83214
AQ MASS PROFILER

OPERATION MANUAL
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83214 Operation Manual

Technical Support

Should you require support, please consult your printed documentation to resolve your problem. If you are still experiencing difficulty, you may contact a Technical Service representative during normal business hours—7:30 a.m. to 4:00 p.m. Pacific Time, Monday through Friday.

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Safety Notice

The contents of this manual have been checked against the hardware and software described herein. Since deviations cannot be prevented entirely, we cannot guarantee full agreement. However, the data in this manual is reviewed regularly and any necessary corrections are included in subsequent editions.

Faultless and safe operation of the product presupposes proper transportation, storage, and installation as well as careful operation and maintenance. The seller of this equipment cannot foresee all possible modes of operation in which the user may attempt to utilize this instrumentation.

The user assumes all liability associated with the use of this instrumentation. The seller further disclaims any responsibility for consequential damages.

NOTICE

CAUTION—Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

WARNING—This product, when properly installed and operated, is considered a Class I laser product. Class I products are not considered to be hazardous.

This product incorporates a laser diode-based sensor that is a CLASS 1 product as defined in 21 CFR, Subchapter J, of the Health and Safety Act of 1968. This applies when the instrument is used under normal operating conditions and with proper maintenance.

Service procedures performed on the sensor can result in exposure to invisible laser radiation. Only a factory-authorized person must perform service on this instrument.

The laser diode-based sensor inside this instrument has a warning label on it as shown below.

Table of Contents

1. INSTALLATION

1.1. Mounting

The AQ Mass Profiler module can be mounted using the eight slotted openings along the edge of the unit.

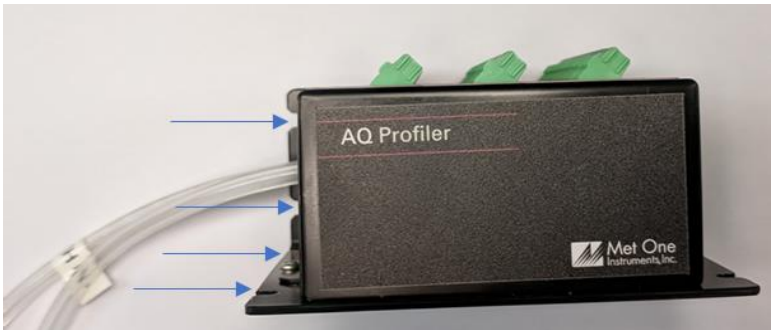

Figure 1.1: AQ Mass Profiler Module

1.2. Connections / Wiring

Three terminal blocks for electrical connectors are located on one side of the AQ profiler. The pin out detail for the electrical connections are clearly labeled at each wire input. Figure 1.2 shows all the connections for the AQ profiler assembly.

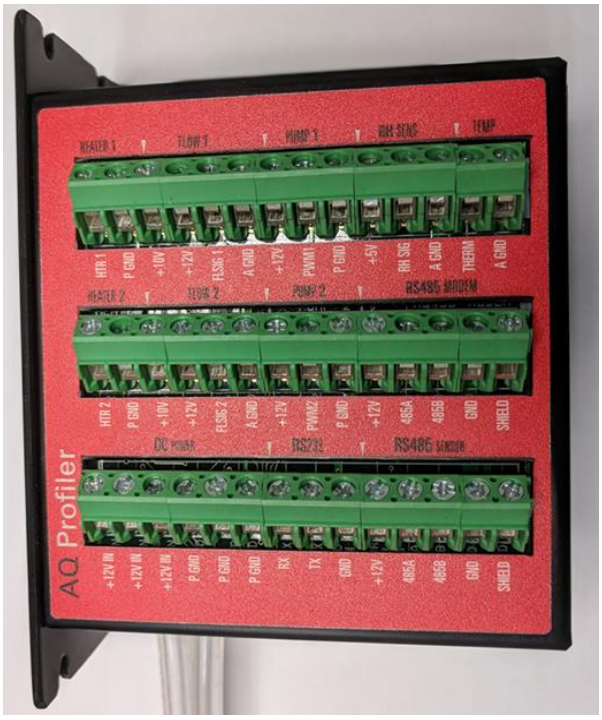

Figure 1.2: Electrical Connection Terminal Blocks

Table 1.2 Terminal Block Connection Descriptions

TB1 (Top Row)			TB2 (Middle Row)			TB3 (Bottom Row)		
1	HTR 1	Heater1	1	HTR 2	Heater2	1	+12V IN	DC Power
2	P GND	Heater1	2	P GND	Heater2	2	+12V IN	DC Power
3	+10V	Flow1	3	+10V	Flow2 ref	3	+12V IN	DC Power
4	+12V	Flow1	4	+12V	Flow2	4	P GND	DC Power
5	FLSIG 1	Flow1	5	FLSIG 2	Flow2	5	P GND	DC Power
6	A GND	Flow1	6	A GND	Flow2	6	P GND	DC Power
7	+12V	Pump1	7	+12V	Pump2	7	RX	RS232
8	PWM1	Pump1	8	PWM2	Pump2	8	TX	RS232
9	P GND	Pump1	9	P GND	Pump2	9	Gnd	RS232
10	+5V	RH Sensor	10	+12V	RS485 Modem	10	+12V	RS485 Sensor
11	RH SIG	RH Sensor	11	485A	RS485 Modem	11	485A	RS485 Sensor
12	A GND	RH Sensor	12	485B	RS485 Modem	12	485B	RS485 Sensor
13	THERM	AT Sensor	13	GND	RS485 Modem	13	GND	RS485 Sensor
14	A GND	AT Sensor	14	SHIELD	RS485 Modem	14	SHIELD	RS485 Sensor

1.3. Default Settings

The AQ Mass Profiler is shipped with the following default settings.

Communication:
115200 Baud Rate, 8 Data Bits, No Parity, 1 Stop Bit, No flow control.

Sample Time: 60 seconds

Sample Mode: Continuous

Unit ID: 1

Modbus Slave Address: 1

2. DESCRIPTION

2.1. AQ Mass Profiler

The AQ Mass Profiler reports 4 particulate mass sizes: PM1.0, PM2.5, PM4.0, and PM10. It has terminal communications protocols. It can also size, count, and report airborne particles in up to eight user selectable size ranges from 0.3µm-10µm.

2.2. Sheath Air

The AQ Mass Profiler is equipped for and requires sheath air for operation. When a particle counter is to be used to sample aerosols containing high concentrations of

particles, the sensor should incorporate sheath air to prevent particles from contaminating the internal optics of the sensor. The particle laden sample air is enclosed in a sheath of clean filtered air that prevents particles from escaping.

2.3. Detection

The particle counter uses scattered light to measure and count particles. Sample air is drawn into the detector chamber and subjected to an intense laser beam located at right angles to the flow. The laser beam has been shaped to produce a flat very thin beam producing a small sample area. Light travels through the sample stream and terminates in the light trap. Particles pass through the laser beam and scatter light. The amount of light scattered is proportional to the size of the particle. A portion of this light scatters toward the elliptical mirror. This light is then directed to the detector. The output of the detector is then analyzed to determine the number of particles and the size of the particles. Detected particles are then used to provide an indicative particulate mass measurement.

2.4. Sizing and Counting

The amount of scattered light is converted to a voltage pulse and based on the amplitude of the pulse signal it will pass through one or more of the size discriminators and into the associated counter(s).

2.5. Calibration

Calibration is performed using ideal (PSL) spheres, which provide a powerful tool for assessing the sensitivity, accuracy, resolution and false count level. The particle detector is compared to a reference mono-dispersed (single size) suspension of polystyrene latex (PSL) spheres in clean filtered air for both calibration and certification of performance specifications. This calibration technique serves two purposes:

1. Provides a standard traceable reference.
2. Provides a measure of how well the unit maintains its calibration (reproducibility).

2.6. K Factor

The AQ Mass Profiler's PSL sphere calibration provides an extremely consistent calibration but does not generally match the characteristics of all ambient particulate. A K-Factor (multiplier) must be established for good accuracy and correlation to collocated instruments.

The K-Factor is only valid at the same site and for the same particulate type. If the local particulate source changes, the K-Factor may no longer be valid. The SK command is used to set the K Factor for each PM mass fraction.

3. OPERATION

3.1. Powering the AQ Profiler

The AQ Profiler can operate from a voltage input of 10.5 to 15.5 volts. See 1.2 for power connector pin out.

3.2. Communication

You can use a terminal program such as Hyper-Terminal to communicate with the profiler.

RS-232 and RS-485 Operation

Communication wires can be directly connected to TB3 of the profiler. See 1.2 for connector pin out.

3.3. Sample Air Flow

You will be required to supply a vacuum to the outlet nozzle of the AQ Mass Profiler in order for it to sample. You will also need to supply filtered air for the air sheath. For an air filter we recommend a 0.1 micron in-line filter (MOI#580294). The filter should be installed upstream from the flow sensor to protect the sensor from contamination generated by the pump. The flow rate is critical to the proper operation of the unit. The vacuum should be smooth, without pulsation. Since most pumps create a pulsation by their very nature a surge chamber and restriction should be employed to reduce the airflow to a steady stream. The calibration of the profiler was done at a 1.0 L/min inlet flow rate and an increase in flow rate will make particles appear smaller. Changes in pump voltage can cause a shift in flow rate as well. Selecting the type of vacuum pump will be of some importance. A diaphragm pump generally has a long life between maintenance but generates large pulsations and requires larger surge chambers to suppress them. Rotary vane pumps generate a higher frequency pulsation and can be filtered with a smaller chamber or a plenum. A coarse filter should be placed before the pump to keep contaminates from damaging the pump. This is especially critical with rotary vane pumps.

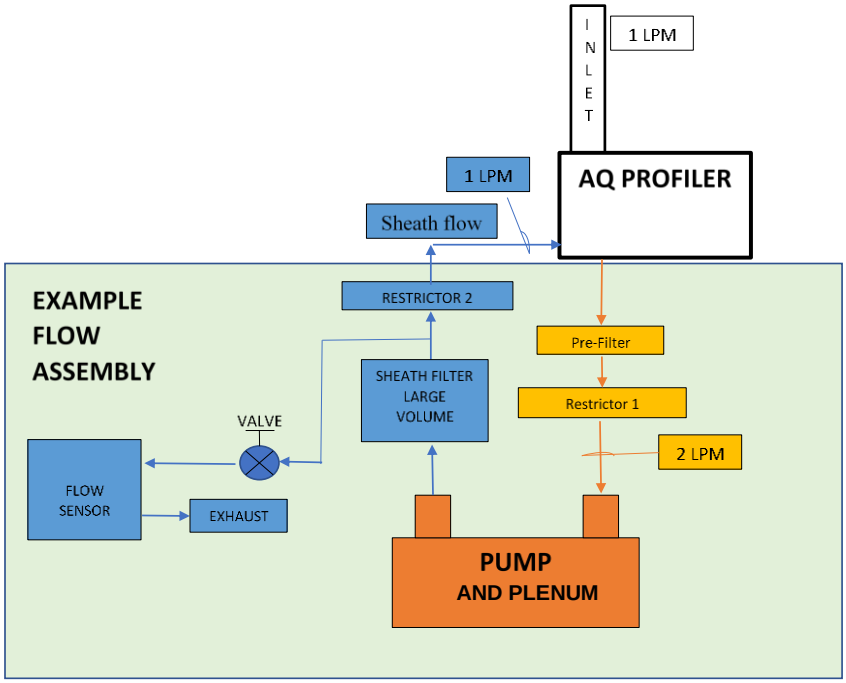

Figure 3.3: Flow Assembly

3.3.1. Flow System specifications

A 10V reference voltage connection is available for the use of a flow sensor that requires this reference. The +10V can only supply 10 mA of current. The flow signal input voltage is 0 to 5V max. Met One also offers a differential pressure flow sensor, part number 82258, which requires power from the +12V flow input due to the higher current demand of the DP sensor. Currently, only this Met One DP sensor is supported.

3.3.2. Pump specifications

DC current limit for an external pump is 0.5A. An open collector pulse width modulated signal is used to control pump speed. It can be used to drive two or three wire DC pumps. Units are configured for 3 wire pumps. Three wire pumps will run full on, when the control wire is open. When the control wire is grounded the pump shuts down. The pump speed is controlled with a 20 kHz PWM signal. A two-wire pump (typically a brush motor) can also be controlled by connecting to the +12V and the PWM1 line, if the logic is reversed. Reversing the logic is done with a hardware jumper (JP2). The jumper JP2 is located on the underside of the terminal board.

3.3.3. RH and Inlet Heater

The RH (Relative Humidity) can affect the size of airborne particles when RH is greater than 50%. The particles swell in size due to moisture absorption and “seeding”. The use of an inlet heater can ‘dry’ out the particles and eliminate this source of error. The AQ Mass Profiler can read an RH sensor and control a solid-state relay which switches the high current required for the heated inlet tube (MOI#9431-7). The set point for turning on the inlet tube heater is user configurable. Generally, a set point of 40% is recommended. The RH sensor can be placed between the outlet nozzle and the vacuum pump. It is

recommended to use an inlet heater with the RH sensor below the heater. Only HTR1 output is currently supported. If the unit will be used in low humidity conditions only then the inlet heater is not necessary and can be omitted.

3.3.4. AQ Flow (MOI #83170)

NOTE: The flow system listed below is an option and is only provided if the customer specifically ordered it.

The AQ Flow system includes a flow sensor, temperature sensor and vacuum pump for connection to the AQ Profiler. Connections from the flow system to the profiler are shown below.

Table 3.3.4**Error! Reference source not found.** AQ Flow to AQ Mass Profiler connections.

Pin	Wire Color	AQ Connection
1	Red	PUMP 1 +12V
2	White	PUMP 1 PWM
3	Black	PUMP 1 P GND
4	Red	FLOW 1 +12V
5	Grey	FLOW 1 F SIG 1
6	Black	FLOW 1 A GND
7	White	TEMP THERM
8	White	TEMP A GND
9	Green	RS485 MODEM SHIELD

3.4. Connecting a Digital Sensor and Modem

Met One Instruments, Inc. offers a variety of meteorological sensors that can connect to the AQ Mass Profiler. There is an RS-485 port for connecting a digital sensor as well as an RS-485 port for connecting a CCS Cloud Modem. Note that the CCS Cloud Modem must use the same sample time as the AQ Mass Profiler for optimal data streaming.

4. SERIAL COMMUNICATION

There are two modes of communication:

1. User communication – This is a user interactive mode using simple letter commands for ease of use.
2. Computer communication – This mode is used for computer-to-device communication. It has a level of data integrity.

The settings must match the computer settings for proper communication. The default settings are 115200 Baud, 8 data bit, no parity, one stop bit.

Table 4.1 Command List

Command	Description
#	Get MetRecord revision.
1	Report settings.
2	Report All data.
3	Report New data.
4	Report Last data.
7	Alarm Report
E	End (Stop) sample cycle.
H, ?	Help menu.
S	Start a sample cycle.
Q	Exit User mode and enter Computer mode.
CM	Count Mode. 0=Cumulative, 1=Differential
CS	Measurement Sizes [8] for the 8 channel particle counters. 0.3, 0.5, 1.0, 2.5, 4.0, 5.0, 7.0, 10.0
CU	Get/Set Count Units. 0=CF, 1=/L, 2=TC, 3=M3 (For particle counter only. Mass is always /M3)
DT	Get/Set date and time. yyyyMMddHHmmss
ID	Get/Set location ID or address. The range is 1 to 999.
MA	Modbus Address. The range is 1 to 247.
MM	Measurement type. 0=Counts, 1=Mass
OI	Interval Output On/Off. 1=Enabled, 0=Disabled.

<table>
<tr><th>Command</th><th>Description</th></tr>
<tr><td>QH</td><td>Query Header</td></tr>
<tr><td>RF</td><td>Reference flow for calibration</td></tr>
<tr><td>RMCS</td><td>Report Mass Channel Size. 1=Enabled, 0=Disabled.</td></tr>
<tr><td>RO</td><td>Report Options. Uses bit flags for the different readings. Add up all the bit flags for combinations needed
<table>
<tr><th>Reading</th><th>Bit</th><th>Add</th></tr>
<tr><td>Flow</td><td>0</td><td>1</td></tr>
<tr><td>Temperature</td><td>1</td><td>2</td></tr>
<tr><td>Pressure</td><td>2</td><td>4</td></tr>
<tr><td>RH</td><td>3</td><td>8</td></tr>
<tr><td>Met Sensor</td><td>4</td><td>16</td></tr>
</table>
e.g. RO 11 = Flow, Temperature, RH</td></tr>
<tr><td>RQ</td><td>Request last reading.</td></tr>
<tr><td>RV</td><td>Get product information.</td></tr>
<tr><td>RZ</td><td>Get available Channel Size information.</td></tr>
<tr><td>SB</td><td>Get/Set serial baud rate. 3=2400, 4=4800, 5=9600, 6=19200, 7=38400,8=57600,9=115200.</td></tr>
<tr><td>SK</td><td>Set PM K Factors. K Factor range is 0.1-20.0. PM1=1, PM2.5=2, PM4=3, PM10=4</td></tr>
<tr><td>SM</td><td>Set Mode 0-Single, 1-Repeat, 2-Logger</td></tr>
<tr><td>SPR</td><td>RH Setpoint to turn inlet heater on.</td></tr>
<tr><td>ST</td><td>Get/Set Sample Time in Seconds.</td></tr>
</table>

4.1. User Communication

In the user communication mode (terminal mode), press the Enter key, <cr>, three times to enter the mode. In this mode simple character commands can be issued with no <Esc> character required.
An asterisk character appears during wake-up, and also after a command has completed. The asterisk indicates that the instrument is ready for a new command.
Commands are echoed back from the instrument in this mode. Commands are terminated by the Enter key <cr>.
A help menu can be viewed by sending H, h, or ?; giving all the commands available to the user.
Pressing <Esc>, X<cr> or Q<cr> will exit user mode.

4.2. Computer Communication

In the computer communication mode, the command format has an optional level of data integrity – checksum. This is enabled whenever an <Esc> character is sent to the instrument. Character echo is suppressed in this mode.

4.2.1. Computer Command Format

The computer command has the following format:

<Esc>Cmd p1 p2*cs<cr>

Computer commands are prefaced with an <Esc> (0x1B) character followed directly by a command, Cmd, which is variable in length depending on the command. After the command characters there can be zero or more parameter fields, p1 p2. Each parameter field is delimited by one or more Space characters (0x20).

A computer command example follows:

<Esc>rv

AQ Mass, 83903, R1.0.4

4.2.2. Checksum Computation

Checksum is calculated as the 16 bit unsigned integer sum of all of the characters after the <Esc> character up to but not Including the Checksum Delimiter Character * (0x2A). It is printed out as an ASCII decimal number.

The result is always 5 characters in length with leading zeros.

A valid checksum may be signaled in the following manner: *//<cr>

A computer command example follows:
<Esc>rv*//
AQ Mass, 83903, R1.0.4*01320

4.3. Serial Command Explanations

4.3.1. User Data Report

The 2, 3, 4 and RQ commands will print the User Data Report.

There are two versions of this report depending on whether the unit is in Count Mode (MM 0) or Mass Mode (MM 1). The Time field is the standard ISO style time stamp. The optional fields follow. These are in the same order as the Volunteered report above. The Met bit is active for this report and if set will include WS, WE, AT, RH and BP at the end of the record.

Following is a Count Mode report.

Time,0.3(TC),0.5(TC),1.0(TC),2.5(TC),4.0(TC),5.0(TC),7.0(TC),10(TC),FLOW1(lpm),FT(C),FP(mmHg),FRH(%),WS(m/s),WD(deg),AT(C),RH(%),BP(mmHg)

2020-06-11
12:19:00,00003454,00000782,00000281,00000111,00000038,00000026,00000021,00000009,1.00,+37.6,659.0,11.1,04.1,154,029.6,19.0,657.1

The Mass Mode report without Met bits enabled is as follows.

Time,PM1(ug/m3),PM2.5(ug/m3),PM4(ug/m3),PM10(ug/m3),FLOW1(lpm),FT(C),FP(mmHg),FRH(%)

2020-06-11 12:19:00,000.5,001.8,004.9,019.7,1.00,+37.6,659.0,11.1

4.3.2. OI Command

When OI is set to 1, the unit will volunteer a record after each sample period similar to the User Data Report.

4.3.3. CS Command

This configures the measurement sizes [8] for the 8 channel particle counters. All channel size choices in microns must be entered after the command as follows:

CS 0.3, 0.5, 1.0, 2.5, 4.0, 5.0, 7.0, 10.0

4.3.4. RMCS command

This command outputs the 50 channel particle count report. The report is volunteered at the end of the sample period.
The Size record has the following columns
From: The beginning of the size range that the bin is for. For example 0.30u
To: The ending of the size range. For example 0.32u
Mass: This is based on a specific gravity of 1.0, NOT compensated with the PM K factors. It is scaled to Per Cubic Meter.
Differential Counts: This is a count of all of the particles that fall between the From and To sizes. It is a only a summation of counts and is not normalized to Differential Counts per Cubic Meter.

Size, 0.20,0.30, 0.83787, 102414
Size, 0.30,0.32, 0.26625, 17069
Size, 0.32,0.34, 0.13258, 7046
Size, 0.34,0.36, 0.08787, 3914
Size, 0.36,0.38, 0.07744, 2920
Size, 0.38,0.40, 0.06398, 2060
Size, 0.40,0.42, 0.05713, 1583
Size, 0.42,0.44, 0.05670, 1362
Size, 0.44,0.46, 0.05038, 1056
Size, 0.46,0.48, 0.05105, 939
Size, 0.48,0.50, 0.04719, 766
Size, 0.50,0.55, 0.10342, 1365
Size, 0.55,0.60, 0.07147, 718

Size, 0.60,0.65, 0.06315, 494
Size, 0.65,0.70, 0.06119, 380
Size, 0.70,0.75, 0.04669, 234
Size, 0.75,0.80, 0.04119, 169
Size, 0.80,0.85, 0.03969, 135
Size, 0.85,0.90, 0.03718, 106
Size, 0.90,0.95, 0.03067, 74
Size, 0.95,1.00, 0.02669, 55
Size, 1.00,1.10, 0.04485, 74
Size, 1.10,1.20, 0.06132, 77
Size, 1.20,1.30, 0.04295, 42
Size, 1.30,1.40, 0.06055, 47
Size, 1.40,1.50, 0.05587, 35
Size, 1.50,1.60, 0.05459, 28
Size, 1.60,1.70, 0.06586, 28
Size, 1.70,1.80, 0.08418, 30
Size, 1.80,1.90, 0.09946, 30
Size, 1.90,2.00, 0.15530, 40
Size, 2.00,2.10, 0.17141, 38
Size, 2.10,2.20, 0.24978, 48
Size, 2.20,2.30, 0.29224, 49
Size, 2.30,2.40, 0.35335, 52
Size, 2.40,2.50, 0.43891, 57
Size, 2.50,3.00, 1.09981, 101
Size, 3.00,3.50, 0.79086, 44
Size, 3.50,4.00, 0.66268, 24
Size, 4.00,4.50, 0.64311, 16
Size, 4.50,5.00, 0.39281, 7
Size, 5.00,5.50, 0.37883, 5
Size, 5.50,6.00, 0.39816, 4
Size, 6.00,6.50, 0.51133, 4
Size, 6.50,7.00, 0.00000, 0
Size, 7.00,7.50, 0.39906, 2
Size, 7.50,8.00, 0.73118, 3
Size, 8.00,8.50, 0.58802, 2
Size, 8.50,9.00, 1.40308, 4
Size, 9.00,9.50, 2.48642, 6
Size, 9.50,10.00, 1.45591, 3
Size, 10.00,10.00, 0.52360, 1

4.3.5. SK Command

This is used to set the K factors for each PM size. PM1=1, PM2.5=2, PM4=3, PM10=4. It is entered as SK (PM#) (K factor). A typical command and response for each PM size is as follows.

*SK 1 3.78
SK 1,3.78,PM1
*SK 2 2.70
SK 2,2.70,PM2.5
*SK 3 2.70
SK 3,2.7,PM4
*SK 4 2.16
SK 4,2.16,PM10

5. MAINTENANCE

5.1. Service Schedule

WARNING: The AQ Mass Profiler can only be serviced or calibrated by factory-authorized personnel. Unauthorized maintenance on the AQ Mass Profiler may result in exposure to laser radiation that can cause blindness and void warranty.

Calibrating particle sensors like the one in the Model 83214 AQ Mass Profiler requires specialized equipment and a skilled technician. Met One Instruments maintains a calibration facility for calibrating particle counters according to industry-accepted methods using NIST traceable standards. The AQ Mass Profiler should be calibrated on a yearly basis.

5.2. Suggested Periodic Maintenance Intervals

The following table shows the Met One recommended period for routine maintenance items. Some of these items will need to be performed more or less often depending on the exact characteristics of your location.

Table 5.2: Maintenance Intervals

Maintenance Item	Suggested Frequency
Calibrate Sensor	Yearly
AQ Flow Audit/Calibration	Monthly

5.3. AQ Flow Calibration

The following procedure is only applicable with a connection to the AQ Flow module (part number 83170).

Connect a flow meter to the inlet nozzle of the AQ Mass Profiler and allow the flow to stabilize. If it is not 1.00 LPM ± 0.02LPM, then it needs to be calibrated:

1. Enter the inlet flow value from a calibrated flowmeter with a 'RF #.###'command.
2. Allow the flow to stabilize.
3. Repeat as necessary to achieve 1.0LPM.

The flow calibration can be defaulted by issuing an "RF 0" command. This may be useful if the calibration is difficult to achieve the flow setpoint.

6. SPECIFICATIONS

Model Number	83214
Operation	Right angle light scatter detection, using a laser diode as light source.
Measurement Range	0-9,000,000 particles per cubic foot
Number of Mass Channels	4
Number of Particle Channels	8 (default particle sizes are 0.3, 0.5, 1.0 ,2.5, 4.0, 5.0, 7.0, and 10.0µm)
Minimum Particle Size	0.3 µm
Accuracy	±10% to calibration aerosol
Sample Air Flow Rate	1.0 LPM
Sheath Air Flow Rate	1.0 LPM
Flow Control	PWM Pump driver
Communications	RS-485, half duplex RS-232
Connections	Terminal block connections on side of enclosure: DC power, RS-232, RS-485 sensor, RS-485 modem, Heater 1, Heater 2, Flow 1, Flow 2, Pump 1, Pump 2, RH sensor, AT sensor.
Operating Temperature	0º to +50º C
Storage Temperature	-20º to +60º C
Power	10.5-15.5 VDC. Average operating current 100mA, 630mA with AQ Flow, 1.4A with AQ Flow and heated inlet.
Size	Height: 3.63in, Width: 4.75in, Length: 2.34in
Weight	1 lb 10 oz
Serial Settings	Baud = 115200, 8 data bits, no parity, and 1 stop bit. (factory Default) 115200, 57600, 38400, 19200, 9600, 4800, 2400 (selectable).
Communications Protocol	Terminal Command Set