

ES-412

PARTICULATE PROFILER

OPERATION MANUAL

REVISION B



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1 INTRODUCTION

1.1 About This Manual

This document is organized with the most important information grouped together for easy reference by the user. All ES-412 owners and operators should read and understand the sections on installation, setup, and field calibrations. Other sections that provide in-depth information on subjects such as theory, diagnostics, accessories, and alternate settings provide valuable information which should be consulted as needed. An electronic version of this manual is also available.

1.2 Technical Service and Warranty

This manual is structured by customer feedback to provide the required information for setup, operation, testing, maintaining, and troubleshooting your ES-412 unit. Should you still require support after consulting your printed documentation, we encourage you to contact one of our expert Technical Service representatives during normal business hours of 7:00 a.m. to 4:00 p.m. Pacific Time, Monday through Friday. In addition, technical information and service bulletins are often posted on our website. Please contact us and obtain a Return Authorization (RA) number before sending any equipment back to the factory. This allows us to track and schedule service work and to expedite customer service.

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1.3 About the ES-412

The Met One Instruments, Inc. model *ES-412 Particulate Profiler* is a near reference air quality sensor which automatically measures and records real-time airborne PM_{2.5} and PM₁₀ particulate concentration levels using the principle of right angle laser light scatter. Detailed descriptions of the ES-412 measurement modes can be found in Section 6. Measurement results are sent to a customized web page dashboard where data can be viewed and downloaded. A geographical map is included on the dashboard.

Laser Light Scatter System

Sample air is drawn into the ES-412 detector chamber and subjected to an intense laser beam located at right angles to the flow. Particles pass through the laser beam and scatter light that is collected by a photodiode detector. The output of the detector is analyzed to determine the number and size of the particles and mathematically processed to provide indicative particulate mass measurements.



1.4 Laser Radiation Safety and Conformity

The ES-412, when properly installed and operated, is considered a Class I laser product. Class I products are not considered to be hazardous.

This system contains a 100 mW diode laser operating at 785 nm wavelength. This is not visible to the naked eye and can cause damage to the eye if directly exposed. A protective optical housing fully encapsulates the laser beam and optics system within the ES-412. Do not attempt to disassemble the optical module. Failure to comply with this instruction could cause accidental exposure to laser radiation. The manufacturer certifies that this product operates in compliance with following standards and regulations:

- **FDA / CDRH This product is tested and complies with 21 CFR, Subchapter J, of the health and Safety Act of 1968.**
- **US 21 CFR 1040.10.**

Always power down the system whenever service or repair work is being performed inside the instrument enclosure. Only trained technicians should attempt to repair the ES-412. Routine maintenance does not require removing the instrument from its weatherproof enclosure.

1.5 ES-412 Specifications

| PARAMETER | SPECIFICATION |
|-----------------------------------|--|
| Measurement Principles: | Right angle light scatter detection, using a laser diode as light source. |
| Number of Mass Channels: | 2 (PM _{2.5} and PM ₁₀) |
| Sample Air Flow Rate: | 1.0 LPM |
| Sheath Air Flow Rate: | 1.0 LPM |
| Flow Control: | Active Volumetric Flow Control |
| Data Storage Resolution: | 0.1 µg/m ³ |
| Laser Type: | Diode Laser, 100 mW, 785 nm. |
| Pump Type: | Brushless Diaphragm Pump. |
| Power Supply: | Universal 100-240 VAC input, 50/60Hz. Optional regulated 12VDC. |
| Power Consumption: | 1.2 amps @ 12 VDC average continuous draw with inlet heater running. 0.85 amps running with inlet heater off. |
| Operating Temperature: | 0 to +50°C |
| Storage Temperature: | -20° to +60° C |
| Ambient Humidity Range: | 0 to 95% RH, non-condensing. |
| Humidity Control: | Automatic 10 Watt inlet heater module controlled to sample RH, with set point. |
| GPS: | External GPS module included. |
| Network Compatibility: | LTE-M (U.S. Domestic) GSM (Internationally w/ over 550 networks) |
| Data Update Rate To Cloud: | Standard: USA: 15 Minute – Optional: USA 5 Minute Standard: Global: 60 Minute – Optional: Global 15 Minute |
| Data Storage on Cloud: | 2 Years (oldest data overwritten after that) |
| Serial Interface: | USB port for PC communications. |
| Compatible Software: | Comet™, terminal programs such as HyperTerminal® |
| Factory Service Interval: | 24 Months typical, under continuous use in normal ambient air. |
| Mounting Options: | Pole or wall mount bracket standard. Optional EX-905 tripod recommended. |
| Unit Weight | 8.5 lb |
| Unit Dimensions | Height: 32" Width: 4.65" Depth: 8.65" |

Specifications may be subject to change without notice.

2 ES-412 SETUP and STARTUP

The ES-412 is designed for rapid deployment and easy setup by a single person in less than 15 minutes in most applications. This section describes the basic assembly, setup, and start-up of the instrument.

2.1 Standard and Optional Accessories

When unpacking a new ES-412, verify that the contents are undamaged. If the shipping cartons are damaged, notify the carrier immediately. Verify that the included accessories are correct and complete. If anything is missing, contact the technical service department at service@metone.com or (541) 471-7111. See the Accessories section at the back of this manual for more details. The normal configuration of the ES-412 is supplied with the following standard accessories:

- Weatherproof TSP inlet with debris screen.
- Instruction manual.
- External power supply and cable.
- USB Cable.
- Grounding Cable.
- Pole/wall mounting bracket.

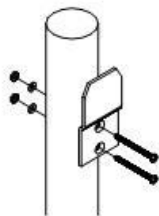
The following optional accessories may or may not also be included, depending on the order:

- EX-905 Aluminum Tripod.
- External DC power cable for batteries or solar systems (source must be regulated).
- Solar power kits (usually drop-shipped from the solar manufacturer). A DC/DC controller is required to regulate incoming voltage to $12V \pm 10\%$.

2.2 Mounting Options

Custom Pole or Wall Mounting:

The ES-412 can be mounted to a pole, mast, or wall using the included mounting bracket. The bracket must be screwed or bolted to the pole or wall with appropriate hardware. The enclosed bolts may not be appropriate for the desired mounting. The slot on the handle of the ES-412 slips over the tab on the mounting bracket.



Typical Mounting Bracket Pole Installation

Note: If mounting the unit to a wall, take care to ensure that there is adequate clear space around the inlet to allow unrestricted airflow into the instrument. Wall mounting is often not considered ideal and not recommended due to the airflow and particulate obstruction of the wall itself. Mount the instrument with no large obstructions nearby whenever possible.

Tripod Mounting:

The Met One EX-905 aluminum tripod is the recommended mounting for the ES-412 for most outdoor applications. It is not included as a standard accessory to save expense for users who do not require it. Deploy the tripod as follows:

1. Remove the three stainless steel detent pins from the tripod base by pulling the rings. Unfold the three tripod legs and reinsert the three pins so that each pin secures a leg in the open position. Make sure the erected tripod is rigid and stable.



Detent Pins

2. Lift the ES-412 assembly and slide the slot on the handle of the ES-412 over the tab on the top of the tripod. Insert the supplied $\frac{1}{4}$ -20 bolt through the hole in the body of the tripod into the hole on the bottom of the ES-412 handle. Turn the rosette handle to screw into place. This prevents the ES-412 from falling or shifting on the tripod.



3. Site the tripod on a surface that is as level as possible. The tripod feet may be secured to the ground or mounting surface with bolts, screws, or tent pegs if necessary. Secure the tripod in windy conditions!

2.3 Setting Up the ES-412

Set up the ES-412 hardware items and accessories as described below:

1. **Install Inlet Tube:** Connect the heater power harness to the mating connector coming out of the top of the ES-412. Slip the inlet tube and heater assembly onto the top of the ES-412. Make sure that the inner aluminum inlet tube is seated fully into the receiver inside the top. You may need to loosen the waterproof fitting at the top of the heater assembly in order to seat the inlet tube correctly. Align the outer housing with the 3 pins on the base mounting and one screw hole, twist, and secure with the 8/32 x 3/8 screw.

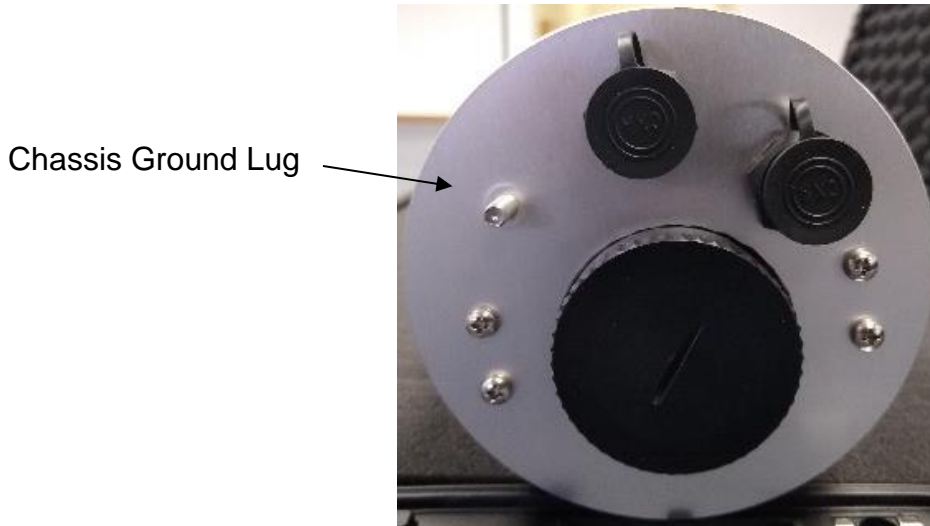


2. **Install TSP inlet:** The included weatherproof TSP inlet is simply installed directly onto the top of the ES-412 inlet tube to keep water, insects, and debris out of the instrument. Lubricate the o-rings if necessary. Never operate the ES-412 outdoors without the TSP inlet in place, as the resulting water/debris damage is not covered under warranty.
3. **Antenna:** Rotate the antenna upwards and secure its position with the quick release pin.
4. **AC Power Supply:** If the ES-412 is to be operated on AC line voltage, bolt the power supply to one of the legs of the tripod with U-bolts. Plug the power supply output cable into the DC power input on the bottom of the ES-412. When the power supply is plugged into AC power, the ES-412 will turn on automatically.

2.4 Electrical Connections

The ES-412 has two weatherproof connectors on the bottom of the enclosure, one for power input and the other for communication. The ES-412 will turn on automatically whenever a 12V power source is connected to the power input.

The ES-412 chassis ground lug should be connected to an earth ground with the supplied grounding cable whenever possible, to reduce potential EMI/RFI electrical noise in the unit.



2.5 Power-Up and Starting Operation

As soon as power is applied to the ES-412, the unit will automatically begin to sample and report data to the Cloud at the proper interval (15 minutes in the USA standard, 5 minute optional, 60 minutes Global version, 15 minute rate optional). Please allow several data intervals worth of time for the first data points to appear.

3 DOWNLOADING and VIEWING DATA

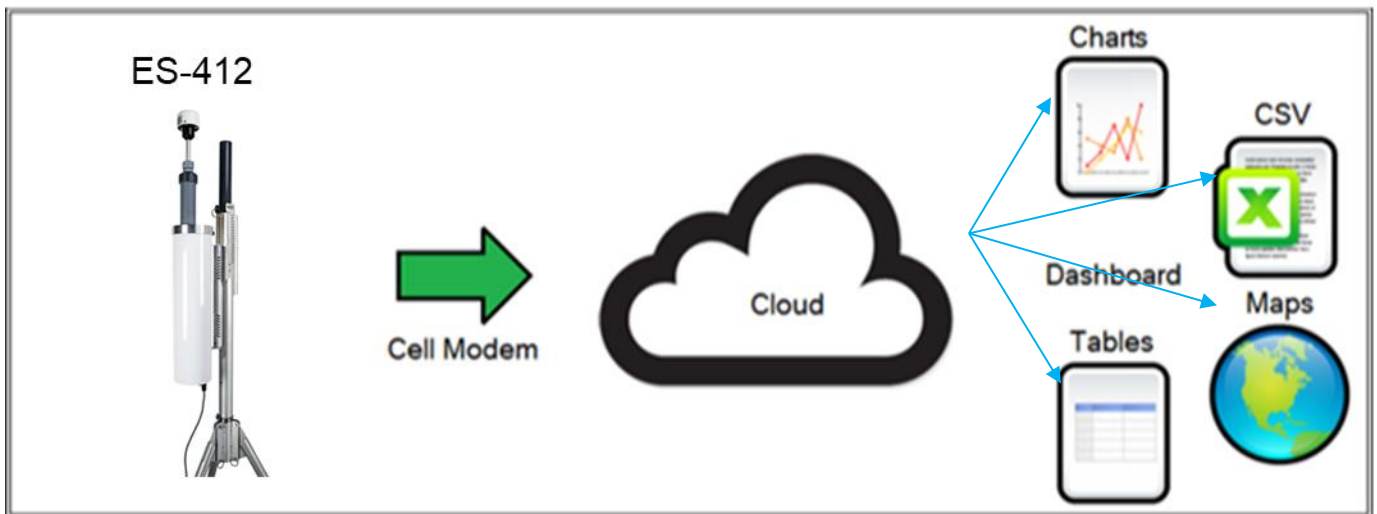
Currently, Met One offers two options for downloading and viewing the data from an ES-412 system; a web interface and a windows application. This section will cover both options.

3.1 Web Interface

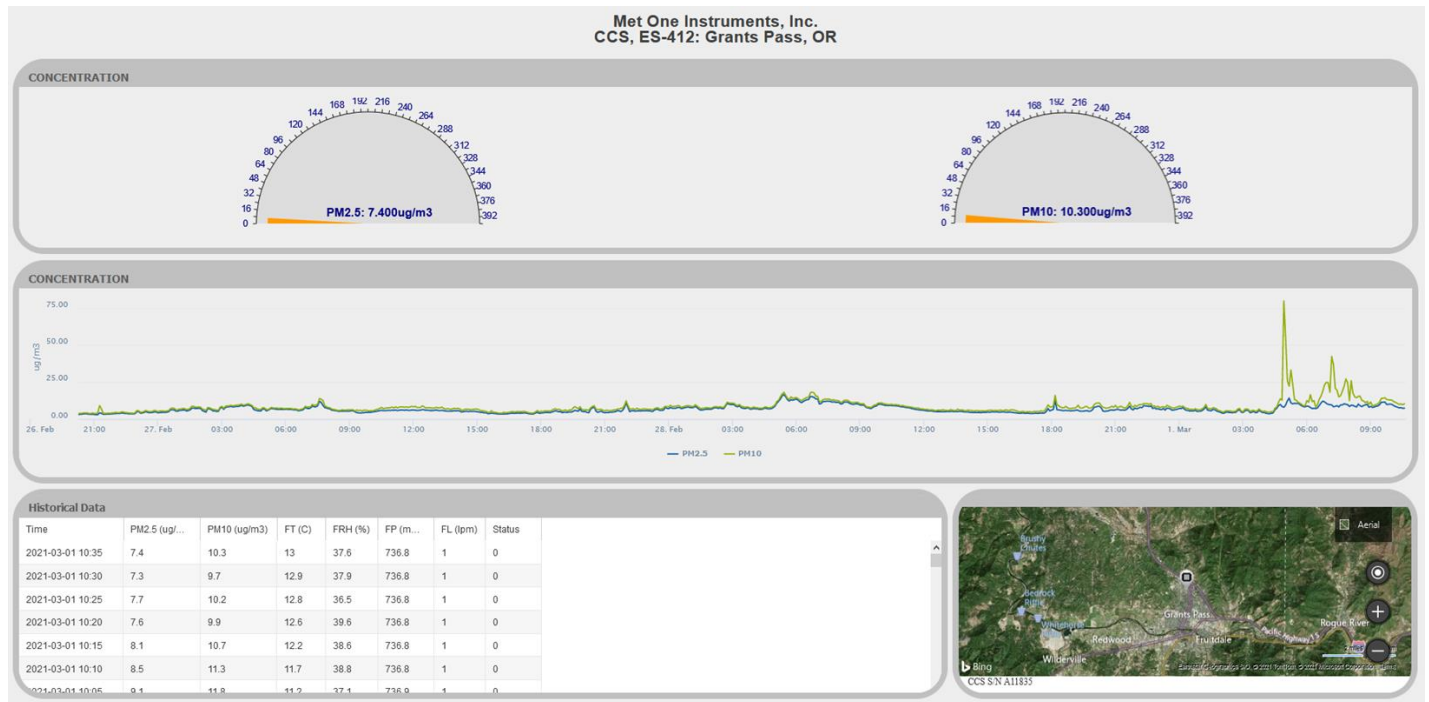
The first method for downloading and viewing the data is through the web portal. Each customer will be sent a private link to a custom dashboard in which users can view, chart, and download/export their data.

3.1.1 How the Cloud Works

The ES-412 uses a cloud service for storing and viewing data from the connected sensors. After the sensor collects the data, it connects to the internet and designated secure Cloud site via its internal cell modem. Once connected it will push the data to the cloud site. Users may then go to their dashboard and view their data in gauge, chart, and tabular formats.



Below is an example dashboard setup:



Note: Customers are sent a unique web link with their system.

3.1.2 Data Retention

The cloud site stores data for a minimum of 2 years, after which the oldest records may be overwritten. Met One recommends using the Comet utility program to routinely download data and store the data to a local computer or network. Comet automatically creates a time stamped, comma separated CSV data file when data is downloaded. The CSV file can be found in the My Documents folder.

3.2 Comet Software

The ES-412 is compatible with the free copy of the Comet™ program. Comet is a simple, Windows-based, communications terminal program developed by Met One Instruments, Inc. Comet allows the user to connect to the cloud and download the data from each cloud service webpage.

The Comet software also contains a comprehensive pdf user's manual for the program. Install the program onto the computer you will be using and review the manual for more operational details.

A link to the Comet software is available at <https://metone.com/software/>.

Comet is a communications terminal program which can retrieve data from the ES-412 using a direct local connection or a remote connection via an IP address or a variety of modem options.

Warning: A Silicon Labs CP210x Driver for the USB connection must be installed before connecting to the USB Type B port. Driver download weblink:

<https://www.silabs.com/products/development-tools/software/usb-touart-bridge-vcp-drivers>

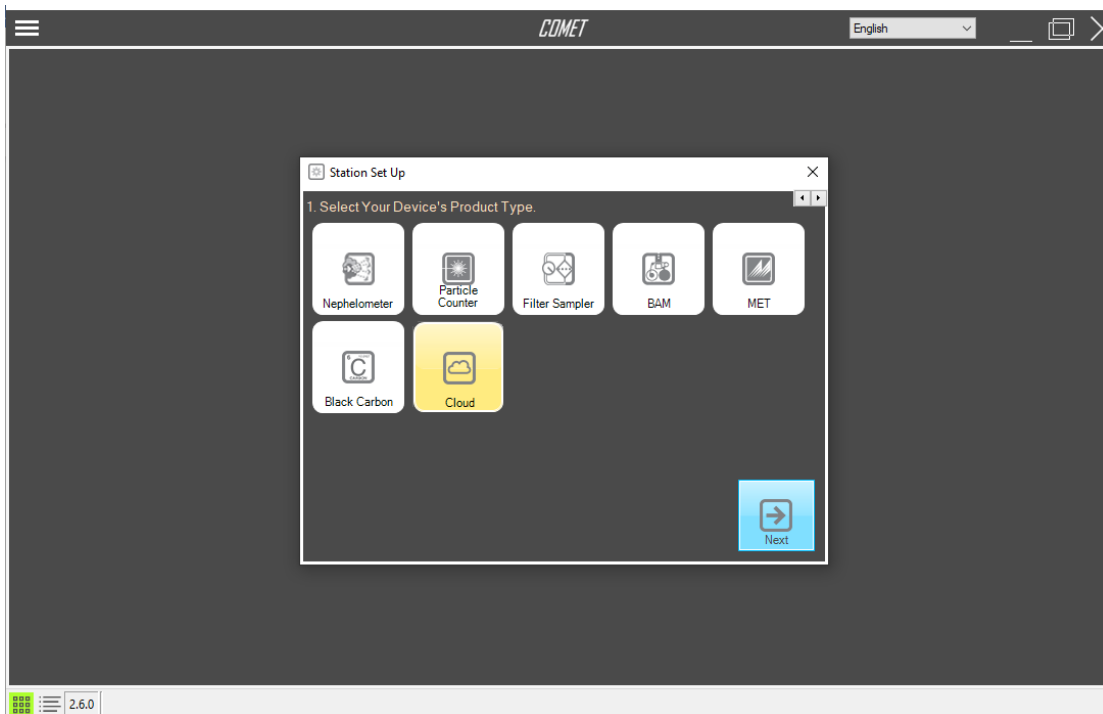
3.2.1 Comet Installation

Download the Comet software onto a PC and run the Windows Installer Package. Follow the on-screen instructions until Comet is successfully installed, then run it from the Programs directory. Create a new station for the ES-412 and use it to retrieve the data from the monitor.

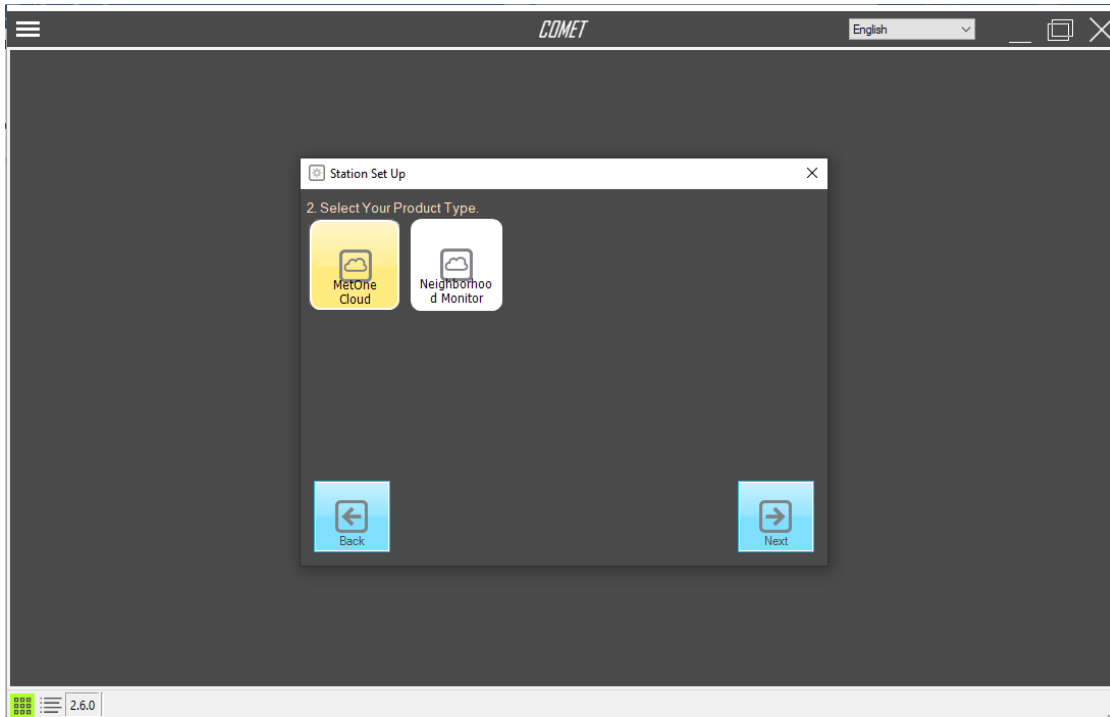
3.2.2 Setting up a Cloud Station

The first time the Comet program is opened it prompts the user to create a new station for your Cloud site. If Comet does not prompt you, go to the top left menu and select Add New Station to create a new station.

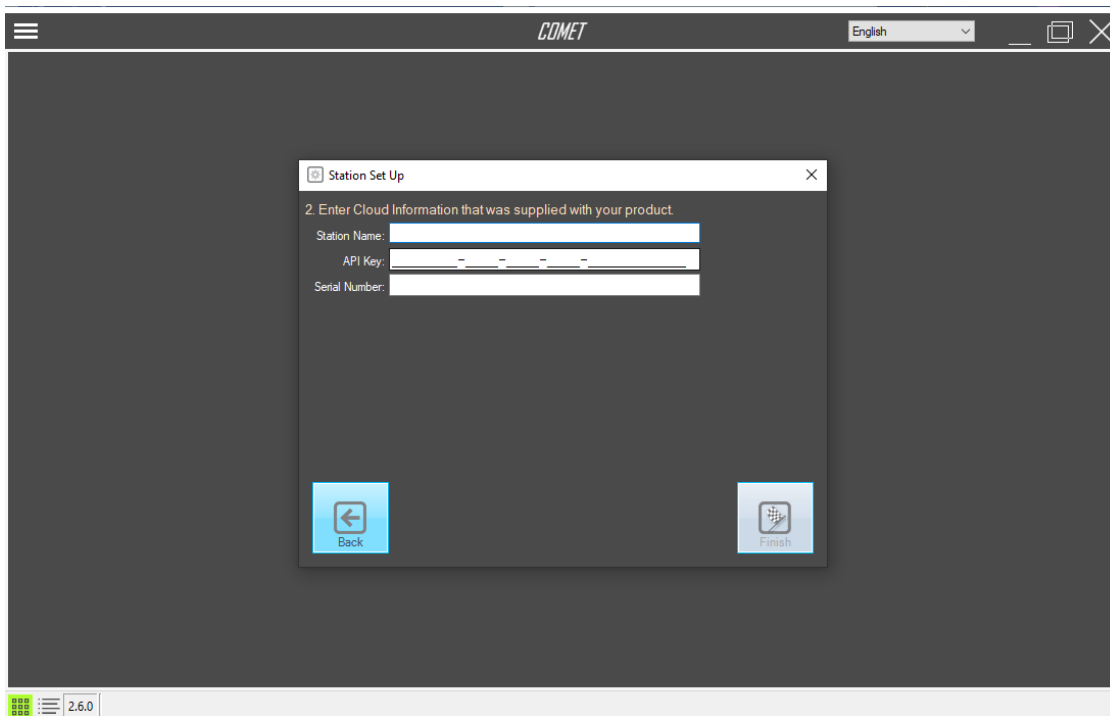
Select the Cloud Device Product Type and click next.



Select the Met One Cloud Product Type and click next.

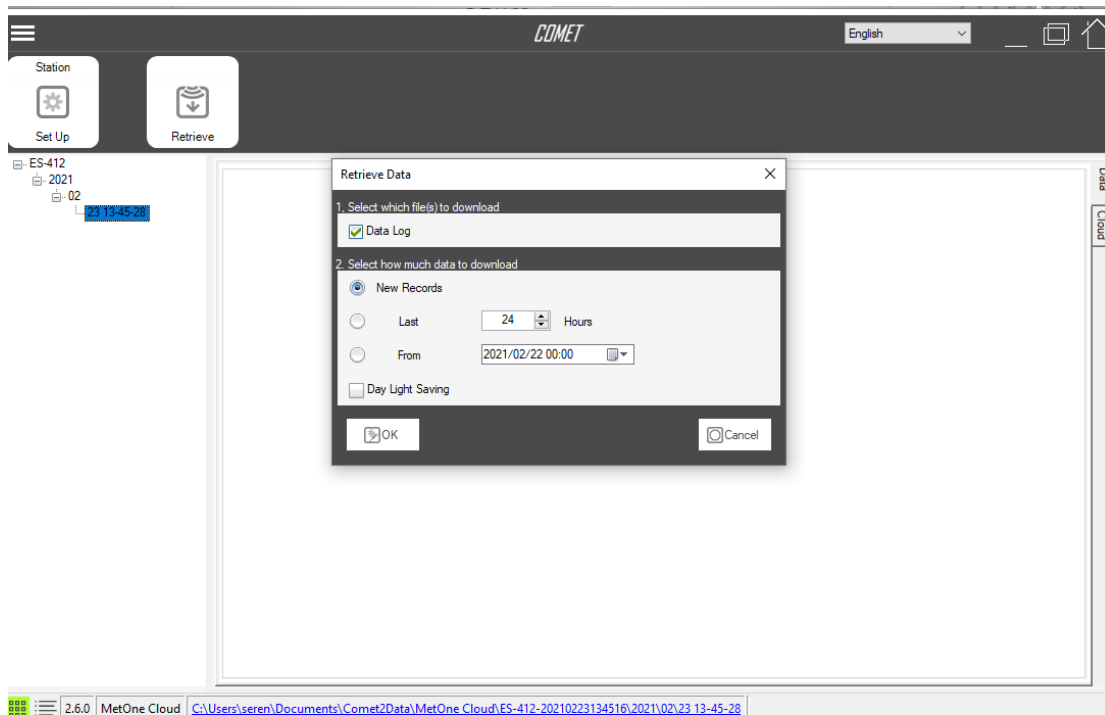


Enter a Station ID, API key, and Serial Number for the ES-412.



Note: Customers will receive an API on the provided configuration sheet; a digital copy can be obtained from the Met One Instruments Service department.

Press the Retrieve button to open the Retrieve Data menu screen. When prompted, enter a data range and press OK to download your station's data from the cloud.



Comet will connect to the cloud site and download the device's data. Users can use the data tab and chart tab to view the data. When Comet downloads the data, a CSV file is created in the users My Documents folder.

4 DATA PLANS AND RENEWALS

The ES-412 includes three years of cellular data and website hosting at no extra charge. The cloud service can be renewed by contacting the Met One Service department at service@metone.com or 541-471-7111.

The following yearly data plans are available:

- | | |
|--------|------------------------------|
| 680785 | CCS Data Plan, 15 Min USA |
| 680786 | CCS Data Plan, 5 Min USA |
| 680783 | CCS Data Plan, 60 Min Global |
| 680784 | CCS Data Plan, 15 Min Global |

5 SERIAL COMMUNICATIONS

This section describes how to communicate with the ES-412 to change settings and perform calibrations. Communication through the serial port is easy using simple terminal or escape commands and a terminal emulator program of choice. The ES-412 default baud rate is 115,200.

5.1 Terminal Commands Through the Serial Port

When a serial connection between the computer terminal program and the ES-412 has been established, you will have access to send the following commands through the serial port with keyboard strokes or ASCII characters.

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.

5.1.1 User Communication

In the user communication mode (terminal mode), press the Enter key, <cr>, three times to enter terminal command mode. In this mode simple character commands can be issued with no <Esc> character required.

An asterisk character appears during wake-up and 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

Note: After a few minutes, the ES-412 will stop waiting for a command and you will have to send another series of three carriage returns to reestablish the command prompt connection.

5.1.2 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.

5.1.3 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 requesting product revision example follows:

<Esc>rv

ES-412, 83505, R1.0.0.2

5.1.4 Checksum Computation

Checksum is calculated as the 16 bit unsigned integer sum of all 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>

The same command example with checksum follows:

<Esc>rv*//

ES-412, 83505, R1.0.0.2*01272

5.1.5 Serial Command List

The command set descriptions are listed in the following table:

| Command | Function | | | | | | | | | | | | | | | |
|------------------|--|---------|-----|-----|------|---|---|------------------|---|---|---------------|---|---|----------|---|---|
| # | 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. | | | | | | | | | | | | | | | |
| DT | Get/Set date and time. yyyyMMddHHmmss | | | | | | | | | | | | | | | |
| ID | Get/Set location ID or address. The range is 1 to 999. | | | | | | | | | | | | | | | |
| OI | Interval Output On/Off. 1=Enabled, 0=Disabled. | | | | | | | | | | | | | | | |
| QH | Query Header | | | | | | | | | | | | | | | |
| RF | Reference flow for calibration | | | | | | | | | | | | | | | |
| RO | Report Options. Uses bit flags for the different readings. Add up all the bit flags for combinations needed <table border="1"> <thead> <tr> <th>Reading</th> <th>Bit</th> <th>Add</th> </tr> </thead> <tbody> <tr> <td>Flow</td> <td>0</td> <td>1</td> </tr> <tr> <td>Temperature (FT)</td> <td>1</td> <td>2</td> </tr> <tr> <td>Pressure (FP)</td> <td>2</td> <td>4</td> </tr> <tr> <td>RH (FRH)</td> <td>3</td> <td>8</td> </tr> </tbody> </table> e.g. RO 11 = Flow, Temperature, RH | Reading | Bit | Add | Flow | 0 | 1 | Temperature (FT) | 1 | 2 | Pressure (FP) | 2 | 4 | RH (FRH) | 3 | 8 |
| Reading | Bit | Add | | | | | | | | | | | | | | |
| Flow | 0 | 1 | | | | | | | | | | | | | | |
| Temperature (FT) | 1 | 2 | | | | | | | | | | | | | | |
| Pressure (FP) | 2 | 4 | | | | | | | | | | | | | | |
| RH (FRH) | 3 | 8 | | | | | | | | | | | | | | |
| RQ | Request last reading. | | | | | | | | | | | | | | | |
| RV | Get product information. | | | | | | | | | | | | | | | |
| SB | Get/Set serial baud rate. 3=2400, 4=4800, 5=9600, 6=19200, 7=38400, 8=57600, 9=115200. | | | | | | | | | | | | | | | |
| SK | Set PM K Factors. K Factor range is 0.1-20.0. PM2.5=1, PM10=2 | | | | | | | | | | | | | | | |
| SPR | RH Setpoint to turn inlet heater on. | | | | | | | | | | | | | | | |

5.2 Serial Command Explanations

5.2.1 User Data Report

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

The Time field is the standard ISO style time stamp. The optional fields follow.

The Data Report is as follows:

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

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

5.2.2 OI Command

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

5.2.3 SK Command

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

*SK 1 2.70

SK 2,2.70,PM2.5

*SK 2 2.16

SK 2,2.16,PM10

6 ES-412 MEASUREMENT METHOD

The Met One Instruments, Inc model ES-412 is a type of air quality sensor which automatically measures and records real-time airborne PM₁₀ and PM_{2.5} particulate concentration levels using the principle of right-angle laser light scatter. This section describes the measurement systems.

6.1 Sheath Air

The Particle Profiler uses a sheath air system. 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. Sample air is drawn into the ES-412 by an internal pump. Flow rate is controlled with a flow sensor to maintain constant 1 LPM flow on the inlet nozzle. Additional air is added around the sample flow to contain the particles.

6.2 Detection

The ES-412 is always ready to detect 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 multiplied by a fixed density to provide an indicative particulate mass measurement.

6.3 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).

6.4 Calibration

Calibration is performed at Met One Instruments 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).

6.5 K-Factor

The ES-412 Particulate 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.

It is best to compare the ES-412 to regulatory monitors distinguished as Federal Reference Monitors (FRM) or Federal Equivalent Monitors (FEM). Contact your local air quality authorities for information on locations and how to access the data. Some sites may have hourly data, while others may have 24-hour data.

Calculate the K-Factor for each particulate size fraction as the reference concentration divided by the ES-412 light scatter concentration over the same time period. For example, if the reference total concentration was $51 \mu\text{g}/\text{m}^3$ and the ES-412 total concentration was $38 \mu\text{g}/\text{m}^3$, then the K-Factor would be 51 divided by 38 or 1.342. It is advisable to calculate this number for each PM size.

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 accuracy of the mass output can be affected by variations in size, color, shape, and index of refraction of the sampled particles.

6.6 Sample RH Control for Light Scatter Mass

The relative humidity (RH) of the sample air has an influence upon the measurement of particulate mass by optical units. At RH values greater than about 50% this effect begins to increase due to particle aggregation and particle size increases as water is absorbed. The ES-412 mitigates this through a heated inlet tube that uses an internal sample RH sensor. The RH of the incoming air is measured, and the inlet heater is turned on whenever the user-set setpoint is exceeded (default 40% RH).

7 MAINTENANCE and TROUBLESHOOTING

This section provides information about routine maintenance of the ES-412, and for performing more detailed diagnostic tests if a problem is encountered. The ES-412 generates error messages on the display or in the data log if a failure or other problem is detected. Many times there is a simple solution, but persistent errors often signify a failure which will require investigation.

WARNING: The ES-412 Particulate Profiler can only be serviced or calibrated by factory-authorized personnel. Unauthorized maintenance on the Particle Profiler may result in exposure to laser radiation that can cause blindness and void warranty.

The ES-412 is an extremely component-dense assembly! Only skilled and trained electro-mechanical technicians should attempt any disassembly or repairs inside the ES-412. Routine maintenance procedures do not involve removing the ES-412 assembly from the enclosure. Calibrating particle sensors like the one in the ES-412 Particulate 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 ES-412 Particle Profiler should be calibrated on a 24-month basis.

7.1 Basic Problem and Cause/Solution Table

The following table contains information on some of the more common ES-412 problems which may be encountered, and some steps to identify and remedy the problems. Met One welcomes customer suggestions for new items to include in this section of future manual revisions. If the solution cannot be found in the following table, contact one of our expert service technicians for help in resolving your problem.

| | |
|------------------------|---|
| Problem: | Flow failures or low flow. |
| Cause/Solution: | <ul style="list-style-type: none"> • Check the filter. This must be replaced periodically. • Try to DEFAULT the flow sensor calibration. If corrupted flow cal parameters are entered into the flow calibration, it may appear that the flow system is not working. • Verify the internal AT and BP sensors function. They appear as FT and FP on the Data Report when their output is enabled. Failed sensors can affect the flow. • The sample pump itself will eventually wear out and need to be replaced. It should last at least a year under normal conditions. Check the other possibilities first. |

| | |
|------------------------|--|
| Problem: | Optical system alarms and failures |
| Cause/Solution: | <ul style="list-style-type: none"> • The ES-412 must be periodically returned to the factory for optical system cleaning. The period will depend on your particulate levels. • Check the filter and replace as needed. • The laser diode has a finite lifetime which will be reduced at high temperatures. It may eventually fail and need to be replaced at the factory. |

| | |
|------------------------|---|
| Problem: | The ES-412 data does not match FEM or FRM data at the same site |
| Cause/Solution: | <ul style="list-style-type: none"> • A K-Factor (multiplier) must be established for good accuracy and correlation to collocated instruments. The K-Factor will sometimes be very significant, such as a multiplier of 3 or 5. See Section 6.5. • 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. • Clean the TSP inlet monthly. • Check the sample RH data and filter RH sensor operation. High sample RH will cause ES-412 over-reading. The sensor itself can occasionally fail. • Check the ES-412 for flow calibration problems. |

7.2 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. The program administrator should review these items and establish SOPs appropriate for your application.

| Maintenance Item | Suggested Period |
|---------------------------|------------------|
| AQ Flow Audit/Calibration | Monthly |
| Replace Filter | Yearly |
| Calibrate Sensor | 24 Months |

7.3 Flow Calibration

Connect a flow meter to the inlet nozzle and allow the flow to stabilize. If it is not 1.00 LPM \pm 0.05LPM, 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.

7.4 Filter Change

The filter cartridge is located on the bottom of the instrument. It can be removed by unscrewing the black Delrin filter holder. The expected lifetime of the filter is one year, but in heavy particulate areas they may need to be replaced more often. The replacement filter p/n is 580358.

7.5 TSP Inlet Cleaning

The TSP inlet must be cleaned periodically. The time interval between cleanings varies depending on the local particulate levels. The TSP inlet should be disassembled and cleaned at least every three months during continuous use.

The TSP inlet can be disassembled for cleaning by removing the three screws in the cap. Soap and water often work best for cleaning the TSP inlet and debris screen. Do not over-tighten the screws during reassembly or the plastic threads will strip out.

7.6 Factory Service Interval





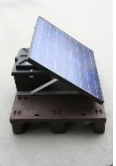
The ES-412 needs to be periodically returned to the factory for service and recalibration. The recommended period is 24 months during continuous use. However, some users establish their own interval depending on the harshness of the sampling conditions, particulate levels, and data scrutiny. High concentration operation will often require more frequent factory service.

Factory service primarily consists of optical system cleaning, laser/detector checks, and recalibration. As-found calibration checks can also be requested. Contact the Met One technical service department to schedule ES-412 service. A Return Authorization (RA) number must be obtained before the unit is returned.

8 PARTS and ACCESSORIES

8.1 Consumables, Replacement Parts, and Accessories

The following parts are available from Met One for maintenance, replacement, service, and upgrades. If unsure about a part you need, please contact the technical service department. Some of these parts may require technical skills or special instructions before use or installation.

| Description | Part Number | Graphic |
|--|----------------|---|
| Sample Pump Module Assembly | 81643 | |
| Flow Sensor, Differential Pressure | 82258-1 | |
| Temperature Sensor Assembly and Harness | 80957-2 |  |
| Air Filter, 0.01 micron | 580358 |  |
| O-Ring, Filter Holder | 720074 | |
| TSP Sampling Inlet Harsh environment, with insect screen and rain cap | 9441 |  |
| Profiler Engine Assembly | 83120 | |
| Power Supply, 100-240 VAC input 12 VDC output, Weatherproof | 9438-4 |  |
| USB Cable, Type A to Mini B Male | 500787 | |
| Solar Power Kit, 160W, 3.7 minimum PSH | 730139 |  |
| Solar Power Kit, 240W, 2.5 minimum PSH | 730140 | |
| ES-412 Factory Service and Recalibration | | Call Met One |