PM Fine Wet Stack Method Development

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Measurement Technology Workshop

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Overview

- Why not Method 201A?
- Objective of these Efforts
- Current Projects
  - CEMS Development
  - Manual Method Development
- Where are we now?

Why Not Method 201A?

- From Method 201A: “You cannot use this method to measure emissions where water droplets are present because the size separation of the water droplets may not be representative of the dry particle size released into the air. Stacks with entrained moisture droplets may have water droplets larger than the cut sizes for the cyclones. These water droplets normally contain particles and dissolved solids that become PM10 and PM2.5 following evaporation of the water.”
- Currently recommend the use of Method 5 (or comparable)
  - For PM-10, anecdotal evidence that Method 5 is pretty close
  - For PM-2.5, Method 5 may provide an overestimation of emissions
    - Have no data to quantify how much
- Method 202, to measure condensable PM **does** work in wet stacks

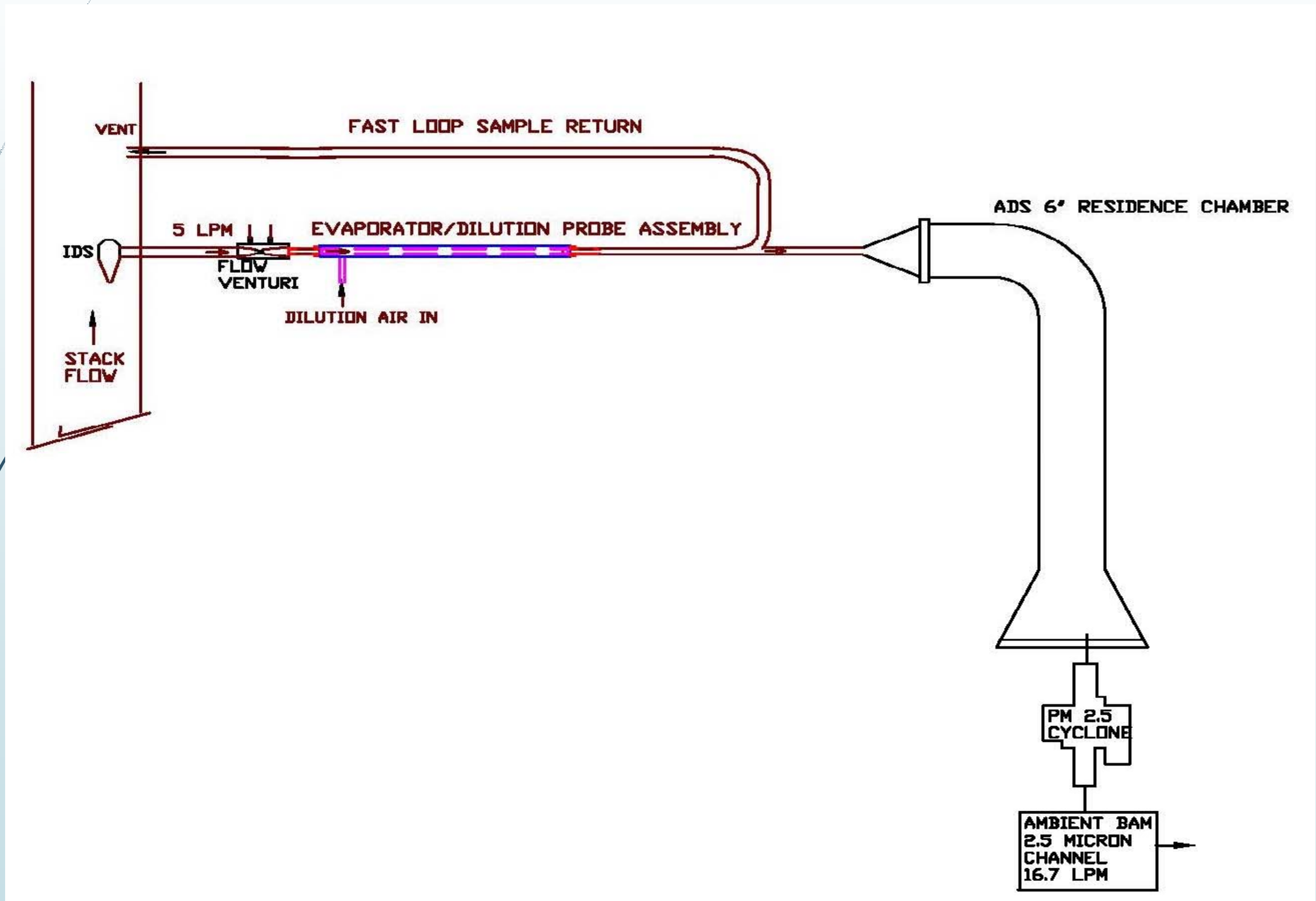
Objectives

- Develop and demonstrate a test method that will
  - Extract the appropriate size water droplets from a wet stack for evaporation
    - Aerodynamic diameter – very important!!!
  - To allow for subsequent analysis for $PM_{2.5}$
  - Using either continuous emissions monitoring system (CEMS) or manual test method.

What is aerodynamic diameter?

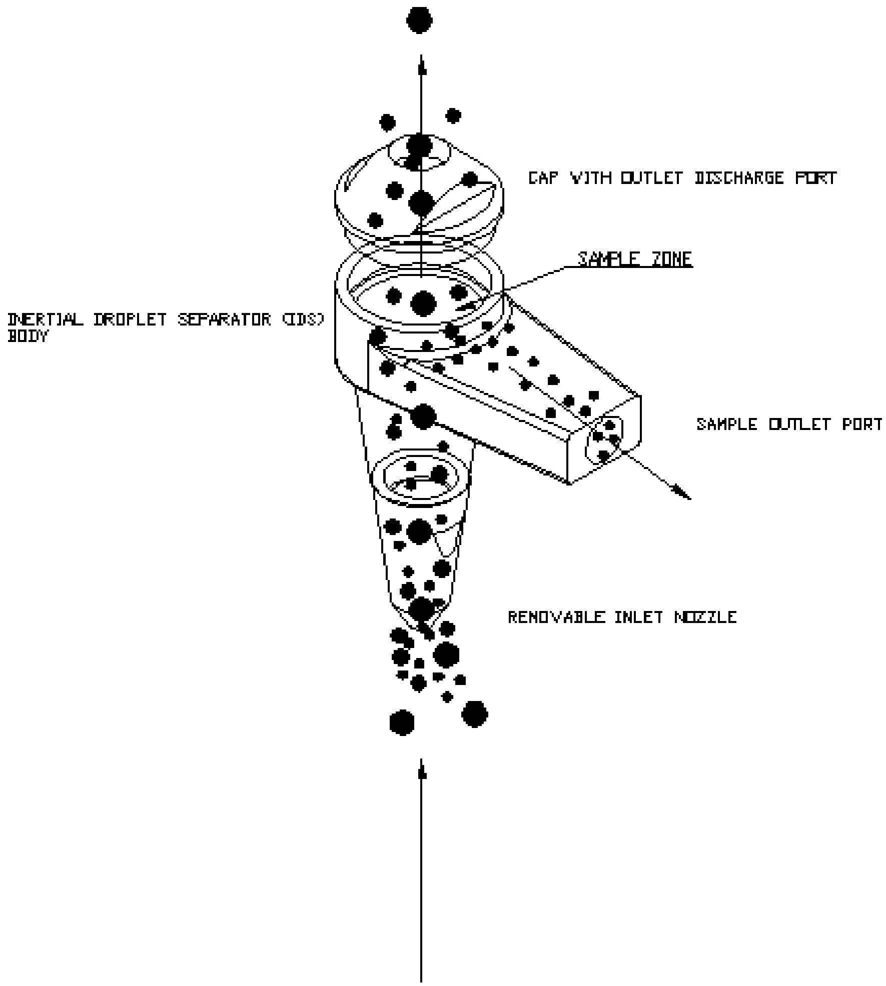
- Airborne particles have irregular shapes, and their aerodynamic behavior is expressed in terms of the diameter of an idealized spherical particle known as **aerodynamic diameter**
- Particles are sampled and described on the basis of their aerodynamic diameter, which is usually simply referred to as **particle size**
- Particles having the same aerodynamic diameter may have different dimensions and shapes
- Dried water droplets are expected to be greatly reduced in size compared to the “parent” droplets

RTI/Baldwin Method Development Project

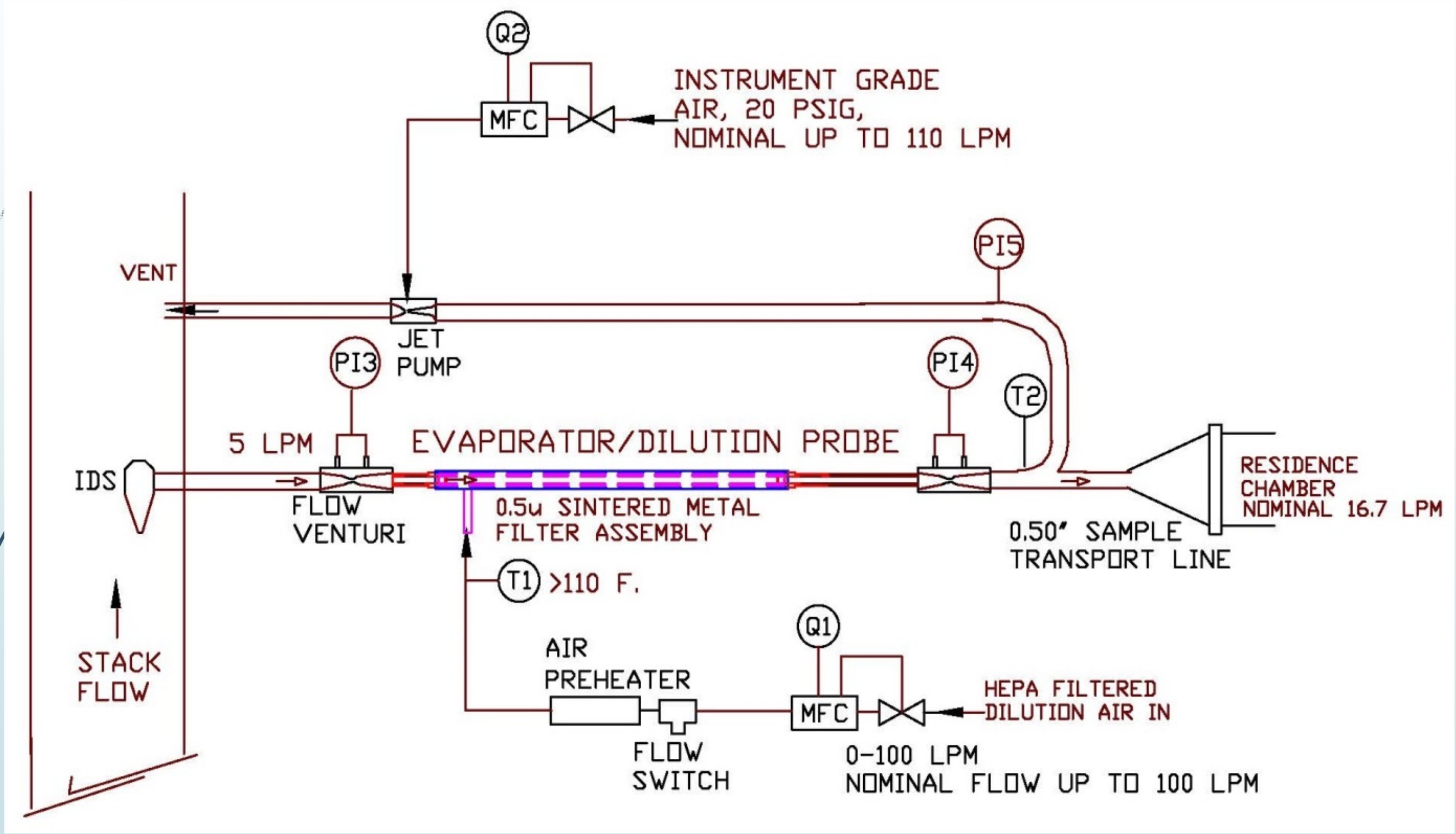


The prototype in action

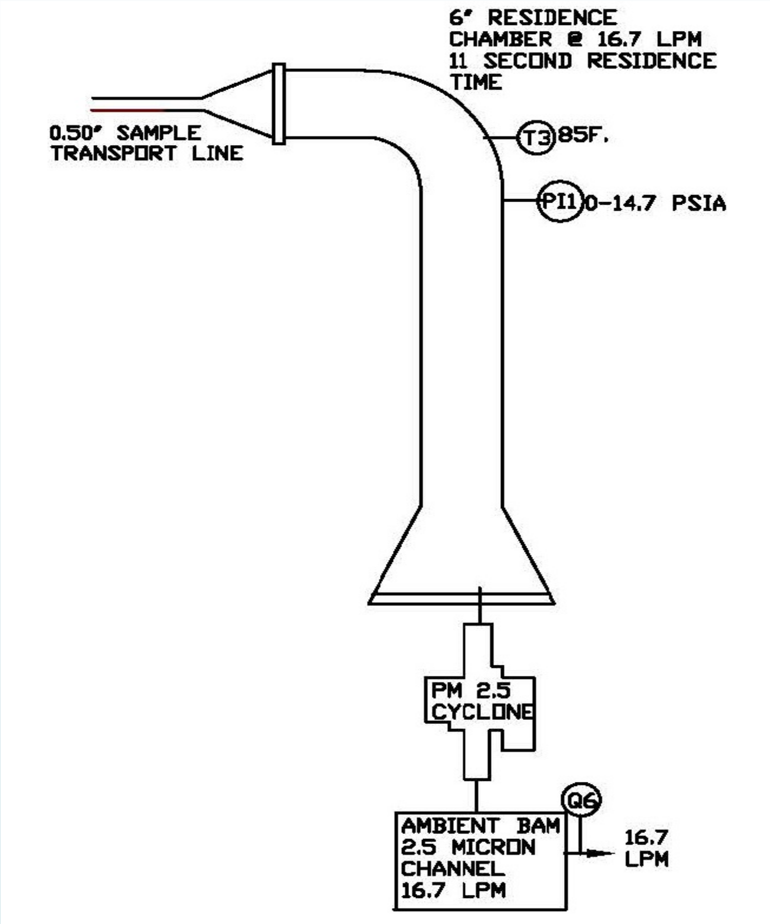
Inertial Droplet Separator



Evaporator - Dilution Probe



Atmospheric Dilution Sampler (ADS)



Phase I: Stack gas simulator test of the IDS with dry particles

- Construct stack gas simulator
- Conduct preliminary tests to verify/characterize gas stream flow
- Test IDS using glass beads
- Test IDS using Arizona Road Dust (ARD)

Phase I - Conclusions

- The velocity profile of the stack simulator is adequate for conducting the tests
- Velocities in the 10 to 34 m/s range are achievable
- Using dry particulate to characterize the PM collection efficiency of the IDS has been problematic
- The IDS is achieving the design objective of separating the larger particles from the sampled gas stream, but the results of the tests do not give a clear indication of the particle size cut point
- The tests with different dry media yield different results and indicate the separation is occurring somewhere in the aerodynamic diameter range of 20 to 60 um
- Additional testing with dry media is not warranted.

Phase II—Stack Gas Simulator and Tests of the IDS with Wet Droplets

- Modify stack gas simulator to generate wet gas stream with droplets
- Conduct preliminary tests to verify/characterize gas stream flow and droplet size distribution
- Test IDS using sodium sulfate media for droplets.

Phase II - Conclusions

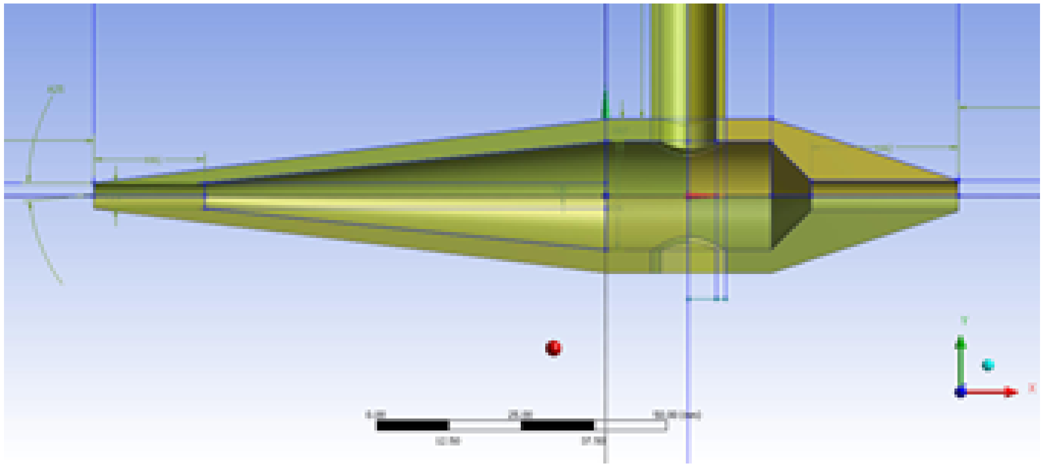
- The wet stack gas simulator met the design criteria
- Sodium sulfate solution [Na_2SO_4] worked well as the spray media
- The IDS is achieving the design objective of separating the larger droplets from the sampled gas stream
- However, the tests indicate the separation is occurring somewhere in the aerodynamic diameter range of 10 to 25 um range
- Additional testing at other operating conditions (e.g., 10 and 30 m/s stack gas flow rates) with Na_2SO_4 droplets is not warranted
- In order to fully evaluate the IDS collection efficiency in the smaller particle size range (i.e., 5 to 20 um aerodynamic diameter), testing with mono-dispersed aerosols is recommended

Monodisperse Testing

- Performed at the University of Minnesota
- Used fluorescent dye oleic acid in a Vibrating Orifice Aerosol Generator (VOAG) to generate 2.5, 5, 10, 15, and 20 µm particles
- Particles were released into a 6 inch wind tunnel with 20 m/s flow Determined IDS Collection Efficiency
- These results showed collection efficiencies of 24.8, 39, and 58.2% at 14.93, 8.19, and 4.82 µm, respectively, far below the design goals

Phase III – Modeling the IDS

The Modeled IDS

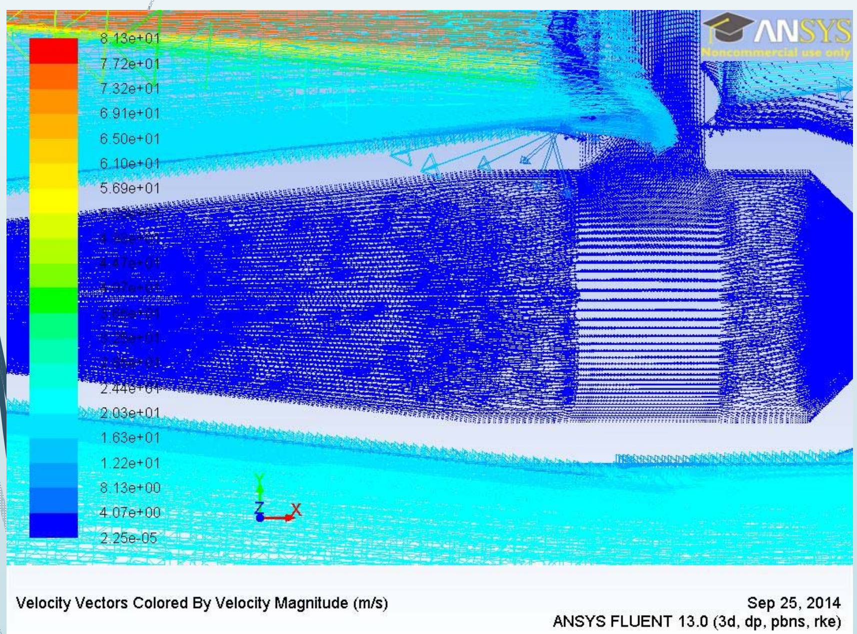


- IDS Nozzle Inlet Diameter: 4.52 mm (0.178 in.)
- Nozzle Cone Angle: 12°
- Nozzle Extension Length: 19.05 mm (3/4 in.)
- Sample Zone Diameter: 19.05 mm (3/4 in.)
- Sample Zone Length: 28.58 mm (9/8 in.)
- IDS Thickness at Sample Zone: 4 mm (0.157 in.)

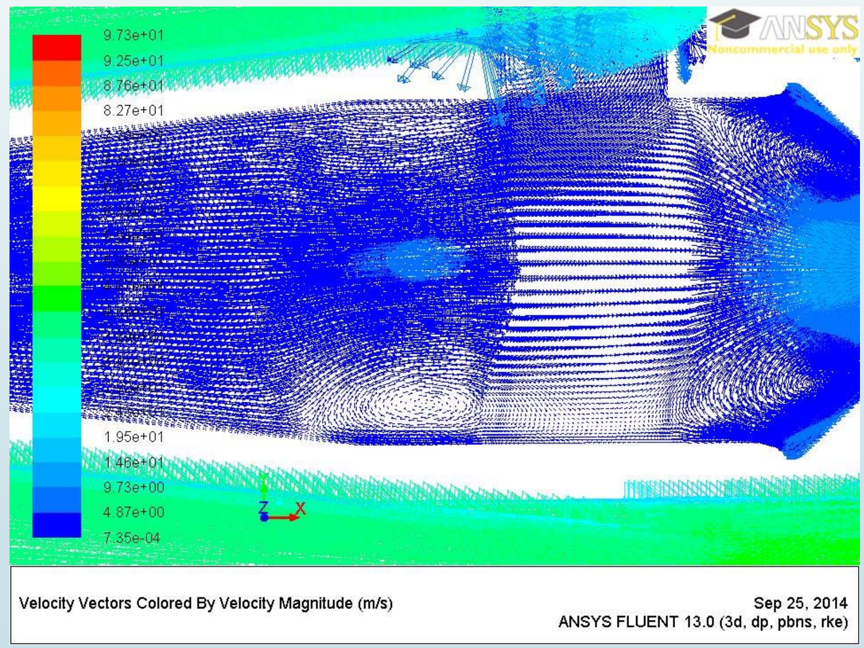
- IDS Cap Outlet Diameter: 5.44 mm (0.214 in.)
- Cap Cone Angle: 90°
- Cap Extension Length: 25.4 mm (1.0 in.)
- Sample Pipe ID: 9.525 mm (3/8 in.)
- Sample Pipe OD: 11.125 mm (7/16 in.)
- IDS Length ~ 150 mm (5.9 in.)
- IDS Width ~ 27.05mm (1.05 in.)

Velocity Vectors inside IDS

20 m/s Stack, 5 lpm Takeoff



40 m/s Stack, 5 lpm Takeoff



Refinement of IDS Configurations

Current Status

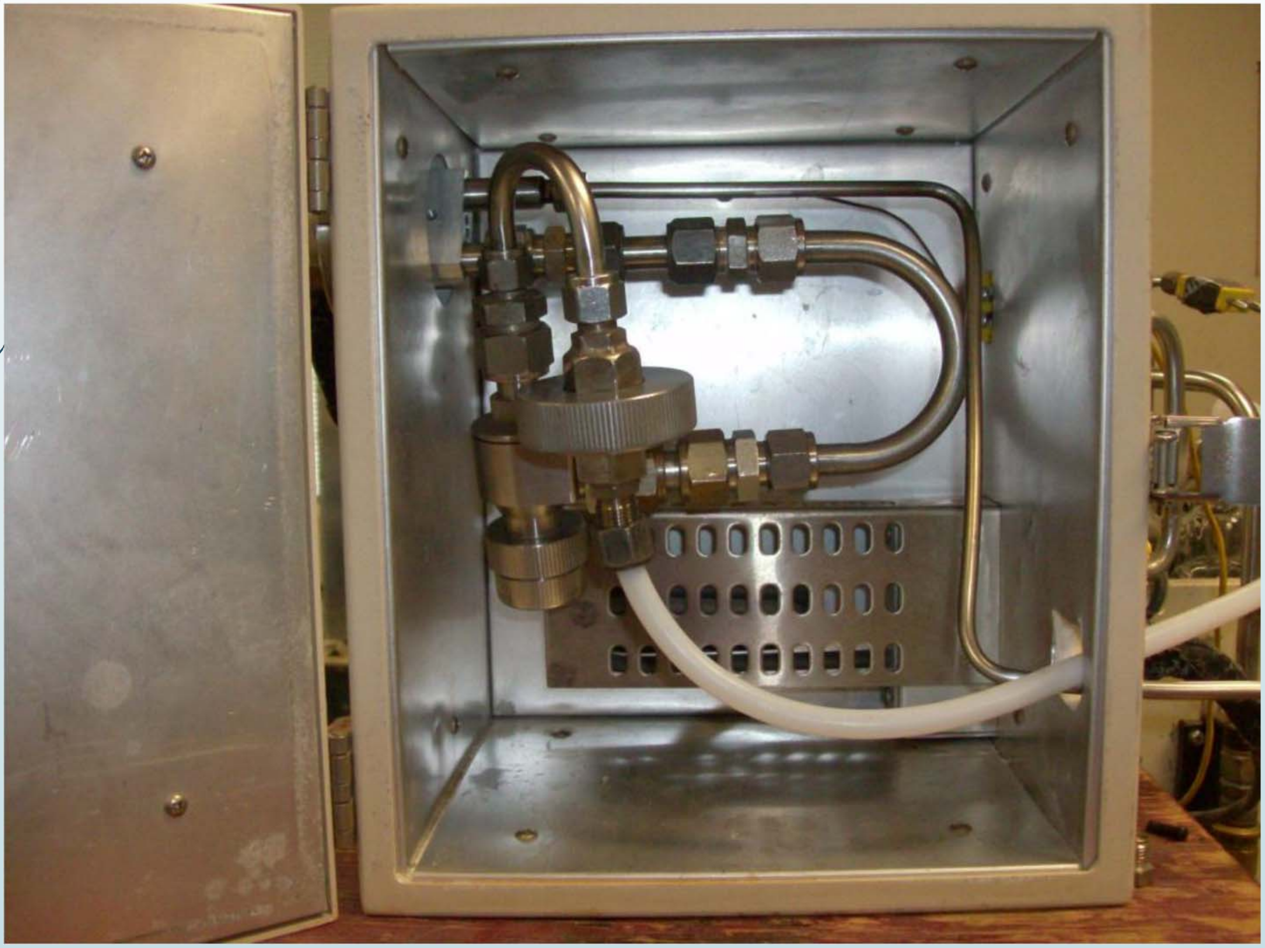
- Returned to University of Minnesota and confirmed the model results
- Currently using model to verify redesigned IDS while varying stack conditions
  - To insure representative sample is collected
- Next steps depend on available resources

API/NCASI Method Development

- American Petroleum Institute (API) began the project
- Air Control Techniques, P.C. is contractor
- National Council for Air and Stream Improvement (NCASI) joined project

Based on M201A Train

Inside Filter Box



Testing to Date

- Initial set of lab tests
- Field tests at 3 FCCUs
  - 2 with wet scrubbers, 1 with an ESP
  - Dilution / bad nozzle type
- Method 301 testing in Moncure, NC

Results to Date

- Method 301/FCCI testing showed the feasibility to use this methodology
- FCCU Nozzles not feasible due to moisture buildup inside it.
- Method 301 testing showed the ability to measure small dried particles
  - Due to difficulties, testing was incomplete
- Lab testing showed the need to refine the nozzle/droplet impactor/precutter

Next Steps

- Redesigned nozzle to reduce cut size to 10-15 micrometers
- Test “new” nozzle design
- Verify cut point, representativeness
- If all goes well, post as Other Test Method (OTM)

Where Are We Now?

- Baldwin Method
  - Verifying the representativeness of sample as stack conditions change
  - Status of resources not clear
- API/NCASI Method
  - Test “new” nozzle design
  - Verify cut point, representativeness
  - If all goes well, post as Other Test Method (OTM)

Questions?