MIE pDR-1500

Instruction Manual
Active Personal Particulate Monitor
Part Number 105983-00
16Apr2013

Thermo SCIENTIFIC

© 2008 Thermo Fisher Scientific Inc. All rights reserved.

Specifications, terms and pricing are subject to change. Not all products are available in all countries. Please consult your local sales representative for details.

Thermo Fisher Scientific
Air Quality Instruments
27 Forge Parkway
Franklin, MA 02038
1-508-520-0430
www.thermo.com/aqi

WEEE Compliance

This product is required to comply with the European Union's Waste Electrical & Electronic Equipment (WEEE) Directive 2002/96/EC. It is marked with the following symbol:

Thermo Fisher Scientific has contracted with one or more recycling/disposal companies in each EU Member State, and this product should be disposed of or recycled through them. Further information on Thermo Fisher Scientific's compliance with these Directives, the recyclers in your country, and information on Thermo Fisher Scientific products which may assist the detection of substances subject to the RoHS Directive are available at: www.thermo.com/WEEERoHS.

About This Manual

This manual provides information about handling, operating, communicating, and maintaining, the MIE pDR-1500 Active Personal Particulate Monitor (pDR-1500). It also contains important warnings to ensure safe operation and prevent equipment damage. The manual is organized into the following chapters and appendices to provide direct access to specific operation and service information.

Chapter 1 "Introduction" provides a general description of the instrument, and lists the specifications.

Chapter 2 "Guidelines and Instrument Layout" provides the guidelines and layout for instrument operation.

Chapter 3 "Operation" describes the operating modes, keypad functions, and menu-driven firmware.

Chapter 4 "Calibration and Particle Size Selection" provides the calibration process and procedures for calibrating the instrument.

Chapter 5 "Maintenance and Service" provides step-by-step instructions for repairing and replacing components, and a replacement parts list.

Chapter 6 "Troubleshooting" provides contact information for product support and technical information.

Chapter 7 "Outputs and Alarm" describes serial communications and analog/alarm output.

Chapter 8 "Optional Accessories" lists the optional accessories that can be used with the instrument.

Appendix A "Warranty" provides a copy of the warranty statement.

Appendix B "Serial Commands" provides a list of the serial port commands that can be used to remotely control the instrument.

Safety

Review the following safety information carefully before using the instrument. This manual provides specific information on how to operate the instrument, however, if the instrument is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Safety and Equipment Damage Alerts

This manual contains important information to alert you to potential safety hazards and risks of equipment damage. Refer to the following types of alerts you may see in this manual.

Safety and Equipment Damage Alert Descriptions

Alert		Description
	DANGER	A hazard is present that could result in death or serious personal injury if the warning is ignored. ▲
	WARNING	A hazard or an unsafe practice could result in serious personal injury if the warning is ignored. ▲
	CAUTION	A hazard or unsafe practice could result in minor to moderate personal injury if the warning is ignored. ▲
	Equipment Damage	A hazard or unsafe practice could result in property damage if the warning is ignored. ▲

Safety and Equipment Damage Alerts in this Manual

Alert		Description
	WARNING	The pDR-1500 must be protected from all forms of precipitation. ▲ Whenever the pDR-1500 is shipped, care should be taken in placing it in its carrying case and repackaging it with the original factory provided packaging. ▲ The pDR-1500 should be operated only from the type of power sources described in this manual. ▲ Shut off pDR-1500 before replacing the internal batteries, or when plugging in or disconnecting the AC power supply. ▲ To operate the unit outdoors, provisions should be made to protect it from environmental extremes outside its specified range, and from any exposure to precipitation. ▲

Alert		Description
		Do not leave this chamber open for any extended period of time, otherwise dust may settle on the internal optical surfaces. Hand-tighten the plastic cap firmly after filter cassette replacement to ensure a proper seal. At no time should the pDR-1500 be running without a filter in place, otherwise serious damage to the internal components may result. ▲
		To operate the unit outdoors, provisions should be made to protect it from environmental extremes outside its specified range, and from any exposure to precipitation. ▲
		Do not apply AC voltage to this connector. Maximum allowable DC voltage is 30 V. ▲
	Equipment Damage	Please note that the important purpose of this filter cassette is to protect the pump. ▲
		It is recommended to turn the instrument and computer OFF before making a connection. ▲
		Verify the the exhaust port and the inlet port are not blocked. ▲
		At no time should the pDR-1500 be running without a filter in place, otherwise serious damage to the internal components may result. ▲
		Unless a MALFUNCTION message is displayed, or other operational problems occur, the pDR-1500 should be returned to the factory once every year after being placed into service for routine check out, test, cleaning and calibration check. ▲
		If unsuccessful, the instrument must be sent back to the factory for service. ▲

WEEE Symbol

The following symbol and description identify the WEEE marking used on the instrument and in the associated documentation.

Symbol	Description
	Marking of electrical and electronic equipment which applies to electrical and electronic equipment falling under the Directive 2002/96/EC (WEEE) and the equipment that has been put on the market after 13 August 2005. ▲

Where to Get Help

Service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Contents

Chapter 1 Introduction 1-1
General Description 1-2
Specifications 1-4

Chapter 2 Guidelines and Instrument Layout 2-1
Unpacking and Parts Identification 2-2
Handling 2-3
Safety 2-4
Positioning 2-5
Air Sampling Guidelines 2-6
Area Monitoring 2-6
Monitoring via Tubing 2-6
Instrument Layout 2-7
Front Panel 2-8
Rear Power Port 2-9
Side PM Inlet, USB, RS232/Analog 2-10
Side Filter Assembly and Exhaust 2-11
Bottom Battery and Belt Clip 2-12
Preparation for Operation 2-13
Power Options 2-13
Before Starting a Run 2-13
Electrical Connections 2-14
Environmental Constraints and Certifications 2-15
Communications with Computer 2-16
Software Installation Procedure 2-16
Communication between pDR-1500 and Computer 2-16

Chapter 3 Operation 3-1
Operating Modes 3-2
Keypad and Screen Cursor Functions and Operation 3-3
Key Press Functions 3-4
Startup 3-5
Operate Menu 3-6
Start A Run 3-6
Concentration/Scattering 3-6
Elapsed Time 3-7
Maximum Run Reading 3-7
STEL 3-7
Battery/Memory 3-8

Temperature/RH 3-8
Flow/Pressure 3-8
Stop Run 3-9
Delayed Start 3-9
Delayed Start Edit 3-9
Start Time/Date 3-9
Start Time/Date Edit 3-10
Delayed Start Countdown 3-10
Zeroing the pDR-1500 3-10
Zero In Progress 3-11
Zero Complete 3-11
Logging Parameters 3-11
Logging Status Edit 3-12
Logging Period Edit 3-12
Logging Site Edit 3-12
Logging Tag Number 3-13
Battery/Memory Status 3-13
Configure Menu 3-14
Display Average Time 3-14
Display Average Time Edit 3-14
Flow Rate 3-15
Flow Rate Edit 3-15
Logging Parameters 3-15
Logging Status Edit 3-16
Logging Period Edit 3-16
Logging Site Edit 3-16
Logging Tag Number 3-17
Inlet Type 3-17
Inlet Type Edit 3-17
RH Correction 3-18
RH Correction Edit 3-18
Alarm 3-18
Alarm Option Edit 3-19
Alarm Level Edit 3-19
Units 3-19
Units Edit 3-20
Analog Output 3-20
Analog Output Edit 3-20
LCD Backlight 3-21
LCD Backlight Edit 3-21
LCD Contrast 3-22
LCD Contrast Edit 3-22
Time/Date 3-22
Time/Date Edit 3-22
Calibrate Menu 3-24
Temperature Offset 3-24

Temperature Offset Edit 3-24
Pressure Offset 3-25
Pressure Offset Edit 3-25
RH Offset 3-25
RH Offset Edit 3-25
Flow Rate Calibration 3-26
Flow Rate Calibration Edit 3-26
Calibration Factor 3-27
Calibration Factor Edit 3-27
Starting a Run 3-28
Filter Requirements 3-28
ZERO/Initialize Operation 3-28
Auto-Start (Optional) 3-29
Configuration Review 3-29
Start the Run 3-32

Chapter 4 Calibration and Particle Size Selection 4-1
Factory Calibration 4-2
How to Apply a Correction Factor 4-3
Site Calibration Factors 4-4
Particle Size Cut Points 4-5

Chapter 5 Maintenance and Service 5-1
General Guidelines 5-2
Replacement Parts List 5-3
Battery Use 5-4
Instrument Storage 5-5
Filter Replacement 5-6
Cleaning of Optical Sensing Chamber 5-8
Service Locations 5-9

Chapter 6 Troubleshooting 6-1
Instrument Status Flags 6-2
Service Locations 6-3

Chapter 7 Outputs and Alarm 7-1
Analog Signal Output 7-2
Alarm Description and Operation 7-3
Alarm Connection 7-4
Real-time RS-232 Output 7-6
Serial Communications Protocols 7-7

Chapter 8 Optional Accessories 8-1

Appendix A Warranty..... A-1

Appendix B Serial Commands B-1

Figures

Figure 2–1. Front Display 2-8
Figure 2–2. Rear Power Port 2-9
Figure 2–3. Side PM Inlet, USB, RS-232/Analog Panel 2-10
Figure 2–4. Side Filter Assembly and Exhaust 2-11
Figure 2–5. Bottom Battery Door and Belt Clip 2-12
Figure 3–1. Keypad Overview 3-3
Figure 3–2. Keypad Functions 3-4
Figure 4–1. Cyclone D50 Curves 4-5
Figure 5–1. Filter Assembly Location – turn counter-clockwise to open 5-6
Figure 5–2. Filter Cassette Assembly – Snap Rings and Filter 5-7
Figure 7–1. pDR-1500 External Alarm Driver 7-4

Figures

Tables

Table 1–1. MIE pDR-1500 Specifications..... 1-4
Table 5–1. pDR-1500 Replacement Parts..... 5-3
Table 6–1. Troubleshooting – Error Code Responses from Zeroing..... 6-2

Chapter 1
Introduction

The Thermo Scientific MIE pDR-1500™ (pDR-1500) is an advanced instrument designed to actively measure the concentration of airborne particulate matter (liquid or solid), providing data logging and a continuous readout. The pDR-1500 offers two (2) ACGIH-traceable particle size-selective inlet cyclones, as optional accessories, which permit size segregated measurements (e.g., PM_{10}, PM_4, $PM_{2.5}$, PM_1, etc.) enabling the user to perform aerodynamic particle discrimination by varying the sampling flow rate. The pDR-1500 incorporates, downstream of its photometric sensing stage, a 37-mm filter holder on which all sampled particles are collected for subsequent analysis or gravimetric reference calibration, if so desired. With proper choice of filter, flow rate and cyclone, the pDR-1500 can also be used to meet NIOSH Test Method 0500 or 0600 for total aerosol mass or aerosol with a 4 µm median cut point, respectively. Additional *Technical Notes* regarding the pDR-1500 are offered on our website at www.thermo.com/ih and will be updated on a regular basis.

The pDR-1500 is the result of many years of field experience acquired with thousands of units of its well known predecessors from MIE, Inc. (i.e., pDR-1200, pDR-1000, and the MINIRAM), and embodies many technological advances made possible by the latest electronic hardware and software.

For a description of the instrument and product specifications, see the following topics:

- "General Description" on page 1-2
- "Specifications" on page 1-4

Thermo Fisher Scientific is pleased to supply this active personal particulate monitor. We are committed to the manufacture of instruments exhibiting high standards of quality, performance, and workmanship. Service personnel are available for assistance with any questions or problems that may arise in the use of this monitor. For more information on Servicing, see Chapter 5, "Maintenance and Service".

General Description

The pDR-1500 is a highly sensitive nephelometric (i.e., photometric) monitor whose legacy light scattering sensing configuration has been optimized for the measurement of the respirable fraction of airborne dust, smoke, fumes and mists in industrial and other indoor and outdoor environments. The pDR-1500 incorporates a temperature and relative humidity (RH) sensor to mitigate the positive bias with elevated ambient RH. Additionally, the flow control is truly volumetric and is maintained through digital feedback of the onboard barometric pressure sensor, temperature sensor, and calibrated differential pressure across a precision orifice.

Downstream of the internal vacuum pump is a HEPA filter which will ensure a clean air source is delivered to the calibrated orifice and exhausted from the instrument. Zeroing is accomplished using one of two methods. The primary zeroing method is accomplished by attaching a HEPA filter to the total inlet for a few minutes. A second zeroing method is the “field zero” by which a piece of tubing is attached to the exhaust port and re-circulated to the inlet. This second method was developed to reduce the potential loss of accessories in the field, while providing a reasonably accessible method for zeroing. By providing filtered air through the optical bench, the optical background of the instrument is established throughout the dynamic range of the instrument.

The pDR-1500 is a compact, rugged and totally self-contained instrument designed for hand-held, belt-worn, as well as unattended operation. It is powered either by its internal replaceable batteries, or by an AC supply (included as standard accessory).

The pDR-1500 covers a wide measurement range: from 0.001 mg/m^3 (1 µg/m^3) to 400 mg/m^3, a 400,000-fold span, corresponding to very clean air up to an extremely high aerosol concentration.

In addition to the auto-ranging real-time concentration readout, the pDR-1500 offers the user a wide range of information by scrolling its two-line LCD screen, such as run start time and date, time averaged concentration, elapsed run time, maximum and STEL values with times of occurrence, battery voltage, data storage memory, temperature, RH, volumetric flow rate, barometric pressure, etc.

Operating parameters selected, diagnostic information, and calibration displays are also available with the pDR-1500. From the instrument display panel the user can:

- Enable a run
- Enable an auto-start run time and date
- Conduct an internal field zero
- Fully configure data logging options
- Adjust display average time
- Adjust analog span output
- Identify type of inlet/cyclone installed
- Adjust flow rate with automatic D50 cut point feedback
- Enable/disable *f* (RH) correction
- Enable/disable and select alarm output threshold
- Adjust time and date
- Enable/disable display backlight and contrast
- Calibrate barometric pressure, temperature, RH, flow rate, and dust response factor

Furthermore, the pDR-1500 features complete, large capacity internal data logging capabilities with retrieval through an externally connected computer via RS-232 or USB device. The stored information (> 450k data points) includes average concentration and maximum values with time information and tag numbers, operating parameters, error codes, and each time-stamped logged record provided concentration, temperature, RH, barometric pressure, and error status.

Selectable alarm levels with built-in audible signal and switched output, a RS-232 communications port, a USB communications port, and a programmable analog concentration output (voltage and current) are all part of this versatile instrument.

A custom software package (pDR Port) is provided with the pDR-1500 to program operating/logging parameters (e.g., logging period, alarm level, concentration display averaging time, etc.) as well as to download stored or real-time data to a PC or laptop for tabular and/or graphic presentation. If required, the data can also be imported to standard spreadsheet packages (e.g., Microsoft Excel™, Lotus 1-2-3™, etc.).

The pDR-1500 combines, easy to use menu-driven software, and advanced diagnostics to offer unsurpassed flexibility and reliability. The pDR-1500 specifications follow.

Specifications

Table 1–1 lists the specifications for the Model pDR-1500.

Table 1–1. MIE pDR-1500 Specifications

Concentration measurement range (auto-ranging)[1]	0.001 to 400 mg/m^3
Scattering coefficient range	1.5 x 10^{-6} to 0.6 m^{-1} (approx.) @ λ = 880 nm
Precision/repeatability over 30 days (2-sigma)[2]	± 2% of reading or ± 0.005 mg/m^3, whichever is larger, for 1-second averaging time ± 0.5% of reading or ± 0.0015 mg/m^3, whichever is larger, for 10-second averaging time ± 0.2% of reading or ± 0.0005 mg/m^3, whichever is larger, for 60-second averaging time
Accuracy[1]	± 5% of reading (± precision) traceable to SAE Fine Test Dust
Resolution	0.1 μg/m^3
Particle size range of maximum response	0.1 to 10 μm
Flow rate range	1.0 to 3.5 L/min
Aerodynamic particle cut-point range	1.0 to 10 μm, with optional cyclone accessories
Concentration display updating interval	1 second
Concentration display averaging time[3]	1 to 60 seconds
Alarm level adjustment range[3]	0.01 to 400 mg/m^3
Alarm averaging time[3]	Real-time (1 to 60 seconds), or STEL (15 minutes)
Data logging averaging periods[3]	1 second to 1 hour
Total number of data points that can be logged in memory	> 450,000
Number of data tags (data sets)	100 (0-99)
Logged data	Record no., concentration or scattering data, temperature, relative humidity, barometric pressure, data flags, time and date
Run summary	Model number, software version, serial no., tag number, start time, start date, logging period, cal factor, units of measure, RH correction setting, max. conc., time of max. conc., max. STEL, time of max. STEL, avg. conc., alarm on/off, alarm threshold, error codes, inlet setting, flow rate setting and site name

Elapsed time range	0 to 100 hours (resets to 0 after 100 hours)
Time keeping and data retention	> 10 years
Readout display	LCD 16 characters (4 mm height) x 2 lines
Serial interface	High Speed USB / RS-232, 19,200 baud
Computer requirements	IBM-PC compatible, 486 or higher, Windows™ '95 or higher, ≥ 8 MB memory, > 10 MB hard disk drive, CD Drive, VGA or higher resolution monitor
Real-time digital signal (1 sec-1)	Concentration, flow, temperature, relative humidity, barometric pressure, time, date
Real-time analog signal[1]	0 to 2 V and 4 to 20 mA. Selectable full scale ranges of: 0 - 0.1, 0 - 0.4, 0 - 1.0, 0 - 4.0, 0 - 10, 0 - 40, 0 - 100, and 0 - 400, mg/m^3 Minimum load impedance for voltage output: 200 kΩ Maximum load impedance for current output: 300 Ω (when powered by AC power supply)
Alarm output	Load impedance > 100 kΩ.. Alarm ON = short to ground. Alarm OFF = open
Internal battery run time with backlight off Run time @ 25 deg C, run time may vary with temperature	4 AA alkaline, > 24-hour run time @ 1.2 L/min; > 6-hour @ 3.5 L/min 4 NiMH rechargeable batteries, > 24-hour run time @ 1.2 L/min; > 8-hour @ 3.5 L/min
Current consumption	70 to 450 mA (in Run Mode); 32 mA (in Ready Mode), @ 5 VDC
AC source	Universal voltage adapter (included) 100-250 VAC, 50-60 Hz (CE marked)
Operating environment	-10 to 50 °C (14 to 122 °F), 10 to 95% RH, non-condensing
Storage environment:	-20 to 70 °C (-4 to 158 °F)
Dimensions (max. external)	181 mm (7.1 in.) H x 143 mm (5.6 in.) W x 84 mm (3.3 in.) D
Weight (w/total inlet and 4-AA)	1.2 kg (41 oz)
Optional Cyclones	GK 2.05 (Red) primarily for PM_4 thru PM_{10} SCC 1.062 (Blue) primarily for PM_1 thru PM_4
Integrated Sample Filter holder	Millipore type MAWP 037 AO (with 0.8 μm pore size filter) Whatman type 1827 037 (with 1.5 μm pore size filter) NIOSH Methods 0500 and 0600 use Millipore type PVC5 037 00 (with 5 μm pore size filter) and a GK 2.05 Cyclone.
Service Filter	Integrated HEPA filter for background zeroing

Notes:

[1] Referred to gravimetric calibration with SAE Fine (ISO Fine) test dust (mmd = 2 to 3 µm, g = 2.5, as aerosolized)

[2] At constant temperature and full battery voltage

[3] User selectable

Chapter 2
Guidelines and Instrument Layout

This chapter includes unpacking and parts identification, positioning and handling of the instrument, monitoring applications, instrument layout, outdoor provisions, and computer requirements.

- Unpacking and Parts Identification on page 2-2
- Handling on page 2-3
- Safety on page 2-4
- Positioning on page 2-5
- Air Sampling Guidelines on page 2-6
- Instrument Layout on page 2-7
- Environmental Constraints and Certifications on page 2-15
- Communications with Computer on page 2-16

Unpacking and Parts Identification

Carefully unpack the pDR-1500 from the shipping container. The pDR-1500 is provided to the user with the following standard accessories:

- Universal power supply cable
- RS-232 communications cable
- USB communications cable
- pDR Port Software CD ROM
- Belt clip kit
- Total particulate inlet
- 8 alkaline batteries
- 2 ea. stainless steel filter support and holder assembly*
- 1pk/100 37-mm glass fiber filters*
- Zeroing/recirculation tubing
- Zeroing filter
- Instruction manual

If any parts are missing, contact Thermo Fisher Scientific immediately.

*One of each is installed in the instrument at the time of shipping

Handling

The pDR-1500 is a sophisticated optical/electronic instrument and should be handled accordingly. Although the pDR-1500 is very rugged, it should not be subjected to excessive shock, vibration, temperature or humidity. As a practical guideline, the pDR-1500 should be handled with the same care as a portable MP3 or DVD player.

WARNING The pDR-1500 must be protected from all forms of precipitation. ▲

If the pDR-1500 has been exposed to low temperatures (e.g., in the trunk of a car during winter) for more than a few minutes, care should be taken to allow the instrument to return near room temperature before operating it indoors. This is advisable because water vapor may condense on the interior surfaces of the pDR-1500 causing temporary malfunction or erroneous readings. Once the instrument warms up to near room temperature, such condensation will have evaporated. If the pDR-1500 becomes wet (e.g., due to exposure to water sprays, rain, etc.), allow the unit to dry thoroughly before operating. Re-zeroing is recommended.

WARNING Whenever the pDR-1500 is shipped, care should be taken in placing it in its carrying case and repackaging it with the original factory provided packaging. ▲

Safety

Review the following information carefully:

- Read and understand all instructions in this manual.
- Do not attempt to disassemble the instrument. If maintenance is required, return unit to the factory for qualified service.

WARNING The pDR-1500 should be operated only from the type of power sources described in this manual. ▲

- When replacing the four internal AA batteries, follow the instructions provided within this manual.
- Shut off pDR-1500 and any external devices (e.g., PC) before connecting or disconnecting them.

WARNING Shut off pDR-1500 before replacing the internal batteries, or when plugging in or disconnecting the AC power supply. ▲

- If the pDR-1500 is to be worn on an individual, please be sure that the belt clip is secured properly, or the pDR-1500 is secured firmly within a sufficient carrying device.

Positioning

The pDR-1500 can be operated in any position or orientation. Exposure to high intensity fluctuating light towards the interior of the sensing chamber, through the toroid inlet, should be avoided. Direct access of sunlight to the sensing chamber should be prevented through the use of the total particulate inlet adapter or an optional cyclone.

Typical modes of instrument support/handling include:

- Hand-held for surveying.
- Belt attached. Use belt clip kit provided as standard accessory. The unit can be worn on a waist belt, or for breathing zone monitoring a sampling tube can be used for extension to the airway.
- Table top operation. The pDR-1500 can be placed on a table on its base (i.e., resting on the belt-clip attachment).
- Tripod support kit (optional)

The inlet tube of the cyclone should be oriented away from the pDR-1500 by rotating the cyclone body within the toroid inlet. Always ensure unobstructed access to the cyclone/inlet when sampling the air directly in the instrument's vicinity. Alternatively, tubing can be connected to the cyclone/total inlet in order to extract a sample stream from a duct, chamber or other enclosed volume, or as an extension to the breathing zone. However, if the duct or chamber that an extracted sample is being drawn from is of an excessive vacuum, the pDR-1500 may not be appropriate for this purpose.

Air Sampling Guidelines

Caution: The pDR-1500 is not designed to sample highly corrosive aerosols or solvent fumes.

Area Monitoring

For typical area monitoring applications, the pDR-1500 should be placed and operated centrally within the area to be monitored, away from localized air currents due to fans, blowers, ventilation intakes/exhausts, etc. This is to ensure representative sampling within the area to be assessed.

Monitoring via Tubing

To sample using a length of tubing, the following guidelines should be applied:

- Minimize tubing length, especially horizontally running lengths.
- Minimize the number bends and angle of change in direction.
- Minimize tubing inner diameter thus maximizing transport velocity (a practical lower limit of about 2 mm, or 0.08 in. ID is indicated for reasons of excessive pressure drop).
- If possible, changes in inner diameter (at unions, couplings, etc.) should be incremental in the direction of flow, that is, the inner diameter should only increase in the direction of flow.
- Use non-electrostatic tubing. Best is electrically grounded metal or conductive plastic (black) tubing; Tygon™ is acceptable; and Teflon is **NOT** to be used.
- For tubing lengths of up to 2 m (6 ft), 6 mm ID (1/4 in. ID) plastic tubing with wall thickness of 1/16 in. is a practical size which can be stretched over the pDR-1500 inlet stem.

Instrument Layout

The user should become familiar with the location and function of all externally accessible controls, connectors and other features of the pDR-1500. Refer to Figure 2–1 through Figure 2–5. All related functions are externally accessible.

Qualified Thermo Fisher Scientific personnel should perform all repair and maintenance. Please contact the factory if any problem should arise. Do not attempt to disassemble the pDR-1500, except as described in Chapter 5, "Maintenance and Service", otherwise voiding of instrument warranty will result.

Front Panel

The front panel contains the five touch switches (keys) and the LCD screen required for the operation of the pDR-1500. The touch keys provide tactile ("popping") feedback when properly actuated. For more information on keys, see “Key Press Functions” on page 3-4

The two-line, 16-character per line LCD indicates either measured values of concentration (instantaneous and time averaged on the same screen), elapsed run time, maximum and short term excursion limit (STEL) values, operating and logging parameters, diagnostics, command prompting or other messages.

The LCD screen is backlit whenever the pDR-1500 is powered by its AC charger/power supply and is selected as an always on feature. When operating from the internal battery, the screen backlighting is disabled in order to conserve power.

Refer to Figure 2–1 for location of controls and display below.

Figure 2–1. Front Display

Rear Power Port

There is only one critical component on the rear panel of the pDR-1500 and this is the CHARGER/EXT. SUPPLY male receptacle. The AC power supply/charger provided with the pDR-1500 should be connected here whenever the internal batteries are exhausted or not present, and/or when running continuously from the AC line. Any other DC source (e.g., solar power supply, external battery, etc.) to be used to power the pDR-1500 would be connected at this location.

Refer to Figure 2–2 below for the location of items on the rear panel of the pDR-1500.

Figure 2–2. Rear Power Port

Side PM Inlet, USB, RS232/Analog

The pDR-1500 includes a Total Suspended Inlet for aerosol aspiration into the scattering chamber. Optional Cyclones are covered in Chapter 8, "Optional Accessories" and also in "Particle Size Cut Points".

The circular connector is multi-purpose and provides RS232 Serial Communication, ANALOG OUTPUT, and VOLTAGE ALARM outputs. Both 4 to 20 mA and 0 to 2 VDC are provided for analog outputs and the ALARM Output will close an alarm circuit up to 30 VDC. Interfacing with this connector is discussed in Chapter 7, "Outputs and Alarm".

The rectangular connector is the USB [Peripheral, standard type 'B', square] and is used for Serial communications. Interfacing with this connector is discussed later in this chapter.

Note Only the USB **or** the RS-232 can be used at one time for communications. ▲

In the figure below, the Total Inlet is shown. At this location either the Total Inlet or one of the optional cyclones are inserted for delivering a representative sample to the instrument. When the pDR-1500 is not in use, the inlet should be protected to prevent accidental entry of objects, debris, or other form of contamination into the sensing stage of the pDR-1500.

Refer to Figure 2–3 below for the location of items on the Side PM Inlet, USB, RS232/Analog Panel of the pDR-1500.

Figure 2–3. Side PM Inlet, USB, RS-232/Analog Panel

Side Filter Assembly and Exhaust

In the figure below, the feature on the left is the exhaust port of the pDR-1500. From this port, HEPA-filtered air is exhausted and may be used as a zero air source for the purpose of zeroing the optical background of the instrument.

The knurled circular feature is the filter holder assembly which houses a 37-mm filter. This filter has two purposes: (1) it protects the pump from any sampled aerosol, and (2) it doubles as a sample collection filter for gravimetric analysis (e.g., NIOSH 0600) and speciation.

Refer to Figure 2–4 below for the location of items on the Side Filter Assembly and Exhaust Port Panel of the pDR-1500.

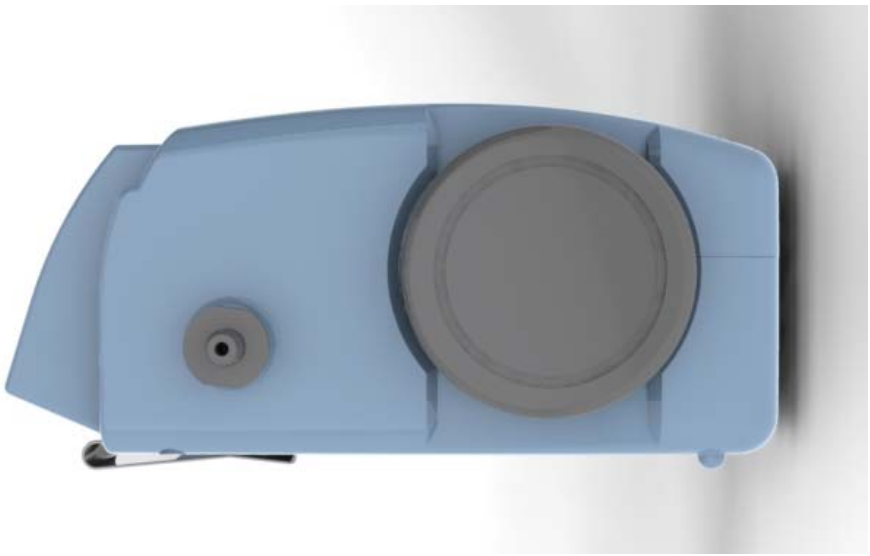


Figure 2–4. Side Filter Assembly and Exhaust

Bottom Battery and Belt Clip

In the figure below, two features are depicted. The first shows a transparent (for purpose of clarity) battery door. This battery door has a single captive thumbscrew to provide easy access to replace the 4 AA batteries. The +/- signs are embossed within the battery compartment to identify the battery positioning. Either Alkaline or rechargeable batteries can be used, however the pDR-1500 will **not** recharge these 4 AA batteries!

The second feature to be pointed out is the belt clip, which is to be used for personal aerosol monitoring.

Refer to Figure 2–5 below for the location of items on the Bottom Battery Door and Belt Clip Panel.

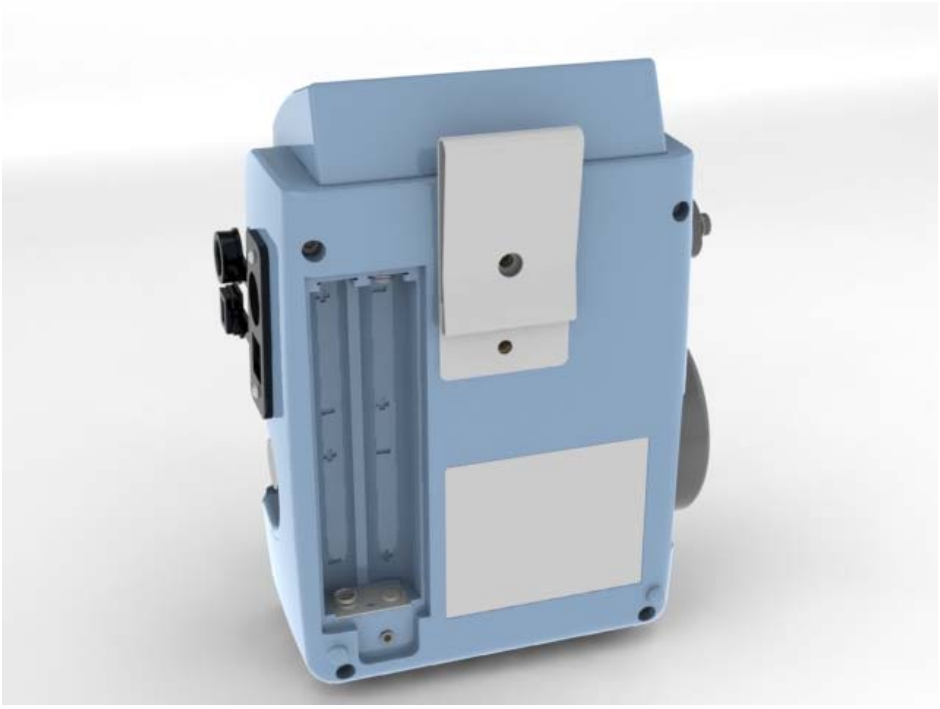


Figure 2–5. Bottom Battery Door and Belt Clip

Preparation for Operation

To begin using the pDR-1500, the user must first verify that either the AC/DC power supply is connected to both the instrument and suitable wall socket, or the instrument is installed with a fresh set of AA batteries.

Power Options

The pDR-1500 has two basic power options:

1. AC Power Supply

2. AA Batteries – Alkaline or NiMH

A universal line voltage AC to DC power supply is provided as standard accessory with the pDR-1500 and includes connection options for most global wall outlets. This power supply can be used with any line with a voltage between 100 and 240 VAC (50 to 60 Hz). When using that power supply, its output plug should be inserted into the external DC receptacle at the base of the pDR-1500 (see Figure 2–2). Insertion of that connector automatically disables the internal batteries of the instrument. Removal of the pDR-AC plug from the instrument automatically begins the draw of power from the internal batteries.

Within the rear battery cover are four AA batteries. Either Alkaline or NiMH batteries may be used, however the pDR-1500 will NOT charge the NiMH batteries if plugged into the universal AC/DC power supply.

Before Starting a Run

Before starting a measurement run, the instrument must be zeroed. For information on zeroing, see "Zeroing the pDR-1500" on page "3-10".

Insert a clean Total Inlet or Optional Cyclone, if not already installed. If tubing is to be used, unscrew the slotted inlet located at the entrance of the Total Inlet and attach the tubing to the barbed fitting. Please note that the pDR-1500 should never be in its run mode (pump operating) with the inlet blocked.

The pDR-1500 is shipped from the factory with a pre-populated 37-mm glass fiber filter cassette in place. See "Filter Replacement" on page 5-6 for procedures to replace this cassette.

Equipment Damage Please note that the important purpose of this filter cassette is to protect the pump. ▲

However, these filters can double as gravimetric filters and/or speciation collection filters.

If not in place already, install a 37-mm filter cassette with either a 37-mm glass fiber filter, or an optional 37-mm PVC membrane filter. Either a 37-mm glass fiber filter can be used as a filter support or a stainless steel filter support. Ensure that one of the two types of filter cartridges has been installed in the filter chamber accessible from the exhaust side panel of the pDR-1500 (see Figure 2–4).

In order to gain access to the filter chamber, the large knurled threaded plastic cap covering the filter chamber must be rotated counter-clockwise (as viewed from the side).

WARNING Do not leave this chamber open for any extended period of time, otherwise dust may settle on the internal optical surfaces. Hand-tighten the plastic cap firmly after filter cassette replacement to ensure a proper seal. At no time should the pDR-1500 be running without a filter in place, otherwise serious damage to the internal components may result. ▲

Electrical Connections

Plugging or unplugging any external equipment (e.g., computer, modem, alarm circuitry, etc.) should be made only while both the pDR-1500 and the external equipment are shut off, in order to prevent damage or interference due to transient electrical effects.

If AC power is not available and continuous operation over more than 20 hours is required, please consult with Thermo Fisher Scientific for a *Technical Note* regarding the use of an external battery or other DC source (e.g., solar power).

Environmental Constraints and Certifications

The pDR-1500 is designed to be reasonably dust and splash resistant; however, it is not weatherproof.

WARNING To operate the unit outdoors, provisions should be made to protect it from environmental extremes outside its specified range, and from any exposure to precipitation. ▲

The pDR-1500 is certified for compliance with the electromagnetic radiation limits for a Class B digital device, pursuant to part 15 of the FCC Rules. The unit also complies and is marked with the CE (European Community) approval for both immunity to electromagnetic radiation and absence of excessive emission interference.

The unit also complies with:

- ANSI/UL 61010-1:2004, 2nd Edition, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use – Part 1: General Requirements
- CAN/CSA C22.2 No. 61010-1:2004 2nd Edition, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use – Part 1: General Requirements
- CENELEC EN 61326-1
- FCC 47 CFR 15B cIA

Communications with Computer

The computer requirements to install and run the software provided with the pDR-1500 (pDR Port) is the following:

- IBM-PC compatible
- Pentium I or higher processor
- Minimum operating system: Windows 95 and later
- 32 MB of RAM
- 10 MB hard disk drive
- CD-ROM
- VGA or higher resolution monitor

Thermo Fisher Scientific custom hardware and software provided with pDR-1500 as standard accessories:

- RS-232 communications cable
- USB communications cable
- Software CD (pDR Port)

Software Installation Procedure

To install the Thermo Scientific provided software (pDR Port) in the computer, proceed as follows:

- Insert the CD labeled pDR Port into the computer
- The install program should start automatically
- The computer displayed install shield then serves to guide the rest of the installation.
- Please be sure to accept the Silicon Laboratories USB Driver installation.

Communication between pDR-1500 and Computer

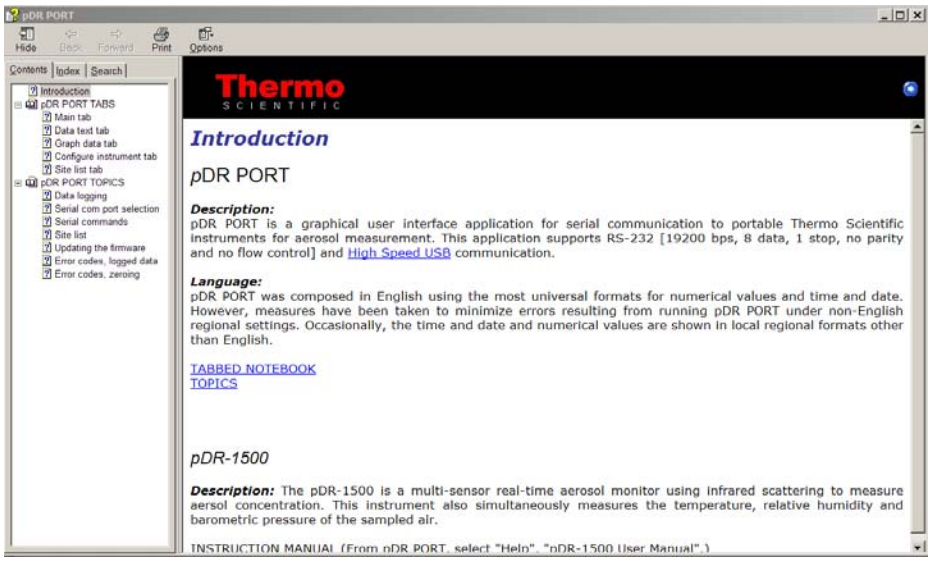
To effect the communication between the pDR-1500 (via the pDR Port software installed in the computer) and the PC, proceed as follows:

Equipment Damage It is recommended to turn the instrument and computer OFF before making a connection. ▲

- Connect the pDR-1500 to one of the computer's USB ports using the USB communication cable
- Key ON the pDR-1500; hold ON/OFF for **4 seconds**

- From your computer Start menu, or your computer desktop, open the pDR Port software program. A multi-tabbed notebook display should appear on the computer screen. From the menu bar or the embedded Settings window, the serial connection port can be selected (e.g., COM 4). Select the port to which the USB cable has connected to on you computer using the Select Port pop-up window and click OK to proceed. The user may now click on the Show Instrument Panel to emulate the instrument keypad or utilize the tabs within the pDR Port notebook display.

Most operations with the pDR Port software program are self-evidently labeled, including fly-over dialog boxes. In addition, instructions may be found in the On-line Help files by selecting Help and then Contents.

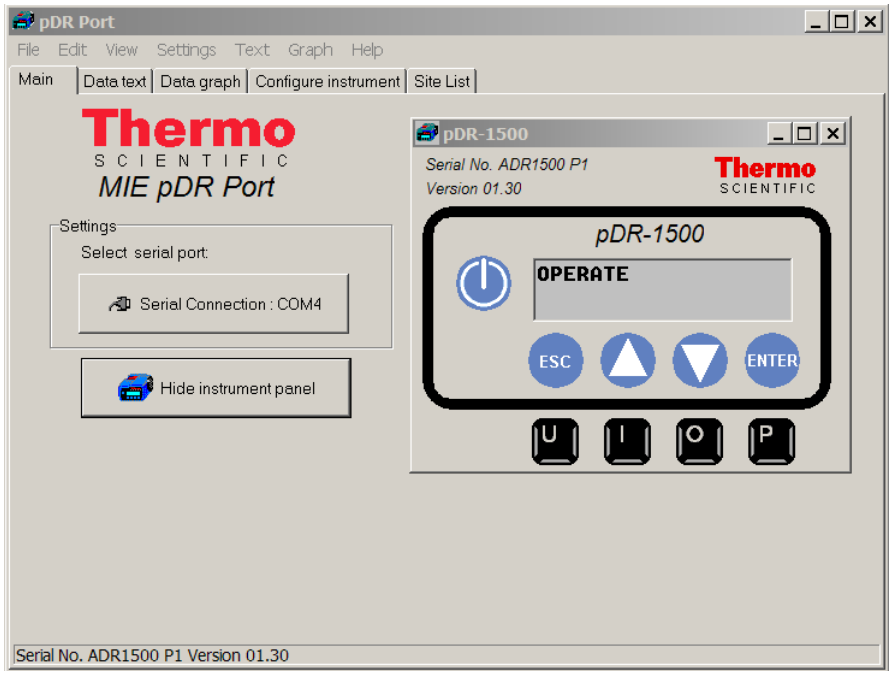


The following operating/logging parameters of the pDR-1500 can be selected (edited) via the computer:

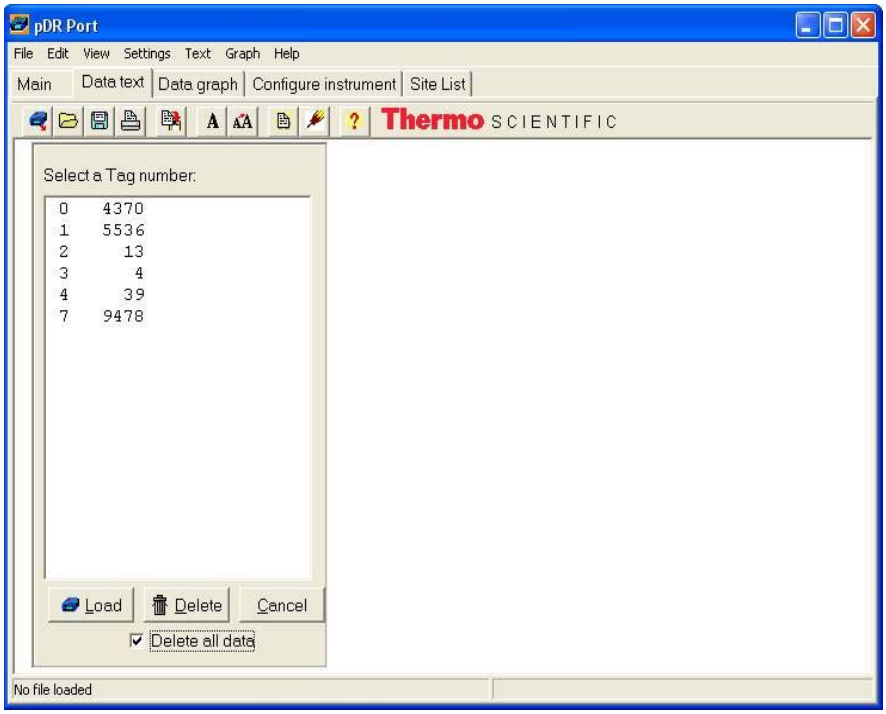
- Current date (year, month and day of the month)
- Current time (hour, minute and second)
- Display averaging time (1 to 60 seconds, in 1-second increments)
- Calibration factor (0.01 to 9.99, in 0.01 increments)
- Analog output full scale concentration (0.1, 0.4, 1, 4, 10, 40, 100, or 400 mg/m^3
- Analog output status (enabled or disabled)
- Alarm level (0.01 to 400.0 mg/m^3, in 1-µg/m^3 increments)
- Alarm status (enabled or disabled)
- Humidity correction (enabled or disabled)

The serial number of the pDR-1500 is transferred automatically to the PC and displayed on the screen. From the multi-tabbed notebook, select from the following options:

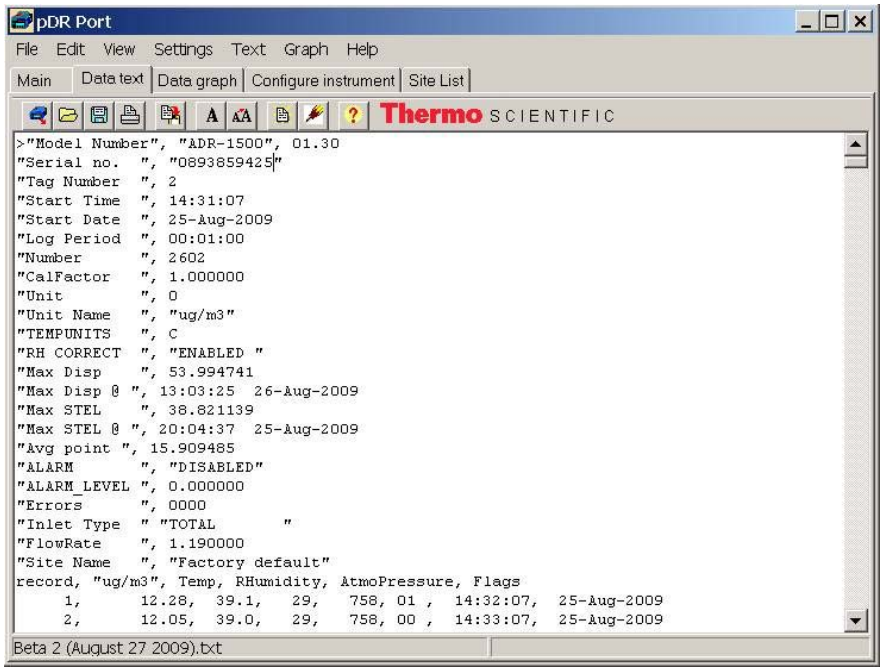
Main. This tab allows the user to select the serial port connection, and show or hide the instrument panel.



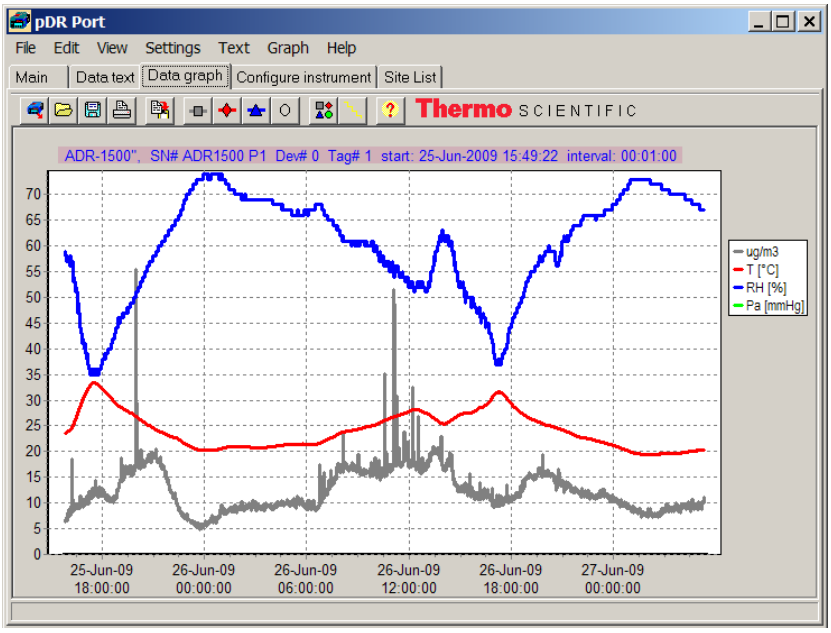
Data text. This tab allows the user to download, tabulate, print and delete data, or transfer to a CSV file of the data downloaded from the pDR-1500. First – click on the blue instrument icon ( ) in the upper left hand corner of this Data text Tab and the "Select a Tag number" window will appear. From this window, the user can select a single Tag (data file) to be loaded or deleted. In the image below, the "Delete all data" box appears with a check mark. By selecting this box and clicking on Delete, all tag files can be deleted at once.



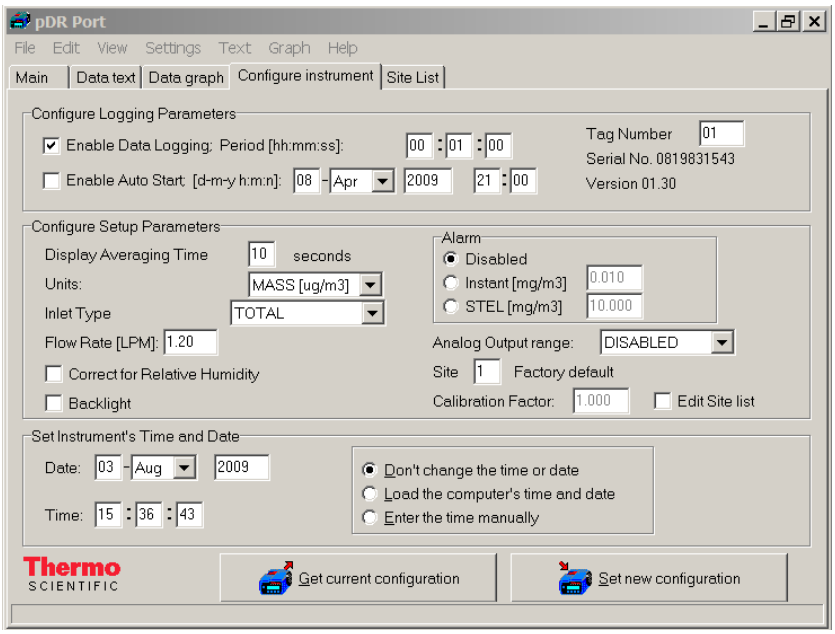
In this second image of the Data Text tab, it shows a Tag File loaded to the window. The data can now be viewed in the Data Graph tab and saved as a CSV file.



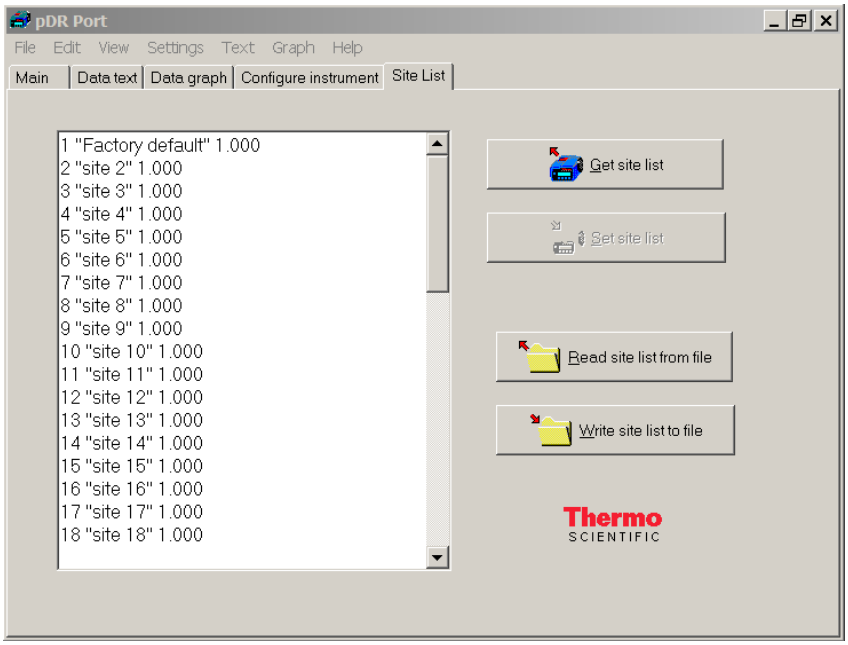
Data graph. This tab automatically plots the data from the Data text tab into a time series plot. Mass concentration or scattering coefficient, temperature, relative humidity and barometer pressure can all be plotted on this graph simultaneously or independently.



Configure instrument. This screen allows the user to edit the instrument configuration. Click on the item to be edited and select or type in the new value. To review the parameter values currently programmed into the pDR-1500, click on **Get current configuration**. After editing the parameters, click on **Set new configuration** to input the newly selected values into the pDR-1500.



Site List. This tab allows the user to retrieve, edit, and set the site list for the instrument. Site lists may also be read and written to a file on a computer.



Chapter 3
Operation

This chapter describes the instrument layout, keypad functions, menu-driven firmware, and starting a run. For details, see the following topics:

- "Operating Modes" on page 3-2
- "Keypad and Screen Cursor Functions and Operation" on page 3-3
- "Operate Menu" on page 3-6
- "Configure Menu" on page 3-14
- "Calibrate Menu" on page 3-24
- "Starting a Run" on page 3-28

Operating Modes

The pDR-1500 has five modes of Operation:

1. *Start-up.* This is accomplished by holding the ON/OFF key for **4 seconds** whereby the splash screen will appear.

2. *Run Mode.* This is when the instrument is measuring aerosol and operating with an active flow rate. Normally the instrument is set for data logging to be enabled in this mode.

3. *Standby.* This is when the instrument is in an idle mode during which the user is interfacing with the instrument menu, configuring the instrument, downloading data, calibration, or when the instrument is set to begin sampling via an auto-start.

4. *Zeroing.* This mode is used to establish the optical background (Rayleigh scattering) of the pDR-1500. During this mode of operation the user is required to install a zeroing tube that connects the inlet stem to a HEPA filter.

5. *Shutdown.* Accomplished by holding the ON/OFF key until text on screen is no longer visible. The instrument is off.

Keypad and Screen Cursor Functions and Operation

Before starting the pDR-1500, it is recommended that the user become familiar with the keypad functionality. There are three menus that outline the keypad functions and these are OPERATE, CONFIGURE, and CALIBRATE. Figure 3–1 below demonstrates the pDR-1500 menu structure. Following is a description of each menu.

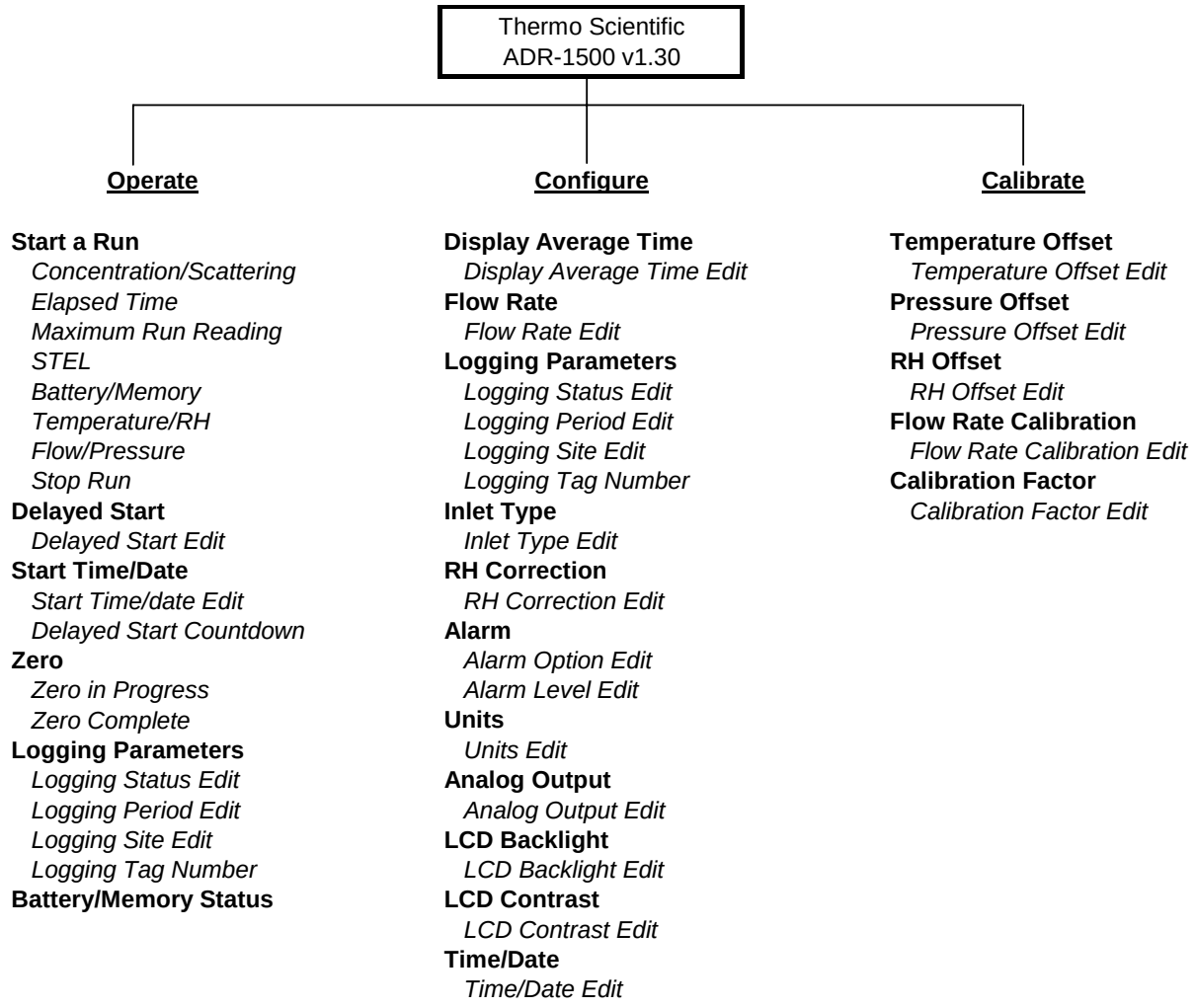


Figure 3–1. Keypad Overview

The Figure 3–2 below depicts the Operate Menu screen of the pDR-1500 after start-up and identifies the specific keys on the keypad.

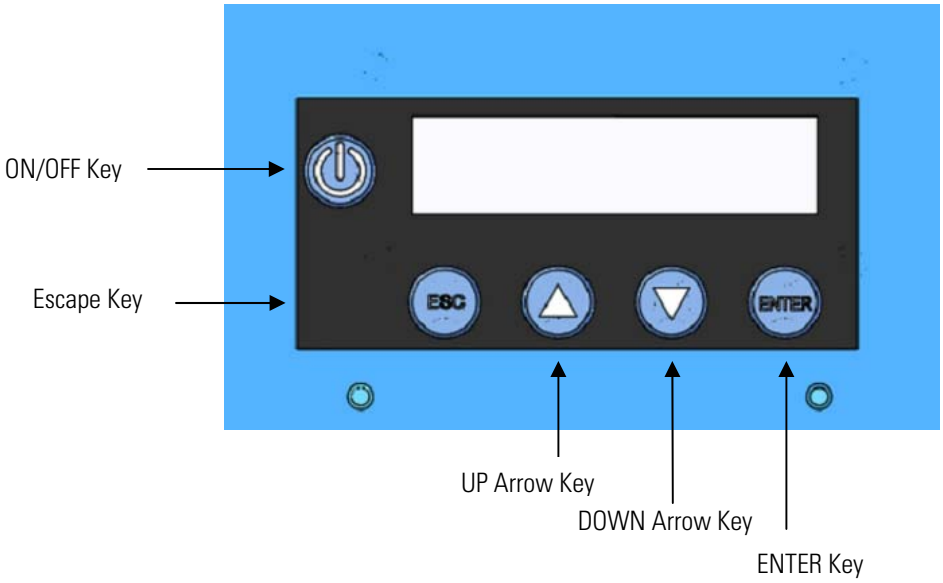


Figure 3–2. Keypad Functions

The equivalent of this screen is represented below, and this format will be used throughout the remainder of this Instruction Manual.

ON
OFF

OPERATE

ESC UP DOWN ENTER

Key Press Functions

The following is a general description of the key press functions:

- **ON/OFF** powers the instrument on or off. Press and hold ON/OFF for at least 4 seconds.
- **ESC** selects the display through which the current display was accessed (back up a level) or to bail out of an edit display without saving and return to the previous display from which the current display was assessed.
- **UP** (▲) scrolls through menu displays that are in a circular list (in a backward direction) or scrolls through values (also in a backward direction) in a display that is not part of a list (an edit display).

- **DOWN** (▼) scrolls through menu displays that are in a circular list (in a forward direction) or scrolls through values (also in forward direction) in a display that is not part of a list (an edit display).
- **ENTER** selects the function displayed on menu displays that are in a circular list, or used to exit and save the values as displayed in an edit display and return to the previous display from which the current display were accessed.

Note Holding down the ▲ or ▼ key will cause the rightmost digit to increase or decrease twice per second. After 5 seconds the next digit to the left will increase or decrease. Releasing the button returns control to the rightmost digit again. ▲

Startup

To place the pDR-1500 into the Startup mode, press and hold the ON/OFF key for 4 seconds until you hear a beep followed by the Splash Screen appearing with the backlight on. The following splash screen appears:

This screen appears for three seconds upon initiation of a power-up sequence, then default directly to the Operate Menu screen. In this screen you may scroll up or down to the Calibrate Menu or Configure Menu, respectively.

Operate Menu

The Operate Menu is used to access the list of displays allowing the user to access the operating modes and run-time parameters of the PDR-1500 including “Start A Run”, “Delayed Start”, “Zero”, “Logging Parameters” and “Battery/Memory Status”.

Start A Run

The Start A Run menu allows the user to begin monitoring/sampling. The run will be logged only if the asterisk (*) appears at the end of the first display line (see below). If the pDR-1500 is ready to begin a monitoring run, press **ENTER** and the instrument will begin operating as configured.

Equipment Damage Verify that the exhaust port and the inlet port are not blocked. ▲

- From the Operate Menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Start a Run screen.
- Press the **ENTER** key and the instrument will begin operating as configured.

Once a run is started, press the ▲ and ▼ keys to view a series of the following displays.

Concentration/Scattering

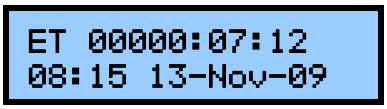
The instrument measures concentration or scattering coefficient of ug/m^3 for concentration or 1/Mm for scattering coefficient. The real-time concentration is presented on the first line and the time-weighted average is presented on the second line. The real-time concentration is an average taken over a time interval called “Display Time”, which is programmed by the user. The presence of the asterisk (*) in the first line indicates that data logging is enabled.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the Conc/Scat screen or press the **ESC** key to stop a run.

Elapsed Time

The Elapsed Time screen allows the user to view the elapsed time in hours, minutes and seconds on the first line and the start time and date of the run on the second line. After ten seconds of key pad inactivity, the display will return to the concentration/scattering screen.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the ET screen or press the **ESC** key to stop a run.



Maximum Run Reading

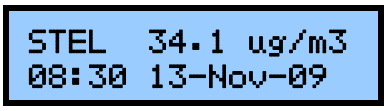
The MAX display screen allows the user to view maximum real-time reading (concentration or scattering coefficient) of the run and the time of occurrence. After ten seconds of key pad inactivity, the display will return to the concentration/scattering screen.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the Max screen or press the **ESC** key to stop a run.

STEL

The STEL screen allows the user to view STEL maximum reading concentration or scattering coefficient. The STEL is based on the average of the last 15 minutes prior to the time of occurrence. After ten seconds of key pad inactivity, the display will return to the concentration/scattering screen.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the Stel screen or press the **ESC** key to stop a run.



Battery/Memory

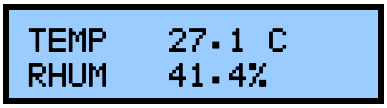
The Battery/Memory screen reads the battery voltage and the percentage of data logging memory left. After ten seconds of key pad inactivity, the display will return to the concentration/scattering screen.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the Battery/Memory screen or press the **ESC** key to stop a run.

Temperature/RH

The Temperature/RH screen allows the user to view the current ambient temperature (degrees Celsius) and relative humidity. After ten seconds of key pad inactivity, the display will return to the concentration/scattering screen.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the Temp/RH screen or press the **ESC** key to stop a run.



Flow/Pressure

The Flow/Pressure screen allows the user to view the flow rate in liters per minute and the (ambient) atmospheric pressure in millimetres mercury. After ten seconds of key pad inactivity, the display will return to the concentration/scattering screen.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the Flow/Pres screen or press the **ESC** key to stop a run.

Stop Run

The Stop Run screen offers the user to confirm that the run is to be stopped.

- From the Start a Run screen, press the **ENTER** key and scroll the ▲ or ▼ key to the Stop Run screen or press the **ESC** key to stop a run.
- Press the **Enter** key and the run is terminated.

Delayed Start

The Delayed Start screen offers the user to view and edit the delayed start status as “enabled” or “disabled”.

- From the Operate menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Delayed Start screen.

Delayed Start Edit

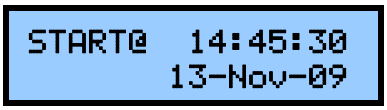
The Delayed Start Edit screen allows the user to edit the delayed start as “enabled” or “disabled”. The asterisk (*) appears to the left of the field being edited.

- From the Delayed Start screen, press the **ENTER** key to enable or disable a delayed start.

Start Time/Date

The Start Time/Date screen allows the user to view and edit the delayed start time and date. The instrument will store the start time and date regardless of whether Delayed Start is enabled or disabled. If the start time and date is earlier than the current time, then it defaults to the current time.

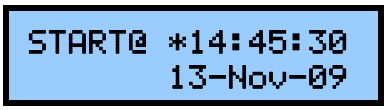
- From the Operate menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Start@ screen.



Start Time/Date Edit

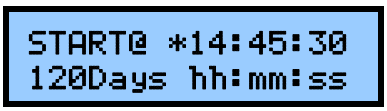
The Start Time/Date Edit screen allows the user to edit the delayed start time and date. In the display, the **ENTER** and the **ESC** keys provide navigation through six fields within the display in the following sequence: hours, minutes, seconds, years, months, and days. The **ENTER** key navigates forward while the **Esc** key navigates backwards. The ▲ and ▼ keys are used to increment/decrement the field values. The asterisk (*) appears to the left of the field being edited.

- From the Start@ screen, press the **ENTER** key and to advance to edit the next field, except if day (of month) is selected: the delayed start time and date saved, the delayed start status is enabled, and the display advances to Delayed Start Countdown.



Delayed Start Countdown

The Delayed Start Countdown screen displays the time of day that the pDR-1500 will start a run on the first line and the amount of time remaining before the instrument starts this run in days, hours, minutes, and seconds. The presence of the asterisk in the first line indicates that data logging is enabled.



Zeroing the pDR-1500

The Zero Instrument screen is used to initiate a zero sequence to measure and store the optical background. The second line displays advice to the user that a filter must be applied to the Total Inlet to provide clean (particulate-free) air to the optics for this process.

- From the Operate menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Zero Instrument screen.

Note Do not zero through the red or blue sharp-cut cyclones. Only zero through a clean Total Inlet. ▲

Zero In Progress

The Zeroing screen is shown while the pDR-1500 is performing a background measurement and optical signal offset adjustment, and key functions are different.

- From the Zero Instrument screen, press the **ENTER** key and the display advances to Zero in Progress (Zeroing).

Note Please be sure a HEPA filter is installed to a clean Total Inlet during this procedure to ensure proper measurements. Do not zero through the cyclones. ▲

Zero Complete

After zeroing is complete, if the measurement was successful and within specification, the following screen appears. If the measurement was successful and outside of specification the instrument will respond with "COMPLETE: BKG HI". If diagnostics indicated that measurement was compromised, the instrument will respond with "FAILURE 0x00ee", where 0x00ee is a hex code indicating the type of error the diagnostic failure encountered during background measurement. Re-zero the instrument. After three attempts, contact customer service.

Logging Parameters

The Logging Parameters display screen indicates on the first line whether data logging is enabled or disabled. The second line of this screen displays the logging period for 3 seconds, displays site label for 3 seconds, and tag number for 3 seconds in sequence.

- From the Operate menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Logging screen.

Logging Status Edit

The Logging Status Edit screen allows the user to enable or disable data logging. The asterisk (*) appears to the left of the field being edited.

- From the Logging Parameters screen, press the **ENTER** key and the display advances to Logging Period Edit.
- Press the **ENTER** key enable or disable data logging.

Logging Period Edit

The Logging Period Edit screen allows the user to the logging period. The asterisk (*) appears to the left of the field being edited. The ▲ and ▼ keys are used to increment/decrement the time. If either button is held, then the logging period will change twice per second but the editing focus will switch to the digit on the left after the button is held for five seconds.

- From the Logging Parameters screen, press the **ENTER** key and the display advances to Logging Period Edit.
- Press the **ENTER** key to enable or disable data logging.

Logging Site Edit

The Logging Site Edit screen allows the user to select from the list of 50 logging sites. Each site has three associated values: Site Number, a Site Name, and a Calibration Factor. The Site Name is the only value displayed

on the second line. Pressing the ▲ and ▼ keys changes the Site Number and the corresponding Site Name appears on the second line. Also, the corresponding Calibration Factor is chosen. The Site Numbers are in range (1, 2, 3..., 50), the Site Names and Calibration Factors are editable only by external serial command. The asterisk (*) appears to the left of the field being edited.

- From the Logging Parameters screen, press the **ENTER** key and the display advances to Logging Period Edit.
- Press the **ENTER** key to save Site selection and forward to Logging Tag Number.

Logging Tag Number

The Logging Tag Number screen allows the user to select the tag no. (00, 01, 02...99), a number assigned to a logged run as label to access/retrieve the stored data. The asterisk (*) appears to the left of the field being edited.

- From the Logging Parameters screen, press the **ENTER** key and the display advances to Logging Period Edit.
- Press the **ENTER** key to save Site selection and forward to Logging Tag Number.

Battery/Memory Status

The Battery/Memory Status screen reads the internal battery voltage on the first line and the percentage of the un-written memory on the second.

- From the Operate menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Battery/Memory screen.

Configure Menu

The Configure Menu is used to access the list of displays allowing the user to configure how the instrument measures and logs data including “Display Avg Time”, “Flow Rate”, “Logging Parameters”, “Inlet Type”, “RH Correction”, “Alarm”, “Units”, “Analog Output”, “LCD Backlight”, LCD Contrast” and “Time/Date”.

Display Average Time

The Display Average Time screen offers the user to adjust the running (boxcar) average time of the displayed concentration (or scattering coefficient) between 1 and 60 seconds. The average concentration displayed is the value scaled to the analog output and offered as an alarm criterion.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Display Avg Time screen.

Display Average Time Edit

The Display Average Time Edit screen allows the user to change the running average displayed on the screen between 1 and 60 seconds. This also doubles as the running average that is provided as an analog output and also as one of the values that triggers the alarm. Use the ▲ and ▼ keys to increase or decrease the display average time by seconds. The asterisk (*) appears to the left of the field being edited.

- From the Display Avg Time screen, press the **ENTER** key and edit the display averaging time.
- Press the **ENTER** key to save the display averaging time and return to Display Avg Time screen.

Flow Rate

The Flow Rate screen displays the set flow rate and the corresponding cyclone mass median diameter 50% cut point (D50).

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Flow Rate screen.

Flow Rate Edit

The Flow Rate Edit screen allows the user to edit the volumetric flow rate. The flow range is 1–3.5 L/min and if a cyclone has already been chosen, the corresponding 50% aerodynamic cut point (D50 in micrometers) will change simultaneously. Use the ▲ and ▼ keys to increase or decrease the flow rate in increments of 0.01 LPM. The asterisk (*) appears to the left of the field being edited.

- From the Flow Rate screen, press the **ENTER** key and edit the flow rate.
- Press the **ENTER** key to save the flow rate and return to the Flow Rate screen.

Logging Parameters

The Logging Parameters display screen indicates on the first line whether data logging is enabled or disabled. The second line of this screen displays the logging period for 3 seconds, the site label for 3 seconds, and the tag number for 3 seconds in sequence.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Logging screen.

Logging Status Edit

The Logging Status Edit screen allows the user to enable or disable data logging. The asterisk (*) appears to the left of the field being edited.

- From the Logging Parameters screen, press the **ENTER** key and edit the logging status.
- Press the **ENTER** key to save the logging status and forward to the Logging Period edit.

Logging Period Edit

The Logging Period Edit screen allows the user to edit the logging period. The asterisk (*) appears to the left of the field being edited. Use the ▲ and ▼ keys to increment or decrement the time. If either button is held, then the logging period will change twice per second but the editing focus will switch to the digit on the left after the button is held for five seconds.

- From the Logging status screen, press the **ENTER** key to edit the logging period.
- Press the **ENTER** key to save the logging period and forward to the Logging Site edit.

Logging Site Edit

The Logging Site Edit screen allows the user to select from the list of 50 logging sites. Each site has three associated values: Site Number, a Site Name, and a Calibration Factor. The site name is the only value displayed on the second line. Use the ▲ and ▼ keys to change the site number and the corresponding site name appears on the second line. Also, the corresponding calibration factor is chosen. The site numbers are in range (1, 2, 3..., 50), the site names and calibration factors are editable only by external serial command. The asterisk (*) appears to the left of the field being edited.

- From the Logging Period screen, press the **ENTER** key to edit the logging site.
- Press the **ENTER** key to save the logging period and forward to the Logging Site edit.

Logging Tag Number

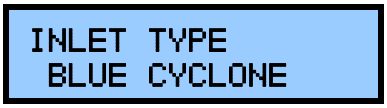
The Logging Tag Number screen allows the user to select the tag no. (00, 01, 02...99), a number assigned to a logged run as label to access/retrieve the stored data. The asterisk (*) appears to the left of the field being edited.

- From the Logging Site screen, press the **ENTER** key to edit the logging tag number.
- Press the **ENTER** key to save Site selection and return to the Logging Parameters display screens.

Inlet Type

The Inlet Type screen allows the user to select the inlet type being used (Red, Cyclone, or Total).

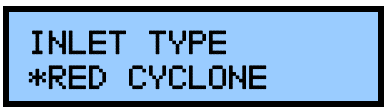
- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Inlet Type screen.



Inlet Type Edit

The Inlet Type Edit screen allows the user to select the type of inlet being used. Inlet types are: Cyclone, Blue Cyclone or Total Inlet. Use the ▲ and ▼ keys to change the inlet type. The asterisk (*) appears to the left of the field being edited.

- From the Inlet Type screen, press the **ENTER** key to edit the inlet type.
- Press the **ENTER** key to save the inlet type and return to the Inlet Type screen.



RH Correction

The RH Correction screen allows the user to view whether RH correction is enabled or disabled.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the RH Correction screen.

Note RH Correction should be enabled when the RH is expected to exceed 50–60%. Ambient monitoring should always use the RH Correction as being enabled. However, precision can be affected between collocated devices. ▲

RH Correction Edit

The RH Correction Edit screen allows the user to enable or disable RH correction. The asterisk (*) appears to the left of the field being edited

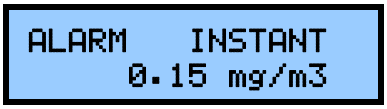
- From the RH Correction screen, press the **ENTER** key to edit the RH correction.
- Press the **ENTER** key to save the RH correction and return to the RH Correction screen.

Alarm

The Alarm screen indicates the alarm options for triggering the alarm (Disabled, Instant, or STEL) and the value at which it is triggered. The instant setting causes the alarm to be triggered when the displayed concentration is higher than the instant alarm level setting. The STEL setting causes the alarm to be triggered when the 15 minute rolling (boxcar) average is higher than the STEL alarm level setting. Each of the two enabled alarm options use separately stored alarm level values.

Note The units mg/m^3 are replaced with /km when the pDR-1500 is measuring scattering coefficient, using the units 1/Mm. ▲

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Alarm screen.



Alarm Option Edit

The Alarm Option Edit screen allows the user to edit the alarm. Alarm options are: Instant, STEL, or Disabled. Use the ▲ and ▼ keys to change the alarm option. The asterisk (*) appears to the left of the field being edited.

- From the Alarm screen, press the **ENTER** key and edit the alarm option.
- Press the **ENTER** key to save the alarm option and forward to the Alarm Level edit screen.

Alarm Level Edit

The Alarm Level Edit screen allows the user to edit the alarm for which the alarm is triggered. Use the ▲ and ▼ keys to increase or decrease the alarm level by 0.001 mg/m^3. The asterisk (*) appears to the left of the field being edited.

- From the Logging status screen, press the **ENTER** key to edit the alarm level.
- Press the **ENTER** key to save the alarm option and return to the Alarm screen.

Units

The Units screen allows the selection of units from micrograms per cubic meter (µg/m^3) or to a measure of the aerosol scattering coefficient in units of inverse mega meters (1/Mm).

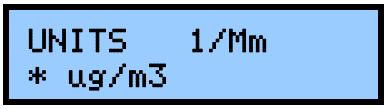
Note When the units /Mm are chosen, the RH correction becomes automatically disabled. ▲

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Units edit screen.

Units Edit

The Units Edit screen allows the user to change the option for units. Use the ▲ and ▼ keys to toggle between the two unit options. The asterisk (*) appears to the left of the field being edited.

- From the Units screen, press the **ENTER** key to edit the units.
- Press the **ENTER** key to save the units and return to the Units screen.



Analog Output

The Analog Output screen indicates the status of the analog output (enabled/disabled) and offers the user the option to enable or disable the analog output and change the analog span range in corresponding units of measure (ug/m^3 or 1/Mm). The proportional voltage output range is 0–2 VDC for the analog output.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Analog Output screen.

Analog Output Edit

The Units Edit screen allows the user to configure the analog output. The values offered for selection are compatible with the selected units. The values offered for /Mm (scattering coefficient) are: disabled, 10/Mm, 100/Mm, 1000/Mm, 10000/Mm, and 100000/Mm. The values offered for µg/M^3 (concentration) are: disabled, 0.10 mg/m^3, 0.40 mg/m^3, 1.00 mg/m^3, 4.00 mg/m^3, 10.0 mg/m^3, 40 mg/m^3, 100 mg/m^3, 400 mg/m^3, and

1000 mg/m^3. Use the ▲ and ▼ keys to cycle through the list of analog output items. The asterisk (*) appears to the left of the field being edited.

- From the Analog Output screen, press the **ENTER** key to edit the analog output.
- Press the **ENTER** key to save the analog output selection and return to the Analog Output screen.

LCD Backlight

The LCD Backlight screen displays whether the backlight is enabled or disabled and offers the user to choose whether to enable or disable the LCD backlight. If the backlight is enabled and the instrument is running solely from battery power, the backlight will come on for a period of 10 seconds after each keystroke. Thereafter, the backlight will automatically shut off in an effort to conserve power. If running on external power supply, the LCD backlight stays on.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the LCD Backlight screen.

LCD Backlight Edit

The LCD Backlight Edit screen allows the user to enable or disable the LCD backlight. Use the ▲ and ▼ keys to toggle between enable or disable. The asterisk (*) appears to the left of the field being edited.

- From the LCD Backlight screen, press the **ENTER** key to edit the LCD backlight.
- Press the **ENTER** key to save the LCD backlight status and return to the LCD Backlight screen.

LCD Contrast

The LCD Contrast screen allows the user to view and edit the contrast of the display. Lower settings darken the contrast and make the display more readable at colder temperatures. Higher settings lighten the contrast and make the display more readable at warmer temperatures. The nominal setting is 25.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the LCD Contrast screen.

LCD Contrast Edit

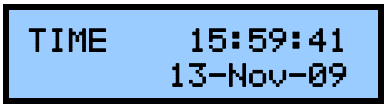
The LCD Contrast Edit screen allows the user to edit the contrast of the display. Use the ▲ and ▼ keys to increment or decrement the LCD contrast. The asterisk (*) appears to the left of the field being edited.

- From the LCD Contrast screen, press the **ENTER** key to edit the LCD contrast.
- Press the **ENTER** key to save the LCD contrast status and return to the LCD Contrast screen.

Time/Date

The Time/Date screen displays the current time and date and offers the user to re-program the time and date.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Time/Date screen.

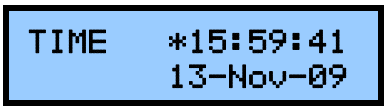


Time/Date Edit

The Time/Date Edit screen allows the user to edit the current time and date. The Start Time/Date Edit screen allows the user to edit the delayed start time and date. In the display, the **ENTER** and the **ESC** keys provide

navigation through six fields within the display in the following sequence: hours, minutes, seconds, years, months, and days. The **ENTER** key navigates forward while the **Esc** key navigates backwards. The ▲ and ▼ keys are used to increment/decrement the field values. The asterisk (*) appears to the left of the field being edited.

- From the Time/Date screen, press the **ENTER** key to and to advance to edit the next field.
- Press the **ENTER** key to save the time/date and return to the Time/Date screen.



Calibrate Menu

The Calibrate Menu is used to access the list of displays allowing the user to calibrate the sensors used to measure scattering, temperature, relative humidity, barometric pressure, flow rate, and the time and date. The displays include “Temp Offset”, “Pressure Offset”, “RH Offset”, “Flow Rate Cal”, and “Cal Factor”.

Temperature Offset

The Temperature Offset screen allows the user to view and edit the temperature offset of the measurement to coincide with their traceable standards.

- From the Calibrate Menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Temp Offset screen.

Temperature Offset Edit

The Temperature Offset Edit screen allows the user to edit the temperature offset. Use the ▲ and ▼ keys to increase or decrease the user temperature offset in increments of 0.1 in degrees Celsius. The asterisk (*) appears to the left of the field being edited.

- From the Temp Offset screen, press the **ENTER** key and edit the temperature offset.
- Press the **ENTER** key to save the temperature offset and return to Temp Offset screen.

Please note that a precise and accurate calibration of the RH-sensor is critical to maintaining precision between collocated devices when using RH Correction enabled.

Pressure Offset

The Pressure Offset screen allows the user to view and edit the pressure offset of the barometric pressure measurement to coincide with their traceable standards.

- From the Calibrate Menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Pressure Offset screen.

Pressure Offset Edit

The Pressure Offset Edit screen allows the user to edit the pressure offset. Use the ▲ and ▼ keys to increase or decrease the user pressure offset in increments of 1 in millimetres of mercury. The asterisk (*) appears to the left of the field being edited.

- From the Pressure Offset screen, press the **ENTER** key and edit the pressure offset.
- Press the **ENTER** key to save the user pressure offset and return to Pressure Offset screen.

RH Offset

The RH Offset screen allows the user to view and edit the RH offset of the barometric pressure measurement to coincide with their traceable standards.

- From the Calibrate Menu, press the **ENTER** key and scroll the ▲ or ▼ key to the RH Offset screen.

RH Offset Edit

The RH Offset Edit screen allows the user to edit the RH offset. Use the ▲ and ▼ keys to increase or decrease the RH offset in increments of 0.1% RH. The asterisk (*) appears to the left of the field being edited.

- From the RH Offset screen, press the **ENTER** key and edit the RH offset.
- Press the **ENTER** key to save the user RH offset and return to the RH Offset screen.

Flow Rate Calibration

The Flow Rate Calibration screen allows the user the option to perform a multi-point inlet flow calibration.

- From the Calibrate Menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Flow Rate Cal screen.

Flow Rate Calibration Edit

The Flow Rate Calibration Edit screen allows the user to calibrate the six flow control settings and define the flow rate at each flow control setting. This will build a table of the six calibration point to be used for interpolating the flow control setting to achieve the flow rate set in the Configure menu's "Flow Rate Edit".

The flow rate calibration is accomplished in a sequence of six displays for six flow calibration points, setting the six flow control settings for the corresponding six defined flow rate setting. The **ENTER** and **ESC** keys are used to navigate through the edit fields, while the ▲ and ▼ keys are used to increase and decrease the values. The asterisk (*) appears to the left of the field being edited.

For factory settings, the flow control adjust is adjusted for flow calibration points (1, 2, 3, 4, 5, and 6) to produce corresponding defined flow rates (1.00, 1.50, 2.00, 2.50, 3.00, and 3.50 liters per minute) and the defined flow rates are kept at the factory default setting. The user may, however, redefine the defined flow rate for each flow calibration point to get a more accurate calibration. However, the defined flow rate values must increase in value as the flow calibration point increases.

In the following screen there are two values shown; ADJ = 188 and LPM = 1.00. In this screen the 188 is the pump speed control value used to achieve 1.00 L/min. The user may adjust the motor speed to achieve 1.00 L/min or

may adjust the measured inlet flow rate that is equal at that pump speed. After pressing the **ENTER** key, the next calibration point is pursued.

Note Should the temperature and pressure be re-calibrated, the accuracy of the flow calibration should be verified. ▲

- From the Flow Rate Cal screen, press the **ENTER** key to navigate forward, until last step (flow calibration point 6, defined flow rate) the display returns to the Flow Rate Cal screen and the new calibration is saved only if at least one of the values was edited.

Calibration Factor

The Calibration Factor screen shows the site number selected and allows the user to edit the calibration factor for that site number. The calibration factor is the value used to scale the concentration output to agree with a primary calibration or user defined standard.

In the following screen, the pDR-1500 shows the instrument is operating for Site 1, and the Calibration Factor is 1.000 which will provide a 1:1 response with the factory calibration. For more information about calibration, see Chapter 4, "Calibration and Particle Size Selection".

- From the Calibrate Menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Cal Factor screen.

Calibration Factor Edit

The Calibration Factor Edit screen allows the user to edit the calibration factor values. Use the ▲ and ▼ keys to increase or decrease the value by 0.001. The asterisk (*) appears to the left of the field being edited.

- From the Cal Factor screen, press the **ENTER** key and edit the values.
- Press the **ENTER** key to save the calibration factor associated with the site number and return to Cal Factor screen.

Starting a Run

The following provides a brief overview of how to start a monitoring and sampling run.

Filter Requirements

Before starting a run, a 37-mm filter must be inserted downstream of the optical assembly. The recommended 37-mm filters are glass microfibre filters. If using the 5-micron PVC filters, use the glass microfibre filters as a backing media when using battery power.

Equipment Damage At no time should the pDR-1500 be running without a filter in place, otherwise serious damage to the internal components may result. ▲

ZERO/Initialize Operation

Before initiating a measurement run it is advisable to perform the zeroing and automatic internal check out sequences, to ensure optimal operation.

- From the Operate menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Zero Instrument screen.

Attach a HEPA filter to the Total Inlet and press **ENTER**. Do not zero through the cyclone.

During zeroing, each range within the auto-ranging potential is used to measure the optical background of the instrument and each value is stored for subsequent data calculations. The duration of a Zero Operation is usually 2-3 minutes. After Zeroing is complete, the following screen should be present:

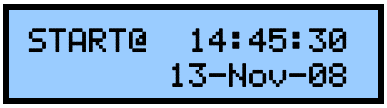
- From the Zero Instrument screen, by pressing the ▼ key, the user proceeds to a series of logging screens in the following order:

In the screens above, by pressing the **ENTER** key, the user can edit the logging tag number, the logged averaging period, and the logging site name.

Auto-Start (Optional)

The desired time and date for the automatic start of a run and data logging can be selected as described previously. This feature is optional.

- From the Operate menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Start@ screen.



In this screen, the user can press **ENTER** to alter a delayed start time and date for the pDR-1500. If this feature is selected, the instrument will remain in Standby mode until the current time reaches the start time.

Configuration Review

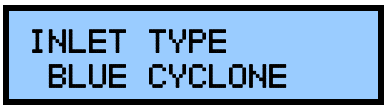
In addition to the description of the "Configure Menu" earlier in this chapter, the configuration of the instrument should be reviewed prior to beginning a run.

In addition to assuring that the data logging features are set, the three most important configuration settings to review are the:

- Inlet Type – Total, Red Cyclone, or Blue Cyclone
- The Flow Rate and respective D50 cut-point, and
- The Enabling or Disabling of the RH Correction

The inlet type, flow rate, and respective particle cut-point (D50) are described in "Particle Size Cut Points" on page 4-5.

- From the Configure menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Inlet Type screen.



In the above screen, the Inlet Type is shown. By pressing **ENTER**, the inlet can be changed from Total to Red Cyclone or Blue Cyclone. If a cyclone is selected, the D50 cut-point will change depending upon the flow rate selected.

When the relative humidity correction function is enabled, the particle growth effect due to a high humidity environment is corrected for. This means that the computed mass concentration is based on the original dry environment particle population. This correction only applies when mass concentration units have been selected, but not when scattering coefficient has been selected.

As with any light scattering device, the scattering efficiency of an aerosol will increase with an increased relative humidity. Furthermore, the scattering efficiency of a particle is maximized when the particle diameter is the same as the wavelength of the incident light. In the case of the pDR-1500 an 880 nm LED light source is used and a RH Correction has been implemented based on data taken from multiple field evaluations. When enabled, the pDR-1500 will normalize the response to a relative humidity of 40% when the measured RH > 40 %. Although the RH Correction is effective at providing a more accurate response, the connector can affect the precision between two instruments.

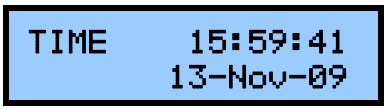
Additional Configuration parameters are the Alarm setting, units of measure, and the Analog Output settings.

By pressing the **ENTER** Key, the user can enable the Alarm whereby the concentration required to trigger the alarm can be adjusted from 0.01 – 400 mg/m^3.

In the screen above, the units of measure can be changed from either micrograms per cubic meter (µg/m^3) to a measure of the aerosol scattering coefficient in units of inverse megameters (1/Mm), whereby the RH Correction should become automatically disabled.

The user can enable or disable the analog output and change the analog span range in corresponding units of measure (µg/m^3 or 1/Mm). The voltage output range is 0-2 VDC for the analog output. The Analog output settings are 0 - 0.1, 0 - 0.4, 0 - 1.0, 0 - 4.0, 0 - 10, 0 - 40, 0 - 100, 0 – 400, and 0 – 1,000 mg/m^3.

The last configuration screen is to set the time. This screen is used to set the time and date, should these require resetting.



In the screen above the current time and date are displayed and may be adjusted as necessary. The first line indicates the time presently registered by the pDR-1500. The second is the present date registered by the pDR-1500.

To set the time accurately, press **ENTER** and a flashing asterisk (*) will appear to the left of the character to change. Adjust the value using the up and down keys and press **ENTER**. The asterisk will move throughout the screen to adjust each respective value.

In the U.S., it is convenient to dial 1-900-410-8463 (U.S. Naval Observatory time information), and at the instant when the time

announced equals the time preset on the second line of the above screen, key **ENTER**, as instructed on the last line.

Start the Run

To start the run, press **ENTER** from the Operate menu.

- From the Operate Menu, press the **ENTER** key and scroll the ▲ or ▼ key to the Start a Run screen.

In this screen, the pDR-1500 prompts the user regarding the valve, which is just an assurance that the exhaust port and the inlet port are not blocked. If the pDR-1500 is ready to begin a monitoring run, press **ENTER** and the instrument will begin operating as configured.

It should be remembered that the measurement units can only be selected in the set-up mode and not during a run.

Chapter 4
Calibration and Particle Size Selection

The following sections discuss the calibration process and procedures for calibrating the instrument:

- "Factory Calibration" on page 4-2
- "How to Apply a Correction Factor" on page 4-3
- "Particle Size Cut Points" on page 4-5

Factory Calibration

For mass concentration measurements, each pDR-1500 is factory calibrated against a set of reference monitors that, in turn, are periodically calibrated against a gravimetric standard traceable to the National Institute of Standards and Testing (NIST).

The primary factory reference method consists of generating a dust aerosol by means of a fluidized bed generator, and injecting continuously the dust into a mixing chamber from which samples are extracted concurrently by two reference filter collectors and by two master real-time monitors that are used for the routine calibration of every pDR-1500.

The primary dust concentration reference value is obtained from the weight increase of the two filters due to the dust collected over a measured period of time, at a constant and known flow rate. The two master real-time monitors are then adjusted to agree with the reference mass concentration value (obtained from averaging the measurements of the two gravimetric filters) to within ±1%.

Three primary, NIST traceable, measurements are involved in the determination of the reference mass concentration: the weight increment from the dust collected on the filter, the sampling flow rate, and the sampling time. Additional conditions that must be met are: a) suspended dust concentration uniformity at all sampling inlets of the mixing chamber; b) identical sample transport configurations leading to reference and instrument under calibration; and c) essentially 100% collection efficiency of filters used for gravimetric reference for the particle size range of the test dust.

The test dust used for the factory calibration of the pDR-1500 is SAE Fine (ISO Fine) supplied by Powder Technology, Inc. It has the following physical characteristics (as dispersed into the mixing chamber):

- Mass median aerodynamic particle diameter: 2 to 3 µm
- Geometric standard deviation of lognormal size distribution: 2.5
- Bulk density: 2.60 to 2.65 g/cm^3
- Refractive index: 1.54

In addition to the mass calibration described above, the pDR-1500 is factory calibrated for temperature, relative humidity, barometric pressure, and volumetric flow rate using NIST-traceable standards.

How to Apply a Correction Factor

If desired, the pDR-1500 can be calibrated gravimetrically for a particular aerosol (dust, smoke, mist, etc.), other than SAE Fine, under field conditions (actual conditions of use). To effect such calibration in the particle environment of interest, proceed as indicated below:

- Place the pDR-1500 within the particle environment.
- Start a run.
- After 1-minute, record the time weighted average (TWA).
- Calculate the run time (t) necessary to collect at least 1 milligram of sample using the following equation:

$$(t) = \frac{500}{TWA}$$

For example, if the 1-minute TWA = 2.5 mg/m^3, the run time necessary to collect approximately 1 mg of sample equals 200 minutes (i.e., t = 200 minutes).

Now that the run time (t) has been calculated from the above 1-minute preliminary test, proceed with the following steps using the optional 37-mm filter assembly:

- Perform a tare weight on a fresh 37-mm filter using a microbalance with at least a 0.001 mg resolution and place into the filter assembly.
- Record the tare weight (m_1).
- Load the filter assembly into the pDR-1500 in place of the large capacity HEPA filter.
- Place the pDR-1500 within the particle environment of choice
- Start a run using a 1-minute data logging.
- Allow the pDR-1500 to run for the run time calculated from the preliminary test (e.g., t = 200 minutes).
- At the end of the run, record the TWA (mg/m^3) run time t (minutes) and flow rate (LPM).
- Stop the run.
- Recover the 37-mm filter assembly from the instrument and return to the microbalance room for weighing.
- Remove the 37-mm filter from the assembly, and weigh the filter after equilibration and anti-static neutralization, as necessary.

- Record the filter gross weight (m_2).
- Calculate the mass increment (Δm) due to the collected particles, as follows:

$$\Delta m = m_2 - m_1$$

With the net mass (Δm) recorded in unit of milligrams, run time (t) recorded in minutes, and flow rate (Q) recorded in liters per minute, calculate the average gravimetric concentration C, as follows:

$$C = \left(\frac{1{,}000 * \Delta m}{t \bullet Q} \right)$$

Now compare the recorded TWA from the pDR-1500 and the calculated gravimetric particulate mass concentration (C) and calculate the calibration factor to be programmed into the pDR-1500 site list as follows:

$$CAL\ FACTOR = \frac{C}{TWA}$$

For example, if C was found to be 3.2 mg/m^3, and TWA had been determined to be 2.5 mg/m^3, the CAL FACTOR equals 1.28. The user can now edit this value on the pDR-1500 calibration screen through the use of pDR Port or via the keypad.

Site Calibration Factors

The Cal-Factors calculated from the above comparison can be stored via pDR Port into the pDR-1500. The pDR-1500 holds up to 50 different site names. Each Site Name has a default Cal-Factor of 1.000. The Cal-Factor of each site can be adjusted either through the Menu Interface or through the pDR Port user interface.

Particle Size Cut Points

The pDR-1500 has three different inlets to choose from Total Inlet, Red Cyclone, and Blue Cyclone.

The Total Inlet is a standard accessory for the pDR-1500 and is designed for use as a total aerosol mass measurement. When operated in a flow range of 1-2 L/min with a tared 37-mm, 5-µm PVC filter NIOSH Method 0500 can be achieved in addition to the real-time measurements.

The Red Cyclone is an optional ACGIH-traceable cyclone that is used primarily for establishing an aerodynamic diameter 50% cut point between 4 to 10 micrometers. When used at a flow rate of 2.65 L/min with a tared 37-mm, 5-µm PVC filter NIOSH Method 0600 can be achieved in addition to the real-time measurements.

The Blue Cyclone is an optional ACGIH-traceable cyclone that is used primarily for establishing an aerodynamic diameter 50% cut point between 1 to 4 micrometers.

The Red and Blue Cyclones have the following 50% AED cut-point characteristics shown in Figure 4–1.

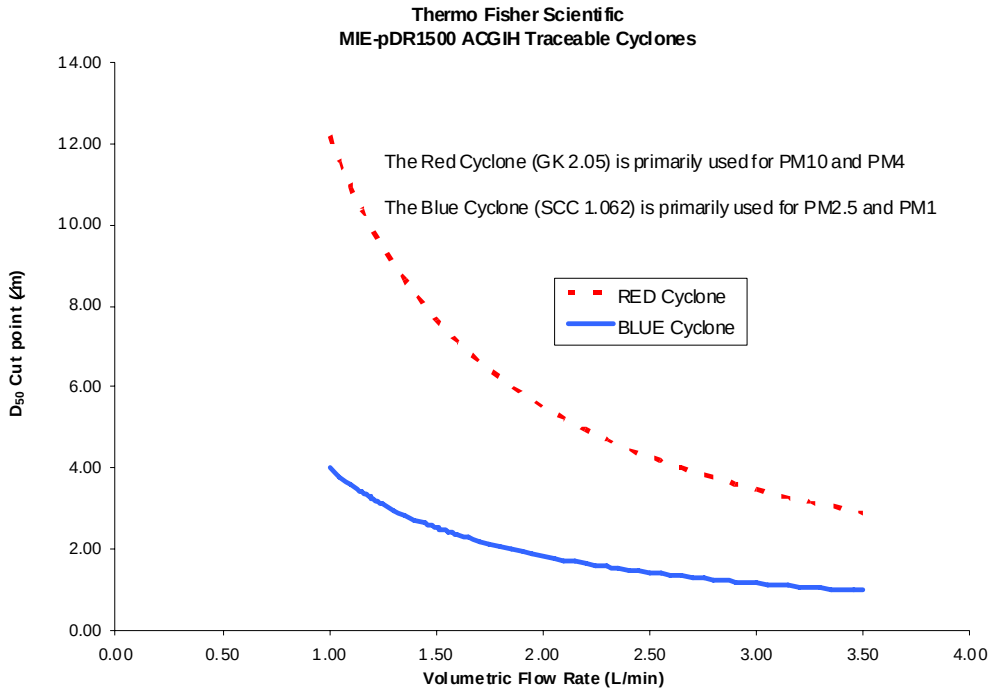


Figure 4–1. Cyclone D50 Curves

Chapter 5
Maintenance and Service

This chapter describes the periodic maintenance procedures that should be performed on the instrument to ensure proper operation. Since usage and environmental conditions vary greatly, the components should be inspected frequently until an appropriate maintenance schedule is determined.

This chapter includes the following preventive maintenance information:

- "General Guidelines" on page 5-2
- "Replacement Parts List" on page 5-3
- "Battery Use" on page 5-4
- "Instrument Storage" on page 5-5
- "Filter Replacement" on page 5-6
- "Cleaning of Optical Sensing Chamber" on page 5-8
- "Service Locations" on page 5-9

General Guidelines

The pDR-1500 is designed to be repaired at the factory. No user serviceable components are inside the enclosure of the pDR-1500 with exception of the 37-mm filter cassette (a.k.a. analytic filter holder) and the 4 AA batteries. Access to the internal components of the unit by others than authorized Thermo Fisher Scientific personnel voids warranty.

Equipment Damage Unless a MALFUNCTION message is displayed, or other operational problems occur, the pDR-1500 should be returned to the factory once every year after being placed into service for routine check out, test, cleaning and calibration check. ▲

Replacement Parts List

Table 5–1 lists the replacement parts for the pDR-1500.

Table 5–1. pDR-1500 Replacement Parts

Part Number	Description
105652-00	Universal Power Supply Cable
105637-00	RS-232 Communications Cable
105639-00	USB Communications Cable
105638-00	Analog data Cable (optional)
107942-00	pDR Port Software CD ROM
105551-00	Belt Clip Kit
105624-00	Total Particulate Inlet
109354-00	Total Inlet O-ring Kit
109355-00	Filter Assembly Service Kit (o-ring and gasket)
109149-00	Red Cyclone (optional)
109148-00	Blue Cyclone (optional)
109170-00	Cyclone O-ring Kit
49-1215	8 Alkaline Batteries
SAFH240P2	37-mm Filter Holders (2 each)
950-3110	Fiberglass Filter 37-mm 100/Box
109356-00	Stainless Steel Filter Support Screens (pkg of 3)
105854-00	PVC 5.0 μm 37-mm Filter 50/Box (optional)
105448-03	Zeroing/Recirculation Tubing
32-000380	Zeroing filter
105983-00	Instruction Manual
105650-00	Carrying Case
109175-00	Tripod Support Kit

Battery Use

If the pDR-1500 is to be operated without its external power supply, that is, deriving power from its internal battery, these 4 AA batteries should be newly purchased Alkaline or fully charged NiMH rechargeable batteries before initiating a run. The pDR-1500 power supply can be connected continuously to the instrument whether the pDR-1500 is on or off. However, the external power supply **will not** charge any rechargeable batteries while inside the pDR-1500 – they must be charged in an independent charging station.

Instrument Storage

If the pDR-1500 is to be stored for an extended period of time (i.e., three months or more), removal of the AA batteries is recommended. This will have no effect on data retention or internal clock function.

During storage always maintain the unit with the inlet covered to protect the sensing optics from gradual dust contamination. Store the pDR-1500 in a dry environment.

Filter Replacement

To replace the 37-mm filter used with pDR-1500, place the instrument on a level surface with the belt clip attachment facing down. Holding the pDR-1500 firmly with one hand, grasp the large threaded plastic knurled filter cover and rotate this cover counter-clockwise (see Figure 5–1). Remove cover and the filter holder within the open cavity

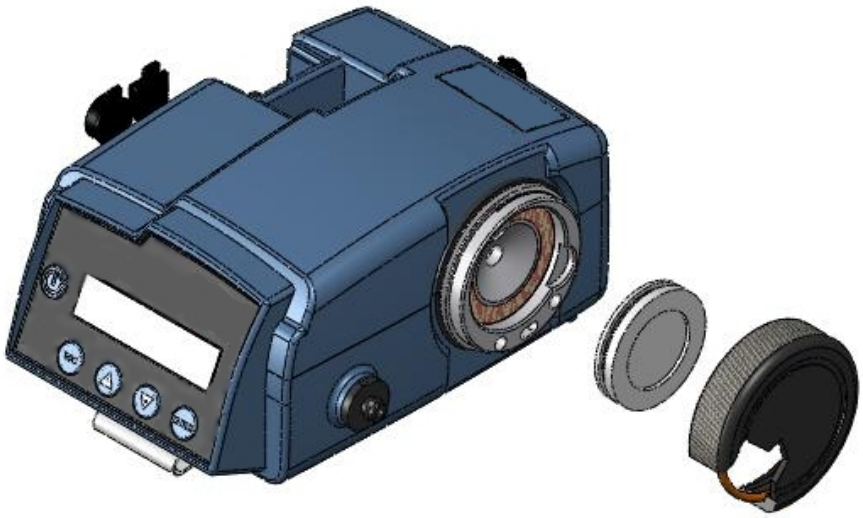


Figure 5–1. Filter Assembly Location – turn counter-clockwise to open

Replacement of the o-ring is to also be maintained in order to provide an adequate seal (see Figure 5–2).

The 37-mm filter holder should have a fresh glass fiber filter installed prior to each day of monitoring in order to keep the pump protected. Operation without this filter in place, or without the filter changed as prescribed, will void the warranty.

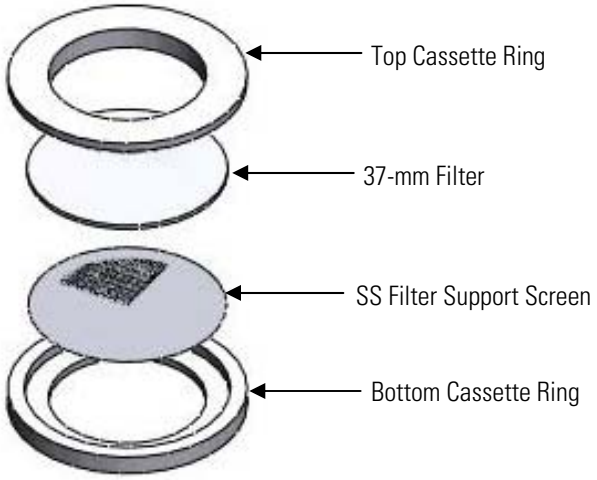


Figure 5–2. Filter Cassette Assembly – Snap Rings and Filter

Cleaning of Optical Sensing Chamber

Although the pDR-1500 incorporates an aerodynamic inlet to optimize aerosol delivery through the sensing chamber, continued sampling of airborne particles at high concentrations may result in gradual build-up of contamination on those interior surfaces of the sensing chamber components. This may cause an excessively high optical background level. If this background level does become excessive, the pDR-1500 will alert the user at the completion of the zeroing sequence. If this message is presented, the pDR-1500 can continue to be operated providing accurate measurements only if the background can be reduced. This "might" be possible by blowing a stream of compressed filtered air through the optical chamber and re-zeroing.

Equipment Damage If unsuccessful, the instrument must be sent back to the factory for service. ▲

Service Locations

Service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Chapter 6
Troubleshooting

This instrument has been designed to achieve a high level of reliability. In the event of problems or failure, the Technical Support Department at Thermo Fisher Scientific can be consulted. See "Service Locations" for contact information. In any correspondence with the factory, please note both the serial number and program number of the instrument.

This chapter provides the following troubleshooting and service support information:

- "Instrument Status Flags" on page 6-2
- "Service Locations" on page 6-3

Instrument Status Flags

During zeroing, the pDR-1500 also performs diagnostics on the optics and flow rates. The only allowable fault is "Background High". All other faults will result in a failure to zero the instrument. All faults are reported with a hex coded error flags. The faults can be determined from the following table, but if a fault persists, the pDR-1500 instrument requires service.

Table 6–1. Troubleshooting – Error Code Responses from Zeroing

Hex code [Flags]	Binary	Fault	Fault criteria
02 x	0000 0010 b	Background High	> 1000 µg/m3
03 x	0000 0011 b	Background calculation FAILED	Detector signal is not sensed or it is not properly amplified.
04 x	0000 0100 b	Source current low	< 50 mA
08 x	0000 1000 b	Source current high	> 75 mA
10 x	0001 0000 b	Ref. detector low	< 75% Factory set
20 x	0010 0000 b	Ref. detector high	> 125% Factory set
40 x	0100 0000 b	Pump low	< 90%
80 x	1000 0000 b	Pump high	> 110%

Service Locations

Service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information or visit us on the web at www.thermo.com/aqi.

1-866-282-0430 Toll Free

1-508-520-0430 International

Chapter 7
Outputs and Alarm

This chapter describes serial communications and analog/alarm output.

- "Analog Signal Output" on page 7-2
- "Alarm Description and Operation" on page 7-3
- "Alarm Connection" on page 7-4
- "Real-time RS-232 Output" on page 7-6
- "Serial Communications Protocols" on page 7-7

Analog Signal Output

The pDR-1500 incorporates the capability to provide both a voltage and a current signal output directly proportional to the sensed concentration of airborne particulates. Both these analog signal outputs are concurrently available. These outputs are provided, principally, for fixed-point applications with hard-wired installations.

The particulate concentration range corresponding to the output voltage and current ranges (0 to 2 V and 4 to 20 mA) can be user selected on the pDR-1500 screen (see "Configuration Review" on page 3-29) or via a PC using the pDR Port communications software package included with the instrument. The most sensitive range available is 0 to 0.10 mg/m^3 (0 to 100 $\mu g/m^3$), and the least sensitive range is 0 to 400 mg/m^3. For example, if the user selects the analog output range of 0 to 0.400 mg/m^3 then the analog output signal levels, at a concentration of 0.200 mg/m^3, would be 1.0 V and 12 mA. This Analog Output concentration range is independent of the ranging used for the digital display, data logging and real-time digital output range which are controlled automatically (auto ranging).

For the 0 to 2 V output signal, the externally connected load must have an impedance of more than 200 kilo-ohms; For the 4 to 20 mA output signal, the externally connected load must have an impedance of less than 300 ohms.

Since both voltage and current outputs are present at the same time, both can be used concurrently, if so required. The accuracy of the analog output signals is better than 1% of the reading with respect to the digital reading.

The 4 to 20 mA current output is available between pins # 1 and 5 of the 6-pin ANALOG OUTPUTS connector on the side panel (see Chapter 2). The 0 to 2 V analog voltage output is available between pins # 1 and 4 of that connector. Pin # 1 is common ground.

Alarm Description and Operation

In addition to an audible alarm, there is a single alarm switched FET output available on the side panel of the pDR-1500. Normally, the switched alarm output is OPEN with respect to ground. During an alarm condition, this output is switched to ground (Rout < 0.1 Ω). Whenever the alarm is triggered, the on-board sound will be activated. The alarm function can be enabled or disabled and the alarm level (trigger threshold) can be selected by the user through the pDR-1500 keyboard. The alarm is triggered whenever the selected alarm level is exceeded.

When the displayed concentration falls below that level the alarm conditions stops. While the alarm is on, the user can disable it momentarily by pressing any key on the pDR-1500. If the concentration continues to exceed the set alarm level after 10 seconds, the alarm condition will be reactivated.

Alarm Connection

The voltage alarm signal is available between pins # 1 and 6 on the ANALOG OUTPUTS connector in the upper middle of the side panel. In Figure 7–1 below, the alarm driver circuit is depicted.

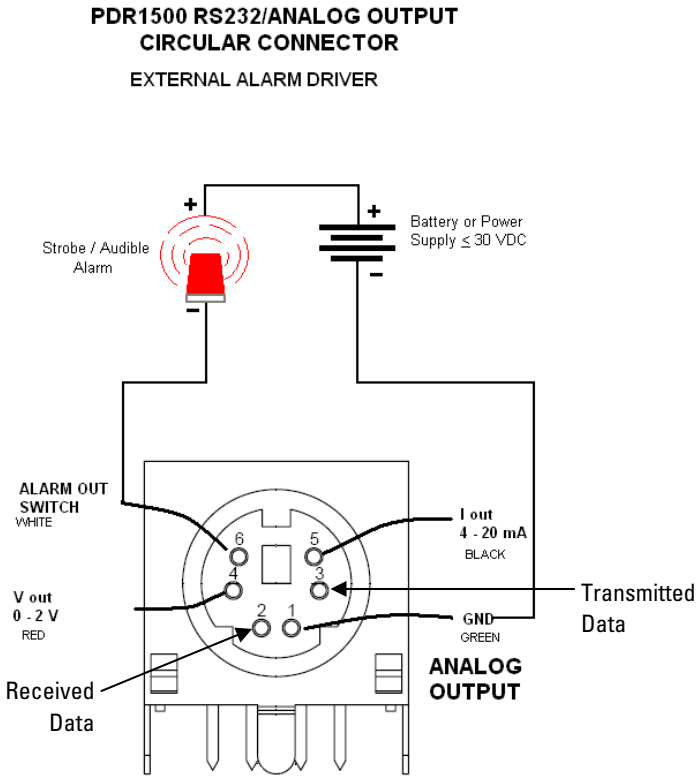


Figure 7–1. pDR-1500 External Alarm Driver

WARNING Do not apply AC voltage to this connector. Maximum allowable DC voltage is 30 V. ▲

The switched alarm output is used to close the circuit of a DC powered device and its power supply at the negative side. For example:

1. The negative terminal of a battery or common ground of a power supply is connected to Pin #1, pDR-1500 ground.

2. The load's (device's) return or negative is connected to #6 (switch alarm output).

3. The positive of the load and battery, or power supply, are connected together.

The minimum external load impedance for this output is 10 kilo-ohms.

Real-time RS-232 Output

During the RUN mode the pDR-1500 can communicate real-time concentration data through its serial port via the pDR Port software package. This software application decodes the data and displays it on the computer screen in both graphical and tabulated form.

In order to use this output with some other application, the following information will enable the user to decipher the encoded output signal. The communication settings for the digital output of the pDR-1500 are:

- Baud rate: 19,200
- Data bits: 8
- Stop bits: 1
- Parity: none
- Flow control: none

Serial Communications Protocols

The pDR-1500 has two serial ports. These are RS-232 or USB. Only one can be active at a time. The active port is selected via the PC, depending on the connection chosen.

The RS-232 and USB ports are for direct connection of a single pDR-1500 to a PCs communication port.

The commands recognized are listed in Appendix B. Mostly these pertain to setup variables in the pDR-1500. The response format will generally repeat the address and command and then follow with the PDR-1500's current settings.

Chapter 8
Optional Accessories

The pDR-1500 is available with the following options:

- Red Cyclone – provides an ACGIH traceable D50 AED cut point ranging from 3 to 12 micrometers
- Blue Cyclone – provides an ACGIH traceable D50 AED cut point ranging from 1 to 4 micrometers
- 5 micron PVC Filters for NIOSH gravimetric methods (use glass fiber filters, as backing filter)
- Stainless Steel Filter Support Screen
- Carrying Case
- Analog Data Cable, supporting both concentration output and alarm status
- Tripod Support Kit

Appendix A
Warranty

Seller warrants that the Products will operate or perform substantially in conformance with Seller's published specifications and be free from defects in material and workmanship, when subjected to normal, proper and intended usage by properly trained personnel, for the period of time set forth in the product documentation, published specifications or package inserts. If a period of time is not specified in Seller's product documentation, published specifications or package inserts, the warranty period shall be one (1) year from the date of shipment to Buyer for equipment and ninety (90) days for all other products (the "Warranty Period"). Seller agrees during the Warranty Period, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said published specifications; provided that (a) Buyer shall promptly notify Seller in writing upon the discovery of any defect, which notice shall include the product model and serial number (if applicable) and details of the warranty claim; (b) after Seller's review, Seller will provide Buyer with service data and/or a Return Material Authorization ("RMA"), which may include biohazard decontamination procedures and other product-specific handling instructions; and (c) then, if applicable, Buyer may return the defective Products to Seller with all costs prepaid by Buyer. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the Delivery provisions of the Seller's Terms and Conditions of Sale. Consumables, including but not limited to lamps, fuses, batteries, bulbs and other such expendable items, are expressly excluded from the warranty under this warranty.

Notwithstanding the foregoing, Products supplied by Seller that are obtained by Seller from an original manufacturer or third party supplier are not warranted by Seller, but Seller agrees to assign to Buyer any warranty rights in such Product that Seller may have from the original manufacturer or third party supplier, to the extent such assignment is allowed by such original manufacturer or third party supplier.

In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which

they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage and handling of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this warranty, Buyer shall pay Seller therefor at Seller's then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS.

THE OBLIGATIONS CREATED BY THIS WARRANTY STATEMENT TO REPAIR OR REPLACE A DEFECTIVE PRODUCT SHALL BE THE SOLE REMEDY OF BUYER IN THE EVENT OF A DEFECTIVE PRODUCT. EXCEPT AS EXPRESSLY PROVIDED IN THIS WARRANTY STATEMENT, SELLER DISCLAIMS ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE PRODUCTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE PRODUCTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT.

Appendix B
Serial Commands

This appendix provides a list of the pDR-1500 Serial Port Commands that can be used to remotely control the instrument.

Connect to the pDR-1500 at 19200, n, 8, 1, no flow control. The USB connection is actually a virtual serial port and will request appropriate drivers the first time it fires up in a windows environment. These are available with the pDR Port install disk.

The protocol is designed for human terminal access. Commands are executed when the user hits Enter. Spaces between tokens do not matter. Generally, parameters not included in the command line are defaulted.

First is a list of key worded commands that should be made available to the end user as a public interface. With these commands you can completely control the instrument.

ALARM [*status*] [*alarm concentration level*]
status= {0, 1, 2,}

0 = DISABLED
1 = INSTANT
2 = STEL

alarm concentration level is specified in mg/m^3 (0.01 to 400 [mg/m^3])

ANALOGOUT [*analog output menu choice*]
If the units are mass concentration (mg/m^3), the *analog output menu choices* = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}

0 = DISABLED
1 = 0.10 mg/m^3
2 = 0.40 mg/m^3
3 = 1.00 mg/m^3
4 = 4.00 mg/m^3
5 = 10.0 mg/m^3
6 = 40 mg/m^3
7 = 100 mg/m^3
8 = 400 mg/m^3
9 = 1000 mg/m^3

If the units are scattering coefficient (1/Mm), the *analog output menu choices* = {0, 1, 2, 3, 4, 5}

0 = DISABLED
1 = 10/Mm
2 = 100/Mm
3 = 1000/Mm
4 = 10000/Mm
5 = 100000/Mm

The response is ANALOGOUT [menu] "menu entry" [factor to be applied to output voltage to yield output units (ie, mg/m^3 or 1/Mm)]

AUTOSTART [*min*] [*hour*] [*day*] [*month*] [*status*]
Returns, or programs, the automatic start feature parameters.
min and *hour* program the start time
day and *month* program the start day
status = {"on", "off"} The automatic start is enabled if "on" is selected.

BACKLIGHT [*Status*]
Returns, or programs, the backlight status.
Status = {"enabled" or "on", "disabled" or "off"}

BATTERY [*battery voltage*] [*alkaline charge*] [*NiMH charge*]
Returns the battery voltage with an estimation of charge time left in percentage if the batteries are Alkaline or NiMH.

CALFACTOR [*float value*]
Returns, or programs, the user calibration adjustment factor. The *value* can range from 0.001 to 10.000.

CONTRAST [*integer value*]
Returns, or programs, the LCD screen contrast setting.
Integer value = {1, 2, 3, …, 255; *Hint: display is only visible between 0 and 40*}

DATE [*day*] [*month*] [*year*]
Returns, or programs, the date in the RTC.
Day, month and *year* are all integer values.

DISPLAY (or **DISP**, or **D**, or **V 5**) [*line 1 (16 characters)*] [*line 2 (16 characters)*] [*state #*]
Return the text currently displayed on the LCD. It comes in two quoted strings for the 2 lines of the display. It is followed by a state-number. Note that response is prefixed with "V 5"; this can be ignored.

DISPLAYAVG [*seconds*]
Returns, or programs, the time period in seconds over which the LCD displayed value is averaged.

FLOWRATE [*flow rate*]
Returns, or programs, the flow rate [LPM] that is to be maintained. This cannot be changed while logging.
Flow rate = {1.00, 1.01, 1.02, …, 3.50} [in LPM]

GAIN [*gain number*]
A debug facility which returns or programs the front end gain of the instrument. If you set it, the gain no longer adjusts automatically. To re-establish auto-gain, use "GAIN 200" or "GAIN A"
Gain number = {0, 1, 2, 3, 4, 5, A} for {1X, 4X, 16X, 64X, 256X, 1024X and AUTOMATIC}

INLET [*integer*]
Returns, or programs, the inlet selection from the choices *integer* = {0, 1, 2}
0 = TOTAL
1 = CYCLONE RED
2 = CYCLONE BLUE

KEY [*name of key*] [*long*]
Simulate a key press.
Name of key = {"ESC", "UP", "DOWN", "ENTER" or "ONOFF"}
Long = {"LONG", ""} LONG is typed only if you wish this to be a long push.

LOGPERIOD [*seconds*]
Returns, or programs, the logging period in seconds.

MEMORY [*percent*]
Returns a reading of how much logging memory remains unused. The response is "V 145 [*percentage of memory remaining*]"

OUTPUT (or **OUT** or **O**) [*conc* or *scat*] [*temp (C)*] [*RH (%)*] [Pa (mmHg)]
Returns the current values of the concentrations, temperature, RH and atmospheric pressure if the pDR-1500 is running.

RHCORRECT [*status*]
Returns, or programs, the status of RH correction to the computation of mass concentration.
Status = {"disable" or "off", "enable" or "on"}

SITE [*site #*]
Returns, or programs, the description of site number sitenum. Sites are numbered 1–50.

SD [*Status*]
Returns, or programs, the streaming data status.
Status = {"enabled" or "on", "disabled" or "off"}

TAG [*Tag #*] [*status*]
Returns, or programs, the tag number to be used when next time logging is to start. And enable or disable logging.
Tag # = {00, 1, 2, …, 99}
Status = {"enabled" or "on", "disabled" or "off"}

TAGDUMP [*Tag #*]
Returns the complete data logged under the file tag number.
Tag # = {0, 1, 2, …, 99}

TAGS [*Tag #*], [*Tag #*], …
Get a list of the tag files currently in the device.

TEMP [*temp*] [*RH*] [*Pa*]
Get current temperature, RH and atmospheric pressure.
temp is in degrees Celsius
RH is Relative Humidity in percent
Pa is barometric pressure in mmHG

TEMPUNITS [T]
Responds with "TEMPUNITS C", degrees Celsius are the only allowed.

TIME [*seconds*] [*minutes*] [*hours*]
Returns, or programs, the RTC's current time.

UNITS [*integer*] the current measurement units:
Units =
0 = µg/m^3 (Mass concentration)
1 = 1/Mm (880 nm scattering coefficient)