MODEL ADR-1200S

AMBIENT PARTICULATE MONITORING SYSTEM

INSTRUCTION MANUAL
P/N 100341-00

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28Jan2004

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1.0 GENERAL DESCRIPTION

The model ADR-1200S is a particulate monitoring system designed for outdoor operation. Its weatherproof enclosure ensures safe and effective operation under a wide range of ambient environmental conditions. The ADR-1200S is designed for continuous unattended monitoring with continuous real-time data transmission to a central location and/or internal data logging. The latter is incorporated in this system, whereas the former requires a separate modem, or telemetry equipment. Real-time and averaged data, as well as maximum and STEL values are displayed on the ADR-1200S.

The ADR-1200S incorporates the proven and highly successful light scattering photometry sensing technology for which MIE is known worldwide. Long-term, precise and drift-less measurements of airborne particulate matter concentrations down to 1 $\mu g/m^3$ are assured by a unique state-of-the-art combination of optical sensing and electronic signal processing techniques refined over the last 25 years.

The ADR-1200S consists of the following modules housed within a weatherproof enclosure:

a) MIE model *p*DR-1200 monitoring unit;
b) MIE model *p*DR-PU pump module;
c) MIE model *p*DR-BP rechargeable battery module;
d) MIE model *p*DR-AC power supply/charger;
e) MIE model *p*DR-RA alarm unit;
f) MIE model DR-OSI omnidirectional sampling inlet

This combination constitutes an uninterruptible monitoring system. Any a.c. line power interruptions/failures (for up to 36 consecutive hours) will have no effect on the operation of the ADR-1200S.

The ADR-1200S can be used for particle size-selective measurements using a special metal cyclone for $PM_{2.5}$ monitoring as well as for respirable particle (with cut point at 4 µm) monitoring, or to obtain information on particle size distribution (by varying the sampling flow rate). For PM_{10} monitoring the cyclone is removed from the inlet flow path.

In addition to the real-time/continuous measurements by light scattering photometry, the system provides the user with the capability to collect the sampled particles on a membrane filter for gravimetric and/or chemical analysis.

A high-intensity flashing beacon is provided on the outside of the ADR-1200S for visual alarm whenever the measured particulate concentration exceeds a user selected alarm threshold level. This alarm signal can be seen from a considerable distance and is intended principally for perimeter monitoring applications.

2.0 HOW TO USE THIS INSTRUCTION MANUAL

The OPERATING MANUAL for the ADR-1200S is provided in three separate sections. One section is entitled: *personal*DataRAM, another is entitled Portable Pump Unit, and the third is this manual entitled Ambient Dust Monitor.

The detailed operation of the particulate monitoring unit model *p*DR-1200 is described in the first of these manuals, whereas the operation of the model *p*DR-PU pump unit is described in the second of these manuals. The user should refer to the present Ambient Dust Monitor, model ADR-1200S manual for all other information, including the following:

- Detailed Functional Description
- Overall Set-Up and Mounting
- AC Power Connection
- PC and Data Output Connection
- External Alarm Connection
- Optional Accessory Power Connection
- Cyclone Selection
- Long Term Unattended Operation
- Zeroing Procedure
- Monitoring Procedure
- Maintenance Procedures

Reference is made in this manual to specific sections in the two accompanying manuals whenever more detailed information is to be provided. Such references will be identified by either **pDR** for sections in the *personal*DataRAM manual, or by **PU** for sections in the pump unit manual. For example, reference to the Operating Modes of the monitor will be identified as Section **pDR** 7.0, corresponding to Section 7.0 of the *personal*DataRAM manual.

3.0 DETAILED FUNCTIONAL DESCRIPTION

The ADR-1200S is a complete particulate monitoring system designed to provide the user with continuous measurements of the concentration of airborne particles in any size fraction ranging from PM_{10} down to PM_1, i.e., the concentration of particles smaller than 10 µm aerodynamic equivalent diameter, to the concentration of particles smaller than 1 µm aerodynamic equivalent diameter.

Reference should be made to Fig. 1 of this manual for the location and identification of various component elements of the ADR-1200S, described in this and subsequent sections of this manual.

The ADR-1200S samples the air through an omnidirectional inlet (model DR-OSI), which ensures representative sampling of particles smaller than 10 µm aerodynamic diameter even under windy conditions.

This inlet rises about 30 cm over the upper surface of the ADR-1200S enclosure.

The sampled air stream then enters a cyclone located inside the ADR-1200S enclosure, wherein particles larger than the cut-off diameter of the cyclone are retained, and those smaller than the cut-off diameter continue into the optical sensing stage of the monitor. The particle cut-off size depends on the sampling flow rate.

After particle size selection within the cyclone, the stream enters the optical sensing stage of the model *p*DR-1200 nephelometric unit within which the instantaneous concentration of airborne particulate matter is measured by light scattering photometry. It is important to point out that this sensing technique is independent of the speed with which the particles pass through the sensing stage, and therefore changes in flow rate have no effect on the measured concentration except in that such changes determine the range of particle sizes allowed to pass the cyclone, as mentioned above.

After the particles have been sensed photometrically, the stream passes through a standard 37-mm filter holder within which a membrane filter can be installed for further particle analysis (gravimetric, microscopic, chemical, etc.). When using the ADR-1200S for continuous unattended monitoring, however, it is advisable to leave out this filter which otherwise would require frequent replacement (see Section 8.2 of this manual).

After passing through the 37-mm filter holder, the sampled air stream passes through a back up tubular filter cartridge which is provided to protect the pump unit from particle contamination in the absence of a 37-mm membrane filter. The filter cartridge is of large capacity and needs to be replaced only infrequently (see Section 11.2 of this manual).

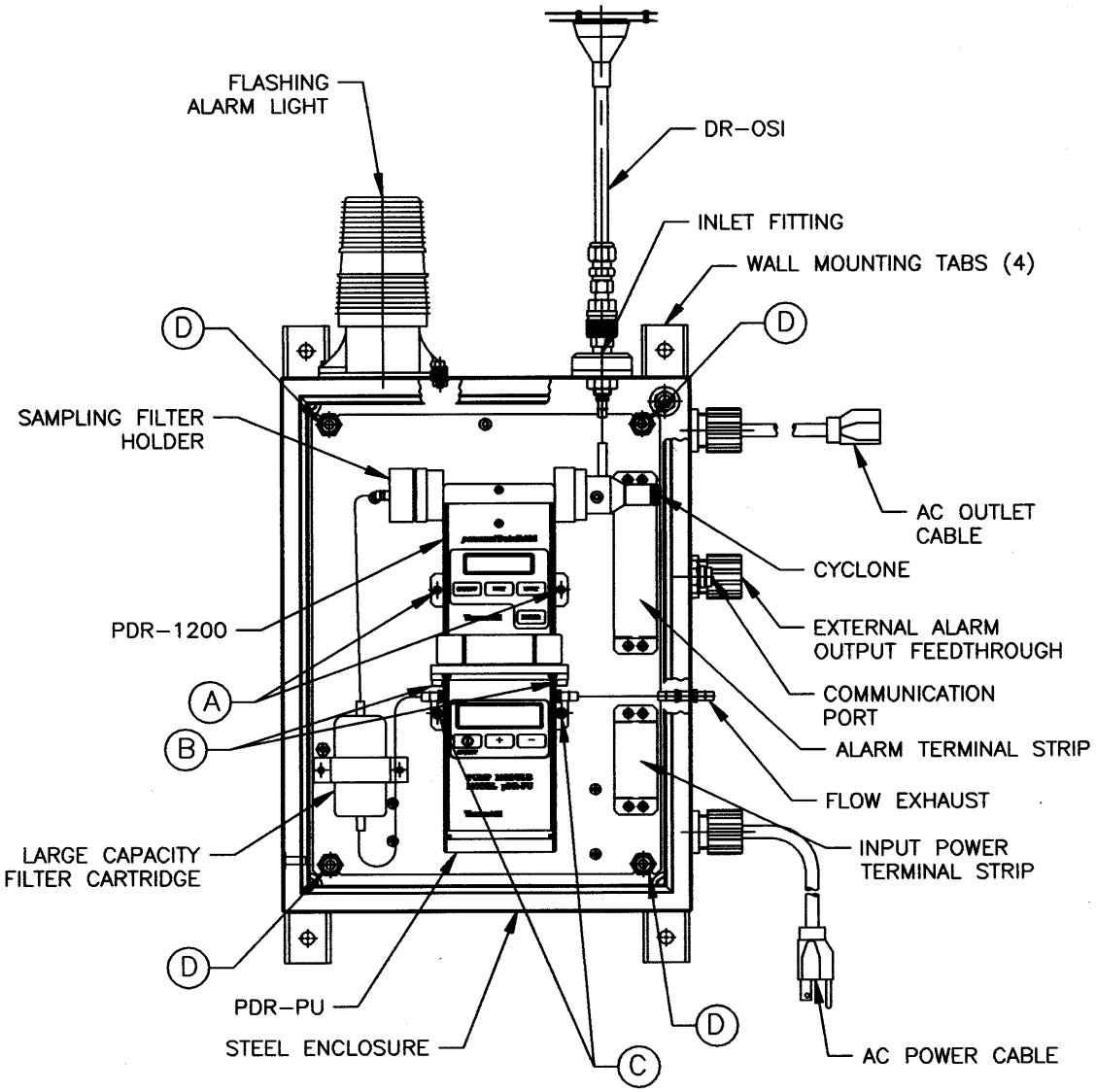

Figure 1. Frontal view of ADR-1200S with door open

The clean filtered air stream then enters the pump unit (model *p*DR-PU). This unit contains a dual-chamber diaphragm pump, flow pulsation dampener, and a volumetric flow rate control system based on sensing the pressure drop across a flow orifice. Sampling flow rate can be selected by key control on the front panel of the pump unit.

After passing through the pump unit, the air is exhausted from the ADR-1200S enclosure through a small feed-through fitting. This exhaust port is used for zeroing purposes (see Section 9.0 of this manual), as well as for flow return in special sampling applications where the inlet of the ADR-1200S is connected to an environment at either positive or negative pressure (with respect to ambient).

Although the ADR-1200S is designed for continuous long-term operation it is recommended that such operation be performed at a flow rate of 2 liters/minute, or less, in order to ensure the longevity of the pump bearings. Higher flow rates can be used for short-term monitoring, particle sizing, etc.

The photometric sensing unit (MIE model *p*DR-1200) and the pump unit (MIE model *p*DR-PU) are powered from a rechargeable nickel-metal-hydride battery (MIE model *p*DR-BP) located behind the black mounting panel. This battery is continuously recharged from an ac-to-dc power supply (MIE model *p*DR-AC), also located behind the black mounting panel, which is connected to the ac line. This mode of operation ensures long-term continuous, stable and uninterrupted operation regardless of ac power transients and power interruptions.

The measured concentration of particulate matter is displayed in real time on the *p*DR-1200 LCD readout, as well as outputted as RS-232 digital, and analog voltage and current signals, updated every second. In addition, the user is provided with an alarm switching output to drive external devices (e.g., siren, shut-off equipment, etc.). The measured data can be logged internally in the ADR-1200S for subsequent downloading to a PC, modem, etc. The communications port also serves to link to a PC for programming internal parameters of the ADR-1200S (e.g., logging period, measurement averaging time, alarm level, calibration constant, etc.).

The component elements of the ADR-1200S are CE certified, and the enclosure is NEMA 4 rated.

4.0 MOUNTING AND SET-UP

4.1 Generalities

The ADR-1200S can be operated either lying horizontally, or mounted in a vertical (upright) position. The latter would be preferred for outdoor fixed location operation as well as for most indoor applications.

The ADR-1200S can be wall (or post) mounted using the four wall mounting tabs (see Fig. 1) that protrude above and below the metal enclosure. These tabs have mounting holes with a diameter of 0.4 in. (10 mm). If required, these mounting tabs can be removed.

When mounting the ADR-1200S care should be taken to ensure that the front door of the unit can be opened without hindrance, and that free access is provided to the connectors and feed-throughs on the right face of the enclosure.

It is important to ensure free access of the air to be monitored to the sampling inlet. For ambient air monitoring, the omnidirectional inlet provided with the ADR-1200S should always be used, and this inlet should not be obstructed by nearby objects, in order to ensure representative sampling.

If possible, the ADR-1200S should be shielded from continuous exposure to the sun. This is recommended to prevent excessive heating of the unit, especially in high temperature environments. Alternatively, during cold winter periods, such solar heating may be desirable to raise the temperature of the unit above its minimum operating temperature.

Under typical operating conditions, the door of the ADR-1200S enclosure should be closed. A lock with key is provided on the handle to prevent unauthorized access to the interior of the unit. The two LCD readouts can be easily viewed through the transparent high impact resistant window (see Section 11.3 of this manual for cleaning instructions). The door should be opened only to access the control keys of the *p*DR-1200 and the *p*DR-PU, to replace either of the filters, or for other maintenance.

4.2 Inlet Connections and Accessories

For ambient air sampling, the omnidirectional inlet unit should be used to minimize wind speed and direction effects on particle sampling representativeness. This special annular inlet (MIE model DR-OSI) is provided as a standard accessory of the ADR-1200S. On receipt by the customer, this inlet will arrive packaged separately, and needs to be installed. Refer to Fig. 1 for the final (installed) appearance of the omnidirectional inlet. To install proceed as follows:

Slide back (upwards) the spring-loaded knurled sleeve at the lower end of the omnidirectional inlet, and insert open end of fitting on inlet stem of the ADR-1200S until it bottoms, and release knurled sleeve. The quick-connect should now be locked. To remove the omnidirectional inlet, lift the knurled ring and remove the unit from the inlet stem on the ADR-1200S.

If the ADR-1200S is to be used for extractive sampling (e.g., from a chamber, duct, stack, etc.) a flexible plastic tubing (preferably electrically conductive) can be used and connected to the inlet stem on the upper face of the ADR-1200S. In this case the omnidirectional inlet is not used.

For sampling situations involving water sprays, fog, etc. it is recommended that the in-line inlet heating unit, model MIE DR-TCH be used. This is an optional accessory that raises the temperature of the sampled air stream before entering the ADR-1200S. This heater uses the quick-connect fittings compatible with the inlet stem and the fitting of the omnidirectional inlet unit. When the in-line heater is used it should be inserted between the omnidirectional inlet and the ADR-1200S inlet stem, following the same procedure as indicated for the insertion of the omnidirectional inlet. Power to operate the in-line heater unit can be obtained from the ac output cable provided for that purpose (short cable and receptacle as shown on Fig. 1).

5.0 AC POWER CONNECTION

The ADR-1200S as received from the factory is provided with a short length of an ac power cord and standard (US) three-prong plug. The user can therefore connect the ADR-1200S, as received, into an ac outlet to operate the system.

For fixed point, permanent or semi-permanent installation the user may want to wire the ADR-1200S power input with conduit or similar wiring configuration. The ADR-1200S is provided with a standard feed-through (through which the power cord passes) and an internal 3-conductor input power terminal strip (see Fig. 1) for such permanent wiring. To perform a permanent wiring connection, make sure to unplug the power plug from any ac power receptacle. Open the ADR-1200S front door, and locate the black sheet metal cover of the input power terminal strip on the lower right side. Remove the four screws securing that cover and remove the three wires of the factory supplied power cord. Run the wires to be permanently connected through the plastic feed-through fitting and complete any external power connections as required. Replace and secure the terminal cover with its four screws.

It should be noted that the ADR-1200S can be powered from any line with a voltage between 100 and 250 volts ac, 50 to 60 Hz. No internal adjustments or selections need to be made for power lines with voltages and frequencies in those ranges. The internal ac-to-dc power unit performs any adjustments automatically.

6.0 COMMUNICATIONS AND DATA PORT CONNECTIONS

The ADR-1200S is provided with a 5-pin connector on the right side of the enclosure, located behind the middle feed-through (alarm output feed-through), as shown on Fig. 1. This connector provides the following: the digital and analog data output from the ADR-1200S, and the communications link with the PC. The pin-out for this 5-pin connector is as follows (as viewed from the outside and counting clockwise from the connector key):

Pin #	Function
1	common
2	0 – 5V analog signal output
3	4 – 20 mA analog signal output
4	digital signal output
5	digital input

The ADR-1200S includes two cables that plug into the 5-pin communications port connector: a digital communications cable whose opposite end has a standard 9-pin connector for the PC port, and an analog signal output cable with three flying leads at the free end. The flying leads of the analog signal output cable are color-coded as follows:

Color	Function
black	common
white	0 –5V analog signal output
blue	4 – 20 mA analog signal output

The digital communications cable of the ADR-1200S is used whenever the ADR-1200S is to be connected to a PC, to display or tabulate data (real-time or logged), or to program the ADR-1200S parameters (see Section **pDR** 9.0). A software disk for communication with the PC is provided in a pouch on the back cover of the *personal*DataRAM Operator Manual.

The analog signal output cable is used for continuous real-time transmission of analog concentration measurements, either using the 0 to 5-V output or the 4 to 20 mA output (see Section **pDR** 10.0). Both outputs are concurrently available. The concentration range corresponding to these voltage and current ranges can be selected via a PC using the digital communications cable and the software provided (see Section **pDR** 10.1).

7.0 EXTERNAL ALARM CONNECTION

The ADR-1200S incorporates the alarm relay unit, model pDR-RA (see Section **pDR** 11.3) which provides a switched alarm output, triggered by the alarm signal of the monitor. This switched output (up to 8 amperes, 250 volts) can be used to control other equipment and/or to activate other external alarm indicators. This switched alarm output operates in conjunction with the flashing alarm beacon on the outside of the ADR-1200S enclosure.

To connect this switched alarm signal to any external equipment, the alarm terminal strip on the upper right of the interior of the ADR-1200S must be accessed. To do so, open the front door, unplug the cyclone and remove it from the enclosure, unscrew the four screws securing the black sheet metal cover (labeled Alarm Terminal Strip on Fig. 1), and identify the eight screw terminals counting #1 from the bottom up to 8# at the top. These screw terminals correspond to the following switch contact functions:

- Terminals #1 and #2 are a normally open switch
- Terminals #3 and #4 are a normally open switch
- Terminals #5 and #6 are a normally closed switch
- Terminals #7 and #8 are a normally closed switch

Each of the above four switches can switch loads of up to 4 amperes. By connecting (jumping) terminals #1 and #3 together, and #2 and #4 together, loads up to 8 amperes can be switched (normally open switch). The voltage rating is 28 VDC or up to 230 VAC.

Once the leads have been connected to the appropriate screw terminals of the alarm terminal strip, the black sheet metal cover should be reinstalled and secured with its four screws. The leads should be passed through the adjacent free feed-through (labeled external alarm output feed-through on Fig, 1), and connected as a switch to apply power to the required external equipment to be controlled by the alarm condition. For dc power application connect the wire from terminal #1 to the negative terminal of the power source (i.e., battery or dc supply). Finally, plug in the cyclone making sure to insert it completely.

8.0 SAMPLING/MONITORING ASPECTS

8.1 Size-selective Measurements

The cyclone provided with the ADR-1200S covers the range of particle size cut points from 4 µm down to about 0.75 µm. The selection of cut point is performed by adjusting the sampling flow rate of the monitoring system. Figure 2 shows the relationship between particle size cut point and flow rate. For example, for respirable particle measurements, the cut point should be at 4 µm which corresponds to a flow rate of 1 liter/minute. $PM_{2.5}$ monitoring would require a flow rate of 1.5 liters/minute, whereas $PM_{1.0}$ should be performed at 3.5 liters/minute. For PM_{10} in general, the cyclone is removed and a direct flow connection is made from the sampling inlet to the photometric sensing chamber (see below). For special PM_{10} applications where there is a large fraction of particulate matter with aerodynamic sizes above 10 µm, it is advisable to use an optional cyclone designed specifically for that purpose. Please consult with the factory on this matter.

The ADR-1200S is shipped with its cyclone (type CSS), as shown in Fig. 1. The cyclone inlet is connected to the inlet fitting of the ADR-1200S by means of a very short length (2-inch) of plastic tubing. For PM_{10} monitoring an alternative coupling is provided with the ADR-1200S. This coupling consists of a 37-mm plastic inlet cup with a fitting and a 5-inch length of plastic tubing. This coupling should be used instead of the cyclone for PM_{10} monitoring. To install proceed as follows:

- Remove cyclone from its black sealing cup on the sensing chamber of the *p*DR-1200 by pulling it away while tilting the cyclone body
- Disconnect the short plastic tubing from the brass inlet fitting of the ADR-1200S inlet fitting, and set aside cyclone with its short tubing
- Insert 37-mm plastic cup with small inlet opening into black sealing cup on the sensing chamber by pushing it in firmly until it bottoms
- Push free end of 5-inch long plastic tubing onto the brass inlet fitting on the ADR-1200S making sure that the tubing slides over the sealing ridge of the brass fitting
- Insert firmly the plastic fitting at the other end of the 5-inch tubing into the opening of the 37-mm plastic cup
- Make sure to dress the plastic tubing such that it remains free of any kinks

For particle size sizing determinations, please refer to Section **pDR** 14.2. However, the curve of Figure 2 of the present manual should be used instead of Figure 7 in Section **pDR** 14.2.

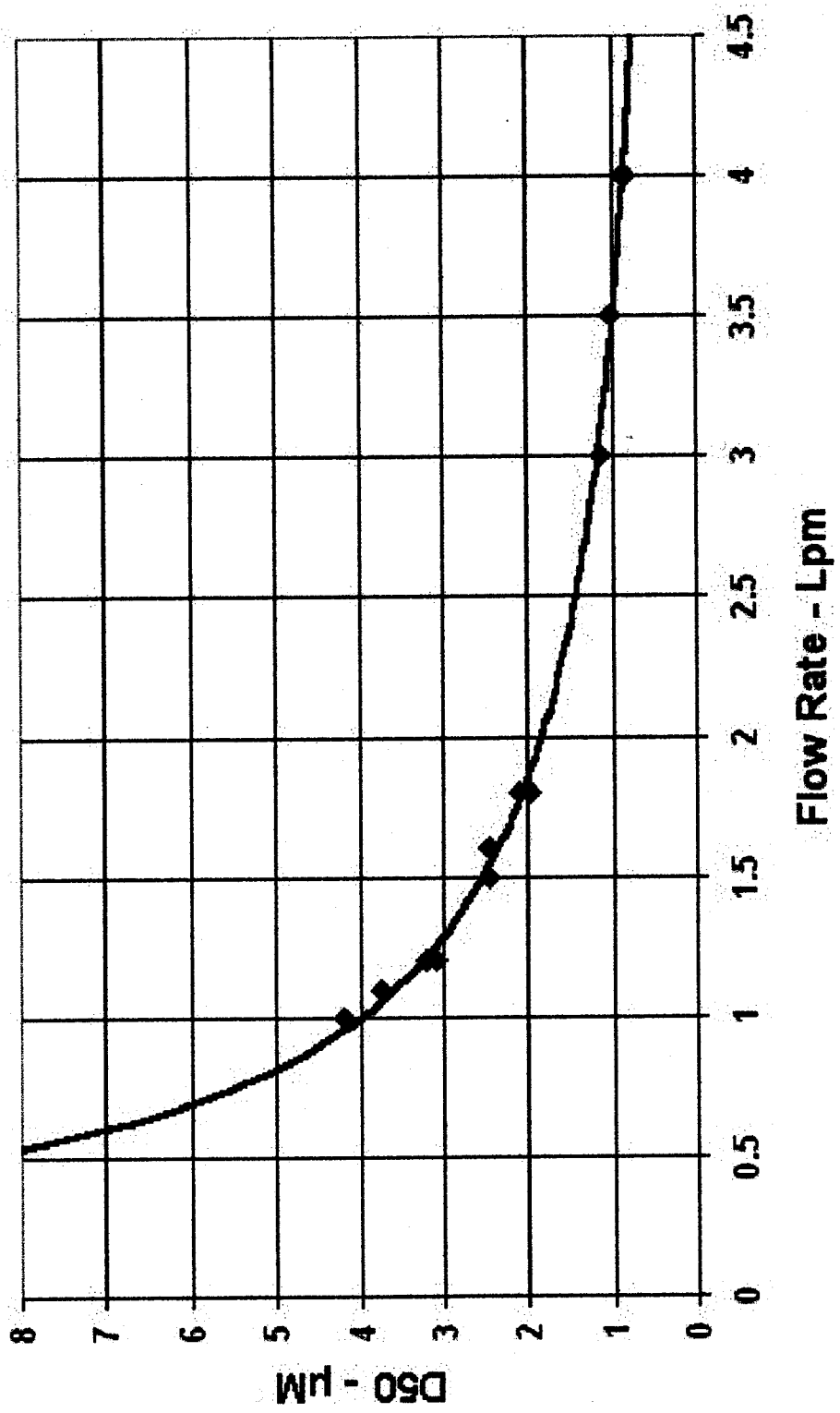

Figure 2. Particle cut point of type SCC cyclone vs. flow rate

8.2 Continuous Unattended Monitoring

When the ADR-1200S is used for continuous unattended monitoring (e.g., ambient air monitoring), the 37-mm filter holder connected directly downstream of the *p*DR-1200 sensing chamber should be left empty, i.e., both the membrane filter and its backing disc should be removed. This ensures that there will not be a build up of collected particles on the membrane filter requiring its frequent replacement in order to prevent excessive flow resistance. In the absence of the 37-mm membrane filter, the particles will be collected within the large-capacity filter cartridge which will require replacement on an infrequent schedule (see Section 11.2 of this manual).

9.0 ZEROING PROCEDURE

Zeroing the ADR-1200S is an important step to ensure measurement accuracy. Please refer to Sections **pDR** 6.5 and **pDR** 8.1 about details of this procedure. The clean filtered air for zeroing is provided by the ADR-1200S itself: the air exiting the flow exhaust port (small brass fitting on right side of the enclosure) is filtered as described in Section 3.0 of this manual, and can be fed into the ADR-1200S inlet. This method of recirculation ensures particle free air within the photometric sensing chamber.

In order to perform an ADR-1200S zeroing sequence proceed as follows:

- Locate the 2-ft length of ¼ in. ID, 3/8 in. OD plastic tubing (Tygon) provided with the ADR-1200S
- Remove the DR-OSI omnidirectional inlet from the ADR-1200S inlet fitting by lifting the knurled sleeve, as described in Section 4.0 of this manual
- Slide one end of the plastic tubing onto the flow exhaust port (see Fig. 1), and the other end onto the inlet fitting stem of the ADR-1200S (this connection may require some stretching of the tubing end)
- Apply ac power to the ADR-1200S (plug into wall receptacle if not connect already to ac power line)
- Open the front door of the ADR-1200S
- Press **ON/OFF** key on front panel of the *p*DR-PU pump unit
- Press **ON/OFF** key on front panel of the *p*DR-1200 monitoring unit
- Refer to Section **pDR** 8.1, and proceed with step 2 of that section (simply key **ENTER**) and wait until the readout on the *p*DR-1200 indicates CALIBRATION: OK
- Press the **ON/OFF** keys on both the *p*DR-PU pump unit and on the *p*DR-1200 monitoring unit in order to shut off both units
- Remove plastic tubing from both the flow exhaust port and from the inlet stem. Replace DR-OSI omnidirectional inlet as indicated in Section 4.0 of this manual
- This completes the zeroing procedure, and the ADR-1200S is then ready to start monitoring

NOTE: Whenever the ADR-1200S is being used to monitor particulate matter at moderate to high concentrations (> 0.1 mg/m^3), it is advisable to run the system in the purging/recirculation mode using the tubing connection between exhaust and inlet described above before terminating a measurement/monitoring run. This procedure will prevent deposition of particles within the system when the flow is stopped.

10.0 OPERATION

10.1 Operating Modes

Please refer to Section **pDR** 7.0 for the various operating modes offered on the ADR-1200S: start-up mode, ready mode, run mode without data logging, run mode with data logging, displays and commands.

10.2 Running the ADR-1200S

For the actual operation of the ADR-1200S refer to Section **pDR** 8.0 for the operation of the *p*DR-1200 monitoring unit, and Section **PU** 4.0 for the operation of the pump unit. Only the following special additional instructions are presented in this manual:

- To achieve immediate readiness it is advisable to start the operation of both the *p*DR-1200 and the *p*DR-PU concurrently by pressing their respective **ON/OFF** keys
- Select the appropriate flow rate on the *p*DR-PU
- Proceed to step 3 of Section **pDR** 8.1
- If the appropriate parameters have been selected via a PC (see Section **pDR** 9.0) and the user is ready to start a run, then key **ENTER**, alternatively proceed as indicated in Sections **pDR** 8.2 and 8.3

11.0 MAINTENANCE

11.1 *p*DR-1200 Monitoring Unit

Refer to Section **pDR** 12.0. In order to access the optical sensing chamber for cleaning as described in Sections **pDR** 12.2 and 12.2.2, proceed as follows referring to Fig. 1 of the present manual:

- Remove cyclone from its black sealing cup on the *p*DR-1200 sensing chamber by pulling the cyclone out moving it back and forth
- Disconnect tubing fitting from 37-mm plastic sampling filter holder at the downstream side of the *p*DR-1200 sensing chamber
- Disconnect both tubing connections at the *p*DR-PU pump unit
- Unplug the phone-type plug on the right side of the *p*DR-1200 monitoring unit
- Unplug the small right-angle power plug from bottom of the *p*DR-PU pump unit, by pulling it out (downward)
- Unscrew and remove the two holding screws of the *p*DR-1200, marked “A” on Fig. 1
- Unscrew and remove the two holding screws of the *p*DR-PU, marked “C” on Fig. 1
- Lift the two joined *p*DR-1200 and *p*DR-PU units out of the ADR-1200S enclosure
- Proceed as described in Section **pDR** 12.2.2
- Once cleaning of the sensing chamber is complete, replace the two joined units into the ADR-1200S enclosure and retrace all steps described above
- Check optical background as indicated in Section **pDR** 8.1

11.2 Large Capacity Filter Cartridge Replacement

If the pump unit begins to sound “labored” even when there is no membrane filter in the sampling filter holder at the exhaust side of the *p*DR-1200 sensing chamber, it is an indication that the large capacity filter cartridge should be replaced. Alternatively, this cartridge should be replaced once a year if the ADR-1200S is used continuously at a concentration averaging 0.1 mg/m^3 (100 µg/m^3) or less.

To replace the large capacity filter cartridge (model), disconnect the plastic tubings from its two ends, and loosen the two screws that secure the strap holding the cartridge to the main base plate of the ADR-1200S. Slide the cartridge out of the strap and discard. Replace with a new cartridge, reversing above steps. Make sure to install cartridge with its arrow pointing downward (toward the connection to the *p*DR-PU pump unit).

11.3 Door Window Cleaning

The front door window of the ADR-1200S is made of a special high impact transparent plastic (HYZOD). In order to clean it proceed as follows:

- Rinse with water to remove any abrasive dust and dirt
- Wash with soap or mild detergent using sponge or cloth. **Do not scrub**
- Rinse once more, then dry with soft cloth or chamois
- To remove grease, wet paint, or stickers, rub gently with a cloth wetted thoroughly in VM&P naphta or in isopropyl alcohol. Wash and rinse. Do not use razor blades, scrapers, squeegees, etc.

To discuss any other problems related to the transparent window material, contact Sheffield Plastics at 1-800-628-5084.

SERVICE LOCATIONS

For additional assistance, Environmental Instruments Division has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

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