TURNKEY® i-PM*portable* OPERATING INSTRUCTIONS

For firmware P0310mjl

The iPM*portable* is powered by an interchangeable 12 Volt Lithium battery that clips into the shoe at the bottom of its handle. The instrument is supplied with two DeWalt XR 3 Ah batteries, when fully charged, each will power the instrument for about 10 hours (excluding the heated inlet). Only recharge the batteries using the supplied DeWalt DCB1104 rapid charger. A full recharge takes just a couple of hours.

The on-off rocker switch on the front panel isolates the battery. For safety, remove the battery during transportation.

To switch on, set the rocker switch to the **I** position.

Operation of the instrument is controlled by the state of its **Feature Flags** and its **Instrument Settings**. Its operational state is indicated by the **Instrument Information** table, **Fault Flag** states and **Diagnostic & Housekeeping Readings.**

Please see Appendix of this document for full lists of the Feature Flags, Instrument Settings, Fault Flags and Diagnostic readings.

The following associated documentation is available from www.i-PM.eu

- ***Connecting to AirQWeb***
- ***iGAS, iGASpod, iEXTRA and iMET***

Please contact Turnkey if you need more help ***techsupport@turnkey-instruments.com***

SAMPLING

Sampling is the process by which the instrument measures and stores readings from the iPHOT laser diffraction photometer. New readings from iPHOT are available every 1 second. Each **sample** consists of a series of readings averaged over successive time intervals known as the **Reporting Interval**. The series of reports, which make up the sample, is known as the time series. The reported readings are the average value of the 1 second iPHOT readings over the reporting interval. Average readings over the duration of the sample are also recorded.

Sampling may be started and stopped automatically as defined by the **Feature Flags**. Automatic samples are generally aligned with 1 minute boundaries. The instrument is set to synchronize its time with an internet NTP time server.

The shortest reporting interval is one second, the longest 50 minutes. You cannot push reports of less than 60 seconds duration. The recommended reporting intervals are between 1 minute and 15 minutes, these give the best compromise between memory use and time resolution. The shortest sampling period is one report interval, the maximum many days.

The instrument's memory can hold up to 100 samples each consisting of many reports. A sample is identified by its **Sample Number**. When the memory is cleared the sample number is reset to 0. The total number of samples measured by the instrument over its life is the **Sample Total** and can only be reset by Turnkey.

SAMPLE CONTROL FEATURE FLAGS

If *Automatic Start* is set, sampling will automatically start on the next 1 minute boundary after the instrument is switched on. If *Timed Sample* is set the sample will last for the **Duration** number of reports (specified in the **Instrument Settings**) and, if *Automatic Start* is set too, another sample of the same duration will start immediately. This process will carry on till the memory fills when a *Memory Full* Fault Flag will end the current sample and prevent another restarting.

If *Circular Buffer* is set, the last sample (i.e. the one just finished) will be overwritten if the Instrument Settings **Sample Stack** value equals 0, if it equals 1 the last but 1 will be overwritten and so on. Hence it is possible to create a stack of samples that will overwrite forever. For example, if the Sample Stack value equal 28, the last 28 samples will always be available in memory. By default, the sample stack is set to 9.

If *New Sample Daily* is set a new sample will start at precisely midnight but only if *Automatic Start* is set. This can be combined with the *Circular Buffer* flag and the value of the **Sample Stack** to create a rotating, N-day, sample block.

HEATED INLET

Using the optional heated inlet reduces the run time because of the extra current drain. How much depends on the inlet temperature set point. A larger 5 Ah battery is available and will power the inlet and instrument for about 5 hours on a full charge. The heated inlet can be set for either constant sample temperature or constant sample humidity operation. For the latter, an ambient temperature probe is required. The temperature and humidity control points are set by the user in **Instrument Settings**

POWER MANAGEMENT AND SLEEPING

If the XR battery voltage drops below 9 Volts, measurements will stop and the current sample will be terminated and the *No 12V supply* Fault Flag will be set. The instrument will go to sleep but will still draw a small amount of power from the battery. Do not leave the instrument in this state as it will eventually fully discharge and may damage the battery. If this happens return the rocker switch to the **O** position and swap the battery.

The *Low Battery* Fault Flag is set when the battery voltage drops below 10 Volts.

The battery is not required for data storage and the instrument uses flash memory to store the results. Data retention is more than 100 years.

To conserve power the display will turn off after about one hour if the OK button hasn't been pressed. The instrument will continue sampling. The display can be restored by pressing the OK button.

If sampling has stopped and the rocker switch left in the on position, the instrument will go into a reduced power sleep state (current draw less than 0.1 mA). It can be awoken from sleep by a local or remote timed sample request or by pressing the OK button.

You may lose some of your results if you switch the rocker switch to O while the instrument is sampling. Stop the sample first, then switch to O.

GETTING STARTED WITH iPM*portable*

Once switched on, the instrument can be operated using the OK button, or via a browser on your smart phone or via the Turnkey AirQMobile App (available free from the Apple and Android stores).

The OK button is used to navigate around a simple menu hierarchy that allows you to start and stop sampling, display and review results and to change the instrument settings as follows:

Single click OK to move to the next choice in the menu

Double click OK to select that item

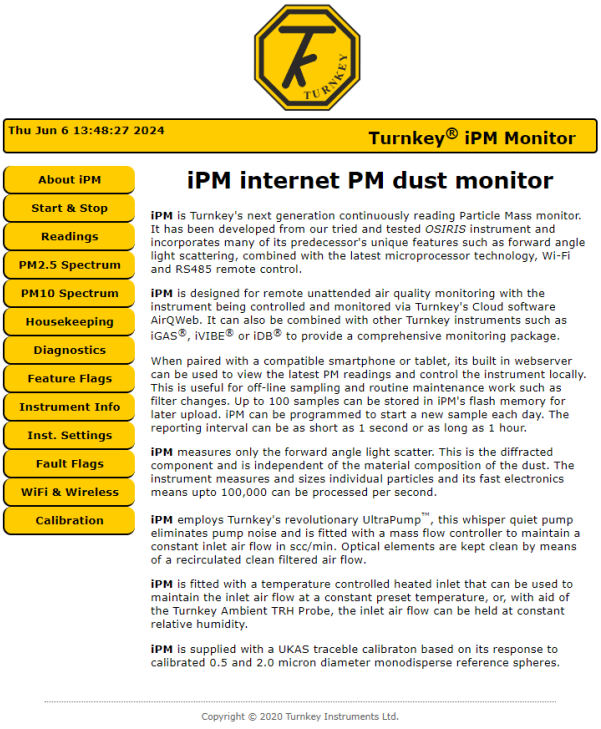
Hold OK to go back to the previous item

To turn the instrument on, switch the **Power Switch** rocker to **I**, after a short delay (2-3 seconds) the display will briefly show the battery and sensor voltages.

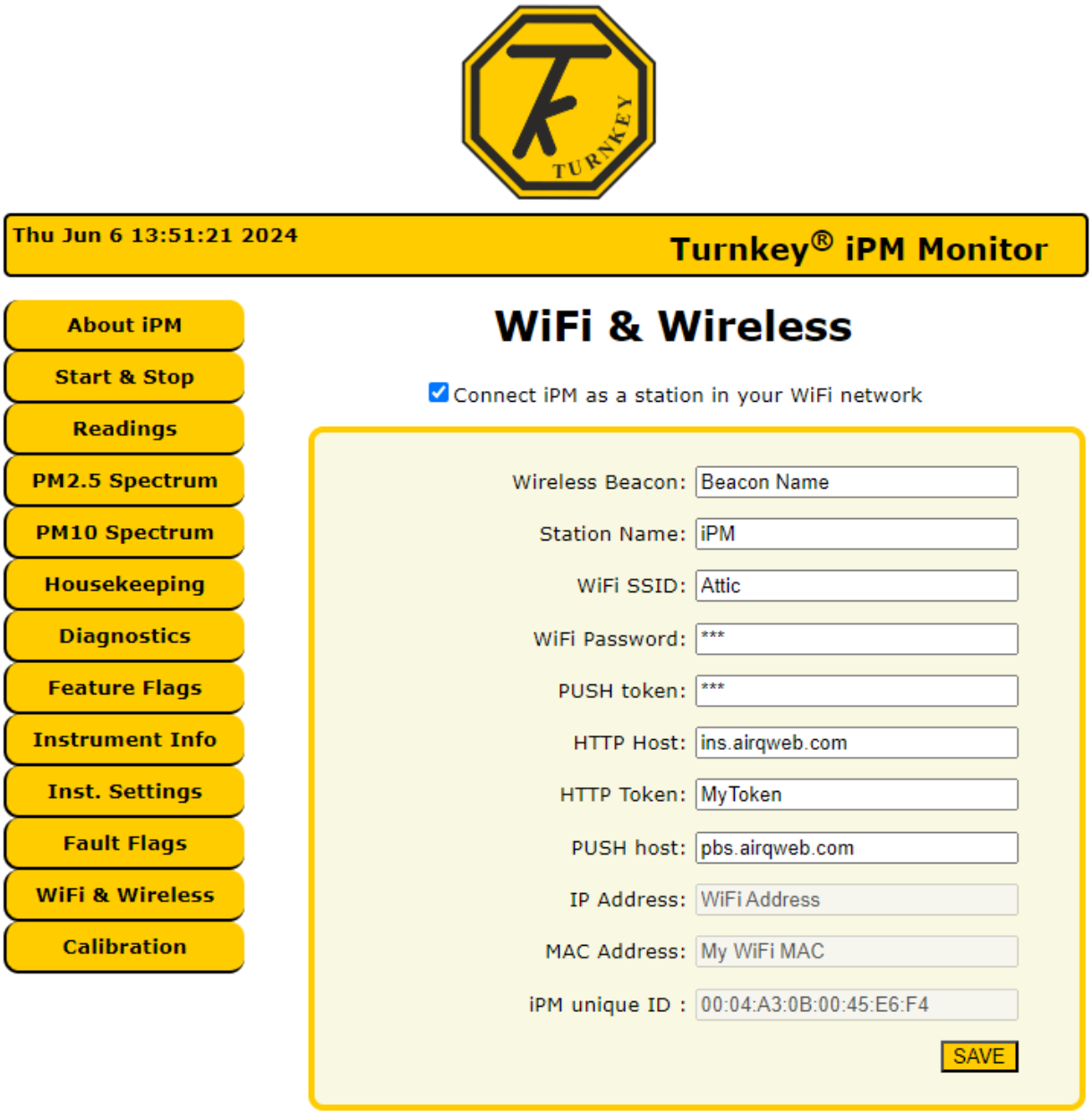
The instrument will only start if the battery voltage is greater than 9 Volts. The red light will appear whenever the instrument is switched on. iPM will attempt to connect as a station of your WiFi network. It will only do so if the *Use WiFi network* flag is set. If you hold the OK button at startup it will force the iPM to create a local WiFi access point or hotspot instead. Similarly, clicking OK during the WiFi network search will cause the search to be abandoned and a hotspot created and the WiFi Hotspot flag to be set.

On first use, or with a new network, you must use this hotspot to tell i-PM the WiFi SSID and password of your network. To do this, search for the i-PM hotspot with your Android or Apple device. It will be called iPM-xx, where xx are the last 2 characters of the ID on the front panel, and connect using the password XXXX (for security, please contact techsupport@turnkey-instruments.com).

Then, in your browser, navigate to 192.168.4.1 and the following page should appear:



Then, using the buttons on the left, select the ***WiFi & Wireless*** page



Select the ***Connect iPM as a station*** checkbox, enter your network's SSID and Password into their edit boxes and click ***SAVE***. The SSID can have 31 characters, the password is AES encrypted and can have a maximum of 15 characters. The plaintext password is never saved in i-PM, only its ciphertext.

Reboot the instrument by toggling the rocker switch. The following sequence should appear on the display.

A valid IP address should have been assigned by your router, you can also see it in the refreshed ***WiFi & Wireless*** page above.

The iPM microsite is available via the hotspot or the network and is useful when setting up the instrument in the field and changing the filter. Please consult the factory before changing any of the instrument's flags and settings.

If you are using a smartphone, it is best to set the phone up as a local WiFI hotspot and connect your iPM to that network. Doing that means the iPM will have access to GPS location information. It will also allow you to use Google charts to plot the PM2.5 and PM10 particle size spectra and get live mapping information for the Turnkey AirQmobile App.

There is a clamp on the bottom LHS of the iPM front panel to allow you to securely attach a smartphone in either landscape or portrait orientation to record videos and audio commentary while you carry out a survey. The iPM readings can also be overlaid on a location map.

POWER ISOLATOR SWITCH

The **Power Isolator Switch** is intended to isolate the battery if the i-PM is not to be used for a long period of time. Only turn the switch to **O** when sampling has finished and results have been stored. Operating the switch when sampling may lose the current sample results. Wait till the iPM has finished sampling before operating the switch.

Please contact techsupport@turnkey-instruments.com if you experience any difficulties.

APPENDIX°

FEATURE FLAGS

(shown as *underlined italics* in the text)

The operation of iPM is controlled by Feature Flags which may be set or cleared by the operator. They are normally set automatically by AirQWeb. The basic set of Feature Flags is as follows, preset factory defaults are shown ticked√ and can be changed by the user:

Feature Flag Name		Explanation/Description
Enable iPM	√	Measure ambient PM concentrations
Enable iGAS		Measure ambient gas concentrations. Requires iGASpod or iGAS manifold to be fitted
Enable iEXTRAS		Measure derived quantities such as NOx
Enable iMET		Measure meteorology T, RH, wind speed & direction, etc.
Alt. Diagnostics		Alternative diagnostic measurements
Alt. Housekeeping		Alternative housekeeping measurements
Gas mass units	√	Measure gases in µg/m^3 instead of ppb or ppm
USA units		Indicate temperatures in °F instead of °C
Auto Start	√	Automatically start sampling whenever power is on and battery condition is OK. Sampling starts on 1 minute boundary. Will be cleared if sampling stopped manually
Daily sample	√	New sample starts at midnight each day, the Auto Start feature must be on. Will terminate active sample at midnight.
Timed sample		Each sampling period terminates after a set number of reports, specified in the Instrument Settings table (IS)
Stop if fault	√	Stops sampling if a fatal fault occurs
Vector Averages	√	Use vector averaging for mean wind speed and direction calculation
Save spectrum		Not used
Mean spectrum		Not used
Smart Baseline		Apply automatic offset drift correction to gas sensors. Auto updates Gas user offsets in Settings. Automatically enables Apply Offsets below. Disables DC blocking filter
Circular Buffer	√	Use circular buffers to record stacked samples, number of stacked samples saved before overwrite is specified in the Instrument Settings Table (IS)
Calculate NOx		Calculate from available NO2 and NO readings as either ppb of µg/m^3
DC blocking filter		Apply DC blocking filter to gas sensors. Sensor must the zeroable and time constant is preset in IGaspod or manifold. Disables smart baseline
Apply Matrix		Use matrix to correct 1st order gas interferences

Apply Ageing		Correct for electrochemical cell ageing
Apply iGAS Offsets	√	Apply gas sensor baseline offsets, values may be change by user or by smart baseline algorithm
Save iPM	√	Save the iPM readings in the dataset, if not selected, just the latest readings are available
Save iGAS		Ditto for gas readings, either iGAS or iGASpod
Save iEXTRAS		Ditto for extra readings
Save iMET		Ditto for meteorology readings
Save housekeep.		Save the Housekeeping readings in the dataset
Save diagnostic		Save the Diagnostic readings in the dataset
Allow to sleep	√	Allow to fall asleep after about 5 minutes if not sampling and no communications.
I need 12 Volts	√	A 12 Volt supply is always needed by iPM
I expect COMMS		If there have been no communications for more than 20 minutes, sampling will stop and iPM will return to standby for 4 minutes and then to sleep. It will awake and reboot after 100 seconds and await communications for 4 minutes. If none it will return to sleep and the cycle repeats. When communications are received a sample will start if AutoStart is set. Communications are any of RS485, WFi, Oked PUSH or OK click.
WiFi reconnect		Automatically set if iPM is trying to reconnect to your WiFi
Pulsed PID		Only operate PID UV lamp for 20 seconds every minute, reporting interval must be at least 1 minute. Extends UV lamp life
Fake readings		For test purposes only
Inlet heat ON	√	Turns on the heater element, it draws about 800mA at 12 Volt. Temperature is held at set point.
RH control ON		Requires an ambient T & RH. Temperature is adjusted to hold inlet flow RH at set point
Flow control ON	√	Automatic volumetric flow control is enabled
User Time Server	√	Clock is set from Internet time server
Use WiFi network	√	Connect as station of your WiFi network, needs your SSD and password. Will repeatedly try to reconnect if the WiFi connection is lost. The password is stored as Ciphertext. Factory set to use Power Portal hotspot
WiFi Hotspot	√	Create a WiFi hotspot to connect your smart device. Allows your network SSID and password to be entered and saved. Clicking OK during reboot will create a hotspot regardless of the state of this flag.
Advertise		Not implemented
Publish AdCode 0		Not implemented
Enable PUSH		PUSH reports to remote secure server.
PUSH my GPS		Add GPS location to PUSH
Use HTTPS		PUSH reports use HTTPS . More SIM data are used as security certificates need to be exchanged each time
Power PID sensor		Set automatically if Photo Ionization Detector for VOCs fitted

Ambient Pressure	√	Measure ambient atmospheric pressure and case temperature
Ambient T & RH		Measure ambient T & RH. A dedicated T&RH sensor should be fitted, however, if this flag is unchecked, the iPM will use the T&RH sensor within the CO2 sensor (if fitted). Two types of dedicated T & RH sensor are available, one manufactured by Honeywell, the other by Sensirion. If the Honeywell sensor is fitted, check the Honeywell flag below.
iPM sample flow	√	Measure iPM sample volumetric flow rate. The default control point is 600 cc/min but this can be adjusted via the Instrument Settings menu
Ultrasonic WSD		Ultrasonic wind speed and direction sensor fitted. Measures vector averaged wind speed, direction and gusts over a two minute periods.
Honeywell T & RH		Honeywell T&RH sensor fitted, consult factory
Manifold T&RH		T&RH sensor fitted in iGAS manifold
Measure CO2		Measure ambient Carbon Dioxide, sensor must be fitted, also makes available T&RH for backup ambient measurements.
Command Echo		For test purposes only
Divert U1 to U0		For test purposes only
HTTP keep alive		For test purposes only

INSTRUMENT INFORMATION

(show in **bold font** in the text)

The Instrument Information table (II) provides additional information about the instrument. It is read only and cannot be modified by the user. Some of the values are automatically uploaded from the iPM photometer (iPHOT) or iGAS manifold. Not all of the Instrument Information is listed below.

Information Table (II)	Explanation/Description
Serial Number	The iPM serial number
Instrument type	iPM Monitor
Manufacturer	Turnkey UK
Software Version	Software version programmed into instrument
Description	PM Particle Mass
Description	Diffracted laser.
Time Server	Default time server europe.pool.ntp.org
Manufacture Date	Date iPM was manufactured
Oscillator tune	RTC oscillator fine tune, usually 0, ±127
Time zone GMT ±	Your time zone relative to GMT
Cal. detail	As iPHOT
Cal. Cert No	As iPHOT
Cal. info	TKI-SCC
Cal. due by	Date next calibration is due
iPM zero flow	Zero offset of flow sensor, set to 0.0
iPHOT /s to /cc	Uploaded from iPHOT. typically 0.25
iPHOT supply V	Uploaded from iPHOT, typically 6 Volts
iPHOT offset mV	Uploaded from iPHOT, typically 500 mV
My key	Not used
User PIN	Not used
Edit PIN	Not used
Fake Particle	For testing purposes, normally 1000
iPHOT Serial No	Uploaded from iPHOT
iPHOT Cal date	Uploaded from iPHOT
iPHOT Cal info	Uploaded from iPHOT
iPHOT Cal Cert	Uploaded from iPHOT

INSTRUMENT SETTINGS

(show in **bold font** in the text)

These settings control the instrument's reporting and sampling. They are normally controlled automatically by AirQWeb. Not all of the Instrument Settings are listed below.

Instrument Setting	Explanation/Description
Sample Total	Running count of total number of samples taken by the instrument over its life. Never normally reset.
Sample Number	Next sample number, is reset to 0 when memory is cleared. Increments by 1 every time a sample is completed. Range is 0 to 99. Sample 0 is always the first sample.
Reporting interval (sec)	Time interval when new results are reported. AirQWeb normally sets this to 1 minutes (60 secs)
Inlet T set (°C or °F)	Inlet temperature set point, normally 50 C or 122 F. Inlet heating must should be enabled
Inlet RH set (%)	Inlet humidity set point, normally 30% RH. Requires Ambient T&RH probe. Inlet temperature is adjusted to maintain constant inlet humidity
Flow (cc/min)	The set point sample flow for iPM, normally 600 cc/min
Autozero (sec)	Not used
Spectrum (sec)	Integration time for particle spectra, normally 20 sec.
Start time	If sampling, start timestamp of current sample. If not, start timestamp of last sample
Stop time	If sampling, timestamp of first report. If not, stop timestamp of last sample
GPS	GPS latitude, longitude and altitude
User PM calibration	User scale factor for each PM size fraction, normally 1.0
User GAS offset	User baseline offset for each GAS, normally 0.0 ppb. Updated automatically if Smart Baseline is active with rate of adjustment preset in iGASpod or manifold
ID#	ID index numbers for Location, etc. Default ID = 1
Sample Stack	Number of samples in the stack before loopback if ***Circular Buffer*** Feature Flag is selected. Default is 10
Report Number	Number of reports in the current sample, or last sample if not sampling.
Duration (rpt)	Number of reports in a sample before it auto-stops, only if ***Timed Sample*** Feature Flag is selected. If *AutoStart* is set, will restart a new sample. If *Circular Buffer* is set will accumulate a circular buffer of samples. *Sample Stack* sets the number of contiguous samples in the buffer.
Company	Company name string, up to 16 bytes
Location	Location name string, up to 16 bytes
Notes	Notes about the sample, up to 16 bytes

Operator	Name of the operator, up to 16 bytes
Site detail	Details of the site, up to 16 bytes
Wireless Beacon	Beacon device address
Idle Pushes (s)	Interval between pushes if not sampling, default 60 secs
Handshake (s)	Max handshake time with push server, default 10 secs
Watchdog (s)	Strobe interval for watchdog timer, default is 20 secs
iPM Mask	iPM active channels, default 11111111 means all active
Housekeeping Mask	Not used, default 11111111
Diagnostic Mask	Not used, default 11111111
iGAS Mask	iGAS active sensor channels, gases A to H, e.g. 11111111 means all 8 gas sensors are active H.G.F.E.D.C.B.A in that order, 00001111 means only sensors D.C.B.A are active. Set automatically by instrument.
iGAS Autozero mask	iGAS sensors that will have zero offsets applied
iPHOT hours	Number of hours the photometer has been used
iPM filter (mg)	Mass in milligrams of dust accumulated on filter, change filter if mass > 4mg. See changing filter (below)
iPHOT changed	Date iPHOT was fitted
iPM filter at	Date iPM filter was changed
iPM Pump Volts	Between 5 and 11 Volts. Typically 7 volts, flow error if more than 10 Volts
Pump frequency	Diagnostic pump frequency, ~25kHz. Two pumps.
PushOked	Number of OKed pushes in this idle or sample session
Push retry.fail	Number of retries and number of fails in this session

FAULT FLAGS

(shown as *underlined italics* in the text)

These flags indicate the faults or errors the instrument has encountered. Many of these are managed automatically by AirQWeb.

FAULT FLAG	Explanation/Description
Directory FULL	100 samples have been stored. Sampling is stopped and cannot restart. Upload and clear memory
Memory FULL	The IPM memory is full. Sampling has stopped. Upload and clear memory. Depending on length of samples, may occur before 100 samples have been saved.
Flow Error	Set when pump voltage is <5 Volts or > 10.5 Volts
Dead battery	Battery voltage < 3.5Volts. Sampling will have been stopped and cannot re-start until 12 Volt connected
I'm too hot!	The laser temperature is >70C. Sampling is stopped
Lost 12 Volts	12 Volt supply is missing
Fatal Error	One of the above faults has occurred, sampling is stopped until fault condition clears.
Memory 90% full	Memory is at 90 % capacity, stop sampling and clear memory.
Low battery	The battery voltage is < 10 Volts..
Cal. < 50 day	Calibration is due in less than 50 days. Have instrument recalibrated.
Cal. OVERDUE	Calibration is now overdue. Soon the instrument will be disconnected from AirQWeb server. Have instrument recalibrated as soon as possible.
PID error	Photo-ionization Detector not working
iPHOT error	Communications error between iPM and iPHOT
No 12V supply	12 Volt supply has disappeared. Sampling will stop.
Pump Volts >90%	Pump volts > 90 % of maximum, check filter
Pump Volts > 95%	Pump volts > 95% of maximum, check filter
No WiFi network	WiFi connection lost, will try to reconnect automatically.
PUSH failed	PUSH not OKed. Will try again
I've lost COMMs	Communications have been lost

Note if a flow error occurs you must restart the instrument by sending a start command via AirQWeb or smart device. It will not restart automatically. Sending the start command will set the pump to mid-voltage and try sampling again. If it fails repeatedly a maintenance visit is required.

Some faults such as over temperature may clear themselves and the instrument will restart if auto-start is set.

Fault Flags are saved at sleep or power down and reloaded at awakening.

CHANGING THE FILTER

The calibration filter is designed to collect dust particles for calibration purposes and to protect the pump and photometer. It is located on the front of the instrument directly beneath the sample inlet and held in place by three countersunk M4 screws.

The recommend filter type is Whatman GF/B 25mm fibre glass circle. Change the filter when the accumulated mass (see Instrument Settings) exceeds 4 mg or if it becomes so clogged the requisite flow of 600 cc/min cannot be achieved.

The command S430 resets the accumulated filter mass to zero, the command S4A sets the filter change date to now.

To change the filter, remove the 3 screws securing the filter cap to the front panel. The cap contains the filter circle secured by an O-ring. Check the O-ring is in good condition when replacing the filter. Check too the smaller O-ring for the exhaust port on the panel. Proper sealing cannot be obtained unless both O-rings are fitted. Make sure the small O-ring is aligned with the exhaust port in the panel before refitting the filter cap. The threaded lugs make sure the filteer is aligned correctly.

Never run the instrument without the calibration filter. There is a high capacity secondary filter in the pump which protects the pump and photometer but this will eventually become clogged too, necessitating replacement.

NOTES

- Clicking OK while iPM is searching for a WiFi network will abort the search and turn off the *Use WiFi Network* feature flag and turn on the *WiFi HotSpot* flag. You must re-set and save the use network flag when you are ready to use it, see note on HotSpot security below.
- If the *Allow To Sleep* feature flag is set, the instrument will fall asleep after 20 minutes in standby. It will awaken every 100 seconds and immediately return to sleep if the 12 Volts has not been restored. This increases the battery life to many days. The battery and supply voltages are momentarily shown on the display every 100 seconds. Note the instrument will wait for a 100 second wakeup before restarting after 12V has been restored.
- You can awake the iPM from sleep at any time by clicking OK. It will stay awake for 20 minutes after the last communication unless power is restored. Communications are any of RS485, WiFi, Oked PUSH or OK click.
- If the *I expect COMMS* feature flag is set, the instrument will go to standby and awakening sleep until communications are restored.
- Sending a stop sampling command will clear the AutoStart feature flag.
- Feature flags are saved at the end of each sample and at sleep or power down. They are reloaded on awakening.

SECURITY

The WiFi HotSpot is only protected by a weak password. After the iPM WiFi network has been setup, you might want to consider turning off the ***WiFi Hotspot*** feature flag. This will stop un-authorized access to your instrument via a smartphone.

For maintenance, you can re-enable again by clicking OK at power on. Remember to re-enable the WiFi network afterwards.

The SSID password and PUSH token are always stored in iPM memory only as Ciphertext, never as Plaintext

Please visit i-PM.eu to access other iGAS, iDUST, and i-PM documentation

If you need assistance, please contact:

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