ApexPortable

PARTICLE COUNTER

OPERATING MANUAL

ApexP3, ApexP5

LIGHTHOUSE
WORLDWIDE SOLUTIONS

Lighthouse Worldwide Solutions

ApexPortable *Airborne Particle Counter*

Operating Manual

248083440-1 Rev 7

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Manufactured by:

Lighthouse Worldwide Solutions

1221 Disk Drive

Medford, Oregon 97501

LWS Part Number 248083440-1 Rev 7

EU DECLARATION OF CONFORMITY

Manufacturer's Name:	Lighthouse Worldwide Solutions, Inc.
Manufacturer's Address:	Lighthouse Worldwide Solutions, Inc. 1221 Disk Drive Medford, OR 97501

Declares that the product:

Product Name:	ApexP Airborne Particle Counters
Model Number(s):	ApexP3/ApexP5

Conforms to the following Product Specifications:

SAFETY	EN61010-1:2010	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use Part I: General Requirements IEC 61010-1:2010
EMC	EN61326-1:2013	Electrical Equipment for Measurement, Control and Laboratory Use EN 61326-1:2013

Supplementary information

The product herewith complies with the requirements of the Low Voltage Directive 2014/35/EU and the EMC Directive 2014/30/EC and carries the CE marking accordingly

Fremont, CA, March 13, 2019

Jerry Szpak – VP Engineering

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About this Manual

This manual describes the detailed operation and use of the Lighthouse **ApexPortable** ***(ApexP3*** and **ApexP5*)*** portable airborne particle counters.

Text Conventions

The following typefaces have the following meanings:

Note: ***A note appears in the sidebar to give extra information regarding a feature or suggestion.***

WARNING: ***A warning appears in a paragraph like this and indicates a condition, which if not met, could cause serious personal injury or death, and damage to the instrument.***

italics	Represents information not to be typed or interpreted literally. For example, *file* represents a file name. Manual titles are also displayed in italics.
boldface	Introduces or emphasizes a term.
`Courier font`	Indicates command syntax or text displayed by the diagnostic terminal.
`Bold Courier`	Indicates commands and information that the user types.
Helvetica Italics	Indicates a comment on a command or text output.

Additional Help

For more information about Lighthouse **ApexPortable** Airborne Particle Counters, contact Lighthouse Worldwide Solutions.

Service and Support
Tel: 1-800-945-5905 (Toll Free USA)
Tel: 1-541-770-5905 (Outside of USA)
techsupport@golighthouse.com

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1 General Safety

Safety Considerations

Warnings and cautions are used throughout this manual and the reader should become familiar with the meaning of a warning before operating the particle counter. Most warnings will appear in the left margin of the page next to the subject or step to which it applies. Take care when performing any procedures preceded by or containing a warning. The classifications of warnings are defined as follows:

WARNING: ***There are no user-serviceable components inside the particle counter.***

- LASER - pertaining to exposure to visible or invisible LASER radiation
- Electrostatic - pertaining to electrostatic discharge
- Network Connect - pertaining to communication ports and instrument damage

LASER Safety Information

This product is considered to be a Class 1 LASER product (as defined by FDA 21 CFR, §1040.10 and IEC 60825-1:2014) when used under normal operation and maintenance. Performing service on the internal sensor can, however, result in exposure to invisible radiation.

WARNING: ***The use of controls, adjustments or procedures other than those specified within this manual may result in personal injury and/or damage to this instrument.***

The particle counter has been evaluated and tested in accordance with EN 61010-1:2012, “Safety Requirements For Electrical Equipment for Measurement, Control and Laboratory Use” and IEC 60825-1:2014, “Safety of LASER Products”.

For further technical assistance, contact our Technical Support Team at 1-800-945-5905 (USA Toll Free), 1-541-770-5905 (Outside of USA).

Sampling Safety

WARNING: ***While the flow path components will not be adversely affected, sampling reactive gasses such as hydrogen and oxygen can be dangerous. Appropriate precautions should be taken.***

Sampling of any pressurized gasses without the use of a properly designed diffuser can cause damage to the instrument and void the warranty.

Do NOT allow water, solvents, or other liquids to enter the instrument as they can damage the instrument and void the warranty.

Operating Safety

WARNING: ***The use of controls, adjustments or procedures other than those specified within this manual may result in personal injury and/or damage to this instrument. Attempts by untrained personnel to disassemble, alter, modify or adjust the electronics or optics may result in personal injury and damage to the instrument and will void its warranty.***

There are no user-serviceable components inside the particle counter. Only factory authorized service personnel should repair or service this instrument and its optical system.

If replacement of the power supply or its AC power cord is required, replace it only with a power supply or cord having as good as or better ratings than specifications provided by Lighthouse Worldwide Solutions. Attempting to use an under-rated power supply or cord can expose the instrument, adjacent equipment or the user to dangerous shock and fire hazards. Failure to meet this requirement will void the CE certification, void the instrument warranty and can result in serious personal injury.

WARNING: ***The ApexPortable uses a 5 Amp 24V DC power supply. It connects to the round connector shown in Figure 1-1. Remove AC power from power supply, connect DC cord to Apex then connect power supply to AC.***

Figure 1-1 ApexPortable Power Input Connector

Electrostatic Safety Information

Electrostatic discharge (ESD) can damage or destroy electronic components. Therefore, any service or maintenance work should be done at a static-free work station. A static-free work station requires an ESD consultant to evaluate the work environment and propose the equipment and apparel needed for a work station to be successful.

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2 Introduction

Overview

This operating manual introduces the Lighthouse **ApexPortable** family of portable Airborne Particle Counters and includes instructions for inspecting, installing, using and maintaining the instrument.

Description

The **ApexPortable** instrument comes standard with four particle-size channels of 0.3, 0.5, 1.0 and 5.0 microns (**ApexP3**) and 0.5, 1.0, 5.0 and 10.0 microns (**ApexP5**) with a flow of 1.0 CFM. Figure 2-1 shows the standard configuration. Figure 2-1 lists features and specifics about the **ApexP3** and Table 2-2 lists the **ApexP5**.

Figure 2-1 ApexPortable Airborne Particle Counter

The instrument uses a LASER diode light source and LASER beam shaping optics to illuminate a cross section of the air flow path. As particles move along this path, they cross the LASER beam and scatter light. The light scattered is collected by an optical imaging system onto a photodiode. The photodiode converts the image into a current which is converted to a voltage and amplified by an electronic circuit.

The result is the electronic circuit outputs a voltage pulse each time a particle crosses the LASER beam. The amplitude of the voltage pulse is proportional to the light scattered which in turn is proportional to the size of the particle.

The voltage pulses created by the particles are then processed by additional electronics that analyze the height of each pulse, therefore, the size of each corresponding particle. The result is that the number of particles of various sizes is determined.

The processed signals are sorted into bins, or channels, and displayed on the screen as counts. The terms Particle Size and Particle Channel are used synonymously to refer to the displayed information.

This instrument is effective in both ultra-clean areas (such as ISO Class 1 or Grade A) and in more traditional cleanzones rated as ISO Class 3 or higher. Refer to Specifications in this manual for additional instrument information.

The **ApexPortable** integrates seamlessly with large facility monitoring and management systems and transfers particle count data using RS485 (using MODBUS RTU or ASCII protocols) or Ethernet via MODBUS TCP.

Accessories

Several items are shipped with each instrument but some optional accessories can be ordered to tailor the instrument to specific needs. Standard and optional accessories are listed below.

- **Standard Accessories:**
  - 24VDC 5A Power Supply
  - Operating Manual on included flash drive
  - LMS Express Download Instructions
  - Read Me First
  - Parts List
  - USB to RS-232 Serial cable
  - Sample Tubing, 10 feet
  - 1.0 CFM Isokinetic Sampling Probe with Tubing
  - 1.0 CFM Purge Filter Assembly with Tubing
- **Optional Accessories:**
  - USB Thermal Printer, with Operating Manual on CD
  - ISO Probe Monopod

ApexP3 Specifications

Size Range	0.3 - 5.0 µm
Channel Thresholds	Standard 2-channel: 0.3, 0.5µm; 4-channel: 0.3, 0.5, 1.0, 5.0µm
Flow Rate	1.0 CFM (28.3 LPM)
Counting Efficiency	Meets ISO 21501-4
Data Storage	Rotating Buffer, 3000 records
Light Source	LASER diode
External Connections	RS485 RJ45 (RS485 and RS232 data); DIN (factory); Ethernet RJ45 (Ethernet data); calibration port
Zero Count Level	<1 count/5 minutes (per ISO 21501-4)
Max ISO Probe tubing	Maximum tubing length to ISO = 16 feet
Calibration	NIST Traceable
Communication Modes	MODBUS ASCII; MODBUS RTU; MODBUS TCP
Supporting Software	LMS Pharma/Pro v7.3.1 or higher, LMS Express 7.5 or higher
Operating Altitude	Sea Level to 2000 meters (6561.66 feet)
Power Input Requirements	24VDC ±5% @ 5.0A, 120W
Power Supply Specifications	100-240VAC, 47-63Hz 1.4A input, 24VDC 5.0A 120W max output
Enclosure	Stainless Steel, VHP compatible
Dimensions	9.00” (w) x 8.46” (h) x 6.21” (d) [22.86 x 21.49 x 15.77 cm]
Weight	10.0 lbs (4.54 kg)
Operating Temp/RH	50° F to 104° F (10° C to 40° C) / 20% to 95% non-condensing at maximum 2000M altitude
Storage Temp/RH	14° F to 122° F (-10° C to 50° C) / Up to 98% non-condensing

Table 2-1 ApexP3 Specifications

ApexP5 Specifications

Size Range	0.5 - 10.0 µm
Channel Thresholds	Standard 2-channel: 0.5µm, 5.0µm; 4-channel 0.5, 1.0µm, 5.0µm, 10.0µm
Flow Rate	1.0 CFM (28.3 LPM)
Counting Efficiency	Meets ISO 21501-4
Data Storage	Rotating Buffer, 3000 records
Light Source	LASER diode
External Connections	RS485 RJ45 (RS485 and RS232 data); DIN (factory); Ethernet RJ45 (Ethernet data); calibration port
Zero Count Level	<1 count/5 minutes (per ISO 21501-4)
Max ISO Probe tubing	Maximum tubing length to ISO = 16 feet
Calibration	NIST Traceable
Communication Modes	MODBUS ASCII; MODBUS RTU; MODBUS TCP
Supporting Software	LMS Pharma/Pro v7.3.1 or higher, LMS Express 7.5 or higher
Operating Altitude	Sea Level to 2000 meters (6561.66 feet)
Power Input Requirements	24VDC ±5% @ 5.0A, 120W
Power Supply Specifications	100-240VAC, 47-63Hz 1.4A input, 24VDC 5.0A 120W max output
Enclosure	Stainless Steel, VHP compatible
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Storage Temp/RH	14° F to 122° F (-10° C to 50° C) / Up to 98% non-condensing

Table 2-2 ApexP5 Specifications

The manufacturer recommends that the Lighthouse instrument be calibrated annually by a Lighthouse Certified Service Provider in order to ensure the unit continues to perform within specifications and to protect its warranty. For information about returning instruments for calibration or service, visit our website www.golighthouse.com/RMA.

3 Get Started

Unpack and Initial Inspection

The instrument is thoroughly inspected and tested at the factory and is ready for use upon receipt.

When the instrument is received, inspect the shipping carton for damage. If any is noted, ensure that the carrier is notified and the carton is saved for carrier inspection. Remove the instrument and other components from the packing materials and inspect them for broken parts, scratches, dents, and other damage. Compare the contents with the pack slip / invoice / parts list. Immediately report any damaged or missing parts to Lighthouse.

Damaged cartons may be replaced by calling Lighthouse Sales. Keep an undamaged carton for reshipment of the instrument for its annual factory calibration.

Report all issues to Lighthouse Support at 1-800-945-5905 in the USA or 1-541-770-5905 outside of USA.

Configuration Kit

Each order is shipped with a ***Ship Kit***, which includes a 24VDC Power Supply and a flash drive containing the Operating Manual.

Interchangeable Terms

The terms **ApexPortable**, instrument, counter, and unit may be used throughout this manual interchangeably; they mean the same thing unless specified otherwise.

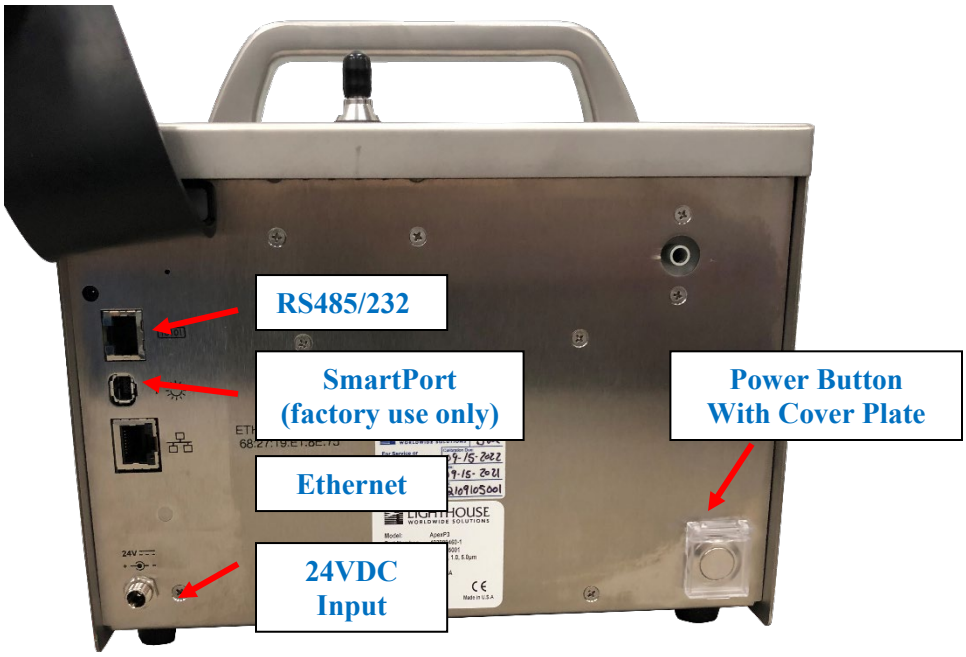

Figure 3-1 ApexPortable Connectors

WARNING: ***Remove AC power from Power Supply, connect DC cable then connect to AC.***

Always have the AC disconnected from the power supply before attempting to connect the DC Output Connector to the **ApexPortable**. This will prevent damaging the Power Input Connector.

It is suggested that the **ApexPortable** be placed in the environment where it will be used and attached to its power supply for several hours to ensure its battery is fully charged before putting the instrument into service.

Set Channels, Thresholds, and Alarms

Push the rear power button (see the image above) in to turn the instrument on - it should latch in the ON state. After about 5 seconds, the unit will display its boot screen then display the Main Screen. The following screens will display how to enable channels, set alarm levels and enable the alarms. They are provided as examples and may vary on individual instruments.

Quick Setup Guide:

Touch the CONFIG button

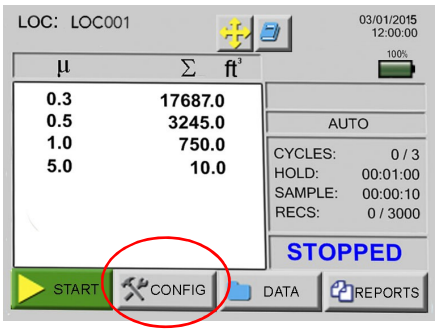

Figure 3-2 MAIN Screen

Then PARTICLE

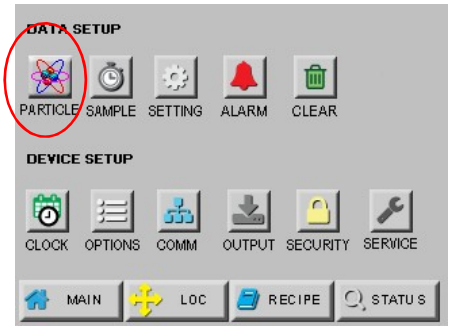

Figure 3-3 Config Screen Choose Particle

Enable Desired Channels

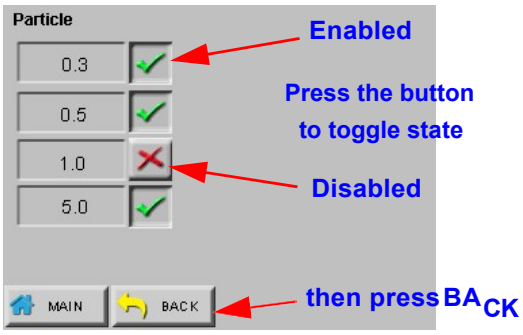

Figure 3-4 Particle Channel ON/OFF Setting

Press a  to change its state to a  to enable the channel.

Press a  to change its state to a  to disable the channel.

Figure 3-5 Config Screen - Choose Alarm

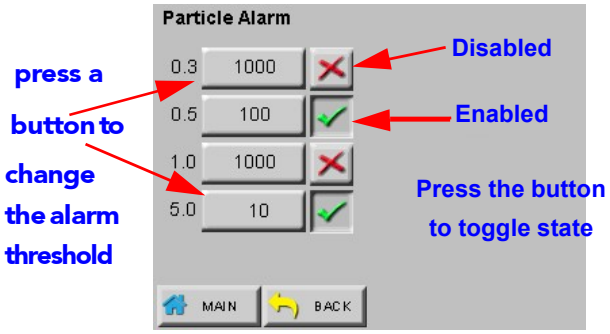

Figure 3-6 Particle Alarm Enable/Disable

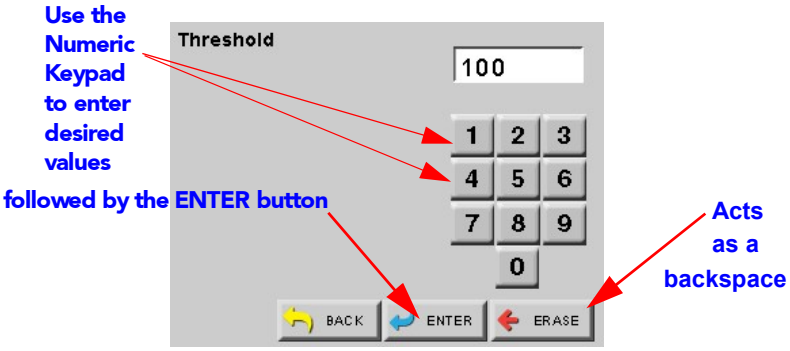

Figure 3-7 Alarm Threshold Change Screen

Return to MAIN screen and note that only enabled channels are displayed

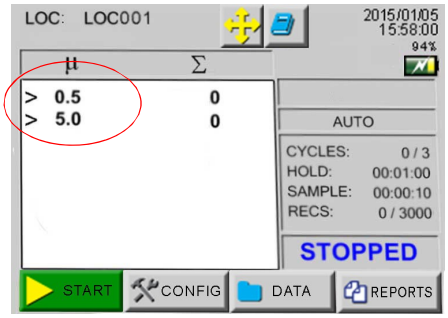

Figure 3-8 Enabled Channels Displayed

Figure 3-8 shows enabled channels and the '>' indicates channels that have alarms enabled, in this case both channels.

At this point, pressing the START button will start the **ApexPortable** counting cycle on the enabled channels. Please refer to Chapter 5, Operating Counter, for detailed operating instructions for the instrument.

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4 Communications

This chapter contains information regarding how to set up communications to program and communicate with the **ApexPortable** instrument.

General

Table 4-1 lists the Communication Port (COMM Port) RJ45 pinouts. Prevent accidental damage to Ethernet hardware: do NOT connect the COMM port to Ethernet equipment, such as network switches, hubs and the like.

Table 4-1 COMM Port RJ45 Pinouts

RJ45 Pin	Signal Name
1	RS232-TX (Output)
2	RS232 RX (Input)
3	RESERVED for future use
4	RS485B
5	RS485A
6	RESERVED for future use
7	RESERVED for future use
8	Ground

To connect the instrument to a computer using USB-to-RS232 cable:

1. Remove power from the instrument.
2. Connect the RJ45 end of a USB-to-RS232 or RS485 cable to the RS485 RJ45 connect port on the instrument.
3. Connect the USB end of the cable to any computer USB Port.

RS485 Communications

RS485 should be used if the instrument is more than 50 feet from the computer or is installed in an industrial network. To do so, an optional RS485 cable must be used. Refer to Table 4-2 for specifics about the RS485 standard.

Table 4-2 shows the Electronics Industry Association (EIA) industry standards specifications.

Table 4-2 EIA Industry Standards for RS485 Communications

SPECIFICATIONS	RS485
Mode of Operation	Differential
Total Number of Drivers and Receivers on One Line (One driver active at a time for RS485 networks)	32 Drivers 32 Receivers
Maximum Cable Length	4000 ft (1,219.2 m)
Maximum Data Rate (40 ft - 4000 ft for RS422/RS485)	100Kbs - 10Mbs
Maximum Driver Output Voltage	-7V to +12V
Driver Output Signal Level (Loaded Min.): LOADED	+/-1.5V
Driver Output Signal Level (Loaded Max.): UNLOADED	+/-6V
Driver Load Impedance (Ohms)	54
Max Driver Current in High Z State (POWER ON)	+/-100µA
Max Driver Current in High Z State (POWER OFF)	+/-100µA
Receiver Input Voltage Range	-7V to +12V
Receiver Input Sensitivity	+/-200mV
Receiver Input Resistance (Ohms), (1 Standard Load for RS485)	≥12k

WARNING: ***The ApexPortable uses a 5 Amp 24V DC power supply. It connects to the round connector shown on the left in Figure 4-1. The symbol shows the voltage and polarity of supplied power.***

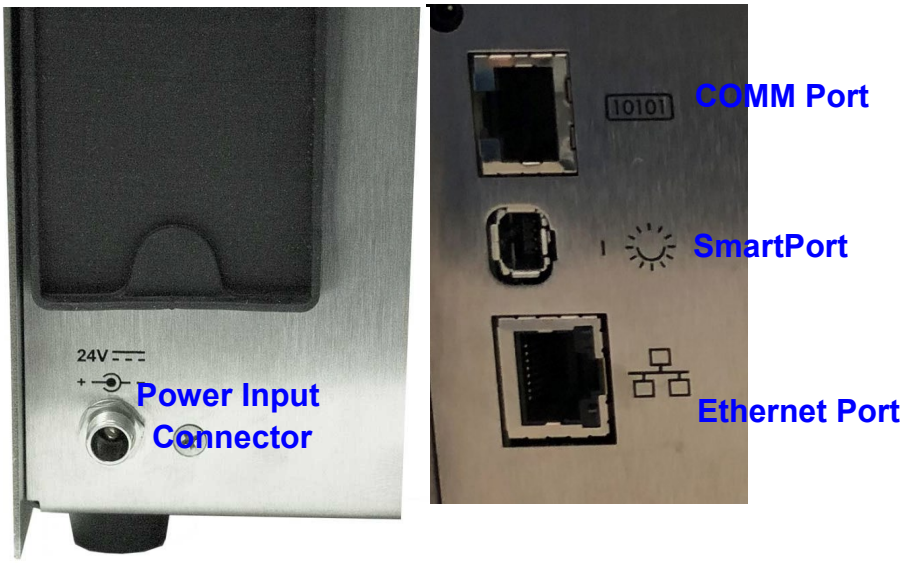

Figure 4-1 ApexPortable Rear Connectors

The **ApexPortable** uses Ethernet for large scale communication, RS485 for industrial networks and RS232 for direct connection to monitoring computers.

WARNING: Always have the AC disconnected from the power supply before attempting to connect the DC Output Connector to ApexPortable. This will prevent damage to the Power Input Connector.

Only use the power cord provided with the instrument. If it becomes necessary to replace the power cord or the power supply, contact Lighthouse Service. Failure to heed this warning may subject the user and equipment to a shock or fire hazard, which may result in serious bodily injury and property damage.

Remote Run via LMS Software

The **ApexPortable** can be remotely accessed, started, stopped and run by LMS Express Standard, LMS Express RT, LMS Net, Professional and Pharma software products. The LMS software can retrieve the data and present it in several user-set reports and report formats.

Facility monitoring products, such as the LMS Net, LMS Professional or LMS Pharma, provide facility-wide and enterprise-wide monitoring, alerting and reporting features that use the **ApexPortable** environment monitoring functions.

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5 Operate the ApexPortable

Using the Instrument for the First Time

This chapter describes how to use the **ApexPortable** 1.0 CFM Airborne Particle Counter. The **ApexPortable** battery is fully charged when it leaves the factory, but should be connected to external power before initial power up.To start using the instrument, proceed as follows:

WARNING: ***While the flow path components will not be adversely affected, sampling reactive gases such as hydrogen and oxygen can be dangerous. Appropriate precautions should be taken.***

Sampling of any pressurized gasses without the use of a properly designed diffuser can damage the instrument and void its warranty.

Please contact Lighthouse at 1-800-945-5905 (USA Toll Free) or 1-541-770-5905 (Outside of USA) for more information.

WARNING: ***To prevent damage to the instrument, water, solvents or other liquids of any kind must never be allowed to enter the ApexPortable via the inlet tube. Failure to heed this warning can void the warranty. Never operate the instrument with the inlet tube capped or plugged. Failure to heed this warning may damage the internal pump and void the ApexPortable warranty.***

1. Position the instrument in the environment to be measured.
2. Attach the external Power Supply and connect AC cord to AC.
3. Remove the protective cap from the inlet barb located on the top of the unit. To use the isokinetic probe, attach the probe to the instrument's inlet barb using the tubing on the probe.
4. Press in on the rear power switch.
5. While booting, the unit displays a startup "splash" screen.
6. The MAIN screen displays.
7. On the touch screen, press the "START" button to start the instrument.
8. "STARTING" will display when the pump starts running.
9. When the **ApexPortable** starts counting, "COUNTING" appears on the display. Particle counts are displayed according to which size channel detected each particle.

10. If the instrument has been programmed with a delay before starting the pump, it displays, “DELAY”.

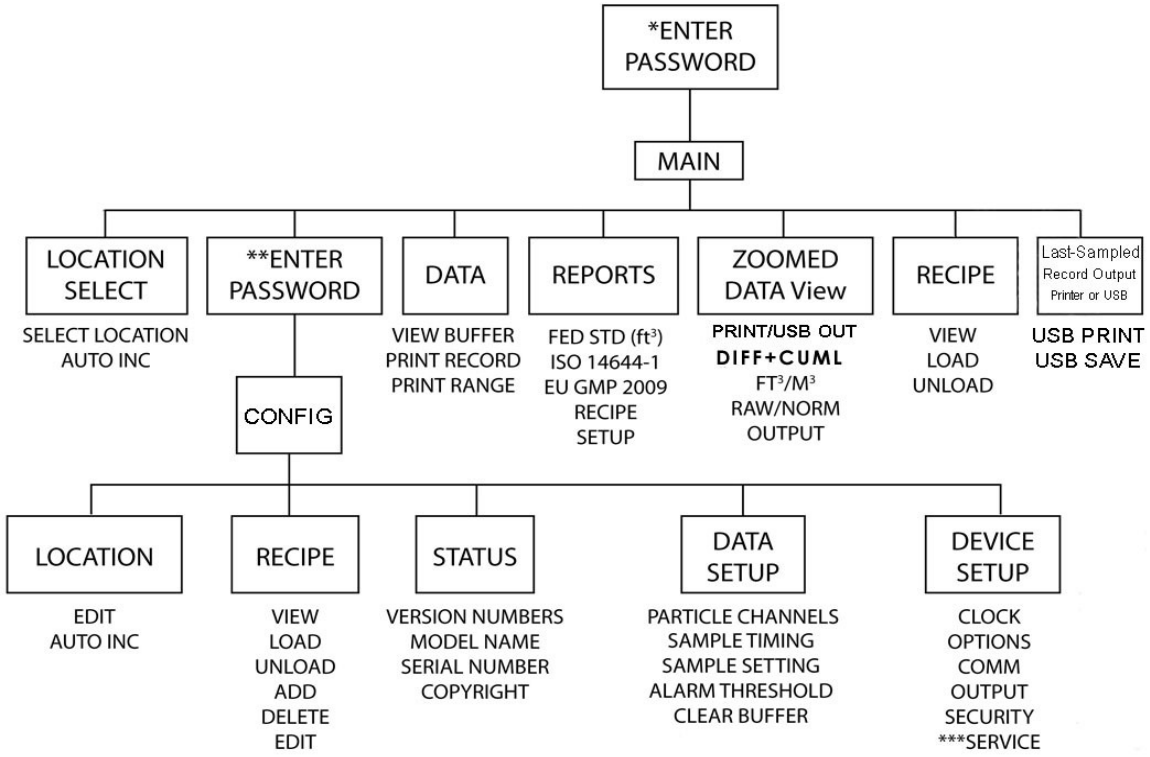
11. If the instrument is in AUTO mode with cycles and a hold time, “HOLDING” will display after each cycle and “FINISHED”will display when all the cycles are complete.

12. Press the "STOP" button to stop the instrument before the cycles are complete. "STOPPED" will display on the screen.

Touch Screen Overview

The **ApexPortable** incorporates a unique touch screen interface, which allows the user to easily view and configure the instrument to specific needs and applications. Figure 5-1 shows the menu tree.

Menu Map



* If POWER ON password is enabled.
** If CFG password is enabled.
*** For Authorized Service Provider Only.

Figure 5-1 Menu Map

MAIN Screen

The MAIN screen provides a snapshot view of the status of the instrument. The instrument can be powered by AC power or the internal battery. When the instrument is using battery power, the battery indicator will show the approximate level and percentage of the battery charge remaining as shown in Figure 5-2.

Note: *The screen examples in this chapter are for reference, only. The values displayed may not be indicative of actual values.*

Figure 5-2 MAIN Screen - Battery Operation

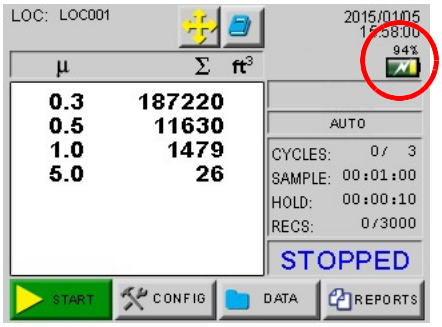


Figure 5-3 MAIN Screen - AC Operation

When an AC-powered power supply is attached, the battery changes to one with a lightning bolt. Its approximate capacity is displayed as a percentage above the icon. See Figure 5-3.

The MAIN screen displays the following options and information:

- **LOC:** Displays the location that is currently being measured. Up to 200 alphanumeric locations can be configured.

- **Location Select button:** At the MAIN screen, displays an Abbreviated Location Screen that allows a user to change location before sampling without requiring use of the CONFIG screen and any associated password.

- **RECIPE button:** Allows the user to view, load and unload recipes that have been configured and saved in the recipe database via an Abbreviated Recipe Screen. To edit the recipe or to add or delete recipes, use CONFIG, which can be password-protected, from the MAIN screen (see Figure 5-47). The CONFIG password is not required here.

- **Last-Sampled Record Print/USB Save:** Indicates attached printer or flash drive to be used to output the Last-Sampled Record currently on the screen. Press the Print ICON to send to the attached printer or USB ICON to send to flash drive. Restart will clear the screen and nothing will be output.
- **Date/Time:** Displays the current date and time.
- **Battery ICONs:** Indicate that the instrument is being powered by the rechargeable battery or its external power supply. The amount of battery life left is depicted by the fill inside the battery icon and the percentage above the icon. When the battery reaches 20% charge, the ICON will start blinking and display a "BATTERY LOW!" message. When it reaches 5% and the user tries to run a sample, the large "Depleted" ICON shown on the left is displayed and the unit will not run the pump until instrument is attached to the external DC power supply for recharging.
- While connected to the power supply, the battery icon changes to indicate charging. See Figure 5-4.

Note: *Users can continue to run samples and take counts while the unit is plugged in.*

Depleted Battery Warning ICON

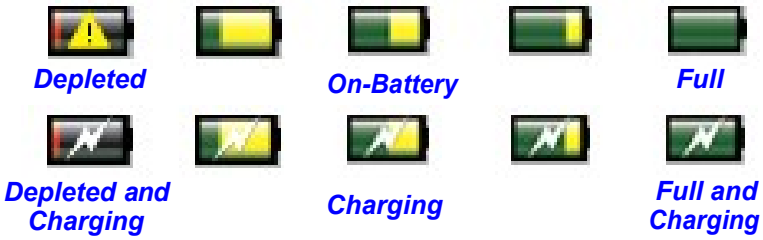


Figure 5-4 Battery Levels, On-Battery and Charging

WARNING: ***If the Air Flow is insufficient, check for and remove any obstructions. If the issue persists, turn the Apex off and contact Lighthouse Worldwide Solutions technical support at 1-800-945-5905 (USA Toll Free) or 1-541-770-5905 (Outside of USA).***

- **Flow Status:** When the instrument is COUNTING, the Flow ICON (left of battery) appears and displays sufficient or insufficient flow.

- **USB:** Indicates that a USB printer or flash drive is attached.

- **Service Indicator:** Indicates that the instrument may be in need of service. If wrench displays, please contact a Lighthouse authorized Service Provider at 1-800-945-5905 (USA Toll Free) or 1-541-770- 5905 (Outside of USA) for assistance or send an email to techsupport@golighthouse.com.

- **µ:** The mu (m-yoo) symbol indicates the particle sizes, in micrometers, configured for the instrument. These sizes are pre-configured at the factory. To order an instrument with non-standard sizes, please contact a Sales at Lighthouse 510-438-0500 (Sales).
- **DATA DISPLAY:** This indicates whether the counts are being displayed in Differential (Diff) mode or in Cumulative (Cuml) mode and, if the counts are normalized to ft^3 or m^3.

Δ **Differential** Σ **Cumulative**

ft^3 **Normalized ft^3** m^3 **Normalized m^3**

- **MODE:** Displays the current mode selected; possible modes are AUTO, MANUAL, CONC (Concentration) and BEEP. The exception to this is when a recipe is being run in which case the MODE area will display number of cycles run versus the total to be run (x / 6).
- **CYCLES:** Indicates the number of times the count will be taken at a given location in Auto mode. "1/ 3" indicates the count is the first of three samples to be recorded at this location. The maximum number of cycles is 999. When set to 0, the unit will run in Auto mode continuously until the STOP button is pressed.
- **SAMPLE:** The Sample Time (hh:mm:ss) is the duration of one counting cycle. The Sample Time will count down on the MAIN screen when the instrument is in AUTO or Manual mode so the user can see how much time is remaining in the sample period. In Concentration mode, the Sample Time will count up to 6 seconds per cycle.

Note: *If Hold time is greater than 1 minute, the pump will stop during that time. At the end of the hold time, the pump will restart.*

- **HOLD:** Displays the hold time in between cycles. The maximum hold time is 23 hours, 59 minutes, 59 seconds.
- **RECS:** This displays the current number of records stored in the instrument and the total number of records that can be stored. The data buffer is a circular buffer. The instrument can store up to 3000 records. An asterisk (*) will appear in front of counts when the buffer wraps.

- **START/STOP:** Press START button on the screen to start counting. STARTING is displayed on the screen until the pump and support electronics are stable and the **ApexPortable** can reliably count particles. COUNTING will display in the lower right corner of the screen as shown in Figure 5-5 when the **ApexPortable** is actually counting. When the STOP button is pressed to stop counting, the word STOPPED will be displayed.
- The instrument may be stopped during sampling by an error-checking process for insufficient battery power, pump over-current or instrument over-temperature. Acknowledge the popup by pressing the OK button to try to return to normal operation. If the error condition persists, contact Lighthouse support.

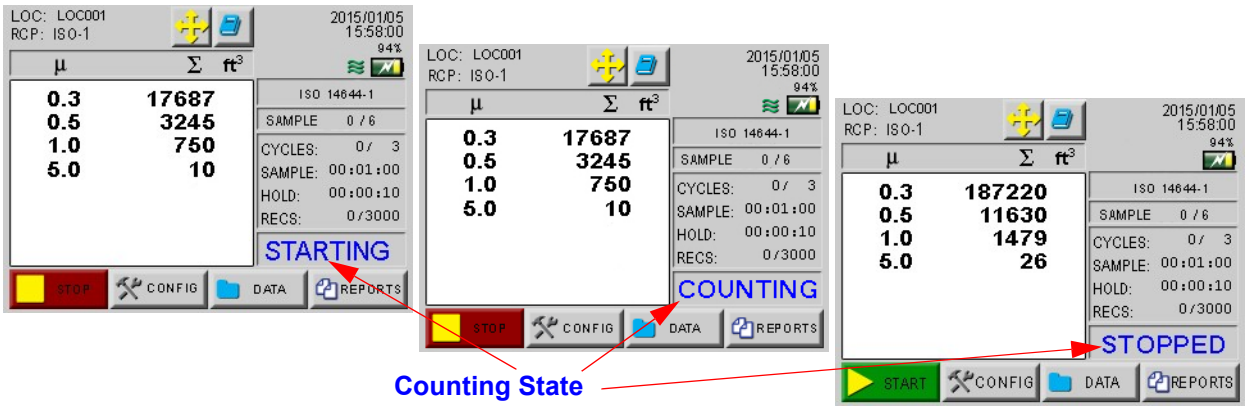
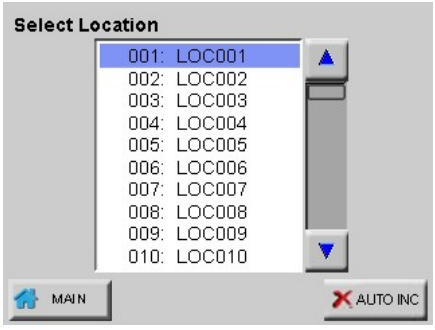


Figure 5-5 Three Counting States

Select Location

The location for the measured environment can be changed by pressing the LOCATION button at the top of the MAIN screen. Figure 5-6 displays the abbreviated Select Location screen. To edit, add or delete locations, the CONFIG button must be used, which can be password-protected. The password is not required here.



54 for more information on Locations.

- The blue highlight indicates which location is currently selected.
- Use the UP and DOWN arrows to highlight a location. The arrows will move pages up and down. Press on the location name desired to select the location. A location that has been assigned to a recipe will display an asterisk at the end of its name.

- When a highlighted location uses a specific recipe, it will be prompted to load when the MAIN button is pressed.
- The AUTO INC button, when active, pauses the **ApexPortable** to allow the user to move the **ApexPortable** to the next location when the current cycle is completed. It waits for the user to ackowledge the change by pressing the Start button to continue counting at the new location.
- Press the MAIN button to return to the MAIN screen. Whichever location that was highlighted / selected will be the location displayed on the MAIN screen.

Locations in AUTO Mode

When the instrument is in Automatic Mode and the START button is pressed, the instrument will start counting particles automatically based on the SAMPLE time, HOLD time and number of cycles that are configured.

Zoomed Data View

There are two different Zoom views. The user can view a single column of data (differential or cumulative) in a larger font or view both differential and cumulative data on the same screen in a smaller font.

While the **ApexPortable** is stopped, tap anywhere in the Particle Data area to display the Zoomed Data View. See Figure 5-7.

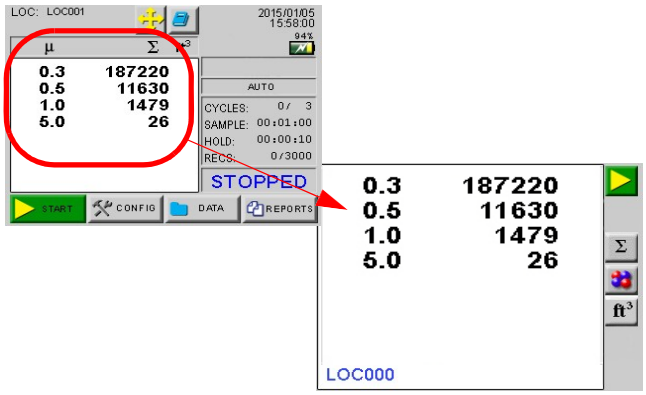


Figure 5-7 Zoomed Data View

In the Zoomed Data View, functions can be enabled using the buttons on the right side bar of Figure 5-7. Figure 5-8 shows examples and explanations of the buttons.

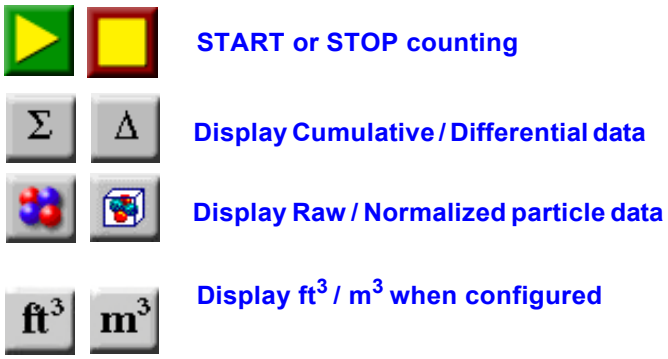


Figure 5-8 Zoomed Data View Buttons

When the instrument is STOPPED or HOLDING, the user may touch anywhere in the white data area to return to the MAIN Screen view.

Viewing Two Columns of Data

The **ApexPortable** can display both Differential and Cumulative data at the same time on the Zoomed View screen. Press the CONFIG then OPTIONS button to display the Options screen (Figure 5-9).

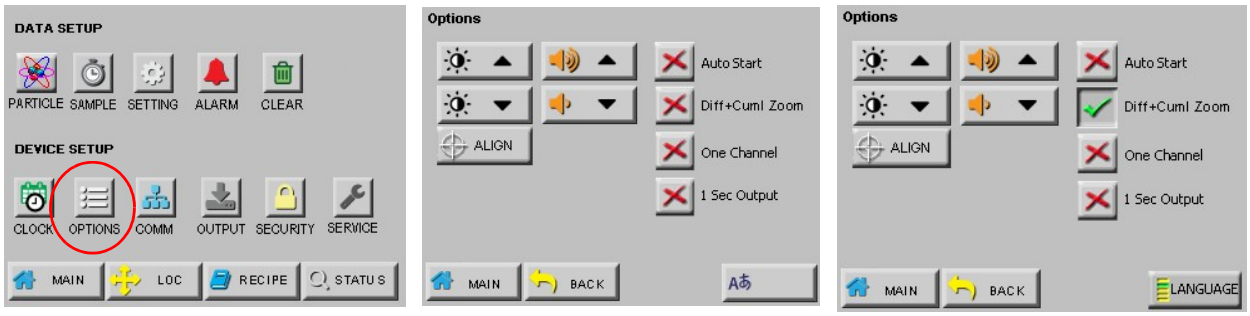


Figure 5-9 CONFIG: Options Screens

Press the “Diff+Cuml Zoom” button as shown in Figure 5-9, right frame, to enable the feature. This will display both differential and cumulative data on the Zoomed View screen as shown in Figure 5-10.

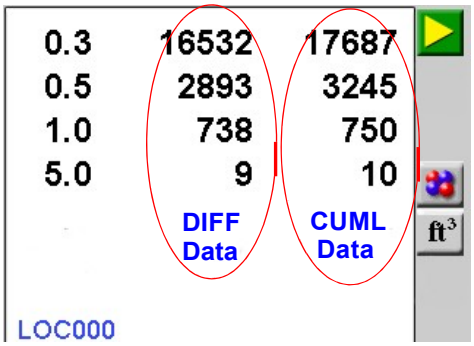
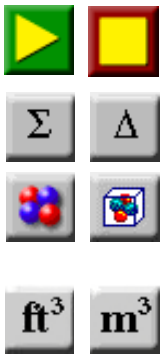


Figure 5-10 Differential and Cumulative Data in Zoomed View

The buttons available after selecting Diff+Cuml Zoom are shown in Figure 5-11. Their functions are the same as on single display screen.



START or STOP counting

Display Cumulative / Differential data

Display Raw / Normalized particle data

Display ft^3 / m^3 when configured

Figure 5-11 Diff+Cuml Zoom Screen Button Actions

To return the instrument to the default single-column zoom view, return to the MAIN Screen, press CONFIG, Options and deselect the “Diff+Cuml Zoom” button. See Figure 5-9.

Press the MAIN button to return to the MAIN Screen or press BACK to return to the previous level where the data type to be displayed on the one-column Zoomed View screen is chosen.

Go to the Settings screen and press Differential or Cumulative for the data type. See Figure 5-12.

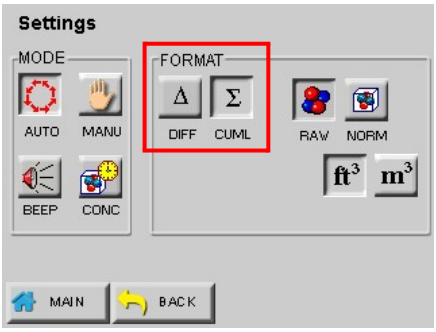


Figure 5-12 Settings Screen

CONFIG (Configuration) Screen

Press CONFIG on the MAIN screen to display the Configuration screen as shown in Figure 5-13. This feature can be password-protected.

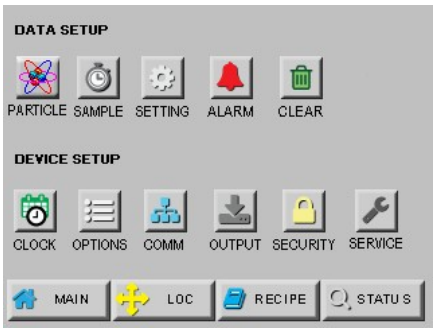


Figure 5-13 Configuration Screen

DATA SETUP provides buttons to enable/disable particle channels, set sample record parameters, sample settings, thresholds, enable/disable alarms and clear the data buffer.

DEVICE SETUP provides buttons to configure the instrument's date and time, set the LCD contrast, adjust the instrument's beep volume, enable the instrument to AutoStart, set it to display only one channel of data, enable real-time MODBUS output, set the instrument's communication address, enabling output on sample, enable password restrictions and/or (with proper authorization) adjust service settings.

DATA SETUP

Figure 5-14 shows the Data Setup option buttons. These options allow the user to configure the parameters for data collection.

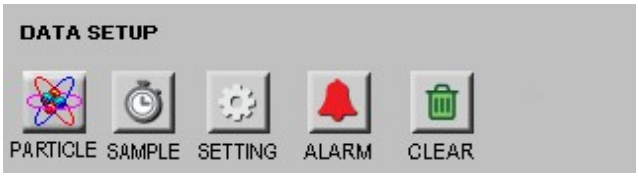


Figure 5-14 Data Setup Options

PARTICLE

The instrument's particle channels can be enabled or disabled on the Particle screen. A checkmark is displayed next to each enabled channel. See Figure 5-15.

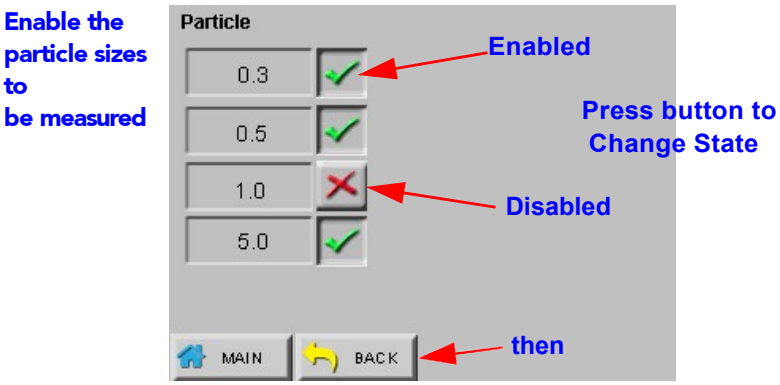


Figure 5-15 Particle Channel Configuration

- The button on the right of each channel size is an ON/OFF toggle. Press once to toggle a channel between a  , disabling the channel and the default  , enabling the channel.

When channels are disabled, they are removed from the MAIN screen display, from the reports and from the printouts.

SAMPLE

The SAMPLE screen configures the number of cycles, count times and volumes during a sample run. See Figure 5-16.

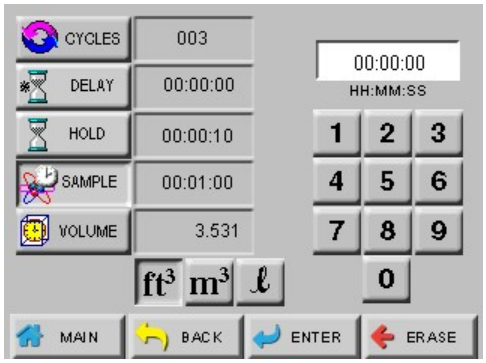


Figure 5-16 Sample Timing Configuration Screen

- **CYCLES:** The number of cycles is set to determine how many times the instrument samples the air in a single location. This is applicable only in AUTO mode. The range is 0 - 999. When CYCLES is set to 0, the instrument will continue running samples indefinitely until the STOP button is pressed.

  Press the CYCLES button; enter the number of desired cycles using the numeric keypad on the right. Press ERASE to erase a number, if needed. Press ENTER to set/save the Cycles.

- **DELAY:** The Initial Start Delay (hh:mm:ss) is the time between when the START button is pressed and the unit actually starts counting.

  The Initial Start Delay gives the operator time to exit the area under test so that the measurement is taken under a controlled condition. The maximum delay time is 23 hours, 59 minutes and 59 seconds.

  Press the DELAY button; enter the initial delay time in hours, minutes and seconds using the numeric keypad. After the value is entered, press ENTER.

Note: *If the Hold time is set to 00:00:00 in Auto Mode, the instrument will run the samples according to the sample time and the # of cycles, but with no hold time in between cycles.*

- **HOLD:** The Hold Time (hh:mm:ss) is the time between count cycles when the instrument is not counting particles. The maximum hold time is 23 hours, 59 minutes and 59 seconds. This field on the MAIN screen will count down to indicate how much time is left for the Hold period.

  Press the HOLD button, enter the time in hours, minutes and seconds using the numeric keypad on the right. Press ERASE to erase a number, if needed. Press ENTER to set the Hold Time.

Note: *The maximum Sample Time is 23:59:59.*

SAMPLE: The Sample Time (hh:mm:ss) is the duration of one counting cycle. The Sample Time will count down on the MAIN screen when the instrument is in Auto or Manual mode to indicate how much time is remaining in the Sample.

Press the SAMPLE button; enter the time in hours, minutes and seconds using the numeric keypad on the right. Press ERASE to erase a number, if needed. Press ENTER to set the Sample time.

Note: *When the particle volume is ft^3, the minimum sample volume is 0.1 ft^3. If the particle volume is liters or m^3, the sample volume will be displayed in liters. If the particle volume is cubic feet (ft^3), the sample volume is displayed in cubic feet (ft^3).*

- **VOLUME:** Instead of selecting a specific Sample Time, the instrument can be set to measure a specific Sample Volume in cubic feet (ft^3), cubic meters (m^3) or liters (l). When this is set, the corresponding Sample Volume will automatically be set. See Figure 5-17.

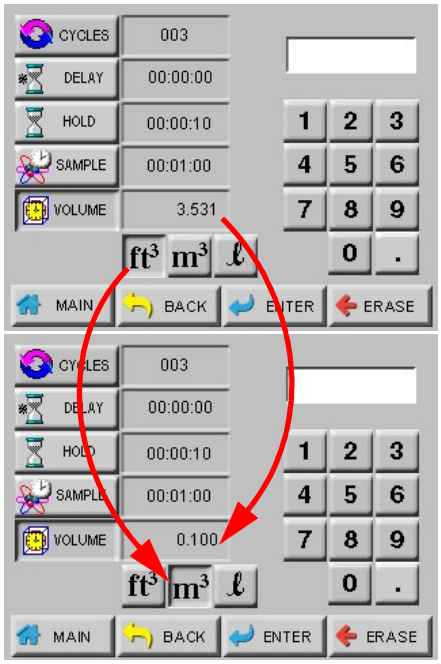


Figure 5-17 Changing Sample Volume Unit of Measure

Press BACK to return to the Configuration screen or press MAIN to return to the MAIN screen.

SETTING

The Settings screen allows the user to configure the instrument to count in different modes and formats when running a sample. See Figure 5-18.

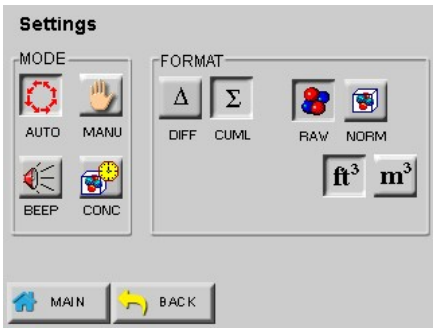


Figure 5-18 Sample Settings Screen

Count MODEs

Count modes available are Auto, Manual, Beep and Concentration. Use of a recipe, however, overrides the display of these modes.

- **AUTO** - When the instrument is in Automatic Mode and the START button is pressed, the instrument will start counting particles automatically according to the Sample Time, Hold Time and the number of Cycles that are configured.

  If Cycles are set to 0, the instrument will continue indefinitely in Auto Mode until the STOP button is pressed.

- **MANU (Manual Mode)** - When the instrument is in Manual Mode, it will start counting when START is pressed and stop at the end of one programmed Sample Time.
- **BEEP** - In this mode, the instrument is pre-configured to beep according to the alarm threshold set in the Alarm configuration and the instrument's sample time when the instrument is set to collect cumulative data. Counting starts after the START button is pressed and the pump flow rate is stable. It will continue until the STOP button is pressed or the number of configured cycles is reached.

  If no channel is set for alarming when BEEP mode is selected, the instrument will automatically use the smallest channel size and its alarm threshold setting to alarm.

  If alarming is enabled on more than one channel when the instrument is in BEEP mode, it will beep if the alarm threshold is exceeded on any of the channels enabled for alarming.

Note: *BEEP mode only works with CUMULATIVE data and for Sample Times equal to or greater than 6 seconds.*

Note: *If BEEP mode is set to one count, each beep may not be for every single count.*

- The data will be recorded based on the set sample and hold times and can be viewed in the View Buffer and on the printouts. There will be no indication on the record that the data was saved while the instrument was in BEEP mode.
- **CONC (Concentration Mode)** - When the instrument is in Concentration mode, it shows the calculated concentration of particles in a volume of air measured and displayed on the MAIN screen in either counts per cubic foot or per cubic meter.

  Counting starts shortly after the START button is pressed and it will continue until the STOP button is pressed or the sample time runs out. The sample time for Concentration mode is six seconds. As the sample time on the MAIN screen counts from one to six, the particle counts are updated continuously.

  Concentration data will be recorded and can be viewed in the Data screen and on the printouts.

Note: *The sample time for Auto, Manual and Beep modes count down and the sample times for Concentration mode count up.*

FORMAT

Instrument data is displayed as **Differential** (DIFF) or **Cumulative** (CUML) counts. For clarity, cumulative mode shows all counts from channel size of interest and above and displays on MAIN as Σ. Differential mode shows all counts from channel size of interest to next channel size and displays on MAIN as the delta Δ.

The data format is either **Raw** (RAW) or **Normalized** (NORM). **Raw** data displays the actual number of particles counted. **Normalized** data shows particle concentrations calculated from the raw data based on the settings chosen (ft^3 or m^3).

- Volume of Air = Sample time (minutes) x FlowRate (CFM)
- Normalized Data = Number of Particles/Volume of Air

Press BACK to return to the Configuration screen or press MAIN to return to the MAIN screen.

ALARM

Press ALARM button to open the Particle Alarm screen shown in Figure 5-19 to enable alarming on specific channels.

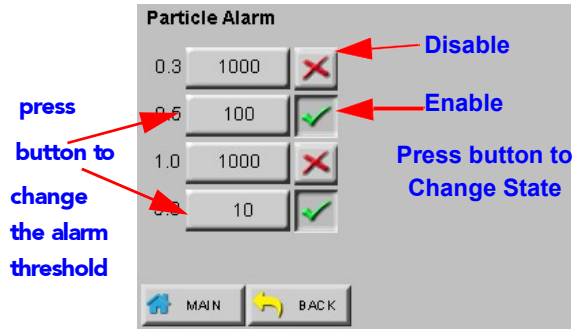


Figure 5-19 Particle Alarm Configuration Example

Note: *Alarming is only applicable for Cumulative Raw particle counts even if the instrument is displaying Normalized data.*

If the instrument is set to display Cumulative data, the alarm threshold will apply to the cumulative counts.

To enable or disable alarming for any channel, press the ICON to the right of the channel. When the  is displayed, the channel is enabled for alarming. Press the ICON to change it to the  and disable the alarming for that channel.

Alarm Threshold

Press the enabled channel's threshold button to set the alarm threshold for that channel. The Alarm Threshold screen will open as shown in Figure 5-20.

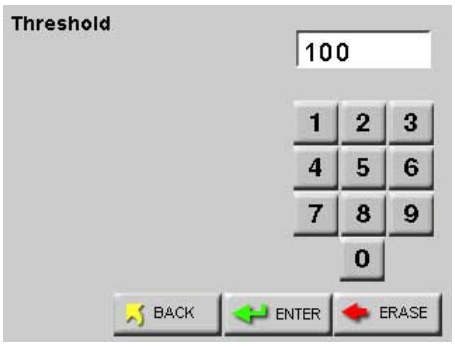


Figure 5-20 Configure Alarm Threshold

Note: *To use alarms, the Sample Time must be greater than 1 second.*

Enter the desired alarm threshold for the channel as a number of particles then press ENTER. The threshold value will be updated on the Particle Alarm screen.

Press BACK to return to the CONFIG screen or press MAIN to return to the MAIN screen. The alarm activated channels will display a selection cursor (>) as shown in Figure 5-21.

Note: *Alarms are triggered per sample record. At the end of the sample time, the alarm is reset.*

Figure 5-21 Channels Enabled for Alarming

When an alarm-enabled channel goes into alarm, the selection cursor (>) and the channel size are highlighted in red. See Figure 5-22.

Note: *If alarms are enabled on two channels and the user presses the screen to acknowledge the alarm when the first channel goes into alarm, the alarm will not sound if the second channel threshold is reached within the same sample period.*

Figure 5-22 Channels in Alarm

When the instrument begins to beep in response to the Alarm settings, touch anywhere on the MAIN screen to silence the beep. The count will be reset when the next sample cycle begins after the alarm is acknowledged.

CLEAR

Press Clear Buffer to clear the instrument data buffer. See Figure 5-23.

Figure 5-23 Clear Buffer Screen

Press OK to clear the data or Cancel to exit the screen without clearing data.

DEVICE SETUP

The DEVICE SETUP buttons adjust how the instrument operates when running samples. Specific functions for display options, data output and security can be enabled or disabled . See Figure 5-24.

Figure 5-24 Device Setup Options

CLOCK

The Date & Time screen allows the user to change the instrument's date and time. See Figure 5-25.

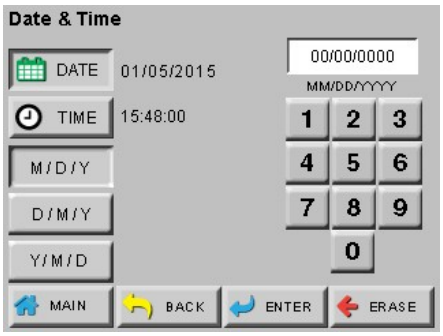


Figure 5-25 Date & Time Configuration Screen

Use the Text Window and numeric buttons to enter the Date values for desired month, day and year then press the ENTER button.

Note: *MONTH 1ST (M/D/Y) is the default date format.*

Press the ***M / D/ Y*** button to display the date as month-first. Pressing the ***D / M/ Y*** button displays the date as day-first and the ***Y / M/ D*** button displays the date as year-first. See Figure 5-26 and 5-27.

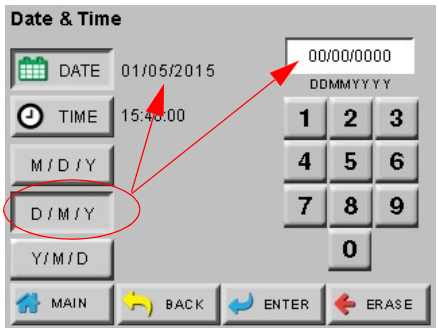


Figure 5-26 Date Option: Day First

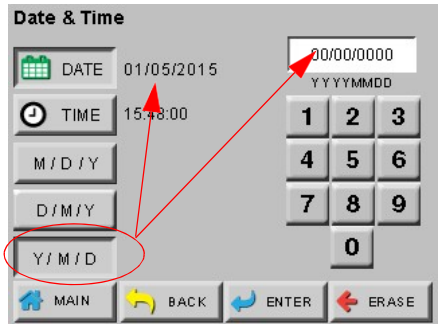


Figure 5-27 Date Option: Year First

Press the TIME button to set the instrument's time. See Figure 5-28.

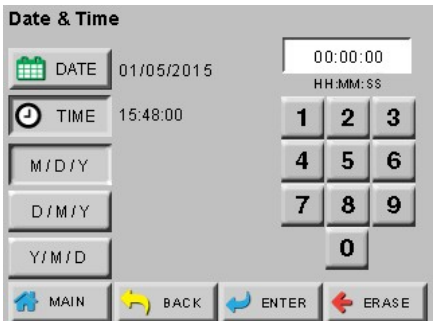


Figure 5-28 Configuring TIME

Enter the desired time in hours, minutes and seconds then press ENTER to save the new time. Press BACK to return to the Configuration screen or press MAIN to return to the MAIN screen.

OPTIONS

The Options screen allows the user to make visual and sound adjustments as well as selecting different language formats and start-up functions. See Figure 5-29.

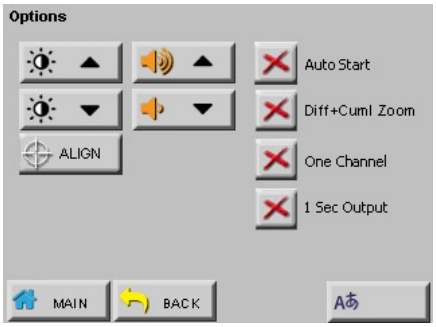


Figure 5-29 Options Configuration Screen

Contrast Adjust

Adjust the contrast/brightness of the LCD screen by pressing the upper UP and DOWN arrows.

Audible Beep Adjust

Adjust the audio level of the BEEP by pressing the lower UP and DOWN arrows.

ALIGN Touch Screen

Align the touch screen by pressing the ALIGN button so the locations touched on the screen correspond to the expected function.

Alignment can also be started from a power-off state by pressing on the screen while turning the **ApexPortable** on. The start screen shown in 5-30 will be displayed at that time. The screens shown on the next few pages will be the same, regardless of how the process was started.

- Press the ALIGN button. 

WARNING: ***Be careful to touch the screen at the specified locations, only. Touching the screen elsewhere during this process will align the screen incorrectly.***

- The screen in Figure 5-30 appears. Touch anywhere on the screen to continue calibration.

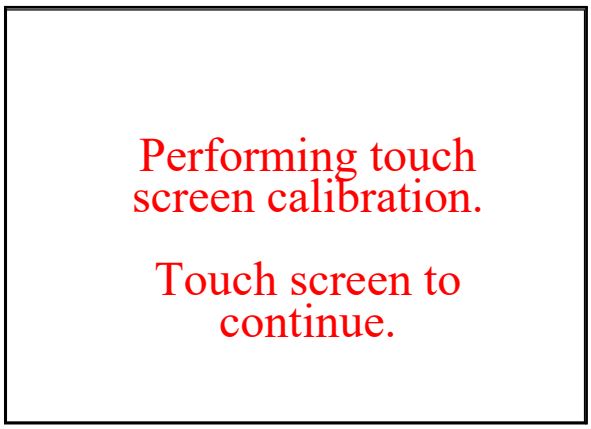


Figure 5-30 Display Calibration Start Screen

Note: *Using a PDA Stylus provides higher accuracy to the touch screen interface.*

- At the next screen, touch in the center of the cicle displayed in the upper left corner. Release the touch to move to the next alignment circle. The tip of a stylus is suggested to successfully complete the alignment by being on-target more accurately than by using a finger tip. Exercise care to prevent puncturing the screen's membrane, which will void the instrument warranty. Figure 5-31 shows the second and third Calibration screens.

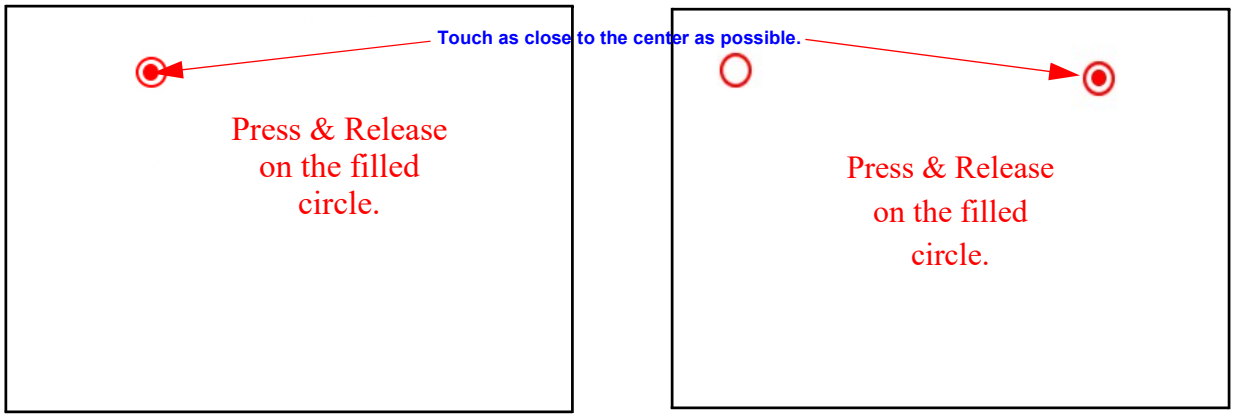


Figure 5-31 Second and Third Calibration Screens

- The fourth and fifth alignment screens are shown in Figure 5-32;

touch the center circle to continue the alignment process.

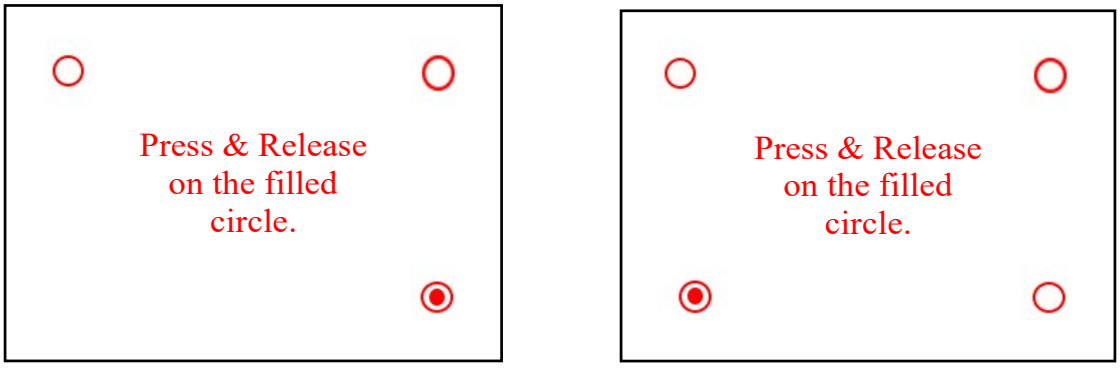


Figure 5-32 Fourth and Fifth Calibration Screens

- Figure 5-32 shows the final alignment screen. Touching the filled circles properly completes the alignment process.

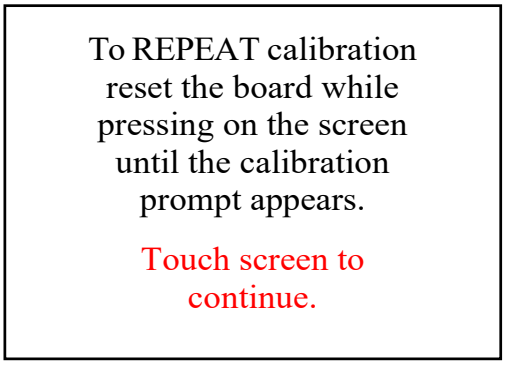


Figure 5-33 Display Calibration Completed

Note: *The screen alignment function can also be accessed by touching the screen when powering the instrument on.*

The final screen, shown Figure 5-33, instructs the operator to Touch anywhere on the screen to complete the process. Touch anywhere on the screen to return to the OPTIONS screen.

Autostart Mode

Autostart mode starts the instrument sampling immediately upon power up. The instrument will sam
ple based on its configured mode, delay, start and hold times.

Diff+Cuml Zoom

If Diff+Cuml Zoom is enabled, the Zoomed display will show two columns of data simultaneously - Differential and Cumulative.

One Channel

If One Channel is enabled, only the first channel will be displayed on the MAIN screen.

Note: *If the first channel is disabled, the display and zoomed data view will be blank.*

One Channel mode only affects how data is displayed on the MAIN screen. When the instrument is in One Channel mode, data will continue to be recorded, printed and downloaded for all channels. See Figure 5-34.

Figure 5-34 One Channel Option Enabled

One Second Realtime Modbus Output

Set One Second Real-time MODBUS Output to change the instrument's settings to the following:

- Mode: AUTO
- Cycles: Zero
- Sample Time: One second
- Hold Time: Zero seconds
- Cumulative/Differential: Cumulative (CUML)
- Raw/Normalized: Raw

When counting, the MAIN Screen will update continuously and data will not be recorded in the data buffer.

Note: *Alarming is not available when One Second Real-time MODBUS Output is enabled.*

Note: *If any setting (mode, sample time, hold time, etc.) is changed, the One Second Real-time MODBUS Output mode will be automatically disabled.*

LANGUAGE

Press the LANGUAGE button to change the operating language as shown in Figure 5-35.

Figure 5-35 Operating Language Screen

Press the button next to the desired language to change it from the  to the  to enable. Press BACK to return to OPTIONS or MAIN button to return to MAIN screen. The default language is English.

COMM

Press the COMM to set the **ApexPortable** communication mode. Press the SERIAL's toggle button to select SERIAL mode; press the ETHERNET's toggle button to select ETHERNET mode.

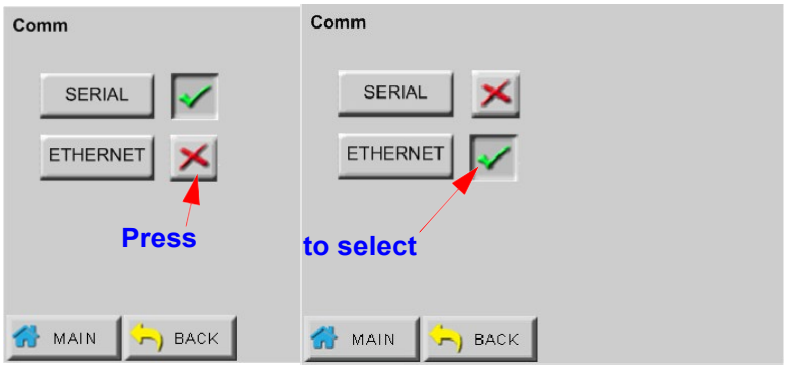


Figure 5-36 COMM-mode Setup Screens

Press the SERIAL button (Figure 5-36) to configure serial settings at the screen shown in Figure 5-37.

COMM Serial Settings

When the **ApexPortable** is connected to a SCADA data collection system or other RS485 network, the **ApexPortable**'s COMM address

identifies it. The communication speed must be matched to the requirements of the network to which it will be connected or the connection will fail. Press the button describing the setting desired to be changed, such as ADDRESS, BAUD, etc.

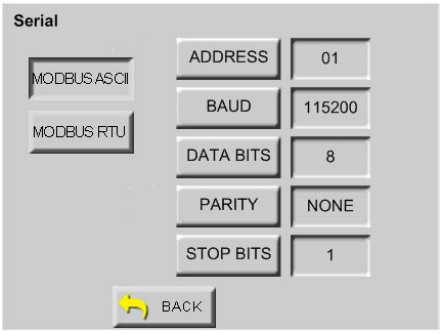


Figure 5-37 COMM Serial Settings Screen

Management programs like LMS Express/RT will search for the instrument by the COMM Address specified on the screen shown in Figure 5-37. COMM addresses can be 1 to 63 for the **ApexPortable**. Each device on a multi-port chain must have a unique address.

Press the ADDRESS button to open the Address input screen (Figure 5-38) and use the numeric keypad to type the address; press ERASE to erase a digit if needed, and ENTER to accept the value and return to the Comm SERIAL Settings screen.

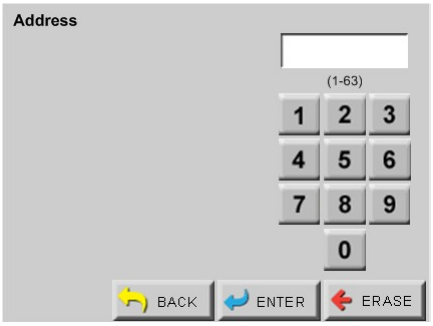


Figure 5-38 Serial Address Input Screen

Note: *The Data-entry screen text box will be empty and won't display the previous values so it may be wise to write down the previous values from the screen shown in Figure 5-37, first.*

Check the other values and change them by pressing the parameter button, such as BAUD, DATA BITS, PARITY. The data entry screen will display a window for entering the value(s) desired. Make sure the values entered are correct for the environment / network or the **ApexPortable** communications will fail. The previously set values will not be displayed.

Set ETHERNET Settings

Press COMM at the Config screen to display Figure 5-39. Press the ETHERNET's toggle button to change it to the green check as shown.

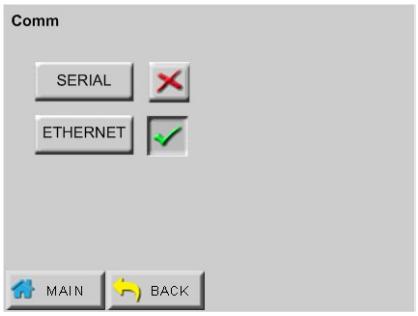


Figure 5-39 Comm ETHERNET Mode

Press the ETHERNET button to open the COMM Ethernet Settings screen, Figure 5-40, which is displaying the original default values.

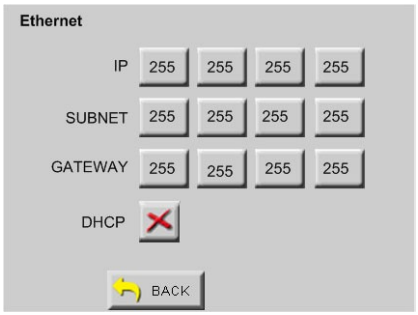


Figure 5-40 COMM Ethernet Settings Screen

Press a number button to open the Data entry screen (Figure 5-41). Enter the new value then ENTER to save and return to the Settings screen. Press BACK to return to Settings screen and lose any changes. Press ERASE to delete one digit at a time.

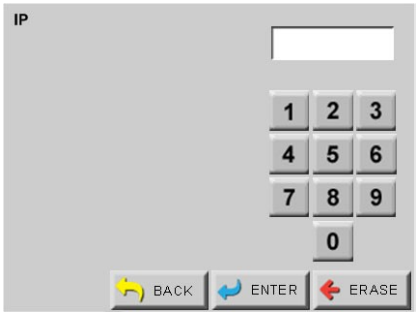


Figure 5-41 IP Data Entry Screen

Make sure the values are correct. Incorrect values can cause the **ApexPortable** to be lost on the network. It is suggested that site IT be consulted for the IP and other values to ensure successful integration.

Typical Ethernet settings for most networks and the **ApexPortable** are a static IP, SUBNET empty/zeroes, and default Gateway is empty. Lighthouse recommends using a static IP adress. .

OUTPUT

The Output Setup screens (Figure 5-42) provide formatting and other options for printing to the optional USB printer or saving the data to a USB flash drive. The port is shown in Figure 5-43.

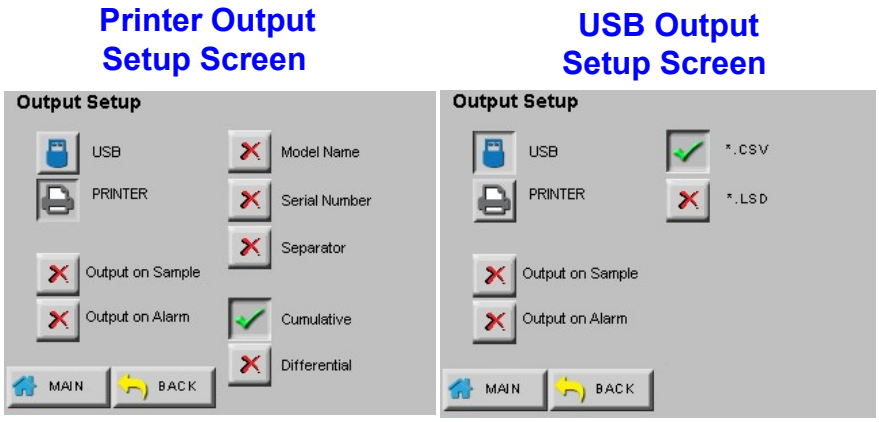


Figure 5-42 Output Setup Screens, Printer and USB Set Up

Figure 5-43 USB Port Location

Printer Output

The default Printer Output or the last chosen screen will be shown when entering the Output Setup screen. Cumulative (with nothing else selected) is the default selection for Printer Output. Reports can be printed using only Cumulative or Differential enabled or with both enabled. At least one must be selected or the instrument will choose Cumulative. Output trigger can be either Sample or Alarm or both.

From the MAIN screen, press CONFIG button then OUTPUT to go to one of the screens shown in Figure 5-42. If USB output is active, go to "USB Output".

- **Model Name** - prints the product model name;
- **Serial Number** - prints the instrument serial number;
- **Separator** - prints a line of dashes to separate Serial Number from data areas;
- **Output on Sample** - when a sample is taken, the data for that sample is printed;
- **Output on Alarm** - When an alarm threshold is exceeded, a report of that data is printed;
- **Cumulative** - Data is reported in cumulative format;
- **Differential** - Data is printed in differential format.

USB Output

When a USB flash drive is attached to the USB port, the **ApexPortable** will acknowledge its presence by displaying the blue USB symbol on the MAIN screen. From the MAIN screen, press CONFIG button then OUTPUT to configure the USB settings - refer to Figure 5-44.

Note: *Use only FAT32 formatted devices; an NTFS formatted device is not compatible with the* **ApexPortable**. *A corrupted device will cause data transfer failures. Check the formatting and functionality on a PC or MAC before use.*

- **Output on Sample** - outputs data to the USB flash drive at the completion of a sample;
- **Output on Alarm** - outputs data to the USB flash drive when an alarm is triggered;
- ***.CSV** - data being stored on the USB flash drive is **C**omma-**S**eparated-**V**alue, a spreadsheet compatible format - this is the default setting displayed for the user;
- ***.LSD** - **L**ighthouse **S**ecure **D**ata format is used and can be downloaded only by LMS Express, LMS Pro or LMS Pharma.

Output on Sample and Output on Alarm can be chosen together or separately, which is the preferred choice. Either *.CSV or *.LSD must be chosen, but not both simultaneously. If neither *.CSV nor *.LSD is chosen, *.CSV will be the default and will not leave screen until it is set. A message will not be displayed when the save is completed. Records are always stored on the **ApexPortable** in LSD.

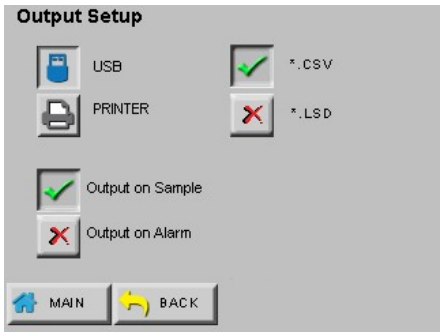


Figure 5-44 Example of USB Output Options

Security

Press the Security button to enter Figure 5-45 screen. User access to the instrument can be restricted by configuring the **ApexPortable**'s two different password levels.

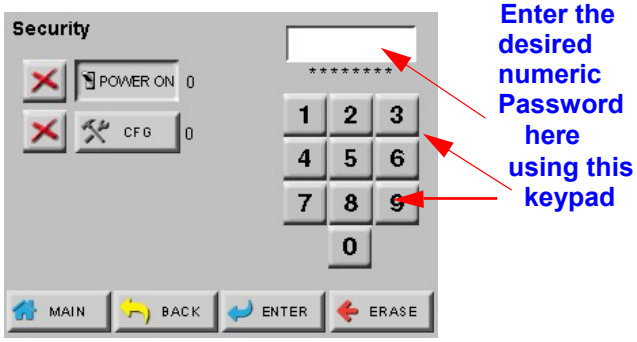


Figure 5-45 Security Password Configuration Screen

WARNING: ***Be sure to record and store the unit's passwords in a safe place. If the password is lost or forgotten, contact Lighthouse technical support at 1-800-945-5905 (USA Toll Free) or 1-541-770-5905 (Outside of USA) for assistance. The unit may have to be returned to the factory to reset the password.***

To restrict who can operate the instrument, enable the POWER ON password. When POWER ON password is enabled, the correct password will be required each time the instrument is turned on.

To restrict who can configure the instrument, enable the CONFIG password. When the CONFIG password is enabled, the correct password will be required before the user can access the CONFIG screen.

- To set the password for the POWER ON, press the POWER ON button, then type in a password using the numeric keypad. Press the ERASE button to delete the last character, if needed.
- Press ENTER to save.
- To set the Configuration password, press the CONFIG button, then type in a password using the numeric keypad.
- Press the ERASE button to delete the last character, if needed.
- Press ENTER to save the changes.
- Press the  buttons to enable either or both passwords.

Press BACK to return to the CONFIG screen or press MAIN to return to the MAIN screen.

Service

This section of the Configuration screen is reserved for Lighthouse Authorized Service Providers only. The correct service password must be entered to access this area.

STATUS

Pressing the STATUS button displays the versions of each of the Instrument's firmware modules. Lighthouse Technical Support personnel usually ask for this information during a support call. See Figure 5-46.

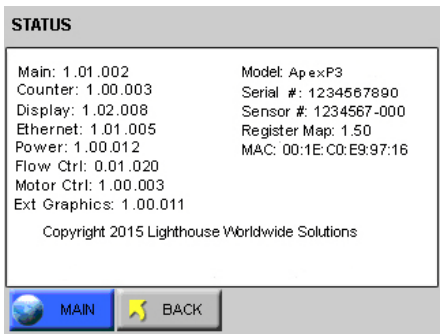


Figure 5-46 ApexPortable STATUS Screen

RECIPE

From the MAIN screen, press the small Recipe button to go into an "abbreviated" menu (shown in Figure 5-47). This allows users the convenience to access recipes without going into the CONFIG screen or requiring a password unlock to view, load and unload a recipe.

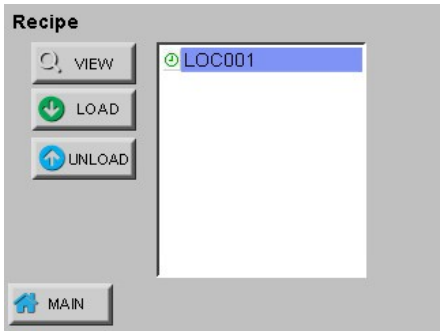


Figure 5-47 MAIN Screen Abbreviated Recipe Screen

To edit, add or delete recipes, though, one must press the Recipe button from the CONFIG screen to display the full Recipe setup screen. Refer to Figure 5-48.

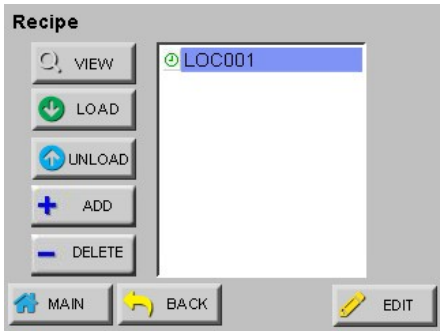


Figure 5-48 Recipe Setup Screen

The full Recipe screen shown in Figure 5-48 provides instrument sampling and reports settings that are saved in a database of up to 50 recipes.

Press BACK to save the settings and return to the RECIPE screen.

If a recipe already exists, the VIEW button will display the settings for it. See Figure 5-49 and Figure 5-50. The examples shown are for USB output with CSV file format.

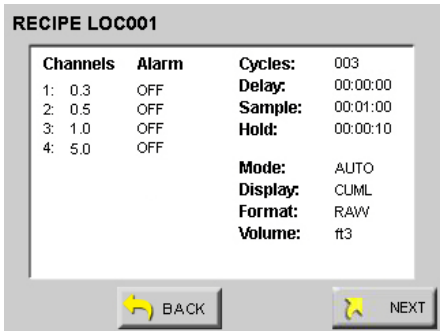


Figure 5-49 Recipe - Channel Settings

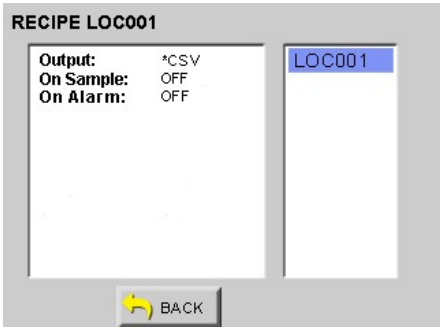


Figure 5-50 Recipe - Second Screen

Use the LOAD and UNLOAD buttons to add or remove the highlighted recipe.

Press the ADD button to display the RECIPE name screen shown in Figure 5-51. The recipe may be named using up to 12 characters.

Note: *If the location selected is already assigned to another recipe or if there are no available free locations, the user will not be able to add a new recipe. The "Add" button will not be displayed.*

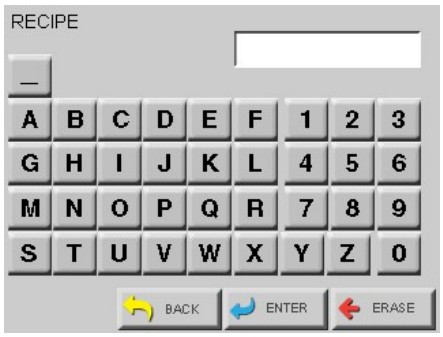


Figure 5-51 Recipe Name Screen

To add the recipe to the database, press ENTER. The recipe CONFIG screen is then displayed as shown in Figure 5-52.

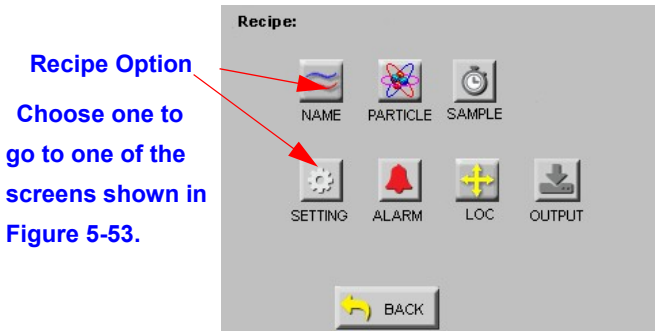


Figure 5-52 Recipe Configuration

Press the option/function buttons shown in Figure 5-52 to open the feature's corresponding screen shown in Figure 5-53. At each screen, choose the feature buttons desired to set up how the Location's output will appear in reports or in files saved.

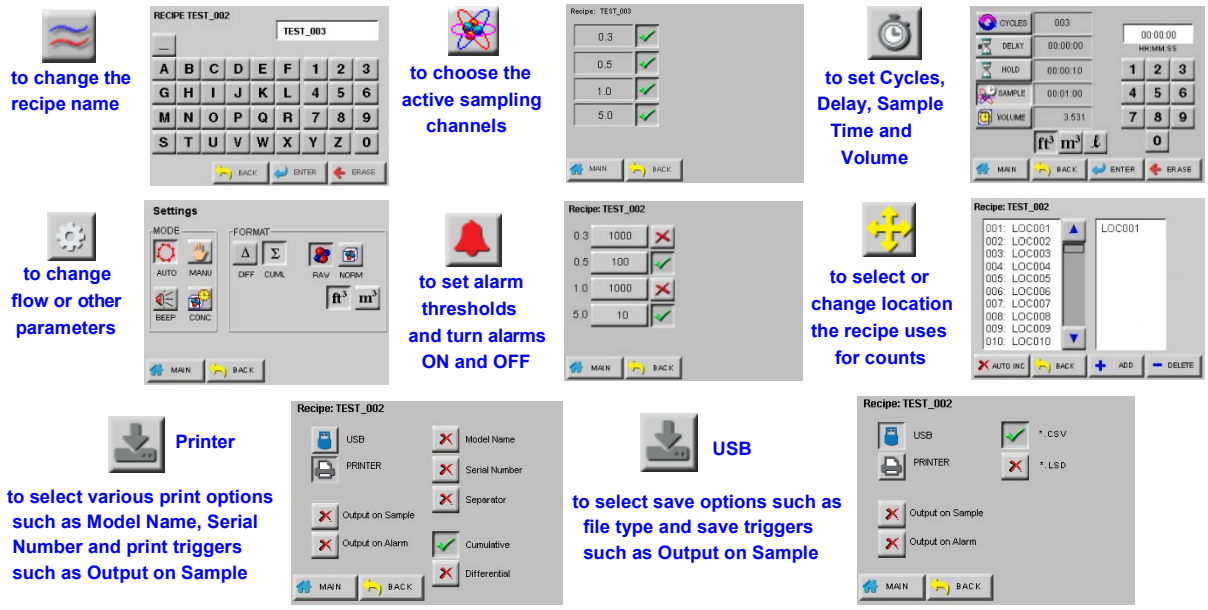


Figure 5-53 Recipe - Output Setting Screens

Use the DELETE button to delete any highlighted recipe from the database.

Press The EDIT button to change a highlighted RECIPE settings. If the **ApexPortable** has the recipe loaded, it will prompt the user for permission to UNLOAD the recipe. Once it is unloaded, the user must press the EDIT button, again, to display the EDIT screen.

LOCATION

The **ApexPortable** allows up to 200 different locations and associated alphanumeric labels.

Press the LOC button on the CONFIG screen to display the Select Location screen as shown in Figure 5-54.

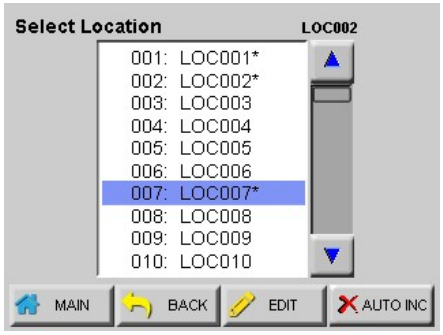


Figure 5-54 LOCATION Setup Screen

On the Select Location screen, the Location name can be selected by pressing the UP or DOWN arrows or by pressing the location name on the screen.

- When enabled, the AUTO INC option automatically selects the next location after completing the current location's number of cycles. After initial power up, the default is AUTO INC OFF, as shown in Figure 5-54.
- The **ApexPortable** can be configured with a maximum of 200 Locations. Each location name may be a maximum of 8 characters.
- Locations associated with recipes are denoted by asterisks (*) to the right of the location names.
- When selecting a location that has an associated recipe, the user is prompted to load the recipe (as shown in Figure 5-55). If the user chooses to not load the recipe, the location can be used with the instrument current settings.

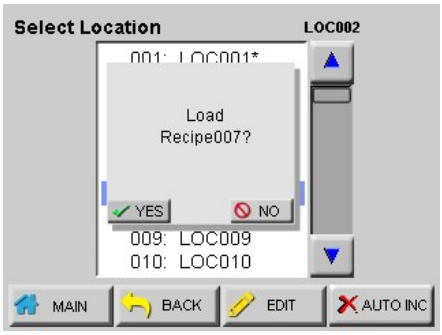


Figure 5-55 Location - Load Recipe

- If a recipe is loaded and a location is selected that is not associated with a recipe, the user is prompted to unload the current recipe. If the user chooses to keep the loaded recipe, the location will adopt the current recipe settings.

To edit a location name, press the EDIT button to display the Edit screen shown in Figure 5-56.

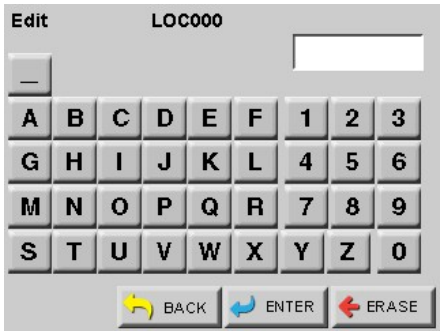


Figure 5-56 LOCATION Name Edit Screen

- Enter the name of the location using the alphanumeric and underscore keys.
- Press the ERASE button to erase the last character typed, ifneeded.
- Press ENTER when done.
- Use the Arrow keys to go to the next location to be edited and press the EDIT button. Continue in the same way to edit as many Locations as desired.

Press the BACK button to return to the CONFIG screen or the MAIN button to return to the MAIN screen.

Press the AUTO INC button to enable automatic incrementing to the next location after completing the number of cycles for the current location. See Figure 5-57. This eliminates the need for the user to manually change the location.

Figure 5-57 Auto Increment Prompt

- **ApexPortable** will prompt the user "Move to LOC***?" as shown in Figure 5-57. A 'Yes' response allows the instrument to change location to the next.

  - If the current location is using a unique recipe, the user will be prompted if OK to unload the recipe before changing to the next location. If the user presses 'YES', it will unload the recipe.

  - If the response is 'NO', the instrument will use the current recipe and switch location.

  - If the new location is associated with a different recipe or report, the **ApexPortable** will prompt to load the new recipe. If the response is 'YES', the recipe/report associated with the new location will be loaded.

  - If the user presses 'NO', it will continue to use the current recipe to sample the next location. Regardless, the user must press the **ApexPortable** MAIN screen Start button to continue sampling.

Remote Operation

The **ApexPortable** can be remotely operated by the different LMS data retrieval and facility monitoring software products, such as LMS Express RT, LMS Net, LMS Professional and LMS Pharma. Remote data retrieval via these products is easy and can be automated with warning levels and alerts programmed to notify specific users or other facilities. Visit www.golighthouse.com or contact Lighthouse Sales for additional information and details.

Data View Buffer Screen

Data stored on the instrument is viewed in the Data View Buffer. New records overwrite the first records stored after the buffer fills to its limit (3000 records). An asterisk (*) next to the word "Records" on the MAIN screen indicates the Buffer is full and data has wrapped. The first record shown in the Data View Buffer after data has wrapped will be the most current record and not the first record stored. In this case, older data will be lost if it hasn't been printed or transferred to a PC or management system.

Particle concentration data displays and prints in ft^3 if the Particle Volume is set to ft^3 (cubic feet). If the Particle Volume is set to m^3 or liters, data displays and prints in m^3 (cubic meters).

Press the DATA button on the MAIN screen to display the Data View Buffer.

Depending on the sample setting configuration, the data displays in either RAW data mode as shown in Figure 5-58 or NORMALIZED to ft^3 or m^3 as shown in Figure 5-59.

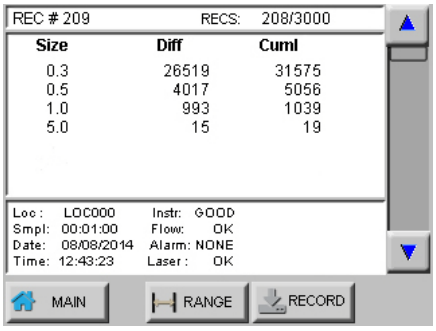


Figure 5-58 Data Screen - RAW Data

Scroll through the data using the UP and DOWN arrow buttons.

The single arrow moves one record at a time.

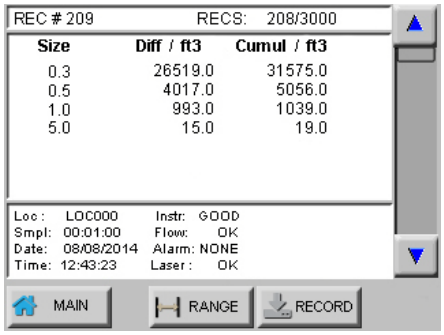


Figure 5-59 Data Screen - Normalized Data in ft^3

Note: *When the buffer has wrapped, the record that is first displayed in the Data screen is the last record in the data buffer. This may not be Rec#1.*

If the single down arrow button is pressed once, the instrument will display the last record in the data buffer.

The Data screen displays the following information for each data record.

- **Rec #** - Identifies which record is currently viewed.
- ***Recs** - Displays how many records are currently stored in the **ApexPortable**'s buffer. An asterisk (*) next to the word "Recs" means that the 3000 record data buffer has wrapped and older data is being overwritten. The basic concept is First In, First Out (FIFO).
- **Size** - Lists the channel sizes used for the report.

- **Diff, Diff / ft3, Diff / m3** - Indicate that each channel size's data is displayed in differential mode. If a channel was disabled, then there is a blank space in its column; # indicates raw counts; ft^3 and m^3 indicate normalized counts.
- **Cuml, Cuml/ft3, Cuml/m3** - Indicates that each channel size's data is displayed in cumulative mode. If a channel was disabled, there will be a blank space in this column. # indicates raw counts while ft^3 and m^3 indicate normalized counts.
- **Loc** - Indicates the location at which the data record was recorded. The Location name listed is the alphanumeric label that was saved.
- **Smpl** - Indicates the Sample Time (HH:MM:SS) at which the data record was sampled.
- **Date** - Indicates the instrument date on which the data was recorded. The date will display in the format selected in the configuration (MM/DD/YYYY, DD/MM/YYYY or YYYY/MM/DD).
- **Time** - Indicates the instrument time at which the data was recorded (HH:MM:SS).
- **Instr** - Indicates the state of the instrument at the time the data was recorded. Instrument states include GOOD or SRVC.
- **Flow** - Indicates the flow state of the instrument at the time the data record was recorded. Flow is recorded as OK or ALRM. If the flow was in alarm, it will print as Flow: Alert on the printouts.
- **Alarm** - Indicates (NONE or YES) if the data record exceeded any of the alarm thresholds of any of the channels that were enabled for alarms. If the data record exceeded alarm thresholds, printouts show "Alarm: Yes".

  Laser - Indicates the status of the laser at the time the data record was recorded; possible laser states include OK or SRVC. If the laser needs to be serviced, it will print as Laser: Service.

  If SRVC appears, printouts will say "Service Required"; the sensor may need cleaning or repair. Please contact Lighthouse Technical Support at 1-800-945-5905 (USA Toll Free) or 1-541-770-5905 (Outside of USA).

Output Data

Output Data to USB Printer

Figure 5-60 USB Printer Attached

1. From the MAIN screen, press the PRINT button (shown in Figure 5-60); the printer will print the record shown on the display, example contents shown in Figure 5-61. Formatting of the printout is based on the settings established via the Printer OUTPUT screen settings.

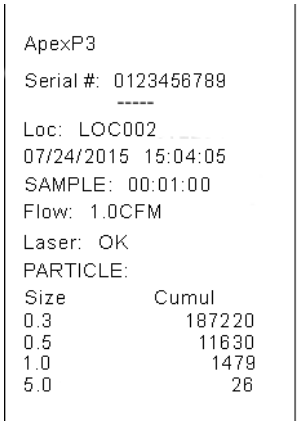


Figure 5-61 Sample Current Record Print

Output a Range of Records to USB Flash Drive

Figure 5-62 Flash Drive Attached, USB Mode

1. From the MAIN screen, press the DATA button and display the desired "start" record by using the UP and DOWN arrows to move the list. Note the ending record desired.

2. Press the Range button to display the # of Records screen to select a range of records to output. Figure 5-63 shows the Data records and the range-select screens. Note that the value in "STOP" is 208 - this is the total of records so far in this example. If the entire list is to be stored, leave the default values and press the OUTPUT button.

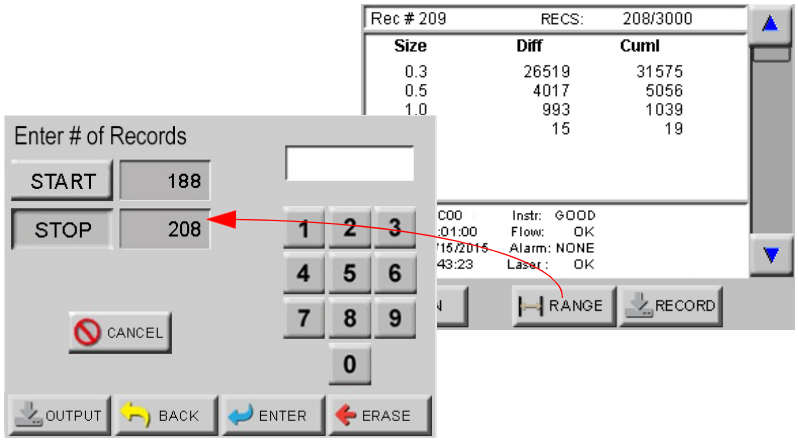


Figure 5-63 Selecting a Range of Data

3. If only a set number of records are to be saved, press the START button and enter the first record's number and press ENTER. If a character is mis-typed, press ERASE to remove it. Press the STOP button and enter the ending record to be stored. Figure 5-63 shows an example where 21 is the total number of records to be stored (1st=188, end=208, difference=21, which includes 188). When the correct numbers are entered, press the OUTPUT button to send the records to the USB. If an incorrect value is entered, the instrument will do nothing.

4. *Records Sent* will be displayed on the screen when the transfer takes place. If the USB flash drive is not installed, NO USB will be displayed.

Each .csv file is managed separately and is added to the flash drive while the flash drive is attached. Because the filename is a function of date and time, no database is kept. These 'csv' text files can be read on any computer system.

LSD files are securely encoded data files, the other type of file that can be stored by the **ApexPortable** on the USB flash drive.

Both file types supply the same data except for Status, which applies only to LSD format; the files contain the following information:

- Model Name:
- Serial Number:
- Flow Rate:
- Data Records including:
    - Sample Date / Time Stamp
    - Status (LSD format, only)
    - Location
    - Number of Samples
    - Sample Volume
    - Particle Channel Data

LSD files require LMS Express to decrypt the information stored. LMS Express provides a new feature that allows the data from an LSD file to be imported into LMS Express. See Figure 5-64.

Figure 5-64 LMS Express LSD File Import

When a USB flash drive is attached to the **ApexPortable**, the USB symbol will display as shown in Figure 5-62.

Report Requirements

Fed Std ft^3

This report requires a minimum of 2 locations be measured, at least 1 sample be taken per location and at least 5 samples total be taken in each cleanroom at a minimum sample volume of 0.1 cubic feet.

The 95% Upper Confidence Limit (UCL) will be calculated by the **ApexPortable** if the number of sampled locations is equal to or less than 9.

Air flow (Unidirectional vs. Non-unidirectional) will have an effect on the minimum locations and minimum samples required. In general, the Non-unidirectional option requires more of both locations and samples.

For the Fed Std ft^3 report, the classification for a particle size is based on its samples taken from all locations in the cleanroom. Each particle size is given one of the following results:

- a classification rating which will be one of the possible classifications (1, 10, 100, 1000, 10000, 100000)
- "Unable to Classify" if it fails one of the above requirements
- an "Out of Range" if the calculated classification at that particle count exceeds 100,000

ISO 14644-1

The ISO14644-1 standard requires a minimum 60 second Sample Time for each sample recorded.

Note: *The EU GMP 2009 report is only valid if the instrument is configured with the 0.5 and 5.0 micron channel sizes and these sizes are active.*

EU GMP 2009

The EU GMP Standard Report requires the unit has the channel sizes 0.5µ and 5.0µ as these are the only channels that apply to this standard.

The EU GMP Report has different concentration limits for cleanroom status "At Rest" versus "In Operation". When the cleanroom is "In Operation", Class D is not available because the standard is not defined for Class D in an operational cleanroom.

REPORT FEATURE

Enable the Report Feature by pressing the  (Default setting) located at the top left of the screen. The check mark indicates the feature is enabled, which enables the PRINT MODE status on MAIN screen. See Figure 5-65 and 5-66.

Note: *If the user sets the Apex for a minimum volume, and takes the exact number of minimum locations and samples, the user could get a "Cannot Classify: too few locations" error if the minimum volume rounds the sample time down so that not enough samples at the minimum volume are taken.*

In this case, add one or two seconds to the sample time so that the volume is over the exact minimum volume.

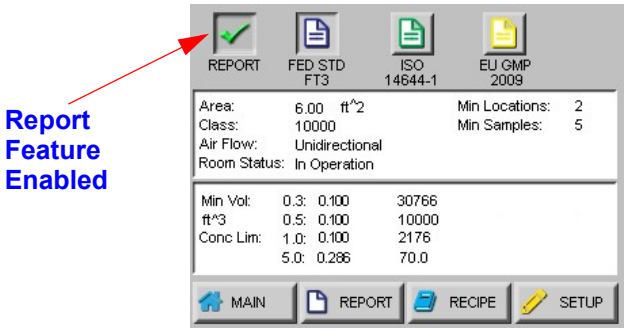


Figure 5-65 Typical Reports Screen

- When the REPORT mode is enabled, the currently selected report type and minimum required samples will be displayed on the MAIN screen as shown in Figure 5-66.

Figure 5-66 Report Mode Status

- Depending on the report's requirements, the number of cycles and minimum sample time will be calculated when the REPORT mode is enabled.
- The number of required locations will be automatically assigned to the report. The user may change the locations via the report's SETUP screen.
- In this example the display format will be changed to Normalized and area measurement to ft^3 for FED-209 and m^3 for ISO and EU GMP. The user may change the display mode in the Reports Settings screen.
- The instrument keeps track of and will display on the MAIN screen the number of samples taken for the report.

- If Auto Increment is enabled, the user will be prompted to move the particle counter to the next assigned location after the current location's number of cycles are completed.
- After all of the required samples have been completed, the instrument will prompt the user to Save the Report Session as shown in Figure 5-67.

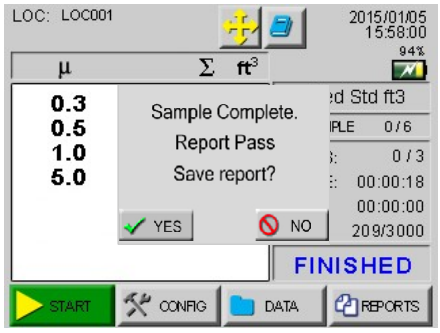


Figure 5-67 Save Reports Prompt

Set Up Report Room Parameters

When one of the report options buttons is pressed, the instrument uses the current Room Area, Class Level, Air Flow and Room Status parameters to determine the minimum number of locations, samples and volume per channel in order to classify a cleanroom with that standard. Use the displayed minimum values to configure the instrument so that the minimum requirements needed to classify the cleanroom will be met. Perform the following steps to set report parameters:

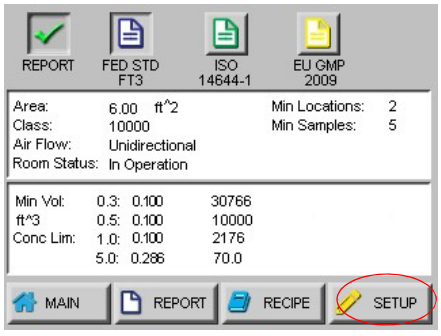


Figure 5-68 Report Setup Step 1

- Press the desired report button then press the SETUP button shown in Figure 5-68.

- Use the Report Setup screen as shown in Figure 5-69.

Figure 5-69 Report Setup Screen

- Press the CLASS button and the Select Class screen displays as shown in Figure 5-70. Touch the desired class so it becomes highlighted. Press the BACK button to save and return to previous screen.

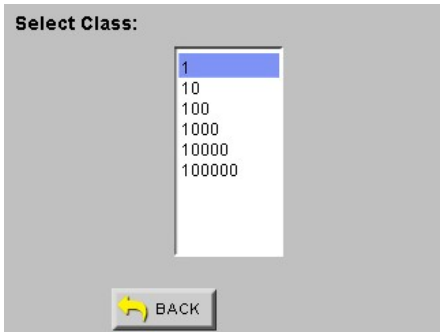


Figure 5-70 Select Class Level

- The selected level will be highlighted in blue.

  Class Levels vary based on which standard has been selected in the PRINT REPORT field. Below are the available Class Levels, per standard:

  FED_209E ft^3- 1, 10, 100, 1000, 10000, 100000

  ISO14644-1 - 1, 2, 3, 4, 5, 6, 7, 8, 9

  EU GMP - A, B, C, D (Rev 2009)

  Changing the Class Level will also change the minimum number of locations, minimum number of samples and the minimum sample volume per channel size required to satisfy the requirements of the chosen report.

Note: *If the entered Area values needs more locations than available, a "Not enough locations" message will be displayed and the user will be asked to enter a lesser area.*

- Press the BACK button then the **AREA** button to display the Area Set Up screen shown in Figure 5-71.

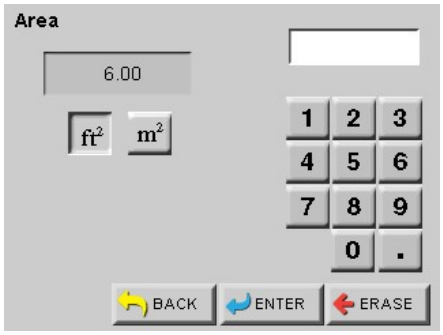


Figure 5-71 Reports Area Set Up Screen

Note: *The minimum area that can be entered is 6 ft^2 or 1 m^2.*

The maximum area that can be entered depends on the number of locations available on the unit.

With all 200 locations available, the Max area that can be entered is limited to a 5 digit value for ft2 and a 4 digit value form2.

- Touch the appropriate unit of measure (ft^2 or m^2) and type in the area using the keypad. Press ENTER to display the value on the screen.
- Press the BACK button.
- Press the STATUS button to display the Room Status screen shown in Figure 5-72.

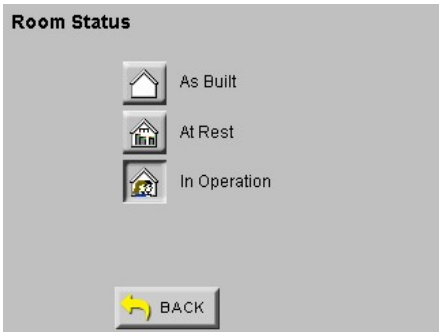


Figure 5-72 Reports Room Status Screen

- Press the appropriate room status (As Built, At Rest, In Operation) followed by the BACK button.

- Press the FLOW button to display screen shown in Figure 5-73.

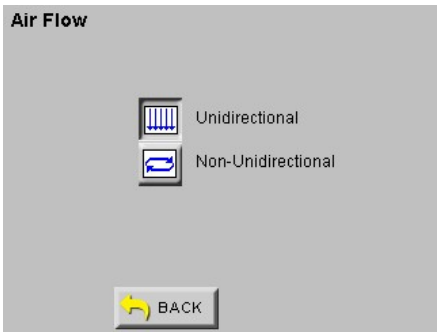


Figure 5-73 Reports Air Flow Set Up Screen

- Choose the appropriate type of air flow (Unidirectional, Non-Unidirectional), then press the BACK button to return to the SETUP screen, which will display the values that were configured so far. Press the PARTICLE button to enable or disable particle channels as shown in Figure 5-74 and press BACK to return to Setup screen.

Figure 5-74 Reports Particle Set Up Screen

- Press the SAMPLE button to configure the number of Cycles, Delay time, Hold time, Sample time and Volume. See Figure 5-75.

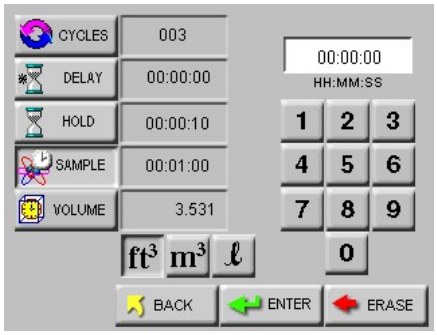


Figure 5-75 Reports Sample Set Up Screen

- Press the BACK button then the SETTING button to format the instrument for CUML/DIFF, RAW/NORM, ft^3/m^3 as shown in Figure 5-76.

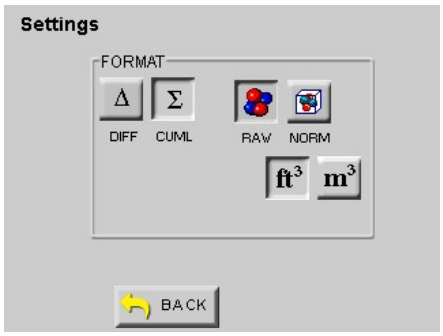


Figure 5-76 Reports Set Up Screen

- Press BACK then LOC to select, add or delete locations or enable AUTO INC as shown in Figure 5-77.

Note: *If the location is already assigned to another recipe or if there are no available free locations, the user will not be able to add a new recipe. The "ADD" button will not be displayed.*

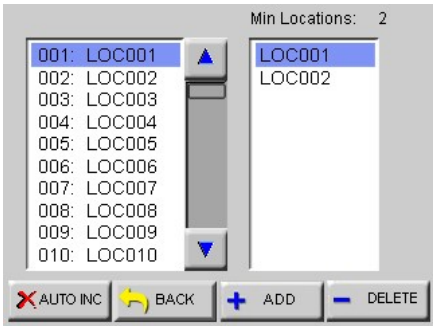


Figure 5-77 Reports Location Set Up Screen

- Press BACK to return to the main REPORTs screen and SAVE to save the configuration in the Recipe database. See Figure 5-78.

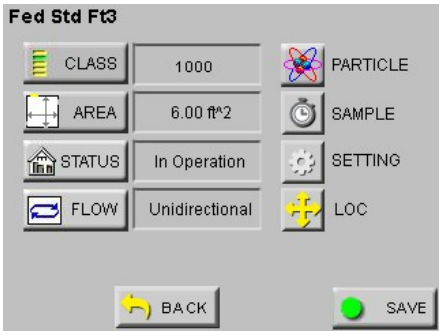


Figure 5-78 Reports Set Up Screen

- When “REPORT” is enabled, the “LOC” and “SAVE” buttons are displayed only when there are at least the minimum number of locations needed for the recipe area available.
- If REPORT is not active or the number of locations do not meet the minimum needed in setup, the LOC and SAVE buttons are not displayed. See Figure 5-79.

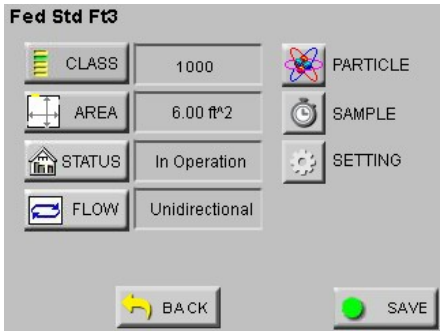


Figure 5-79 Report Setup Screen - No Locations

The next section contains an example of setting up the instrument to run a report.

Set Up Counter to Run Reports

For this example, the FED STD FT^3 report will be used. See Figure 5-80.

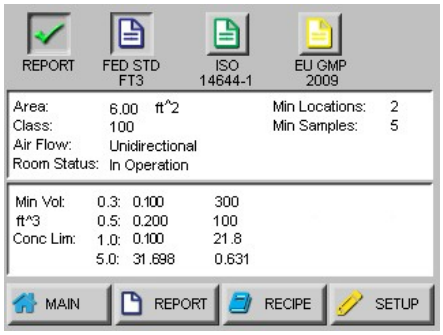


Figure 5-80 FED STD FT3 Report Screen

- Set the instrument for the Fed Std ft^3 report, 100 ft^2, Class 100, unidirectional air flow, In Operation room status.
- This will generate the following minimum requirements:
  - Min Locations: 2
  - Min Samples: 5

Note: *The Minimum Volumes are measured in the standard measurement required by each specific report.*

The number of digits allowed for area to calculate volume is limited to a 5 digit value for ft2 and a 4 digit value for m2.

Table 5-1 Minimum Volume per Channel Size

Ch Size (µ)	Min Vol (ft^3)
0.3	0.100
0.5	0.200
1.0	0.919
5.0	31.698

Based on the minimum requirements displayed in Table 5-1, configure the instrument as follows:

- Press MAIN to return to the MAIN screen.
- Press CONFIG to enter the Configuration screen.
- Press SAMPLE.
- Press the CYCLES button.

Note: *The Sample time automatically changes to 31:42 (31 minutes, 42 seconds).*

- Set the CYCLES value for 1 and press ENTER. Note that the instrument beeps twice and clears the value. This is intentional as the minimum cycles is 2 and changing to 1 will cause errors. Entering more than 2 will work, though, if needed.
- Once the primary settings of Class and Area are entered, the values are set for sample time/volume and cycles. Unless required by SOP, there is no need to change these other values.
- Make sure to add the needed locations and press BACK.
- Press the MAIN button.

Note: *This is all that is needed to meet the minimum requirements to classify the report.*

Increase any of the configuration parameters in order to meet additional reporting needs.

- Press START and allow the instrument to record the required sample(s) at the first location.

Figure 5-81 Prompt to Change Location

- When it has finished, it will prompt to change to next location; a YES response will change the Location but the user must press the START button when set up and ready in the next Location.
- Move the instrument to the second location and press START.

- Continue to move the **ApexPortable** to each location so it may run the necessary samples, responding 'YES' to the move prompts and pressing START to sample at new locations.
- After the instrument finishes recording at the last location, the instrument is ready to print the report.

Save Report

Reports are generated as "Report Sessions". All report parameters and calculated data are stored in these sessions internally on the **ApexPortable.** The files are saved as user-named Report Sessions in user-readable format.

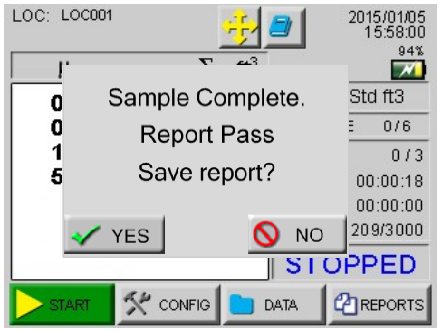


Figure 5-82 Saving Report Session

After completing a report session, the user will be informed if the Report Session passed or failed and prompted if the user would like to save the report. Saving the report allows the user to print the desired report(s) at a later time or remotely by connecting to its web page. The file name can imply the Report Session purpose and will make it easier to identify, such as, "FED_STD_1" or "LOAD_ EU_GMP_4".

Figure 5-83 Report Name Save Prompt

Reports can only be printed by using an external USB printer or using the instrument's Web Server to load the saved report from the **ApexPortable**. The Ethernet-configured **ApexPortable**'s internal Web Server allows the user to view any of its stored Report Sessions through any web browser by typing the **ApexPortable**'s IP address. Report Sessions can be printed as easily as one would print any web page.

Data and settings cannot be changed via the instrument web page. The **ApexPortable** must be set up using the Ethernet interface and correct IP for the network in which it is installed. Serial-configured (RS485 LAN) **ApexPortable** instruments do not support the web page feature. The web page feature requires a valid TCP/IP address to be assigned to the **ApexPortable**.

Generate a Report From Data

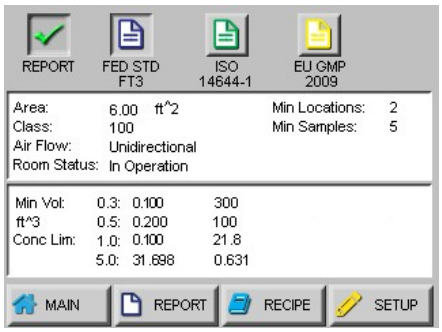


Figure 5-84 Reports Main Screen

From the MAIN screen, press REPORTS.

1. Select the Report desired: FED STD FT3, ISO 14644-1 orEU GMP 2009.

2. Press REPORT ENABLE to turn on green check (Figure 5-84).

3. Press the REPORT button, which will display the saved reports list.

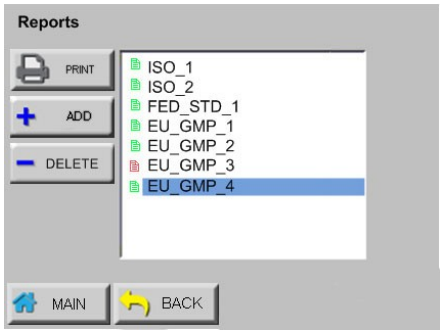


Figure 5-85 Reports Screen

4. Press ADD, which displays the Data View Buffer screen.

5. Choose the record (for a single record print) or records by using the RANGE button to select the records to be printed.

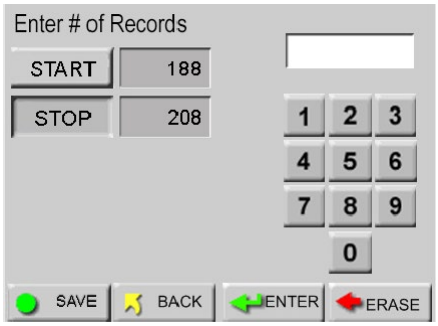


Figure 5-86 Entering Records Screen

6. Press the SAVE button to save the Report. Label it so its configuration is easily understood.

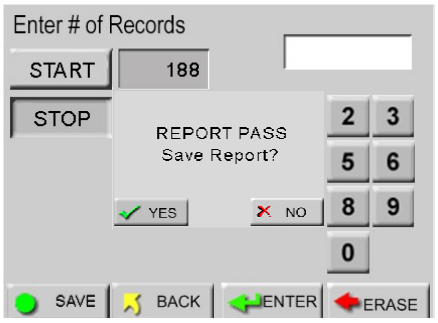


Figure 5-87 Save Report Prompt

7. The **ApexPortable** will validate the data and display a REPORT PASS or FAIL and prompt the user if it should be saved (Figure 5-87). Reply, "YES".

Figure 5-88 Filename Entry Screen

8. The screen for entering a filename is displayed. Label the Report so its configuration is easily understood and press ENTER.

9. Press the REPORT button.

10. Choose the Report name just saved and press PRINT.

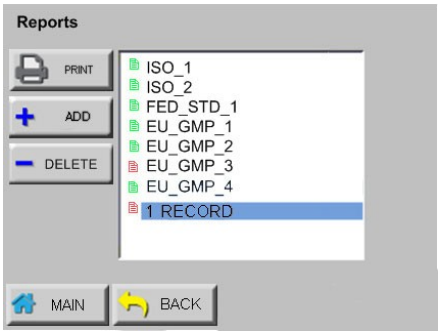


Figure 5-89 Reports Screen, New Report Showing

11. If no USB printer is attached, the **ApexPortable** will report "NO USB".

Printing a Previously Printed Report

To print a Report Session (see Figure 5-90), choose a report format by pressing REPORTS then enable the REPORT check box and choose a report format. Press the REPORT button then select a previously saved report. Press the PRINT button and the report will print to the USB printer.

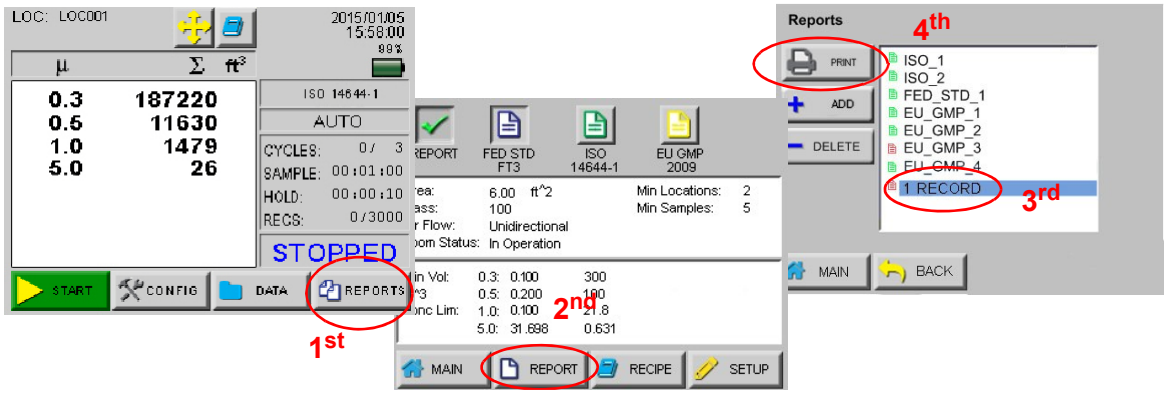


Figure 5-90 Print a Previously Run Report

The optional USB printer must be installed or the **ApexPortable** will present the error message, "NO USB". The report can also be printed from a PC by using the **ApexPortable**'s Web Server. Locate the report and print to any printer attached to the PC.

Web Reports Interface

The **ApexPortable** has a Web Server that allows the user to view its data in real time and print reports from the web page's Reports tab (see Figure 5-91 through 5-93). The instrument must be set up on an Ethernet LAN to have this feature work. The PC locating and printing these reports must be connected to a LAN that has access to the instrument's LAN. Refer to Figure 5-36 and Figure 5-39 through Figure 5-41 for details on LAN setup.

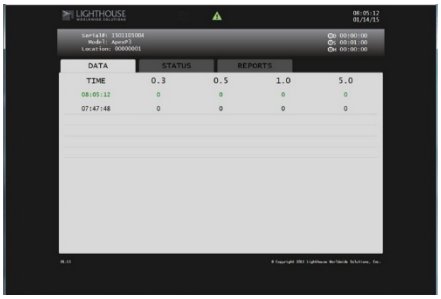


Figure 5-91 ApexPortable Web Data Interface

The web interface provides an almost real-time look at the data as the **ApexPortable** is counting.

Figure 5-92 ApexPortable Web Status Tab

Figure 5-93 ApexPortable Web Reports Tab

Web Page Reports

Examples of passed and failed reports available via the **ApexPortable**'s Web interface are shown in Figure 5-94 and Figure 5-95.

LIGHTHOUSE WORLDWIDE SOLUTIONS

Federal Standard 209E (ft)

Model:	ApexP3	Session:	FED_PSD2
Serial Number:	1501105004	Targeted Class Level:	100000
Data Start:	01/14/2015 09:37:40	Floor area:	1200.00 ft²
Data End:	01/14/2015 09:42:54	Air Flow:	Unidirectional
Sampled Volume:	1.00 ft³	Status:	In Operation
Minimum Samples:	5		
Minimum Locations:	2		

Particle Size: 0.3µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
LOC002	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		0.00

Target Class Concentration Limit: 307657.00
Minimum Volume: 0.10
Classification: PASS

Particle Size: 0.5µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
LOC002	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		0.00

Target Class Concentration Limit: 100000.00
Minimum Volume: 0.10
Classification: PASS

Particle Size: 1.0µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
LOC002	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		0.00

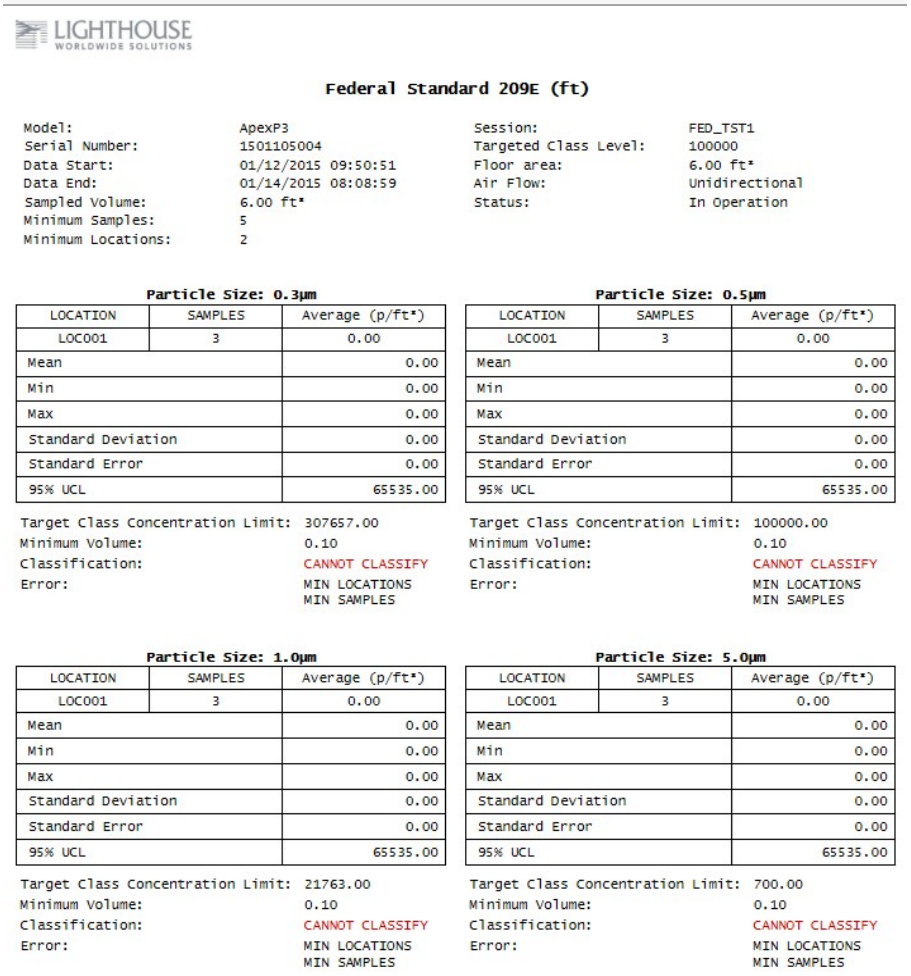
Target Class Concentration Limit: 21763.00
Minimum Volume: 0.10
Classification: PASS

Particle Size: 5.0µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
LOC002	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		0.00

Target Class Concentration Limit: 700.00
Minimum Volume: 0.10
Classification: PASS

Figure 5-94 Passed Report Sample



LIGHTHOUSE
WORLDWIDE SOLUTIONS

Federal Standard 209E (ft)

Model:	ApexP3	Session:	FED_TST1
Serial Number:	1501105004	Targeted Class Level:	100000
Data Start:	01/12/2015 09:50:51	Floor area:	6.00 ft²
Data End:	01/14/2015 08:08:59	Air Flow:	Unidirectional
Sampled Volume:	6.00 ft³	Status:	In Operation
Minimum Samples:	5		
Minimum Locations:	2		

Particle Size: 0.3µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		65535.00

Target Class Concentration Limit: 307657.00
Minimum Volume: 0.10
Classification: CANNOT CLASSIFY
Error: MIN LOCATIONS
MIN SAMPLES

Particle Size: 0.5µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		65535.00

Target Class Concentration Limit: 100000.00
Minimum Volume: 0.10
Classification: CANNOT CLASSIFY
Error: MIN LOCATIONS
MIN SAMPLES

Particle Size: 1.0µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		65535.00

Target Class Concentration Limit: 21763.00
Minimum Volume: 0.10
Classification: CANNOT CLASSIFY
Error: MIN LOCATIONS
MIN SAMPLES

Particle Size: 5.0µm

LOCATION	SAMPLES	Average (p/ft³)
LOC001	3	0.00
Mean		0.00
Min		0.00
Max		0.00
Standard Deviation		0.00
Standard Error		0.00
95% UCL		65535.00

Target Class Concentration Limit: 700.00
Minimum Volume: 0.10
Classification: CANNOT CLASSIFY
Error: MIN LOCATIONS
MIN SAMPLES

Figure 5-95 Failed Report Sample

Sample Printouts of Standard Reports

Figure 5-96, Figure 5-97, and Figure 5-98 are examples of a Federal Standard Ft3, ISO 14644-1, and EU GMP 2009 reports.

Note: *If a recipe is loaded, the name of the report session will be printed on the report.*

```
************************
Fed Std Ft3
ApexP3
Serial #:  1412105005
Report Name: FS_26_2_D
Targeted Class:   1000
Room Area:    10.76 ft^2
Air Flow: Unidirectional
Room Status: In Operation
Minimum Samples: 5
Minimum Locations: 2
Data Start:
     2015/01/26 09:55:57
Data End:
     2015/01/26 10:06:59
Sample Volume: 0.100 ft^3
     --------------------------


Particle Size: 0.3
Loc    Samples     Avg Conc
LOC001    5        8003.5
LOC002    5        6524.5

Mean: 7264.0
Min: 6524.5
Max: 8003.5
Std Deviation: 1045.8
Std Error: 739.5
95% UCL: 11930.2
Min Vol: 1.467 ft^3

Concen Limit: 3007
Min Volume: 0.100
Classification: FAIL
     --------------------------


Particle Size: 0.5
```

Figure 5-96 Sample Federal Standard ft^3 Report

Note: *If a recipe is loaded, the name of the report session will be printed on the report.*

```
*************
ISO 14644-1:2015
  ApexP3
Serial#:  1512105005
Targeted Class: 8
Room Area:      1.49 m^2
Room Stat: Operational
Air Flow: Unidirect
Min Loc: 2
Min Samples/Room: 2
Recipe: ISO TEST
        --------
01/10/2016, 13:10:17
        --------

Particle Size: 0.5
Cumulative, p/m^3
Vol Req:      2.000 L
Concen Limit: 3520000
        --------
 Loc   Samples AvgConcen
 LOC0013 8781.6
 LOC002  1       12271.8
         --------
Mean:             10526.7
StdDev:            2468.0
StdError:          1745.1
95% UCL:          21521.0
Min Vol:        28.317 L
         -------

Particle Size: 1.0
Cumulative, p/m^3
Vol Req:      2.000 L
Concen Limit:  832000
        --------
 Loc  Samples  AvgConcen
 LOC001  3          361.2
 LOC002            947.1
        --------

Mean:              2816.3
StdDev:             187.3
StdError:           132.4
```

Figure 5-97 Sample ISO 14644-1 Report

Note: *If a recipe is loaded, the name of the report session will be printed on the report.*

```
************
EU GMP 2009
  ApexP3
Serial #:  1412105005
Targeted Class:    C
Room Area:       9.00 m^2
Room Stat: Operational
Air Flow: Unidirect
Min Loc: 3
Min Samples/Room: 3
Recipe: EU GMP TEST
        --------
 01/10/2015, 14:12:09
        --------


Particle Size: 0.5
Cumulative, p/m^3
Vol Req:      2.000 L
Concen Limit:   3520000
       ------------
  Loc   Samples  AvgConcen
 LOC003  3        6121.2
 LOC004  3        4620.3
 LOC005  3        5414.9
       ------------
Mean:              5385.5
StdDev:             750.9
StdError:           433.5
95% UCL:           6642.7
Min Vol:       56.634 L
        --------


Particle Size: 5.0
Cumulative, p/m^3
Vol Req:   2.000
Concen Limit:     29000
        --------

 Loc    Samples  AvgConcen
 LOC003    3       553.3
 LOC004    3       253.1
```

Figure 5-98 Sample EU GMP Report, Revision 2009

The preceding printouts are samples and require the optional USB printer to be attached in order to print.

Power Shutdown Levels

When the instrument is powered only by its rechargeable battery, a Power Shutdown feature protects the battery from discharging completely. A complete discharge can damage the battery. It is not recommended to allow the battery to discharge completely. The battery levels are displayed in Table 5-2.

Table 5-2 Levels of Battery Life

Battery Icon	Description
	FULL
	75%
	50%
	25%
	20% The battery ICON will flash to indicate the charge is getting low.
	Empty; at this level, the instrument will begin to beep and will display "BATT LOW!" on the main screen. It is recommended to connect to the Power Supply, attach AC cord and plug it into an outlet at this level.
	Pump Shutdown: battery level of 5% or lower, if the instrument is sampling, the pump will turn off. Any attempt to start or restart the instrument will produce a popup battery low screen then shut down.

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6 Maintenance Procedures

Introduction

This chapter provides routine maintenance instructions for the **ApexPortable**.

The maintenance procedures described in this chapter are not required on regular or prescribed intervals and should be performed only if the user has reason to question the data they are receiving.

Safety

Before performing any of the maintenance tasks described in this chapter, read Chapter 1 of this manual and become familiar with the warnings and caution labels.

Maintenance

Calibration

To maintain optimum performance of this instrument, it should be recalibrated annually by a Lighthouse Authorized Service Provider.

Zero Count Test

This section provides the user with the particle counter zero count test procedure. A purge filter must be attached to the instrument and four (4) five (5) minute samples must be taken. There shall be no more than 1 count during the four sample runs.

1. Start with the instrument OFF.
2. Connect the Purge filter to the sample inlet.
3. Apply power to the instrument.
4. Configure the unit to sample for 30 minutes.
5. Run a 30-minute sample period. This time allows the unit to warm up and purge any residual particles that might be inside it.
6. Configure the unit to sample for 5 minutes with a 10-second hold.
7. Set Cycles to 4 so the instrument will take 4 5-minute samples.

8. Run the test.

9. If more than one count is reported during the four five-minute samples, allow the instrument to sample for 30 minutes to purge it then repeat the test. If the second run fails, contact Lighthouse support.

10. After the instrument has met the requirements of the Zero Count test, return the instrument to its normal location and operating status.

Fault Isolation

If the instrument does not pass the Purge Count test, perform the following procedure:

1. Check the data over the last 6 five-minute sample times.

2. If sporadic counts are occurring over all channels, the unit may still have particles inside it. Allow the unit to sample overnight with the purge filter attached before retesting it. If the counts are still high after the overnight purge, call Lighthouse Technical Support for assistance.

3. If the data shows consistent counts in the smallest channel only, the instrument may have electrical problems and may need to be returned to Lighthouse. Call a Lighthouse Service Representative for assistance.

7 Program with the MODBUS Protocol

General Info

The **ApexPortable** family of instruments can be programmed using the MODBUS Protocol. The full protocol, as used, is detailed in Appendix A: "ApexPortable MODBUS Register Map v1.50" on page A-1.

This chapter contains the information needed to program the basic configuration for the instrument using the MODBUS protocol.

Protocol Settings

The MODBUS Protocol is defined through an RS232 or RS485 interface with:

- Baud Rate: 19200
- Data Bits: 8
- Stop Bits: 1
- Parity: None
- Flow Control: None

Power On/ Auto Start

When powering up the instrument, it will begin sampling using the default configuration:

- Sample Time = 60 seconds
- Hold Time = 0 seconds
- Alarm Channel = Disabled

Note: *The automatic starting of the sampling accommodates systems that do not send a START command, but just polls the instrument for its data.*

To stop the sampling, send the command **12** to command register 40002.

Stopping the sampling will set the Device Status bit in Register 40003 to 0.

Running the Instrument Using MODBUS

The applicable action commands are displayed in Table 7-1.

Table 7-1 Action Commands

Value	Action
1	Saves all writable 4xxxx register values to the EEPROM.
3	Clears the Data Buffer. Record count is set to zero.
4	Saves the instrument parameters in the 40xxx registers to the EEPROM. Parameters include Sample Time, Hold Time, and Location.
11	Instrument Start (Automatic Counting). Uses defined Hold Time and Sample Time. Instrument executes samples and holds until an Instrument Stop command is issued.
12	Instrument Stop. Aborts current sample. Stops data collection.

Each of the described action commands above are written to the command register (40002).

AUTOMATIC Counting Mode

In Automatic counting mode, the instrument uses the configured sample time and hold time to record samples.

The instrument will continue running samples at the configured sample time until it receives a stop command. When the stop command is given, any partial data will not record to the buffer.

After setting all the instrument parameters as described in “Changing the Default Instrument Parameters” on page 7-4, write these commands to the Command register (40002):

11 Start Instrument; to start recording

12 Stop Instrument; to stop recording

Configuring with the MODBUS Protocol

Setting the Real Time Clock

The Real Time Clock (RTC) can be read in registers 40027 and 40028 as shown in Table 7-2.

Register 40027 is the high word for the real time clock; 40028 is the low word. The date/time is calculated as the number of seconds since midnight of 1/1/1970.

The date & time is stored in a 4-byte unsigned integer or as a 32-bit unsigned integer.

Table 7-2 Real Time Clock Registers

Register	Data Type	Description
40027	unsigned integer	Real Time Clock (RTC) [high]. Works in conjunction with 40028. Displays date and time, in number of seconds since midnight, 1/1/1970.
40028	unsigned integer	Real Time Clock [low]

In order to change the RTC to the current local date/time, enter the high and low values as unsigned integers to registers 40035 and 40036 respectively, which are the Data Set registers. See Table 7-3.

Table 7-3 Data Set Registers

Register	Data Type	Description
40035	unsigned integer	Data Set [high]. Works in conjunction with 40036. Data entered here is applied to the device through the command register.
40036	unsigned integer	Data Set [low]

Then write the command **13** to the command register 40002. This will write the values in the Data Set registers (40035 and 40036) to the RTC registers (40027 and 40028).

The Real Time Clock can also be set in the Configuration Software Tool.

Changing the Default Instrument Parameters

The main instrument parameters involved with the operation of the **ApexPortable** are Location, Sample Time and Hold Time. See Table 7-4.

Sample Time and Hold Time both use 2 registers, a high word and a low word. If the desired value for any of these parameters is less than or equal to 9 hours, 6 minutes and 7 seconds (32,767 seconds), then only the low word register needs to be written with the value in seconds.

The low word register for Sample Time is 40034.

The low word register for Hold Time is 40032.

Table 7-4 Instrument Parameters

Register	Data Type	Description
40026	unsigned integer	**Location number (low)** Provides Location ID for where data was recorded. When Smart Bracket is not used, state is read/write. When Bracket Mode is used, the location value is read-only in 40054-40055 and low is duplicated in 40026.
40031	unsigned integer	**Hold Time [high].** Works in conjunction with 40032. Number of seconds to wait between sample periods. Max value is 359,999, which equals 99h 59m 59s
40032	unsigned integer	**Hold Time [low]**
40033	unsigned integer	**Sample Time [high].** Works in conjunction with 40034. Number of seconds to sample. Max value is 86,399, which equals 23h 59m 59s.
40034	unsigned integer	**Sample Time [low]**

Using Sensor Setting Registers

Certain configuration settings can be sent to the counter through these registers.

Sensor Setting Registers 40001 and 40003 through 40023 are protected and should not be changed.

Location (Register 40026)

For Particle Counters, this value specifies the location where a sample was recorded.

Hold Time (Registers 40031, 40032)

The Hold Time is used for pausing in between samples for multiple cycles.

This time is specified in seconds. The maximum value is 359,999 seconds (high word: 5, low word: 32319) which is 99 hours, 59 minutes, and 59 seconds. To set the Hold Time to a value less than 9 hours, 6 minutes, 7 seconds, enter the number of seconds in the *low register* (40032).

During Hold Time, the Device Status bit is 0 (Idle).

Sample Time (Registers 40033, 40034)

The Sample Time specifies the time period of each sample. This time is specified in seconds. The maximum value of the sample time is 86,399 seconds (high word: 1, low word: 20863) which is 23 hours, 59 minutes, 59 seconds.

To set the Sample Time to a value less than 9 hours, 6 minutes, 7 seconds, enter the number of seconds in the *low register* (40034).

During the Sample Time, the Device Status is 1 (Sampling).

Alarm and Threshold Registers

Alarm Enable Registers

The Alarm Enable input registers (43xxx series) shown in Table 7-5 are read/write. All enable data items are 4 bytes long and are stored across 2 registers. Byte and word ordering is big-endian. Thus, data items are formed by placing the high bytes in front of the low bytes. For example:

<High Bytes><Low Bytes> = <4 Byte Data Item>

The 43xxx register series is used to determine which particle data channels are set to ALARM ENABLE.

Table 7-5 Alarm Enable/Disable Bits

Bit	Description
0	Channel Enable (0=disable, 1=enable), works in conjunction with Alarm Enable.
1	Alarm Enable (0=disable; 1=enable), requires channel enable, as well.
2	RESERVED

These registers run in parallel with the data registers (30xxx series). For example, data register 30010's enable alarm register would be 43010. Data register 30016's enable alarm register would be 43016.

Note: *Alarm Enable currently only works for Particle Channels.*

Enabling the Alarm for a particle channel requires the channel be enabled, as well, setting the bit in the low word of that channel. The user can enable any or all active particle channels at a time and can set a different alarm threshold for each.

Particle data registers for the Alarm Enable setting start at 43009 for the high word and 43010 for the low word for channel 1. See Table 7-6.

Table 7-6 Alarm Enable Registers

Register	Data Type	Description
43009	unsigned int	Alarm Enable for Particle Channel 1 [high] (smallest particle size starts here)
43010	unsigned int	Alarm Enable for Particle Channel 1 [low]
43011	unsigned int	Alarm Enable for Particle Channel 2 [high]
43012	unsigned int	Alarm Enable for Particle Channel 2 [low]

Table 7-6 Alarm Enable Registers

Register	Data Type	Description
43013	unsigned int	Alarm Enable for Particle Channel 3 [high]
43014	unsigned int	Alarm Enable for Particle Channel 3 [low]
43015	unsigned int	Alarm Enable for Particle Channel 4 [high]
43016	unsigned int	Alarm Enable for Particle Channel 4 [low]

Enable Alarming for a Channel

Alarm and threshold registers are independent of each other. Any one register's settings will not affect the others and any channel alarms may be enabled or disabled as the user requires. For example, to enable alarming on just the first particle channel as shown in Table 7-7, the user would enable Bit 1 by writing the value of '3' to register 43010. To disable alarming on the first channel and enable alarming on the second channel, write a '1' to register 43010 and a '3' to register 43012. To enable all alarms, write a '3' to each of the registers 43010 and 43012.

To disable alarming completely, write a '1' to the enabled register or registers (43010, 43012, 43014 or 43016).

Table 7-7 Example of Alarming on Channel 2

Registers	Particle Channel	Bit 1 Enabled
43009 - 43010	1	0
43011 - 43012	2	1

Use the Threshold registers to set the alarm threshold value. This is described in the next section.

Threshold Setup Registers

Threshold data is stored in the input registers in the 45xxx series which are read/write. All threshold data items are 4 bytes long and are stored across 2 registers. Byte and word ordering is big-endian.

For particle channels, the threshold value is a 32-bit unsigned integer. If the data value exceeds the threshold value and the alarm is enabled for that channel, the threshold flag in the Data Status register (30007-30008, bit 4) is set.

The Data Status flag is set if any of the channels have a threshold exceeded state as true.

Note: *The ApexPortable comes standard with 4 particle channels.*

The threshold registers (45xxx series) shown in Table 7-8, run in parallel with the data registers (30xxx series). For example, data register 30010's corresponding threshold register would be 45010. Data register 30016's threshold register would be 45016.

Table 7-8 Alarm Threshold Registers

Register	Data Type	Description
45009	unsigned int	Threshold for Particle Channel 1 [high] (smallest particle size starts here)
45010	unsigned int	Threshold for Particle Channel 1 [low]
45011	unsigned int	Threshold for Particle Channel 2 [high]
45012	unsigned int	Threshold for Particle Channel 2 [low]
45013	unsigned int	Threshold for Particle Channel 3 [high]
45014	unsigned int	Threshold for Particle Channel 3 [low]
45015	unsigned int	Threshold for Particle Channel 4 [high]
45016	unsigned int	Threshold for Particle Channel 4 [low]

Setting the Alarm Threshold Value

The Alarm Threshold Value is set in the low register of the channels. Each channel has independent threshold value registers. Since any or all channels can be enabled for alarms at any given time, each threshold value applies to the corresponding channel. Setting a value for channel 1 as 100 will not affect channel 2 setting of, say, 500. See Table 7-9.

Table 7-9 Alarm Threshold Registers set to 1000

Registers	Particle Channel	Threshold Value
45009 - 45010	1	1000
45011 - 45012	2	1000
45013 - 45014	3	1000
45015 - 45016	4	1000

A ApexPortable MODBUS Register Map v1.50

COMM Settings

Lighthouse particle counters with MODBUS use the following communications settings:

Table A-1 MODBUS Communications Settings

Baud Rate	19200
Data Bits	8
Stop Bits	1
Parity	None
Hardware Protocol	RS232 or RS485 standard
Software Protocol	MODBUS ASCII (supports upper/lower case) and MODBUS RTU

Note: ApexPortable *currently supports only upper case.*

The MODBUS slave address is set on the particle counter.

Supported MODBUS Commands

Table A-2 MODBUS Registers

Hex Command	Description
03	Read Holding Registers
04	Read Input Registers
06	Write Single Holding Register

Visit www.modbus.org for documentation on how to use these commands.

Register Map

Sensor Settings Registers

Instrument settings are stored in holding registers (the 40xxx series), which are mostly read/writable. Not all holding registers are writable. Table A-3 describes the content of these registers.

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40001	unsigned integer	MODBUS register map version. Matches the version number of this document. Major version digits are hundreds. Minor version digits are tens and ones. For example, 135d = v1.35.
40002	unsigned integer	Command register. Makes the counter execute a command. See the description of this register in the table below.
40003	unsigned integer	Device Status. [bit 0=RUNNING, bit 1=SAMPLING, bit 2=NEW DATA]
40004	unsigned integer	Firmware version. Major version digits are hundreds. Minor version digits are tens and ones. For example, 235d=v2.35
40005	unsigned integer	Serial Number [high]
40006	unsigned integer	Serial Number [low]
40007	ASCII string	Product Name char[0], char [1] (NULL terminated string)
40008	ASCII string	Product Name char[2], char [3]
40009	ASCII string	Product Name char[4], char [5]
40010	ASCII string	Product Name char[6], char [7]
40011	ASCII string	Product Name char[8], char [9]
40012	ASCII string	Product Name char[10], char [11]
40013	ASCII string	Product Name char[12], char [13]
40014	ASCII string	Product Name char[14], char [15]
40015	ASCII string	Model Name char[0], char [1] (NULL terminated string)
40016	ASCII string	Model Name char[2], char [3]
40017	ASCII string	Model Name char[4], char [5]
40018	ASCII string	Model Name char[6], char [7]
40019	ASCII string	Model Name char[8], char [9]
40020	ASCII string	Model Name char[10], char [11]

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40021	ASCII string	Model Name char[12], char [13]
40022	ASCII string	Model Name char[14], char [15]
40023	unsigned integer	Flow Rate. See registers 40041-40042 for flow rate units. Liquid Particle Counters and Samplers: Value equals flow rate. For example: 100d=100 All Other Instruments: Divide by 100 to get flow rate. For example: 100d=1.00
40024	signed integer	Record Count. Total number of records stored in the counter
40025	signed integer	Record Index. Zero based index to data in 3xxxx register series. Must be lower than the record count (register 40024). Set this index to expose a counter's record in the 3xxxx registers. Set to -1 to retrieve last record stored in the counter.
40026	unsigned integer	Location number Particle Counters: Specifies location of Particle Counter where data was recorded. Must be 1 to 200 (maps to location names associated with registers 40200 - 40999).
40027	signed integer	Real Time Clock (RTC) [high]. Displays instrument's real-time clock. Works in conjunction with 40028. Displays date and time, in number of seconds since midnight, 1/1/1970. Can be generated by ANSI C/C++ time() function.
40028	signed integer	Real Time Clock [low]
40029	unsigned integer	Initial Delay [high]. Works in conjunction with 40030. Number of seconds to wait before starting the first sample. Max value is 359,999, which equals 99h 59m 59s.
40030	unsigned integer	Initial Delay [low]
40031	unsigned integer	Hold Time [high]. Works in conjunction with 40032. Number of seconds to wait between sample periods. Max value is 359,999, which equals 99h 59m 59s
40032	unsigned integer	Hold Time [low]
40033	unsigned integer	Sample Time [high]. Works in conjunction with 40034. Number of seconds to sample. Max value is 86,399, which equals 23h 59m 59s.
40034	unsigned integer	Sample Time [low]

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40035	unsigned integer	Data Set [high]. Works in conjunction with 40036. Updates the instrument's real time clock. Setting is the number of seconds since midnight, 1/1/1970. This number can be generated by the ANSI C/C++ time() function.
40036	unsigned integer	Data Set [low]
...		
40041	ASCII string	Flow Unit - Defines the Unit that FlowRate value is based on. char[0], char[1]. (NULL-terminated string)
40042	ASCII string	Flow Unit. char[2], char[3]
40043	unsigned integer	Calibration Reference Voltage (millivolts)
...		
40047	signed integer	**ApexPortable:** Calibration Due Date [high]. Indicates when instrument is due for calibration. This number can be generated by the ANSI C/ C++ time() function.
40048	signed integer	Calibration Due Date [low].
...		
40050	signed integer	Device Options
...		
40056	unsigned integer	Device Status[high]
40057	unsigned integer	Device Status[low].
40058	unsigned integer	Serial number [high].
40059	unsigned integer	Serial number [low].
40060	signed integer	Last Sample Timestamp [high] (# of seconds since midnight, 1/ 1/1970.).
40061	signed integer	Last Sample Timestamp [low].
40062	signed integer	Last Setting Change Timestamp [high] (# of seconds since midnight, 1/1/1970.). Value indicates.
40063	signed integer	Last Setting Change Timestamp [low].
40064	signed integer	Run-time particle channel alarm high flags (bit 0 = channel 1, …).

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40065	signed integer	Run-time particle channel alarm low flags (bit 0 = channel 1, …).
40074	signed integer	**ApexPortable**: Last Calibration Date [high]. Indicates when instrument was last calibrated. This number can be generated by the ANSI C/ C++ time() function.
40075	signed integer	**ApexPortable**: Last Calibration Date [low]

Device Status

The Device Status registers (40003 and 40057) display the current status of the device (Table A-4). Additional status bits are shown in 40056 (Table A-5).

.

Table A-4 Current Device Status (40003/40057)

Bit	Description
0	**RUNNING:** Set when a start command is executed via Command 11 (instrument start) or through the user interface. The flag will remained set until a stop command is executed.
1	**SAMPLING:** This is set only when the instrument is actually sampling data that is to be recorded. Caution must be used in sending a command during this time that may invalidate current sample.
2	**NEW DATA:** Set to 1 to indicate that a new data record has been recorded and it hasn't been read via modbus yet. When a data record has been read via modbus (registers 30001 to 30999), then this flag is reset to zero.
3	**DEVICE ERROR:** in the event that there is a failure on the device, this bit is set to indicate possible invalid data has been collected.
11	**ApexPortable:** **LASER STATUS:** Set to 1 when unit's LASER is out of spec, else set to 0.

Table A-4 Current Device Status (40003/40057)

Bit	Description
12	**ApexPortable:** **FLOW STATUS:** Set to 1 when unit's flow is out of spec, else set to 0.
13	**ApexPortable:** **SERVICE STATUS:** Set to 1 when unit needs to be serviced, else set to 0.
14	**ApexPortable:** **THRESHOLD HIGH STATUS:** Set to 1 when unit's high alarm threshold is exceeded, else set to 0.
15	**ApexPortable:** **THRESHOLD LOW STATUS:** Set to 1 when unit's low alarm threshold is not met, else set to 0.

Additional status bits are shown in 40056 displayed in Table A-5.

Table A-5 Additional Device Status (40056)

Bit	Description
0	**ApexPortable:** **LASER POWER STATUS**: Set to 1 when unit's LASER current is out of spec, else set to 0
1	**ApexPortable:** **LASER CURRENT STATUS:** Set to 1 when unit's LASER power is out of spec, else set to 0
2	**ApexPortable:** **LASER SUPPLY STATUS:** Set to 1 when unit's LASER supply is out of spec, else set to 0
3	**ApexPortable:** **LASER LIFE STATUS:** Set to 1 when unit's LASER supply is out of spec, else set to 0
4	**ApexPortable:** **NO FLOW STATUS:** Set to 1 when unit's flow is below no flow threshold causing LASER to turn off, else set to 0
5	**ApexPortable:** **PHOTOAMP SUPPLY STATUS:** Set to 1 when unit's photoamp supply is out of spec, else set to 0

Table A-5 Additional Device Status (40056)

Bit	Description
6	**ApexPortable:** **BACKGROUND STATUS:** Set to 1 when unit's photoamp background is out of spec, else set to 0
7	**ApexPortable:** **PHOTODIODE STATUS:** Set to 1 when photodiode has failed, else set to 0
8	**ApexPortable:** **CALIBRATION DUE DATE STATUS:** Set to 1 when unit is past calibration due date, else set to 0

Command Register

The Command Register (40002) is used to make the device perform an action. The register performs an action when an integer value is written to it. The action is completed when the device sends a MODBUS response. When this register is read, it always returns a zero. Table A-6 displays the registers' values and related actions.

Table A-6 Command Register

Value	Action
1	Saves all writable 4xxxx register values to the EEPROM.
2	Reserved for future use.
3	Clears the Data Buffer. Record count is set to zero.
4	Saves the instrument parameters in the 40xxx registers to the EEPROM. Parameters include Sample Time, Hold Time, Initial Delay, and Location.
11	Instrument Start (Automatic Counting). Particle Counters: Uses defined Initial Delay, Hold Time, Sample Interval and counting mode. Instrument executes samples and holds until an Instrument Stop command is issued. For instruments with pumps, this command will start the pump. Manifold Controller: Uses defined Manifold Sequence. Stops counting and changing position when Instrument Stop command is issued.
12	Instrument Stop. Aborts current sample. Stops pump, if applicable. Stops data collection.

Table A-6 Command Register

Value	Action
13	Set Real Time Clock. Writes "Data Set" values (from Registers 40035 & 40036) to the local Real Time Clock. New time value is saved.

Alarm and Threshold Registers

Alarm Enable Registers

The Alarm Enable input registers (43xxx series) are read/write. All enable data items are 4 bytes long and are stored across 2 registers. Byte and word ordering is big-endian. Thus, data items are formed by placing the high bytes in front of the low bytes. For example:

Note: *These registers currently apply only to ALARM enable/disable, **not** to Channel enable/disable.*

<High Bytes><Low Bytes> = <4 Byte Data Item>

The 43xxx register series is used to determine which particle data channels are set to ALARM ENABLE.

Table A-7 Alarm Enable/Disable Bits

Bit	Description
0	CHANNEL ENABLE (0=disable, 1=enable)
1	ALARM ENABLE (0=disable; 1=enable)
2	RESERVED

These registers run in parallel with the data registers (30xxx series). For example, data register 30010's enable alarm register would be 43010. Data register 30016's enable alarm register would be 43016.

Note: *Alarm Enable currently only works for Particle Channels. Any or all channels and their alarm thresholds can be enabled and configured independently of each other.*

To enable the Alarm for a particle channel, set the bit in the low word of that channel. Because Bit-0 is reserved and must always be ON, only Bit-1 will change for any channel alarm setting and Bit-0 must always be written as a '1'. What this means is that these registers will receive a '3' to turn the setting ON and a '1' to turn it OFF.

Particle data registers for the Alarm Enable setting start at 43009 for the high word and 43010 for the low word for channel 1.

Table A-8 Alarm Enable Registers

Register	Data Type	Description
43009	unsigned int	Alarm Enable for Particle Channel 1 [high] (smallest particle size starts here)

Table A-8 Alarm Enable Registers

Register	Data Type	Description
43010	unsigned int	Alarm Enable for Particle Channel 1 [low]
43011	unsigned int	Alarm Enable for Particle Channel 2 [high]
43012	unsigned int	Alarm Enable for Particle Channel 2 [low]
43013	unsigned int	Alarm Enable for Particle Channel 3 [high]
43014	unsigned int	Alarm Enable for Particle Channel 3 [low]
43015	unsigned int	Alarm Enable for Particle Channel 4 [high]
43016	unsigned int	Alarm Enable for Particle Channel 4 [low]

Enable Alarming for a Channel

To enable alarming on particle channel #1, write a ’3’ to register 43010, which enables its Bit 1 and maintains Bit 0 as ’1’. To disable alarming on channel 1 and enable it on channel 2, write a ’1’ to register 43010 and a ’3’ to register 43012. To enable all, write a ’3’ to 43010, 43012, 43014 and 43016.

To disable alarming completely, write a ’1’ to disable Bit 1 to registers 43010, 43012, 43014 and 43016.

Table A-9 Example of Alarming on Channel 2

Registers	Particle Channel	Bit 1 Enabled
43009 - 43010	1	0
43011 - 43012	2	1
43013 - 43014	3	0
43015 - 43016	4	0

Use the Threshold registers to set the alarm threshold value. This is described in the next section.

Threshold Setup Registers

Threshold data is stored in the input registers in the 45xxx series which are read/write. All threshold data items are 4 bytes long and are stored across 2 registers. Byte and word ordering is big-endian. Thus, data items are formed by placing the high bytes in front of the low bytes.

For example:

<High Bytes><Low Bytes> = <4 Byte Data Item>

For particle channels, the threshold value is a 32-bit unsigned integer. If the data value exceeds the threshold value and the alarm is enabled for that channel, the threshold flag in the Data Status register (30007-30008, bit 4) is set.

Note: *Table A-10 shows the registers for an 8 channel particle counter. Counters with fewer channels do not use the extra registers. The smallest particle channel starts at the xxx09 position.*

The Data Status flag is set if any of the channels have a threshold exceeded state as true.

The threshold registers (45xxx series) run in parallel with the data registers (30xxx series). For example, data register 30010's corresponding threshold register would be 45010. Data register 30016's threshold register would be 45016.

Table A-10 Alarm Threshold Registers

Register	Data Type	Description
45009	unsigned int	Threshold for Particle Channel 1 [high] (smallest particle size starts here)
45010	unsigned int	Threshold for Particle Channel 1 [low]
45011	unsigned int	Threshold for Particle Channel 2 [high]
45012	unsigned int	Threshold for Particle Channel 2 [low]
45013	unsigned int	Threshold for Particle Channel 3 [high]
45014	unsigned int	Threshold for Particle Channel 3 [low]
45015	unsigned int	Threshold for Particle Channel 4 [high]
45016	unsigned int	Threshold for Particle Channel 4 [low]

Setting the Alarm Threshold Value

Note: *Thresholds are independent of each other, so the value set for one channel does not affect another.*

The Alarm Threshold Value is set in the low register of the channels. Each channel has independent threshold value registers. Setting a value for channel 1 as 100 will not affect channel 2 setting of, say, 500.

Table A-11 Alarm Threshold Registers set to 1000

Registers	Particle Channel	Threshold Value
45009 - 45010	1	1000
45011 - 45012	2	1000

Table A-11 Alarm Threshold Registers set to 1000

Registers	Particle Channel	Threshold Value
45013 - 45014	3	1000
45015 - 45016	4	1000

Data Registers

Data is stored in the input registers (30xxx series), which are read-only. All data items are four bytes long and are stored across two registers. Byte and word order is big-endian. Thus, data items are formed by placing the high bytes in front of the low bytes.

Example:

<High Bytes><Low bytes> = <4 Byte Data Item>

Not all particle and analog channels are active. Retrieving data from an inactive channel returns garbage. See the Data Enable Registers section of this document for details on how to record data from active channels.

This entire series of registers represents one data record in the device. The Record Index Register (40025) must be changed to index other records here.

The first record in the data buffer is located at Index=0. The most recently saved value is at Index=-1.

Table A-12 Data Registers

Register	Data Type	Description
30001	signed integer	Timestamp [high] (# of seconds since midnight, 1/1/1970)
30002	signed integer	Timestamp [low]
30003	unsigned integer	Sample Time [high] (in seconds)
30004	unsigned integer	Sample Time [low]
30005	signed integer	Location [high] (where data was recorded)
30006	signed integer	Location [low]
30007	unsigned integer	Sample Status [high]
30008	unsigned integer	Sample Status [low]

Table A-12 Data Registers

Register	Data Type	Description
30009	unsigned integer	Particle Channel 1 [high]
30010	unsigned integer	Particle Channel 1 [low]
30011	unsigned integer	Particle Channel 2 [high]
30012	unsigned integer	Particle Channel 2 [low]
30013	unsigned integer	Particle Channel 3 [high]
30014	unsigned integer	Particle Channel 3 [low]
30015	unsigned integer	Particle Channel 4 [high]
30016	unsigned integer	Particle Channel 4 [low]

30063	IEEE Float	LASER Supply [low]
30064	IEEE Float	LASER Supply [high] (percentage based on LASER Supply Reference Value)
30065	IEEE Float	Background Voltage [low] (percentage based on Calibration Reference value) - **ApexPortable**
30066	IEEE Float	Background Voltage [high]

30069	IEEE Float	LASER Voltage [low] (Percentage based on LASER Reference value)
30070	IEEE Float	LASER Voltage [high]

Table A-13: Instrument Current Status

Value	Action
0	Service LASER Status 0 = LASER is good. 1 - LASER needs to be serviced.
1	Bad Flow Status 0 = Flow rate is good. 1 = Flow rate is bad.
2	Particle Overflow Status 0 = No overflow 1 = Overflow occurred.

Table A-13: Instrument Current

Value	Action
3	Instrument Service Status 0 = Instrument is working correctly. 1 = Service light is on. Instrument malfunction detected.
4	Threshold High Status 0 = Threshold not exceeded. 1 = Threshold exceeded
5	Threshold Low Status 0 = Threshold not exceeded. 1 = Threshold exceeded.
6	Instrument Sampler Status 0 = Nominal Operation. 1 = Sampler Error.
7	**ApexPortable:** 0 = LASER power in spec. 1 = LASER power out of spec.
8	**ApexPortable:** LASER current status 0 = LASER current in spec. 1 = LASER power out of spec.
9	**ApexPortable:** LASER supply status 0 = LASER supply in spec. 1 = LASER supply out of spec.
10	**ApexPortable:** LASER life status 0 = LASER life in spec. 1 = LASER life out of spec.
11	**ApexPortable:** No flow status 0 = There is flow in the unit. 1 = no flow in unit.
12	**ApexPortable:** Photoamp supply status 0 = Photoamp supply in spec. 1 = Photoamp supply out of spec.
13	**ApexPortable:** Background status 0 = Photoamp background good. 1 = Photoamp background out of spec.

Table A-13: Instrument Current

Value	Action
14	**ApexPortable:** Photodiode health status 0 = Photodiode good. 1 = Photodiode failure
16	**ApexPortable:** Calibration due date status 0 = Unit has not passed calibration date. 1 = Unit has passed calibration.

Note: *Particle data is a cumulative raw count regardless of the instrument's settings.*

The timestamp field indicates when the data record was recorded. Timestamps are stored as the number of seconds since 1/1/1970, the Unix time epoch. This value can be written directly into a C/C++ time_t data type to be used by ANSI C time functions.

Device Status Word

The registers used for the Sample Status Word are 30007-30008 to sample status.

The bit order of the Device Status Word is 7 to 0 (right to left), where bit 7 is the most significant bit and bit 0 is the least significant bit.

The bits within the Device Status Word are flagged to indicate particular conditions of the currently indexed data record.

If multiple states occur, the bits are added together. For example, a Flow Alert and a Particle Overflow would return a value of 6 in register 30008 (bits 1 and 2 are set TRUE).

Table A-14 Device Status Word

Bit	Description
0	LASER Alert Status 0 = LASER is good 1 = LASER Alert
1	Flow Alert Status 0 = Flow Rate is good 1 = Flow Rate Alert
3	Instrument Service Status 0 = Working correctly 1 = Instrument malfunction detected.
4	Particle Threshold Exceeded Status 0 = Threshold not exceeded 1 = Threshold exceeded

Note: *All data records have the same enable states. The user does not have to read the enable registers for every record.*

Data Enable Registers

The 31xxx register series is used to determine which data items in 30xxx are enabled. Enabled items contain recorded data. Data retrieved from disabled items return garbage. Data items are disabled for particle and analog channels not supported by the device or when the device software is configured not to record data for those items.

The Enable Registers (31xxx series) run in parallel with the Data Registers (30xxx series). For example, Data Register 30010's Enable Register is 31010. Data Register 30016's Enable Register is 31016.

The 31xxx register states are:

00000000h = Disabled
FFFFFFFFh = Enabled

Note: *All data records have the same data types assigned to them. The user does not have to read the data type registers for every record.*

Data Type Registers

The 32xxx register series is used to identify the type of data in the 30xxx series. The Data Type registers run in parallel with the Data Registers. For example, Data Register 30041's Data Type register is 32041.

Data Types are assigned 4 ASCII characters across 2 registers. If a Data Type string contains less than 4 characters, then the rest of the string is padded with NULL characters. Note that a Data Type using all four characters will not end with a NULL character. Table A-15 displays the Data Type Register Strings and their meanings.

Table A-15 Data Type Registers

String	Description
TIME	Timestamp
STIM	Sample Time
SVOL	Sample Volume
LOC	Location
STAT	Status
TEMP	Temperature
RH	Relative Humidity

Table A-15 Data Type Registers

String	Description
AIRV	Air Velocity
DPRS	Differential Pressure
ESD	Electrostatic Discharge
FLOW	Flow Rate
LASV	LASER Voltage
VOLT	Voltage
PRES	Pressure
CURR	Current
LASV	LASER Current
LASP	LASER Power

Note: *Only Particle data types have numbers in their strings.*

Particle data items are typed specially. They contain numbers, sometimes a space and sometimes a period used as a decimal point. These entries are used to identify particle channel sizes and are always expressed in microns. These types represent raw counts only.

Table A-16 Examples of Particle Data Items

String	Description
0.3	Particle type of size 0.3 micron
1.0	Particle type of size 1.0 micron
20.0	Particle type of size 20.0 micron
.015	Particle type of size 0.015 micron or 15 nanometer

Data Units Registers

The 33xxx register series identifies the units used by data items in the 30xxx series. The Units Registers are paralleled by the Data Registers. For example, Data Register 30010's Units Register is 33010.

Note: *Not all data types have units.*

Units are stored as 4 character ASCII strings across 2 registers. If the Units string contains less than 4 characters, or no characters at all, the

rest of the string is padded with NULLs. Note that a Units string using all 4 characters does not end with a NULL.

Note: *Be aware that LWS Particle Counters may use units not on the table.*

The Table A-17 shows units that may be sent by the device. Some are not currently used but are reserved for future use.

Table A-17 Data Units

Units	Description	Units	Description
#	Count (For Particles)	ft/m	Feet per minute
%	Percent	m/s	Meters per second
s	Seconds	"H2O	Inches of water
min	Minutes	"Hg	Inches of mercury
hour	Hours	mmWa	Millimeters of water
F	Fahrenheit	mmHg	Millimeters of mercury
C	Celsius	cmHg	Centimeters of mercury
K	Kelvin	Pa	Pascals
ft	Feet	kPa	Kilopascals
m	Meters	Bar	Bar
ft^2	Square feet	mBar	Milli-bar
m^2	Square meters	V	Volts
ft^3	Cubic feet	mV	Milli-volts
m^3	Cubic meters	A	Amperes
L	Liters	mA	Milli-amps
CFM	Cubic feet per minute	Ohm	Ohms
CMM	Cubic meters per minute	mOhm	Milli-ohm
L/m	Liters per minute	p/m3	Particles per cubic meter
p/f3	Particles per cubic foot		

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B Limited Warranty

Limitation Of Warranties:

A. Lighthouse Worldwide Solutions (LWS) warrants that all equipment shall be free from defects in material and workmanship under normal use for a period of two years from date of shipment to Buyer except that LWS does not warrant that operation of the software will be completely uninterrupted or error free or that all program errors will be corrected. Buyer shall be responsible for determining that the equipment is suitable for Buyer's use and that such use complies with any applicable local, state, or federal law. Provided that Buyer notifies LWS in writing of any claimed defect in the equipment immediately upon discovery and any such equipment is returned to the original shipping point, transportation charges prepaid, within two years from date of shipment to Buyer and upon examination LWS determines to its satisfaction that such equipment is defective in material or workmanship, i.e. contains a defect arising out of the manufacture of the equipment and not adefect caused by other circumstances, including, but not limited to accident, misuse, unforeseeable use, neglect, alteration, improper installation, improper adjustment, improper repair, or improper testing, LWS shall, at its option, repair or replace the equipment, shipment to Buyer prepaid. LWS shall have reasonable time to make such repairs or to replace such equipment. Any repair or replacement of equipment shall not extend the period of warranty. If the Instrument is modified or in any way altered without the explicit written consent of LWS then the warranty is null and void. This warranty is limited to a period of two years, except as noted below, without regard to whether any claimed defects were discoverable or latent on the date of shipment. The length of warranty for pumps in hand held particle counters is one (1) year. Batteries and accessories with all products are warranted for one (1) year. Fuses and purge filters carry no warranty. If a third party battery is used in the product, the product warranty is null and void. If the battery is charged by a third party battery charger the battery warranty is null and void.

B. If Buyer shall fail to pay when due any portion of the purchase price or any other payment required from Buyer to LWS under this contract or otherwise, all warranties and remedies granted under this Section may, at LWS's option, be terminated.

C. THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER REPRESENTATIONS, WARRANTIES AND COVENANTS, EXPRESS OR IMPLIED WITH RESPECT TO THE EQUIPMENT AND ANY DEFECTS THEREIN OF ANY NATURE WHATEVER, INCLUDING AND WITHOUT LIMITATION WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. LWS SHALL NOT BE LIABLE FOR, AND BUYER ASSUMES ALL RISK OF, ANY ADVICE OR FAILURE TO PROVIDE ADVICE BY LWS TO BUYER REGARDING THE EQUIPMENT OR BUYERS USE OF THE SAME. UNDER NO CIRCUMSTANCES SHALL LWS BE LIABLE TO BUYER UNDER ANY TORT, NEGLIGENCE, STRICT LIABILITY, OR PRODUCT LIABILITY CLAIM AND BUYER AGREES TO WAIVE SUCH CLAIMS. LWS's SOLE AND EXCLUSIVE LIABILITY AND BUYERS SOLE AND EXCLUSIVE REMEDY, FOR ANY NONCONFORMITY OR DEFECT IN THE PRODUCTS OR ANYTHING DONE IN CONNECTION WITH THIS CONTRACT, IN TORT, (INCLUDING NEGLIGENCE), CONTRACT, OR OTHERWISE, SHALL BE AS SET FORTH IN THE SUBSECTION A HEREOF AS LIMITED BY SUBSECTION B HEREOF. THIS EXCLUSIVE REMEDY SHALL NOT HAVE FAILED OF ITS ESSENTIAL PURPOSE (AS THAT TERM IS USED IN THE UNIFORM COMMERCIAL CODE) PROVIDED THAT THE SELLER REMAINS WILLING TO REPAIR OR REPLACE DEFECTIVE EQUIPMENT (AS DEFINED IN SUBSECTION A) WITH A COMMERCIALLY REASONABLE TIME AFTER RECEIVING SUCH EQUIPMENT. BUYER SPECIFICALLY ACKNOWLEDGES THAT SELLER'S PRICE FOR THE EQUIPMENT IS BASED UPON THE LIMITATIONS OF LWS'S LIABILITY AS SET FORTH IN THIS CONTRACT.

Warranty Of Repairs After Initial Two (2) Year Warranty:

A. Upon expiration of the initial two-year warranty, all parts and repairs completed by an authorized Lighthouse repairtechnician are subject to a six (6) month warranty.

B. Other than the above, LWS makes no warranty of any kind, expressed or implied, except that the products manufactured and sold by LWS shall be free from defects in materials and workmanship and shall conform to LWS's specifications; Buyer assumes all risk and liability resulting from use of the products whether used singly or in combination with other products. If instrument is modified or in any way altered without the explicit written consent of LWS, then the warranty is null and void.

C. WARRANTY REPAIRS SHALL BE COMPLETED AT THE FACTORY, BY AN AUTHORIZED SERVICE LOCATION, BY AN AUTHORIZED SERVICE TECHNICIAN, OR ON SITE AT BUYER'S FACILITY BY A LIGHTHOUSE AUTHORIZED EMPLOYEE. BUYER PAYS FREIGHT TO FACTORY; SELLER WILL PAY STANDARD RETURN FREIGHT DURING THE WARRANTY PERIOD. BUYER MAY SELECT A FASTER METHOD OF SHIPMENT AT ITS OWN EXPEN

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