NIST Workshop June 28, 2017 Improving Measurement for Smoke Stack Emissions

Utility Stacks are Not Designed for Accurate Flow Measurement

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Utility Stacks are Not Designed for Accurate Flow Measurement

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Utility Stacks are Not Designed for Accurate Flow Measurement

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.

Utility Stacks are Not Designed for Accurate Flow Measurement

- 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

Utility Stacks are Not Designed for Accurate Flow Measurement

- 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

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Case 1: 650 MW Unit, Bituminous Coal, New Wet FGD and New Single Breach Stack

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Isometric View - Colored by Gas Velocity Magnitude

CASE 1

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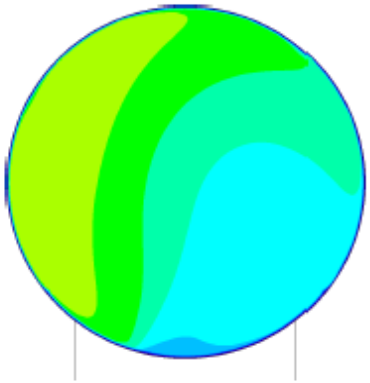
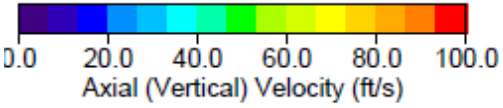
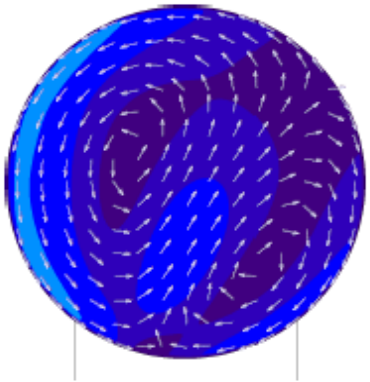
Plan View - Stack Test Plane (EL 366'-9.375")

Case 1

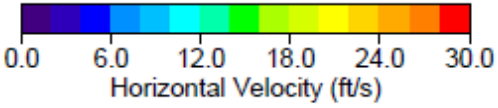


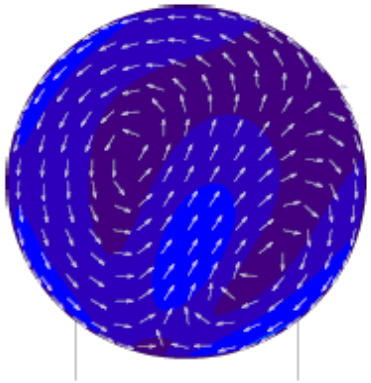
Average = 45.9 ft/s
Maximum = 59.9 ft/s (+31%)
RMS = 17.5%



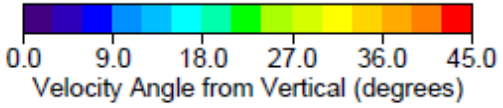


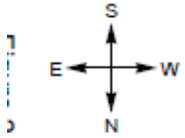
Average = 3.2 ft/s
Maximum = 7.0 ft/s





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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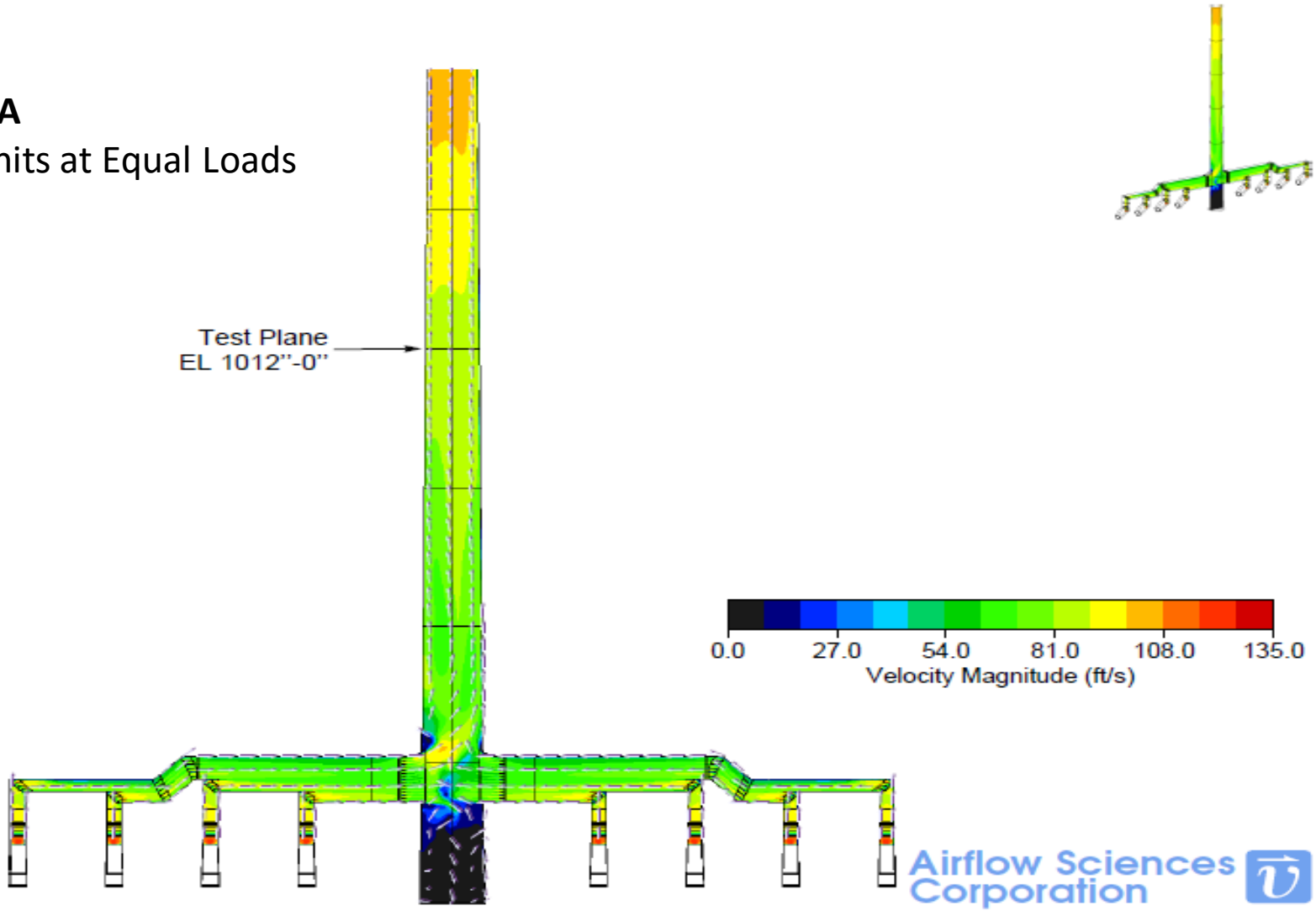
Case 2: Two 550 MW PRB Units Common Stack - Dry Four ID Fans per Unit ; 1,420,747 scfm per Unit

- 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



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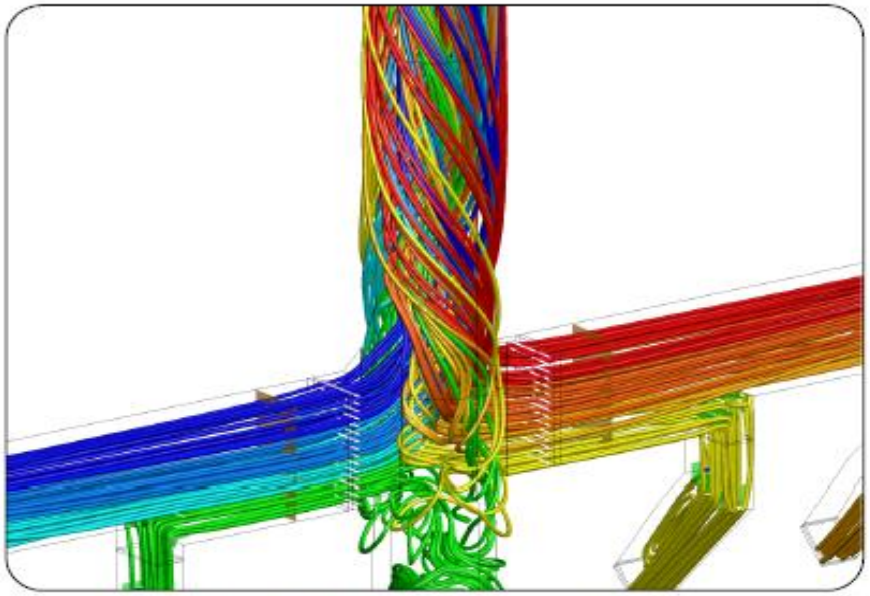
Case 2A

Two Units Equal Loads

End View - Colored by ID Fan

Test Plane
EL 1012''-0''



Isometric Close-Up of Breaching

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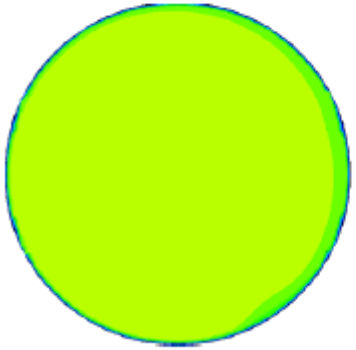
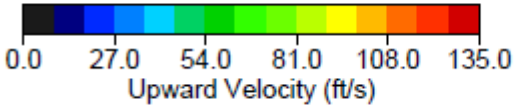
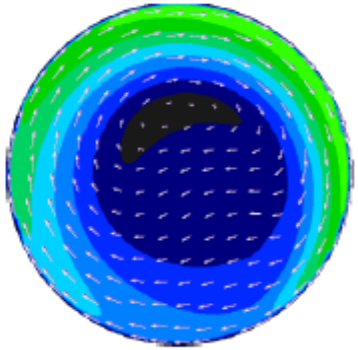
Case 2A

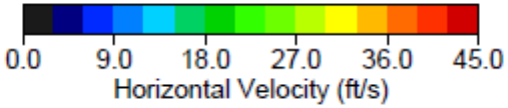


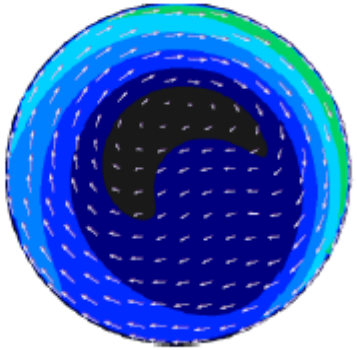
Average = 84.5 ft/s
Maximum = 87.2 ft/s (+3%)
RMS = 4.1%



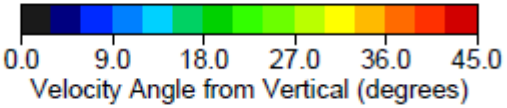


Average = 10.4 ft/s
Maximum = 24.0 ft/s





Average = 7.1°
Maximum = 19.3°
S_D = 4.1°



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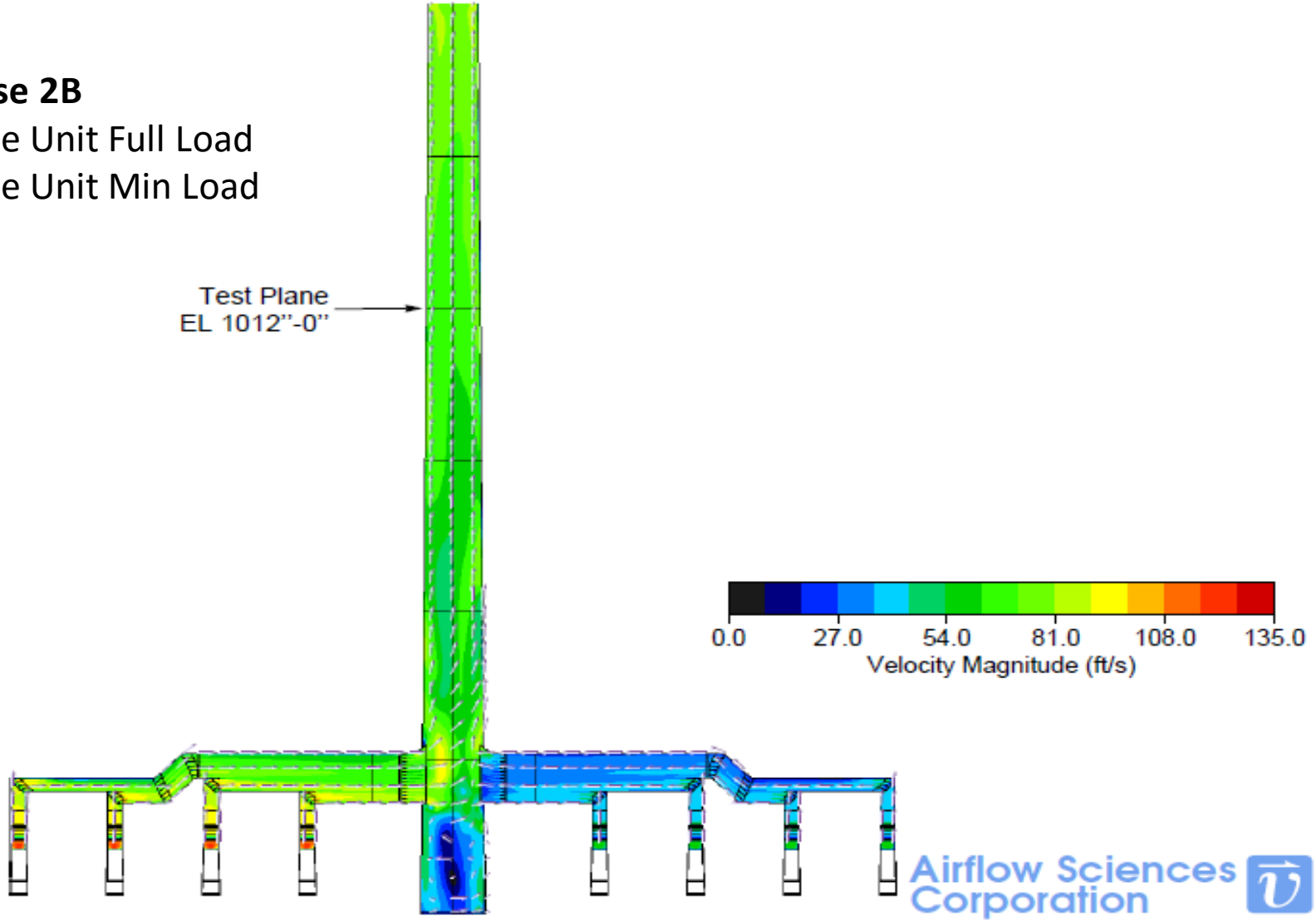
Case 2B

One Unit Full Load

One Unit Min Load



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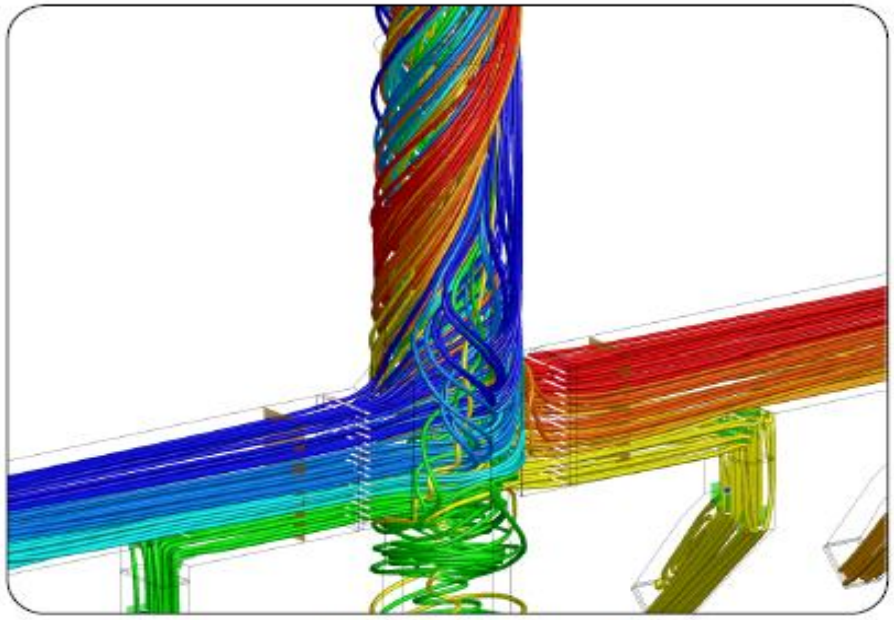
Case 2B

One Unit Full Load

One Unit Min Load

End View - Colored by ID Fan

Test Plane
EL 1012"-0"



Isometric Close-Up of Breaching

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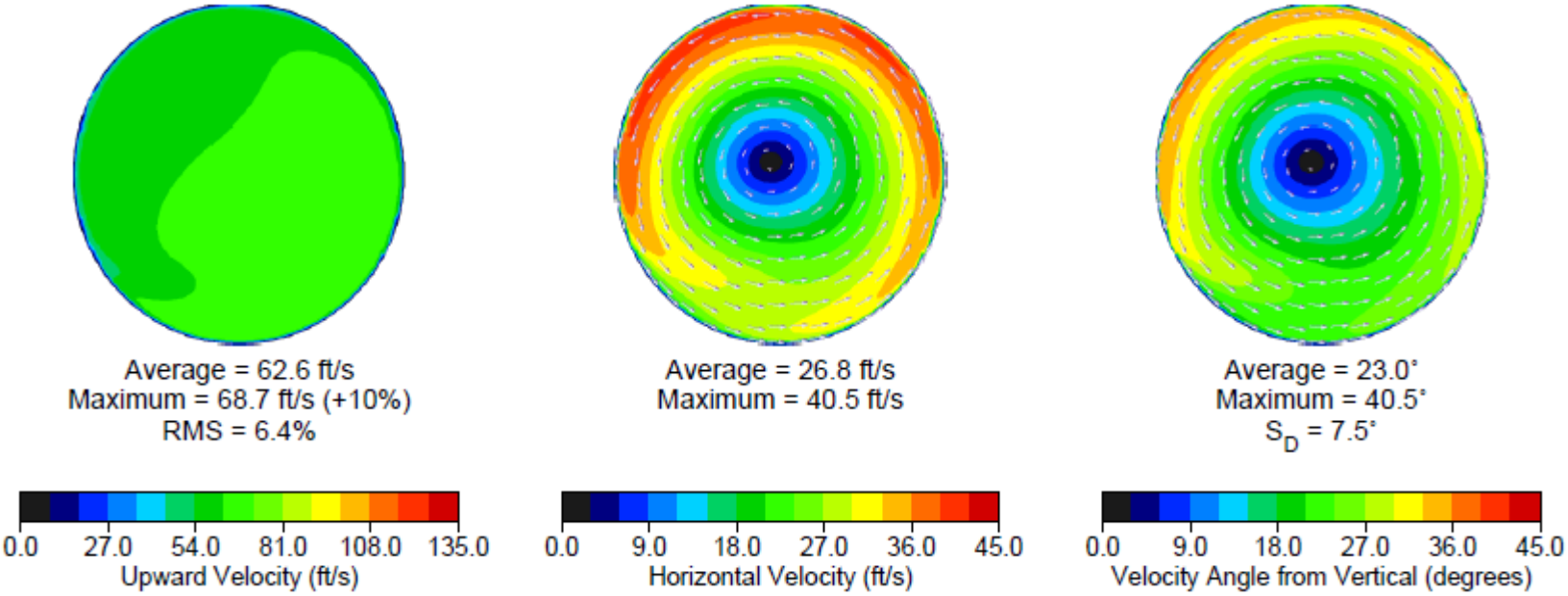
Case 2B

One Unit Full Load

One Unit Min Load



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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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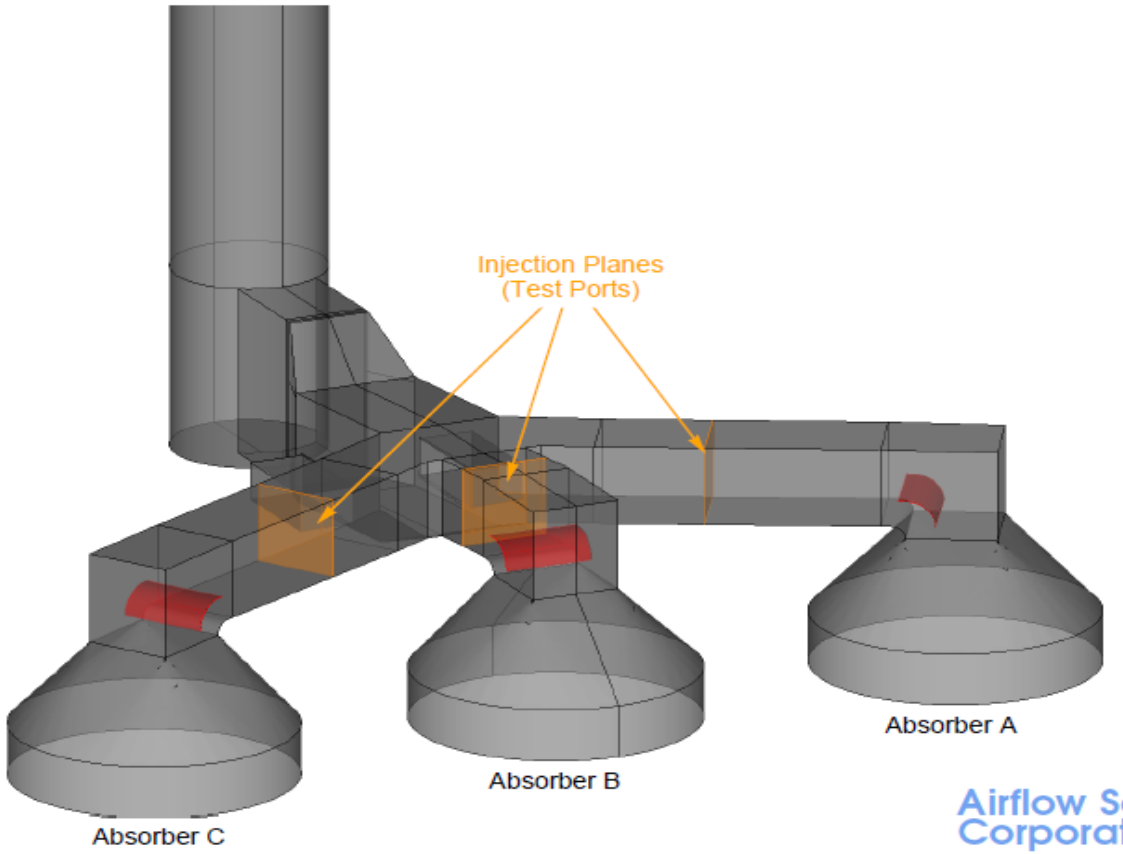
Case 3: 500 MW Bituminous Unit Single Breach Stack – 3 Wet FGD Modules, Combinations of 2 Modules ; 1,710,000 scfm

- 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)



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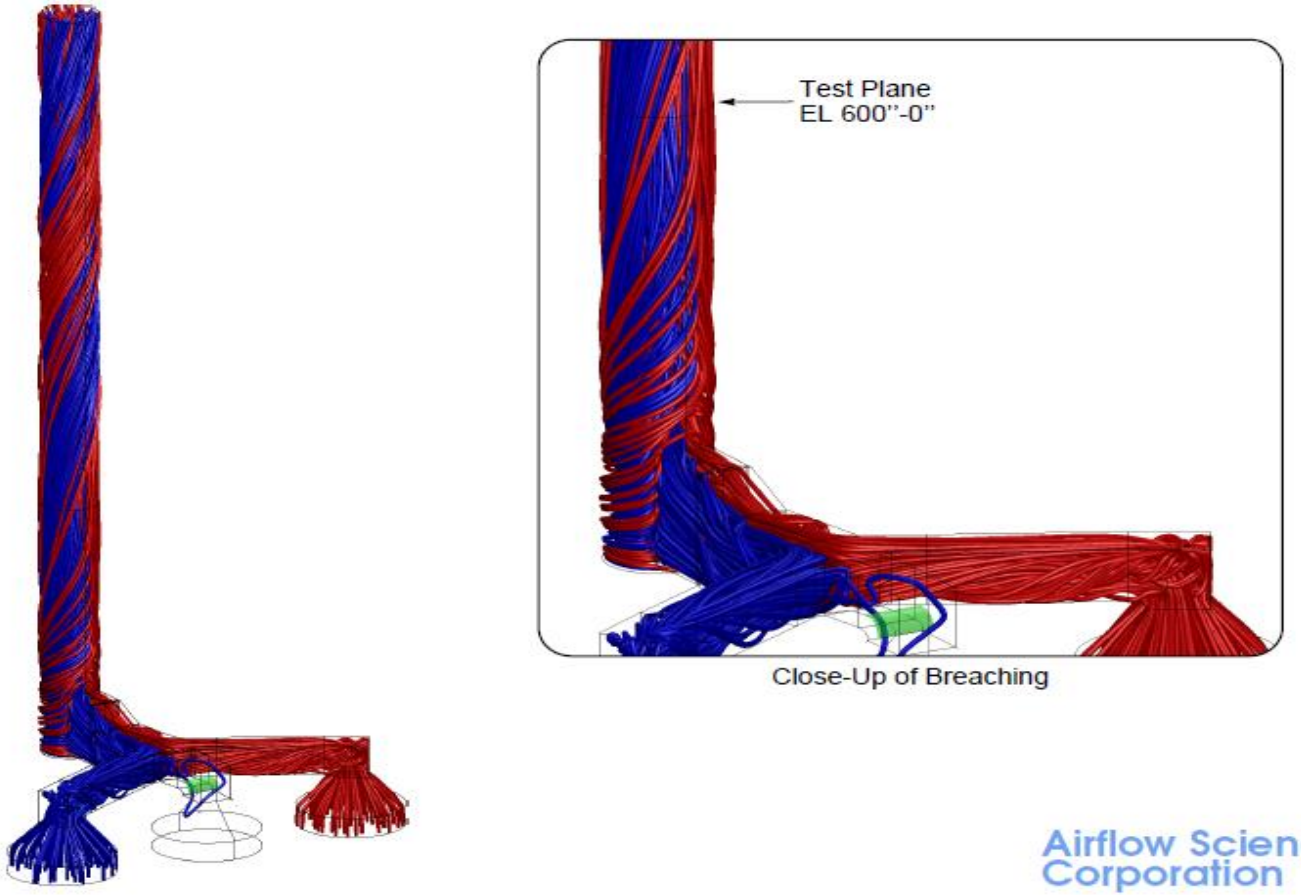
Case 3 Modules AC



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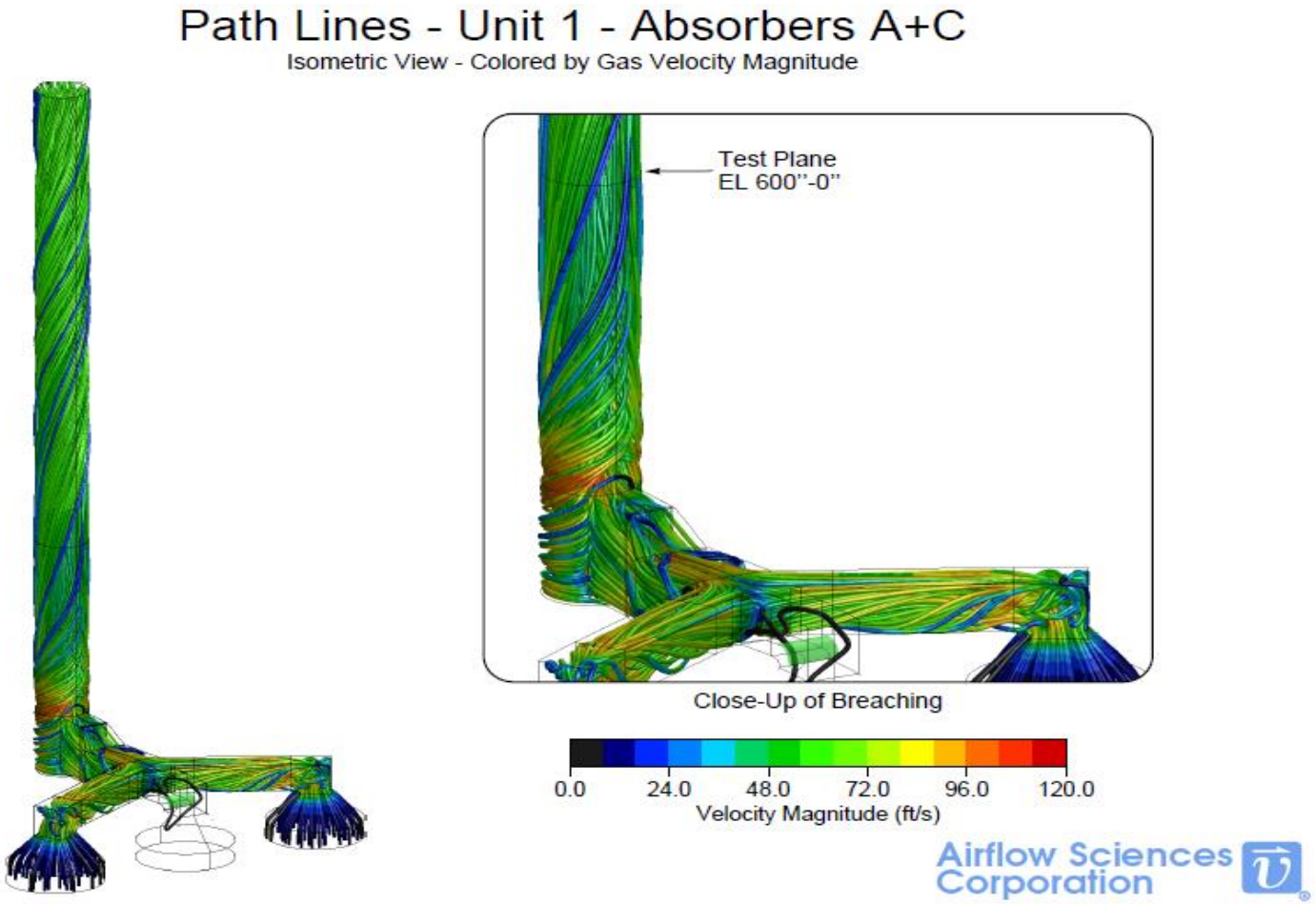
Case 3 Modules AC



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Case 3 Modules AC

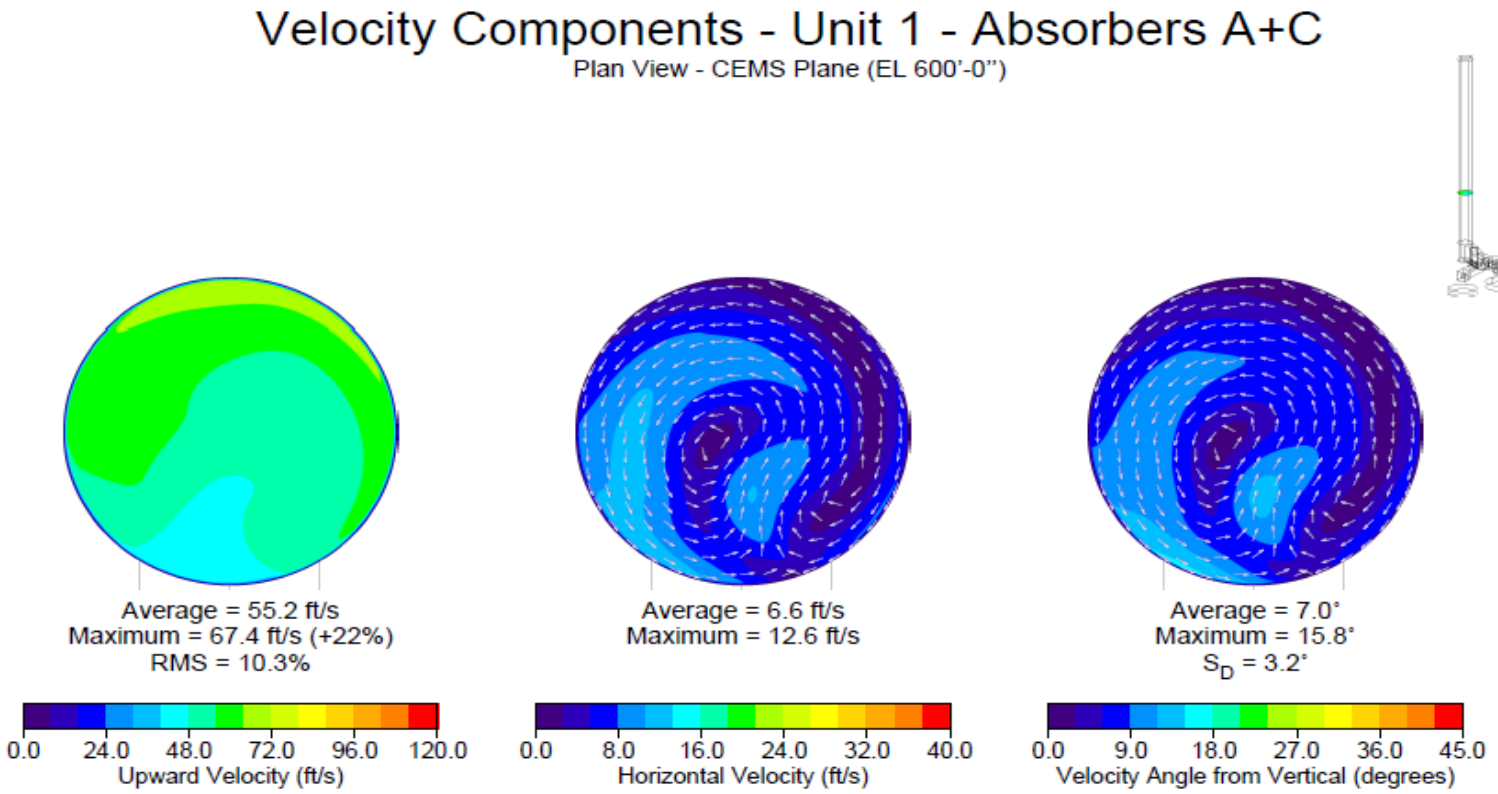
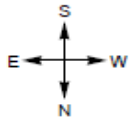


Figure 6



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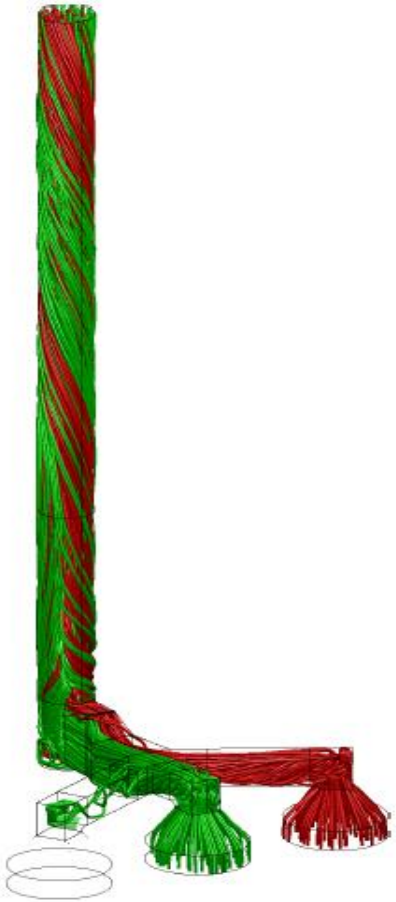
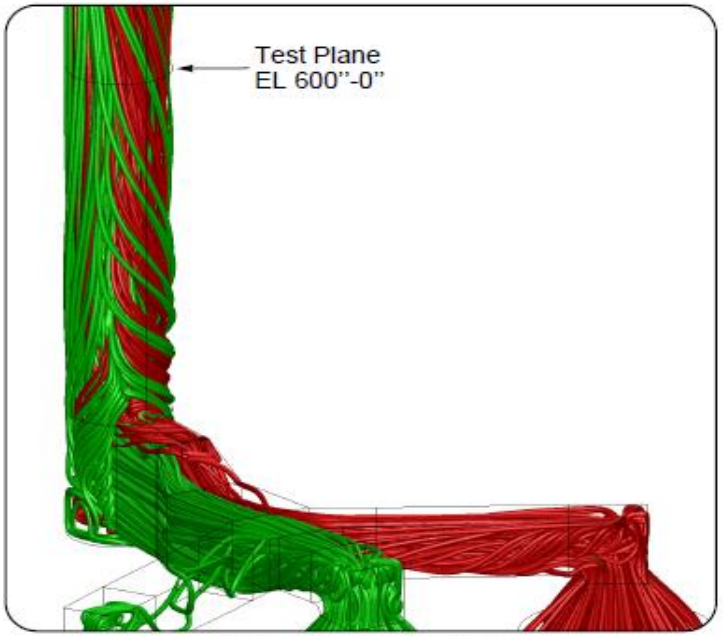
Case 3 Modules AB

Path Lines - Unit 1 - Absorbers A+B

Isometric View - Colored by Absorber





Close-Up of Breaching

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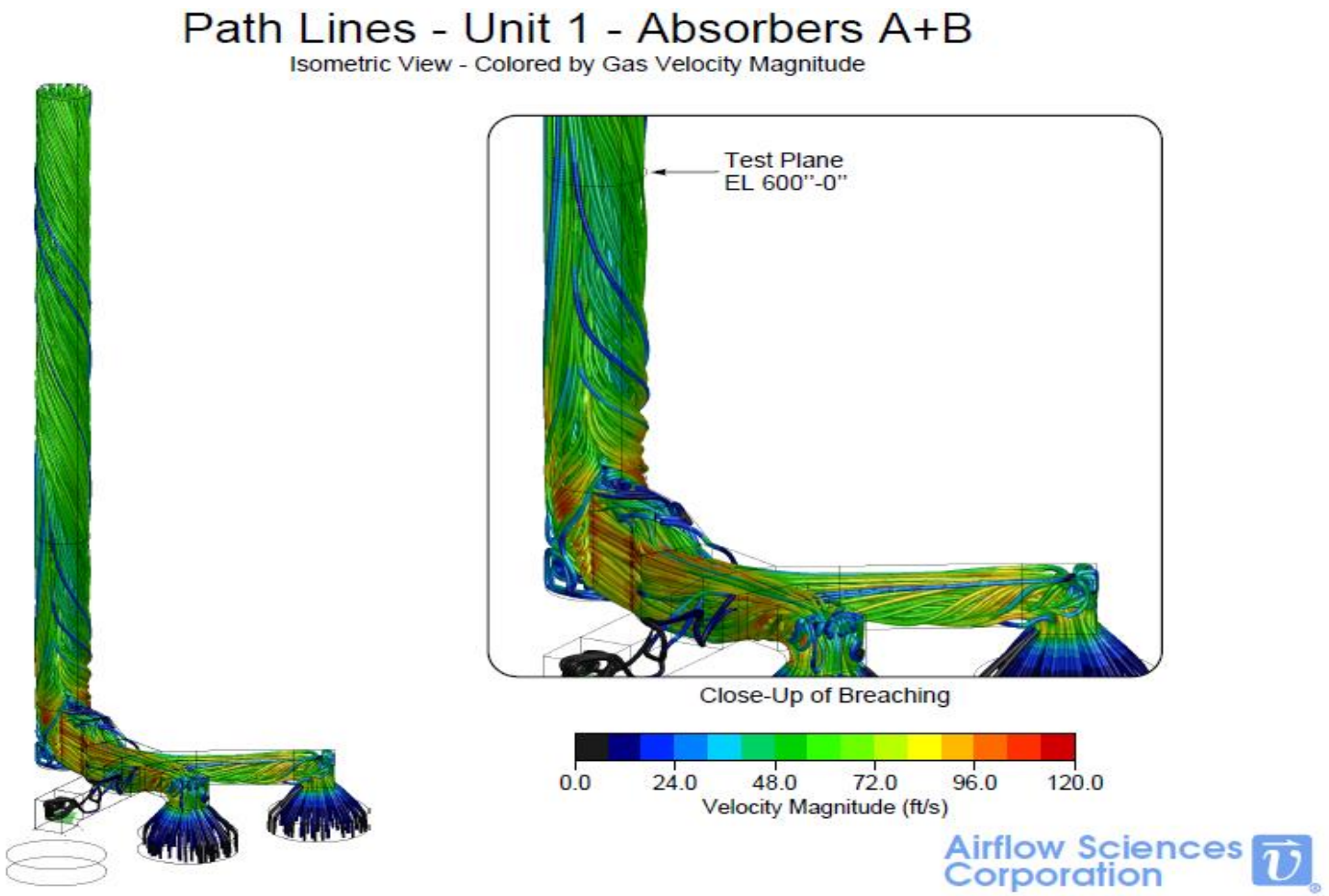
Case 3 Modules AB



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Case 3 Modules AB

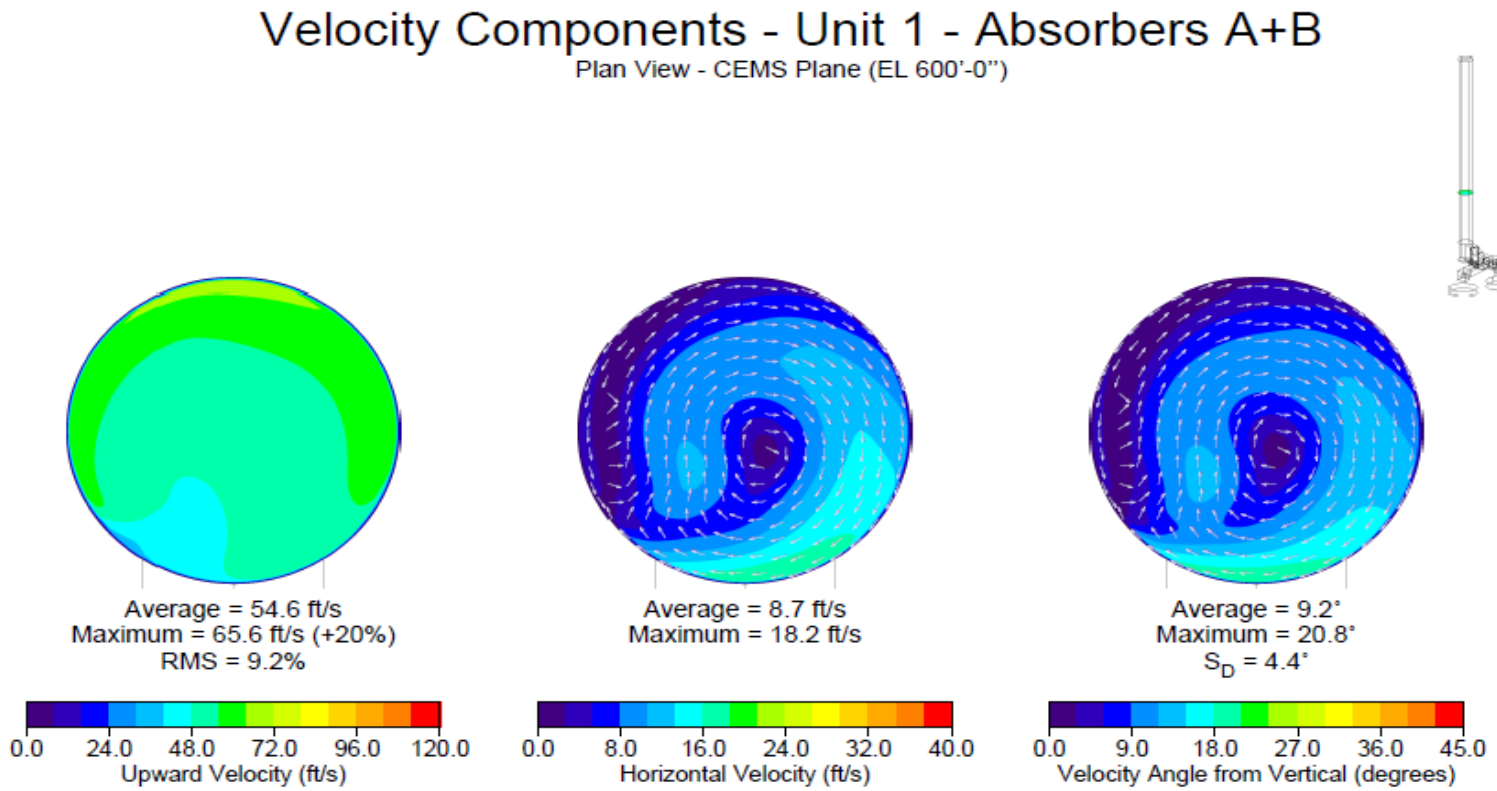

Figure 3

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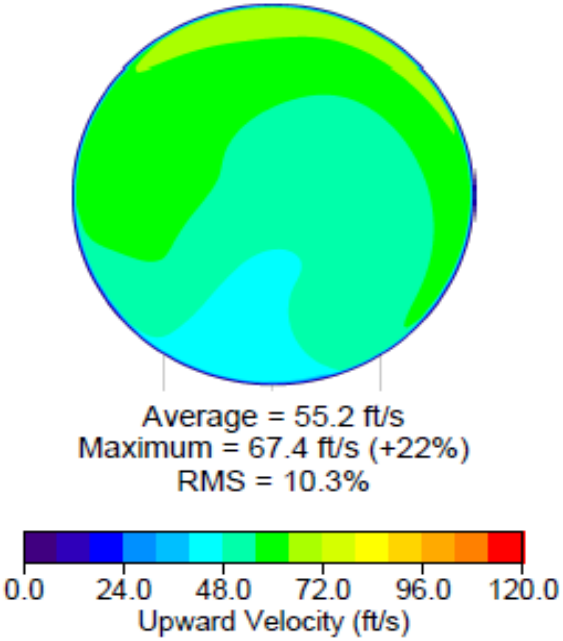
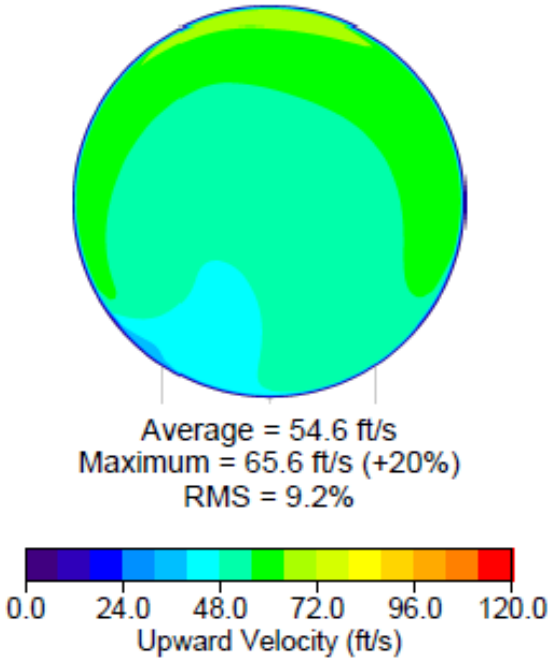
Case 3 Modules AC verses AB

AC



AB



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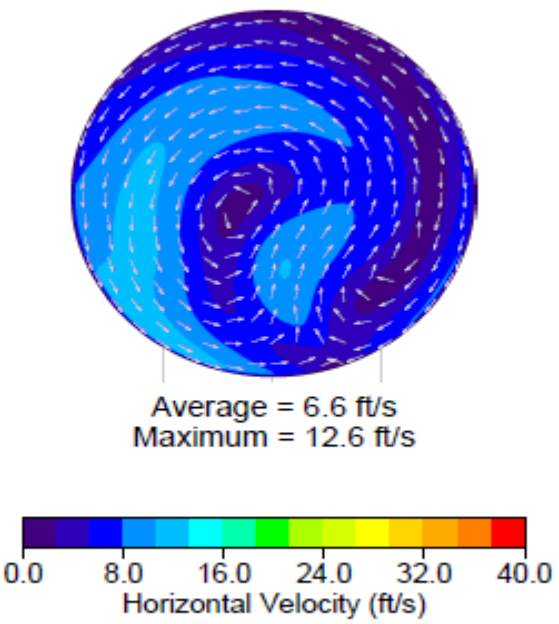
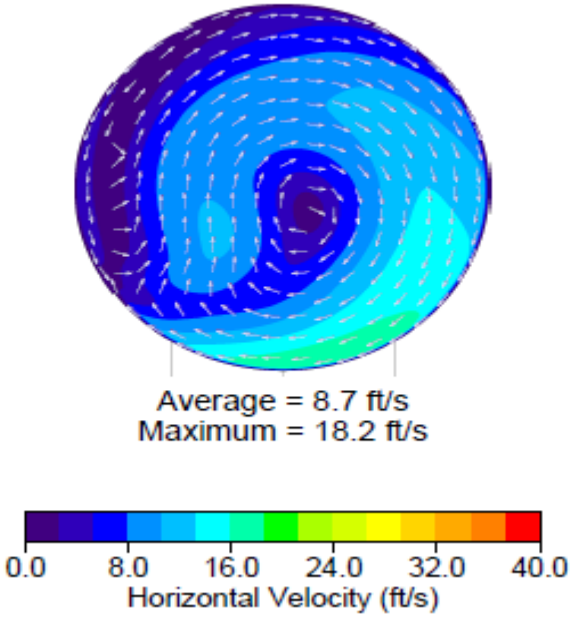
Case 3 Modules AC Verses AB





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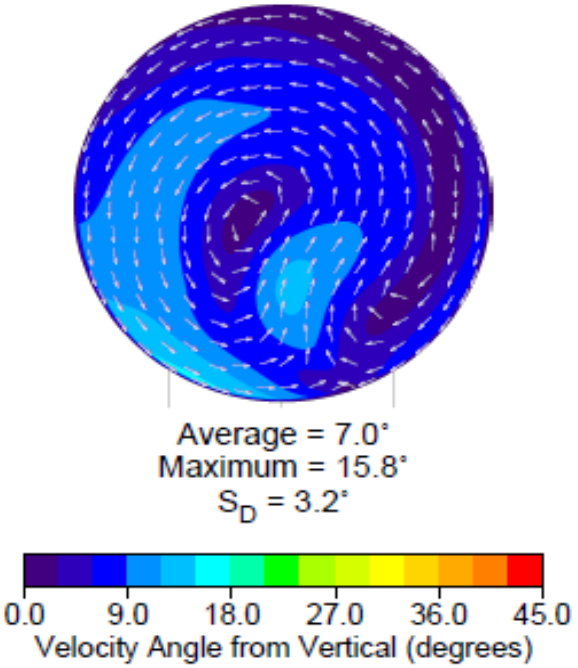
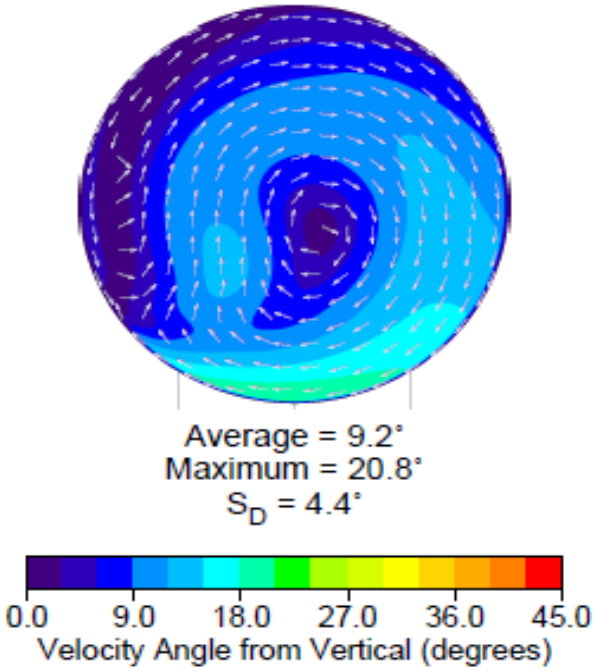
Case 3 Modules AC Verses AB

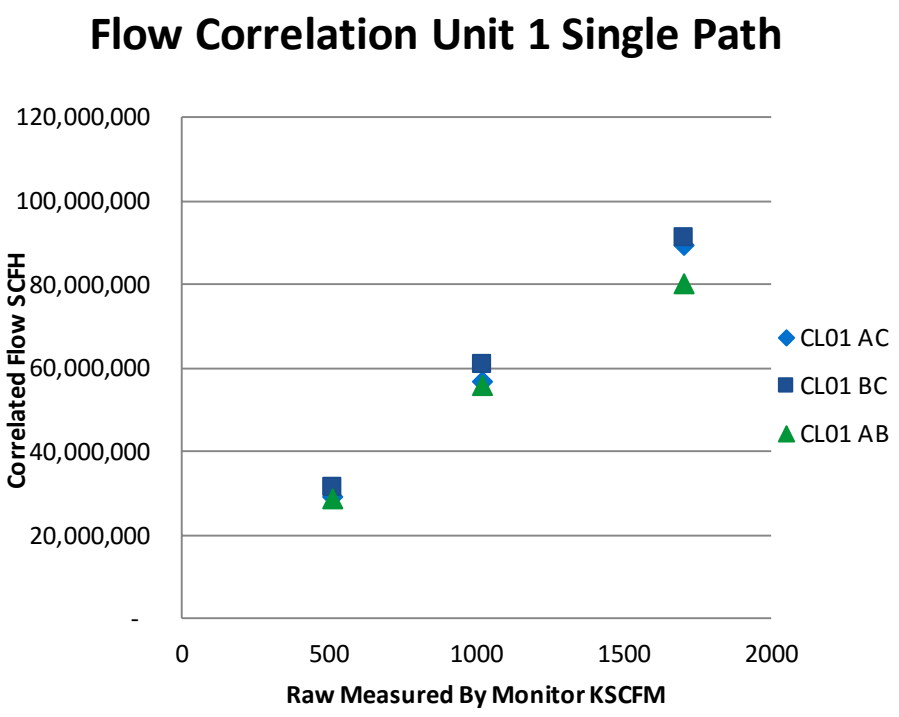


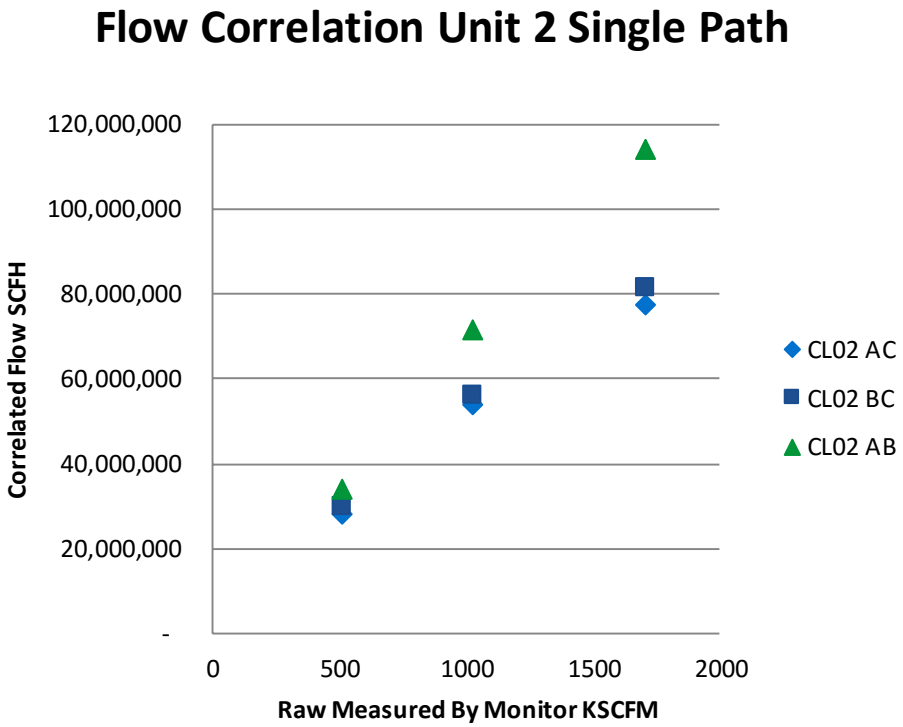


Case 3 Flow Monitoring

- 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





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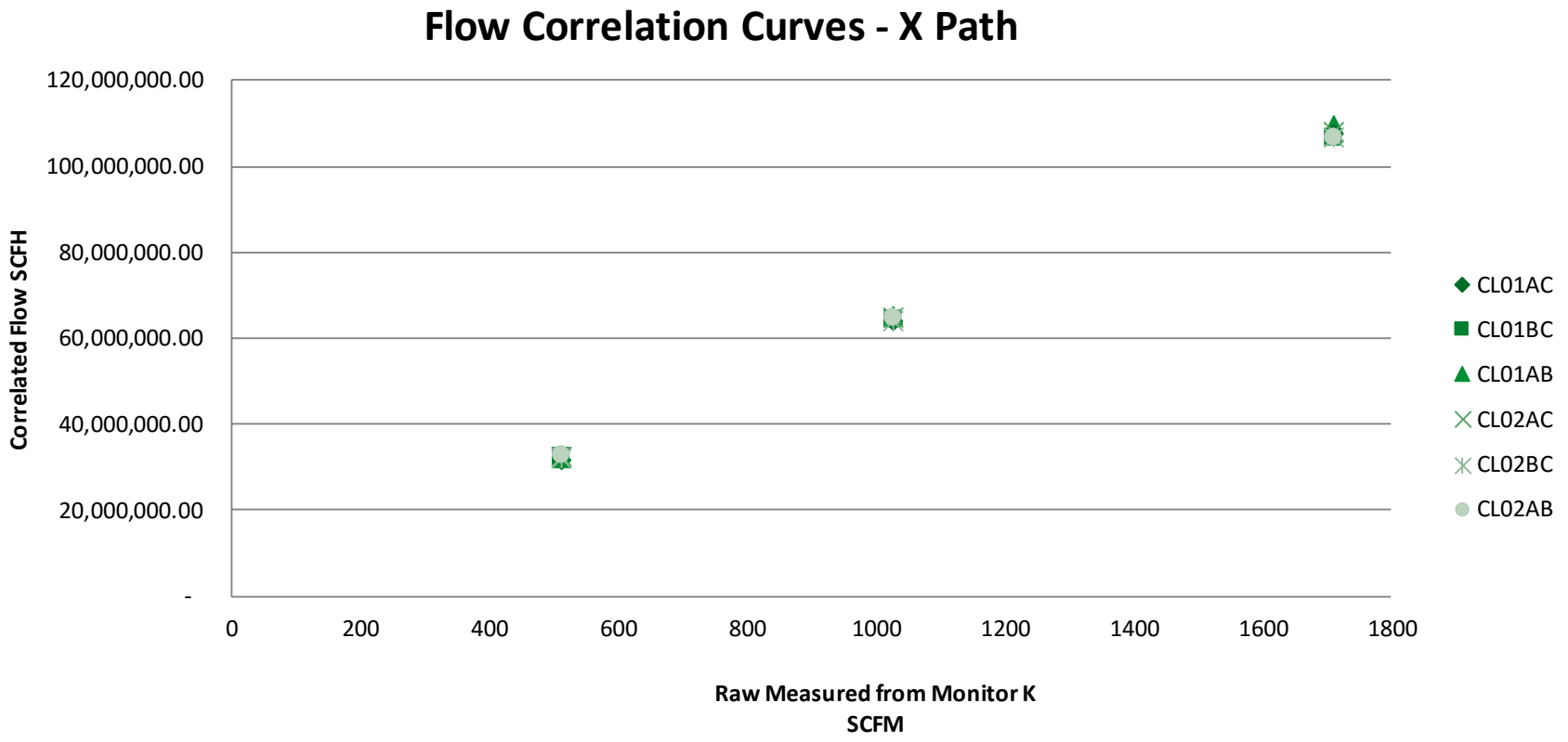
Case 3 Flow Monitoring

- Replaced Flow Monitor – Teledyne Ultaflow 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



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