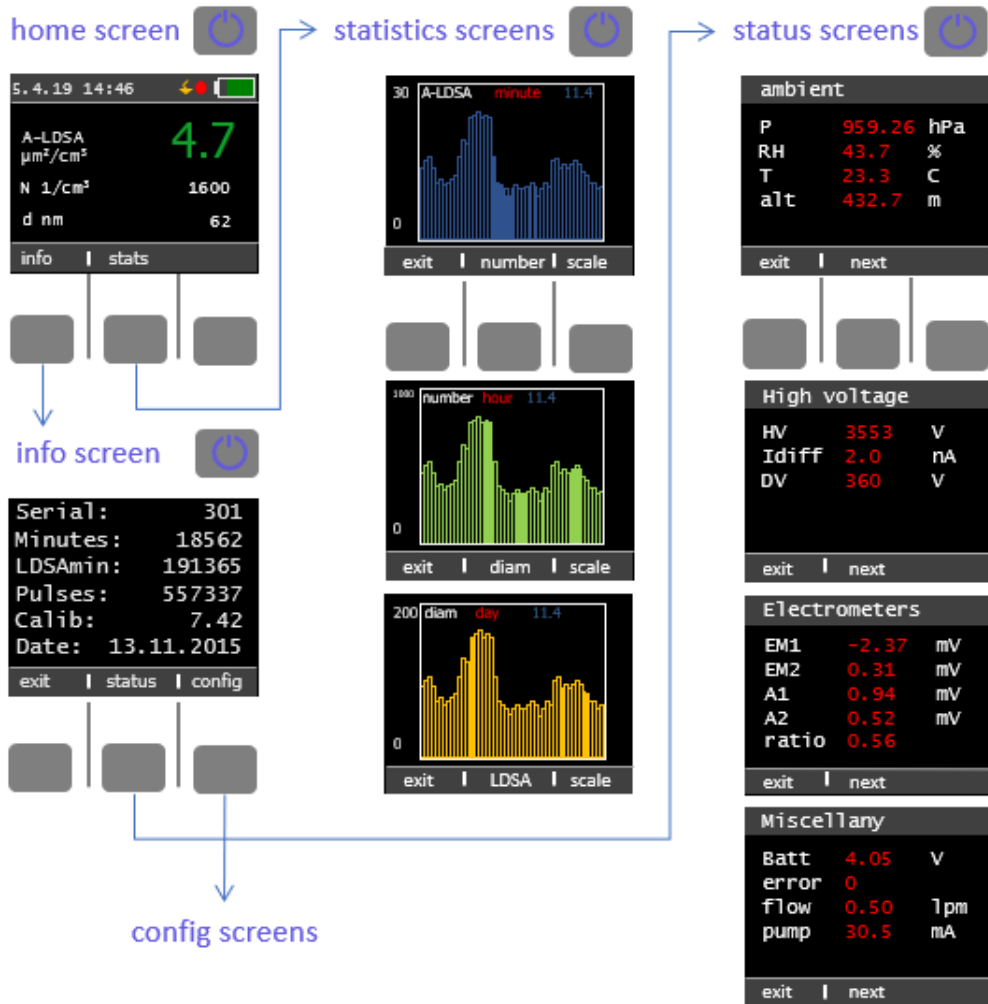
If you insert the μ SD-card while the device is running, the data logging will not start automatically. You need to turn the device on after inserting the card. The Partector 2 will complain that the SD card is missing if it is not in the slot at startup. When the Partector 2 is recording data, you can see a blinking red dot in the status bar of the main screen.



Do not remove the μ SD-card while the device is running. The data file needs to be closed properly, otherwise it will be corrupt.

Keypad functions & symbols

In the picture below, you can see the Partector 2 display screens:



config screens



Figure 4: Partector 2 menu screens

Home screen

On the home screen you can see the LDSA, the number concentration, the average particle diameter, date and time and the charge state of the battery. If no key is pressed for more than one minute and the low power option is activated in the configuration, the display goes dark to prolong battery life. By pressing any key, the display turns on again.



The lightning symbol indicates that the high voltage in the charger is on and working properly.



The blinking red dot indicates that data is being written on μ SD-Card.



The exclamation mark indicates that an error occurred at some point during the current measurement.

Color coding of LDSA values

The LDSA display is color-coded to provide a quick assessment of air quality. LDSA values below $50 \mu\text{m}^2/\text{cm}^3$ are displayed in green, values above $250 \mu\text{m}^2/\text{cm}^3$ in red, and values in between in yellow.



Figure 5: color coding of LDSA values

Info screen

The info screen displays device specific system information:

Serial:	serial number of the device
Minutes:	total operating time in minutes
LDSAmin:	LDSA value integrated over time
Pulses:	number of high voltage charging pulses
Calib:	calibration factor for LDSA
Date:	date of calibration

Pressing the “status” soft button brings you to the status screens. Pressing the “config” soft button brings you to the config screen.

Status screens

The status screens show the most important device data. You can switch between the individual status screens by pressing “next”.

Ambient

p	air pressure [hPa]
RH	internal relative humidity [%]
T	internal temperature [°C]
alt	calculated height above sea level [m]

Note: Altitude is calculated for average pressure. It may be off by several 100 meters if ambient air pressure is very high or low due to a high or low pressure area passing through.

High voltage

HV	charger corona voltage [V]
Idiff	charger diffusion current [nA]
DV	deposition voltage [V]

Electrometers

EM1	signal of electrometer 1 [mV]
EM2	signal of electrometer 2 [mV]
A1	electrometer 1 amplitude [mV]
A2	electrometer 2 amplitude [mV]
Ratio	Ratio A2 / A1

Miscellany

Batt	battery voltage [V]
error	displays the current error status (0 = no error)
flow	approximate flow through device [lpm]
pump	pump current [mA]

Config screens

In the config screens, you can change some settings of the Partector 2.

Alarm: use the “up” and “down” soft key to change the alarm level to the desired value. When the measurement value exceeds the alarm level, the internal buzzer of the Partector 2 will produce an audible warning.

Heater: The Partector 2 can use the built-in buzzer for the alarm to heat the device slightly. This can only increase the temperature of the device by about 2°C compared to not using the heater; but this is sufficient to reduce the internal relative humidity by 5-10% depending on ambient conditions. If you are operating the Partector 2 in a very humid environment (e.g. in the tropics) the heater may help to avoid issues with high humidity. Please note that the heating power is low, so it will take several minutes to make a noticeable difference. Please also note that “wasting” power for heating the device will reduce battery life. For all normal conditions, it is recommended to keep the heater off. The heater will also turn on automatically if a relative humidity > 80% is detected.

Wireless: The Partector 2 has a built-in wireless communication module. This allows other devices, like smartphones with BT low energy support, to receive data from the Partector 2 via wireless communication.

Adaptive DV: The Partector 2 can either operate with a fixed voltage on the internal precipitator, and measure particles in the size range of 20-150nm, or it can switch to lower/higher deposition voltages if the particles are very small or very large – this is called the "adaptive DV" mode. In this mode, the Partector 2 can measure particle diameters from 10 – 300nm. However, there may be small jumps in the measured values at the times when it switches its internal precipitation voltage.

Timebase: Here you can choose over which interval the Partector 2 should integrate its signals to calculate its readings. You can choose between 2, 4, 8 and 16 seconds. Shorter integration times give a faster response at the cost of higher noise levels.

Time and Date: the internal clock of the Partector 2 has an accuracy of about 1s per day. It does not change to daylight saving time and back automatically. Therefore, you may need to set the clock from time to time. Press the “next” soft button until you are on the field you want to modify, then use the “up” and “down” soft buttons to change the field’s value.

Metrics (metric 1, metric 2, metric 3): The Partector 2 main screen is configurable – you can choose which metric you would like to have displayed as main information (large, metric 1), and which 2 additional metrics you would like to have displayed additionally (smaller, metrics 2 and 3). By default, metric 1 is LDSA, metric 2 is particle number, and metric 3 is average particle diameter. You can choose to change the order of these, and you can also choose to display calculated total surface area (instead of the lung-deposited fraction of the surface area), or calculated particle mass (PM_{0.3}). Please note that the calculation of particle surface area and in particular of particle mass depend on a number of assumptions (particle density, morphology, shape of the particle size distribution) and are inherently less accurate than the standard metrics that are shown as default.

SD: The SD card of the Partector 2 can be used as a serial port if you need a serial connection to the device. Naneos offers an SD-to-serial adapter piece that you can use for this purpose. To use the SD card as a serial port, change the setting from SD to UART. You need to restart the Partector 2 for the change to become effective. In the UART mode, you can no longer use an SD-card, and the Partector 2 will no longer write data files to SD-cards! If you want to use this feature (e.g. to integrate the Partector 2 in a data acquisition system) please contact naneos for details.



Demo mode: In the demo mode, the entire screen of the Partector 2 changes to the color corresponding to the LDSA value, and only the LDSA

value is shown in white. This mode can be helpful to demonstrate air quality changes.

Low power mode: you can choose whether the device should operate in low-power mode or not. In low power mode, the display turns darker automatically after a minute of inactivity to increase battery lifetime, and turns off completely after 10 minutes of inactivity. Pressing any button (also the power button) will turn on the display again. The display will also turn on automatically if an error message is displayed.

Hardware: shows hardware version of the device, only for information

Firmware: shows firmware version of the device, only for information

BT Firmware: shows BT firmware version of the device, only for information.

Reset: Reset some of the device parameters to factory settings. This should not be used in normal operation.

Statistics screen

The statistics screen allows you to view the time series of the measured data over a recent time interval. Press the central soft button to change the displayed metric (LDSA, number concentration, average particle diameter). Press the “scale” soft button to change the time scale (last minute, last hour, last day).

Extended information

Different inlet options

The Partector 2 comes with a standard inlet – a 6mm tube fitting with a steel mesh. You can use either this or you can add a cyclone in front of the tube inlet to remove coarse particles. The internal pump cannot support high pressure drops, so you should not use an impactor.

The Partector 2 is a miniature instrument with extremely sensitive internal electrometers. Fibers or dust particles which are larger than about 1 mm in size can produce short circuits in the instrument. Therefore, the tube inlet has a steel mesh to prevent really coarse dust particles or small insects from entering the instrument. If you do not use the inlet, you risk aspirating coarse dust that may result in a deteriorated instrument performance.



We recommend the use of a cyclone if you are measuring in dusty environments where a large number of coarse particles are present. For example, the SKC GS-3 cyclone would be useful for this purpose. <https://www.skcinc.com/products/gs-3-respirable-dust-cyclone-conductive-25-mm>

A possible assembly of the cyclone is shown in Figure 6.



Figure 6: SKC GS-3 cyclone mounted on a Partector 2

If you are certain that you have no coarse particles in your air (which is normally the case in ambient air), then you can also use the standard tube inlet.

In normal ambient and indoor air measurements, no cyclone is necessary.

The Partector 2 data file

To view the measured and stored Partector 2 data, remove the μ SD and insert it in your PC as described in a previous section. Now you either download the Partector 2 data analysis tool from the naneos website to view the data or you open the data file with your favourite data analysis program (Excel, Origin, Igor etc). The data file is a simple tab-delimited text file. File names encode the recording time and device serial no. For example, if you start recording a file on 2nd August 2017 at 12:35:44 with a device with the serial no. 8019, the file will be stored in the folder 2018_08_02 with the file name 8019_123544.txt.

The Partector data analysis tool allows you to quickly view graphs of all instrument parameters, to average data in different intervals, and to combine measured data with a GPS signal and plot it in Google Earth. Read the separate quick guide on our website for more information.

Wireless communication

The Partector 2 supports wireless communication. It works in the advertising mode, i.e. it continuously sends out small data packets that can be read by nearby BTf low energy (BLE) receivers. An Android app and an IoT solution are under development. Contact naneos for more information if you are interested.

If you wish to develop your own application to listen for the Partector 2 advertisements, this is fairly easy by scanning for nearby devices, filtering by the name "P2", and reading the advertisement custom data. Contact naneos for details on the data format if you are interested in developing your own application.

Error messages

Error conditions

Whenever an operation parameter of the Partector 2 is outside of its normal range, a warning message appears on the Partector 2 screen. The warning shows up in red on the home screen:

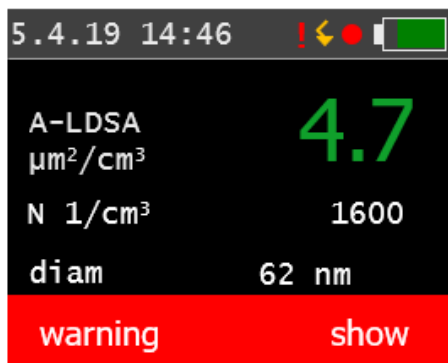


Figure 7: generic warning message on home screen

There are different reasons for warnings to appear, and a click on the “show” soft button will display details on the warning. Some error conditions may disappear again by themselves (particularly such related to high humidity), upon which the warning message will also disappear again. However, it can be important to know that an error occurred, and therefore, a red exclamation mark remains in the title bar as a reminder that an error occurred at some point:

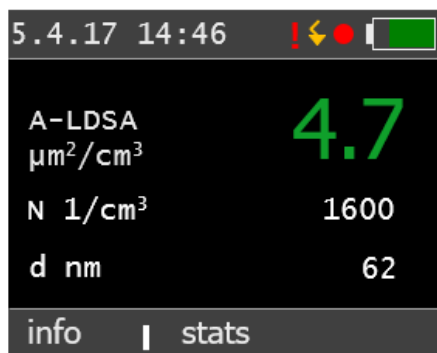


Figure 8: home screen after recovery from an error condition

The following table gives an overview over the possible error conditions and on what to do to remove them.

message	possible cause	what to do
SD card error: “Card missing?” “FS init”	<ul style="list-style-type: none"> - no SD card inserted - SD card initialisation problem - bad card format 	<ul style="list-style-type: none"> - insert SD card - reboot device - format SD card - try a different SD card
Pulse low error	<ul style="list-style-type: none"> - too high relative humidity - device contamination 	<ul style="list-style-type: none"> - try measurement with lower humidity - contact naneos
Pulse high error	<ul style="list-style-type: none"> - diffusion current does not reach setpoint 	<ul style="list-style-type: none"> - contact naneos for customer self-repair
Pulse unstable error		<ul style="list-style-type: none"> - contact naneos
Ucor low	<ul style="list-style-type: none"> - high voltage module broken 	<ul style="list-style-type: none"> - contact naneos for customer self-repair
Dep volt. Low	<ul style="list-style-type: none"> - high voltage module broken 	<ul style="list-style-type: none"> - contact naneos for customer self-repair
Buffer overflow	<ul style="list-style-type: none"> - software loop time delayed. 	<ul style="list-style-type: none"> - report error to naneos. You can still measure with the device if it only appears infrequently.
RH high	<ul style="list-style-type: none"> - relative humidity is very high and may affect measurement 	<ul style="list-style-type: none"> - if possible, measure at lower RH (use a dryer at inlet or turn on heater)
EM 0 x.y mV	<ul style="list-style-type: none"> - high RH - device contamination 	<ul style="list-style-type: none"> - if possible, measure at lower RH (use a dryer at inlet or turn on heater)

EM overflow	- extremely high aerosol concentration	- use a diluter for the measurement as the instrument will age quickly and readings will be inaccurate
EM1 gain error EM 2 gain error	- electrometer defective	- contact naneos
Flow error or pump current error	- pump defective - clogged Inlet	- check flow with a flowmeter - clean the inlet - contact naneos
Selftest error		- contact naneos and report error code on display
Calib error		- contact naneos

Some of the error conditions are rather harmless (e.g. high electrometer zero offset, high RH error), whereas others like the pulse errors or broken high voltage modules will interfere with a correct measurement. If you experience frequent errors, please contact us by email, and send us a description of the error message, what you were doing when it occurred, and the data file of that measurement. A data file helps us a lot in diagnosing the problem.

Maintenance

High voltage is present in the device – do not open!
unless you have received other instructions from naneos.



Clean the device

Use a soft, slightly damp cloth to clean the housing surface.

Clean the inlet

Use a 14mm open-end wrench to detach the inlet. Clean the inlet with water, in an ultrasonic bath if possible. Dry the inlet thoroughly and only screw it back on when it is completely dry, because the remaining water could damage the device.

Disposal

The device contains a lithium ion battery and must be disposed of accordingly. Under no circumstances should it be disposed of with domestic refuse, nor crushed or burnt. Naneos offers to take products back for correct disposal.

Standards and approvals

The Partector 2 is in conformity with the provisions of the following European Directives:

2011/65/EU	Restriction of hazardous substances (RoHS)
2014/53/EU	Radio Equipment Directive (RED)
	EN61000-3-2:2014, EN61000-3-3:2013, EN61326-1 :2013, IEC61010-1 :2010, EN300 328 V.2.1.1

Related documents

Partector 2 quick start guide:

www.naneos.ch/pdf/partector2_quick_guide.pdf

Partector 2 data analysis tool quick start guide:

www.naneos.ch/pdf/javatool_quick_guide.pdf

In-depth explanation of lung-deposited surface area (LDSA)

www.naneos.ch/pdf/LDSA.pdf

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