Photometer Basics

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Overview

Aerosol physics
How photometer technology works
Strengths and limitations of photometers
Why photometers are used for aerosol monitoring
Photometer field application examples
Q & A
Exposure Monitoring

Aerosol:
Fume, mist, smoke, dust
Aerosol Characteristics

Size
Shape
Density

Aerodynamic diameter
Not all particles are spheres

Mass concentration is calculated from known density
Aerosol science

Physics of aerosols

Properties
Behavior
Measurements
Aerosol Size Matters

- **HUMAN HAIR**
  - Diameter: 50-70 µm (microns)
- **PM$_{2.5}$**
  - Combustion particles, organic compounds, metals, etc.
  - Diameter: < 2.5 µm (microns)
- **PM$_{10}$**
  - Dust, pollen, mold, etc.
  - Diameter: < 10 µm (microns)

Image courtesy of the U.S. EPA
Respiratory Tract

Extrathoracic region

Tracheobronchial (TB) region

Alveolar (A) region

Aerosol properties

- Aerosols absorb, reflect, refract and diffract light
- Light passing through an aerosol concentration is affected by the properties of the aerosol.
Light Scattering Photometer Technology

8533 DustTrak DRX
Particle counting vs. light scattering

Particle counting is like counting the number of rain drops or snow flakes that hits the window

OPCs count the number of raindrops (or snow flakes) hitting the windshield.

- Works for certain size drops at low concentration levels

CPCs count the number of ultrafine particles
Photometric light scattering

Photometers measure the amount of light scattered by the fog.

Think of how bright the fog is in the headlights.

“thicker fog” is brighter.

A photometer would calculate more mass based on a brighter response from thicker fog based on the calibration aerosol.
Calibration aerosol

Photometers are calibrated to a known test aerosol.

- known density
- known refractive index
- known size distribution

A bucket of golf balls will not weigh the same as a bucket of ping pong balls.

The photometer sees Ping Pong balls, but calculates mass concentration based on the calibration aerosol (golf balls).
Calibration factors are developed to ‘inform’ the instrument that the sampled aerosol is different than the test aerosol. Thus the mass measurement needs correction.

Density
Size
Refractive index
Aerosol distribution

A photometer sees aerosols of all shapes and sizes

The photometer measures the light scattering of these particles as a group.

Mass is calculated based on the properties of the calibration aerosol.

Fly ash – FHWA.dot.gov
Strengths and limitations of photometers

Limitations

Calibrated to test aerosol
Humidity effects
Contaminated optics
Strengths and limitations of photometers

**Strengths**

Real-time
Data logging
Alarms
Traditional IH Sampling
Gravimetric Measurement

Results:
Total mass 0.527 mg/m³
Real-Time Instruments
Photometric Measurement

Total Mass: 0.527 mg/m³
Why photometers are used for aerosol monitoring

Real time
Direct read
Data logging
Alarm notification

AM510 Personal Aerosol Monitor
Aerosol / Dust Sources

Construction, Mining, Agriculture
- Total dust  PM100 – PM10
- Silica  PM4 “respirable”

Welding Fume
- Hexavalent chrome

Foundry
- Silica
- Metal fume

Woodworking / machine shop
Application examples
Personal monitoring

Mining
Organization has characterized site aerosol exposures and developed custom calibration factors for silica.

Miners wear AM510 personal aerosol monitors on a regular basis to track silica exposure levels.
Forest Fires:

DustTrak used to measure smoke levels for worker safety
Australian Outback
Dust storm & wild fire alerts
Fugitive Dust

FUGITIVE DUST means any solid particulate matter that becomes airborne, other than that emitted from an exhaust stack, directly or indirectly as a result of the activities of any person.
Perimeter Fence Line Monitoring
Meadowlands Stadium - New Jersey
Comstock Mining – Virginia City, Nevada

8537 Environmental Enclosure, DustTrak II, Heated Inlet, Netronix GSM Modem
BP OIL SPILL
GULF OF MEXICO

• TRACK SMOKE PLUMES
• Protect Firefighters & Clean Up Crew Health
• Quantify particle mass exposures to help EPA reporting
DustTrak and P-Trak In Space!

DustTrak and P-Trak used on NASA Space Shuttles and the International Space Station (ISS) for over 10 years to measure crews working and living space air quality and for use as smoke/fire detectors.
China PM2.5 Levels
Ambient urban pollution

Mission China
Beijing

Beijing - PM2.5

Past 24-hour AQI was Unhealthy

Most Recent AQI
Jul 16, 2014 11 PM
161 AQI
Unhealthy
If at this level for 24 Hours
Concentration: 74.0 μg/m³
Summary

Light Scattering Photometers
Precise
Portable
Real Time
Direct Reading

AM510 Personal Aerosol Monitor

DustTrak II and DustTrak DRX
Environmental Enclosures

8537 Environmental Enclosure
Q & A

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