Presentation
on
Suitable Method for PM2.5 Measurement in Ambient Air

By

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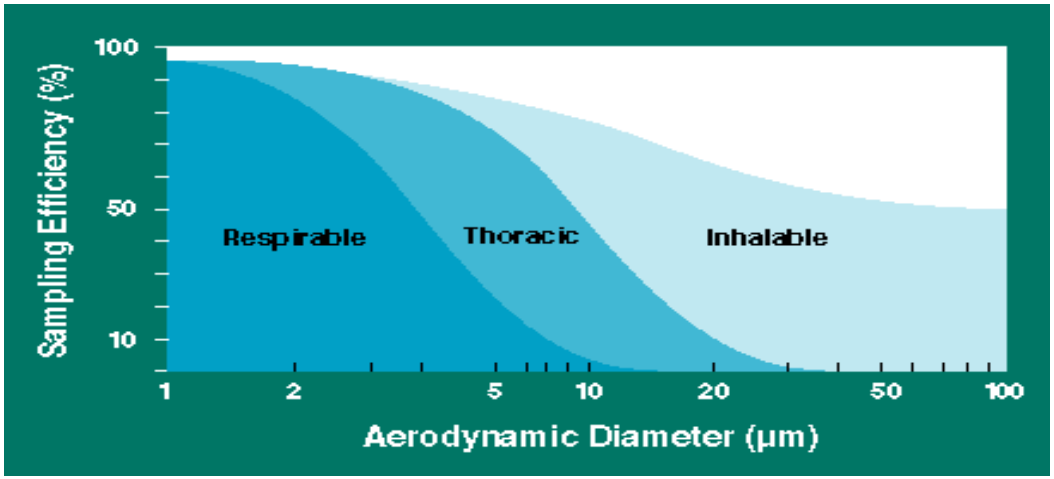
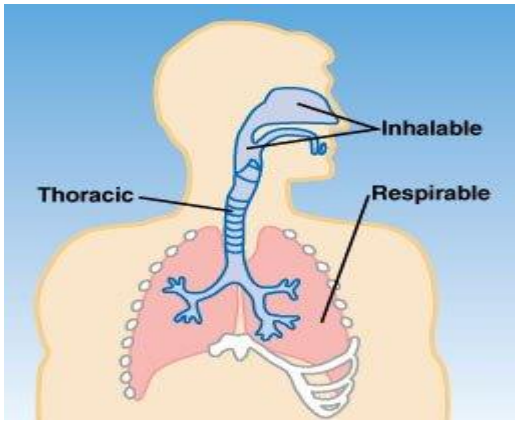
Particulates in Ambient Air
The Size Conventions

- Health effects are related to where the particles get deposited
  - **Inhalable:** Particles that can be breathed into the nose or mouth.
  - **Thoracic:** Particles that penetrate into the respiratory tract below the larynx.
  - **Respirable:** Particles that reach deep into the alveolar region of the lung

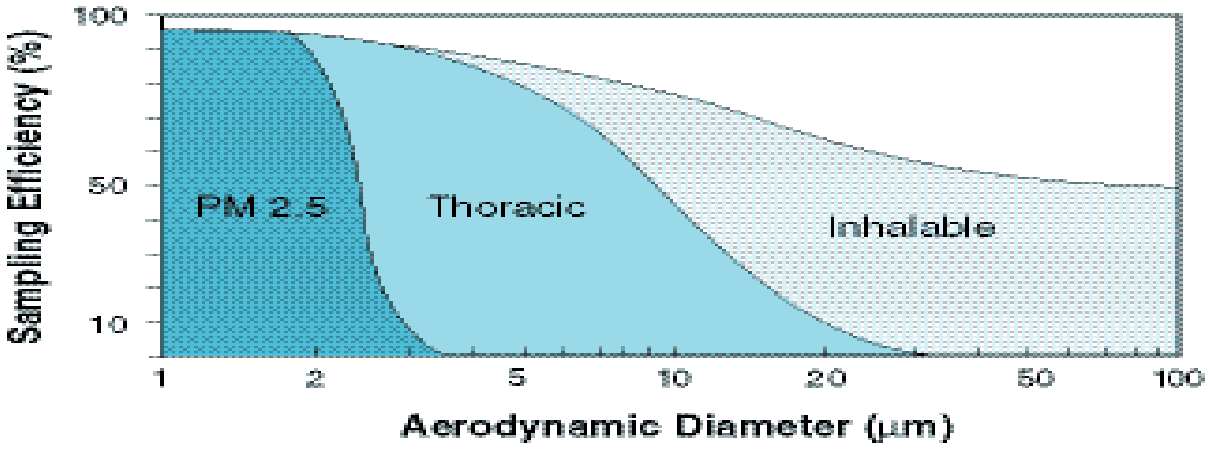




These size conventions were co-developed and adopted by the International Organization for Standardization (ISO), the American Conference of Governmental Industrial Hygienists (ACGIH), and the Comité European de Normalization (CEN) in the early 1990s..

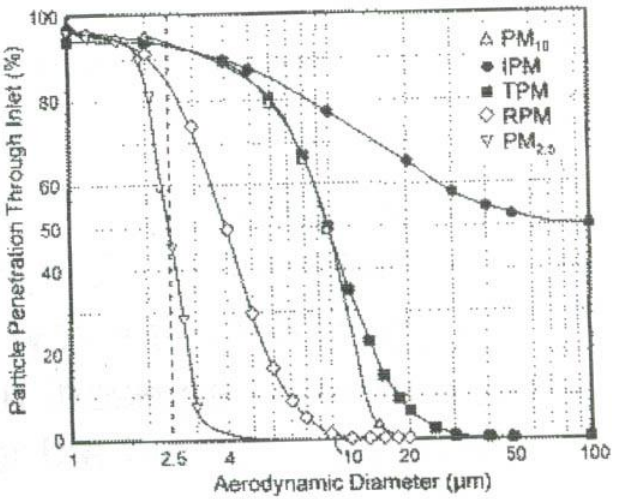
Measurement of Particulate Pollutants in Ambient Air

- Initial approach measured the Total Suspended Particulate Matter (TSP)
- Much of the TSP would not enter the nose or be retained in the upper respiratory tract. This led to the development of PM10 samplers.
- It is now believed that most of the health impacts are related to Fine Particles that reach deep into the lungs leading to development of Fine Particle or PM2.5 Samplers.



Definitions of PM10 & PM2.5

- **Inhalable** particles enter the respiratory tract.
- **Thoracic** particles travel past the larynx & reach the gas exchange region of the lungs.
- **PM10** Particle size distribution closely resembles the thoracic distribution with a D50 at 10µm.
- **PM2.5** size distribution with D250 at 2.5µm AD



Specified particle penetration (size-cut curves) through an ideal (no-particle-loss) inlet for five different size-selective sampling criteria. PM_{10} is defined in the Code of Federal Regulations (1991a). $PM_{2.5}$ is also defined in the Federal Register (1997). Size-cut curves for inhalable particulate matter (IPM), thoracic particulate matter (TPM) and respirable particulate matter (RPM) size cuts are computed from definitions given by American Conference of Governmental and Industrial Hygienists (1994).

It is important to note that particle sizes referred above are NOT physical particle sizes but ***Aerodynamic Diameters****.*

- **Aerodynamic Diameter** is defined as the diameter of a spherical particle with a settling velocity equal to that of the particle in question, but with a density of 1g/cm^3.

Suitable Methods for Monitoring PM2.5 Particulate Matter in Ambient Air

- **Preamble**
- The concern for measurement of this pollutant is growing day by day as more and more information on its impacts on environment is becoming available. Several studies across the world has revealed that its presence in ambient air is severally impacting
- Human Health

  a) It aggravates respiratory symptoms

  b) Decrease lung function

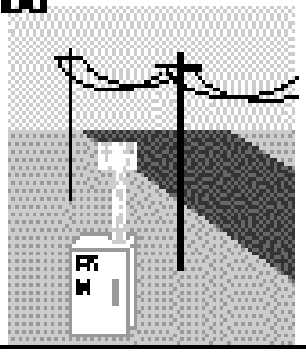
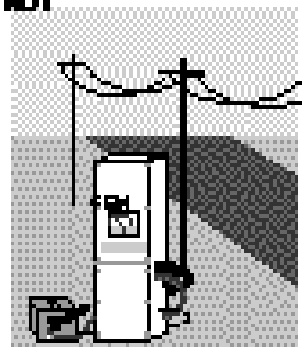
  c) Causes alterations in lung tissue and structure.

  d) Reduces respiratory tract defense mechanism
- Vegetation and Eco System
- Visibility
- Radiative transfer of energy leading to consequences on climate change

- It is present in low concentration, in non uniform sizes and get attached to moisture in the ambient air.

TECHNIQUES TO ASSESS PM2.5

BIO Indicators	Samplers	Online Systems
a) Most Simple Techniques b) Gives qualitative assessment only Reliable quantitative assessment not possible c) Used for long term exposures d) They get affected by total dust. Thus it is difficult to single out presence of PM2.5 Example Lichens/Plants	•Generally conform to reference manual methods •Provides direct measurement of the mass of ambient PM2.5 •These are electrically powered air samplers that draw air at constant rate through a cyclone or an impactor, which acts like a particle separator where suspended PM2.5 is separated for collection on a filter. Filter is then removed from sampler, brought back to lab, equilibrated and weighed to determine ambient mass concentration of PM2.5 •Costly, Time Consuming and Laborious •Prone to Errors during sampling, transportation to lab, equilibrium, weighment loss of semivolatile component (like organic and nitrate through evaporation) during variable temp. and humidity conditions.	A) Opacity Monitors B) Light Scattering Systems i) Nephlometer ii) Orthogonal Light Scattering iii) Laser (light detection and ranging) C) Beta Gauges D) TEOM Tapered Element Oscillating Microbalance * The online monitors do not make direct measurement of mass but instead measure secondary property of particles from which the mass must be inferred. * These technologies are sensitive to change in flow, temp, particle size density and colour. * These require calibration against manual reference methods. * TEOM does measure mass but is sensitive to humidity and temp and requires periodic filter change that result in downtimes of one half hour to two hrs after each filter change. * However they provide a real time data.

PM Monitor	Advantages	Disadvantages
Federal Reference Method 	• Detects mobile sources • Detects fugitive emissions • Direct measure of mass • Not sensitive to particle size, density, and color	• Manual method • Not continuous • Not real-time • Loss of semivolatile components • Time consuming • Laborious • Costly
Continuous Ambient PM Monitor 	• Detects mobile sources • Detects fugitive emissions • Continuous • Real-time • Automated	• No direct measure of mass • No source attribution • Requires site-specific calibration • Sensitive to particle size, density, and color • Loss of semivolatile components

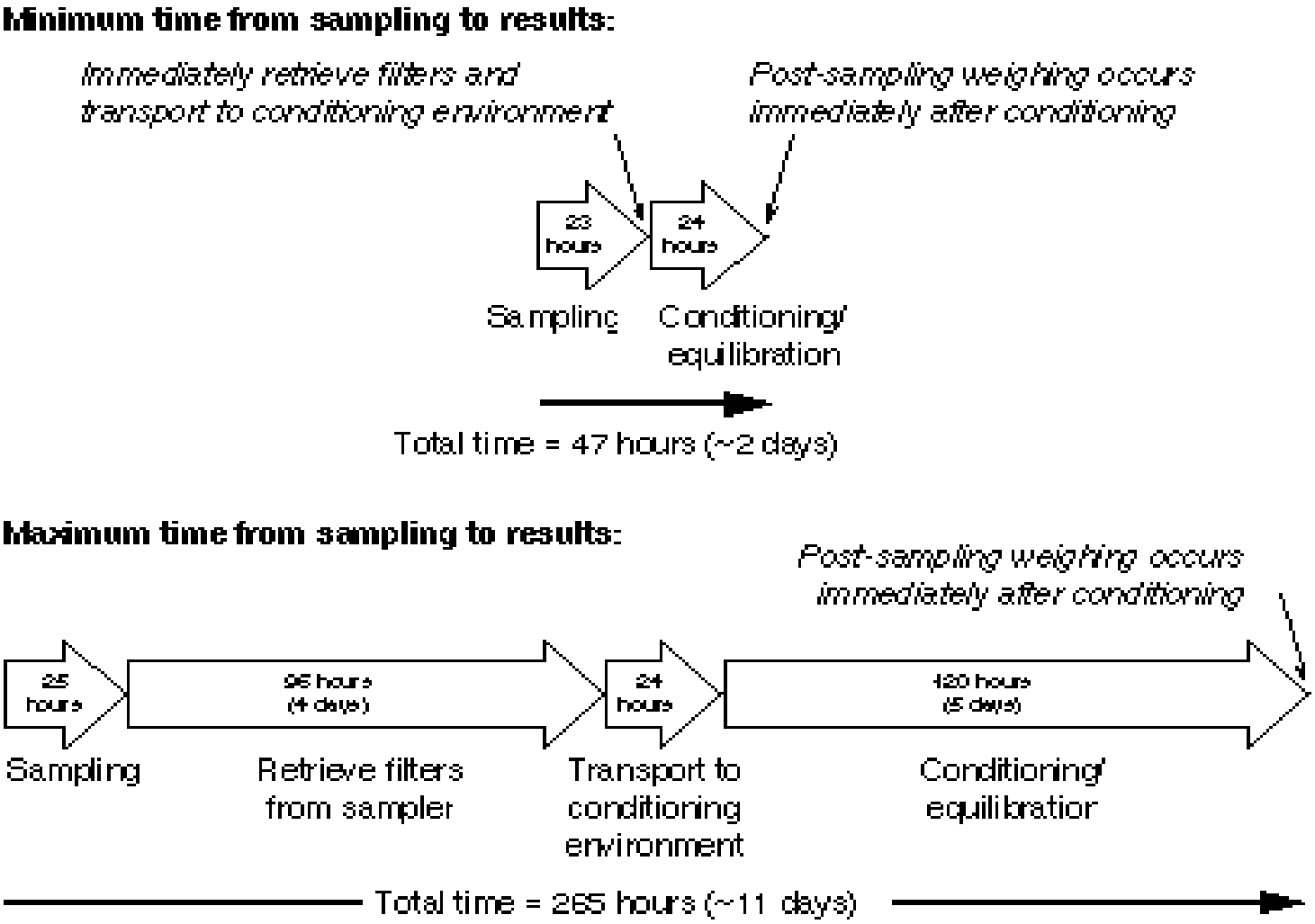
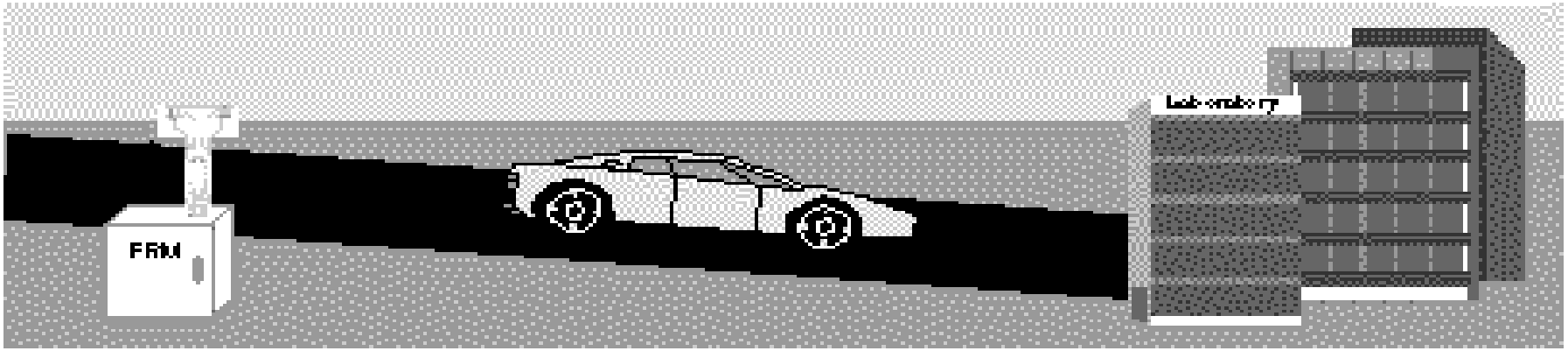


Figure 1--Sampling Time Line for the FRM. The sampling time line for the FRM illustrates the minimum and maximum time from sampling to measurement of PM2.5 mass. Chemical analysis of PM2.5 composition would require additional time and is not depicted in this figure.



Sampler error

- Loss of semivolatile components
- Ambient temperature <–30°C (–22°F) or >45°C (113°F)
- Filter temperature >3°C above ambient temperature
- Adverse weather conditions
- Sampler malfunction
- Sampler design
- Sampler age and cleanliness
- Sampler leakage
- Flow rate and sampling time

Transport error

- Temperature >32°C (90°F)
- Humidity
- Removal of filter from sampler
- Protective container failure
- Transportation time
- Handling and storage

Laboratory error

- Conditioning/equilibration
  - Variations of mean temperature from 20-30°C (68-73°F) ± 2°C
  - Variations of mean humidity from 30-40% ± 5%
  - Time <24 hours
- Pre- and post-sampling filter weighing
- Handling and storage

Figure 2--Sources of Error. The EPA's precision goal for PM2.5 measurements is ±15 percent. However, collocated samplers have shown errors of 50 percent due to sample, transport and/or laboratory error.

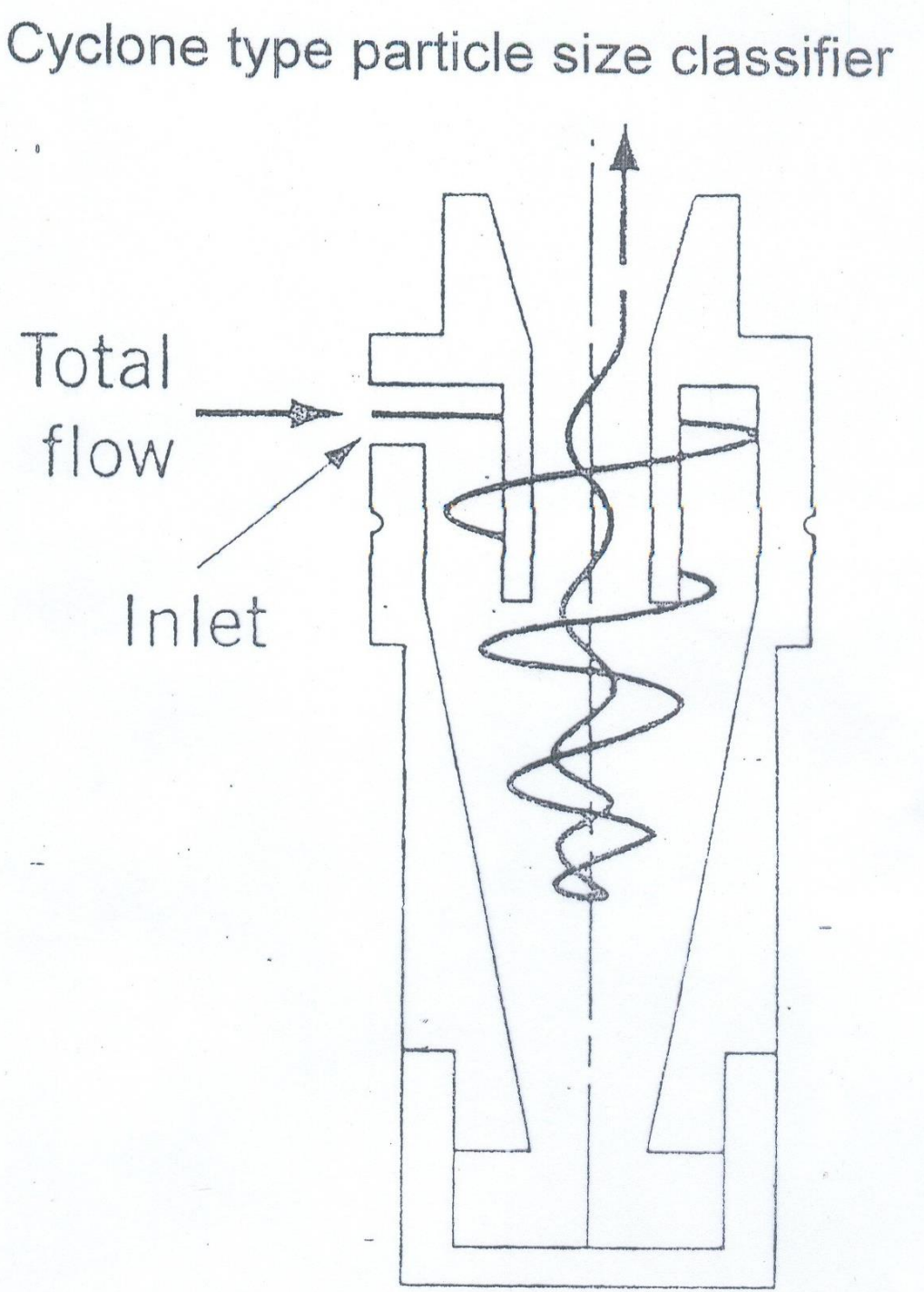
US EPA Standards

Primary $PM_{2.5}$ Standards

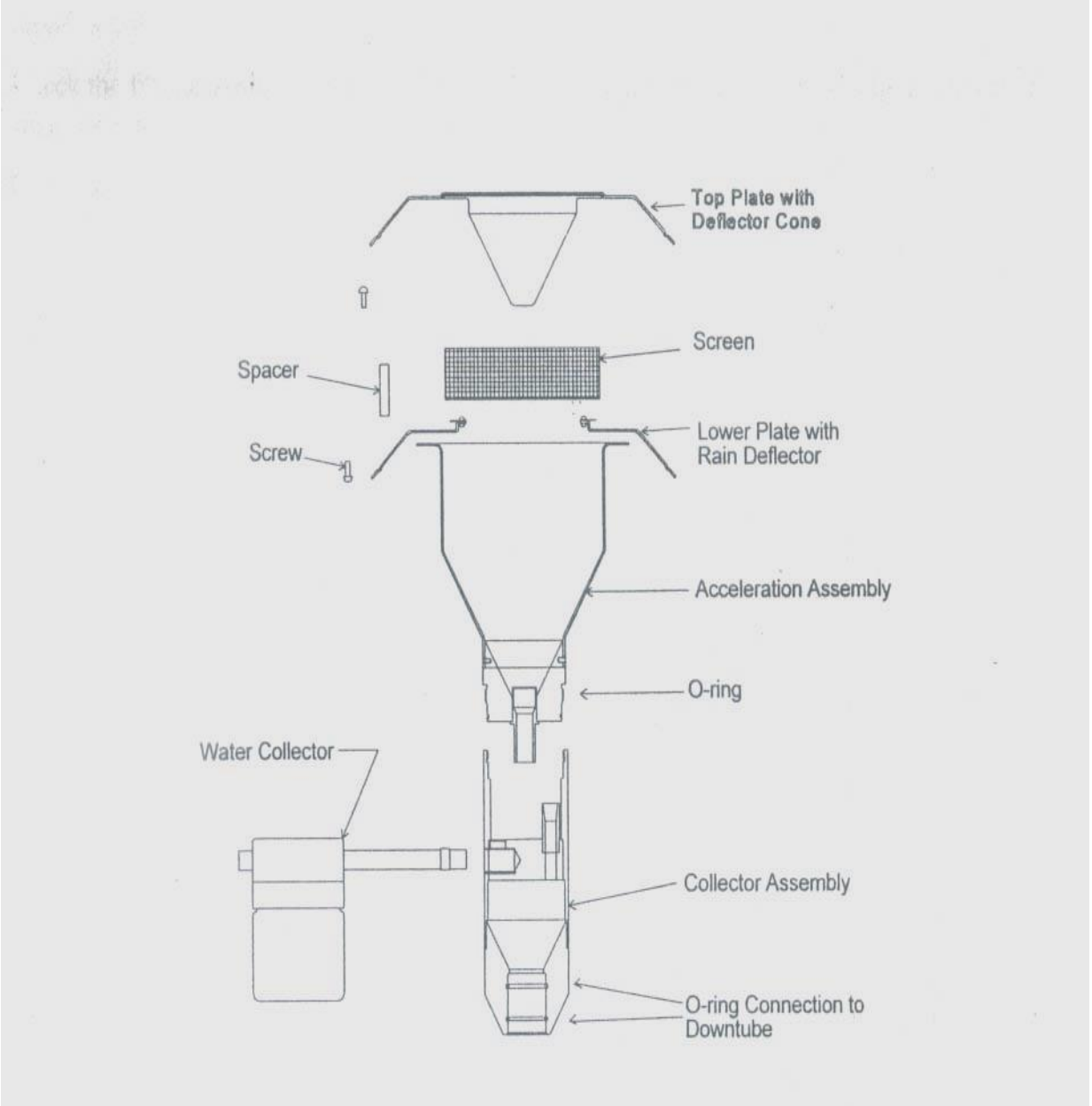
Two new primary $PM_{2.5}$ standards, set at 15 $\mu g/m^3$, annual arithmetic mean, and 65 $\mu g/m^3$, 24-hour average, were added to provide increased protection against the PM-related health effects found in community studies. EPA also established a new Federal Reference Method to measure fine particles which define $PM_{2.5}$.

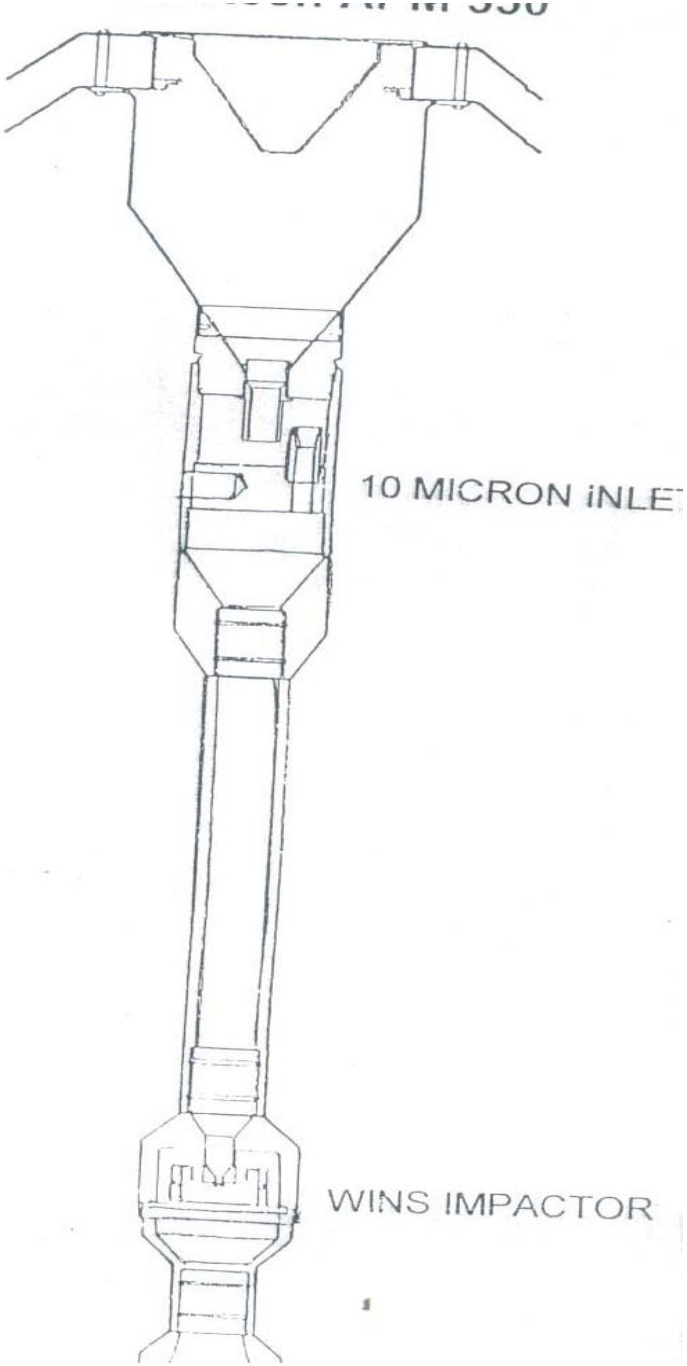
- Size Cut-Off depends upon

1. Inlet Velocity ($1m^2/min$)
2. Specific gravity o particles.

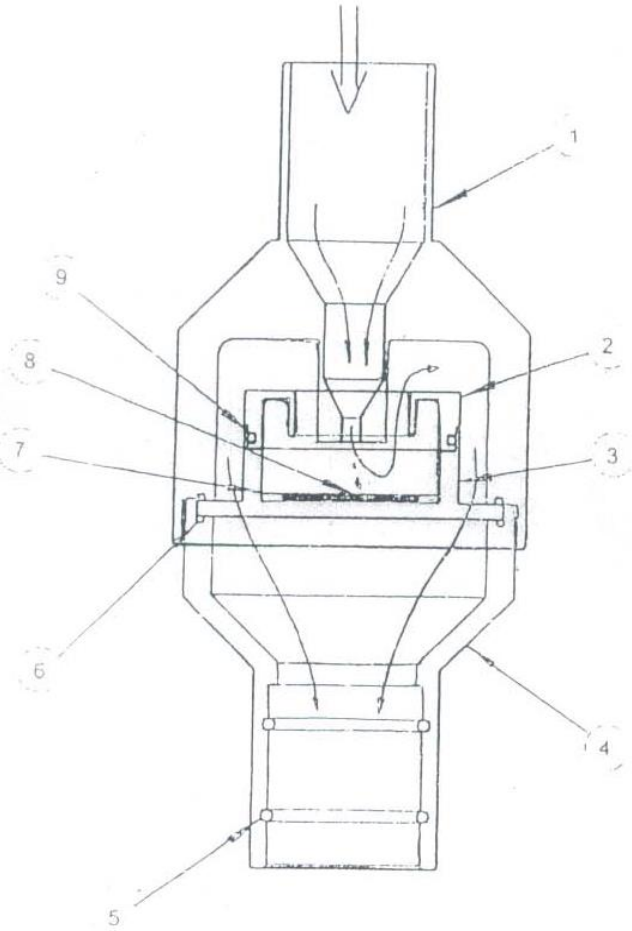


EXPLODED CROSS-SECTIONAL VIEW OF A PM10 SAMPLER INLET HEAD

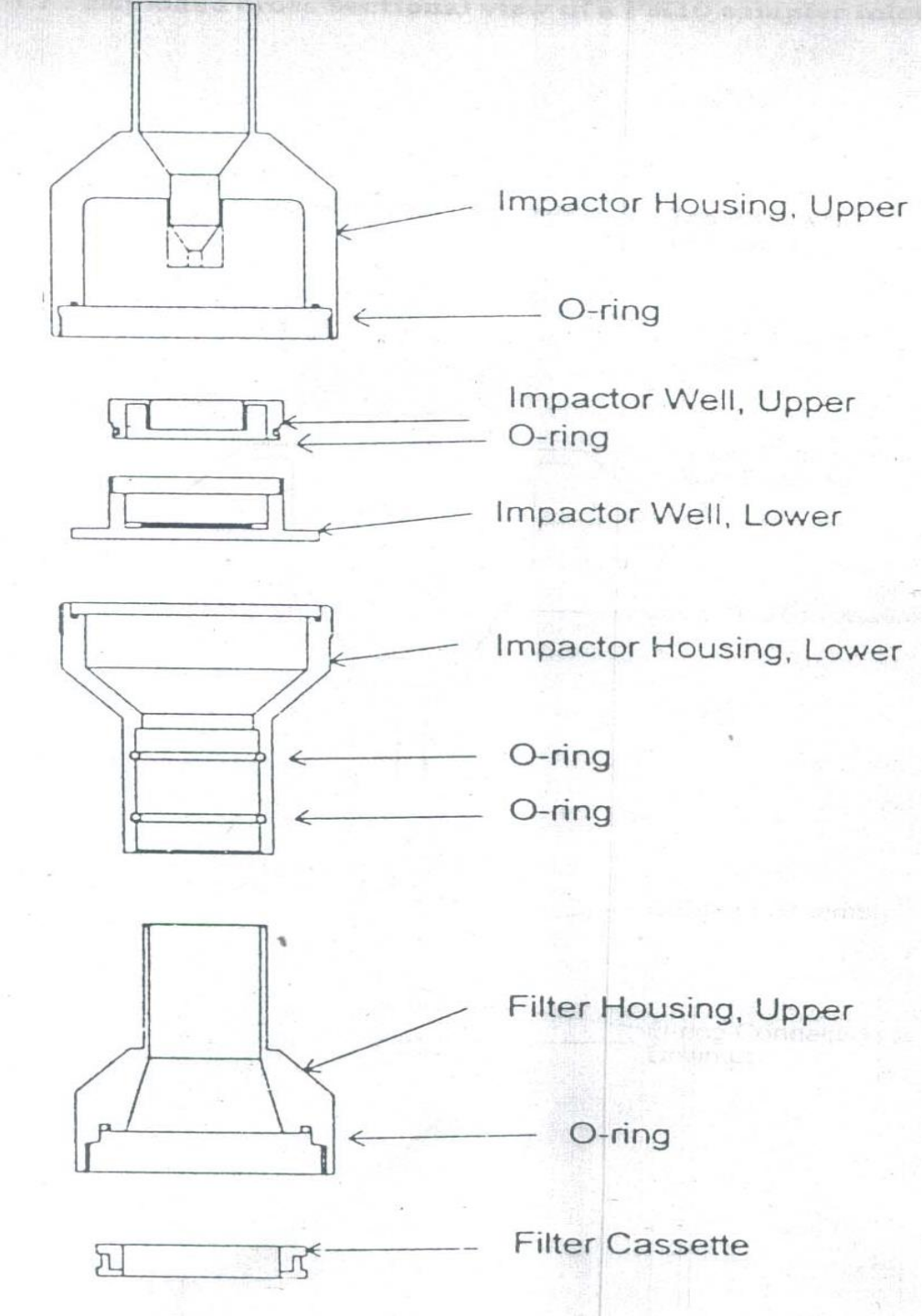



10 MICRON INLET
WINS IMPACTOR

PM 2.5 WINS Impactor



ITEM	DESCRIPTION
1	2.5 Micron Impactor Housing Upper
2	2.5 Micron Impactor Well Upper part
3	2.5 Micron Impactor Well Lower part
4	2.5 Micron Impactor Housing Lower
5	O Ring
6	O Ring
7	Impaction Oil
8	Filter 37 Dia.
9	O Ring



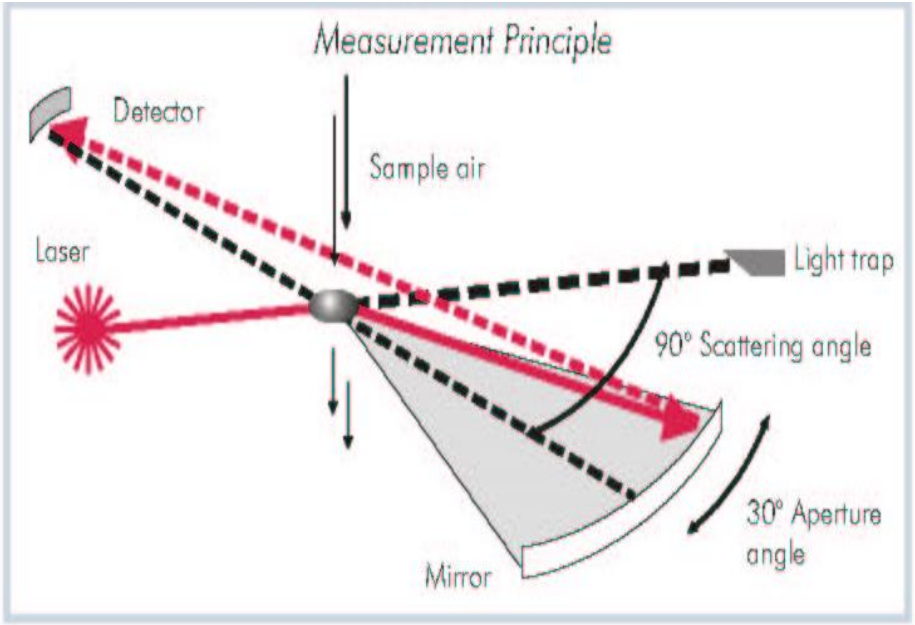
Exploded Cross-sectional view wins impactor well and filter holder

Light- Scattering Technolgies

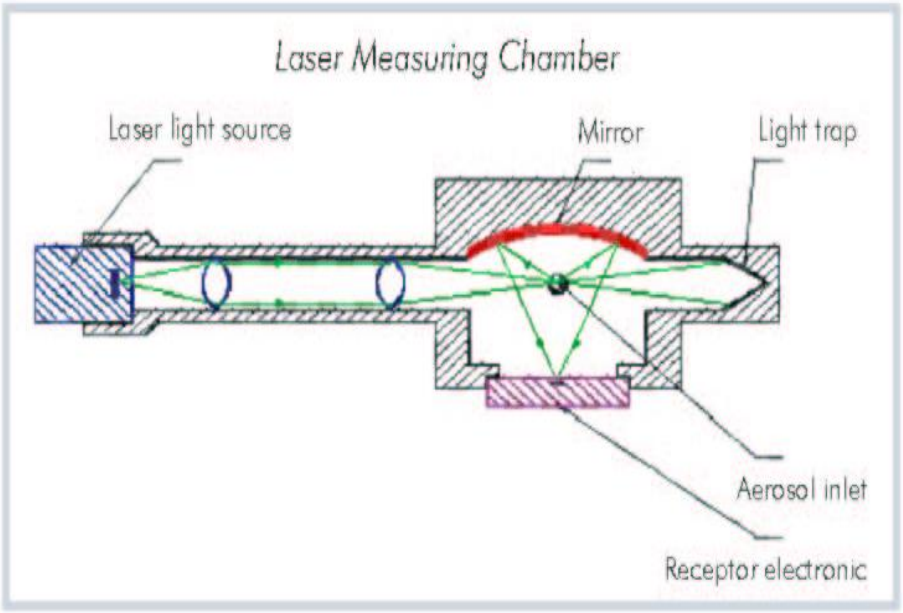
- Provide an indirect measurement of fine PM concentration by utilizing the relationship between particle concentration and light scattering. Light scattering technologies, employ forward, back and 90-degree (side) scattering technologies, to monitor particle loading by measuring the scattering of light in addition to the transmitted intensity. The measurement is related to volume of PM present particle density has to be assumed. It is also assumed that relation between measured response and PM mass loading does not change with time. Side scattering technologies have excellent sensitivity and are capable of detecting particles as small as 0.1 um but these are sensitive to particle size distribution and particle characteristic and may require calibration in each individual case.

PRINCIPAL OF OPERATION

- Orthogonal Light Scattering (90^0)



- Laser Measuring Chamber



- The dust particles are measured by the physical principle of orthogonal light scattering. Here particles are illuminated by a laser light in an angle of 90 degree. The scattered signal from the particle passing through the laser beam is collected at approximately 90° by a mirror and transferred to a recipient diode. These counts of each channel are converted every 6 seconds in a mass distribution from which the different PM values derive.

Light- Scattering Technolgies

i) **Nephelometers** measure the visual quality of local ambient air by measuring the scattering of light due to particles in continuous air samples.

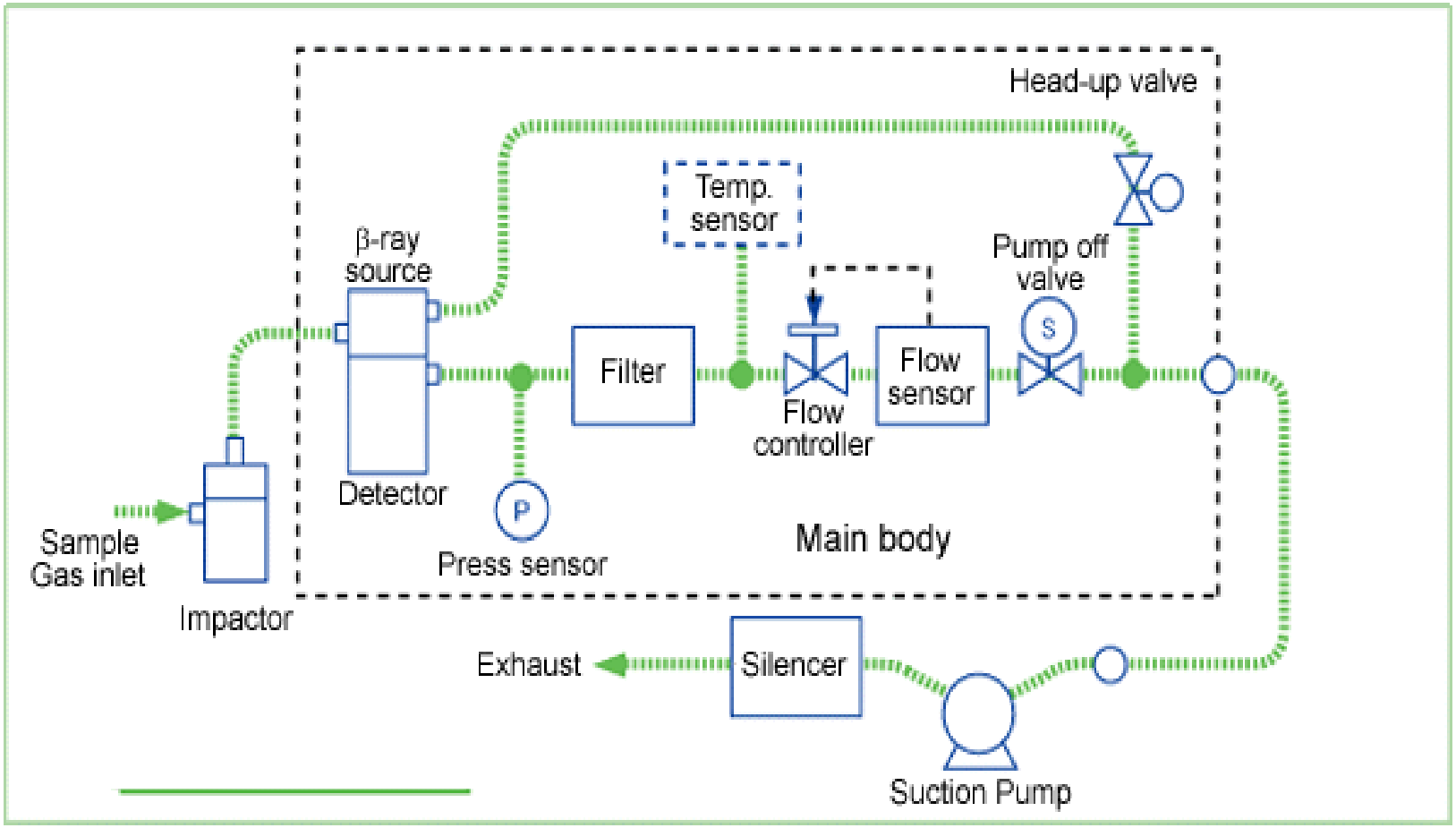
ii) **Light detection and ranging (lidar)** is used for remote detection of the presence, velocity, and chemical makeup of “particles” ranging from aircraft and missiles to smoke, dust, and “invisible” gases by measuring backscattered light.

iii) **Side-scattering technologies**, have been approved by the German equivalent of the EPA.

The Beta Gauge

- Uses a radio active source and measures the attenuation of radiation through an exposed filter. The sample is collected on a fitler, which, at the end of sampling period is moved, using a continuous filter tape machanisum to a measurement location between carbon-14 beta particle source and detector. The beta gauge uses C-14 radioactive source to measures the attenuation of radiation through filter containing the sample. The beta transmission through each blank filter is determined before sampling begins

BETA GAUGE
CONTINUOUS PARTICULATE MONITORING DEVICE

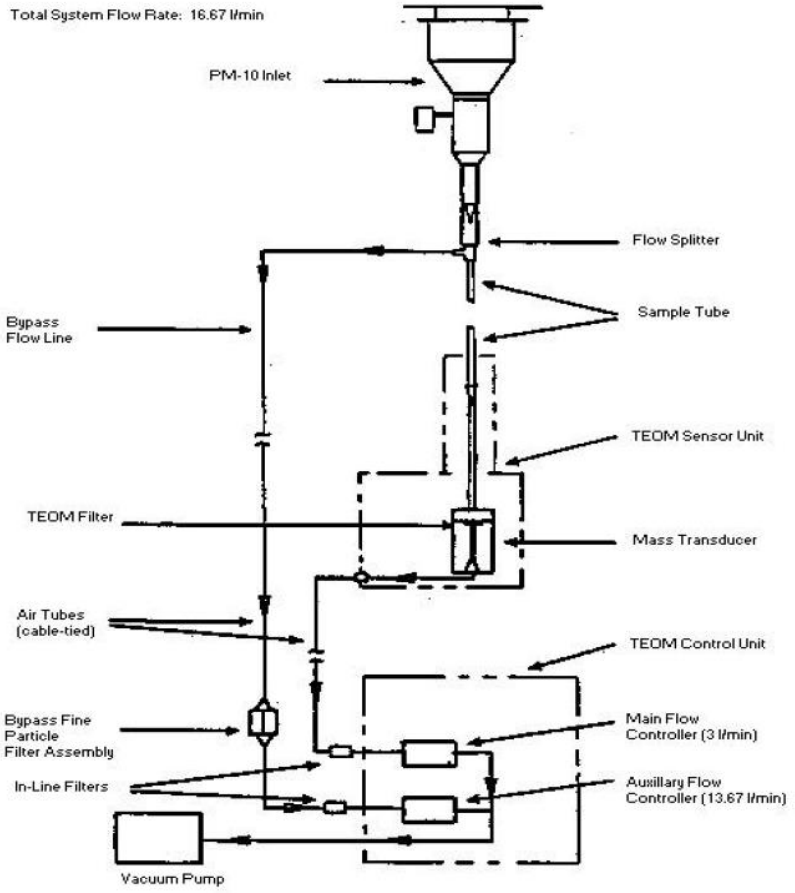


- **Principles:** The analyzer collects suspended particles on its filter and measures the weight of those particles by the absorbance of a beta-ray. The absorption coefficient depends upon the source of the beta-ray only, not upon materials, or the materials size or color. So the particles weight is determined only by the absorbance of the beta-ray

TEOM
TAPERED ELEMENT OSCILLATING MICROBALANCE

- TEOM directly measures PM mass by measuring the changing frequency of oscillation of a filter as it accumulates particles. It acts a tuning fork so if the mass of the tapered element is increased its resonant frequency decreases. Conversely, if the mass of the element decrees, the system measures a corresponding increase in frequency. Attached to the free end of the element is a disposable filter cartridge. As particulate laden air passes through the filter, the particle become trapped causing the mass of the tapered element filter combination to increase. The clean air stream pass down the hollow element and out to an electronic flow control system and vacuum pump. A frequency sensor associated with the tapered element sends information to a microprocessor where the instrument converts raw signals to a mass measurement.
- TEOM is a direct measurement of mass.

The Tapered Element Oscillating Microbalance (TEOM), the particle mass is determined by continuous weighing of particles deposited onto a filter. The filter is attached to a vibrating hollow tapered glass element. The frequency of mechanical oscillation of this element is a function of its mass. Deposition of particles on the filter leads to changes in the mass of the element and results in changes of its frequency of oscillation. A microprocessor directly converts the vibration frequency to mass concentrations.



OPACITY MONITORS

- Measure the degree to which PM reduces the transmission of light. These are least sensitive as small changes in the transmission of light is being measured in large quantity of air.
- Aethalometer TM is a type of opacity monitor used for ambient monitoring of suspended particles, such as black carbon from combustion of fossil fuels (industrial, vehicle).

a) **Mechanism of Action:** The AethalometerTM was developed as a real-time analyzer for measuring black carbon concentrations in the atmosphere, which can be related to the light-absorption coefficient. The AethalometerTM measures the attenuation of a light beam transmitted through a quartz fiber filter on which black carbon is collected as a sample is drawn through. The system automatically advances the quartz fiber tape to a new position after a specified attenuation or time period is reached. The rate of accumulation of black carbon is proportional to both the black carbon concentration in the air stream and to the flow rate. A separate portion of the filter tape outside of the sample stream is used as an optical reference. The two parts of the filter, exposed and referenced, are illuminated by a stabilized lamp that provides diffused lighting. The light passing through the exposed and referenced portions of the filter is captured by two matched photodiodes, compared, and converted to optical attenuation values that are proportional to the quantity of light-absorbing particles collected on the filter.

b) Its sampling port may be preceded by a size-selective inlet (e.g., cyclone, impactor) to measure particles in a specified aerodynamic size fraction. The AethalometerTM is especially well suited for measuring light absorption from burning diesel, oil, and coal. It was used in the Gulf War to monitor the effects of various smokes on health, visibility, and weapon systems. AethalometersTM have also been installed at remote sites, including the Arctic, remote islands, wind-swept ocean coasts, the periphery of the Antarctic, and the South Pole, to measure the presence of black carbon in the atmosphere as an indicator of the long-range distribution of combustion-derived pollution. Aethal-ometersTM are in operation at the South Pole, in the deserts of Iraq and Iran, and across Europe and have been flown to the North Pole and all places in between.

c) The AethalometerTM can also be fitted with a special inlet to measure the amount of black carbon incorporated in fog or cloud droplets. In this way, the interaction between pollution and clouds or fogs can be studied in real time.

d) **Disadvantages:** The AethalometerTM does not make direct measurements of PM mass, but instead responds to the optically absorbing carbonaceous component of suspended particles from which the mass must be inferred. Therefore, the AethalometerTM must be calibrated against the EPA's FRM. In addition, the AethalometerTM only measures PM containing a carbonaceous component and cannot measure total PM, which can be made up of several different chemical species, including organics, sulfates, and nitrates.

Manufacturer of Air Pollution Monitoring Equipment

Hi-Vol PM 2.5 Sampler

The Hi-Vol PM 2.5 ambient air sampler is designed to provide owners of Tisch Environmental model TE-6001 PM-10 samplers with the option of retro-fitting existing equipment rather than procuring a new family of apparatus. An adapter is placed into the model TE-6001 sampler in lieu of the existing PM-10 fractonator. The adapter has a new plate that contains multiple impactor jets, which collect particles larger than PM 2.5 aerosol on a oil-wetted surface. The PM 2.5 aerosol is transmitted through the impactor and collected on a hi-vol filter.

Technical Discussion

Ambient air enters the Hi-Vol PM 2.5 unit at a flow rate of 40 CFM (1.13 m3/min) through an opening under the weather proof hood. The air then flows into a stilling chamber and through a screen that is designed to prevent the entry of insects and large sized air-borne debris into the fractioning system. The air then flows through a set of 40 impactor jets that direct the air towards a wetted collection surface. Impaction of particles with sizes larger that 2.5 micron AD (i.e. non-PM 2.5 aerosol) takes place on a porous disc that is wetted with oil. Particles smaller than 2.5 micron aerodynamic diameter are vented from the impaction zone and flow downward to the sampling filter. The filter is standard 8 inch x 10 inch (203mm x 254mm) hi-vol collector.

Advantages of the PM 2.5 Retrofit Approach

Tisch Environmental offers this retrofit kit because it allows characterization of PM 2.5 with existing methodologies. Neither extensive additional training is required nor is extensive additional apparatus needed.

* No need to procure expensive electronic balances for weighing filters.
* Sample flow measurement and control with the Tisch critical flow venturi. Flow rate determined directly in actual m3/min, which are the units that EPA requires for PM 2.5 data reporting.
* Existing quality assurance procedures that are used for PM-10 sampling are virtually unchanged for PM 2.5 sampling.
* Sampling methodology is essentially unchanged, so technical personnel will not need to be retrained.
* The cost of retrofit to a hi-vol is only a fraction of the cost of a sampler specially designed for PM 2.5

Tisch Environmental Inc., 145 South Miami Ave. Village of Cleves, OH 45002 USA

Phone: 513.467.9000 Toll Free: 877.263.7610 Fax: 513. 467. 9009 Website: www.tisch-env.com

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PQ200 AMBIENT FINE PARTICULATE SAMPLER

- First EPA PM2.5 sampler designated (Designation No. RFPS-0498-116)
- First sampler approved by EPA for use as a portable audit sampler (Designation No. RFPS-0498-116)
- Modified design approved for PM10 sampling (Designation No. RFPS-1298-125)
- Only designated reference sampler capable of a 24 hour run on internal batteries
- Manufactured in ISO 9001 registered facility
- Ordered by EPA under contract for reference samplers
- Only designated reference sampler with solar power augmentation
- Convertible to designated PM10 reference sampler

PQ200 AMBIENT FINE PARTICULATE SAMPLER

- **Applications**
  - PM2.5 sampling to U.S. EPA specifications
  - Useful for daily, intermediate, or audit sampling
  - Meets or exceeds specifications for Federal Reference Method (FRM) per 40 CFR Part 50, Appendix L
  - Easily reconfigurable for PM10 or TSP
- **Features**
  - Single channel design for maximum reliability and portability
  - Friendly operator interface and easy data collection and downloading
  - Includes built-in 12-volt DC battery power system charger (U.L. approved)
  - Advanced flow control system
  - Download software included
  - BGI Incorporated produces the PQ200 Ambient PM2.5 Federal Reference Method (FRM) and FRM "Portable Audit" Sampling Systems. The PQ200 is designed to meet exacting criteria for collecting 24-hour samples of ambient "Fine Particulate," according to the U.S. National Ambient Air Quality Standards (NAAQS), published July 18, 1997.
  - PM2.5 (particles less than 2.5 micrometers in aerodynamic diameter) is collected on 47 mm PTFE membrane media at a volumetric sample rate of 16.67 Lpm after being size discriminated through two U.S. EPA designed inertial separators. Ambient temperature and barometric pressure measurements are made at actual sample conditions. A microprocessor and sophisticated volumetric flow control system are integrated to maintain precise sampling parameters while sampling data are continuously logged into the processor memory. Five minute actual ambient temperature and pressure conditions with volumetric sample flow rate, filter temperature, and pressure are recorded. Measured values and identification of flags indicating any anomalies are recovered by the operator by downloading a sample summary to a laptop computer or a BGI Datatrans Data Communicator.

PQ200 AMBIENT FINE PARTICULATE SAMPLER

- **Datatrans**
- The BGI Datatrans Data Communicator eliminates the need to carry a notebook computer to a field site, also eliminating the need for the field technician to be computer literate. With a mere press of a button, the Datatrans will collect up to 20 PQ100 and/or PQ200 runs from a sampler network. The progress of the download is apparent from the light-emitting diodes. The field technician knows when the download begins, sees a flashing yellow light while the download occurs, and knows when the download is finished. Data capture is therefore completely assured. Upon return to base, data may be loaded into whatever computer is running the PQ100 or PQ200 software.
-
- Additional features:
- No expensive notebook computer necessary
- Download information from either the PQ100 or PQ200
- Store up to 20 PQ100 and PQ200 runs
- Each downloaded run is automatically "stamped" with the instrument's serial number
- Low cost

PQ200 AMBIENT FINE PARTICULATE SAMPLER

- **Solar Panel**
  - The BGI Solar Panel accessory for the PQ200 will extend its operational time range from 24 hours to an indefinite period, depending upon the amount of ambient sunlight available in the region of use. As a practical matter the panel with the reconnected ballast battery will provide a minimum of 10-14 days of operation with only minimum ambient light. When interval sampling on three or six day cycles is contemplated operations far from a source of power are achievable.

PARTISOL 2000 FRM SAMPLER

- USEPA approved
- PM10/PM2.5/PM1.0 can be monitored one parameter at one time.
- 8-24 hrs sample can be collected on PTFE. Operator has to collect sample after sampling
- Data logging is existing and data can be transferred to computer.
- Remote data access is not available.
- Automatic Temperature Pressure are recorded to give standard volume
- Constant sampling flow rate $1m^3$/hr is maintained by mass flow controller
- Flow calibrator is available.
- Power Consumption is only 2.5 amp
- Battery operation is not possible due to high power consumption
- Very precise balance accurate up to 1μg is required

Fine Particulate Sampler Envirotech Model APM 550
As Per US EPA Designs

•For determining the mass of fine particulate matter having an aerodynamic diameter less than or equal to 2.5 μm (PM2.5) is a manual method that provides a direct measurement of the mass of ambient PM2.5 over a 24-hour period.
•The Instrument utilizes an electrically powered air sampler to draw air at a constant rate through an impactor, which is a particle size separator, where suspended $PM_{2.5}$ is separated for collection on a filter.
•The filter is then removed from the sampler, brought back to the laboratory, equilibrated, and weighed to determine the ambient mass concentration of PM2.5.
•Operable for 8 Hrs on 12V battery/Invertor System

AQM Ambient Air Quality Monitor

Features

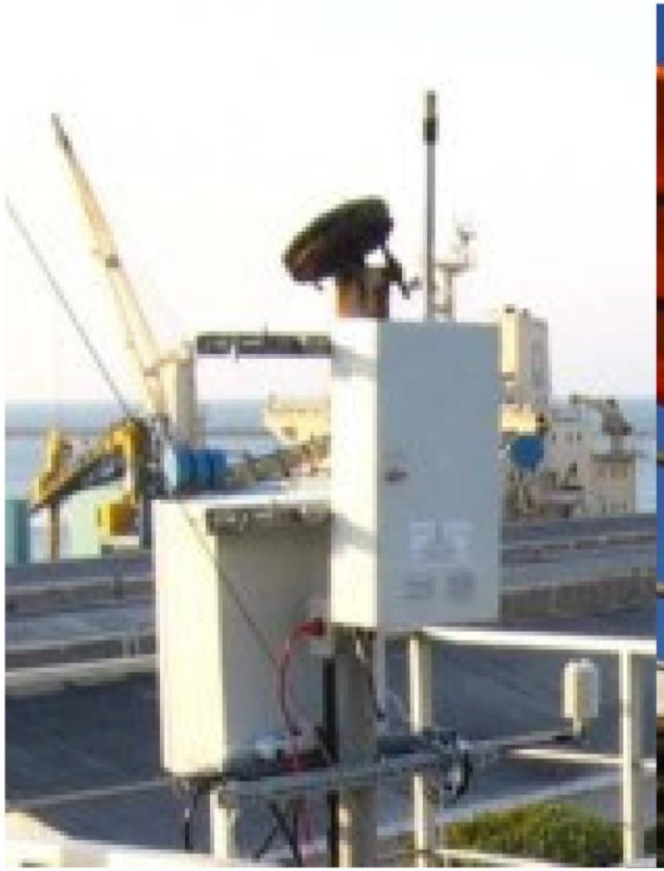
- Ambient multi-parameter monitor with sensors for O_3, NO_2, CO, VOC, SO_2, CO_2, NMHC, Temperature, Humidity and PM_{10}
- NIST traceable certification
- Compact and lightweight (15 Kg)
- Low power requirements and pole-mount
- Modem (GSM, GPRS, UTMS, RF) or Ethernet (LAN, WLAN)
- SD data card (>10 year storage capacity)
- Programmable automatic zero calibration
- Span calibration via supplied software

AQM 60 with Particle Monitor

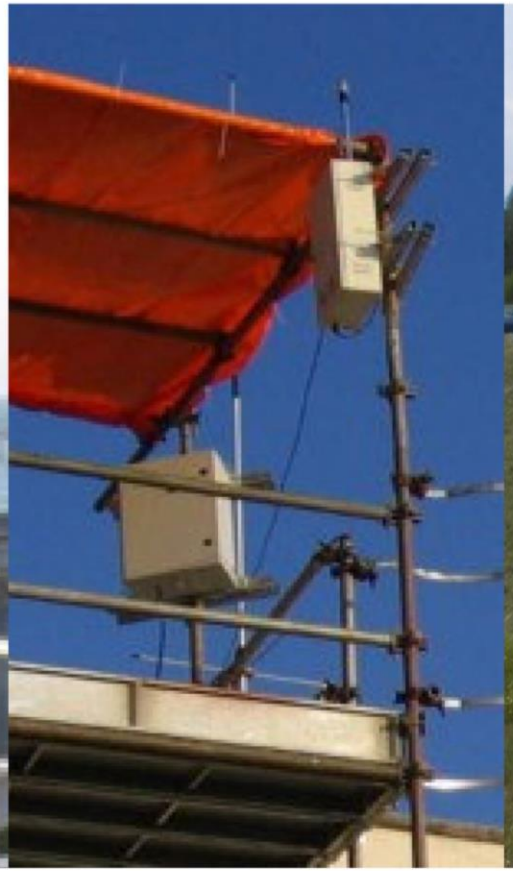
ANALYTIC G.S.S. TECHNOLOGY

aeroQUAL

AQM General Installations



Industrial and urban monitoring



Perimeter monitoring

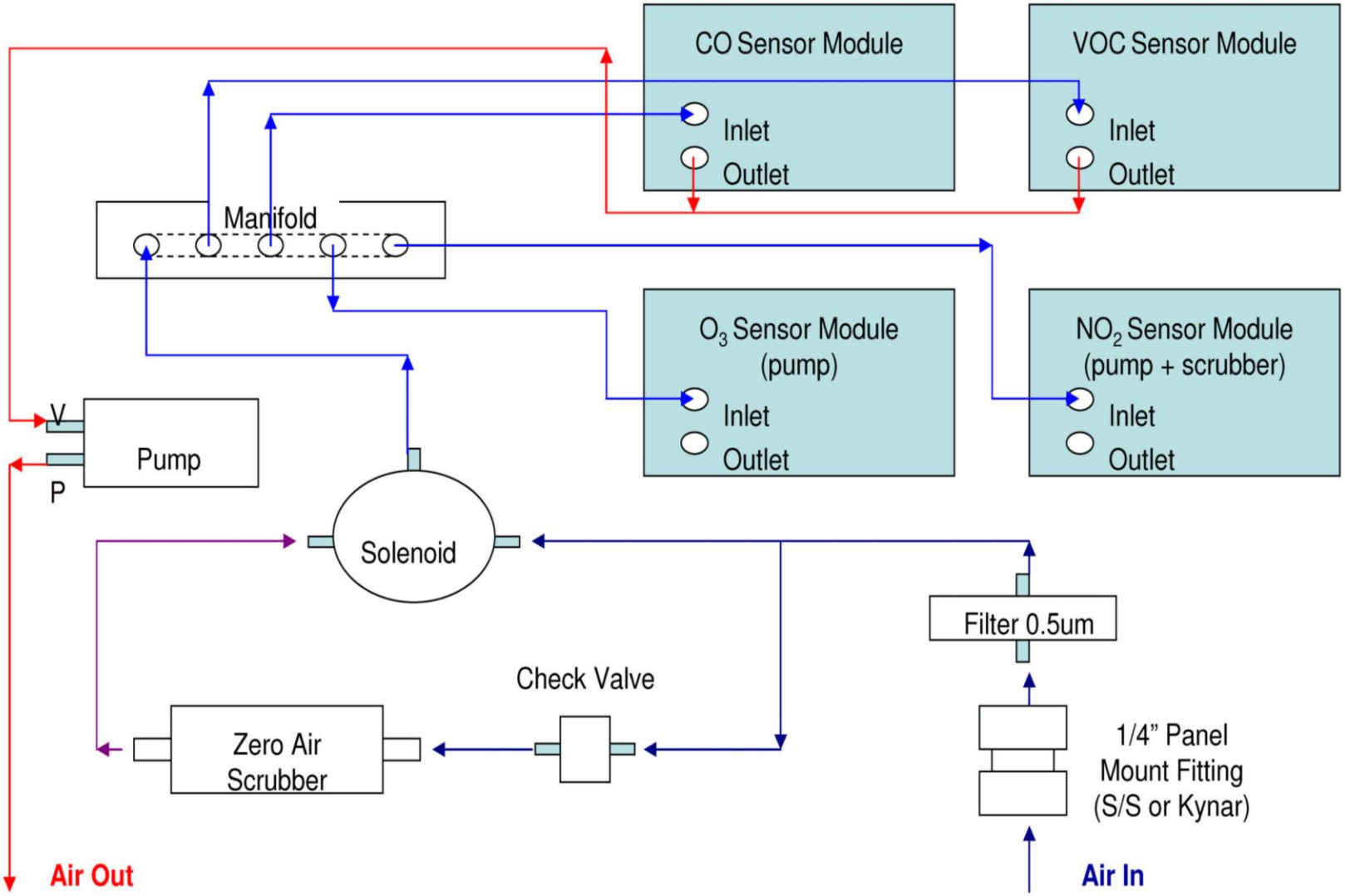
Roadside and traffic monitoring

AQM Sensor Specifications

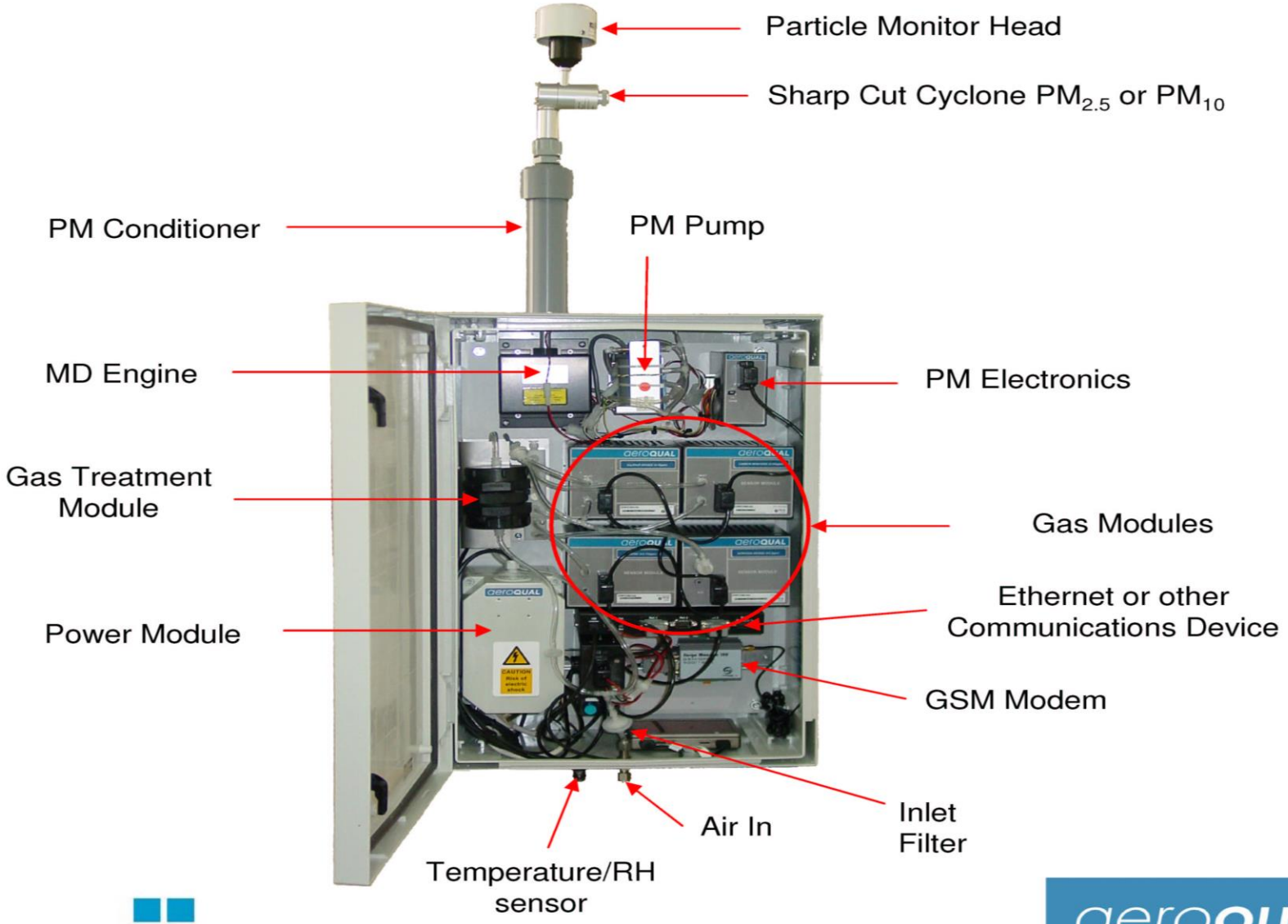
Gas Sensor Modules	Calibrated Range	Lowest Detection	Accuracy	Precision	Resolution
Ozone *	0 - 150 ppb	1 ppb	<± 0.005 ppm	0.002 ppm	0.001 ppm
Nitrogen dioxide	0 - 200 ppb	1 ppb	<± 0.010 ppm	0.005 ppm	0.001 ppm
Carbon monoxide	0 - 100 ppm	0.5 ppm	<± 5 ppm	1 ppm	0.1 ppm
Sulphur dioxide	0 - 10 ppm	0.2 ppm	<± 0.5 ppm	0.4 ppm	0.01 ppm
Non-methane hydrocarbon	0 - 25 ppm	0.1 ppm	<± 0.5 ppm	0.2 ppm	0.1 ppm
Volatile Organic Compounds	0 - 25 ppm	0.1 ppm	<± 10%	0.2 ppm	0.1 ppm
VOC (PID)	0 - 20 ppm	10 ppb	< 10%	0.02 ppm	0.01 ppm
Hydrogen sulphide	0 - 10 ppm	10 ppb	<± 0.5 ppm	0.02 ppm	0.01 ppm
Carbon dioxide (NDIR)	0 - 2000 ppm	6 ppm	< 40 ppm + 3%	6 ppm	1 ppm
* Also available in 0 - 500 ppb					

Temperature & Humidity	Temperature sensor Relative humidity sensor	Range -20°C to 100°C 0 - 100% RH	Sensitivity 0.01°C 1% RH	Resolution 0.01°C 1% RH
Particulate Monitor (optional)	Forward light scatter nephelometer (laser-diode precise optical engine) Available cut points (cyclones) TSP, PM_1, $PM_{2.5}$, PM_{10}	Range 0 - 2 mg/m^3	Sensitivity 0.001 mg/m^3	Precision 0.003 mg/m^3
		Particle Size 0.1 - 100 micron	Accuracy 8% NIOSH 0600	LT Stability 5% reading
Anemometer (optional)	Ultrasonic or mechanical options Wind speed Wind direction	Range 0 - 60 m/s 0 - 359°	Accuracy ± 2% (12 m/s) ± 3° (20 m/s)	Resolution 1.0 m/s 1°

AQM Gas Module Pneumatics



AQM Components



Grimm Dust Monitor

- The Grimm 107 monitor performs particulate size measurements by 90-degree laser light scattering. Air with multiple particle sizes passes through a flat laser beam produced by an ultra low maintenance laser diode. A 15-channel pulse height analyzer for size classification detects the scattering signals. Due to the lack of a sample heater inlet even aerosols and semi volatile liquid particles can be identified. These counts from each precisely sized pulse channel are converted to mass using a well-established equation and the data is then formatted for USA EPA categories of PM10 and PM2.5. The user can also program several averaging functions.
- The Environmental Weather Housing, Model 165, consists of a fiberglass frame that supports the optical instrument (# 107) on a central mounting plate. All the electronic and mechanical components, such as the moisture absorbent container, the ventilation system, the heating and control system, the temperature and humidity sensor, and the DC power supply, are mounted on the same frame to minimize vibration.
- The Sampling System of Model 170M consists of our proven omni-directional sampling head inside a rain and 2 mm particle eliminator as well as a dry air mixture and a heater system, all built into a 50cm inlet tube.
- GRAVIMETRIC OPERATION

  Inside the 107 unit is a removable PTFE 47mm filter (in accordance to PM2.5). All sampled dust is collected on the filter and a gravimetric and/or chemical analysis may be made later. This unique combination ensures a perfect site-specific field calibration and monthly revalidation.

Grimm Dust Monitor
Installed 165 Systems in Operation

The photo shows a 165 unit installed in a shipping harbor. In the photo to the immediate right you will see a unit which is used at a truck stop control point (photos courtesy from Spain).

Grimm Dust Monitor Stand-Alone Model 165

The above photo shows the System 165 with the front panel open. Visible is the dust monitor (in green), on the left (in blue) the dryer, above (in black and white) is the electronic control system. Located on top of the housing is on the left the environmental sensor and on the right the sampling tube inlet shown.

Grimm Dust Monitor

- In accordance to the final rule of the United Stated federal regulation for 40 CFR, section 53, this automated system is being evaluated as an EQUIVALENT method for PM10
- **Product Specifications**
- **Data Presentation**

USA EPA	Simultaneous PM10 and PM2.5 convention - even ready for PM-1
Size Range	0.3 to 25 microns Dae
Size Channel error	+/- 2% µg/m3
Concentration range	1 to 6,500 µg/m3
Accuracy	+/- 1 µg for one minute averaging
Sample Flow	1.2 liters/min, flow controlled
Range Power supply	12V DC Battery or 110/220 VAC with external power supply
Keyboard	10 key foil membrane
Display	2 x 16 character LCD
Meaurement Period	1 minute to constant
Data Logging System	Memo card from 16KB - 1MB (1 day to 1 year)
Dust collection filter	47mm Ø PTFE, EPA filter for PM-2.5, removable for gravimetric and/or chemical analysis

KEY FEATURES

- E P A - Under EPA for PM10 evaluation, also PM2.5 candidate, even capable of sub micron (PM-1 ready) dust mass
- Real Time measured data are storable on data logger from one minute to one day averages
- Temperature Controlled Housing - set for 22oC
- Moisture Compensation System - programmable by user
- External Temperature and Humidity Sensors - are standard items
- Auto Zero instrument software performs an optical system electronic and pump check upon startup
- Data Logging System - removable memory card for storing data from one day to one year, makes this an easy way to transport data to PC
- Corrosion Resistant Housing - made of polished stainless steel and also available as fiberglass.
- Tamper Resistant Lock - mounted on a sturdy support base
- Portable - 40x40x20cm (15.5" x 15.5" x 8"), weight 15.9 kg (33 lbs.)
- Dual Technologies - both light scattering and regulatory-compliant gravimetric methods are standard features
- Optional - can present the particle counts in 15 different size channels in real time
- Software - GRIMM's WINDOWS 95™ compatible data presentation and analysis program allows many viewing and organizing modes
- Low Maintenance - usually only three months for filter exchange
- Power Supply - 18V DC by battery , but also at 110/60 or 220/50

GRIMM DUST MONITOR
165 WEATHER RESISTANT HOUSING

Dimensions	40 x 40 x 20 cm (15.5" x 15.5" x 8 ")
Housing	Stainless Steel or Fiberglass
Weight	15.9 kg (33 lbs.) complete with dust monitor. May be used as stand-alone unit in the field-
Operating Temperature	20^oC to $+40^oC$ ambient
Automatic internal heater system	Preset for $+20^oC$
Automatic air exchange ventilation system	Progressive start above 22oC
Automatic moisture ompensation system	Preset above 85% rH, complete with air drying tank for three months use
Temperature Sensor	F -20^o; C to + 40o; C (-20 to 100o; F)
Humidity Sensor	Ranges from 0 to 100%
RS-232 Compatible	9-pin connection cable bi-directional for remote operation from PC, even on a remote base.
Software package	Numeric statistic graphic and analysis

Sampling head 170M permits proper ambient sampling and fits directly into the 165 housing.
Optional: GRIMM's Poly-Aromatic-Hydrocarbon (PAH) Sensor which can be fitted into the 165 housing.

DUSTTRAK™ Aerosol Monitor

- The DUSTTRAK provides a real-time measurement based on 90° light scattering. A pump draws the sample aerosol through an optics chamber where it is measured. A sheath air system isolates the aerosol i the chamber to keep the optics clean for improved reliability and low maintenance.

DUST TRAK

- Dust trak is suitable system for monitoring of PM10 or PM2.5 dust
- Weather proof housing is provided to operate system for long period in field without effecting its performance.
- System is battery operated 24hrs sampling is possible after full charge of batteries
- Data recording is available.
- Values can be reported in $\mu g/m^3$.
- Suitable for Monitoring of PM2.5 in the range of 1 to 1500 $\mu g/m^3$.
- Power consumption is only 15 mA.
- Logged data can be down loaded to PC.
- Remote data access is possible
- 1 Minutes values for 21 days can be stored in the memory
- In setup starting time ending time, Alarm recording interval can be user defined.
- Filter replacement is required after 140 hrs.
- Cyclone cleaning is required every day.
- Calibration is possible at site by operating it with reference sampler.

- The DUSTTRAK. Aerosol Monitor measures aerosols in a wide variety of environments, from offices and industrial workplaces to outdoor environmental and construction sites. TSI's DUSTTRAK provides reliable exposure assessment by measuring particle concentrations corresponding to PM10, PM2.5, PM1.0 or respirable size fractions.
- The DUSTTRAK is a portable, battery-operated laser photometer which gives you a real-time digital readout with the added benefits of a built-in data logger. Suitable for clean office settings as well as harsh industrial workplaces and outdoor applications, the DUSTTRAK detects potential problems with airborne contaminants such as dust, smokes, fumes and mists.

- The DUSTTRAK is easy to use, too. You can perform quick spot checks or you can program the advanced logging modes for long-term sampling. You can program the start/stop times, recording intervals and other parameters. You can even set up the instrument for continuous unattended operation.
- The DUSTTRAK's new continuous analog output and adjustable alarm output allow remote access to real-time particle concentration data. Applications include site perimeter monitoring, ambient monitoring, process area monitoring and other remote uses. The alarm output with user-defined set point alerts you when upset or changing conditions occur. This feature allows you to program a switch closure at a concentration value of your choosing.

Specifications

Model 8520 DustTrak Aerosol Monitor

Sensor Type	90° light scattering
Range	0.001 to 100 mg/m³ (Calibrated to ISO 12103-1, A1 test dust)
Resolution	±0.1% of reading or ±0.001 mg/m³, whichever is greater
Zero Stability	±0.001 mg/m³ over 24 hours using 10-second time-constant
Particle Size Range	0.1 to approximately 10 micrometers
Flow Rate	Adjustable 1.4 to 2.4 l/min (1.7 nominally)
Temperature Coefficient	+0.001 mg/m³ per °C (for variations from temperature at which the DustTrak was zeroed)
Operating Temperature	32° F to 120° F (0°C to 50°C)
Storage Temperature	-4° F to 140° F (-20°C to 60°C)
Operating Humidity	0 to 95% rh (non-condensing)
Time Constant	Adjustable from 1 to 60 seconds
Data Logging	31,000 data points (21 days of logging once/minute)
Logging Interval	Adjustable from 1 second to 1 hour
Physical	
External Dimensions	8.7 in. × 5.9 in. × 3.4 in. (221 mm × 150 mm × 87 mm)
Instrument Weight	3.3 pounds with batteries (1.5 kg)
Serial Interface	RS-232 1200 baud
Power	
AC	AC adapter (included)
Battery	Four C-size alkaline batteries (included)
Battery Run-time	Alkaline 16 hours
Analog Output Specifications	
Analog Output Voltage	0 to 5 VDC
Analog Output Scaling[1]	0 to 100 mg/m³ 0 to 10.0 mg/m³ 0 to 1.00 mg/m³ 0 to 0.100 mg/m³
Output Impedance	0.01 ohm
Maximum Output Current	15 mA

The DustTrak comes complete with TSI's TrakPro™ Data Analysis Software to allow you to perform a more comprehensive analysis of your measurement results. This exclusive Windows®-based program helps you generate the detailed graphs and reports needed to effectively communicate your findings.

Specifications are subject to change without notice.
Windows is a registered trademark of the Microsoft Corporation.

Alarm Output Specifications

Type	Non-latching, MOSFET solid state (polarized analog switch
Setpoint Range[1]	0.010 to 100 mg/m³
Maximum Voltage	15 VDC
Maximum Current	1 Amp
Deadband	-5% of alarm setpoint
Connector	4-Pin, Mini-DIN connector

1 User selectable through TrakPro™ Data Analysis Software.
2 See TSI Application Note ITI - 074 for important wiring information.

Ordering Information

Model	Description
8520	The DustTrak Aerosol Monitor and accessories includes: Auxiliary Analog and Alarm Outputs, Carrying Case, Alkaline Batteries, TrakPro™ Data Analysis Software, Filter, Computer Cable, 25-pin to 9-pin Adapter, Operation Service Manual, Calibration Certificate, 10 mm Nylon Dorr-Oliver Cyclone, Inlet Conditioning Kit 1.0 and 2.5 µm, Sampling Extension Tube, Miscellaneous Service Tools and Two-Year Warranty.

Optional Accessories

Model	Description
8520-1	Environmental Enclosure

Met One EBAM

Met One EBAM

Positives

- Easy to install and use
- Tripod mount
- Portable/lightweight
- Heater and PM2.5 cutoff
- Environmentally enclosed
- Can add other met instruments
- Mains or Solar power consumption
- Temp and Pressure compensated
- Simple mass calibration using “foils” filter for calibration
- Low Cost of ownership

Negatives

- Low levels tend to read zero
- Reliability DC pump only operates for 12 months

Met One EBAM

SPECIFICATIONS:

Range 0 -100 mg per m3
Accuracy 2.5 µg in 24 hour period
Measurement Cycle Standard @ 60 Minutes, actual sampling time 59 Minutes
Beta Source C14, less than 75 microcurie, Half life of 5730 years
Detector Scintillation probe
Analog Output 0-1V, 0-5V, 0-10V selectable, 12 bit accuracy
Filter Tape Continuous glass fiber filter
Inlet PM10 impactor type
Flow Rate 16.7 liters per minute, adjustable
Flow accuracy +/- 3% of reading, volumetric flow controlled
Sample Pump Dual diaphragm type, internally mounted
Alarm Signals Filter, flow, power and operation failure
Input Power 12 Volts DC @ 36 Watts , 25°C
Alarm Contact Closure 2 Amp @ 240 VAC
Operating Temperature -30 to 40° C

BAM OPERATION

The BAM1020 monitor has certain limitations or interferences. In high-humidity or rainy climates, water may collect on the filter tape and cause artificially high mass readings. In these same climates where the instrument is housed in an air-conditioned environment, the ambient air inlet tube should be insulated to avoid condensation or the inlet tube should be heated to ensure that any water drawn into the unit is vaporized. (Same as TEOM installations).

The MetOne monitor can measure ambient mass concentration with a resolution of about 3 µg/m3 for a 1-h sampling period. A constant volumetric flow rate for the PM10 inlet of 13.67 L/min is used.

A major difference between some monitors is the beta source. The BAM1020 monitor uses a carbon-14 beta source compared to Krypton-85 gas for the Andersen monitor. The carbon-14 source does not require a license by the Nuclear Regulatory Commission, whereas the Krypton-85 does.

ONLINE: TEOM AMBIENT PARTICULATE MONITOR

- Tapered Element Oscillating Microbalance Technology
- Features
  - USEPA approved
  - PM2.5 values are generated for desired period of time 30min to 24hrs
  - Choice of sampling inlet is available TSP, PM10, PM2.5 PM1 etc.
  - Collected dust can be analyzed for various constituents
  - Constant volumetric flow rate, Temp, Pressure sensor are attached for online standardization of flow rates
  - Data logging available collected can be transferred to PC as per requirements

COMPARATIVE OF FOUR MANUAL SAMPLERS

S. No.	Feature	TISCH	PARTISOL	BGI PQ200	Envirotech APM 550
1.	Approvals	USEPA	USEPA	USEPA	As per design standardized by USEPA
2.	Flow Rate	1130 lpm	1000 lpm	16.67 lpm	16.67 lpm
3.	Flow Control	Flow Controller available	Flow Control through MFC	Advance Flow Control	Flow Control through MFC
4.	Portable	Bulky	Portable	Portable	Portable
5.	Battery Operable	No	USES low current 2.5AMP (Option through invertor/ battery possible)	Uses internal batteries that run for 24 hrs	Uses low current 2.5AMP option through invertor battery possible
6.	Calibration in field	Yes	Yes	Yes	Yes
7.	Data logging of temp., pressure, flow, filter temp and pressure	No	No	Yes	No
8.	Sample Collection	8'' x10'' GFA	PTFE	PTFE	PTFE
9.	Precision Balance	Not required	Required upto 1μg	Required upto 1μg	Required upto 1μg
10.	Cost (Approx)	7,000 US$	15,000 US$	20,000 US$	5,000 US$

COMPARATIVE OF FOUR ONLINE MONITORS

S. No.	Feature	Aero Qual	Grimm	Dust Trak	Metone- EBAM
1.	Approvals	NIST Traceable Certification	USEPA Equivalent	None	USEPA Equivalent
2.	Principle	Forward light scattering Nephelometer	90^{O} light scattering as well as gravimetric method	90^{O} light scattering	Beta ray attenuation
3.	Flow rate and Flow Control	?	1.2LPM	1.7LPM	16.7LPM
4.	Portable	Compact and light weight 15Kg. Poll mountable	Portable 15.9Kg	Portable 1.5Kg	Portable tripod mountable
5.	Power	AC Power supply but low Amp	DC power on 12v battery or 110/220V AC	DC power on 12V batteries	DC power on 12V batteries
6.	Solar Power Augmentable	Available	NA	NA	Available
7.	Data logging and software for data presentation and analysis	YES >10Years	Memory Card 10KB-10MB (1day -1Year)	Available 1 min value for 21 days	Available
8.	Temp and Humidity Control	Available	Available	-	Available

COMPARATIVE OF FOUR ONLINE MONITORS

S. No.	Feature	Aero Qual	Grimm	Dust Trak	Metone- EBAM
9.	Range	0-2 mg/m^3	0.001- 6.5 mg/m^3	0.001 to 100 mg/m^3	0-100mg/m^3
10	Sensitivity	1$\mu g/m^3$	1$\mu g/m^3$	1$\mu g/m^3$	2.5 $\mu g/m^3$
11.	Unattended Operation	YES	YES	YES	YES
12.	Weather Proof Housing	YES	YES	YES	YES
13.	Calibration	Programmable 0 cal and span cal through software	Monthly site calibration	With any reference sampler	At site with “foil” filter
14.	Possibility of Assessment of Chemical Composition	NO	YES	NO	NO
15.	Additional Features	Sensors for O_3, NO_2, CO, VOC, SO_2, CO_2, NMHC, WS, WD can be added	NA	NA	NA
16.	Cost				

COMPARATIVE OF TWO MOST APPROPRIATE INSTRUMENTS

S. No.	Features Required	E- BAM	PGI PQ 200
1.	Low Concentrations	YES	YES
2.	Operable on Rechargeable Batteries	YES	YES
3.	Low Maintenance	YES	YES
4.	Un attended Operation	YES	YES
5.	Weather Proof Housing	YES	YES
6.	Calibration in field	YES	YES
7.	Same Instrument for PM10/PM2.5	YES	YES
8.	Portable	YES	YES
9.	Assessment of Chemical Composition	Not Possible	Possible

Features required in the PM2.5 Monitor for its successful operation at sites in various SAARC Countries

1. Capable of monitoring low concentrations
2. Should be operable on rechargeable batteries which can be charged with solar panel.
3. Should require low maintenance
4. Unattended operation for long periods.
5. Should have weather Proof housing with ventilation to withstand variable climate conditions.
6. Capable of calibration in field itself
7. Assessment of chemical composition of particle is also essential for source identification

RECOMMENDATIONS

- Air quality is a serious topic and measuring pollutants is like making the unseen visible. It requires selection of right technique and good instrument beside competent, trained motivated man with dedication and zeal.
- Under Male programme, looking at the remoteness of locations, non-availability of round the clock power, difficulties of constant recalibration, the most suitable equipment could be one of the following.

  i) E-BAM – Online Monitor based on beta gauge technique

  ii) BGI PQ200 – Manual Sampler

Role of Envirotech

- Arrange procurement of Equipment with all requisite accessories and consumables from manufacturers so that equipment starts per forming straight away.
- Arrange proper installation and commissioning at site in each country.
- Train operators in each country on operation, maintenance and periodic calibration
- Provide maintenance support (during warranty and after warranty)
- Carryout audit or validation of data generation by the equipment.

Thanks