Meeting New Stationary Source PM Limits - Is it Possible?

Avogadro Environmental Corporation
1350 Sullivan Trail ⬩ Easton, PA 18040
www.avogadro.net
eburgher@avogadro.net

TOPICS

- PM Basics
- How is PM Quantified: PM Reference Methods / PS-11 Requirements
- Ensuring Method PM Measurement Performance

TOPICS

- PM Basics – What Are We Measuring
- PM Reference Methods / PS-11 Requirements
- Ensuring PM Measurement Performance

Mass emission rate

❖ ❖

Mass concentration

❖ ❖

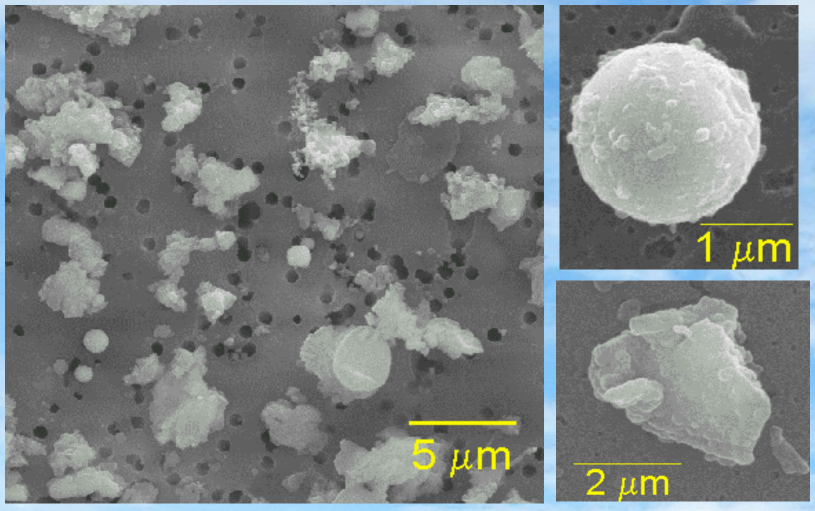
Mass & Volume

❖ ❖

Flow & Velocity

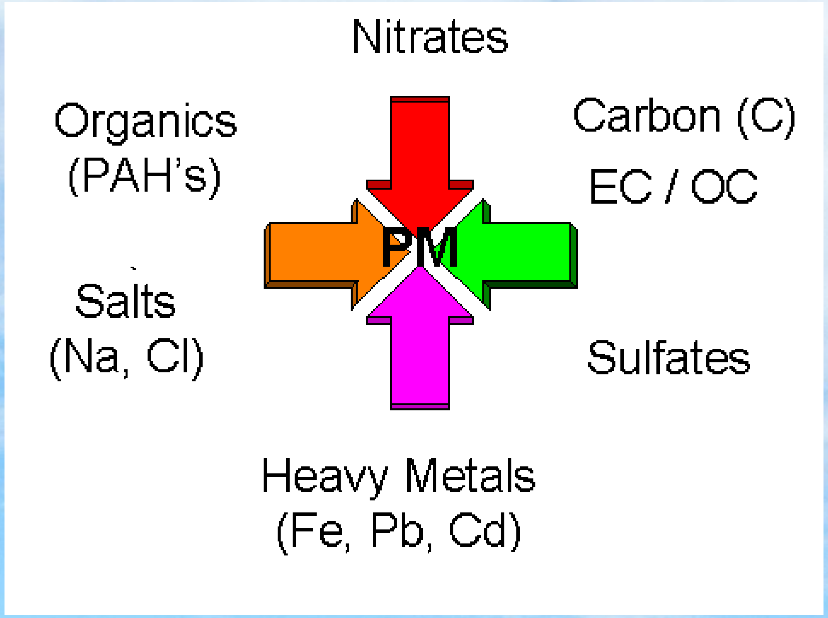
What is Particulate Matter?

Particle Morphology



- Can exist in either solid or liquid form, or a mixture of both
- Generally NOT unit density spheres
- Wide range of particle size
- Can exist as crystals, aggregates, complex chains, rough surfaced spheres, hollow spheres

Particle Composition



- PM characteristics dependent on source and control system characteristics as well as temperature/pressure conditions during sampling and analysis

US EPA RM 5 Definition of PM (re: Stationary Sources)

1. Any material
   a) withdrawn isokinetically from the source and collected on a glass fiber filter maintained at a temperature of 120   14°C (248   25°F) or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application
   b) that condenses at or above the filtration temperature
2. PM mass is determined gravimetrically after the removal of uncombined water.

A definition of "Filterable PM"!

US EPA RM 202
Definition of Condensable PM

- Condensable PM (CPM) means material that is vapor phase at stack conditions, but condenses and/or reacts upon cooling and dilution in the ambient air to form solid or liquid PM immediately after discharge from the stack.
- Note that all condensable PM is assumed to be in the PM2.5 size fraction.

Important: PM is method dependent!

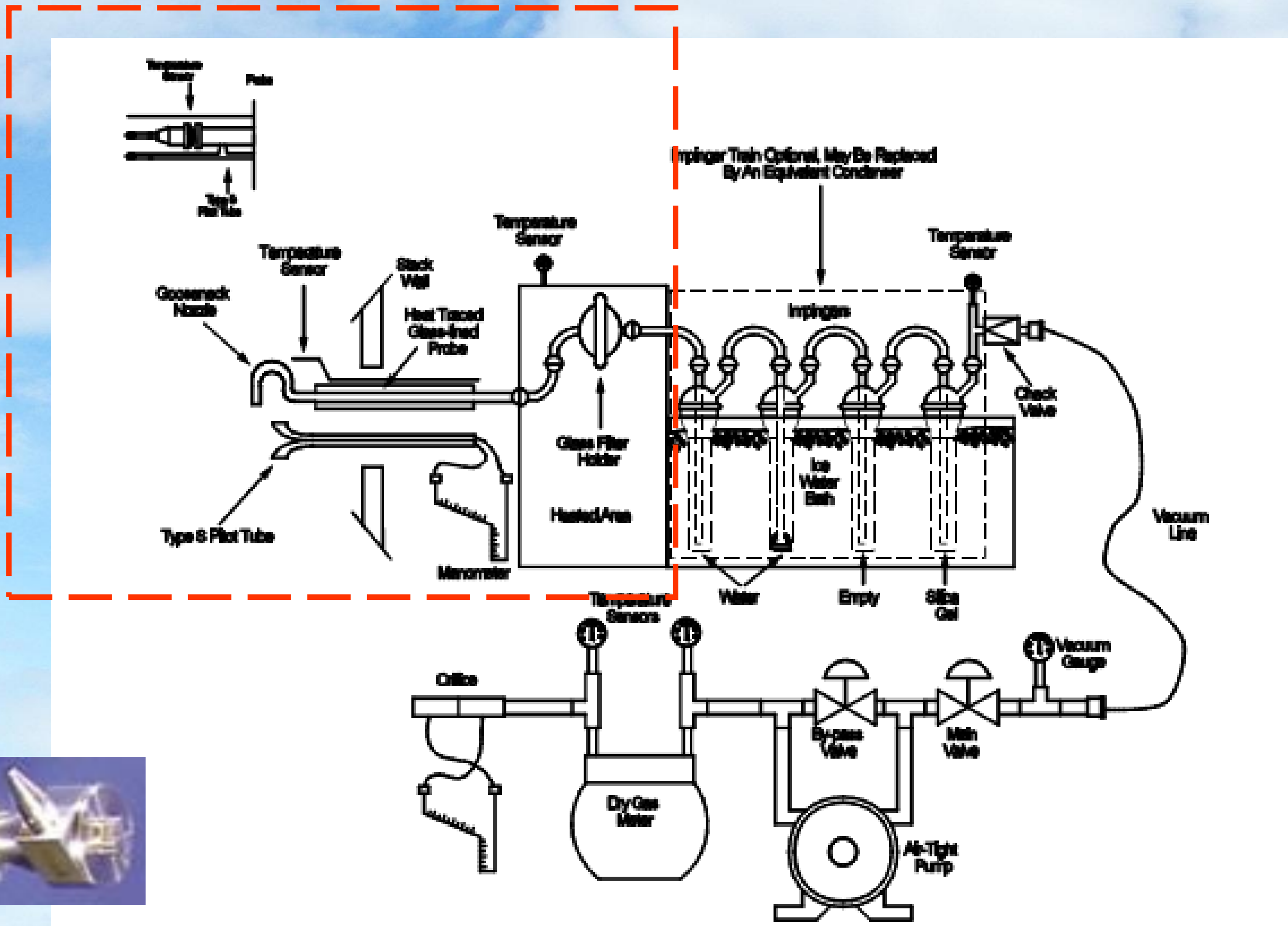
TOPICS

- PM Basics
- **How is PM Quantified: PM Reference Methods / PS-11 Requirements**
- Ensuring Method 5 Measurement Performance

The "Short" List of EPA PM Test Methods

- Method 5 – Filterable PM
- Method 5b – Non-sulfuric acid filterable PM
- Method 5i – Determination of Low Level Particulate Matter Emissions
- Method 17 – In-stack filterable PM (can add "back half" to include Condensable PM)
- Method 201 – Determination of PM10 – In-stack procedure
- Method 201a – Determination of PM10 and PM2.5 (Constant Sampling Rate Procedure)
- Method 202 - Condensable PM – Dry Impinger Method

RM 5 Filterable PM Sampling Train

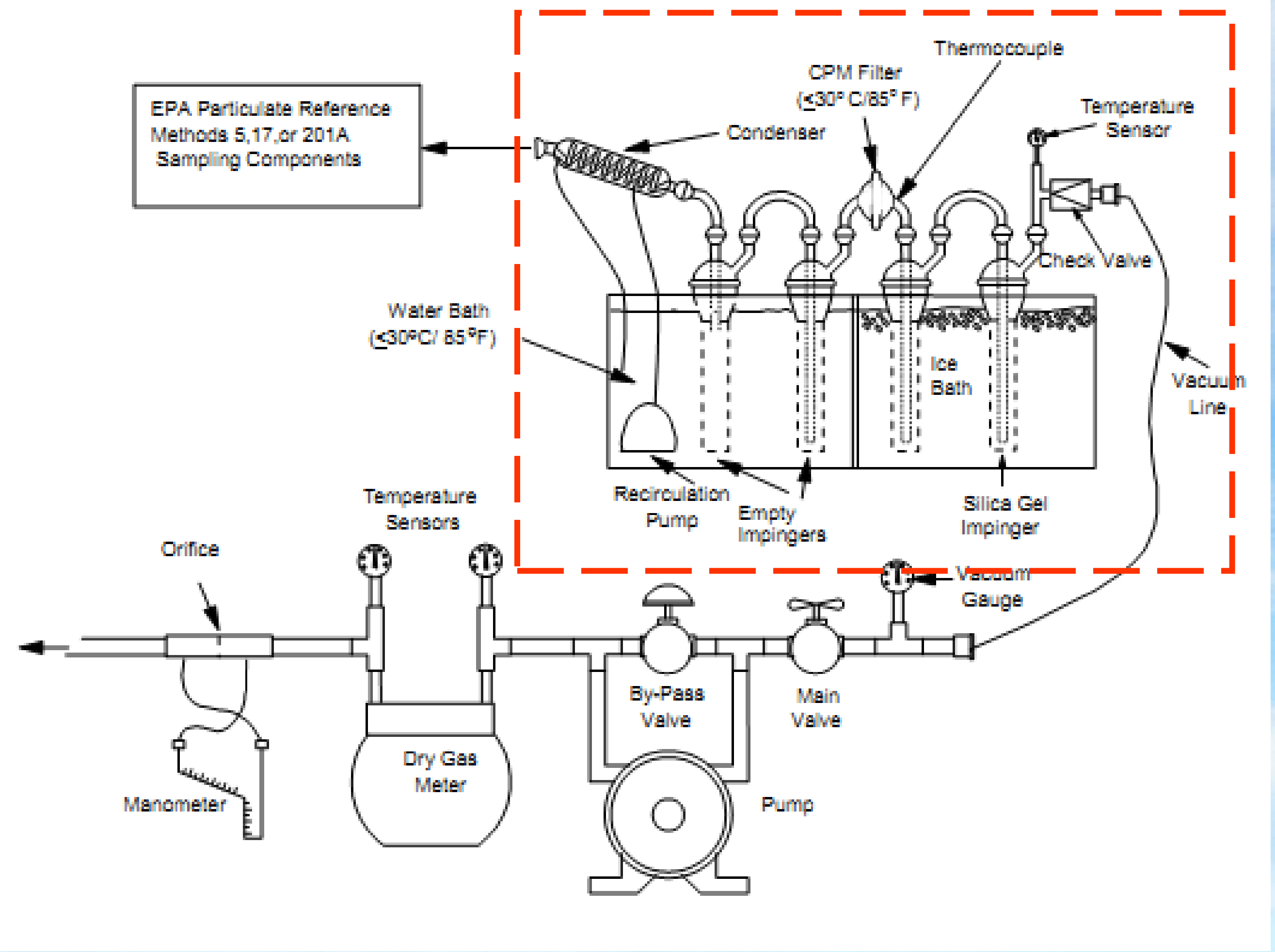


- Replace sample nozzle with a cyclone for Method 201 / 201a

Method Considerations

- Method 201 and 201a - PM10 and PM10/PM2.5 Cannot be Used in a “Wet” Stack
  - Water droplets present contain both dissolved and suspended solids which form PM upon evaporation after emission gases exit stack
  - Methods cannot reconstitute PM via evaporation into the particle sizes that would occur after discharge from the stack due to shattering, agglomeration, and deposition on sampling equipment

RM 202 Condensable PM Train



Impact on PM Limits (Utility MACT)

- Compliance with the standards is (or will be) based on the measurement of Total PM
- Total PM = Filterable PM + Condensable PM = Method 5 (or 5i, etc.) + Method 202
- Continuous compliance determined by PM CEMS operated in accordance with PS-11/Quality Spec. 2
- Check the PM method requirements in the applicable rule!

PS-11:
PM CEMS Performance Specification

- Specifications and Test Procedures for Particulate Matter Continuous Emission Monitoring Systems at Stationary Sources
- Incorporates 40 CFR Part 60 Appendix F, Quality Spec. 2 to cover PM CEMS operating practice
- PM CEMS tested in accordance with PS-11 measures *filterable PM*
- Successful correlation of PM CEMS predicated on quality reference method test data

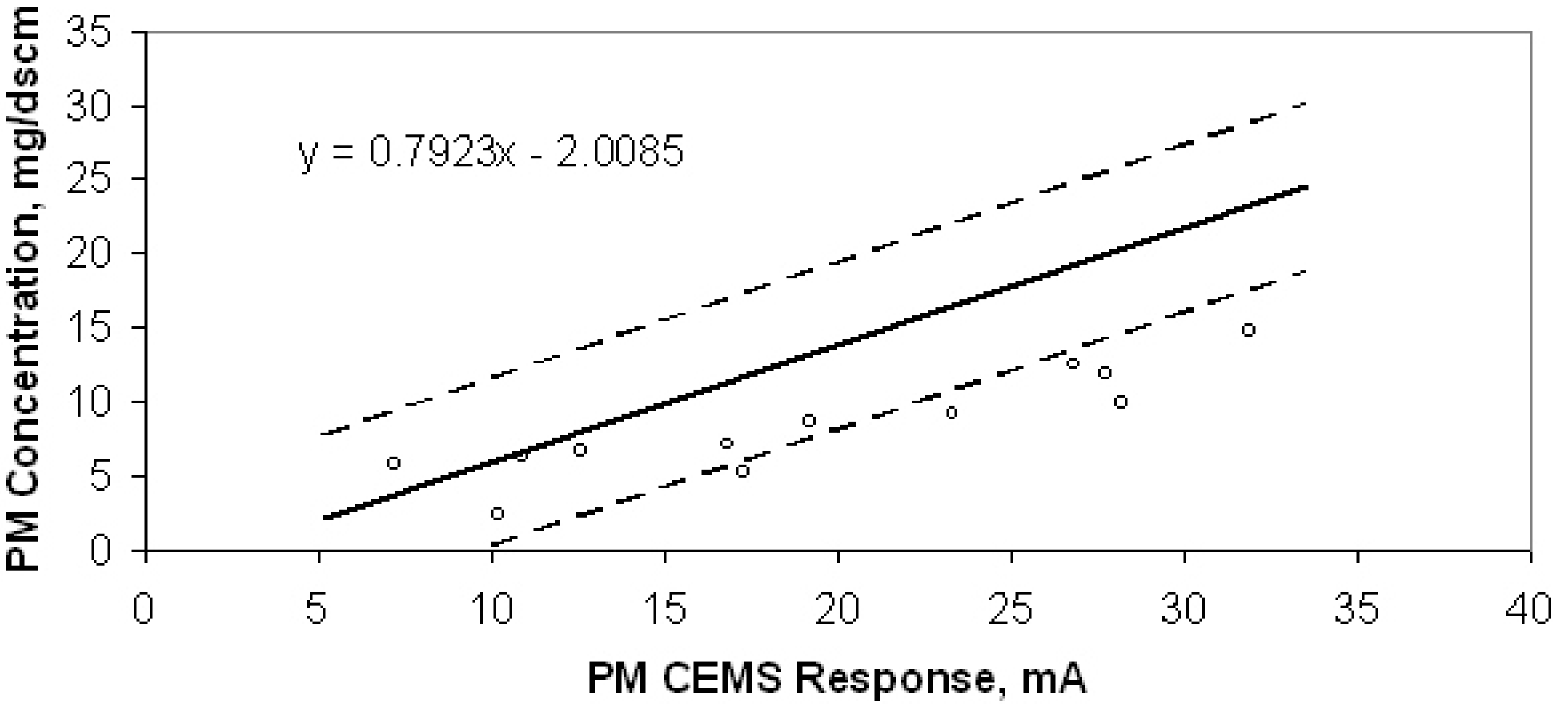
PS-11 Elements

- **Pre-operating phase - Install monitor and:**
  - Characterize PM CEMS sampling location
  - Characterize PM CEMS performance over plant operating range
  - Evaluate PM CEMS calibration and measurement drift
  - Verify PM CEMS DAS records properly over entire plant operating range
- **Conduct Initial Correlation Test to establish PM CEMS output over plant operating range, e.g., correlate PM CEMS vs. EPA Reference Method**
  - Minimum 15 sample runs, with 5 runs at each of 3 plant operating conditions
  - Correlation relationship can be linear, polynomial, logarithmic, or exponential (or power)
  - Correlation must meet Confidence Interval (CI) spec (≤10%)
  - Correlation must meet Tolerance Interval (TI) spec (≤ 25%)

Key Objective:

Characterize PM CEMS response over the range of expected plant operating conditions

Correlation Analysis



QA/QC Elements
Spec 2 (40 CFR Part 60, Appendix F)

- **Response Correlation Audit (RCA): 12 runs at frequency specified in rule or permit**
- **Relative response audit (RRA): 3 runs at freq specified in rule or permit**
- Absolute correlation audit qtrly
- Sample volume audit qtrly (if applicable)
- Daily zero/span drift check
- Daily optics check (if applicable)
- Response Time - document response time measured during correlation test and maintain during operation

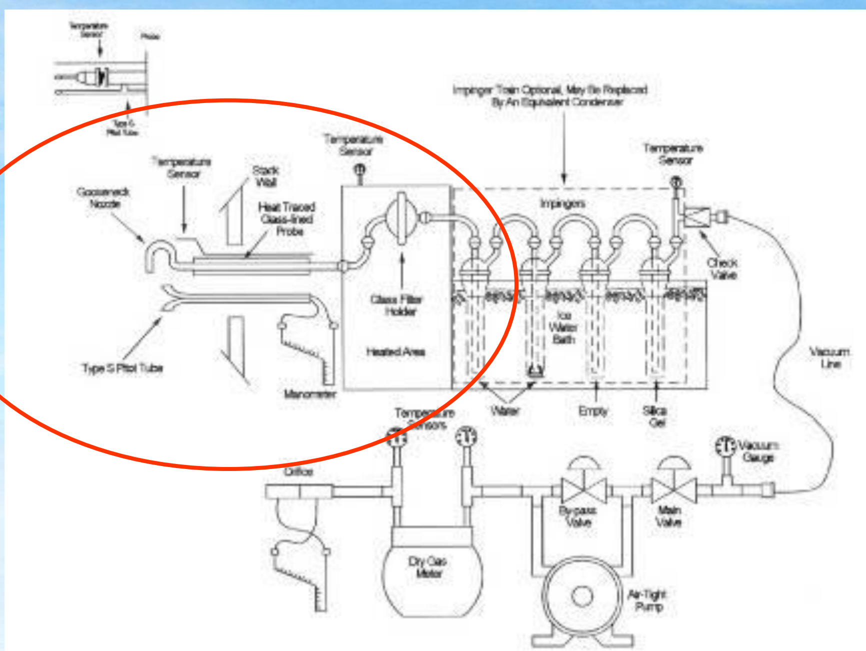
TOPICS

- PM Basics
- PM Reference Methods / PS-11 Requirements
- **Ensuring Reference Method Measurement Performance**

Method 5 Measurement Operational Influences

Recall:

PM characteristics dependent on source and control system characteristics as well as temperature/pressure conditions during sampling and analysis

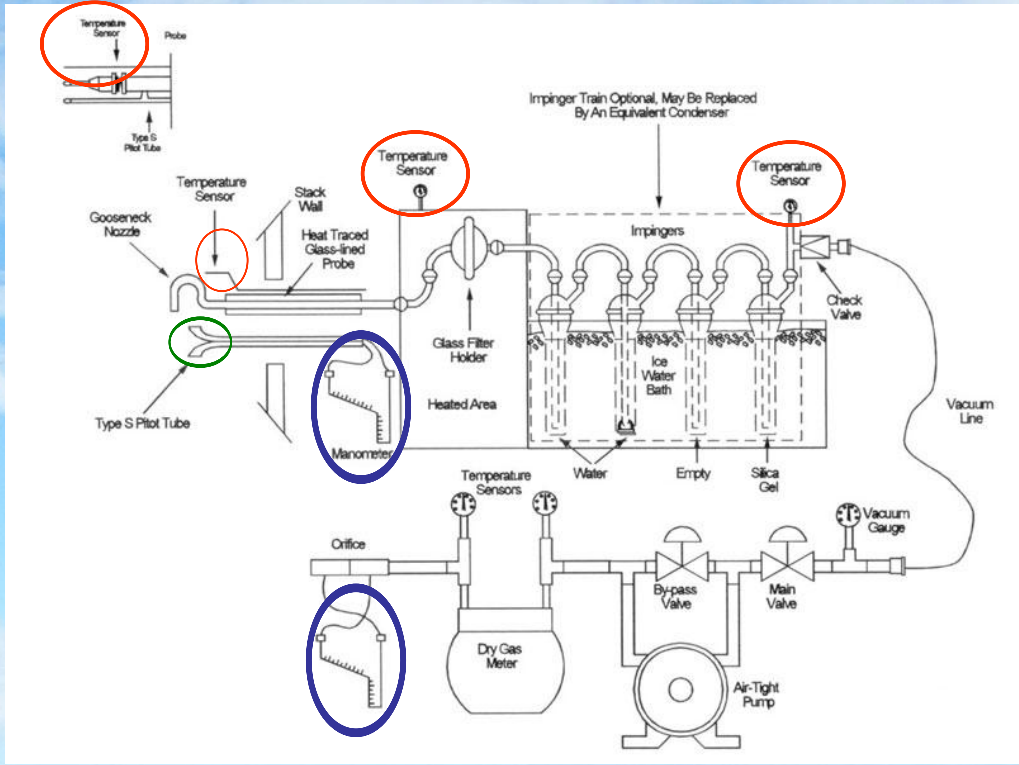


Method Operation

- Probe temperature: 120 14°C (248 25°F) or higher
- Filter temperature:120 14°C (248 25°F)
- Sample velocity:
  - In probe: dependent on probe ID, isokinetic sampling parameters
- Isokinetic sampling requirement: 100 10%
- Filter material: borosilicate glass
- Probe length: depends on stack dimensions

Method 5 Measurement Calibration Influences

- System Calibration
  - Temperature measurements
  - Sample Volume
  - Pressure Measurement
  - Pitot tube geometric alignment
  - Sample time

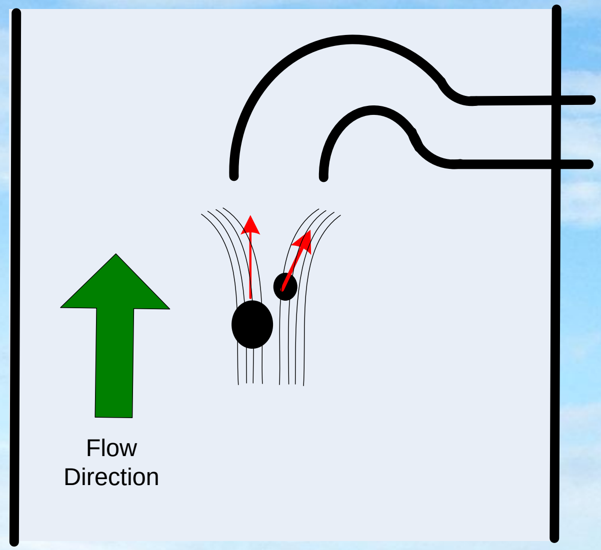


Why is Isokinetics Important?

<100% Isokinetic

Sample Velocity < Gas Velocity biases the concentration

low or high?

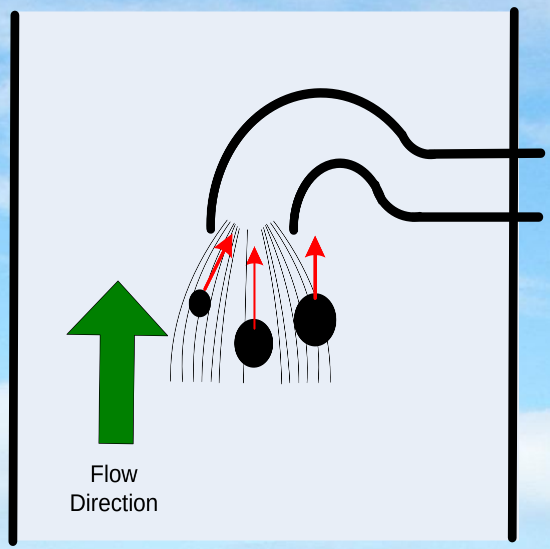


Sample gas volume contains big particles that should not be have been collected Concentration biased HIGH

>100% Isokinetic

Sample Velocity > Gas Velocity biases the concentration

low or high?



Sample volume missing big particles. Concentration biased LOW

Method 5 Data Quality

Test No.	Method 5 Results Train 1 (mg/m3)	Method 5 Results Train 2 (mg/m3)	Difference (Train 1 - Train 2) (mg/m3)	Rel % Diff	Series 7000 Results System 1 (mg/m3)	Series 7000 Results System 2 (mg/m3)
Site 1, Set 1, Run 1	5.11	5.78	-0.67	-3.1%	4.40	4.19
Site 1, Set 1, Run 2	1.57	1.43	0.14	2.3%	2.12	1.59
Site 1, Set 1, Run 3	1.93	2.12	-0.19	-2.3%	1.44	1.65
Site 1, Set 1, Run 4	1.64	1.34	0.30	5.0%	1.09	1.28
Site 2, Set 4, Run 1	7.97	6.83	1.14	3.9%	6.04	6.12
Site 2, Set 4, Run 2	3.51	4.10	-0.59	-3.9%	3.45	3.34
Site 2, Set 4, Run 3	7.23	6.59	0.64	2.3%	5.79	6.14
Site 2, Set 4, Run 4	6.42	5.81	0.61	2.5%	6.00	6.96
Site 4, Set 2, Run 1	7.82	9.98	-2.16	-6.1%	9.57	9.20
Site 4, Set 2, Run 2	10.47	9.94	0.53	1.3%	9.56	9.41
Site 4, Set 2, Run 3	8.91	8.84	0.07	0.2%	8.05	7.10
Site 4, Set 2, Run 4	10.21	9.67	0.54	1.4%	11.66	9.09
Site 7, Run 1	3.94	5.26	-1.32	-7.2%	2.95	4.10
Site 7, Run 2	5.56	5.58	-0.02	-0.1%	5.09	5.04
Site 7, Run 3	3.16	2.98	0.18	1.5%	4.32	2.41
Site 7, Run 4	4.95	4.67	0.28	1.5%	5.14	4.08
		Averages	-0.52	-0.8%		

Source: ASTM Test Method D6831-02, Precision Data Summary (Oct. 2002)

Correlation Test Considerations

- Reference Method System Considerations
  - System calibration – ensure all sensors are properly calibrated.
  - Allowable filter temperature variation is huge (+/-25%); maintain same temperature run to run.
  - Allowable isokinetic variation is +/- 10%; goal should be +/- 0%.
  - Measurement includes Method 2, 3 and 4; verify gas composition assumptions during testing.
  - Method allows SS or glass probe liner & nozzles; use glass.
  - Weigh filters to constant weight (within +/- 0.5 mg).
  - Allowable system leak rate 0.02 ft^3/min (0.0057 m^3/min) – strive to eliminate leaks.

Correlation Test Considerations

- Reference Method Operations
  - Ensure proper orientation of probe in gas stream; improper positioning can affect both sample catch and velocity measurement.
  - Cover sample ports during sampling.
  - Start / Stop RM sampling and PM CEMS data collection precisely at same time.
  - Sample exactly the same amount of time at each sample point and port. *(STAY OFF THE CELL PHONE!)*
  - Use gloves when handling samples and when rinsing the probe.
  - Use clean probe brush.
  - Maintain filter box and probe temperatures religiously during entire test run.
  - Minimize run to run variability in probe and filter temperature.
  - Strive to eliminate potential for sample contamination.

Key Points

- The choice of PM test method determines the nature of PM being measured. Verify the test method requirement in the standard.
- PM sampling for condensables is NOT the same as for filterable PM.
- PM sampling for correlating a PM CEMS is NOT the same as PM sampling for a compliance test.
- There is no "PM" SRM.
- Reference method operational factors critical to meeting data quality objectives:
  - System Calibration
  - Filter handling
  - Maintaining sampling conditions, i.e., probe/filter temperature
  - Maintaining isokinetics
  - Sample recovery procedures for nozzle, probe, filter(s) as well as impingers, size selective inlets, etc., depending on method used.
  - Maintaining Pre & Post-filter conditioning / weighing conditions
- Successful PM CEMS correlation highly dependent on quality of reference method measurements.

Success is simple.

Do what's right, the right way, at the right time.

Arnold H. Glasow

?? Questions ??

Thanks for Your Attention