Reinhold Environmental Ltd.

2009 NOx-Combustion Round Table & Expo Presentation

February 9 & 10, 2009, Cleveland, OH

Do You Believe Your SO_3 Data?

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February, 2009

Reinhold NOx Rountable – Cleveland, OH

Any SO_3 Experience?

Generation

Mitigation

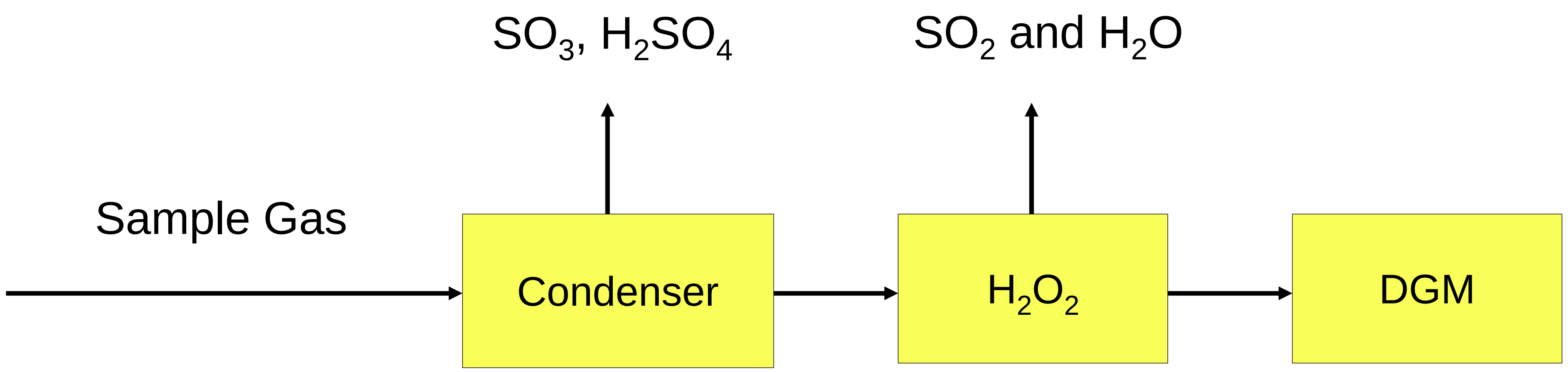
Testing

What Do We Know?

- USEPA Method 8 = 

CCM – Theory of Operation

- Controlled Condensation Technique



Timeline

- 1974 – ASTM D3226-73T (withdrawn in 1978)
- 1977 – TRW Method
- 1984 – EPA MACS
- 1990 – Consol
- 1990 – CleanAir Method 8B
- 1996 – NCASI Method 8A (OTM-013)

What Do We Know?

- Old ASTM Method for Controlled Condensation Method (CCM) withdrawn
- No ASTM Replacement
- Several variations of CCM in use.

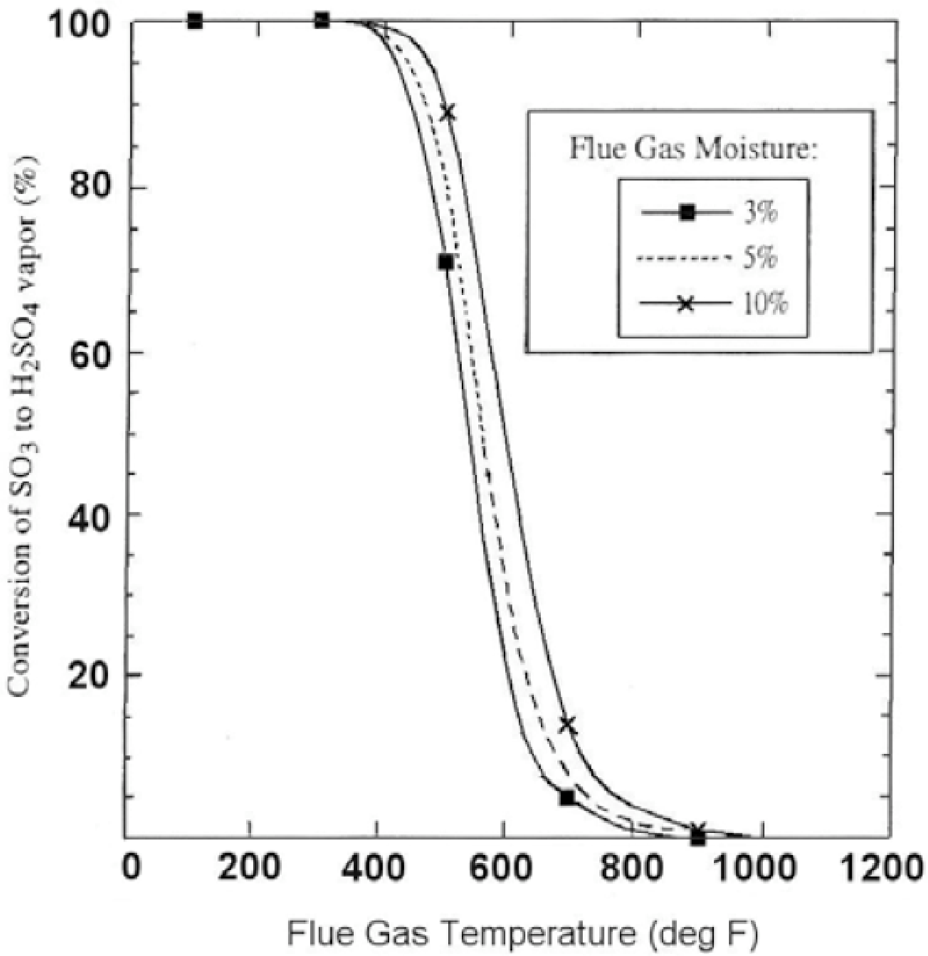
Problems Facing Measurement

- High Precision / High Temp / High Dust
- Low Detection / High Moisture – Wet Stacks
- Tighter Permits
- No Clearly Defined Method or Technology
- Fossil-Fired Stream Itself

Quick & Dirty SO_3

- Hygroscopic Compound

$$SO_3 + H_2O \leftrightarrow H_2SO_4$$

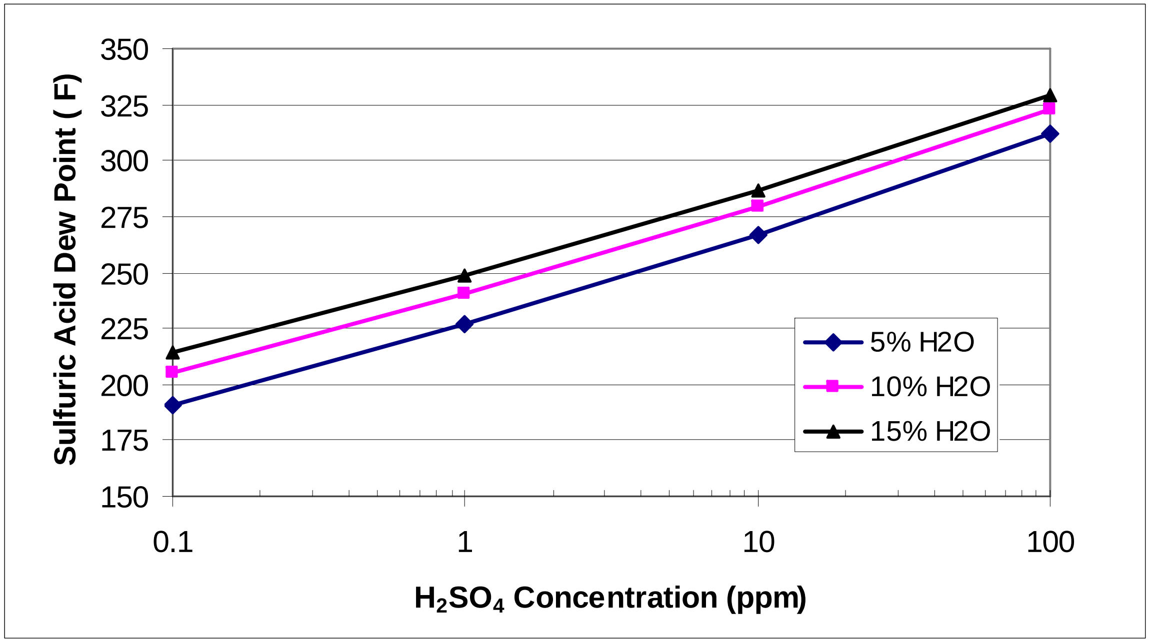


* EPRI, Dooley

Quick & Dirty SO_3

- Formation of aerosol

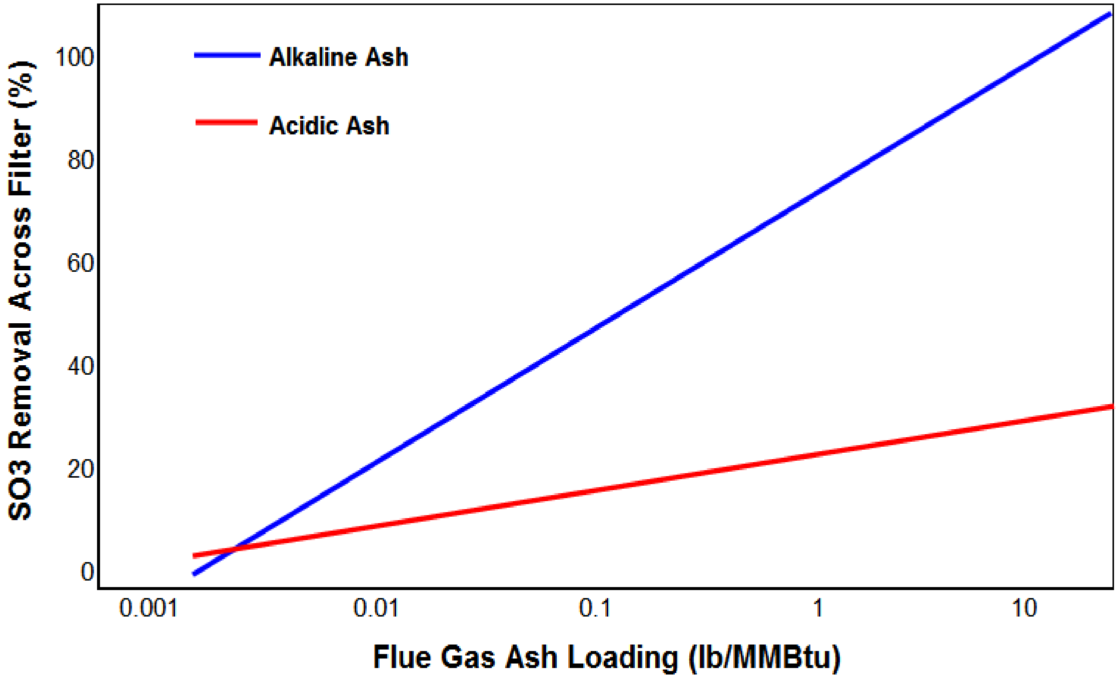
$$H_2SO_4 + H_2O \leftrightarrow H_2SO_4 \bullet H_2O$$



* Verhoff, 1975

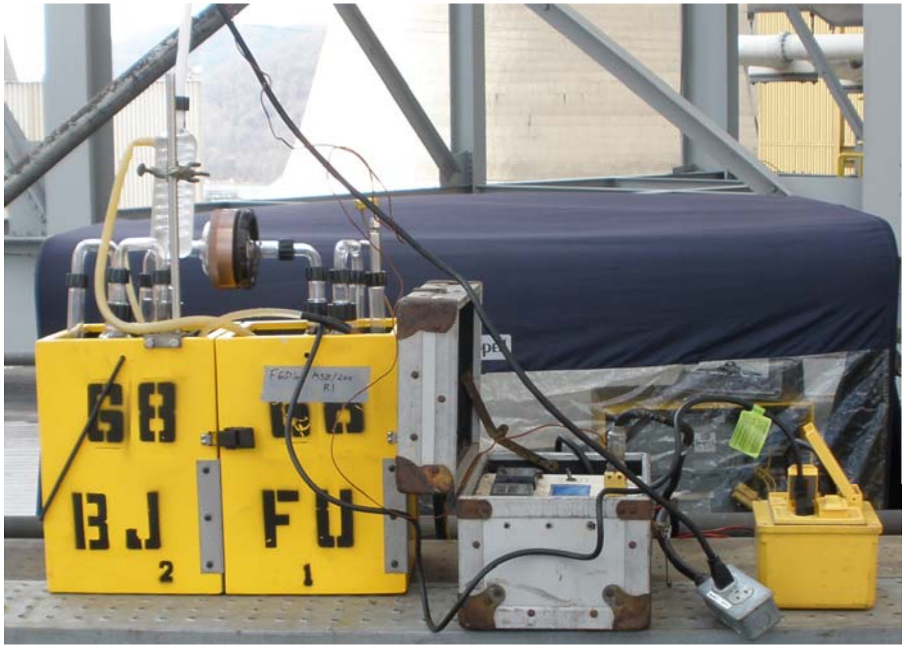
What Do We Know?

- Several Sources of Bias
  - Alkali
  - Moisture
  - Phase of SO_3



What Do We Know?

- Need Precise and Accurate Measurement
- Data We Can Believe In
  - Contracts
  - Low Permit Limits
  - Opacity
  - Fine PM



What Can We Do?

- Improve QA
- Improve Apparatus
- Be Consistent

Solution: A New ASTM Method

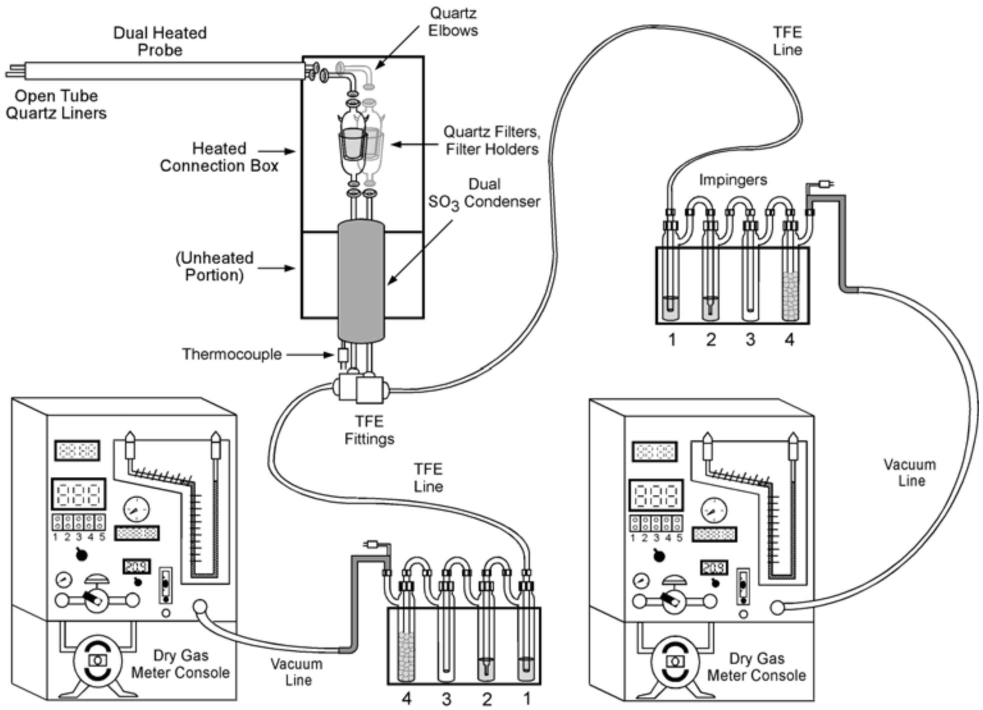
New ASTM Work Group

- WK 22846
- D22.03 Committee
- Initial draft of method completed by Clean Air and will be used as starting point for ASTM process
- Target date for completion: Early 2010

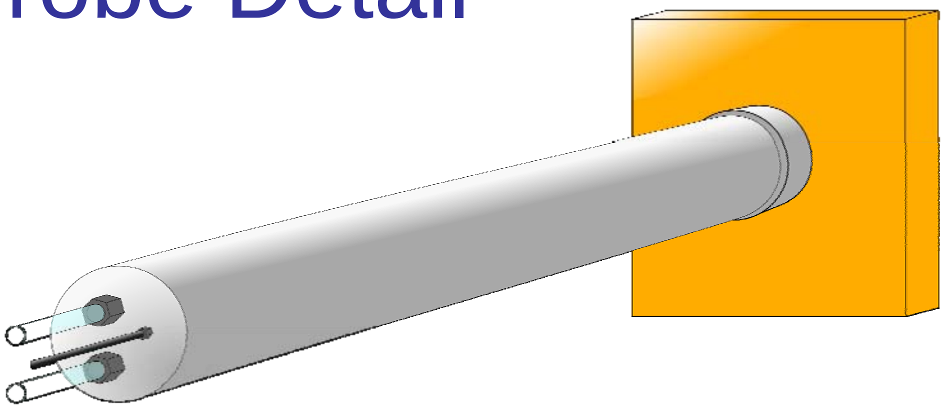
New Method Rundown

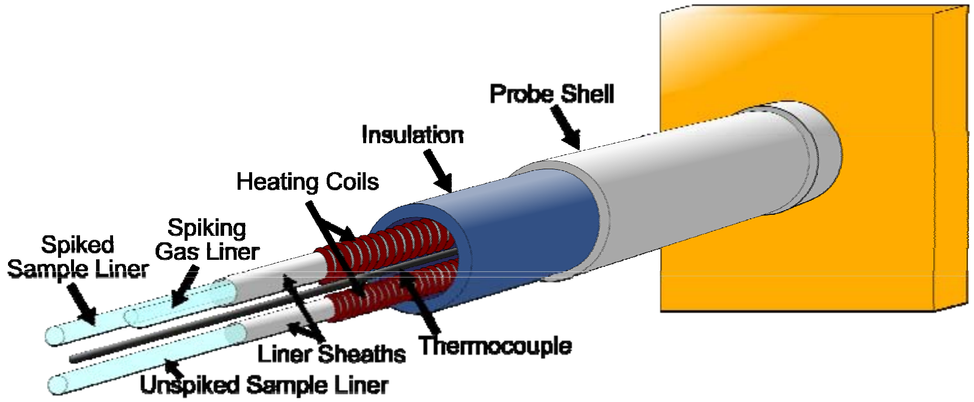
- Consistent and Thorough Approach
- Account taken of recent research
- Modifications for Variety of Sampling Conditions
- IMPROVED QA
  - O_2 Monitoring
  - Paired Trains
  - Front-Half Analysis
  - Spiking

Sampling Train Diagram



Sample Probe Detail





CleanAir

Consistency

- Blanking
- Audit Samples
- Point Selection
- Sample Collection, Processing, Analysis

Repeatable Results!!!

Attention to Sampling Conditions

- Hot Side vs. Cold Side
- Post FGD testing
- Ammonia
- Performance-Based Approach

Method Adaptable to Stack Conditions

- Special procedure for wet stack
  - 10 foot probe
  - Moisture, O_2 determination
  - Increased replicates
- Special procedures for ammonium salts
  - Sampling at lower temperature
  - Probe liner/filter holder rinse
  - Ammonium and sulfate analysis

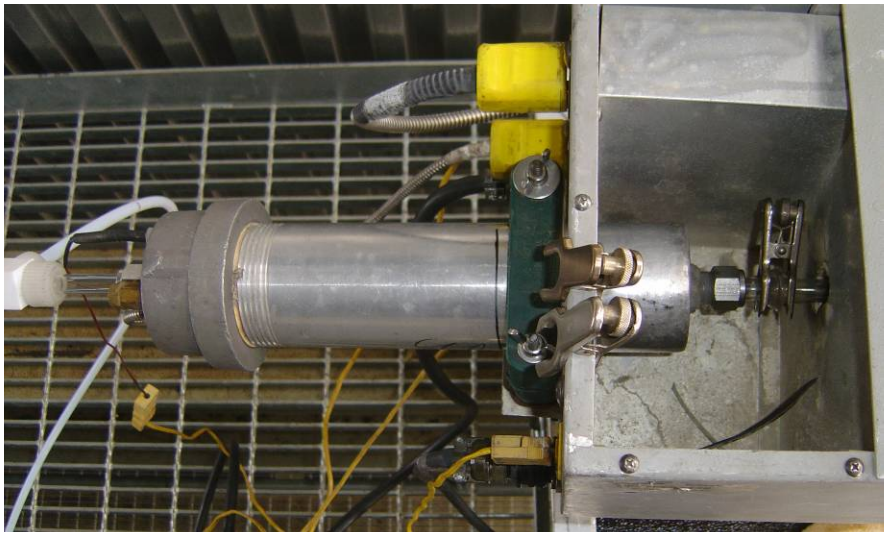
Sampling in Saturated Gas Streams

Initial Conditions			Final Conditions at End of Numerical Integration					
							% Droplet Evaporated	
Droplet Diameter (microns)	Probe Length (ft)	Initial Droplet Acid Conc. (%, wt)	Droplet Diameter (microns)	Remaining Probe Length (ft)	Droplet Acid Conc. (%, wt)	Droplet Temp. (F)	% of Droplet Volume	% of Sulfuric Acid Mass
1.0	5.0	5	0.21	0.97	82	312	99.1	75.1
1.0	5.0	20	0.28	0.80	84	323	97.8	86.1
1.0[a]	5.0[a]	5[a]	0.09[a]	0.85[a]	83[a]	318[a]	99.9[a]	98.0[a]
4.0	5.0	5	0.78	0.32	87	351	99.3	78.4
1.0	10.0	5	0.10	3.72	82	313	99.9	97.3

* EPRI, 2000

[a] Heat transfer coefficient at 10% of value for other cases.

QA Counts – O_2 Monitoring



QA Counts – Paired Trains

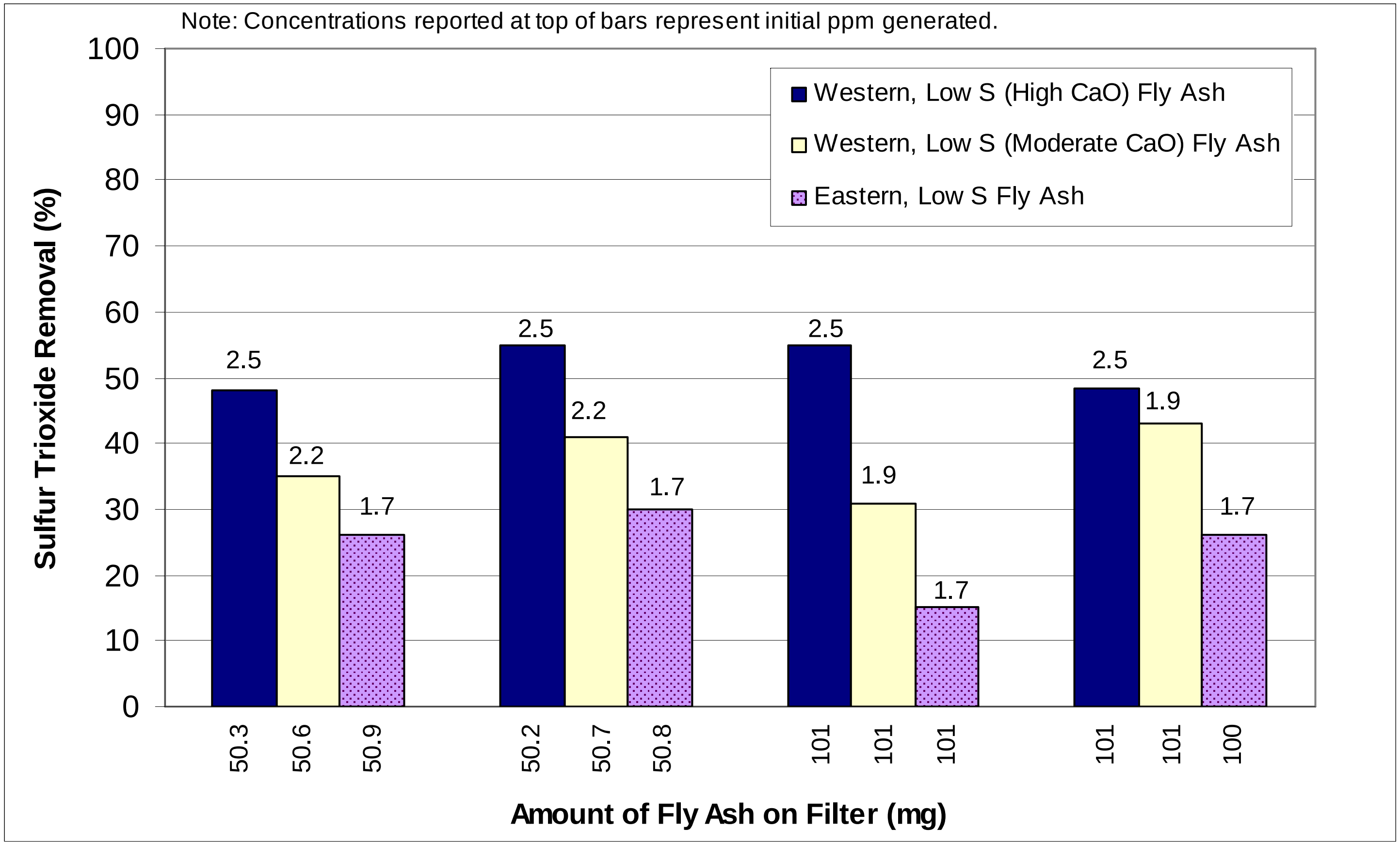
Method Diagnostic Summary

Paired Train Agreement (using ppmdv @ 3% O_2)

	Run No.	1	2	3	Average
WESP Inlet					
ABS	Absolute Difference (<1.0 ppm)[1]	0.26	1.27	0.25	**0.59**
%RD	% Relative Deviation (<10%)[1]	1.8	8.7	2.1	**4.2**
WESP Outlet					
ABS	Absolute Difference (<1.0 ppm)	0.40	0.17	0.18	**0.25**
%RD	% Relative Deviation (<10%)	10.5	7.3	4.9	**7.6**

[1] Either the Absolute Difference of Relative Deviation may be used to verify performance.

QA Counts – Front-Half Analysis



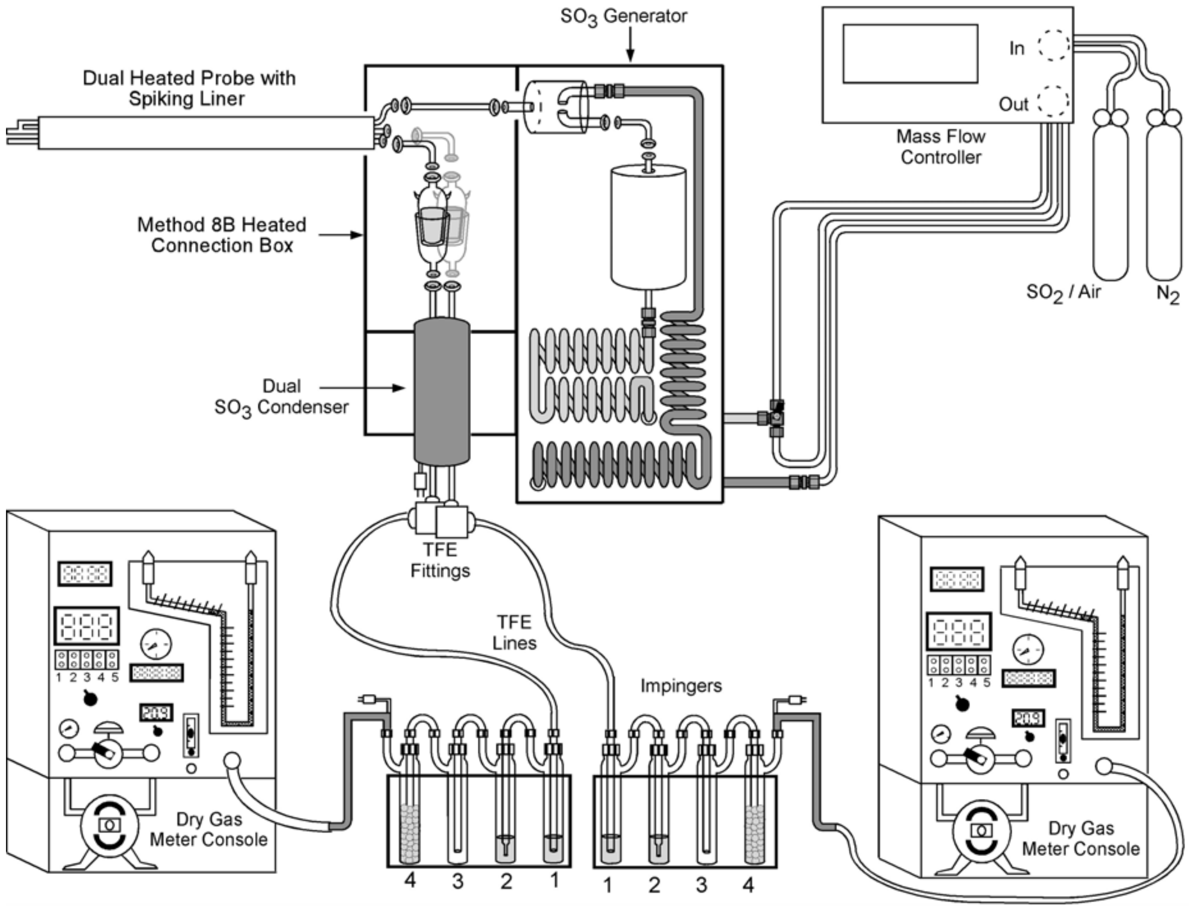
QA Counts – Spiking

- Quantify Bias in Real-Time
- No Assumptions
- Procedure to Handle Bias Factor

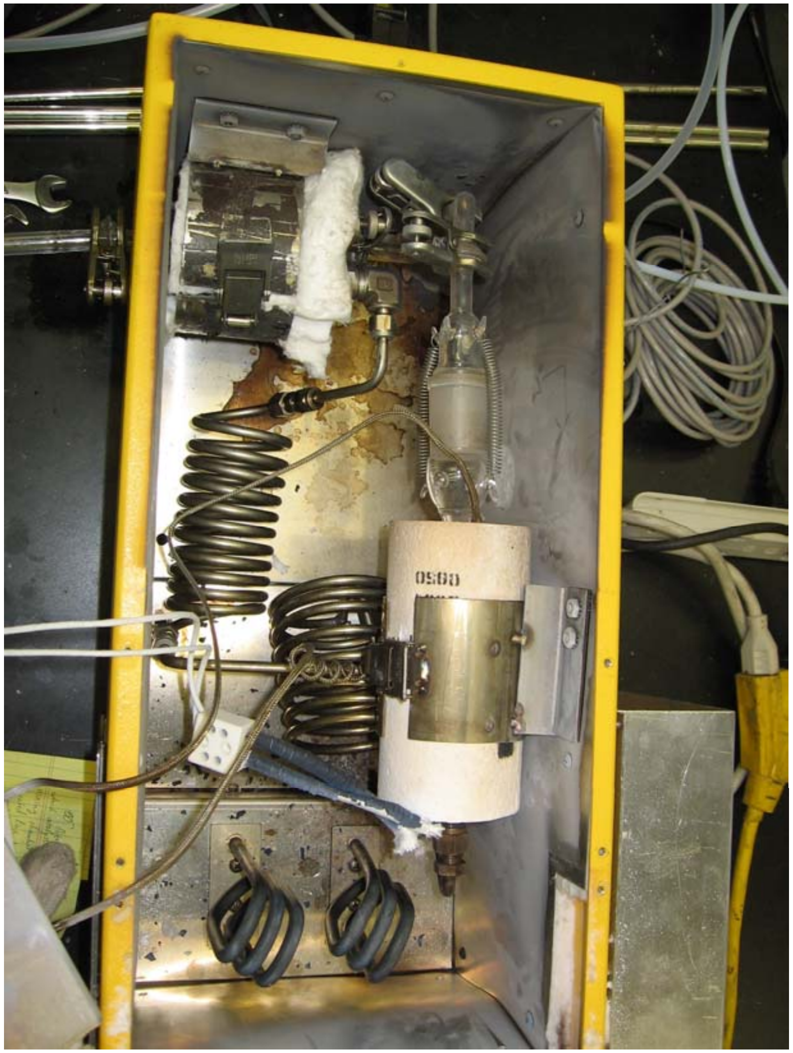
Spiking Apparatus

- Based on Cheney design
- Gases preheated to about 400 °C in oven
- SO_2 oxidized on Pt catalyst at 550 °C to SO_3
- SO_3 diluted with nitrogen in mixing chamber
- Diluted spike mixed with flue gas

Sample Train w/Field Spike



Field Spiking Prototype



Does This Really Work?

- 3 Phase Design Test
  - Phase 1 – Optimize Catalyst Application
  - Phase 2 – Prove Dilution and Control
  - Phase 3 – Show Spiking on Lab Scale

Phase 1 – Catalyst Application

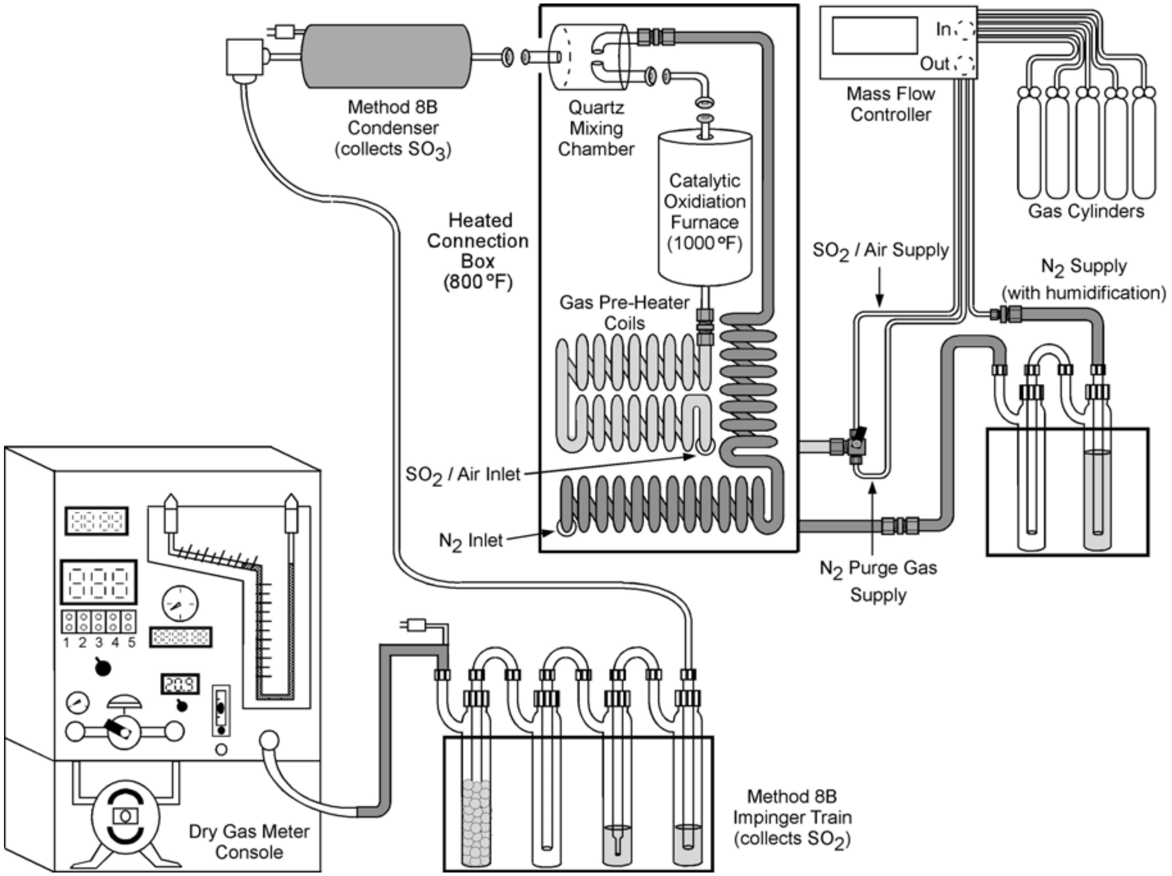
Three applications tested

Quartz wool mixed with Pt catalyst performed best

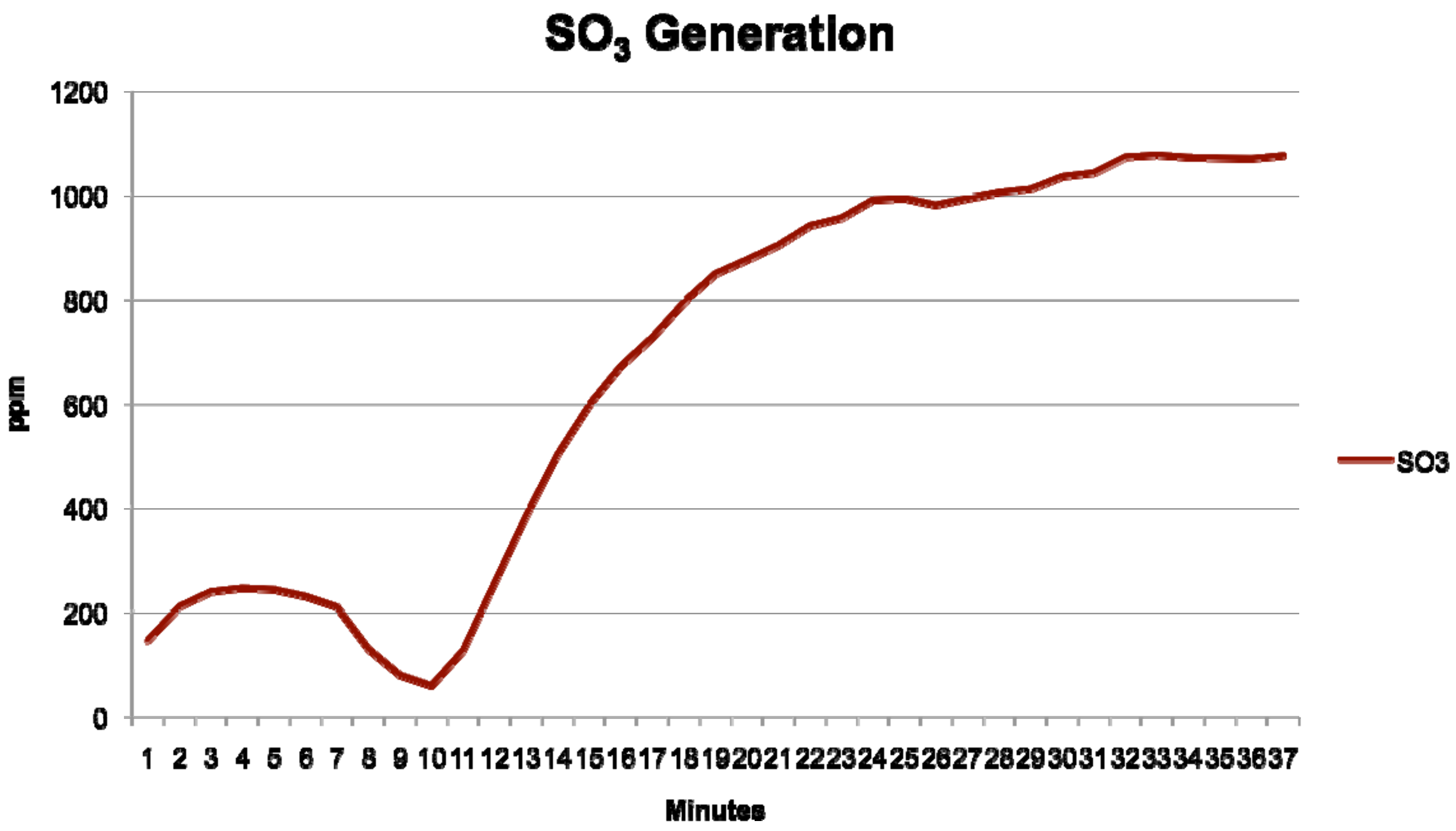
Condition catalyst with nitrogen then SO_2 for one hour before measuring oxidation

Purged with nitrogen after each run before cooling down

Experimental Setup



Lab Generation of SO_3

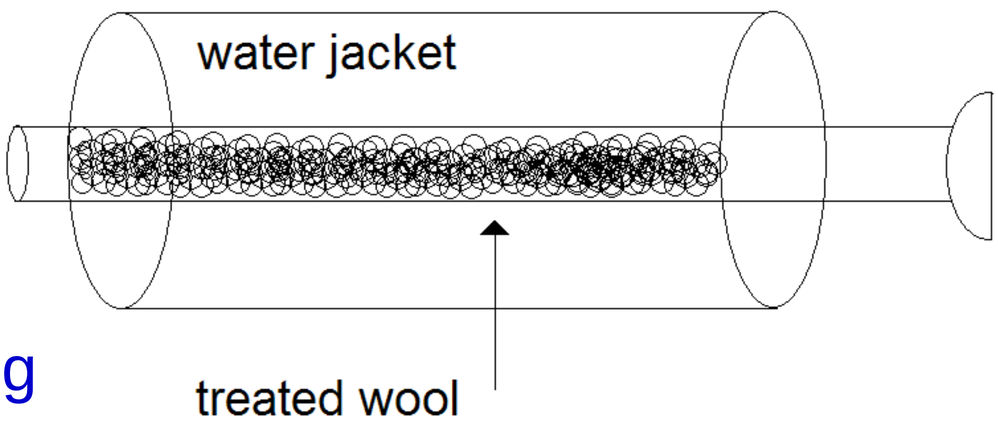


Phase 2 - Dilution

- Mixed SO_3 with nitrogen in heated mixing chamber
- 92% recovery achieved at 100 ppm and 50 ppm
- Lower recovery observed at lower concentrations

Phase 3 – Lab Bench Spiking

- Still in development stage
- Dynamic spiking of flue gas with desired concentration SO_3
- Incorporate with existing controlled condensation sampling equipment



Thanks…

- Bill Walker
- Caleb Wiza
- Jack Bionda
- Kevin O'Halloren
- Andy Vella
- Daniel Roesler

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Questions ????