Utility Stacks are Not Designed for Accurate Flow Measurement

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Goals for Presentation

➢ Increase Awareness of the Variations in Stack Design and Construction.

➢ Will Present 3 Cases with CFD Models

➢ Not to Offer Solutions
Utility Stacks are Not Designed for Accurate Flow Measurement

➢ Most Utility Coal Fired Stacks were Designed with Little or No consideration of Accurate Flow Measurement.

➢ Many have been Retrofitted around Add-on Emissions Controls

➢ Multiple Unit Common Stacks are Common.
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➢ Some Stacks have Single Breach
➢ Some Stacks have Two or More Breaches, (Single and Multiple Unit)
➢ Some have Divider Walls at the Breach, Parallel or Angled Some Do Not.
➢ Some have Large Inaccessible Annular Spaces so the Ports are Long
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- Dominion Contracted Airflow Sciences Corp to Conduct CFD Models
- Purpose of CFD Models was for PM CEMS Installations
- Had to Develop Flow Profiles to Develop PM Models
- Plots In Presentation are from these Models
Case 1: 650 MW Unit, Bituminous Coal, New Wet FGD and New Single Breach Stack
CASE 1
Case 1

Plan View - Stack Test Plane (EL 366'-9.375'”)

Average = 45.9 ft/s
Maximum = 59.9 ft/s (+31%)
RMS = 17.5%

Average = 3.2 ft/s
Maximum = 7.0 ft/s

Average = 4.0°
Maximum = 9.5°
S_D = 1.9°

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Case 2: Two 550 MW PRB Units Common Stack - Dry
Four ID Fans per Unit; 1,420,747 scfm per Unit
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➢ Common Stacks Can be Especially Problematic

➢ Different Flows Entering from Opposite Sides

➢ Variations in Flow Volume from Each Unit Setup Different Velocity and Swirl Profiles at the CEMS Flow Monitor.

➢ Change in Profile Change Monitor Measurements
Case 2A
Two Units at Equal Loads
Case 2A
Two Units Equal Loads
Case 2A

Average = 84.5 ft/s
Maximum = 87.2 ft/s (+3%)
RMS = 4.1%

Average = 10.4 ft/s
Maximum = 24.0 ft/s

Average = 7.1°
Maximum = 19.3°
$S_D = 4.1°$
Case 2B
One Unit Full Load
One Unit Min Load
Case 2B
One Unit Full Load
One Unit Min Load
Case 2B
One Unit Full Load
One Unit Min Load

Average = 62.6 ft/s
Maximum = 68.7 ft/s (+10%)
RMS = 6.4%

Average = 26.8 ft/s
Maximum = 40.5 ft/s

Average = 23.0°
Maximum = 40.5°
$S_{D} = 7.5°$
Case 3:  500 MW Bituminous Unit Single Breach Stack – 3 Wet FGD Modules, Combinations of 2 Modules ; 1,710,000 scfm
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➢ Three FGD Scrubber Modules A, B and C
➢ Merge into Single Duct into Stack Breach
➢ Operate Pair Combinations: AC, BC, AB
Case 3

CFD Domain - Unit 1 / 2
Isometric View Looking South-East - Close-Up of Absorber Outlets to Stack
(Same Geometry for Units 1 and 2)

Injection Planes (Test Ports)

Absorber C

Absorber B

Absorber A
Case 3 Modules AC

Path Lines - Unit 1 - Absorbers A+C
Isometric View - Colored by Absorber

Test Plane
EL 600”-0”

Close-Up of Breaching

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Case 3 Modules AC

Path Lines - Unit 1 - Absorbers A+C
Isometric View - Colored by Gas Velocity Magnitude
Case 3 Modules AC

Velocity Components - Unit 1 - Absorbers A+C
Plan View - CEMS Plane (EL 600'-0")

Average = 55.2 ft/s
Maximum = 67.4 ft/s (+22%)
RMS = 10.3%

Average = 6.6 ft/s
Maximum = 12.6 ft/s

Average = 7.0°
Maximum = 15.8°
S_D = 3.2'
Case 3 Modules AB

Path Lines - Unit 1 - Absorbers A+B
Isometric View - Colored by Absorber

Test Plane
EL 600"-0"

Close-Up of Breaching

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Case 3 Modules AB

Path Lines - Unit 1 - Absorbers A+B
Isometric View - Colored by Gas Velocity Magnitude

Test Plane
EL 600".0"

Close-Up of Breaching

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Case 3 Modules AB

Velocity Components - Unit 1 - Absorbers A+B
Plan View - CEMS Plane (EL 600'-0'')

Average = 54.6 ft/s
Maximum = 66.6 ft/s (+20%)
RMS = 9.2%

Average = 8.7 ft/s
Maximum = 18.2 ft/s

Average = 9.2'
Maximum = 20.8'
S_D = 4.4'

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Case 3 Modules AC verses AB

For AC:
- Average = 55.2 ft/s
- Maximum = 67.4 ft/s (+22%)
- RMS = 10.3%

For AB:
- Average = 54.6 ft/s
- Maximum = 65.6 ft/s (+20%)
- RMS = 9.2%
Case 3 Modules AC Verses AB

Average = 6.6 ft/s
Maximum = 12.6 ft/s

Average = 8.7 ft/s
Maximum = 18.2 ft/s
Case 3 Modules AC Verses AB

Average = 7.0°
Maximum = 15.8°
$S_D = 3.2°$

Average = 9.2°
Maximum = 20.8°
$S_D = 4.4°$
Case 3 Flow Monitoring

- Original Flow Monitor – United Sciences Ultrasonic Single Path
- Flow Correlation Based on AC Scrubber Vessels
- Flow RATAs With BC and AB Failed
- Petitioned CAMD to have 3 Different Correlation Curves
Case 3 Modules AC BC and AB Correlation Curves

Flow Correlation Unit 1 Single Path

Flow Correlation Unit 2 Single Path
Case 3 Flow Monitoring

➢ Replaced Flow Monitor – Teledyne Ultraflow 150 Ultrasonic with X Path
➢ Flow Re-correlation Based on Separate Curves for AC, BC, and AB Scrubber Vessels
Case 3 Modules AC BC and AB Correlation Curves

Flow Correlation Curves - X Path

Correlated Flow SCFH

- 0 200 400 600 800 1000 1200 1400 1600 1800

Raw Measured from Monitor K
SCFM

- CL01AC
- CL01BC
- ▲ CL01AB
- × CL02AC
- × CL02BC
- · CL02AB

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Conclusion:
Stack Flow Monitors Need to be Designed for Changing Flow Profiles