Condensable Particulate Matter: The New Challenge for Electric Power Companies Complying with PM2.5 Emission Standards

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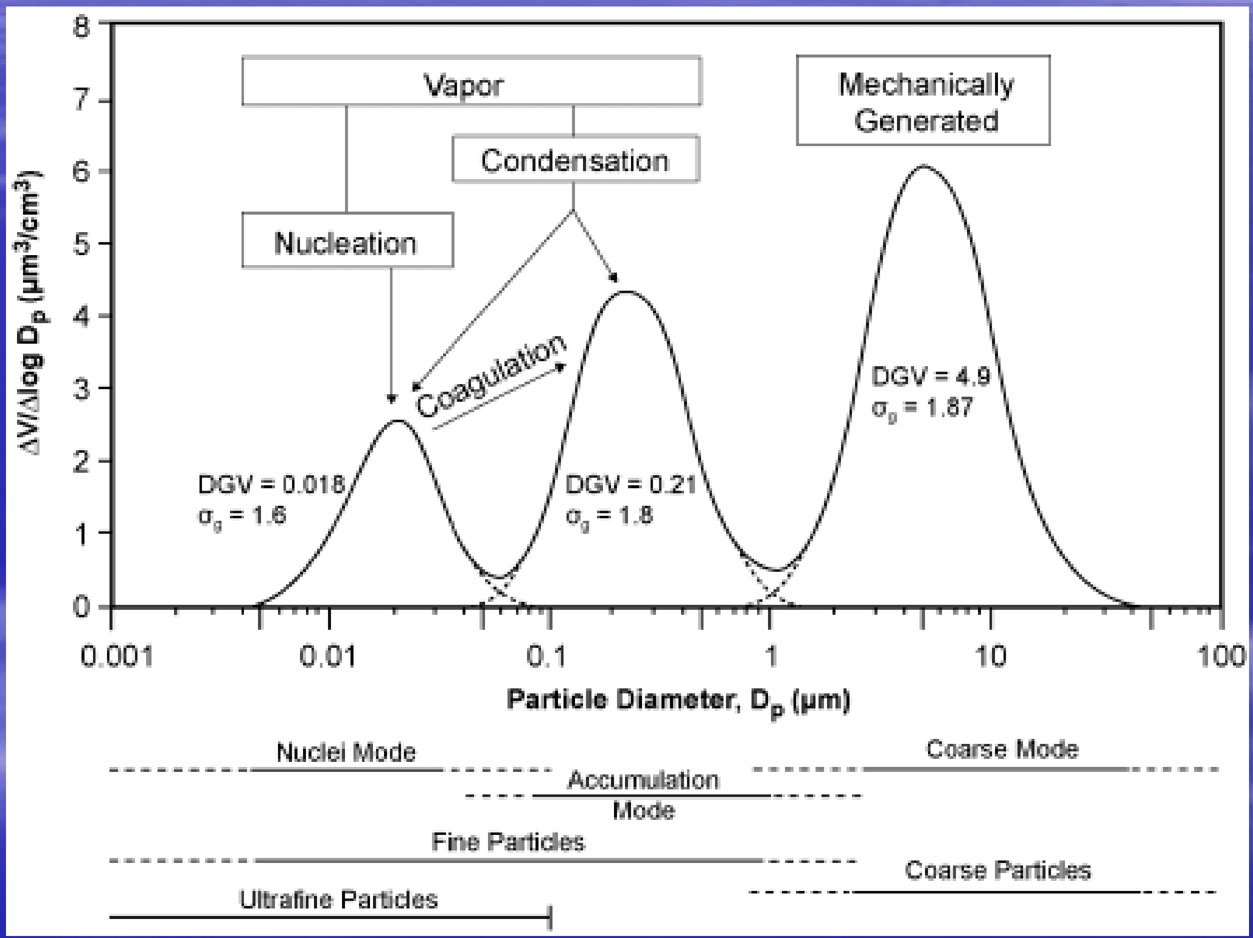
Overview

- Atmospheric Particulate Matter (PM) Physical Properties and Formation
- Regulatory History of PM Control
- EPA Filterable PM (FPM) and Condensable PM (CPM) Stack Test Methods

Overview

- Recent Developments in CPM Stack Test Methods
- Issues of Concern in the Development of PM2.5 Emission Standards

Atmospheric PM Physical Properties and Formation



Regulatory History

- Air Quality Criteria and NAAQS Review Process
- 1971: Total Suspended Particulate (TSP) NAAQS
- 1987 PM NAAQS Revision: PM10 Standards
- 1997 PM NAAQS Revision: PM2.5 Standards
- 2006 PM2.5 24-Hour NAAQS Revision

Current PM2.5 Ambient Air Quality Standards:

- 15 $\mu g/m^3$ Annual Average Based on a 3-Year Average
- 35 $\mu g/m^3$ Based on a 3-Year Average of the 98th Percentile of Daily 24-Hour Concentrations

Changing Focus in PM Air Quality Management

- Until promulgation of the PM2.5 NAAQS, air quality management of PM emissions focused mainly on relatively large solid, filterable PM (i.e., fugitive dust controls and stack PM control equipment).

- *CPM was a less significant fraction of the overall air quality problem.*

Changing Focus in PM Air Quality Management

- With the advent of the PM2.5 NAAQS, *all* facets of PM air quality management are becoming more important, including the accurate measurement of condensable PM emissions.

PM2.5 Implementation Rule
40 CFR Part 50.1002 (c)

"After January 1, 2011, for purposes of establishing emissions limits under 51.1009 and 51.1010, States must establish such limits taking into consideration the condensable fraction of direct PM2.5 emissions."

PM2.5 Implementation Rule
40 CFR Part 50.1002 (c)

"Prior to this date, States are not prohibited from establishing source emission limits that include the condensable fraction of direct PM2.5."

PM2.5 Issues of Concern to Electric Power Companies

1. Many of the emission factors in U.S. EPA's Compilation of Emission Factors (AP-42) either do not include or inaccurately represent the condensable portion of the PM2.5 emissions

PM2.5 Issues of Concern to Electric Power Companies

2. Emission factor inaccuracies of up to *an order of magnitude or more are occurring* due largely to problems with stack test methods for CPM (positive bias caused by sampling train artifact formation)

PM2.5 Issues of Concern to Electric Power Companies

3. The AP-42 PM2.5 emission factors are average emission factors that do not accurately characterize the expected maximum 3-hour emission rates from a stack test compliance method

Formation of CPM from Fossil-Fuel-Fired Combustion Units

- Predominantly inorganic (i.e., sulfuric acid mists, salts, trace metals), particularly from coal- and oil-fired units

$$SO_3(\text{gas}) + H_2O(\text{gas}) \rightarrow H_2SO_4(\text{gas}) \rightarrow H_2SO_4(\text{liquid})$$

Formation of CPM from Fossil-Fuel-Fired Combustion Units

- Organic CPM derived from incomplete combustion of organic constituents of the fuel

U.S. EPA AP-42 FPM and CPM Emission Factors for the Electric Power Industry

Fuel	PM Control	Average Emission Factor			
		FPM	FPM2.5	CPM	Units
Natural Gas	Uncontrolled	1.9	1.9	5.7	lb/MMcf
No. 2 Fuel Oil	Uncontrolled	2	0.24	1.3	lb/Mgal
No. 6 Fuel Oil	ESP	2.9(1)	1.2	1.5	lb/Mgal
Bituminous Coal	FF/FGD	0.08(2)	0.04	0.02	lb/ton

Notes:

(1) Based on a fuel oil sulfur content of 2.8% and 90% FPM control efficiency

(2) Based on a coal ash content of 8% and 99.9% FPM control efficiency

How Accurate are the U.S. EPA PM2.5 Stack Test Methods for FPM and CPM Emissions from Electric Power Plants?

EPA Stack Test Methods

- Method 5 was the initial EPA source test method for PM proposed in 1971 for use with the first group of NSPS (40 CFR 60, Appendix A).

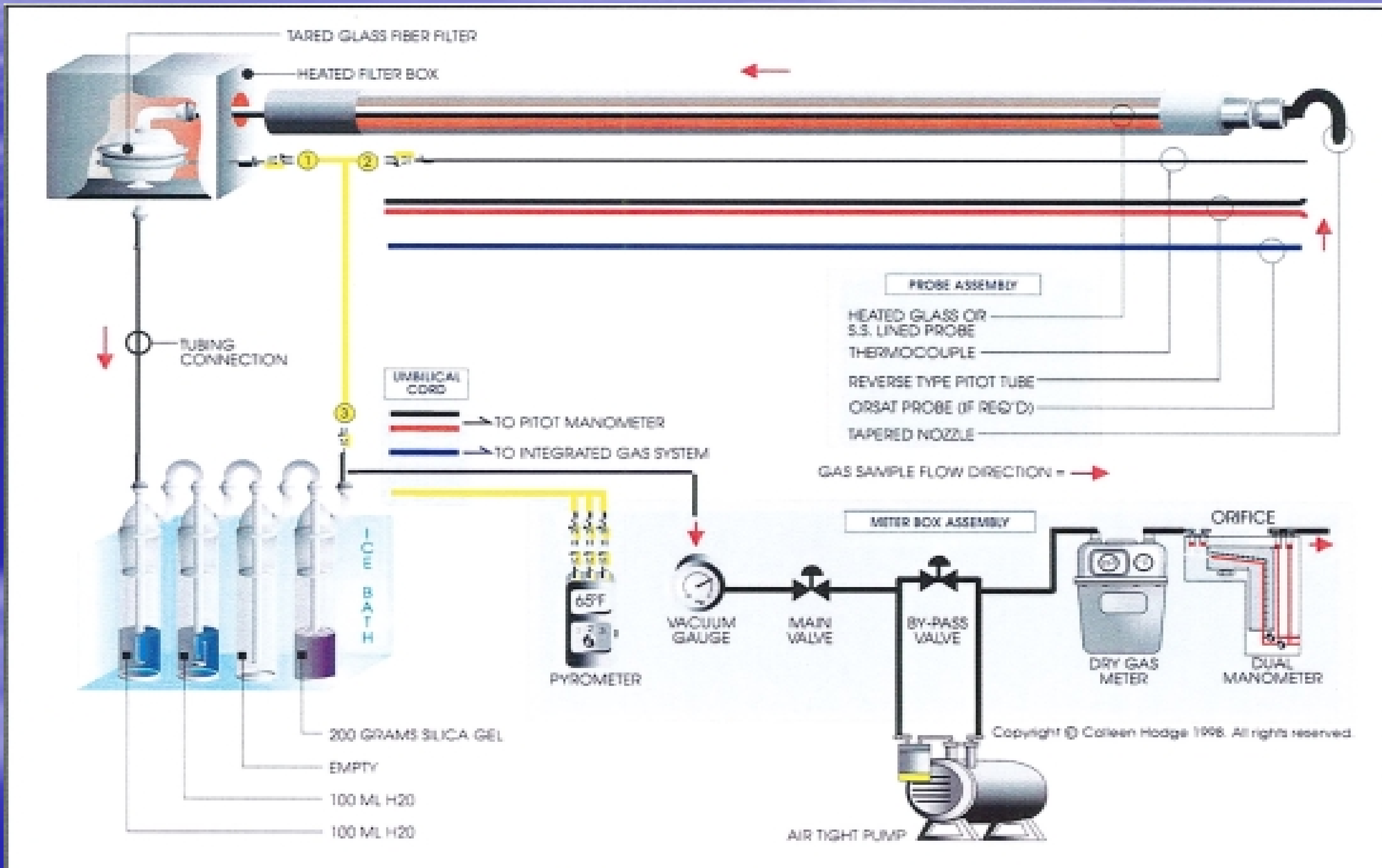
EPA Stack Test Methods

- Method 5 consisted of a heated filter to collect filterable PM followed by a series of impingers containing chilled water to collect condensable PM.

EPA Stack Test Methods

- Since a major objective of the NSPS program was to evaluate the performance of pollution control equipment, Method 5 was revised to quantify only the filterable component of PM.

Method 5 Sampling Train



U.S. EPA Method 5 Sampling Train

Condensable PM: EPA Method 202

- Isokinetic/constant sampling method
- Collection in back-half of Method 5 sampling train at ambient temperature
- Used in conjunction with filterable methods to provide PM_{10} or $PM_{2.5}$

Condensable PM:
EPA Method 202

- Provides two fractions, inorganic and organic condensable PM
- Chemical speciation can be performed on each fraction

Main Problems with Method 202

- Significant positive bias, due to sampling train artifact formation, resulting mainly from the dissolution of SO_2 into impinger water and subsequent oxidation to sulfate

Main Problems with Method 202

- Lack of reproducibility in stack test results

- Artifact formation function of test duration and flue gas composition (e.g., SO_2 concentration)

Main Problems with Method 202

U.S. EPA Conducted Laboratory Study

- 36 samples
- SO_2 bubbled through impingers
- 300 ppm for 1 & 3 hours
- 50 ppm for 6 hours
- Nitrogen purge and no purge
- Hold times from 1 to 20 hrs for initial analysis

Method 202 Artifacts in U.S. EPA Test

SO_2 ppm	Test Duration	H_2O Volume	Artifact Mass (mg)	
			No Purge	Purge
300	1 Hr	400 ml	180 ± 6	10 ± 0.5
300	3 Hr	800 ml	400 ± 25	20 ± 5
50	6 Hr	1400 ml	200 ± 10	20 ± ??

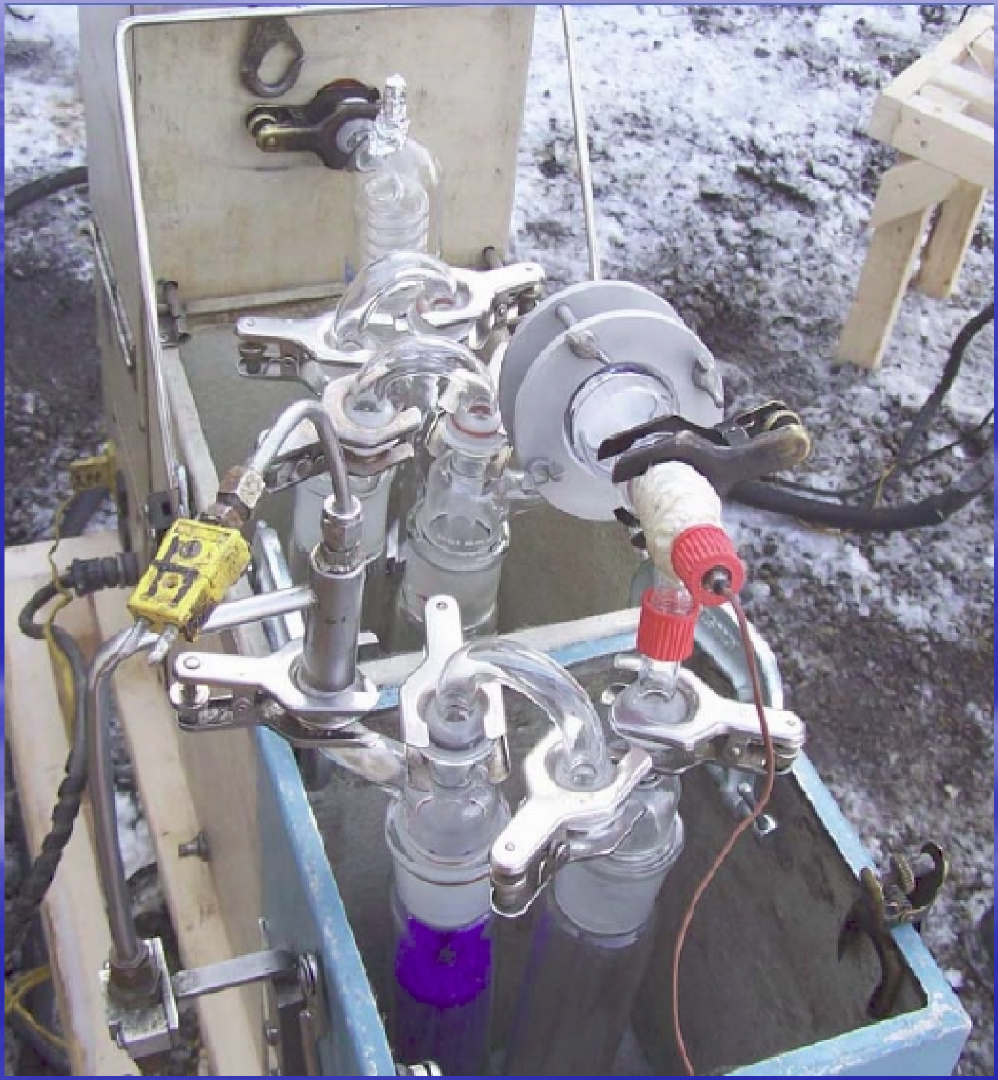
Recent Developments: Method 202 Evaluation and Improvement

- EPA has engaged several industrial and State agency stakeholders, including several electric utility groups (e.g., EPRI, UARG), to evaluate proposed Method 202 improvements and to extend laboratory evaluations to additional gas matrices

Recent Developments: Method 202 Improvements

- One-hour nitrogen purge immediately after sampling to remove dissolved SO_2
- Dry impinger method to eliminate artifact problem

Dry Impinger Method



Recent Developments: Method 202 Improvements

- Dilution to simulate atmospheric conditions within which PM condenses
- Final method expected to be proposed in Federal Register in March, 2008

Issues of Concern in the Development of PM2.5 Emission Standards

- Without accurate CPM test data, how will regulatory agencies set realistic PM2.5 emission limits in Title V Permits?

Issues of Concern in the Development of PM2.5 Emission Standards

- Current PM2.5 emissions inventory data in AP-42 and in the regional emissions inventories used to model PM2.5 NAAQS attainment are average emission rates

Issues of Concern in the Development of PM2.5 Emission Standards

- How can regulatory agencies use these average (and inaccurate) PM2.5 emission rates to determine the emission limits to place in the Title V Permit with a 3-hour stack test compliance method not to be exceeded?

EPA Emissions Factor Uncertainty Assessment Document (Feb., 2007)

- EPA has developed AP-42 emissions factor uncertainty ratios for a number of target statistics (e.g., 95th percentile) to quantify emissions variability

EPA Emissions Factor Uncertainty Assessment Document (Feb., 2007)

Problems:

– Assessments have been completed for only four industries, none of which include the electric power industry

– There is no reliable database of electric utility FPM + CPM emission test results with which to develop emission factor frequency distributions

EPA Emissions Factor Uncertainty Assessment Document (Feb., 2007)

Problems:

– PM2.5 emission factor frequency distributions will vary from one electric generating unit (EGU) to another

What to Do?

- When the new PM2.5 FP+CPM stack test method is issued in 2008, conduct a set of stack tests for each EGU

What to Do?

- Statistically analyze the stack test results with Monte Carlo Simulation to develop a cumulative frequency distribution of emission rates

What to Do?

- Review results and conduct other statistical analyses to determine what stack test averaging time PM2.5 FP+CP emission rate to propose as the emission limit in the Title V Permit so there is an acceptably small chance of exceeding this emission limit over the remaining EGU lifetime

Summary

- PM2.5 Implementation Rule requires that, starting in 2011, the condensable portion of PM2.5 be included in air permit limits

- Much of the existing data base of CPM emission factors is incomplete and positively biased

Summary

- Improvements in EPA stack test methods for CPM (e.g., Method 202) will minimize testing bias and provide more accurate and reproducible test results

- With a lack of reliable CPM emission rate test data, impending PM2.5 emission limits for Title V Permits will be difficult to determine

Summary

- To develop proposed PM2.5 Title V Permit emission limits, conduct a set of stack tests with the new U.S. EPA PM2.5 stack test method to be proposed in 2008

Summary

- Statistically analyze stack test results using Monte Carlo Simulation and other methods to determine a proposed emission limit for the Title V Permit so there is an acceptably small chance of exceeding this it over the remaining EGU lifetime

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