

***Seminar: Sampling, Real-time Monitoring and
Conditioning of Air Samples
for Determination of Particle Mass***

***A Review of Ambient PM Monitoring Trends
and Regulations in the United States***

2 April 2004

Copenhagen, Denmark

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PM Regulatory Trends



PM National Ambient Air Quality Standards (NAAQS)

The NAAQS are promulgated by the USEPA to meet the requirements set forth in Sections 108 and 109 of the U.S. Clean Air Act (CAA).

- 1971: TSP (Total Suspended Particulates) → (replaced by PM-10 in 1987)
- 1987: PM-10 (Particles $\leq 10 \mu\text{m}$ diameter)
- 1997: PM-2.5 (Particles $\leq 2.5 \mu\text{m}$ diameter)

	PM₁₀		PM_{2.5}		TSP	
	<u>Annual</u>	<u>24-hr</u>	<u>Annual</u>	<u>24-hr</u>	<u>Annual</u>	<u>24-hr</u>
Previous	50	150	n/a	n/a	75	260
Current*	50	150	15	65	n/a	n/a

Values in $\mu\text{g}/\text{m}^3$

* Promulgated 16 September 1997



California PM Standards ($\mu\text{g}/\text{m}^3$)

	PM₁₀		PM_{2.5}	
	<u>Annual</u>	<u>24-hr</u>	<u>Annual</u>	<u>24-hr</u>
Previous	30	50	n/a	n/a
Current*	20 (50)	50 (150)	12 (15)	25* (65)

- Proposed May 2002

- Effective June 2003

(USEPA NAAQS Limit Values Shown in Parentheses)

* Pending review

Regulatory Recognition

California Air Resources Board

- The agency tested the Series 8500 Filter Dynamics Measurement System in *Bakersfield, California, from October 2001 to February 2002*. The area typically experiences very high particulate nitrate concentrations during the wintertime.
- As a result of the test, the Air Resources Board has selected the Series 8500 FDMS System to be a *California Approved Sampler (CAS)* for PM-2.5 and PM-10 in connection with state standards promulgated June 2003*.

*(<http://www.arb.ca.gov/research/aaqs/std-rs/std-rs.htm>)



USEPA Designated PM Methods



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EXPOSURE RESEARCH LABORATORY
HUMAN EXPOSURE & ATMOSPHERIC SCIENCES DIVISION (MD-D205-03)
Research Triangle Park, NC 27711
919-541-3737

Office of
Research and Development

LIST OF DESIGNATED REFERENCE AND EQUIVALENT METHODS

Issue Date: May 5, 2003
(www.epa.gov/ttn/amtic/criteria.html)



Reference and Equivalence - Definitions

- *Reference* is the *defined* sampling methodology used to gather PM indicator data. It includes a combination of design and performance based criteria for both the sampler and subsequent laboratory treatment of the sample filter.
- *Equivalency* is the comparison of a measurement method to a reference *method* (*not* a primary traceable standard).
 - *Equivalent* methods are defined through their comparability to a *reference* method ($C_m = \Psi C_{mref}$).
 - *Aside: Accuracy* is the comparison of a measurement method to a known or traceable standard.

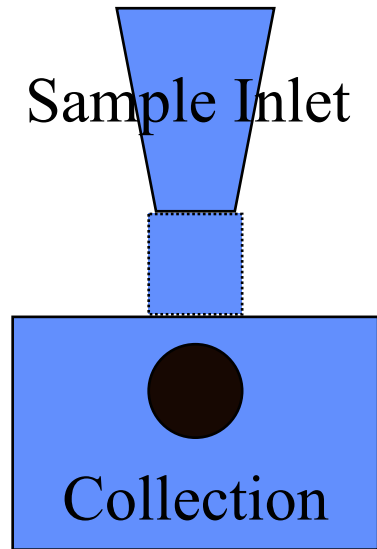
Reference Measurements

(USEPA Statement)

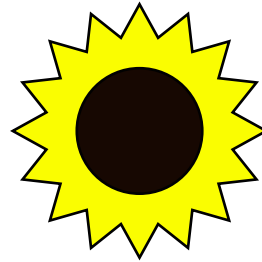
- “*No reference standard exists* for aerosol concentration measurements in air. The *calibration* of aerosol samplers relies primarily on characterizations under controlled conditions of the sampler sub-systems, including the size selective inlet, sample conditioning and transmissions system, the flow control system, and, if used, subsequent size separators, sample collection and storage elements, and sensors and associated electronics.”
- “Although the precision of an aerosol sampler is readily obtained by using replicate, collocated samplers, the *accuracy can only be estimated* by comparison with either designated “*reference*” samplers or with computations of expected aerosol mass collections. *Performance specification* limits are used to *control* the overall aerosol sampling accuracy.”



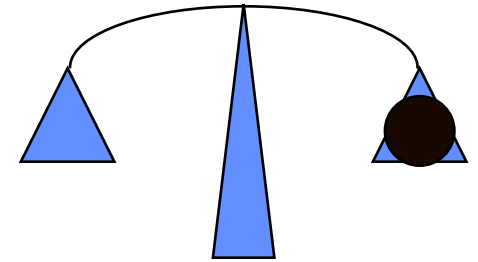
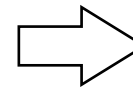
Reference PM Methods



- No active conditioning – sampling at or near ambient conditions



- Sample filter is equilibrated to specified T, RH% (pre-sampling equilibration conditions)



- Sample filter is weighed

Gravimetric

- Governing Equation:

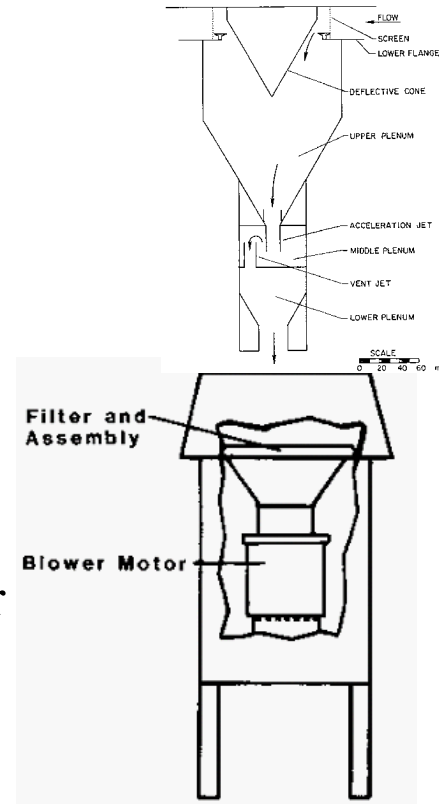
$$C_{mref} = \frac{M}{V}$$

where:

C_{mref} is PM reference mass concentration,

M is the mass of the PM collected on the sample filter

V is the volume of air sampled



USEPA and European Filter Conditioning Requirements

- **USEPA PM-10**
 - Temperature range
 - 15 to 30 deg C
 - Temperature control
 - +/- 3 deg C
 - Humidity range
 - 20 to 45% RH
 - Humidity control
 - +/- 5% RH
 - Conditioning period
 - At least 24 h
- **USEPA PM-2.5**
 - Temperature range
 - 20 to 23 deg C
 - Temperature control
 - +/- 2 deg C
 - Humidity range
 - 30 to 40% RH
 - Humidity control
 - +/- 5% RH
 - Conditioning period
 - At least 24 h
- **EN12341 PM-10**
 - Temperature range
 - 20 deg C
 - Temperature control
 - +/- 1 deg C
 - Humidity range
 - 50% RH
 - Humidity control
 - +/- 3% RH
 - Conditioning period
 - 48 to 72 h

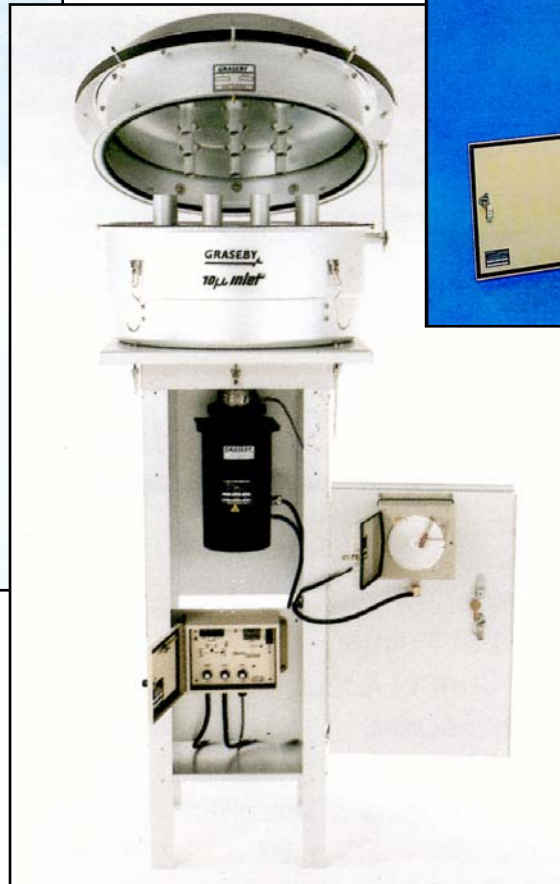


USEPA Designated PM-10 Reference Methods

Andersen Model RAAS10-100 PM10 Single Channel PM10 Sampler RFPS-0699-130	<i>Manual Reference Method:</i>
Andersen Model RAAS10-200 PM10 Single Channel PM10 Audit Sampler 131	<i>Manual Reference Method: RFPS-0699-131</i>
Andersen Model RAAS10-300 PM10 Multi Channel PM10 Sampler RFPS-0699-132	<i>Manual Reference Method:</i>
BGI Incorporated Model PQ100 Air Sampler 124	<i>Manual Reference Method: RFPS-1298-</i>
BGI Incorporated Model PQ200 Air Sampler 125	<i>Manual Reference Method: RFPS-1298-</i>
Graseby Andersen/GMW Model 1200 High-Volume Air Sampler RFPS-1287-063	<i>Manual Reference Method:</i>
Graseby Andersen/GMW Model 321-B High-Volume Air Sampler RFPS-1287-064	<i>Manual Reference Method:</i>
Graseby Andersen/GMW Model 321-C High-Volume Air Sampler RFPS-1287-065	<i>Manual Reference Method:</i>
Graseby Andersen/GMW Models SA241 and SA241M Dichotomous Sampler RFPS-0789-073	<i>Manual Reference Method:</i>
Oregon DEQ Medium Volume PM10 Sampler * 071	<i>Manual Reference Method: RFPS-0389-071</i>
Rupprecht & Patashnick Partisol Model 2000 Air Sampler 098	<i>Manual Reference Method: RFPS-0694-098</i>
Rupprecht and Patashnick Co. Partisol®-FRM Model 2000 PM10 Air Sampler RFPS-1298-126	<i>Manual Reference Method:</i>
Rupprecht and Patashnick Partisol®-Plus Model 2025 PM10 Seq. Air Sampler RFPS-1298-127	<i>Manual Reference Method:</i>



USEPA Designated PM-10 Reference Methods



Source: Various manufacturer's literature

USEPA Designated PM-2.5 Reference Methods

**Andersen Model RAAS2.5-200 PM2.5 Ambient Audit Air Sampler
RFPS-0299-128**

Manual Reference Method:

BGI Inc. Models PQ200 or PQ200A PM2.5 Ambient Fine Particle Sampler

Manual Reference Method: RFPS-0498-116

**Graseby Andersen Model RAAS2.5-100 PM2.5 Ambient Air Sampler
RFPS-0598-119**

Manual Reference Method:

**Graseby Andersen Model RAAS2.5-300 PM2.5 Sequential Ambient Air Sampler
RFPS-0598-120**

Manual Reference Method:

Rupprecht & Patashnick Partisol®-FRM Model 2000 PM-2.5 Air Sampler

Manual Reference Method: RFPS-0498-117

Rupprecht & Patashnick Partisol® Model 2000 PM-2.5 Audit Sampler

Manual Reference Method: RFPS-0499-129

Rupprecht & Patashnick Partisol®-Plus Model 2025 Sequential Air Sampler

Manual Reference Method: RFPS-0498-118

**Thermo Environmental Instruments, Incorporated Model 605 “CAPS” Sampler
RFPS-1098-123**

Manual Reference Method:

URG-MASS100 Single PM 2.5 FRM Sampler

Manual Reference Method: RFPS-0400-135

URG-MASS300 Sequential PM 2.5 FRM Sampler

Manual Reference Method: RFPS-0400-136

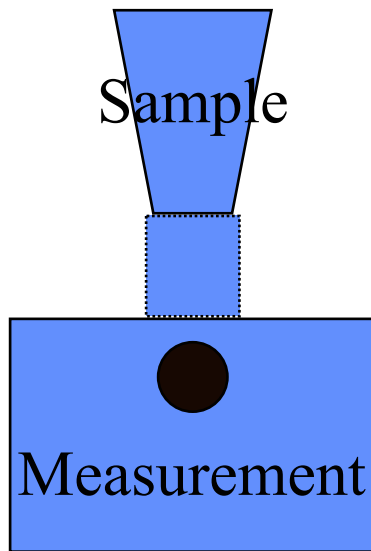


USEPA Designated PM-2.5 Reference Methods

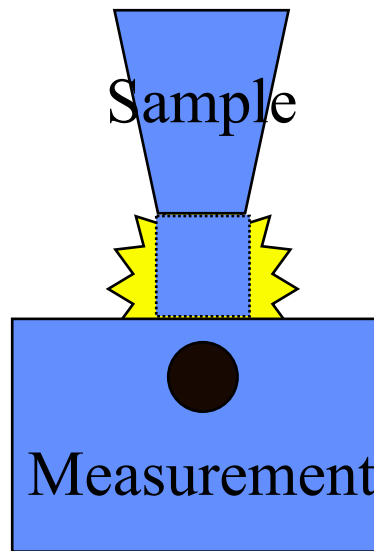


Source: Various manufacturer's literature

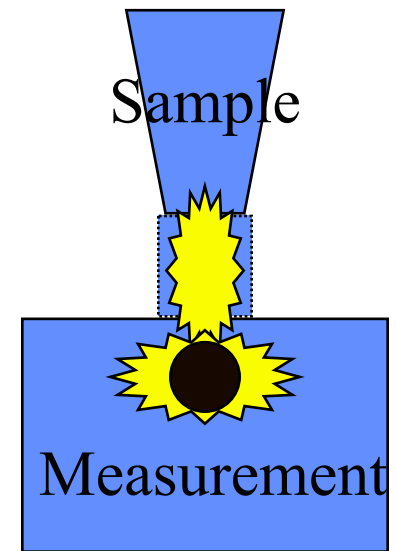
Equivalent PM Methods Use Different Approaches



- No active conditioning



- Outside of sample tube is heated



- Sample air stream is heated and/or dried
- Filter environment is heated

USEPA Designated PM-2.5 Equivalent Methods

**BGI Inc. Models PQ200-VSCC or PQ200A-VSCC PM2.5 Sampler
EQPM-0202-142**

Manual Equivalent Method:

**Rupprecht & Patashnick Partisol®-FRM Model 2000 PM-2.5 FEM Air Sampler
EQPM-0202-143**

Manual Equivalent Method:

Rupprecht & Patashnick Partisol® Model 2000 PM-2.5 FEM Audit Sampler *Manual Equivalent Method: EQPM-0202-144*

**Rupprecht & Patashnick Partisol®-Plus Model 2025 FEM Sequential Sampler
EQPM-0202-145**

Manual Equivalent Method:

No Automated Equivalent Methods Exist For PM-2.5



USEPA Designated PM-10 Equivalent Methods

Graseby Andersen/GMW Model FH621-N Beta Monitor

Automated Equivalent Method: EQPM-0990-076

**Met One or Sibata Models BAM/GBAM 1020, BAM/GBAM 1020-1
EQPM-0798-122**

Automated Equivalent Method:

**Rupprecht & Patashnick TEOM Series 1400/1400a PM10 Monitors
EQPM-1090-079**

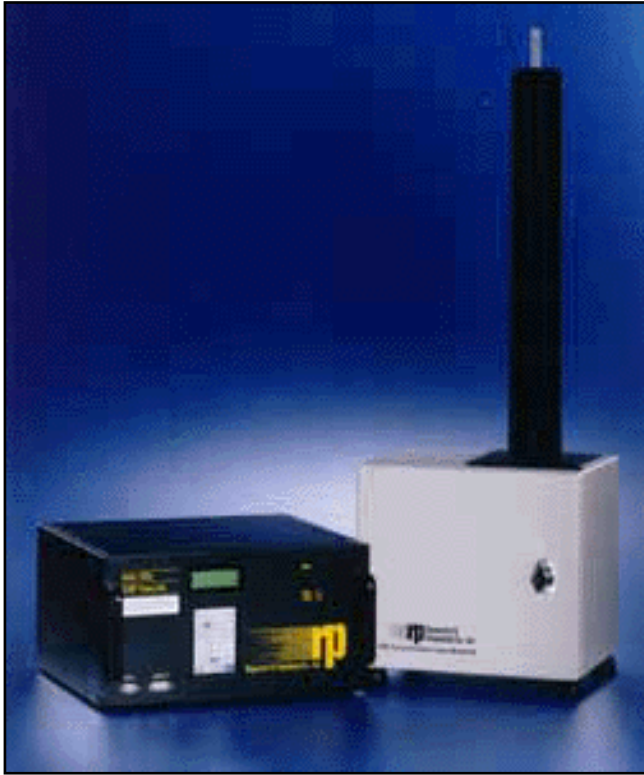
Automated Equivalent Method:

**Wedding & Associates' or Thermo Environmental Instruments Inc.
EQPM-0391-081
Model 650 PM10 Beta Gauge**

Automated Equivalent Method:



USEPA Designated PM-10 Equivalent Methods



Coarse Particulate Matter Monitoring

R&P Involvement in USEPA Coarse PM Monitoring Study



USEPA Considering PM-coarse Standard by Early 2006

- Regulatory standards for both fine and coarse particulate matter would be in place
- Would join PM-2.5 as a regulated particulate matter indicator
- PM-coarse would phase in to replace PM-10

USEPA Considering PM-coarse Standard by Early 2006

Approaches:

- *PM-10 minus PM-2.5 (reference)*
 - Original thinking at USEPA until July 2002
 - May be eliminated under the renewal of the Transportation Equity Act
 - Possible equivalent method
- *PM-coarse directly*
 - Dichotomous sampler (reference)
 - Continuous monitor (equivalent)
- *USEPA PM-coarse method field study, Nov 02- Jan 04*
 - Field evaluation of representative candidate reference and equivalent technologies
 - Results to provide guidance on measurement methods and regulatory standards



USEPA PM-coarse Method Field Study

(November 2002 - January 2004)

Summary of R&P donated instrumentation:

5 - 1400's SN's: 140ab236730106, 140ab237570109, 140ab237580109, 140ab237590109, 140ab237880110

4 - 2025 Dichots SN's: 202da202010203, 202da202060204, 202da202080204, 202da202110206

1 - 2025 Partisol Plus SN: 2025a201549803

1 - DustScan Module SN-3010a201390011

2 - SES SN's: SESDA202590109, SESDA202600109, SESIB202480109, SESIB202490109

2 - 8500 (FDMS)

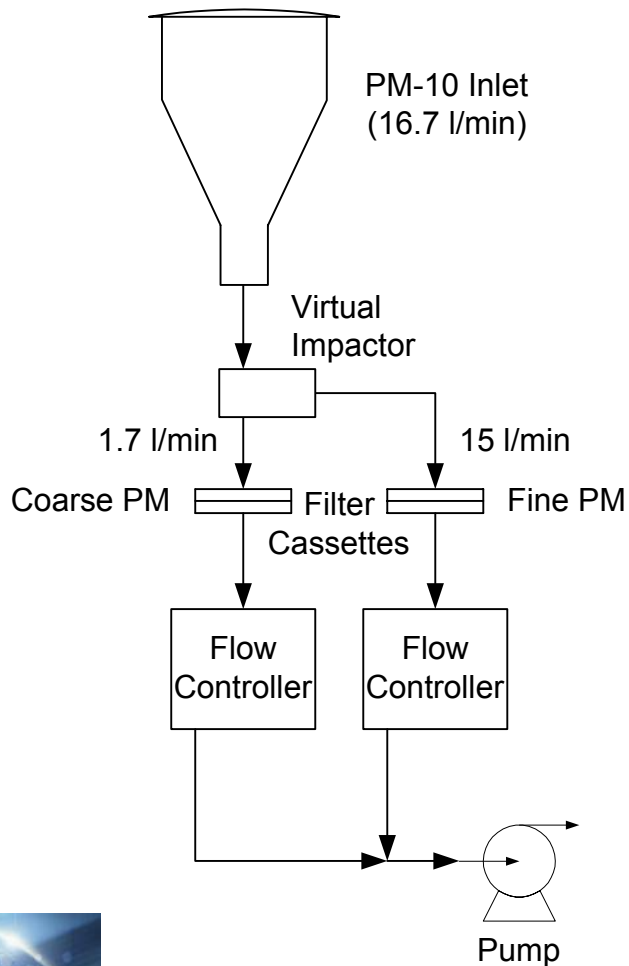
Miscellaneous items: 2 - 1 lpm flow splitters; 4 - Tripods; 4 - 1/2" roof flanges; 2 - Sample Tube Extensions

Approximate Total Value: \$200,000



Coarse PM FRM?

(2.5 to 10 micrometer diameter)



Partisol-Plus Model 2025-D Dichotomous Low Volume Sequential Air Sampler

Coarse PM FEM?

(2.5 to 10 micrometer diameter)

TECHNICAL PAPER

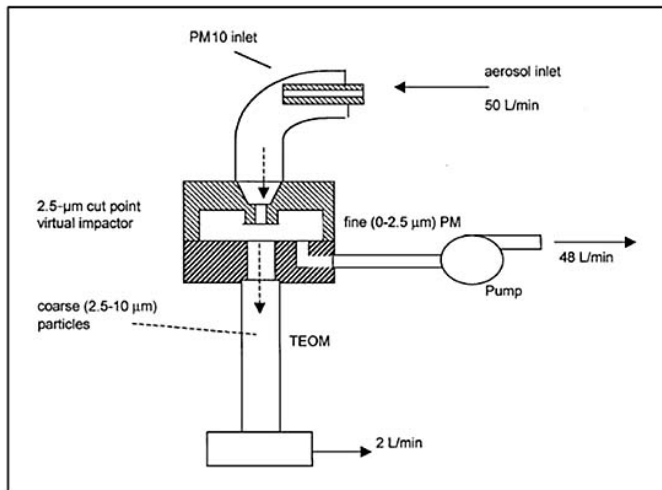
ISSN 1047-3289 *J. Air & Waste Manage. Assoc.* 51:1309-1317

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Development and Evaluation of a Continuous Coarse (PM₁₀-PM_{2.5}) Particle Monitor

Chandan Misra, Michael D. Geller, Pranav Shah, and Constantinos Sioutas
Civil and Environmental Engineering, University of Southern California, Los Angeles

Paul A. Solomon
National Exposure Research Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada



- TEOM technology for time resolved coarse PM measurements
- 25:1 concentration of coarse PM to minimize fine contamination
- Field and laboratory results

Figure 1. Schematic of the CCPM.



TEOM Coarse PM Monitor

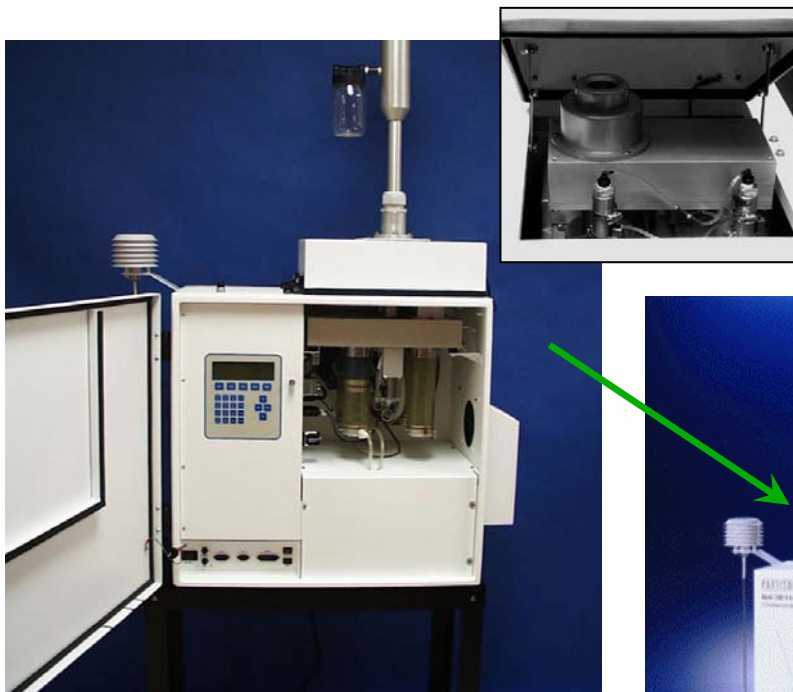
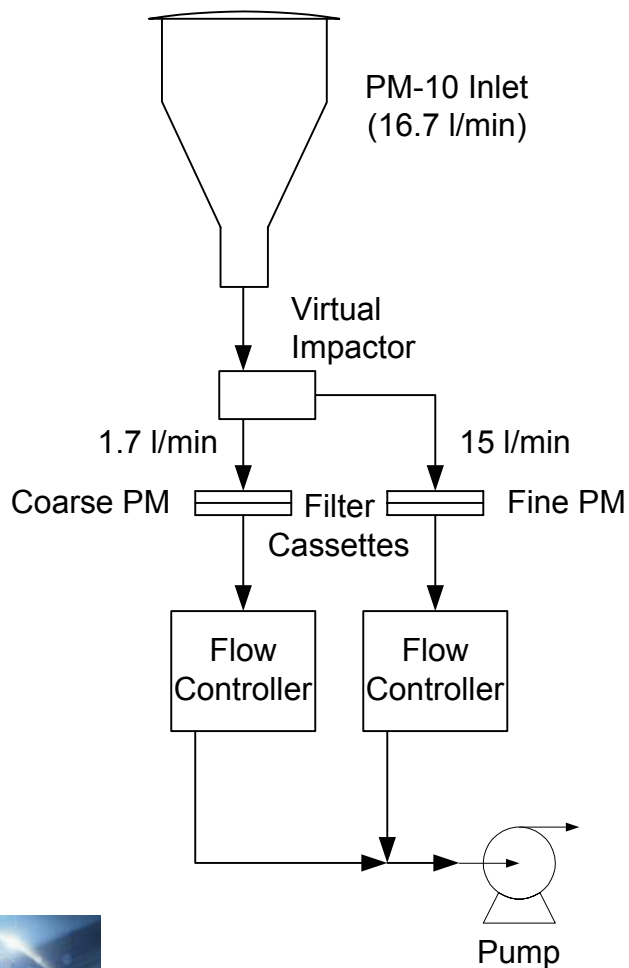
Coarse Particulate Matter Monitoring

New Developments:

Single Event Dichot Partisol Sampler

Dichot TEOM Monitor

Single Event Dichot Partisol Sampler

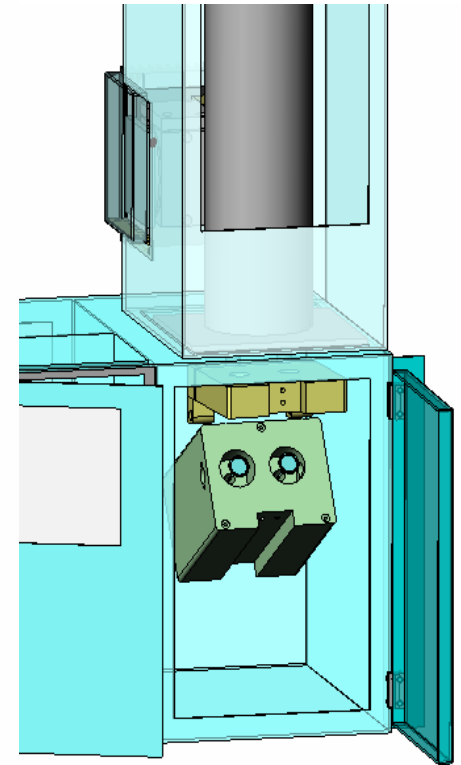
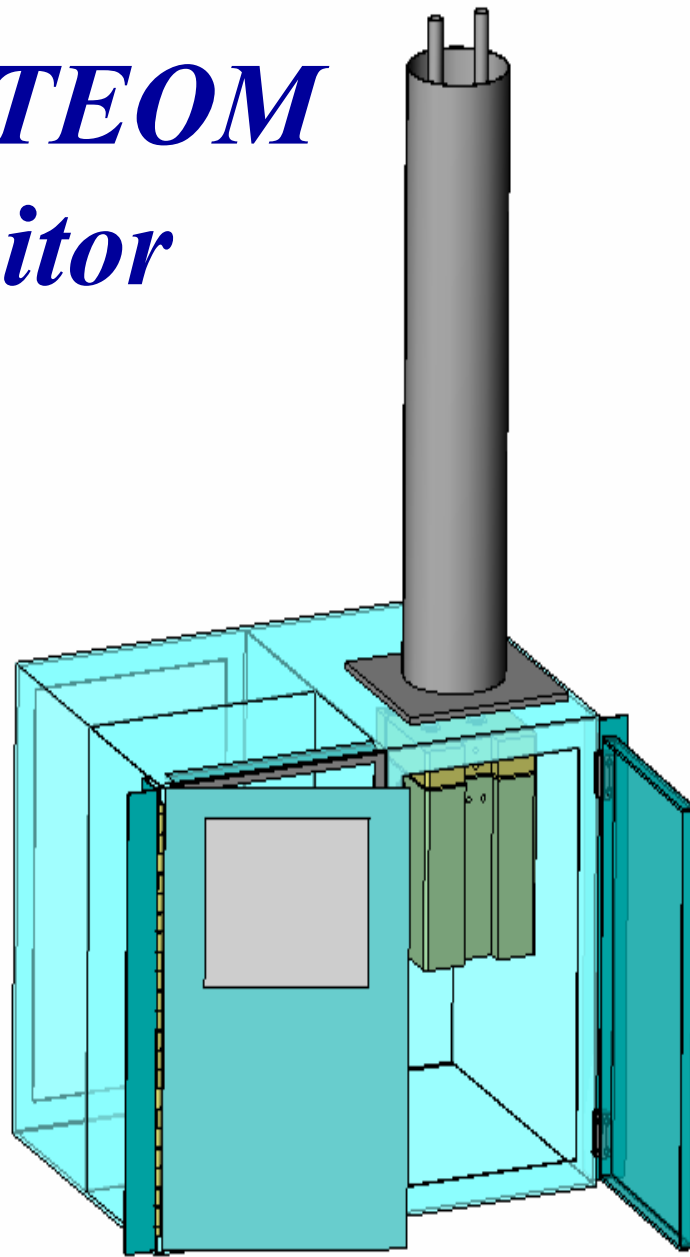


Partisol-Plus Model 2025-D
Dichotomous Low Volume
Sequential Air Sampler

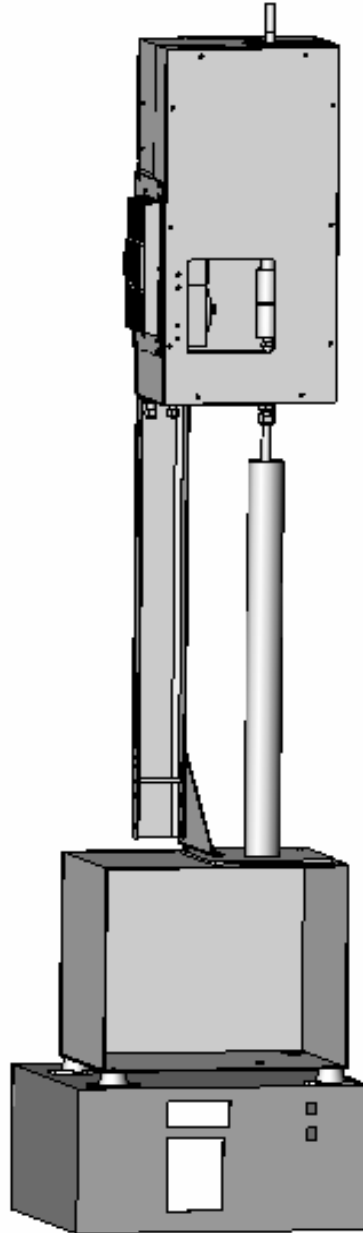


Partisol-FRM Model 2020-D
Dichotomous Low Volume
Single Event Air Sampler

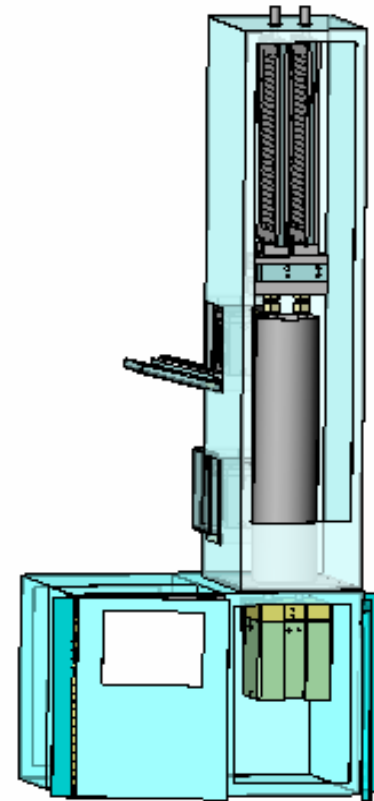
Dichot TEOM Monitor



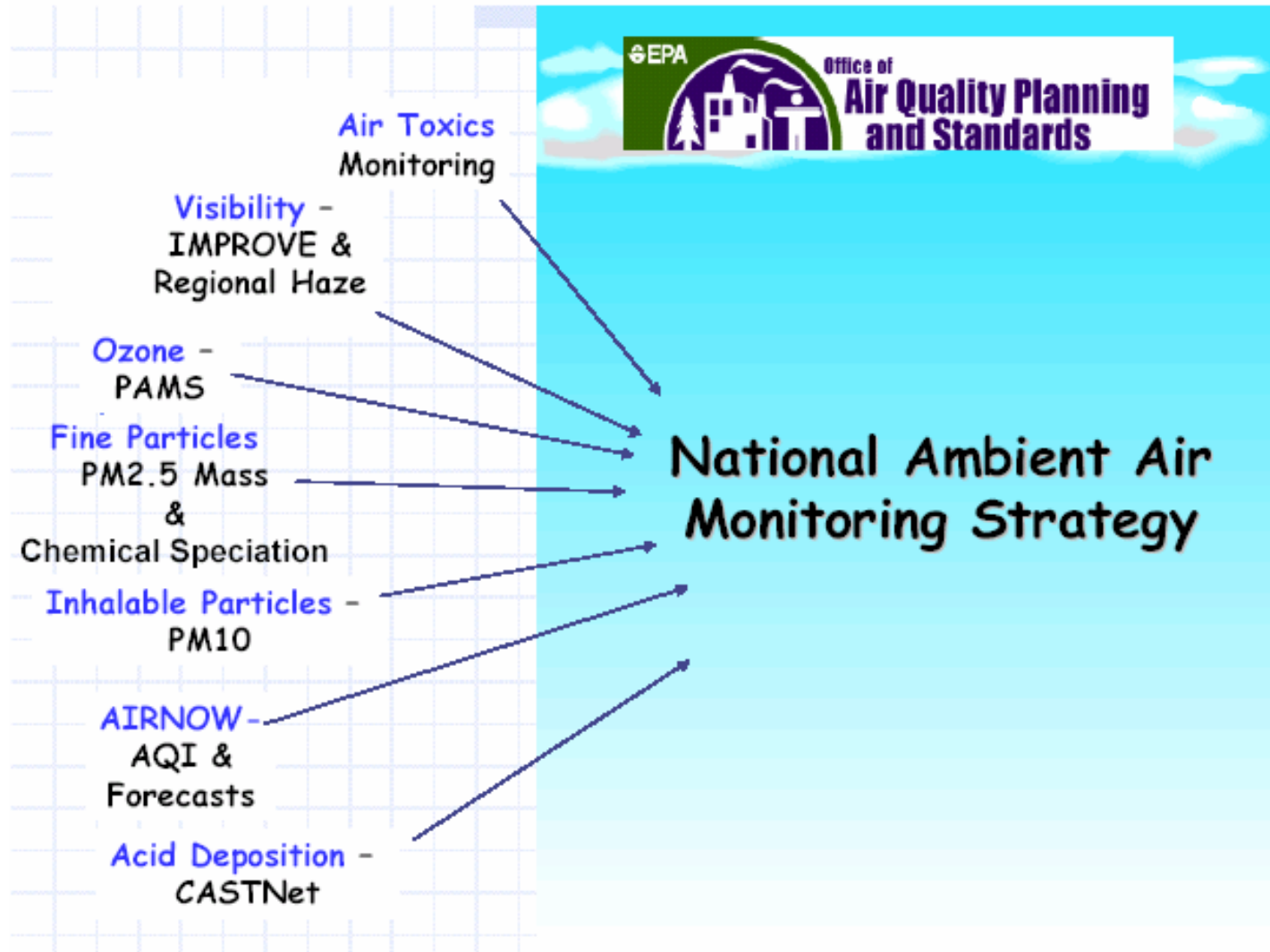
*Series 8500
FDMS System*



*FDMS Equipped
Dichot TEOM*



USEPA National Ambient Air Monitoring Strategy



Source: USEPA National Ambient Air Monitoring Strategy presentation (OAQPS – EPA website)



USEPA National Ambient Air Monitoring Strategy

Principal Recommendations

- ◆ Need insightful measurements to ensure the \$\$\$ allocated for emission reductions are effective.
 - Enhanced real-time data delivery to public
 - Increase capacity for hazardous air pollutant measurements
 - Future predictions suggest air toxics pose collectively greater risks than criteria pollutants
 - Increase in continuous PM measurements
 - Support for research grade/technology transfer sites

- ◆ Multiple pollutant monitoring must be advanced
 - Air quality is integrated through atmospheric processes, health/eco effects, emission sources.

- ◆ Technological advances must be incorporated
 - Information transfer technologies
 - Continuous PM monitors
 - High sensitivity instruments to address today's (and later) low levels
 - Model-monitor integration must advance to effect benefits for both tools

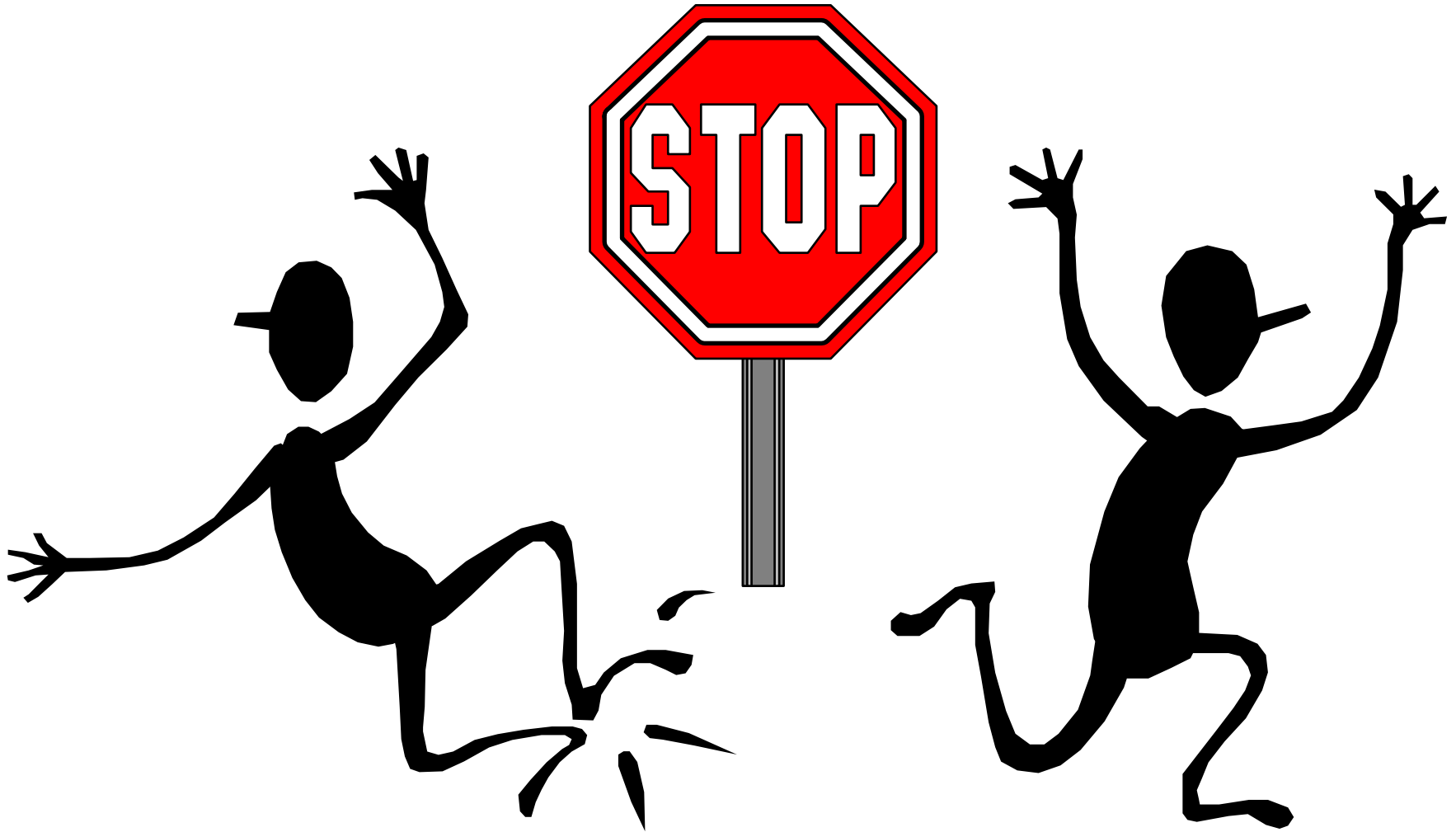


USEPA National Ambient Air Monitoring Strategy

National Core Network: **NCORE**

Goal: Move from loosely tied single-pollutant networks to coordinated, highly leveraged multi-pollutant networks with real time reporting capability





Thank you for your attention