

REINHOLD ENVIRONMENTAL Ltd.



**2018 APC & Wastewater Round Table  
& Expo Presentation**

July 23 & 24, 2018 in Lexington, KY / Hosted by East Kentucky Power Coop

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# Wet & Dry Stacks: Flow, CEMs, and Plumes

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2018 APC Wastewater Round Table  
July 23, 2018  
Lexington, KY

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# Introduction

- Why do we care about the stack?
- It's just the plant's tailpipe, as long as it points toward the sky that's all that matters, right?



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# Introduction

- Why do we care about the stack?
- It's just the plant's tailpipe, as long as it points toward the sky that's all that matters, right?
  
- ..... So why are we here again? .....
  
- Of course the stack matters a great deal !!



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# Agenda

- Stack Flow Problems
  - Dry stacks
  - Wet stacks
  - Gas turbines
- CEMs Measurement Accuracy
- Plume Dispersion



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# Stack Flow Problems

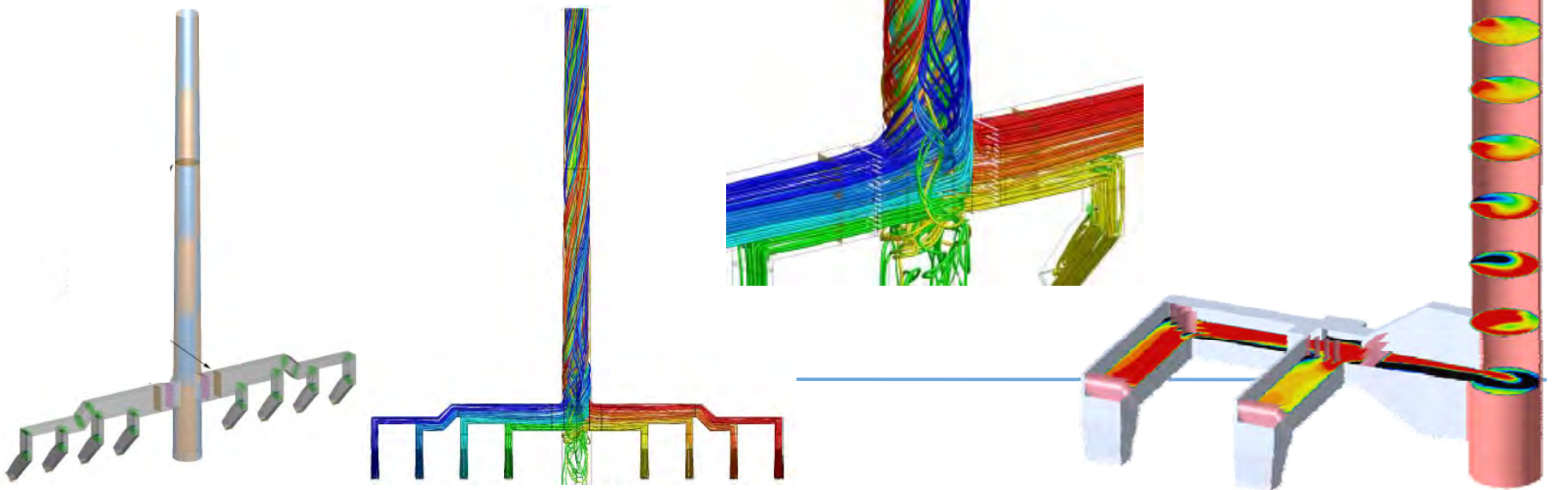
- Cyclonic and skewed flow
- Pressure fluctuations / flow-induced vibration
- Wet FGD droplet carry over



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# Cyclonic and Skewed Flow

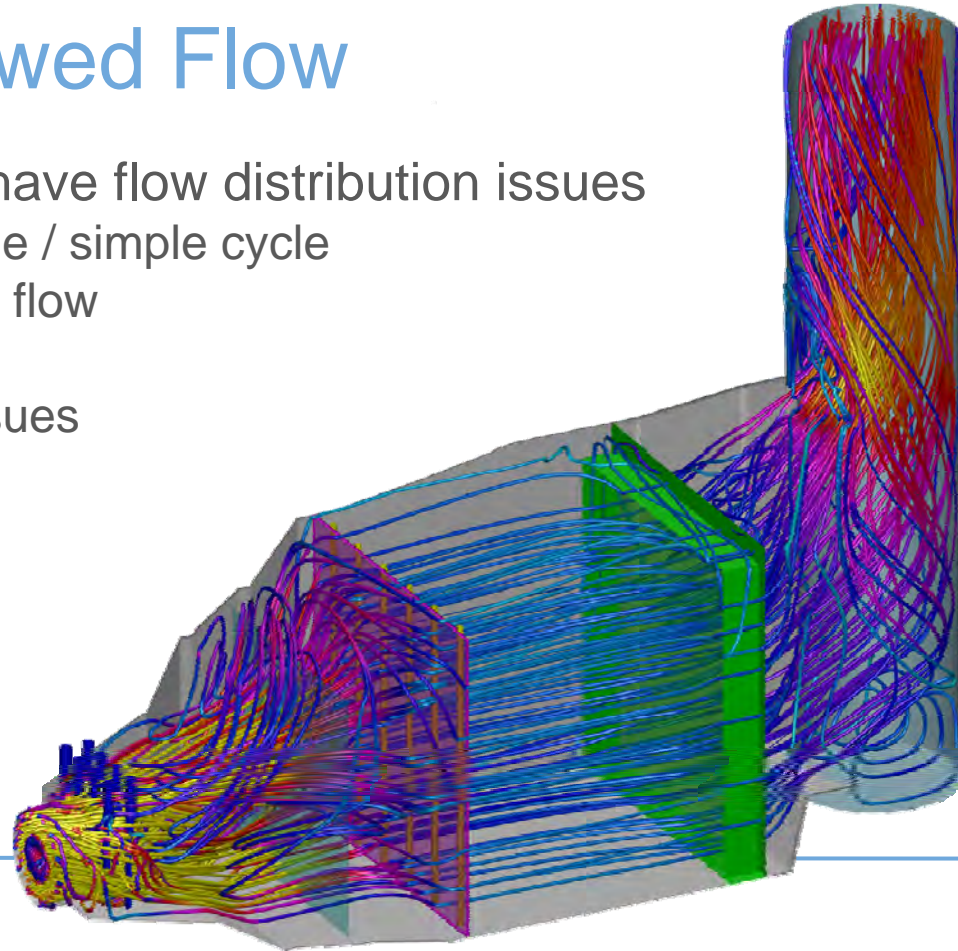
- Coal and gas plant stacks can have a range of flow issues
  - Cyclonic / non-uniform flow
  - Pressure fluctuations
  - Flow measurement issues



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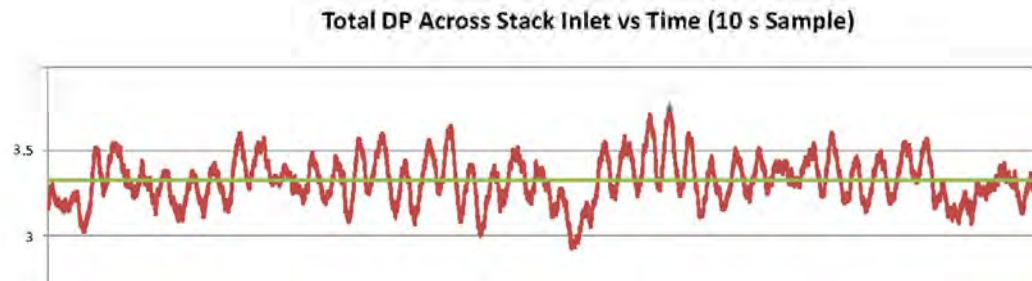
# Cyclonic and Skewed Flow

- Gas turbine stacks can have flow distribution issues
  - HRSG / combines cycle / simple cycle
  - Cyclonic / non-uniform flow
  - Pressure fluctuations
  - Flow measurement issues



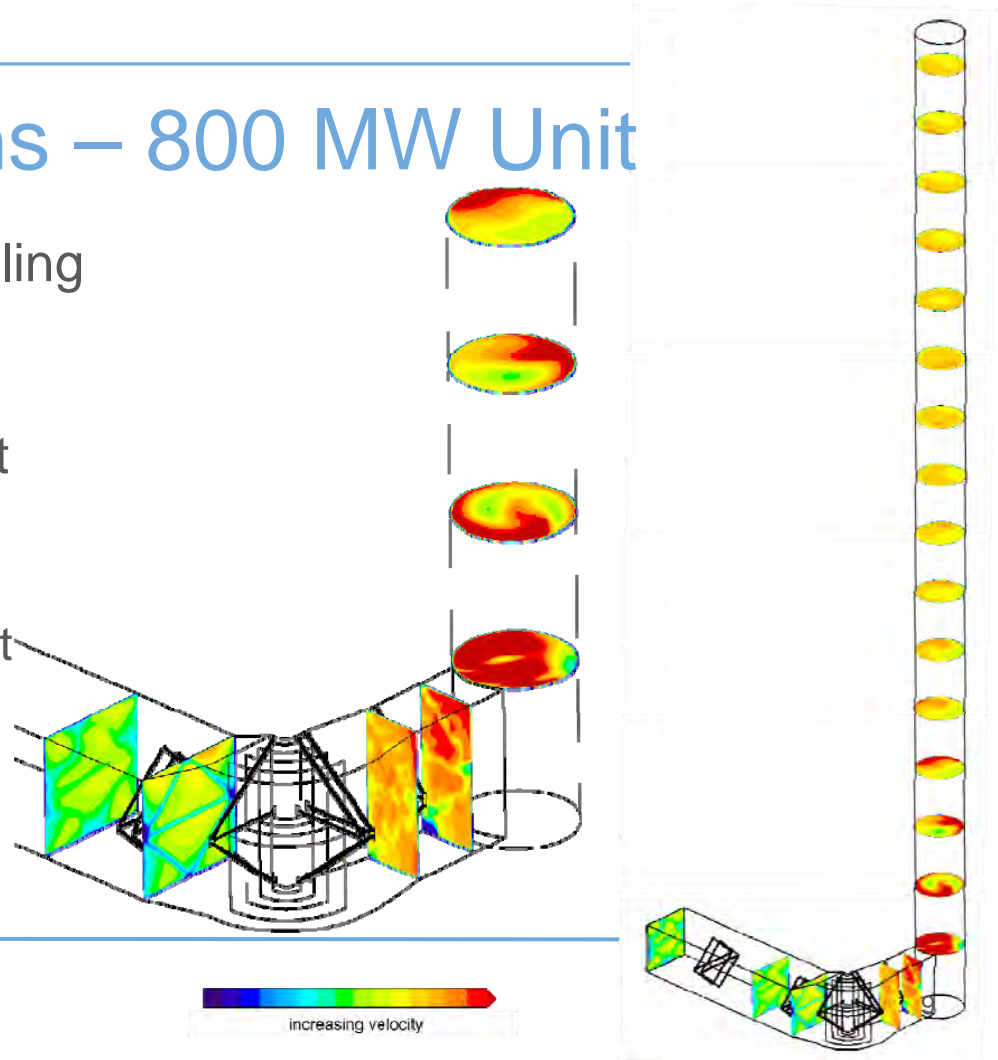
# Pressure Fluctuations - 800 MW Unit

- Case study: 800MW coal fired unit with dry stack
- ID fan control in a portion of the load range was problematic
  - Static pressure variance of over 1 IWC
  - Affects unit operation and furnace pressure stability
  - Vibration issues in duct evident



# Pressure Fluctuations – 800 MW Unit

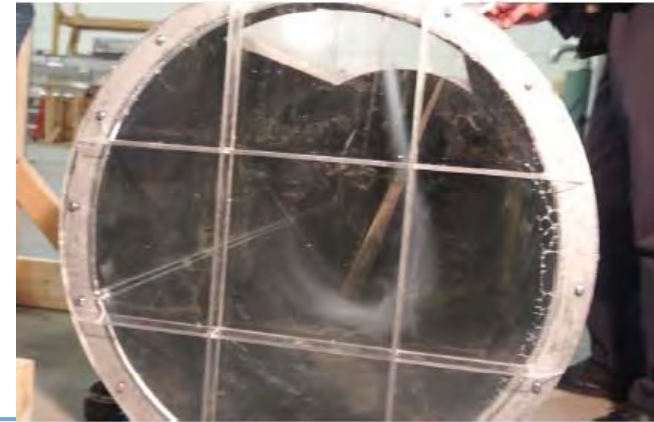
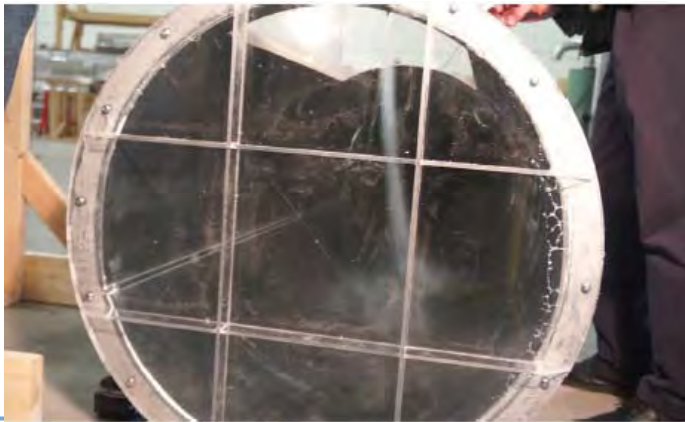
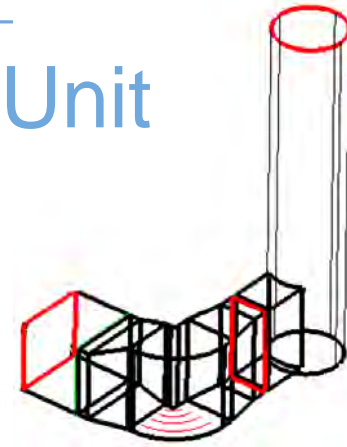
- CFD and physical flow modeling was performed to determine root cause of the problem
- Flow separation at stack inlet resulted in a transient flow behavior
  - Inconsistent, swirling flow at different loads
  - Pressure fluctuations and vibration



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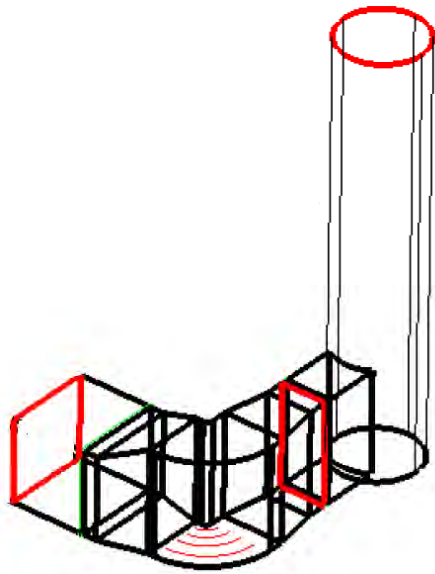
# Pressure Fluctuations – 800 MW Unit

- Physical flow modeling results
  - Smoke visualization showed varying stack entry flow with time
  - Pressure fluctuations of 1 IWC
  - Model vibration



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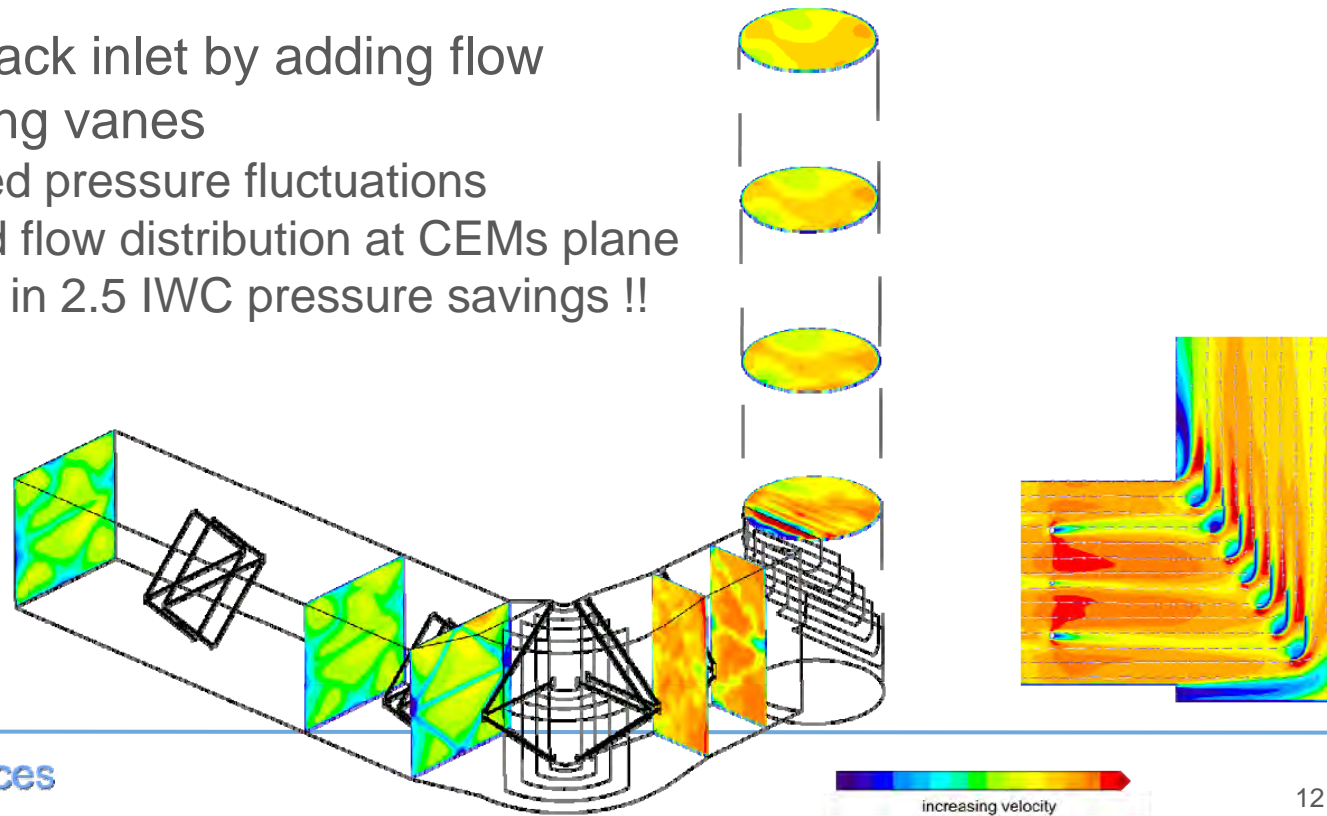
# Pressure Fluctuations – 800 MW Unit



Physical model video

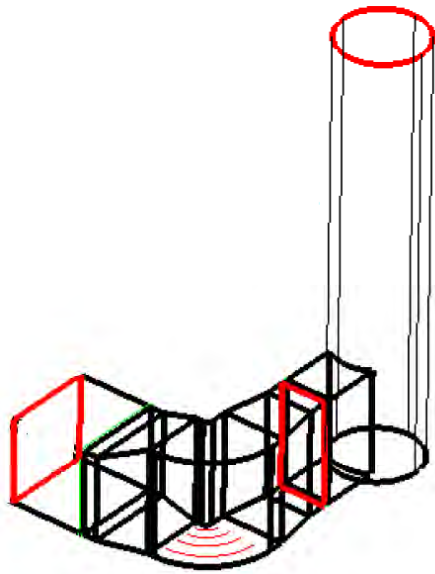
# Pressure Fluctuations – 800 MW Unit

- Redesign stack inlet by adding flow control turning vanes
  - Eliminated pressure fluctuations
  - Improved flow distribution at CEMs plane
  - Resulted in 2.5 IWC pressure savings !!



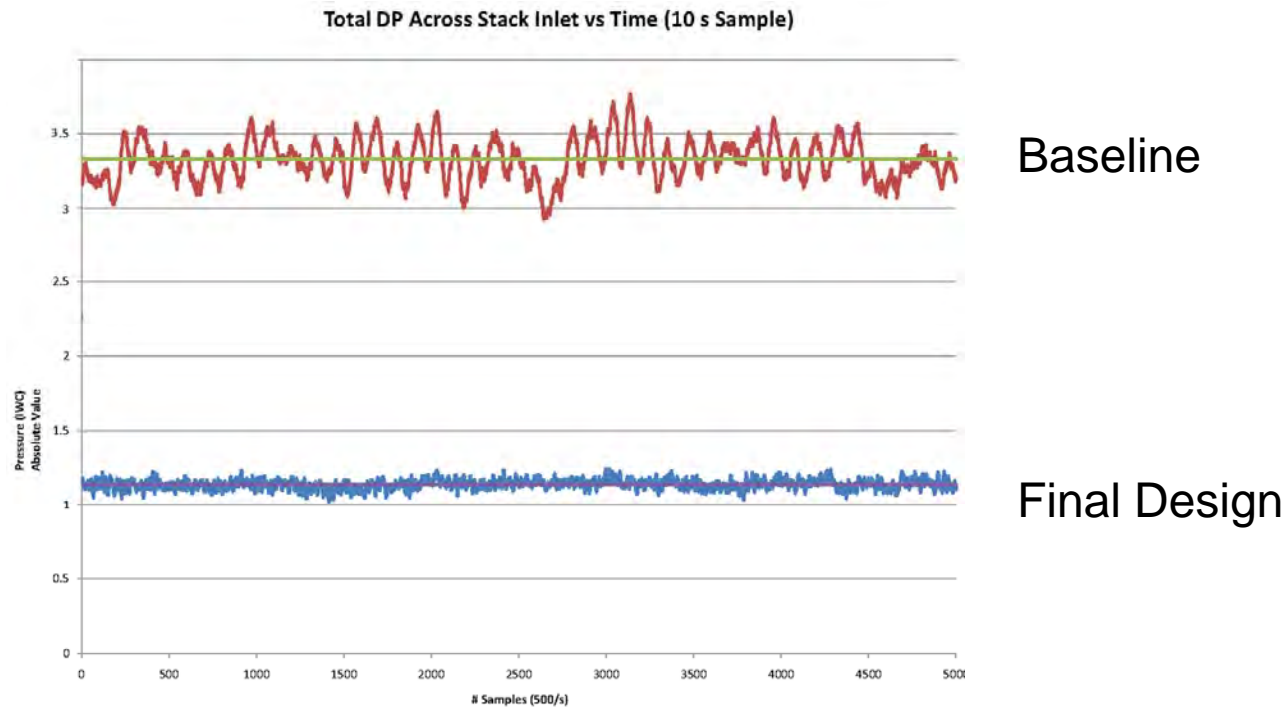
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# Pressure Fluctuations – 800 MW Unit



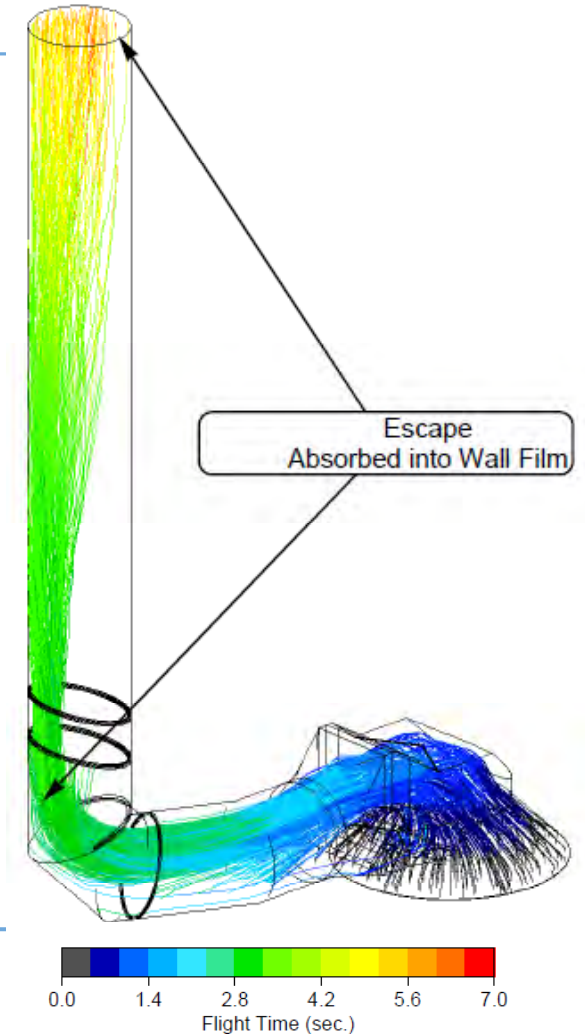
Physical model video

# Pressure Fluctuations – 800 MW Unit



# Wet Stack Flow Issues

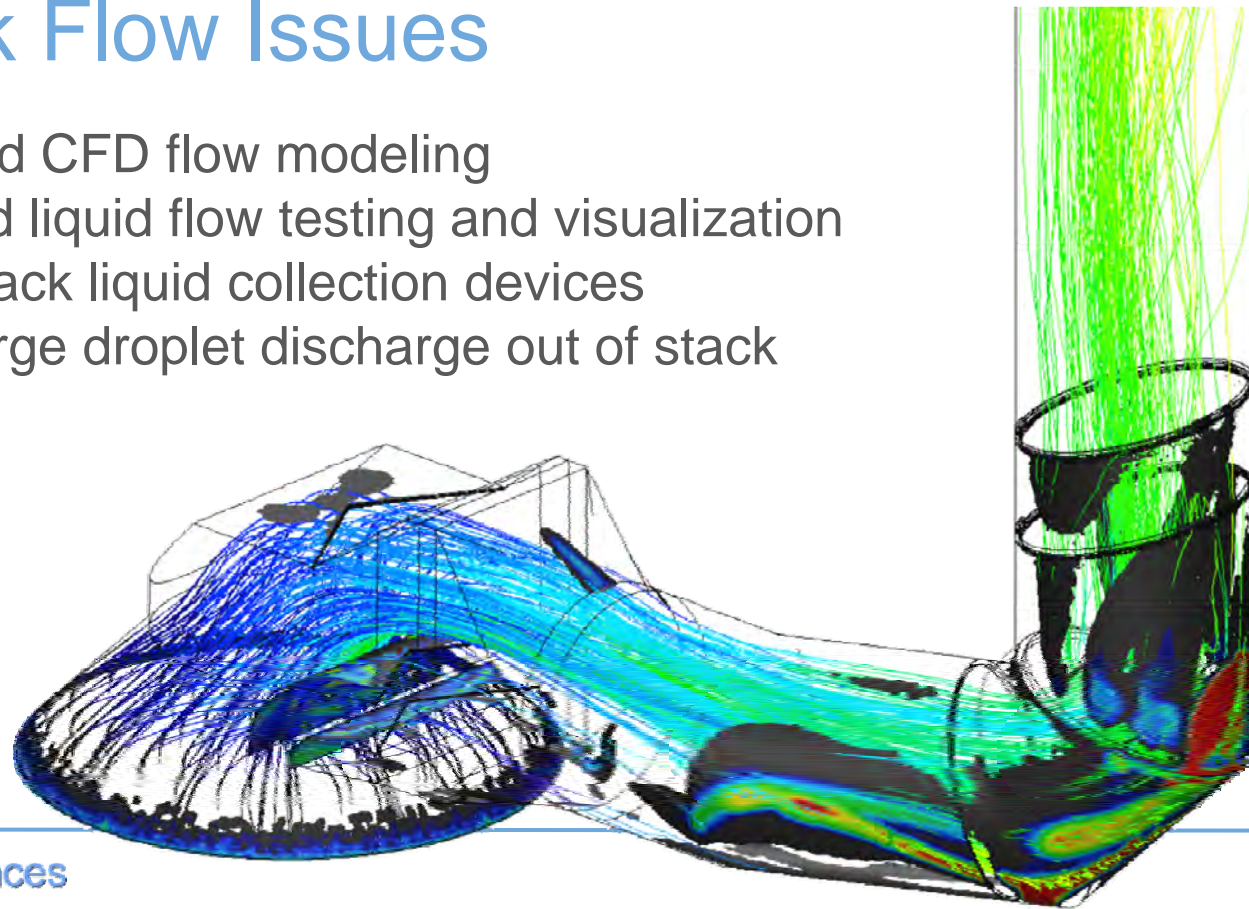
- Droplet capture after wet FGD
  - Mist eliminators are not perfect
  - Droplets impinge on duct and lower stack walls
  - Need to collect and drain droplets in lower stack
  - Avoid re-entrainment of liquid along upper walls



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# Wet Stack Flow Issues

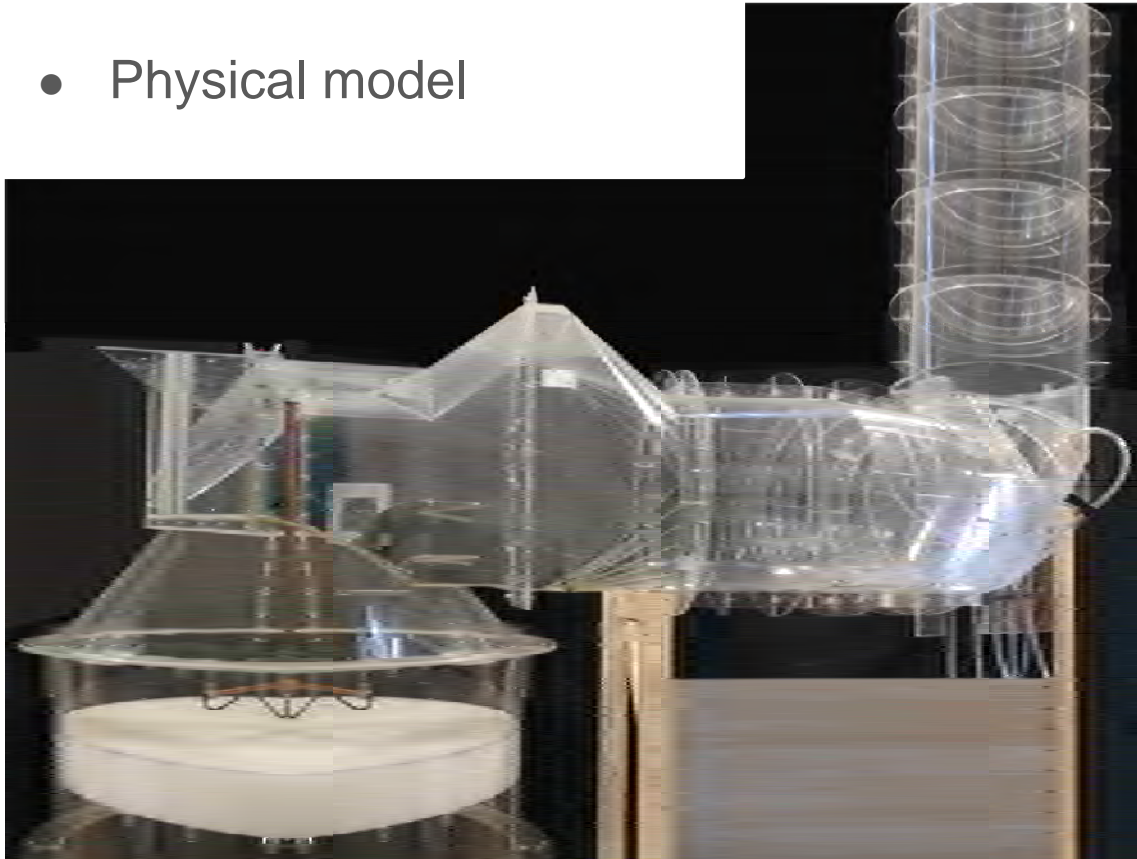
- Physical and CFD flow modeling
- Velocity and liquid flow testing and visualization
- Optimize stack liquid collection devices
- Minimize large droplet discharge out of stack



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# Wet Stack Flow Issues

- Physical model



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# Wet Stack Flow Issues

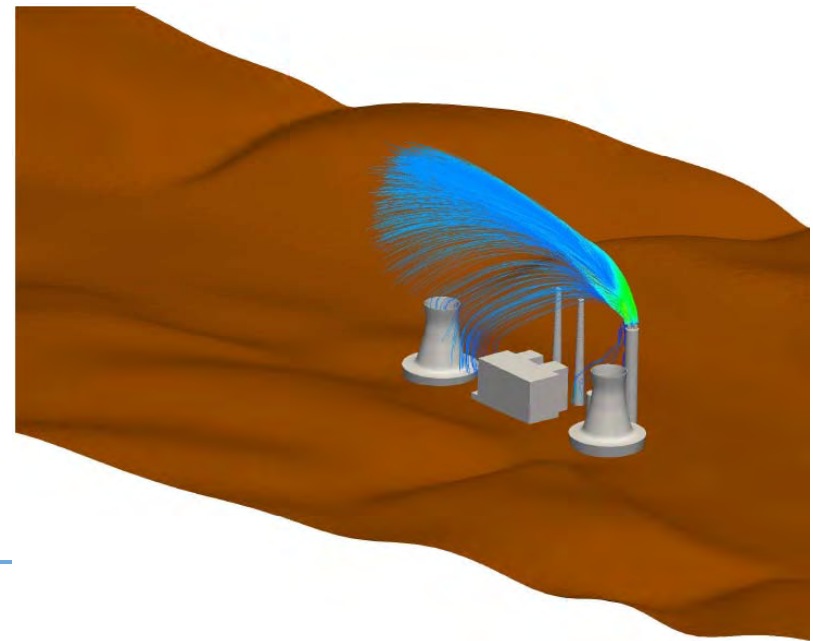
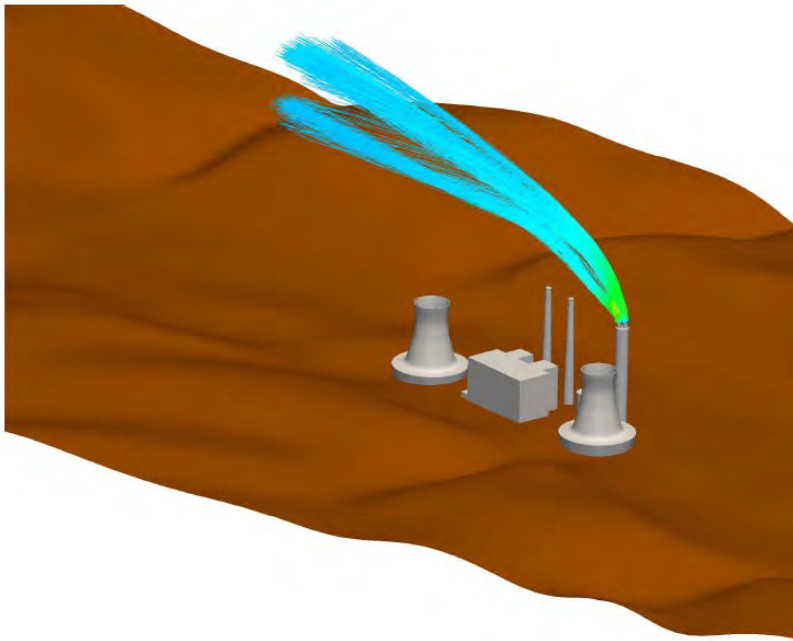
- Physical model

Physical model video

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## Wet Stack Flow Issues

- Avoid droplet carryover to stack discharge



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# Wet Stack Flow Issues

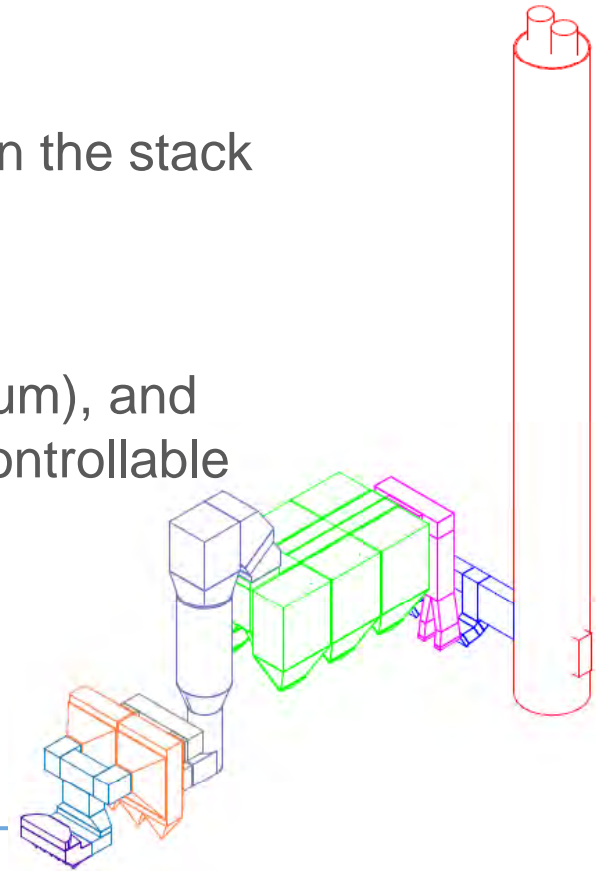
- Liquid film on inside stack wall

Stack internal flow video

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# CEMs Accuracy

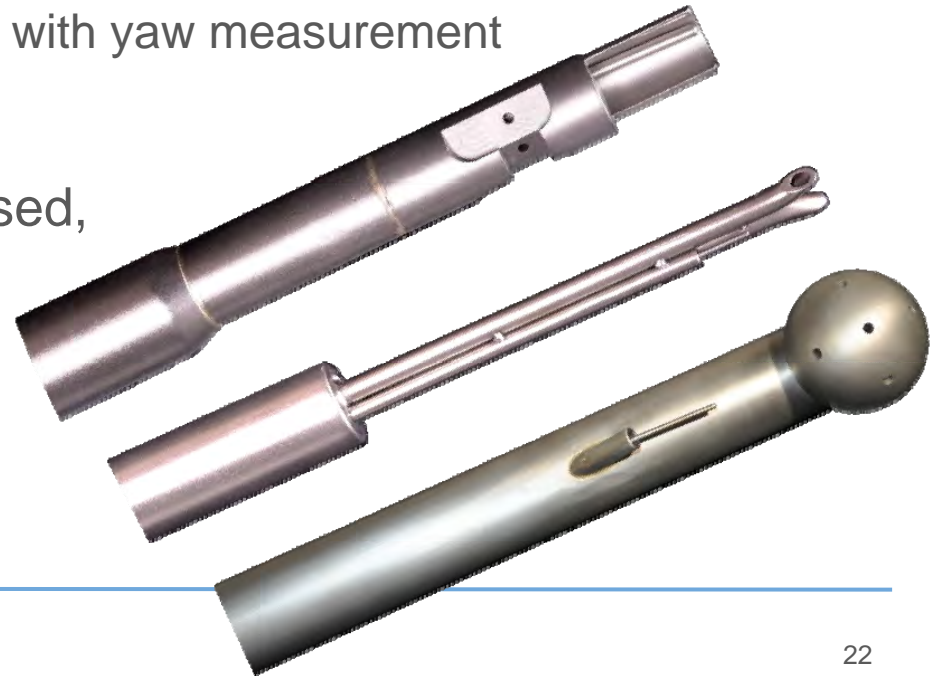
- The accuracy of the flow rate measurement in the stack has a direct, linear effect on
  - NO<sub>x</sub>, SO<sub>2</sub>, PM emissions
  - Heat Rate
- The CEMs is calibrated annually (at a minimum), and the calibration accuracy depends on many controllable factors
- What level of accuracy do you want?
  - 20%? 10%? 5%? 2%? 1%?



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## CEMs Accuracy

- The “Reference” to calibrate the CEMs is based on EPA Methods
  - Method 2: S-type pitot probe
  - Method 2G: S-type pitot probe with yaw measurement
  - Method 2F: 3D pitot probe
  - Method 2H: wall effects
- S-type is the most commonly used, but 3D is the most accurate



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## CEMs Accuracy

- The EPA Methods were first written in the early 1970s
- Some updates to improve accuracy and efficiency in 1999 and 2016
- The Methods still offer fairly generous margins on choice of instrumentation, decisions that can greatly affect accuracy
- Today's instrumentation and test equipment are capable of better
- Statistical error analysis shows measurements meeting the EPA test protocols can be as much as 8-15% off depending on
  - Probe type and calibration
  - Selection of pressure transducers
- Automated versus manual testing methods can also play a large role
- **What is the proper balance of accuracy vs. effort ?**

# CEMs Accuracy

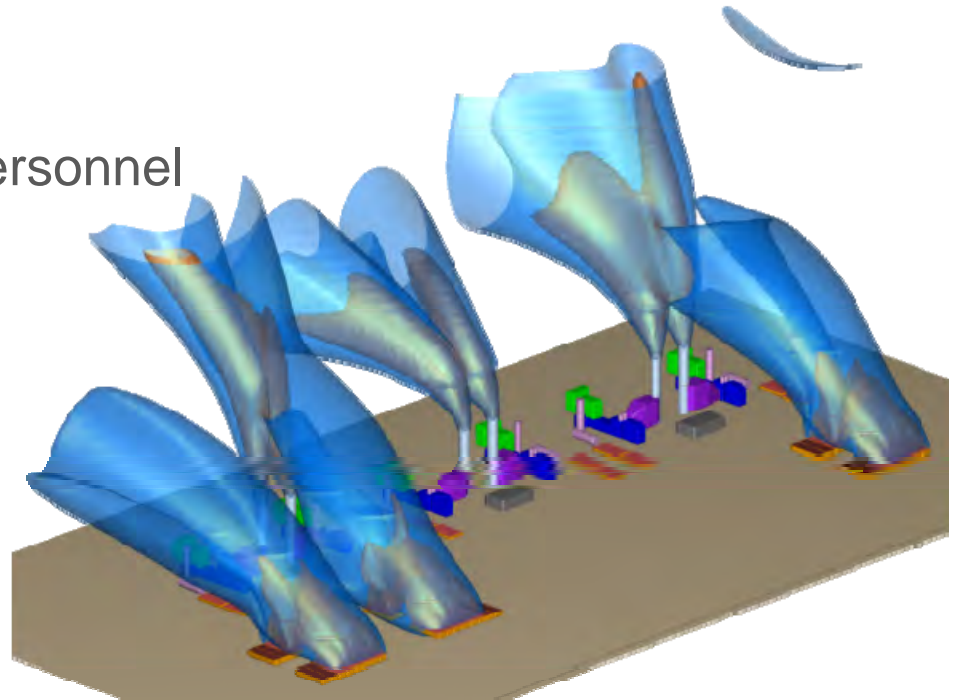
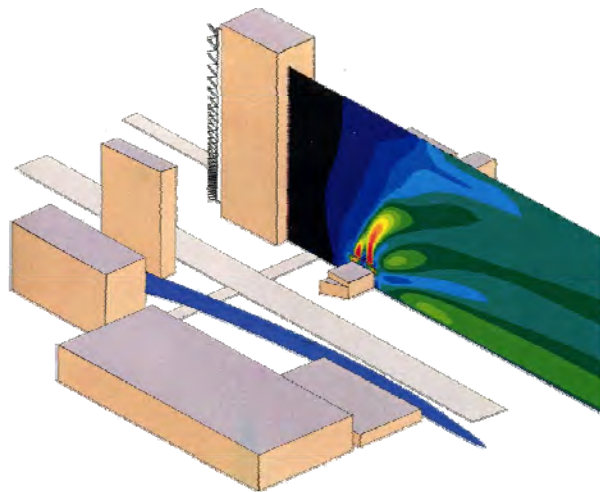
- EPRI, NIST, and Airflow Sciences are researching flow measurement accuracy as it relates to
  - Probe type and calibration
  - Selection of pressure transducers
  - Automated versus manual testing methods
- Tasks
  - Plant field trials
  - NIST Smokestack Simulator
  - Wind tunnel round robin
  - New probe designs
  - Revised test methods
- Stay tuned as results are released



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# Plume Dispersion

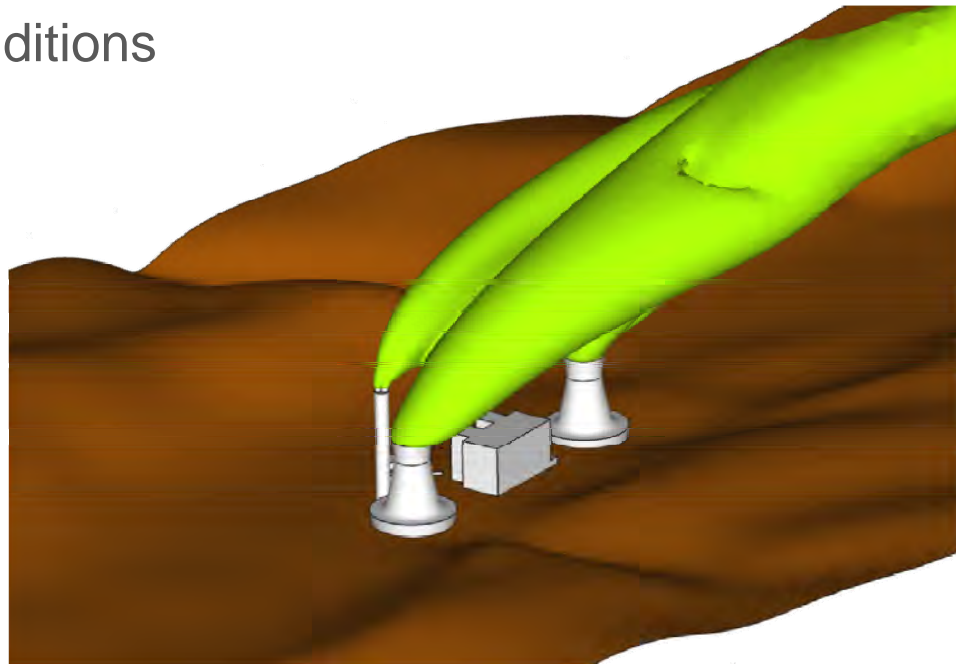
- Applies to all stacks
- Affects neighbors
- Affects plant equipment and personnel



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# Plume Dispersion

- Assess varied wind conditions
- Flue gas tracking
- Moisture / humidity
- Seasonal issues



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## Summary

- The stack is the final piece in the flow path, and plays an important role for emissions, flow measurement, and dispersion
- When stack flow problems exist, they can cause significant issues
  - Vibration / pressure fluctuation
  - Droplet carry over
  - Inadequate plume dispersion
  - Inaccurate flow rate measurement
- Flow modeling and testing can be used to resolve stack flow issues
- Proper test procedures and choice of test equipment can improve stack CEMs flow measurement accuracy

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# Acknowledgements

- EPRI
- NIST
- Airflow colleagues
  - Kanthan Rajendran
  - Matt Gentry
  - Brian Dumont
- Plant sites

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# Questions & Contact Information

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