IP-10A METHOD UPDATE

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DETERMINATION OF FINE PARTICULATE MATTER IN INDOOR AIR USING SIZE-SPECIFIC IMPACTION

- **Personal Environmental Monitor (PEM) with Leland Legacy Pump**

- **Sioutas Personal Cascade Impactor Sampler with Leland Legacy Pump**

(9)

Publication 1660 Rev. 1901

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By SKC Inc.
Year 2004
www.skcinc.com

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1. Scope

1.1 The term fine particulate matter (PM) is typically used to describe airborne solid particles and liquid droplets less than 2.5 microns in aerodynamic diameter. Fine PM results from a variety of sources including fuel combustion from power plants, industrial facilities, and motor exhaust. Fine particles can also be formed in the atmosphere when combustion gases such as sulfur dioxide and nitrogen oxides are chemically transformed into particles.

1.2 Since the *Compendium of Methods for the Determination of Air Pollutants in Indoor Air* was first published in April 1990, the focus on particulate matter has grown in the research and regulatory communities (1). Specifically, fine particulate matter has become a national concern because it can penetrate deep into the lung causing significant health effects. Health effects include an increase in respiratory symptoms and related hospital visits, aggravated asthma, chronic bronchitis, and premature death. Those most at risk include the elderly, individuals with preexisting heart or lung disease, and children, particularly those with asthma.

1.3 Several studies have reported that stationary monitors are poor estimators of personal exposure to PM. Differences in one's activities combined with the localized nature of certain particle types can cause large interpersonal sample variability. Therefore, to better assess the effect of PM exposures on the health of individuals, it is necessary to sample the indoor microenvironment. Indoor microenvironmental (personal) samples can be used to better characterize the mass, size, and chemical composition of PM pollutants along with their impact on health. (2-3)

1.4 The collection of meaningful sampling data in the indoor microenvironment has been hampered by the available technology. Size-selective personal sampling devices that measure PM have been limited to single-stage impactors such as the Personal Environmental Monitor (PEM) with an impactor cut-point of either 2.5 or 10 microns. As such, the PEM does not provide information on the complete size distribution of PM pollutants. Similarly, the status of sampling pump technology has created obstacles to personal sample collection of indoor PM. Typical indoor PM concentrations dictate the need for high flow rates and long run times to collect enough sample for analysis. (4-6) However, to be worn comfortably by a person for an extended period, the pump has to be of a reasonable size and weight and produce a low noise level.

1.5 To address the need for complete characterization of PM pollutants indoors, the Sioutas Personal Cascade Impactor Sampler has been developed. (7) This miniaturized cascade impactor, hereafter referred to as the Sioutas Impactor, consists of four impaction stages, followed by an after-filter. Its PTFE impaction substrates permit gravimetric analysis of PM mass or chemical analysis of PM constituents. The Sioutas Impactor can be connected to the participant's lapel and used with a new high-efficiency pump, the Leland Legacy®, which provides the required 9 L/min flow rate for 24 hours.

1.6 If, however, a single-stage impactor is sufficient for the study, the Leland Legacy pump can be used at 10 L/min with the PEM (fully described in the 1990 version of Method IP-10A). The Leland Legacy pump provides for improved analytical sensitivity because 24-hour sampling is possible using the PEM for size-specific sample collection.

1.7 This method may involve hazardous materials, operations, and equipment. This method does not purport to address all the safety problems associated with its use. It is the responsibility of whoever uses this method to consult and establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2. Applicable Documents

2.1 ASTM Standards

D1356 Definitions of Terms Relating to Atmospheric Sampling and Analysis
D1605 Sampling Atmospheres for Analysis of Gases and Vapors
D1357 Planning the Sampling of the Ambient Atmosphere

2.2 Other Documents

Compendium of Methods for the Determination of Air Pollutants in Indoor Air
Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air
U.S. Environmental Protection Agency Technical Assistance Documents
Laboratory Studies for Monitoring Development and Evaluation

3. Summary of Method

3.1 For determining fine particulate matter in indoor air, two sampling devices will be described along with a new high-efficiency pump that allows 24-hour sampling with either device. The two sampling devices are the Personal Environmental Monitor (PEM™) and the Sioutas Personal Cascade Impactor. Both sampling devices operate on the principal of impaction. The PEM is a single-stage impactor with an after-filter; the Sioutas Impactor is a 4-stage impactor with an after-filter.

3.2 With the PEM, particle-laden air is accelerated through a number of nozzles and the exiting jets impinge upon a ring. The particles larger than the designated cut-size impact onto the ring due to inertia. The smaller particles are carried along in the airstream and are collected on the 37-mm PTFE after-filter. Six versions of the PEM are available to collect either PM2.5 or PM10 at one of three different flow rates: 2, 4, or 10 L/min. This method will focus on the PEM designed for PM2.5 at 10 L/min using the Leland Legacy pump for 24-hour sampling.

3.3 The Sioutas Impactor is a miniaturized cascade impactor consisting of four impaction stages and an after-filter. Particles are separated in the following aerodynamic particle diameter ranges: < 0.25, 0.25-0.5, 0.5-1.0, 1.0-2.5, and > 2.5 μm. The Sioutas Impactor operates at a flow rate of 9 L/min.

3.4 A known volume of air is drawn for a measured period of time through either impaction device to a tared filter or filters.

3.5 Size-specific PM levels are calculated from the weight gain of the filter in each stage and the total volume of air sampled. The Sioutas Impactor does not require the coating of filters to minimize particle bounce. Therefore, with this sampler, chemical species analysis can also be performed on the filter-collected PM following Chapter IO-3 in the *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air*.

4. Significance

4.1 There is a need to obtain meaningful exposure data for PM in the indoor environment to better assess health effects in epidemiological studies. Indoor PM levels are affected by a number of indoor and outdoor sources and there is high interpersonal variability in exposures. To meet this need, sampling pumps must be suitable for sampling in the microenvironment and must provide extended run times up to 24 hours to increase the amount of PM collected.

4.2 Particle size and particle components such as sulfate and acidity are important factors when studying the adverse health effects and increased mortality from PM exposures. Therefore, sample collection devices should allow for the calculation of particulate mass as well as for the identification of particle size and chemical species.

4.3 For these reasons, it is imperative that a sampling protocol addressing the sampling and analysis of speciated particulate matter in indoor air be developed.

5. Definitions

Note: Definitions used in this document and any user-prepared Standard Operating Procedures (SOPs) should be consistent with ASTM Method D1356. All pertinent abbreviations and symbols are defined within this document at point of use.

5.1 Particulate matter — a generic classification in which no distinction is made on the basis of origin, physical state, and range of particle size. (The term “particulate” is an adjective, but it is commonly used as a noun.)

5.2 Dust — dispersion aerosols with solid particles formed by comminution or disintegration without regard to size. Typical examples include: (1) natural minerals suspended by the action of wind; and (2) solid particles suspended during industrial grinding, crushing, or blasting.

5.3 Smokes — dispersion aerosols containing both liquid and solid particles formed by condensation from supersaturated vapors. Generally, the particle size is in the range of 0.1 to 10 μm. A typical example is the formation of particles due to incomplete combustion of fuels.

5.4 Fumes — dispersion aerosols containing liquid or solid particles formed by condensation of vapors produced by chemical reaction of gases or sublimation. Generally, the particle size is in the range of 0.01 to 1 μm.

5.5 Mists — suspension of liquid droplets formed by condensation of vapor or atomization; the droplet diameters exceed 10 μm and, in general, the particulate concentration is not high enough to obscure visibility.

5.6 Primary particles (or primary aerosols) — dispersion aerosols formed from particles that are emitted directly into the air and that do not change form in the atmosphere. Examples include windblown dust and ocean salt spray.

5.7 Secondary particles (or secondary aerosols) — dispersion aerosols that form in the atmosphere as a result of chemical reactions. A typical example is sulfate ions produced by photochemical oxidation of SO_2.

5.8 Particle — any object having definite physical boundaries in all directions, without any limit with respect to size. In practice, the particle size range of interest is used to define “particle.” In atmospheric sciences, “particle” usually means a solid or liquid subdivision of matter that has dimensions greater than molecular radii (~10 nm); there is also not a firm upper limit, but in practice, it rarely exceeds 1 mm.

5.9 Fine particles — those particles with diameters less than 2.5 µm; this fraction is usually defined in terms of the separation diameter of a sampler.

6. Method Limitations and Limits of Detection

6.1 PEM

6.1.1 The PEM’s limit of detection (LOD) is a function of the weighing room environment and the precision of the microbalance used to perform mass measurements.

6.1.2 The 1990 version of this method suggested a minimum weight of 20 micrograms (µg) of particles on the filter using the PEM and a maximum loading of 600 $\mu g/cm^2$.

6.2 Sioutas Impactor

6.2.1 Particle loading tests indicated that the 0.25-µm stage in the Sioutas Impactor could retain its collection efficiency for particle loadings up to 3.16 mg. (8) Maximum particle loadings for other stages vary. (8) The Sioutas Impactor also showed the ability to preserve labile species during sampling; this is highly desirable because a significant fraction of fine particles is associated with such species.

7. Apparatus Description

7.1 Personal Environmental Monitor (PEM™)

7.1.1 A schematic diagram of the PEM is shown in Figure 1. The sampler weighs 48 grams (1.7 ounces) and consists of three basic sections: an inlet nozzle cap, impaction ring assembly, and base.

7.1.2 Inlet nozzle cap — The PEM designed for PM2.5 collection at 10 L/min has 10 nozzles located in a circle along the outer edge of the nozzle cap through which the aerosol enters the sampler.

7.1.3 Impaction ring assembly — This section serves as both an impaction surface and a clamping ring for the after-filter. Aerosol passing through the inlet nozzles impacts onto an annular disc of porous material cemented onto the ring that clamps the after-filter to the base. To reduce particle bounce, oil is applied to the impaction ring. The airstream containing the remaining smaller particles flows through the circular opening in the center of the impaction plate.

7.1.4 Base — The base houses a stainless steel support screen used to support the after-filter. The force applied by attaching the nozzle cap clamps the after-filter to the support screen to form an airtight seal between the filter and base. The base also has an exit plenum and outlet tube that connects by tubing to the pump.

7.1.5 Filter — A 37-mm, 2.0-µm pore size PTFE filter with PMP support ring is used as the filtration medium. It is supported by a stainless steel screen that is supplied with the PEM.

Notes:

- *Back pressure on PTFE filters can vary within the same lot.*
- *The maximum operating temperature for PTFE filters with PMP support is 464 F (240 C).*

7.1.6 Flow Calibration Attachment — A special attachment known as the PEM Calibration Adapter provides for a single inlet to the PEM to which a calibrator can be attached. The calibration adapter is pressed onto the inlet nozzle cap of the PEM. A calibrator is attached to the ½-inch diameter inlet tube on the top of the calibration adapter. An optional fitting is attached to the side of the calibration adapter for purposes of attaching a pressure gauge if there is a large pressure drop across the calibrator. Under normal operation, however, the pressure need not be measured and the pressure tap can be closed off.

7.2 Sioutas Personal Cascade Impactor

7.2.1 The Sioutas Impactor is constructed of aluminum and weighs 159 grams (5.6 ounces). An exploded view of the sampler is shown in Figure 2. It consists of an inlet plate, four accelerator plates that have slits that perform the size selection, four collector plates that hold the impaction substrates, and an outlet plate that holds the after-filter. The device is held together by two thumbnuts on threaded studs.

7.2.2 The outlet plate houses the 37-mm after-filter, which is supported by a screen and secured in place by a compression ring and O-ring all supplied with the Sioutas Impactor.

7.2.3 A collector plate rests on top of the outlet plate such that the indicated marks are in alignment. A 25-mm filter that serves as the impaction substrate is then placed in the collector plate and it is held in place with a filter retainer ring.

7.2.4 The appropriate accelerator plate is then placed on top of the collector plate in the proper alignment. These steps are repeated until all collector plates with substrates and accelerator plates are in place. Finally, the inlet plate is put in place on top of the sampler and the thumbnuts are tightened to secure the device.

7.2.5 Filters and Substrates — A 37-mm, 2.0-µm pore size PTFE filter with PMP support ring is used as the after-filter in the outlet plate. The recommended impaction substrates on the collector plates are either 25-mm, 0.5-µm PTFE filters with PTFE support or 25-mm, 3.0-µm PTFE filters with PMP support ring.

Notes:

- *Back pressure on PTFE filters can vary within the same lot.*
- *The maximum operating temperature for PTFE filters with PMP support is 464 F (240 C).*

7.2.6 Flow Calibration — The inlet and outlet plates have ⅜-inch OD, ¼-inch ID fittings to which flexible tubing can be attached. The outlet fitting is connected to the sampling pump. The inlet fitting is connected to the calibrator for flow calibration.

7.3 Leland Legacy Sampling Pump

7.3.1 Pump — This method is written for use with the PEM designed to collect PM2.5 at 10 L/min or with the Sioutas Impactor at 9 L/min. The Leland Legacy pump will provide constant flow (± 5%) with either sampling device for 24 hours or more (see Figure 3). If during sampling the pump flow rate drops by more than 5%, the pump will stop but retain in memory all valid sampling data prior to the flow fault. In addition, upon fault shutdown, the pump will automatically make up to 10 attempts to restart itself and run at the flow rate originally set.

7.3.2 Electronics — The pump electronics feature an internal flow sensor that measures flow directly and acts as a secondary standard, crystal-controlled real-time clock, sensors that automatically maintain flow calibration by compensating for differences in temperature and atmospheric pressure during sampling, a liquid crystal display (LCD), battery status indicator, and low battery switch-off.

7.3.3 The three-button controls can be used to program the pump and to scroll through the recorded data. Recorded values include start date and time, stop date and time, total sample time, flow rate, sample volume, temperature, and atmospheric pressure. Programming options include a security/tamper-resistance feature. To change any sampling parameter, the user must enter a security code (button sequence is the same for all the pumps). For ultimate tamper resistance, the user can set a lockout option through the optional DataTrac® software program.

7.3.4 Automation — The DataTrac software program (purchased and installed separately) affords the user ultimate flexibility in pump scheduling and complete record keeping capabilities. Through the “Pump Scheduler” window shown in Figure 4, the user can program up to 100 sampling intervals with defined start and stop times and flow rates. Through the “Sample Set-up” window, the user can record all sample identification information. DataTrac software also records critical pump parameters such as run time, flow rate, and air volume and notes any changes in pump operational status such as flow fault or an exhausted battery. This pump history can be saved to a file or printed.

7.3.5 Flow Calibration Options — The pump will display the flow rate in L/min on the LCD as measured by the internal flow sensor. Flow can be verified by a calibrator and adjusted based on the reading.

Note: *Use PEM Calibration Adapter (SKC Cat. No. 761-202) designed specifically for the PEM.*

7.4 Cahn Microbalance

7.4.1 The Cahn Model 30 balance is capable of weighing up to 3.5 grams with an accuracy of ± 0.5 µg. It operates on the principle of balancing the sample with torque motor input. The electric current flowing in the torque motor produces an equal and opposite force on the balance beam when the beam is at the reference position, identified by a photocell detection system. The current is directly related to the sample weight through the calibration process.

7.4.2 The same analytical microbalance and weights must be used for weighing filters before and after sample collection.

7.5 Weighing Room Environment

The weighing room should be a temperature and relative humidity-controlled environment. Temperature should be maintained within the range of 17 to 23 C.

Relative humidity should be maintained between 38 and 42%. Weekly strip chart recordings of temperature and humidity should be maintained on a hygrothermograph. Temperatures should be read from a calibrated maximum-minimum thermometer and relative humidity should be calculated from a calibrated motor aspirated psychrometer. The weighing area should be cleaned with paper towels and deionized distilled water each day before weighing. Forceps should be cleaned once a week with detergent in a sonic bath and then rinsed in deionized distilled water. Approximately once a month, the balance chamber and pans should be cleaned with diluted ammonium hydroxide and each cleaning should be noted in the weighing room logbook. Filters, weights, and pans should be handled only with non-serrated tip forceps (SKC Cat. No. 225-8371). The Cahn balance should be left on continuously because it requires six hours to warm up for stable operation. Polonium 210 alpha sources should be replaced at one-year intervals from date of manufacture. The replace by date should be engraved on the source by the manufacturer and noted in the weighing room logbook. The filters should be conditioned in the weighing room for at least 24 hours before they are weighed. Each filter should be passed over a deionizing unit before weighing.

8. Apparatus Listing

8.1 Personal Environmental Monitor (PEM)

8.1.1 Sampler — MSP Corporation, 5910 Rice Creek Parkway, Suite 300, Shoreview, MN (SKC Cat. No. 761-203B) with optional Calibration Adapter (SKC Cat. No. 761-202) and Clamping Device (SKC Cat. No. 761-201)

8.1.2 Filter — 37-mm, 2.0-µm nominal pore diameter PTFE membrane filter disc with PMP support ring (SKC Cat. No. 225-1709 or equivalent)

Notes:

- *Back pressure on PTFE filters can vary within the same lot.*
- *The maximum operating temperature for PTFE filters with PMP support is 464 F (240 C).*

8.1.3 Pump — Leland Legacy Pump, SKC Inc., 863 Valley View Road, Eighty Four, PA (SKC Cat. No. 100-3000NULK or equivalent)

8.1.4 Pump Calibrator — TSI 4146 (SKC Cat. No. 740-4146) or equivalent

8.1.5 Analytical Microbalance — refer to Section 7

8.2 Sioutas Personal Cascade Impactor

8.2.1 Sampler — SKC Inc., 863 Valley View Road, Eighty Four, PA (SKC Cat. No. 225-370)

8.2.2 After-filter — 37-mm, 2.0-µm nominal pore diameter PTFE membrane filter disc with PMP support ring (SKC Cat. No. 225-1709 or equivalent)

Notes:

- *Back pressure on PTFE filters can vary within the same lot.*
- *The maximum operating temperature for PTFE filters with PMP support is 464 F (240 C).*

8.2.3 Collection Substrate — 25-mm, 0.5-µm nominal pore diameter PTFE membrane filter disc (SKC Cat. No. 225-3708 or equivalent)

8.2.4 Pump — Leland Legacy Pump, SKC Inc., 863 Valley View Road, Eighty Four, PA (SKC Cat. No. 100-3000NULK or equivalent)

8.2.5 Pump Calibrator — TSI 4146 (SKC Cat. No. 740-4146) or equivalent

8.2.6 Analytical Microbalance — refer to Section 7.4

9. Filter Preparation

9.1.1 All filters are conditioned in the balance room for at least 24 hours before initial or final weighing to reduce the humidity effects on the filter weights.

9.1.2 A Cahn microbalance with electronic data transfer capability should be used to weigh the filters and collection substrates used in the samplers. With this microbalance, a portable computer can be connected through a serial port. Filter numbers are printed in barcode and assigned to filter containers. In operation, the filter numbers are scanned with a barcode reader and the filter placed on the balance pan. A key is then pressed on the computer keyboard to indicate that the filter is in position for weighing. The computer sends the balance a request to weigh. The balance responds with weight and stability code. The operator is signaled by a tone and a message on the computer screen when weighing is complete. The operator then removes the filter and places it back in its container. The process is repeated for each filter to be weighed. The initial weight, time, and data are written to the data file by the computer.

9.1.3 After the filter has been used, it should be transported back to the laboratory in a suitable container such as the SKC Filter-Keeper (SKC Cat. No. 225-8301/2) for conditioning and final weighing. The weighing procedure is the same as for initial weighing. The computer will check the data file for the initial weight entry. The final weight will be matched with the initial weight for that filter number in the data file. The computer subtracts the initial weight from the final weight to determine the particle load which is used to calculate the particulate concentration in $\mu g/m^3$ at each sampler location. After weighing, the filters are carefully returned to suitable containers for archiving or further analyses.

10. Sampler Preparation

10.1 Preparation of PEM

10.1.1 The PEM should be disassembled by removing the two screws holding the nozzle cap to the base. After the screws are removed, the nozzle cap should be lifted up to clear the impaction ring assembly. The impaction ring assembly is removed exposing the after-filter housing. If used previously, the sampler should be cleaned before reuse. The nozzle cap can be cleaned by rinsing with isopropyl alcohol. The particles on the impaction ring should be removed by scraping the surface with a knife or razor blade. Oil can be removed from the ring by placing it in a soap solution or a solvent such as cyclohexane followed by complete rinsing and drying.

10.1.2 The impaction ring must be coated with a light machine oil to eliminate particle bounce. The oil can be applied to the ring by using an eyedropper to place drops evenly around the ring. Fourteen drops is the maximum amount that the impaction ring will hold. Excess oil can be removed by touching a tissue to the porous surface.

10.1.3 To assemble the PEM, place a filter on the filter support screen in the base and set the impaction ring assembly on the filter. Place the nozzle cap over the impaction ring assembly and replace the two screws. An optional Clamping Device (SKC Cat. No. 761-201) is available to ensure that the nozzle cap is clamped parallel to the base and that the correct clamping force has been applied.

10.1.4 After assembly, attach flexible tubing to the outlet fitting of the sampler and to the inlet of the Leland Legacy pump.

10.1.5 The PEM Calibration Adapter (SKC Cat. No. 761-202) provides for a single inlet to the PEM to which a calibrator can be attached. The calibration adapter is pressed onto the nozzle cap of the PEM. The calibrator is attached to the ½-inch diameter inlet tube on the top of the device.

10.1.6 The recommended flow rate for the PEM specified in this method is 10 L/min. Start the pump, adjust the flow to 10 L/min, and run the pump for a minimum of 5 minutes to stabilize the flow. Adjust pump flow until 10 L/min appears on the calibrator. Record the initial flow rate as indicated by the calibrator. Disconnect the calibrator and calibration adapter.

10.1.7 Place the pump and PEM in the desired sample location. Initiate sampling by turning on the pump and recording all pertinent sampling details.

10.1.8 At the end of the sampling period, turn off the pump and document all pertinent sampling details including the sample time displayed on the pump LCD. Repeat the flow calibration as indicated in 10.1.5 and 10.1.6. The flow rate for the overall sample period will be the average of the flow rates determined in the pre and post flow calibration. The pre and post flow calibration values should agree within ± 5%. Multiply the flow rate by the sample time to determine the air volume for individual samples.

10.2 Preparation of Sioutas Impactor

10.2.1 The Sioutas Impactor should be disassembled by loosening the two thumbnuts and removing all stages. To remove O-rings, align the head of a small flat-head screwdriver with the notch in the inner wall of the plate. Gently lift the O-ring up and out. Wash parts in water with detergent or in isopropyl alcohol. Parts may also be cleaned in an ultrasonic bath. Rinse and dry all parts thoroughly with compressed air if available or airdry in a clean environment. Inspect all accelerator plates by holding them up to a light to ensure that none of the impaction slits are clogged. Impaction slits may be cleaned with compressed air.

10.2.2 In a clean environment, assemble the Sioutas Impactor from outlet to inlet as follows: (1) insert the 37-mm after-filter into the outlet plate and replace the compression ring and O-ring; (2) place a collector plate on top of the outlet plate and align the marks; (3) use forceps to place a 25-mm filter in the collector plate, place a filter retainer on top of the filter, and press retainer down firmly; (4) place the designated accelerator plate on top of the collector plate and align the marks; (5) repeat steps (3) and (4) for all stages; (6) put inlet plate in place; and (7) replace thumbnuts.

10.2.3 Using flexible tubing, connect the outlet of the Sioutas Impactor to the inlet of a Leland Legacy pump or other pump capable of maintaining a constant 9 L/min flow rate for up to 24 hours. Connect the inlet of the Sioutas Impactor to the outlet of a calibrator such as the TSI 4146 (SKC Cat. No. 740-4146) or other calibrator capable of measuring 9 L/min.

10.2.4 The recommended flow rate for the Sioutas Impactor is 9 L/min. Start the pump, adjust the flow to 9 L/min, and run the pump for a minimum of 5 minutes to stabilize the flow. Adjust pump flow until 9 L/min appears on the calibrator. Record the initial flow rate as indicated by the calibrator. Disconnect the calibrator.

10.2.5 Place the pump and Sioutas Impactor in the desired sample location. Initiate sampling by turning on the pump and recording all pertinent sampling details.

10.2.6 At the end of the sampling period, turn off the pump and document all pertinent sampling details including the sample time displayed on the pump LCD. Repeat the flow calibration as indicated in 10.2.4. The flow rate for the overall sample period will be the average of the flow rates determined in the pre and post flow calibration. The pre and post flow calibration values should agree within ± 5%. Multiply the flow rate by the sample time to determine the air volume for individual samples.

11. Filter Removal and Transport

11.1.1 After sampling with either the PEM or the Sioutas Impactor, the filters should be carefully removed from the device for weighing and/or other analyses. The filters should be handled with the aid of tweezers to avoid sample loss. Do not turn filters upside down. If transporting samples to an offsite laboratory, place filters in marked, sealed containers for transport such as the SKC Filter-Keeper (SKC Cat. No. 225-8301/2).

11.1.2 For each set of samples, submit a blank sample. The filters to be used as blanks are handled in the same manner as the samples except that no air is drawn through them. Label these as blanks.

11.1.3 As the filters are unpacked in the laboratory, the date received and the condition of the filters should be noted on the accompanying Field Data Sheet and laboratory logbook.

11.1.4 Filters should be placed in an environmentally controlled weighing room and allowed to equilibrate for a minimum of 24 hours. Final weighing of the filters must be performed on the same balance as the original weighing using the same standard operating procedures.

12. Calculation

12.1 Mass of particles found on the sample filter:

$$M_s = (m_2 - m_1) - m_3$$

Where:
M_s = mass found on the sample filter
M_1 = tare weight of the clean filter before sampling, µg
M_2 = the weight of the sample-containing filter, µg
M_3 = the mean value of the net mass change found on the blank filters, µg

Note: The blank filters must be subjected to the same equilibrium conditions.

12.2 The sampled volume is:

$$V_s = Q \times t/1000$$

Where:
V_s = volume of the air sampled, m^3
Q = average flow rate of air sampled, L/min
T = sampling time, min
1000 = conversion from L to m^3

Note: There are no temperature or pressure corrections for changes in sampled volume since the flow calibration is typically performed with the impactor in place at the sampling location. In addition, the Leland Legacy pump will compensate for any additional changes in temperature and atmospheric pressure.

12.3 The concentration of the particulate matter in the sampled air is expressed in micrograms/m^3.

$$C = M_s/V_s$$

Where:
C = mass concentration of particulate matter, µg/m^3
M_s = mass found on the sample filter, µg
V_s = volume of air sampled, m^3

13. Method Safety, Performance Criteria, and Quality Assurance

13.1 Method Safety

13.1.1 This procedure may involve hazardous materials, operations, and equipment. This method does not purport to address all the safety concerns associated with its use. It is the user's responsibility to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to the implementation of this procedure. This should be part of the user's SOP manual.

13.2 Performance Criteria and Quality Assurance

13.2.1 SOPs should be generated by the users to describe and document the activities in their laboratory including: assembly, calibration, operation of the samplers, pumps, and other equipment; sample transport; and data recording and processing.

13.3 Quality Assurance Program

13.3.1 The user should develop, implement, and maintain a quality assurance program to ensure that the sampling system is operating properly and collecting accurate data. Established protocols for calibration, operation, and maintenance should be conducted on a regularly scheduled basis and should be part of the quality assurance program.

14. References

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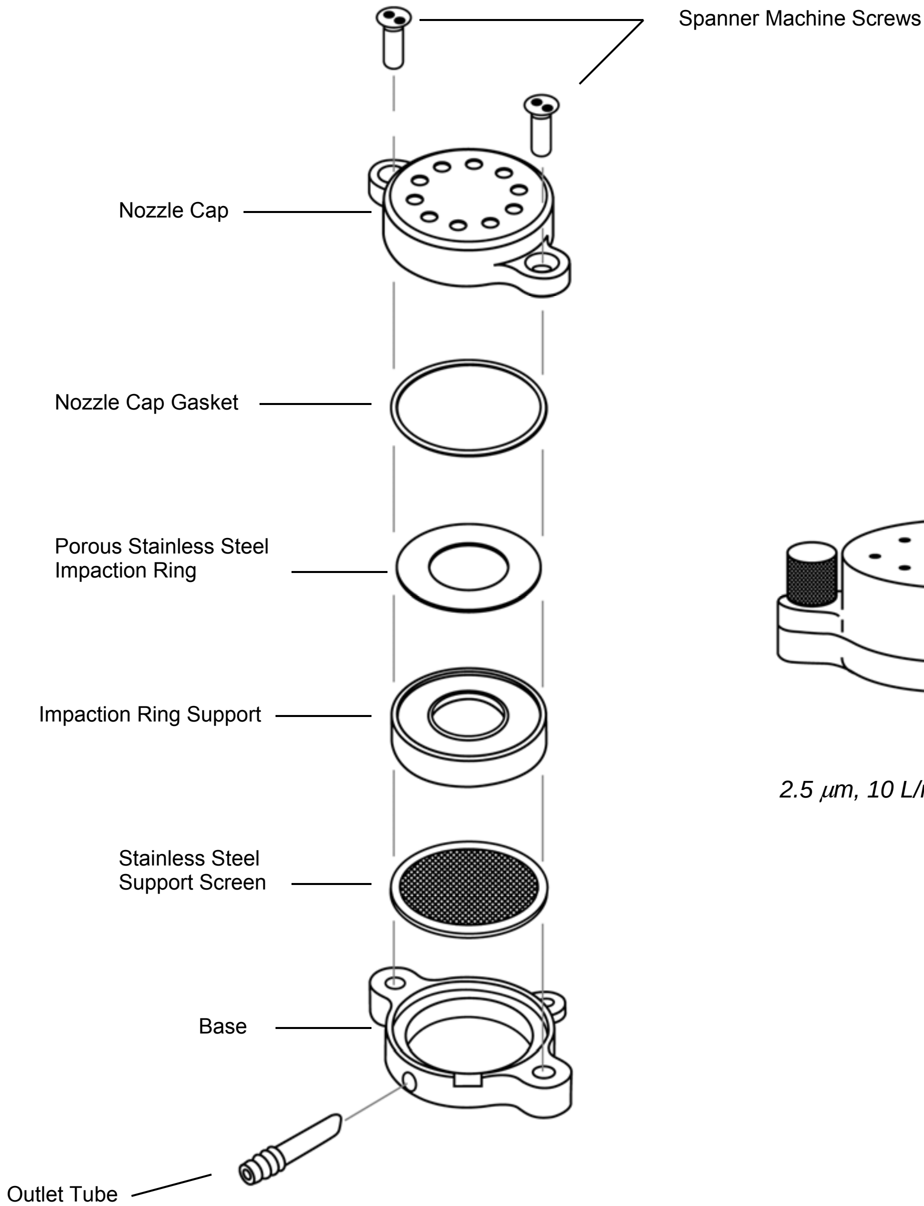
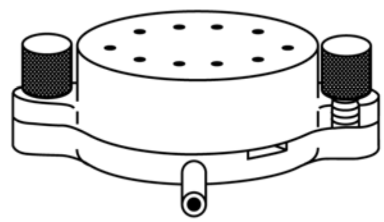
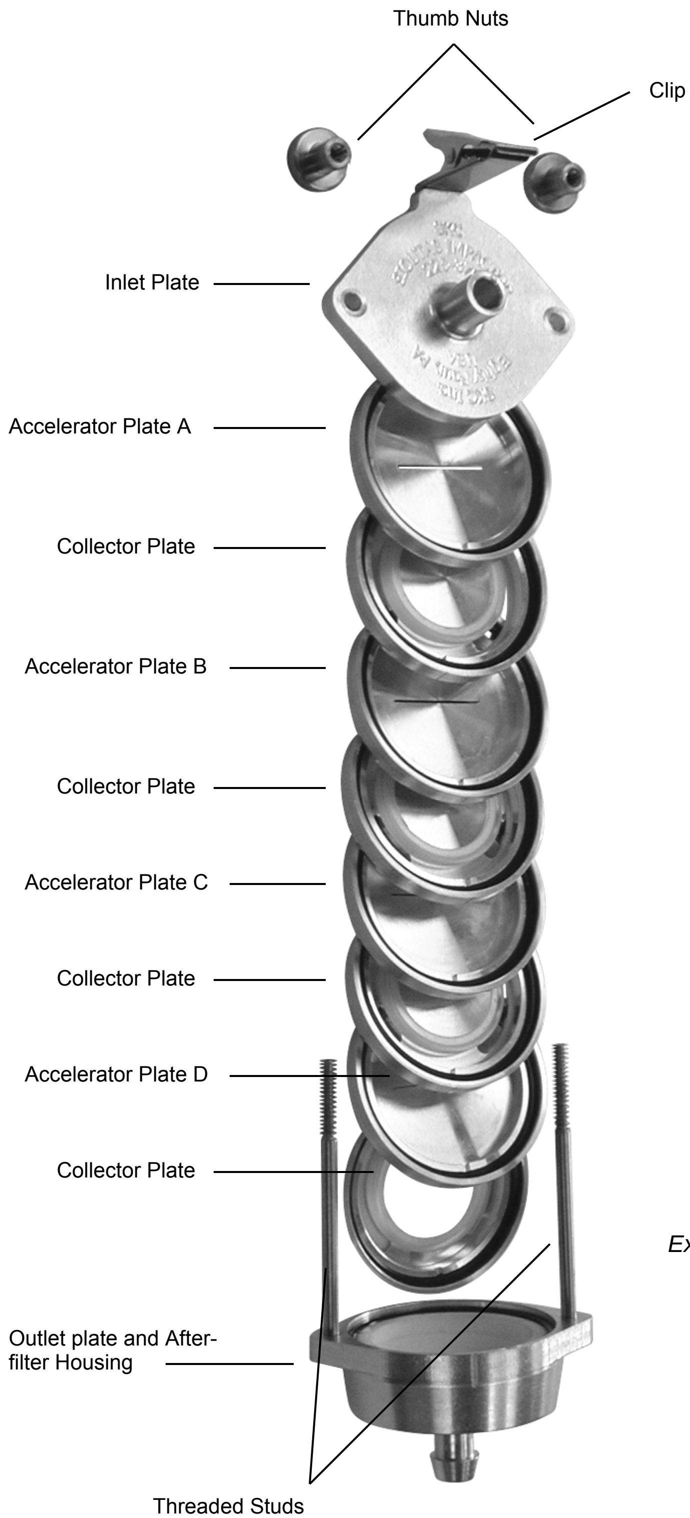
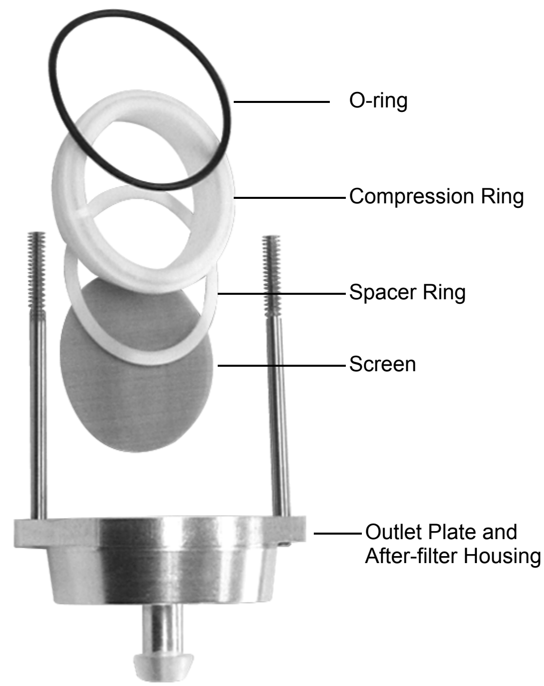




2.5 µm, 10 L/min PEM, assembled

Figure 1. Schematic Diagram of Personal Environmental Monitor (PEM™)





Exploded View of Sioutas Impactor Outlet Plate

Figure 2. Exploded View of Sioutas Personal Cascade Impactor

Not shown:
Beltclip (back)

Battery Charging Jack (top)

Computer Interface Port (top)

Sioutas Personal Cascade Impactor in Sampling Train

Figure 3. Leland Legacy Sample Pump

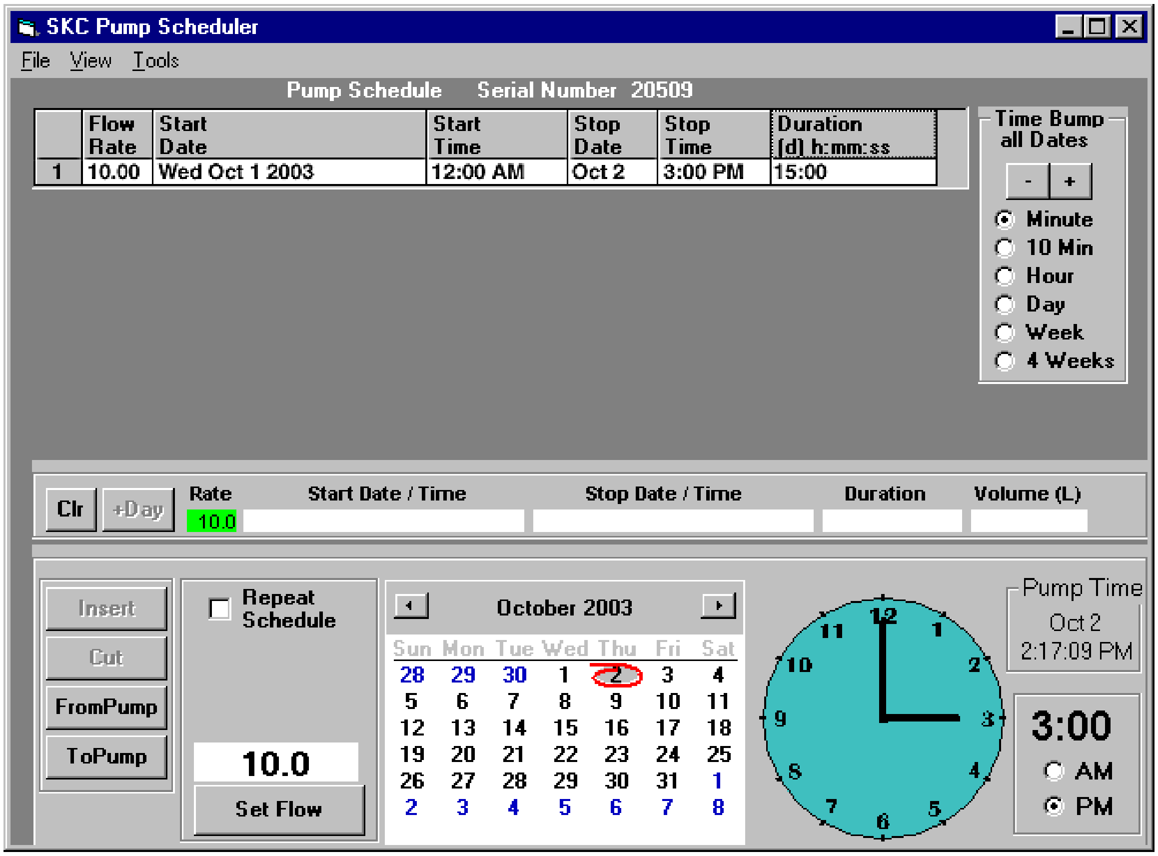


Figure 4. Pump Scheduler Window in DataTrac Software for Leland Legacy Pump