

Reinhold Environmental Ltd.



2008 APC Round Table
& Expo Presentation

July 13-15, 2008, in Savannah, GA

Fine Particulate and Gaseous Species Testing

Presented by:

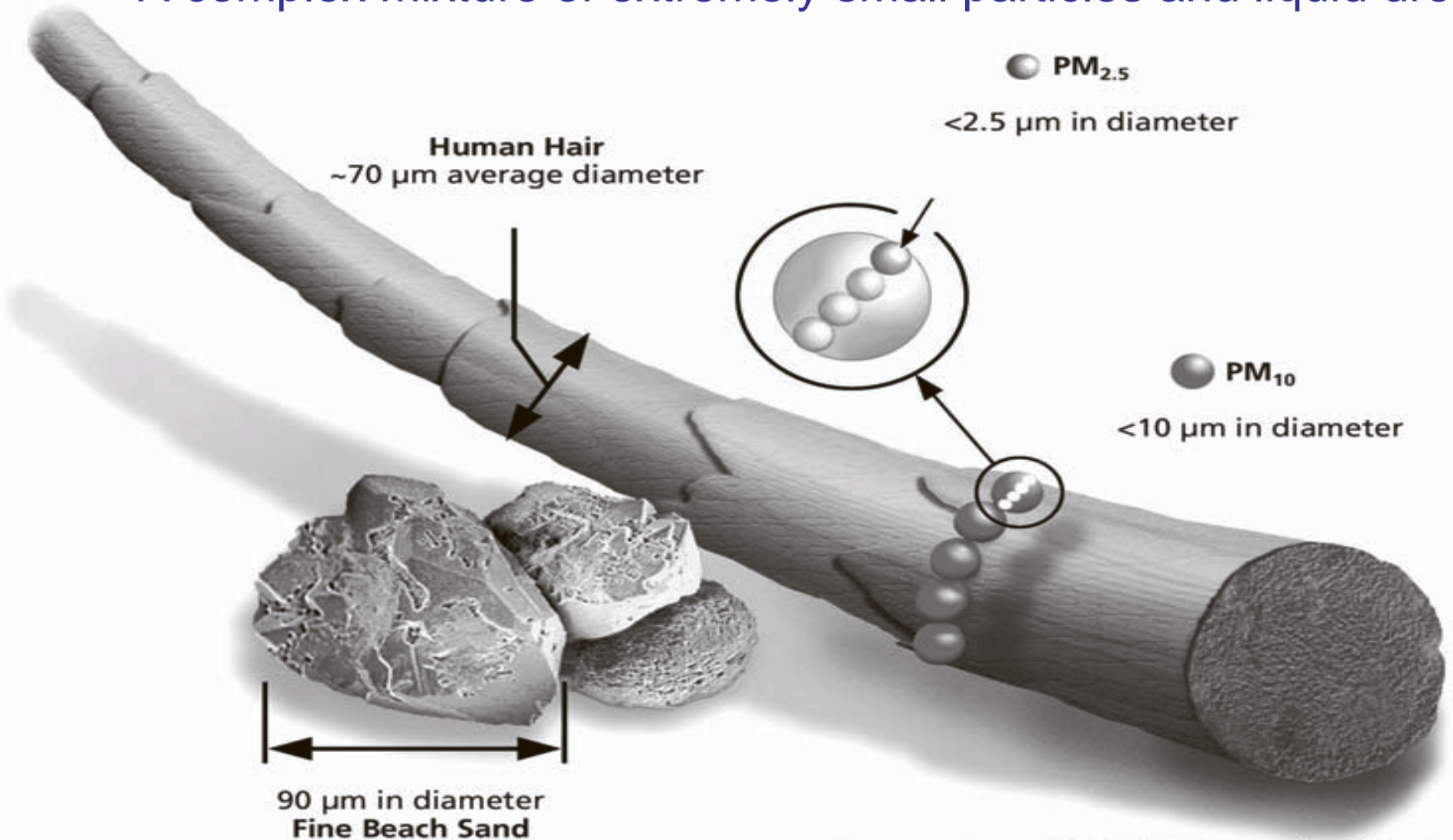
Allen Kephart
Clean Air Engineering

APC Round Table & Exposition
July 15, 2008



What is Particulate?

A complex mixture of extremely small particles and liquid droplets



What is Particulate?

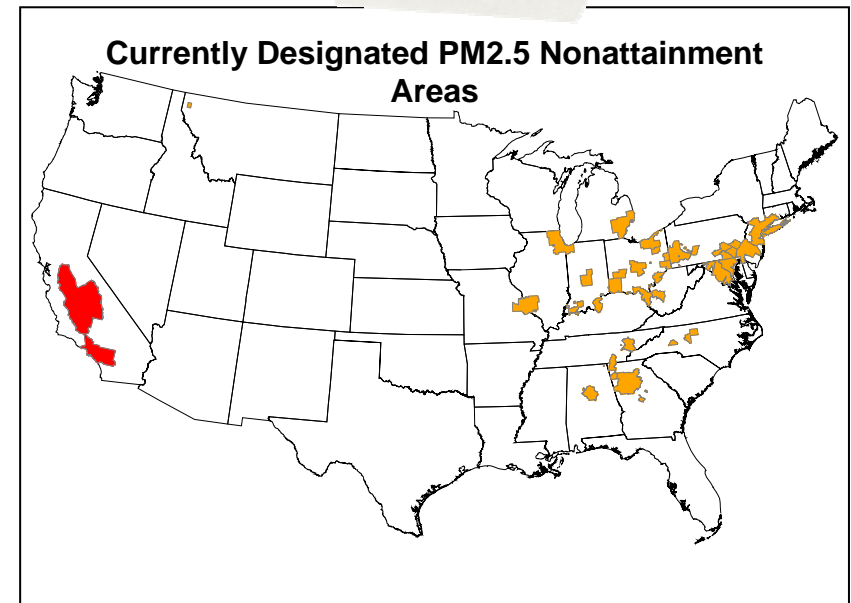
US EPA defines particulate matter as:

“... all finely divided solid or liquid material, other than uncombined water, emitted to the ambient air as measured by applicable reference methods, or an equivalent or alternative method, specified in this chapter, or by a test method specified in an approved State implementation plan.”

40 CFR 51.100(qq)

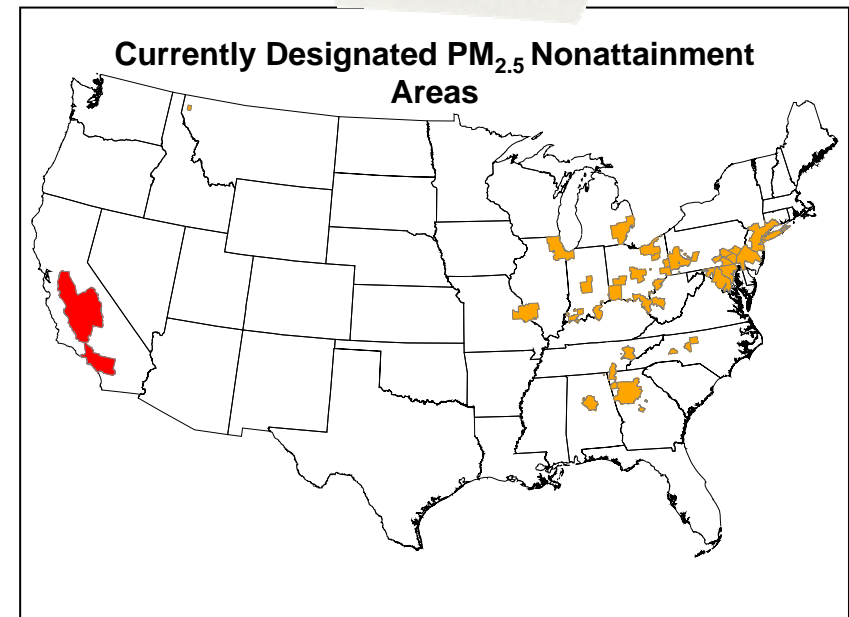
Fine Particulate (PM_{2.5}) - So what is the issue?

- Among the criteria pollutants, exposure to PM_{2.5} poses the greatest health risk
- EPA issued National Ambient Air Quality Standards for PM_{2.5} in 1997 and 2006
- Power plants are considered a major source
- PM_{2.5} Implementation Rule

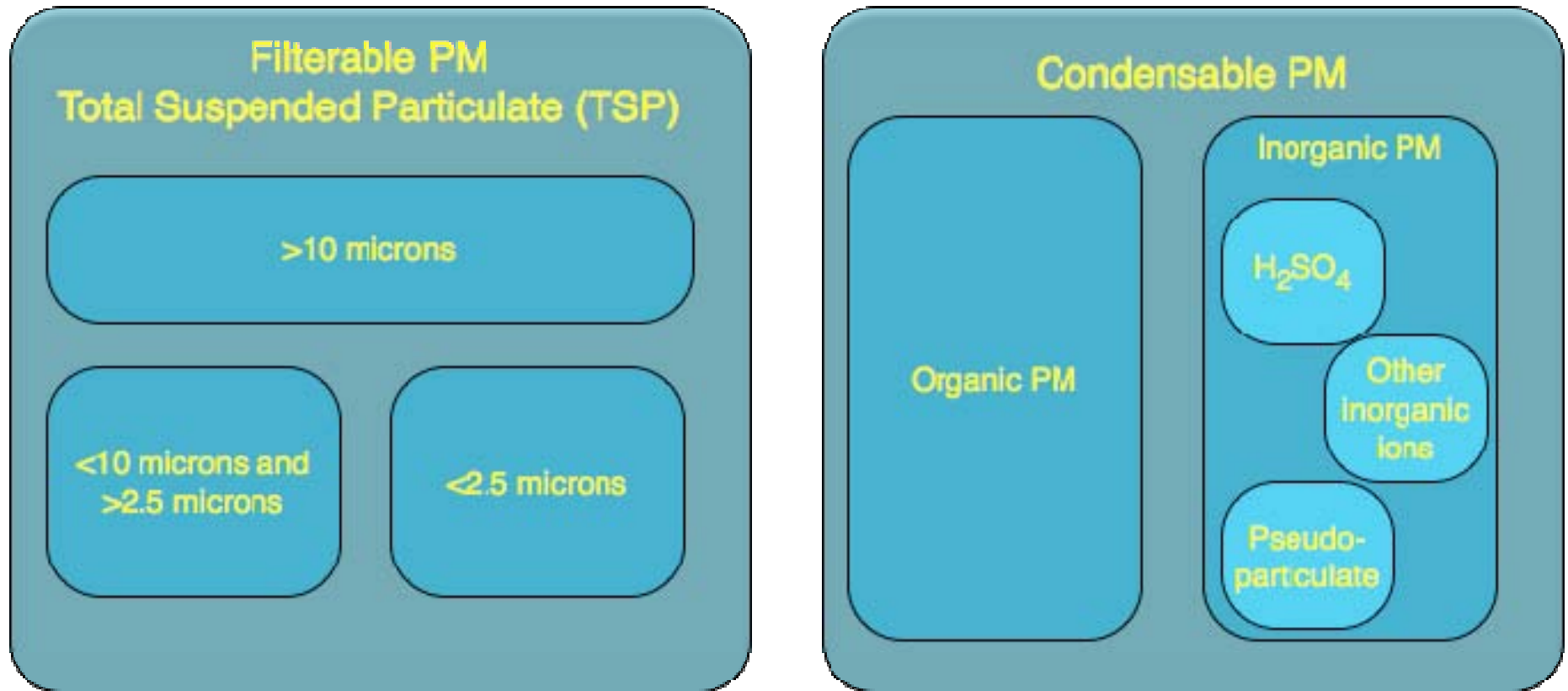


Fine Particulate ($PM_{2.5}$) - What can you expect?

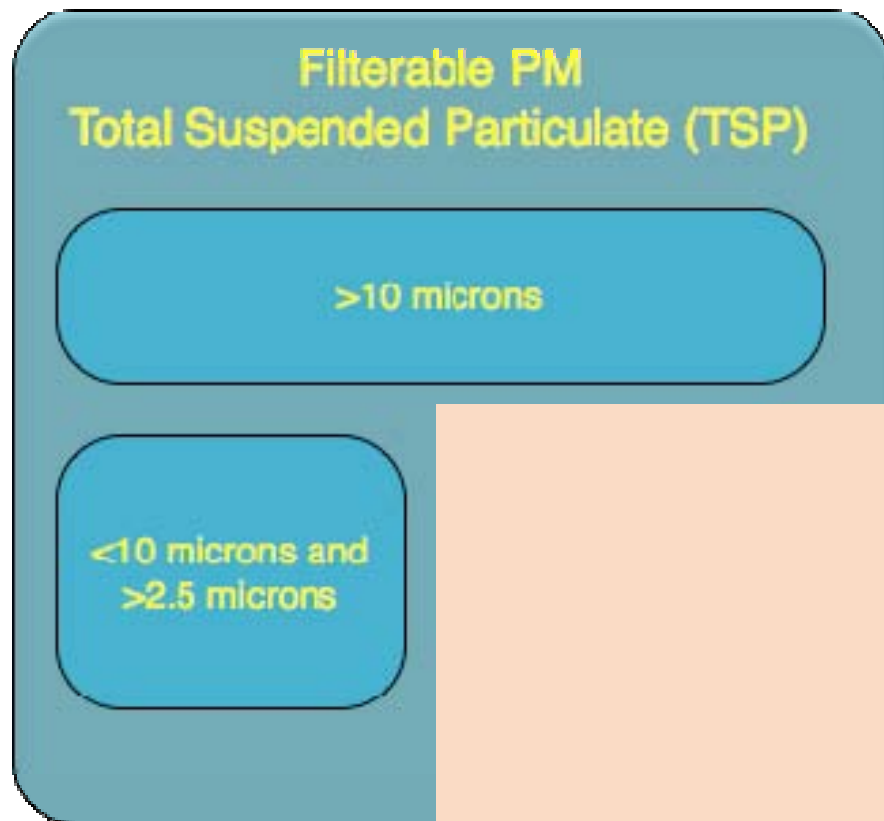
- In the near term states may ask for condensable PM data to update inventories
- Emissions limits including condensable PM required after 2011 for sources included in $PM_{2.5}$ attainment plans
- New plants may require BACT analysis and potential $PM_{2.5}$ emission limits (e.g., Highwood Generating Station)



Particulate Emissions include:



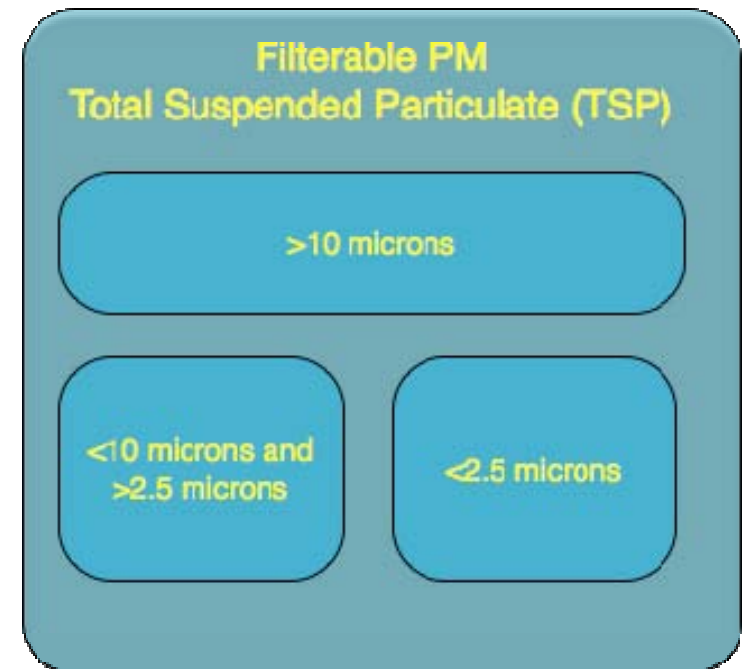
What is Fine Particulate?



PM 2.5

How is Filterable PM Measured?

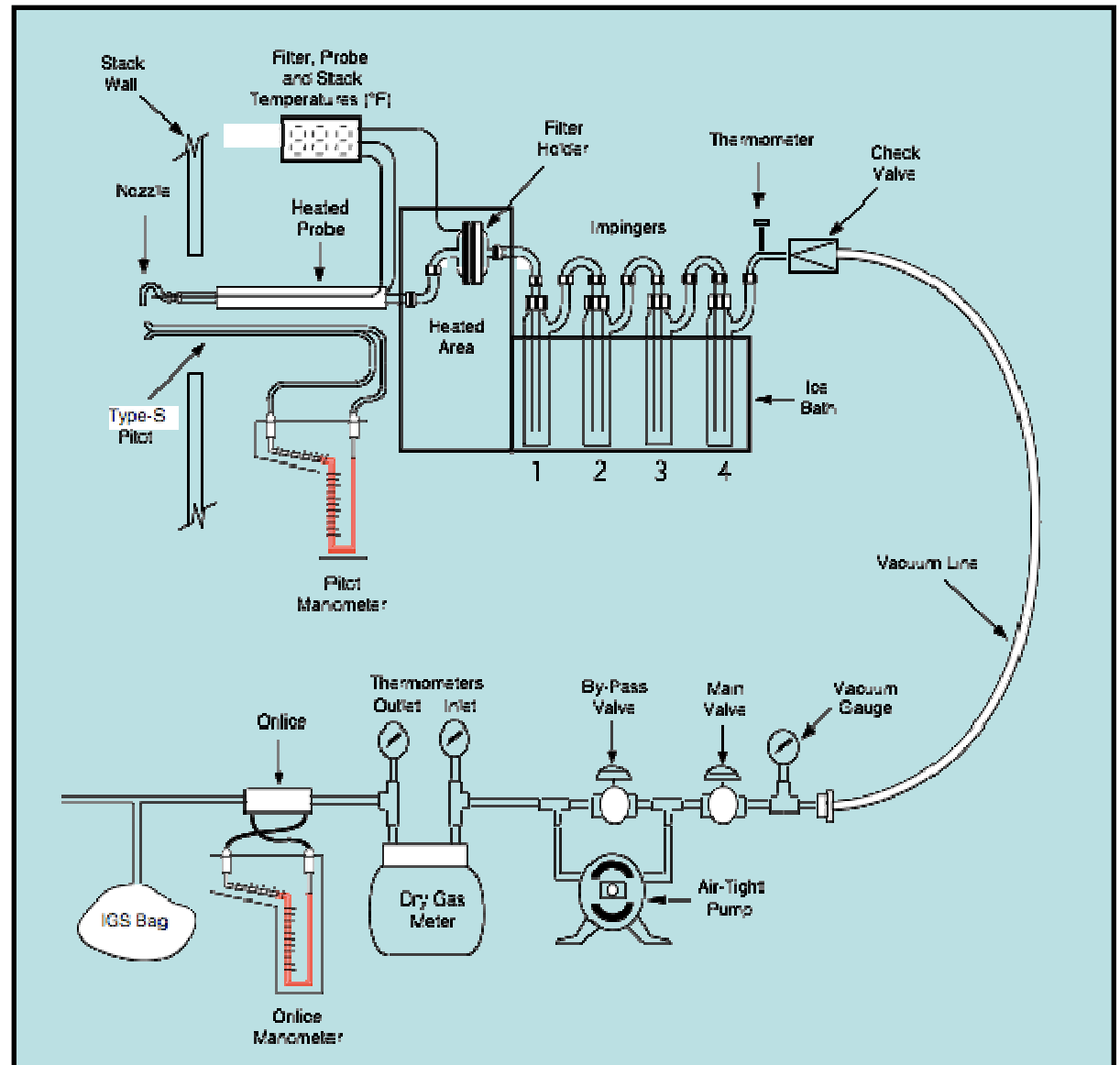
Particulate Matter	EPA Method
Total Suspended Particulates	5
Nonsulfuric Acid Particulate	5B
In-Stack Particulate	17
PM ₁₀	201A
PM _{2.5}	OTM-27



PM is defined by the method used to measure it

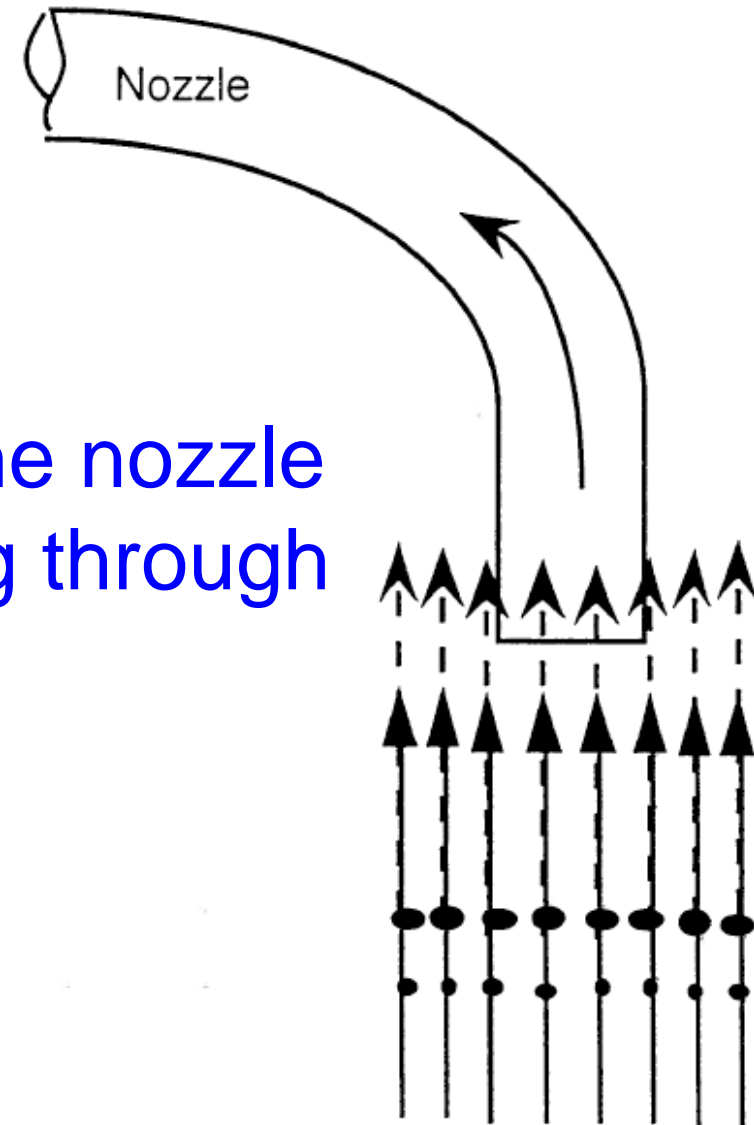
- **Method 5 – Total Suspended Particulate**
 - Probe and filter at 250 °F
 - Any compounds in a vapor phase at 250 °F will not be measured
- **Method 5B - Non-sulfuric acid PM**
 - Probe and filter at 320 °F
 - Filter desiccated at 320 °F

Method 5 Sampling Train

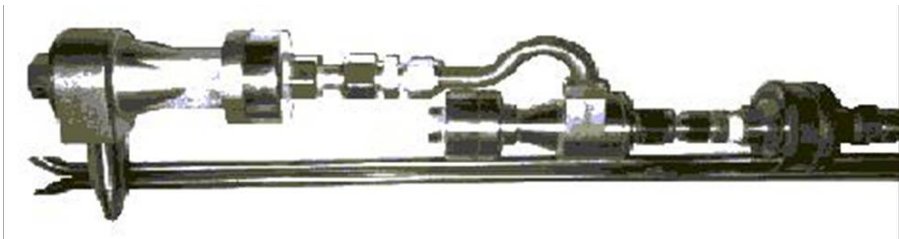


Isokinetic Sampling

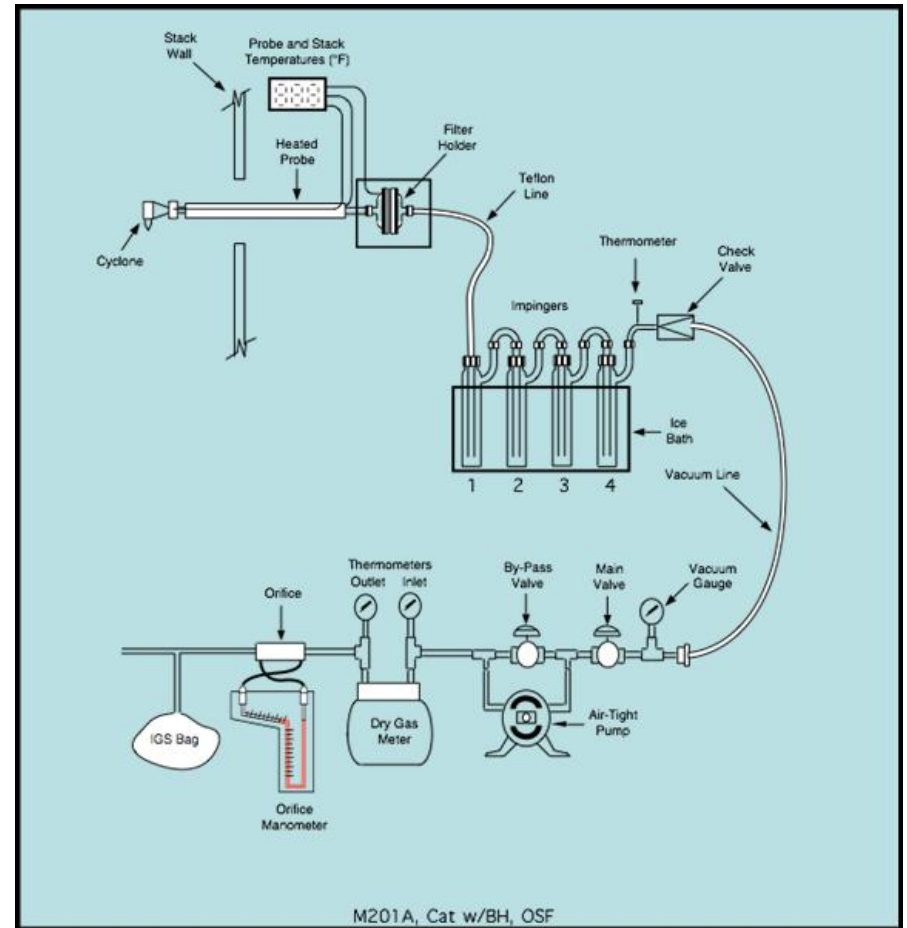
Pulling the stack gas through the nozzle at the same velocity it is moving through the stack



Methods 201A and OTM-27 for PM_{10} and $PM_{2.5}$



OTM-27 Dual Cyclone for $PM_{2.5}$



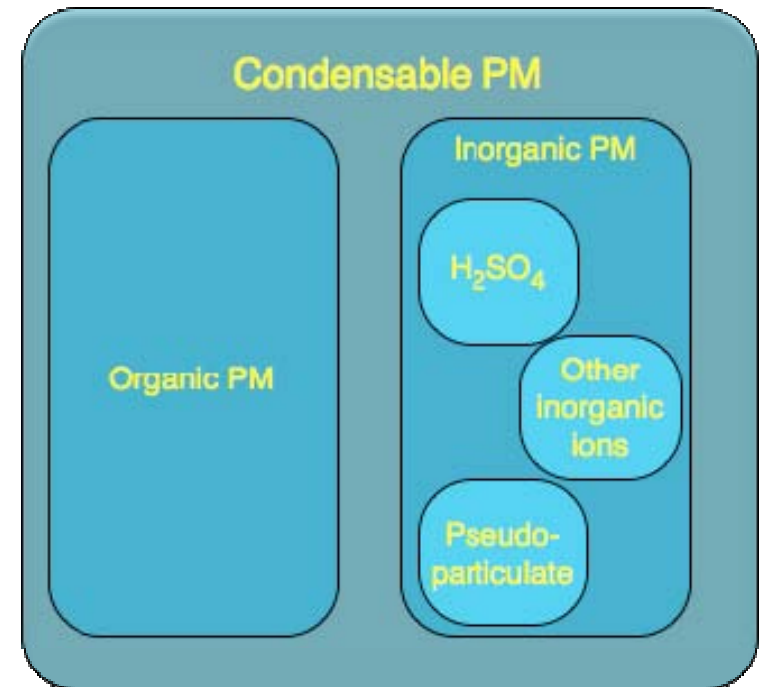
Combination of PM Methods

Typical Permit Language

Whenever compliance emission testing is required, US EPA Method 5 or 5B including back-half (Method 202) shall be used to demonstrate compliance or an alternate method approved in writing by the Department, shall be used.

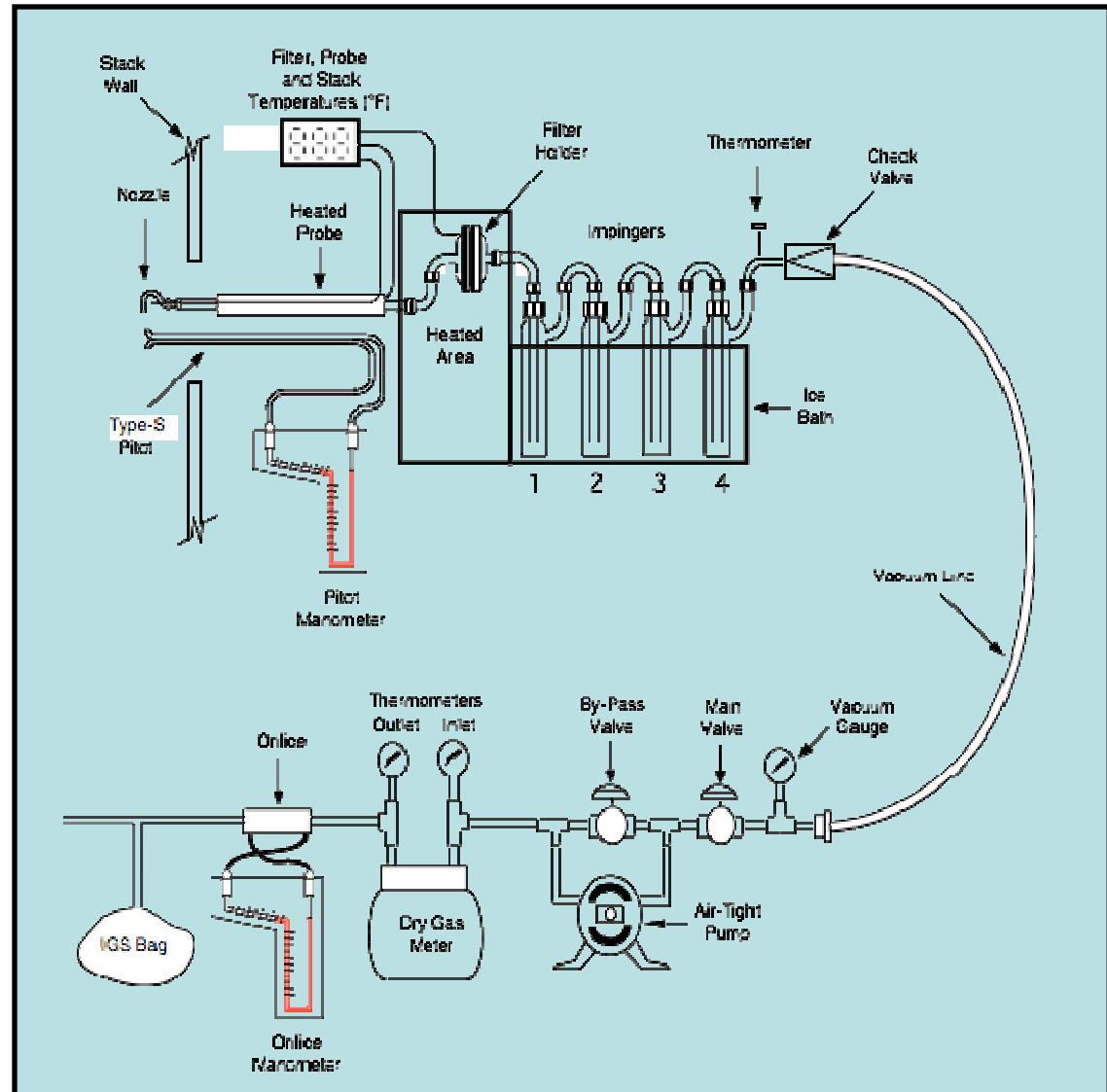
Measuring Condensables

- EPA originally developed Method 202
- M202 problematic due to “pseudo-particulates” or artifacts
- New Method Developed
 - Dry Impinger (M20x or OTM-028)



EPA Method 202

- Uses back-half of filterable PM train (e.g., Method 5/17 method)
- Nitrogen purge to remove dissolved SO_2
- Inorganic and organic fractions
- Allows correction for HCl in the presence of NH_4

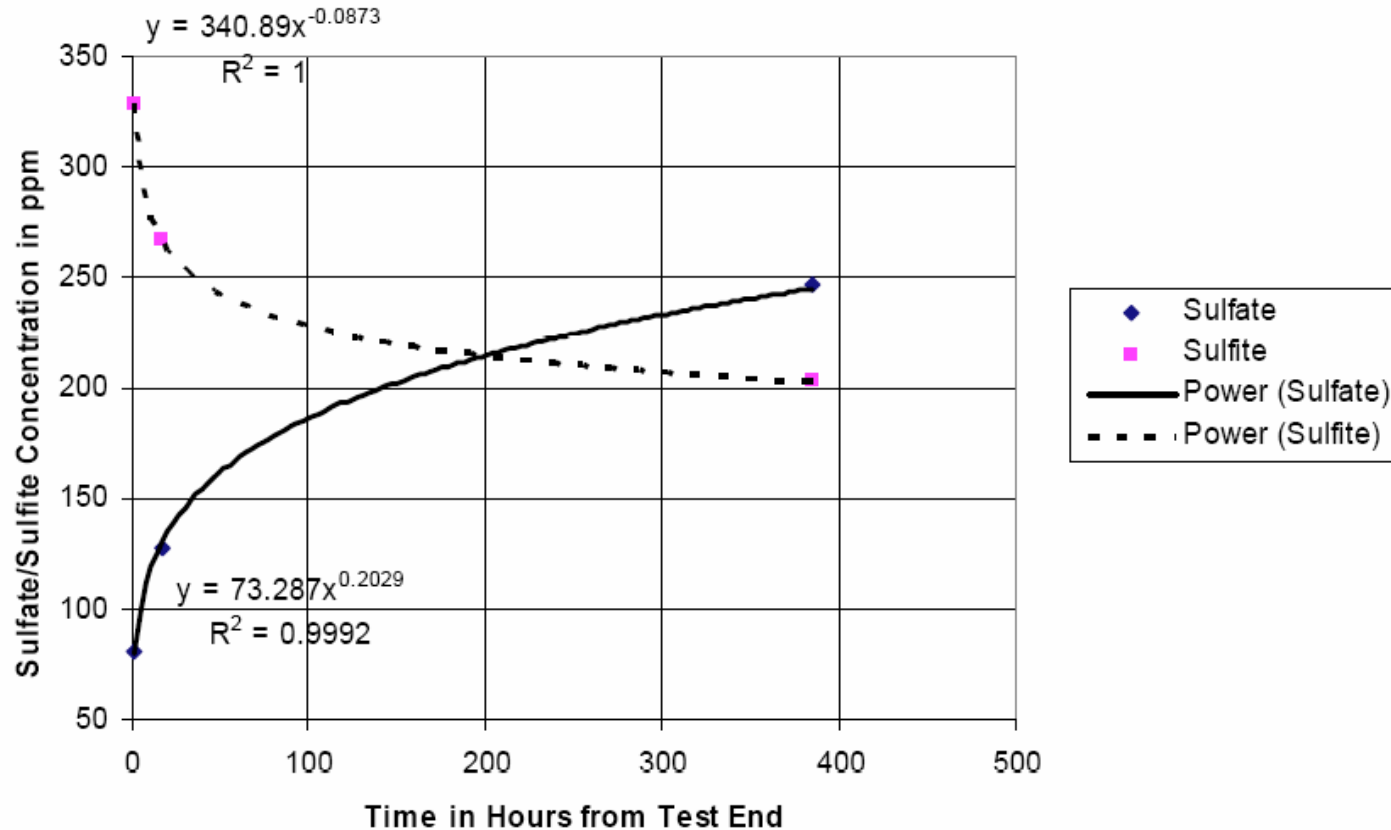


The Problem with M202

- Dissolved SO_2 reacts to form sulfites and bisulfite artifacts which are counted as CPM
$$\text{SO}_2 \rightarrow \text{H}_2\text{SO}_3 \rightarrow \text{H}_2\text{SO}_4$$
- Free NH_4 enhances this effect and increases artifact formation. HCl measured as CPM.
- Post-test N_2 purge not as effective as once thought to remove dissolved SO_2

Transformation of SO_3^- to SO_4^- over time

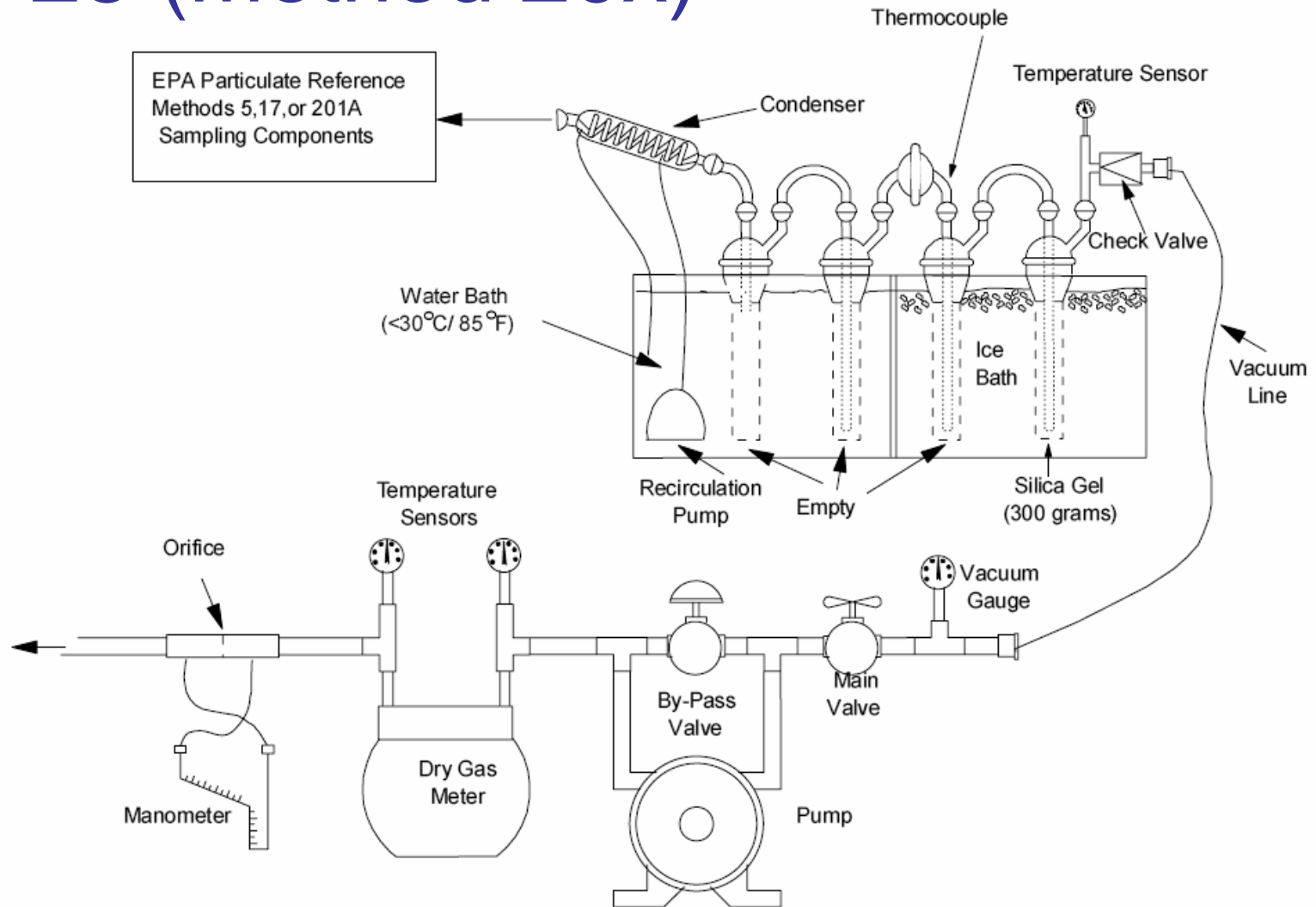
Non-Purged Sulfate/Sulfite Concentration with Time



The Dry Impinger Approach (OTM-028)

- Removes water from impingers
- Uses ambient (85 °F) temperature condenser in place of chilled impinger as main cooling mechanism
- Method in final phase of validation
- Now EPA's preferred approach

OTM-28 (Method 20x)



Method Comparison Test Results

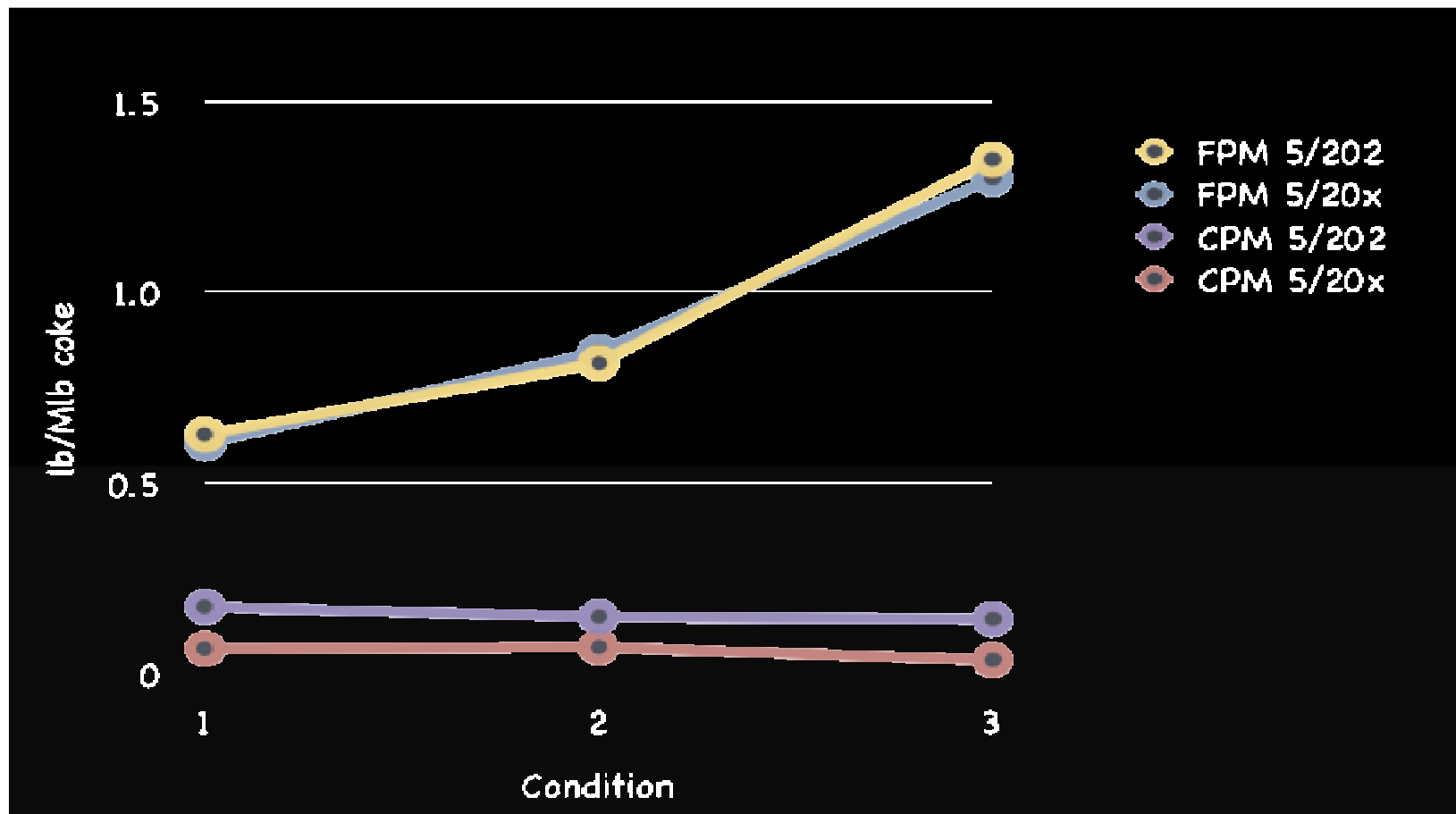
Method Comparison - Test Results

Condition ->	1	2	3
5/202	F: 0.628 C: 0.176 T: 0.804	F: 0.815 C: 0.150 T: 0.966	F: 1.35 C: 0.144 T: 1.49
5/20x	F: 0.605 C: 0.066 T: 0.671	F: 0.846 C: 0.070 T: 0.916	F: 1.30 C: <DL T: 1.30

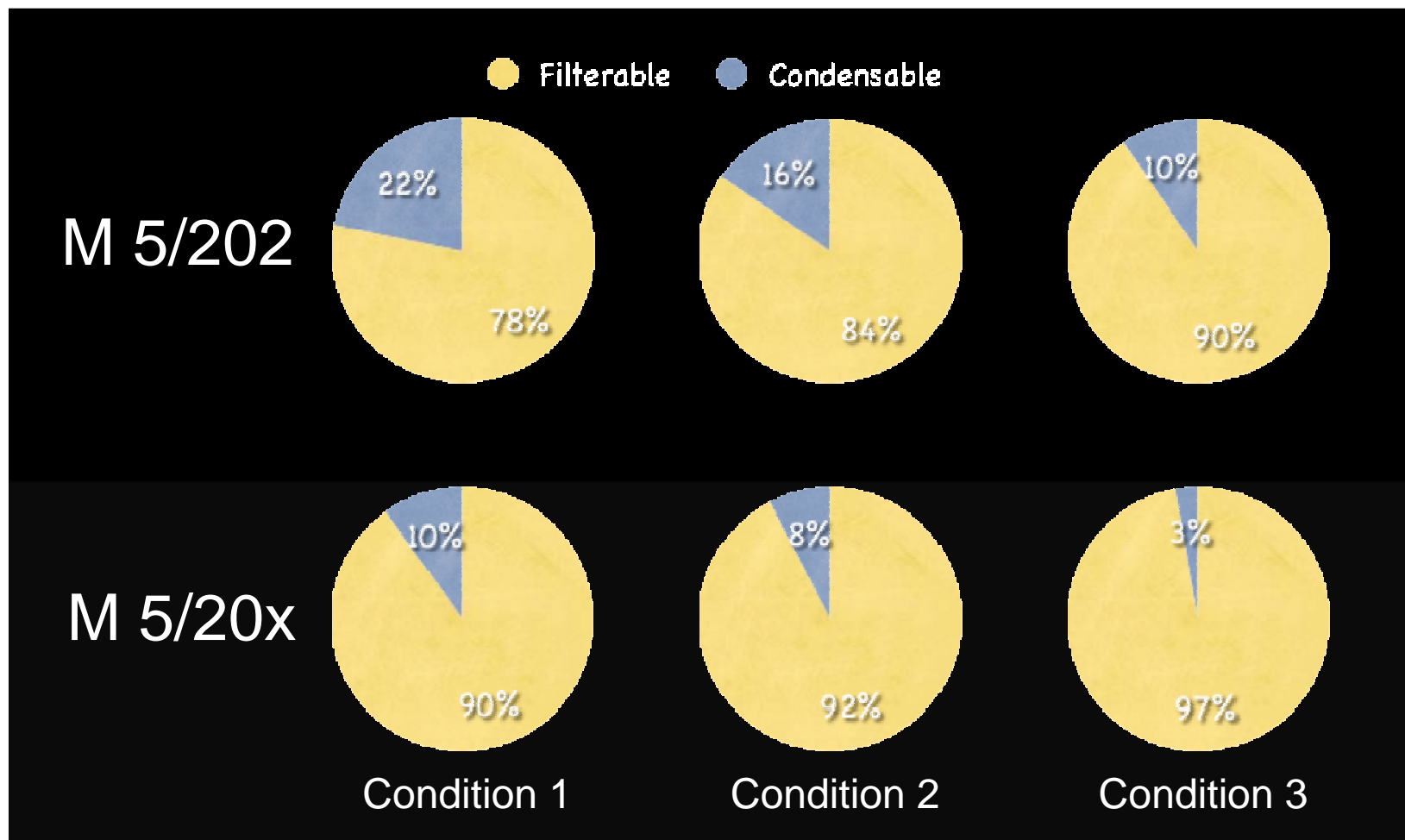
Compared the two methods under three ESP conditions...

PM data in lb/1000 lb coke

M5/202 vs M5/20x



FPM/CPM Fractions



Future PM considerations?

Consider performing testing comparing M202 and OTM-28 (M20x) if you think you will need to:

- Report CPM data
- Permit a new facility
- Develop APC performance guarantees

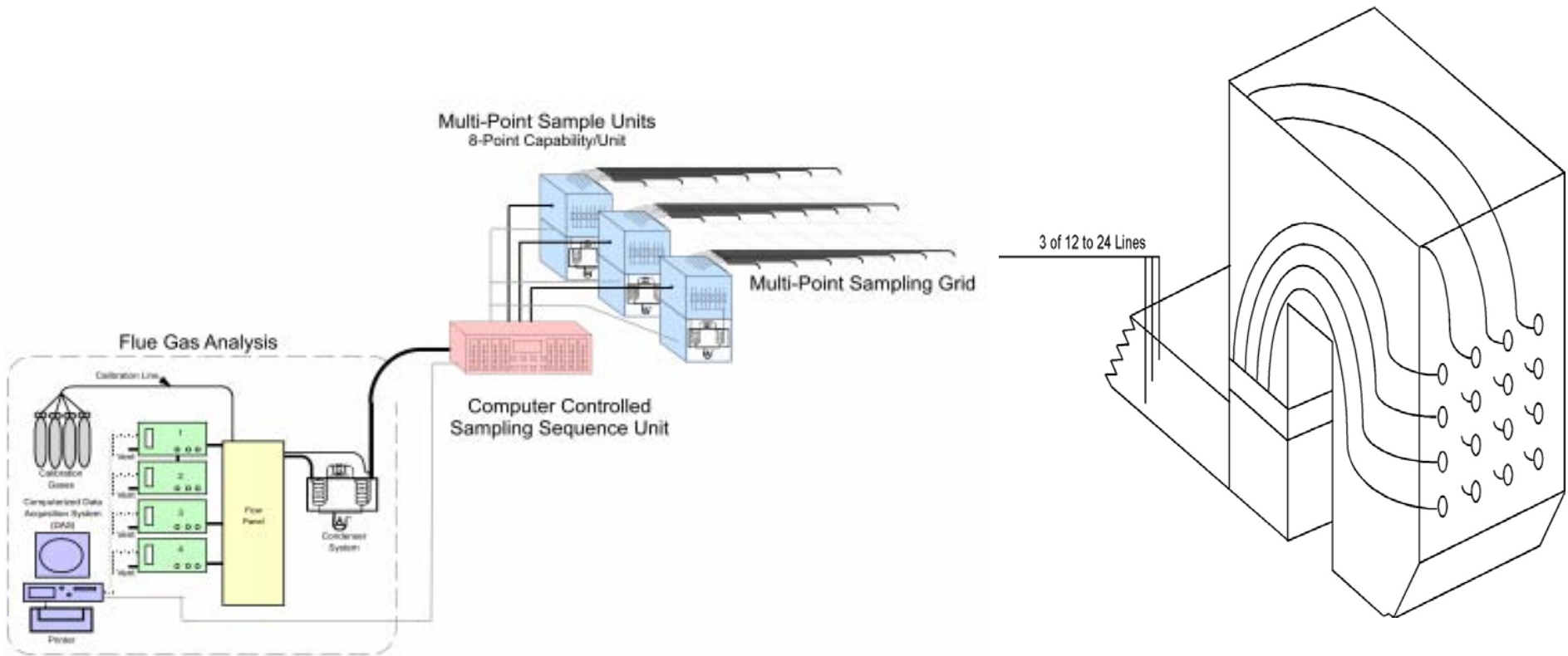
Gaseous Emissions Sampling Using Multi-point Extractive Gas Sampling and EPA Reference Method Analyzers



Multi-Point Automated Sampling (MASS) System

- The MASS uses a series of automated 8-point PLC-controlled sample selection modules that direct the flue gas to a mobile CEMS for NO_x, O₂, CO₂ and/or CO analysis
- The MASS can be configured to measure a 128-point sample grid in less than 15 minutes (in comparison a point-by-point traverse could take as long as 4 hours)
- Data can be monitored in real-time to see the cause-and-effect relationship of operating parameter changes

Typical Multi-Point NO, CO, O₂ Analyzer Installation for Burner Tuning / Combustion Optimization



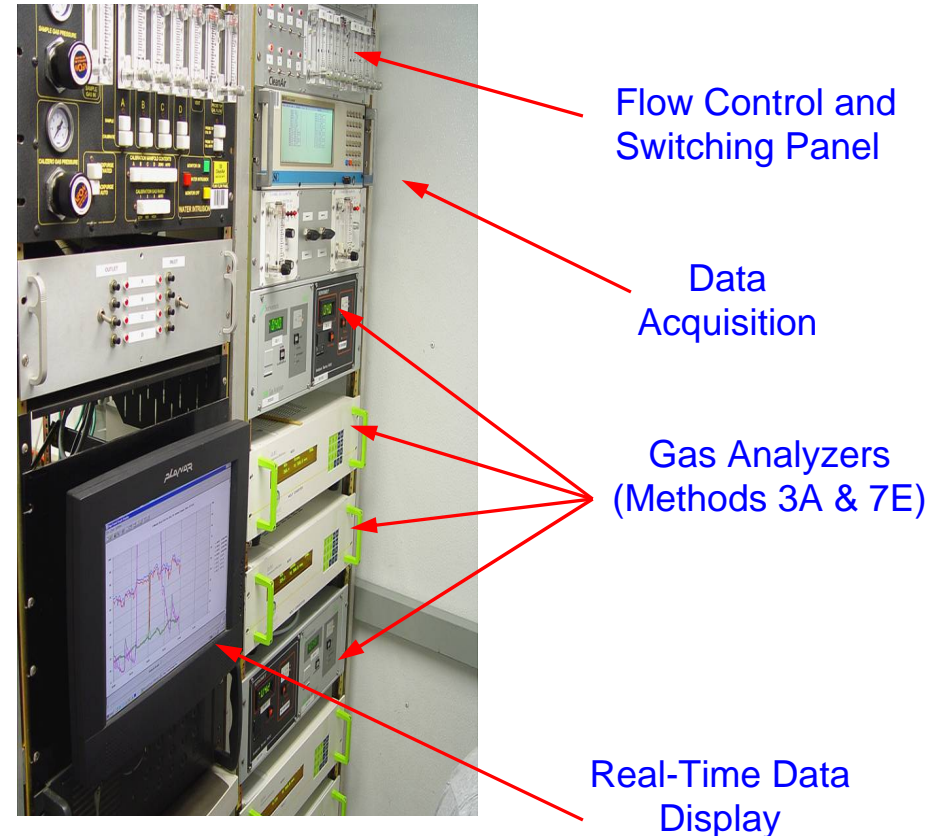


Multi-Point Automated Sampling System (MASS) Installed on a 32 point grid





Multi-Point Automated Sampling System (MASS) Gas Analysis System

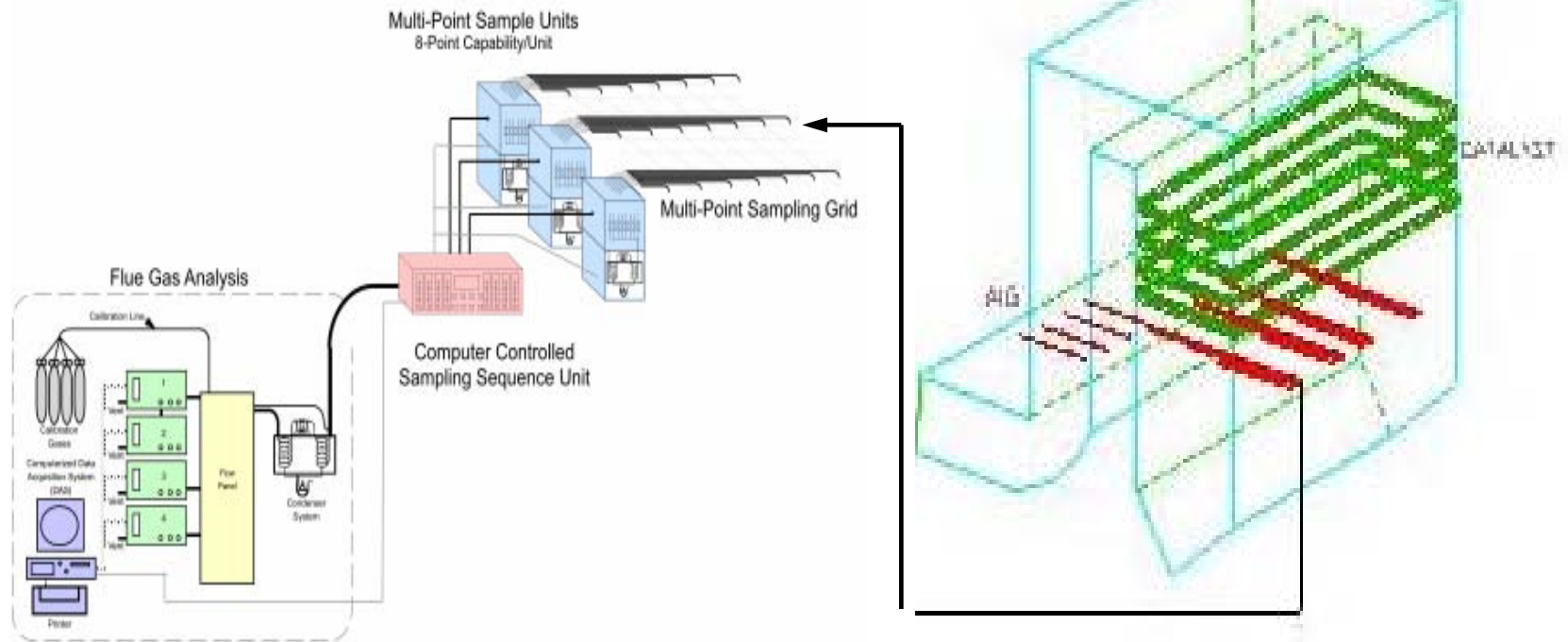


Ammonia Injection Grid (AIG) Tuning

Purpose of AIG Tuning

- Maximize SCR System Efficiency
- Reduces Ammonia Slip
- Reduces Airheater Fouling (ABS Formation)
- Extend Catalyst Life

AIG Tuning Equipment



CleanAir's MASS System

AIG Tuning Procedure

1. Obtain the SCR inlet NO_x profile.
2. Operate the NH₃ injection system so as to achieve a 50-60% (intermediate) NO_x reduction.
3. Obtain a reduced NO_x profile at the SCR outlet.
4. Calculate the local NH₃/NO_x ratios using the inlet/outlet NO_x data and this equation:

$$\text{NH}_3/\text{NO}_x = (1 - \text{NO}_{x,\text{out}}/\text{NO}_{x,\text{in}})$$

5. Tune the AIG to obtain a uniform NH₃/NO_x distribution.
6. Increase the total NH₃ flow to achieve the desired NO_x reduction at the SCR outlet, within the allowable NH₃ slip limit.
7. Make final adjustments to achieve a DeNO_x RMS of less than or equal to 5%.
8. Confirm that NH₃ slip is within limits using CTM-027 test.

CASE STUDY:

AIG Tuning on a 500 MW Pulverized Coal Fired Utility Boiler

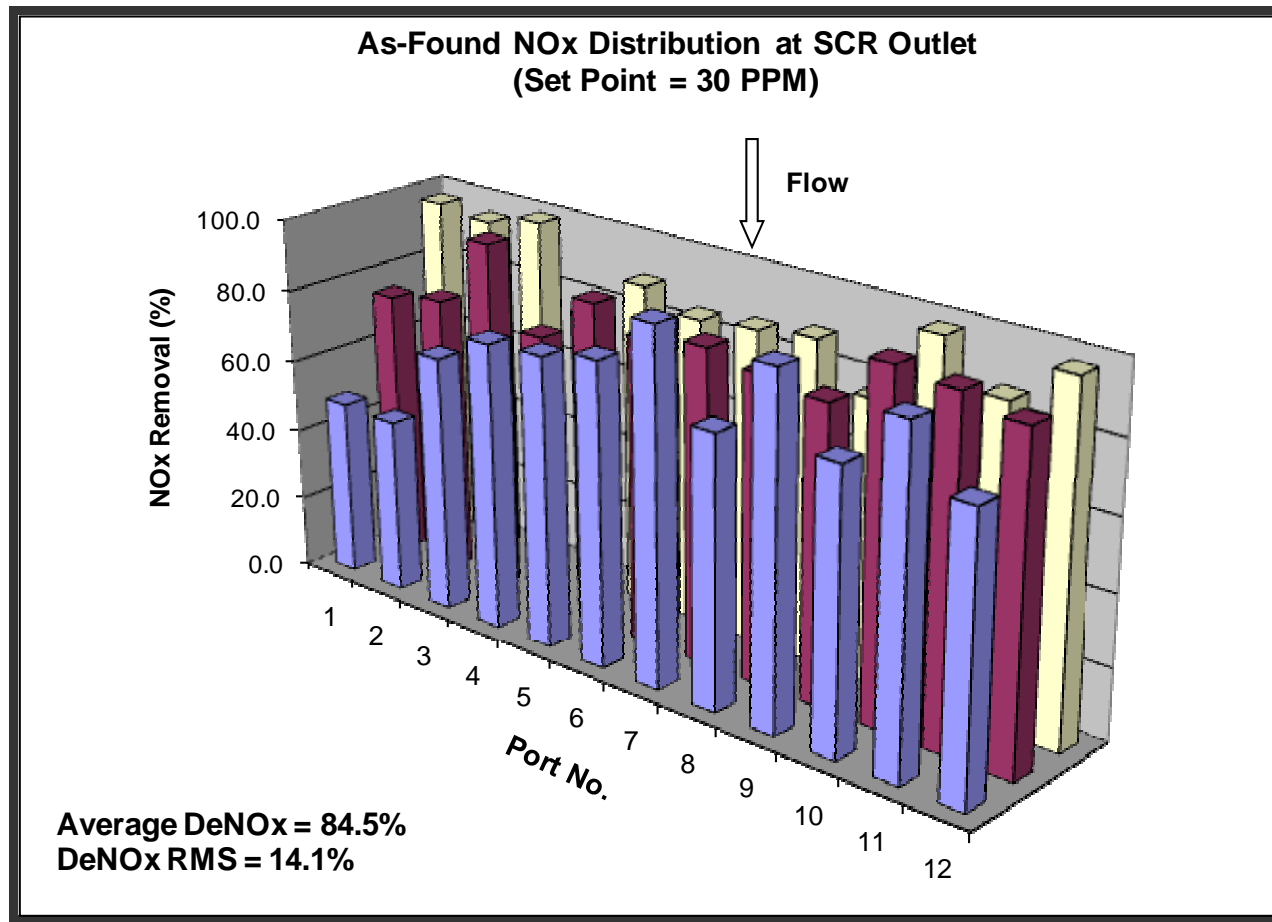
Unit Description

- 500 MWg
- Riley Stoker
- Turbo-Fired Design
- LNB's and SCR for NOx Control
- 13,100 Btu/lb Coal

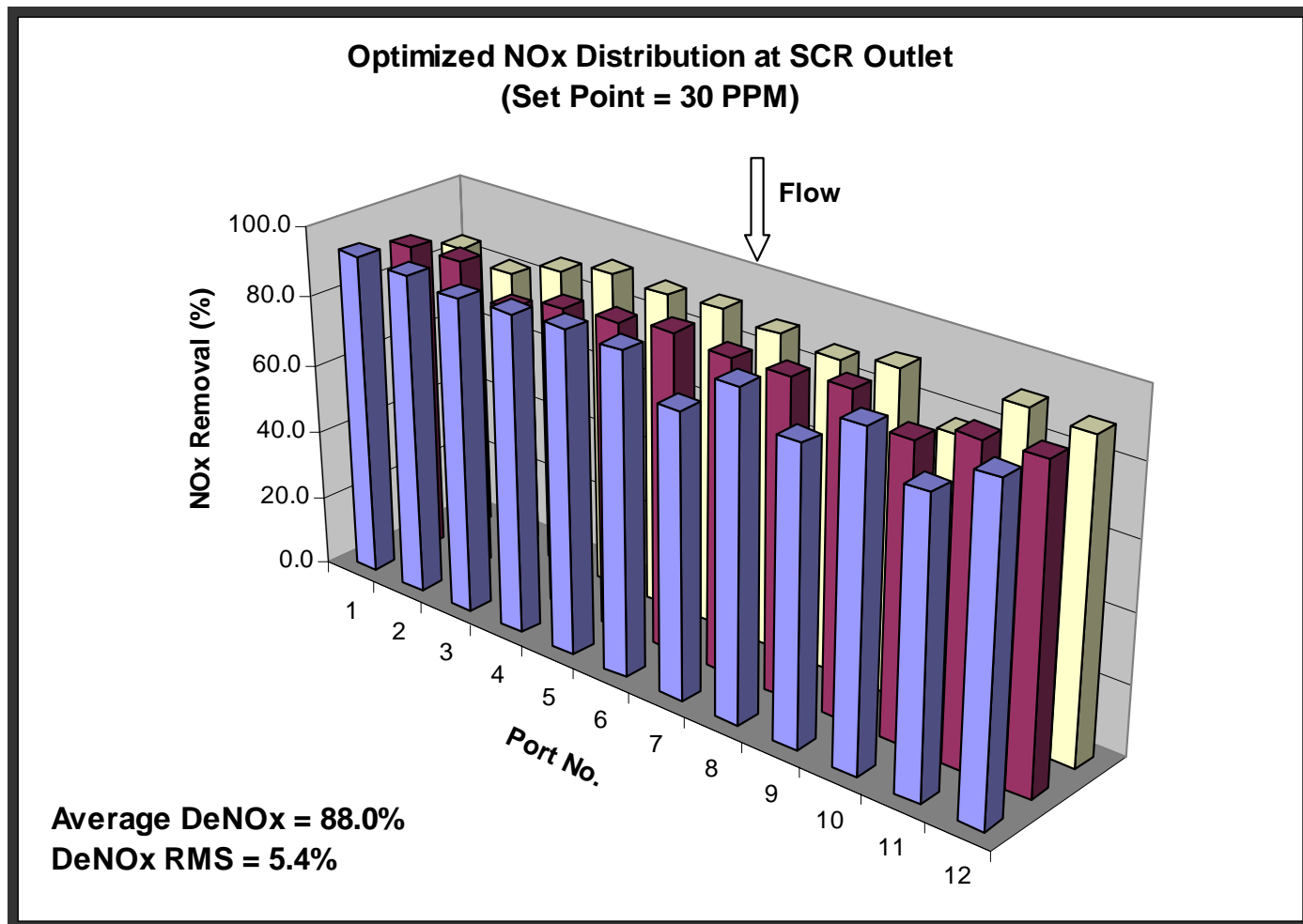
SCR System Description

- Two Catalyst Layers
- 40 NH₃ Injection Lances
- 36-Pt Fixed Test Grid at SCR Outlet
- Inlet NO_x Concentration = 225 ppmv
- Outlet NO_x Set Point = 30 ppmv

As-Found SCR Outlet NOx Distribution



Optimized SCR Outlet NOx Distribution



Combustion Optimization Testing

Benefits of Combustion Optimization Testing

- Increases boiler efficiency
- Lowers boiler heat rate
- Reduced NO_x emissions entering SCR or SNCR can result in a reduction in ammonia or urea usage (lower O&M costs)
- Reduced CO₂ emissions

Combustion Optimization Methodology

- Install temporary Multi-Point grid at the economizer outlet
- Measure concentrations of O₂, CO and NO
- Measure Fly Ash LOI
- Establish cause and effect relationship by varying O₂ level, firing pattern, mill loading and burner register settings

Combustion Optimization Methodology

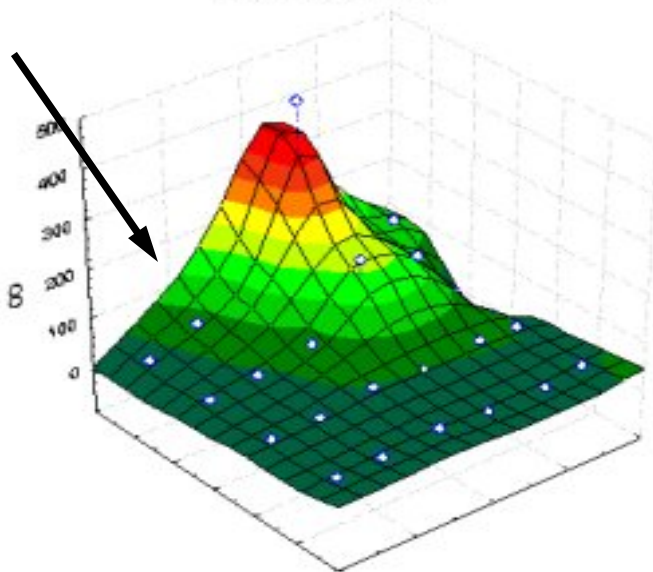
- Localized regions of elevated CO can be traced back to individual burner(s)
- Gas samples taken upstream of airheater are stratified (i.e. limited gas mixing has occurred)
- Burner secondary air registers are adjusted to match combustion air flow to prevailing burner coal flow characteristics
- After several iterations the CO (and NO_x) distribution is much more uniform
- When uniform CO distribution achieved, excess air can be lowered which reduces NO_x emissions and improves efficiency

“Typical” As-Found and Optimized Spatial CO Distributions

As-Found

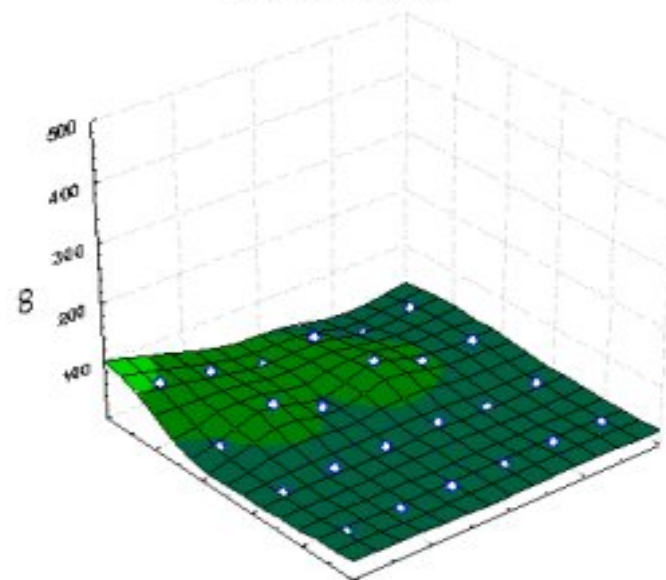
As-Found Spatial CO Distribution
(ppm CO at 3% O₂)

Localized Fuel/Air
Imbalance (High CO)



Optimized

Optimized Spatial CO Distribution
(ppm CO at 3% O₂)



Tuning Criteria: *RMS of All CO and NO_x Data Points at the Economizer Outlet Less Than 5%*

CASE STUDY:

Combustion Optimization on a 400 MW Pulverized Coal Fired Utility Boiler

Unit Description

- 400 MWg
- B&W Boiler
- Opposed Wall-Fired Design
- LNB's and SCR for NO_x Control
- 12,500 Btu/lb Coal

Pre- and Post- Tuning Results

	O ₂ (%)	CO (ppm)	NO (ppm)	NO (lb/MMBtu)	LOI (%)	Efficiency (%)
Baseline	4.1	187	328	0.450	10.5	87.5
Post-Tuning	3.5	90	296	0.405	7.2	88.0
Change	- 0.6 %	- 97 ppm	- 32 ppm	- 0.045	- 3.3%	+ 0.5%

Economic Benefits of Combustion Optimization

- Heat Rate Improvement saves \$285,000/yr
- Boiler NOx Reduction saves \$230,000/yr
- SCR NH₃ Usage Reduction saves \$30,000/ozone season
- CO₂ Reduction saves \$114,000/yr

- Annual Savings ~ \$659,000/yr



Questions?