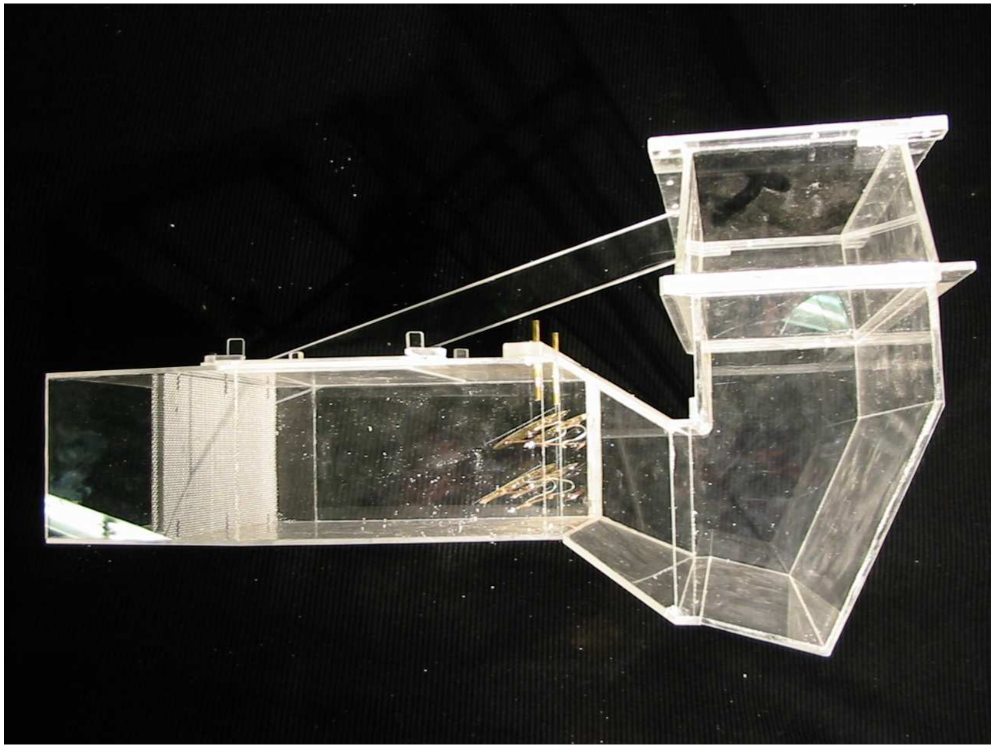
Babcock Power Environmental Inc.

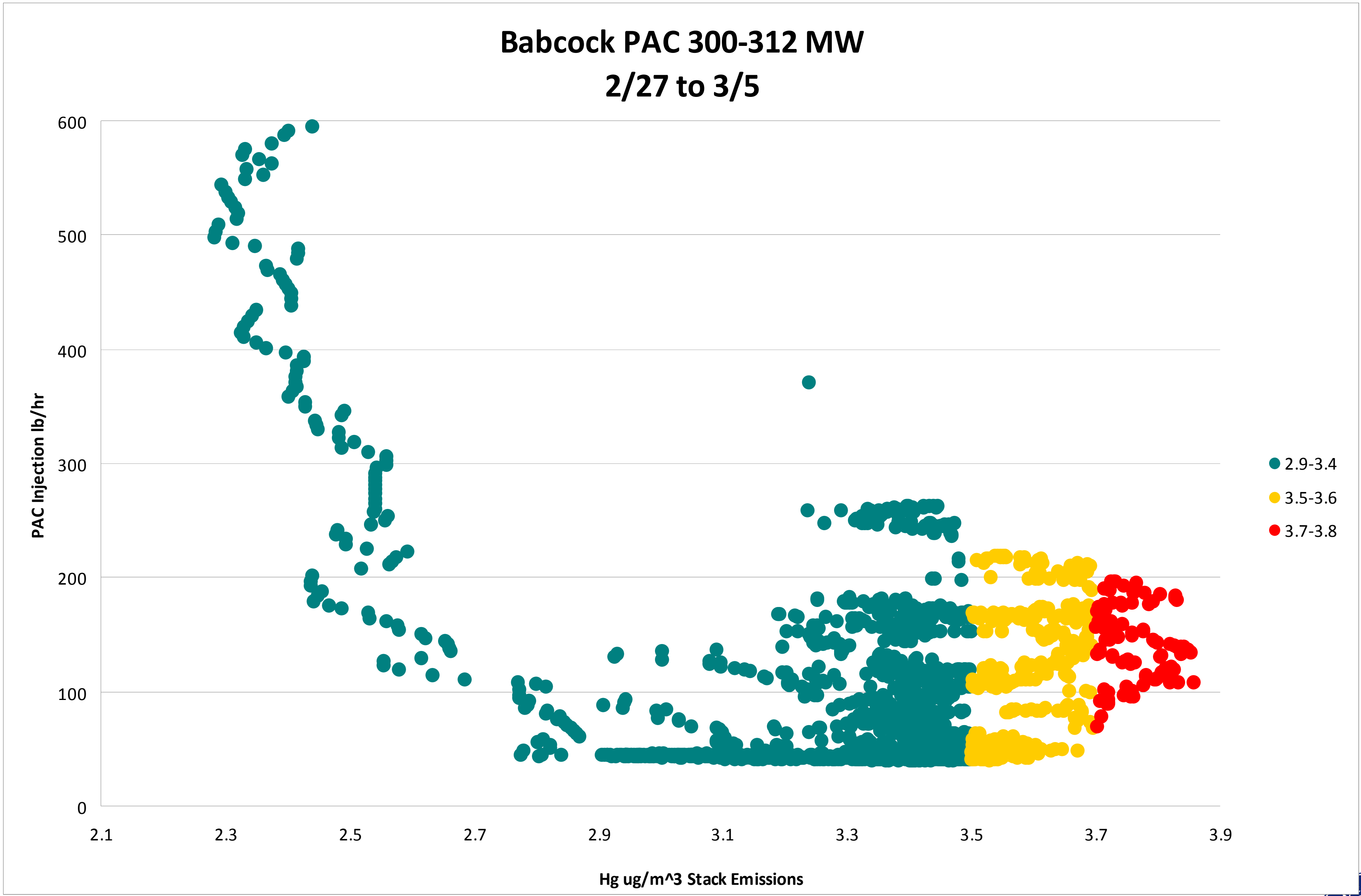


Impact of Mixing on Performance of Dry Sorbent Injection/Activated Carbon

Tony Licata

Introduction

- How do we achieve lower emissions of Hg and SO_3?
- What is the impact of mixing on sorbent usage?
- What tools are available to predict performance?



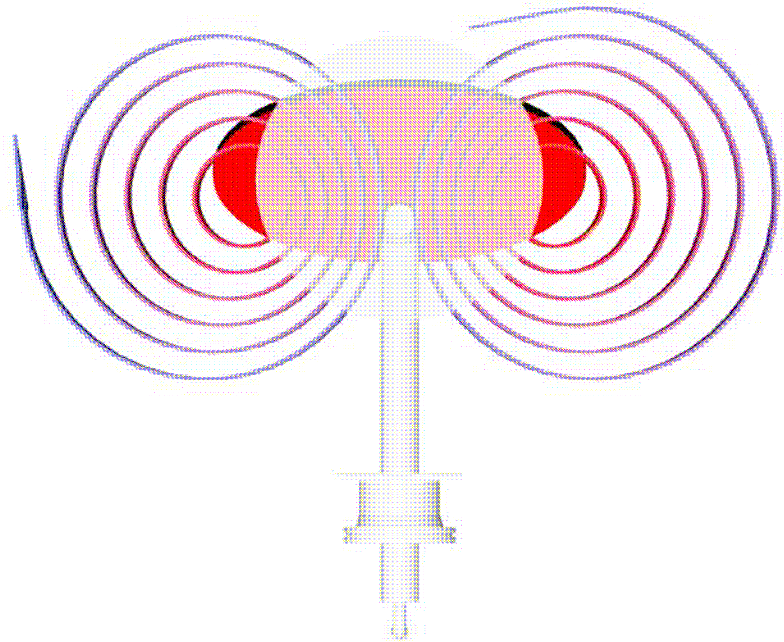
Babcock PAC 300-312 MW
2/27 to 3/5
600
500
400
300
200
100
0
PAC Injection lb/hr
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
Hg ug/m^3 Stack Emissions
2.9-3.4
3.5-3.6
3.7-3.8

Study Object

- Modeling study will provide a design to improve the RMS (distribution) of sorbent in the flue gas that will enhance Hg or SO_3 removal.
  - Improved mixing increases NTUs which allows system to maintain higher removals and higher sorbent utilization
  - Mixing required
    - Location and number of mixers
    - RMS<10%
- Use existing test and new modeling data to develop a model that will estimate:
  - Amount of sorbent required
  - Performance

RMS/NTUs Performance Predictions

- ESPs
- SCRs
- FGDs



Definition - Transfer of a gaseous component (absorbate) from the gas phase to a liquid (absorbent) phase through a gas-liquid interface

•Number of contact stages required to achieve a required % removal

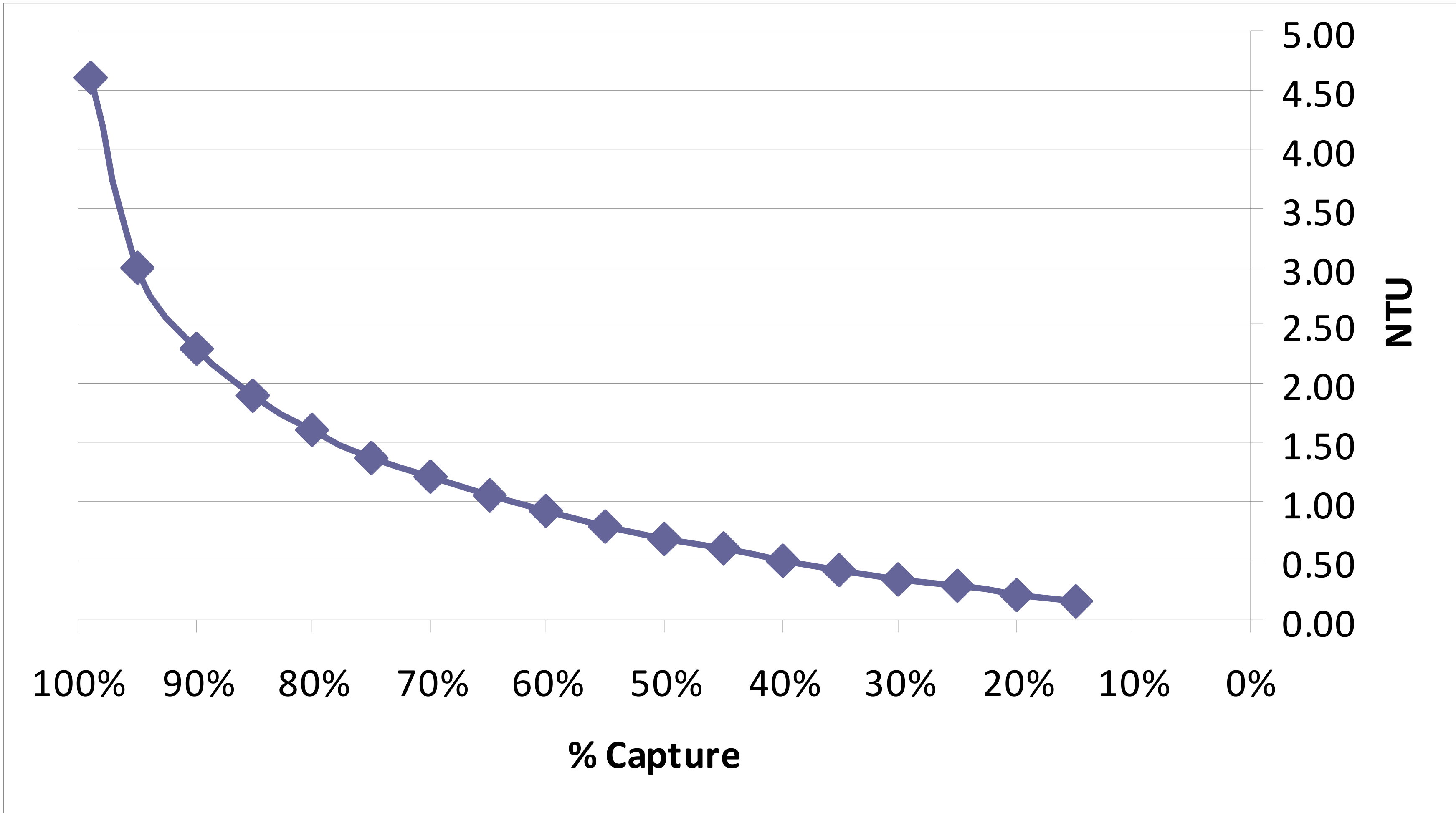
•Mixing increases contact or reduces required NTUs

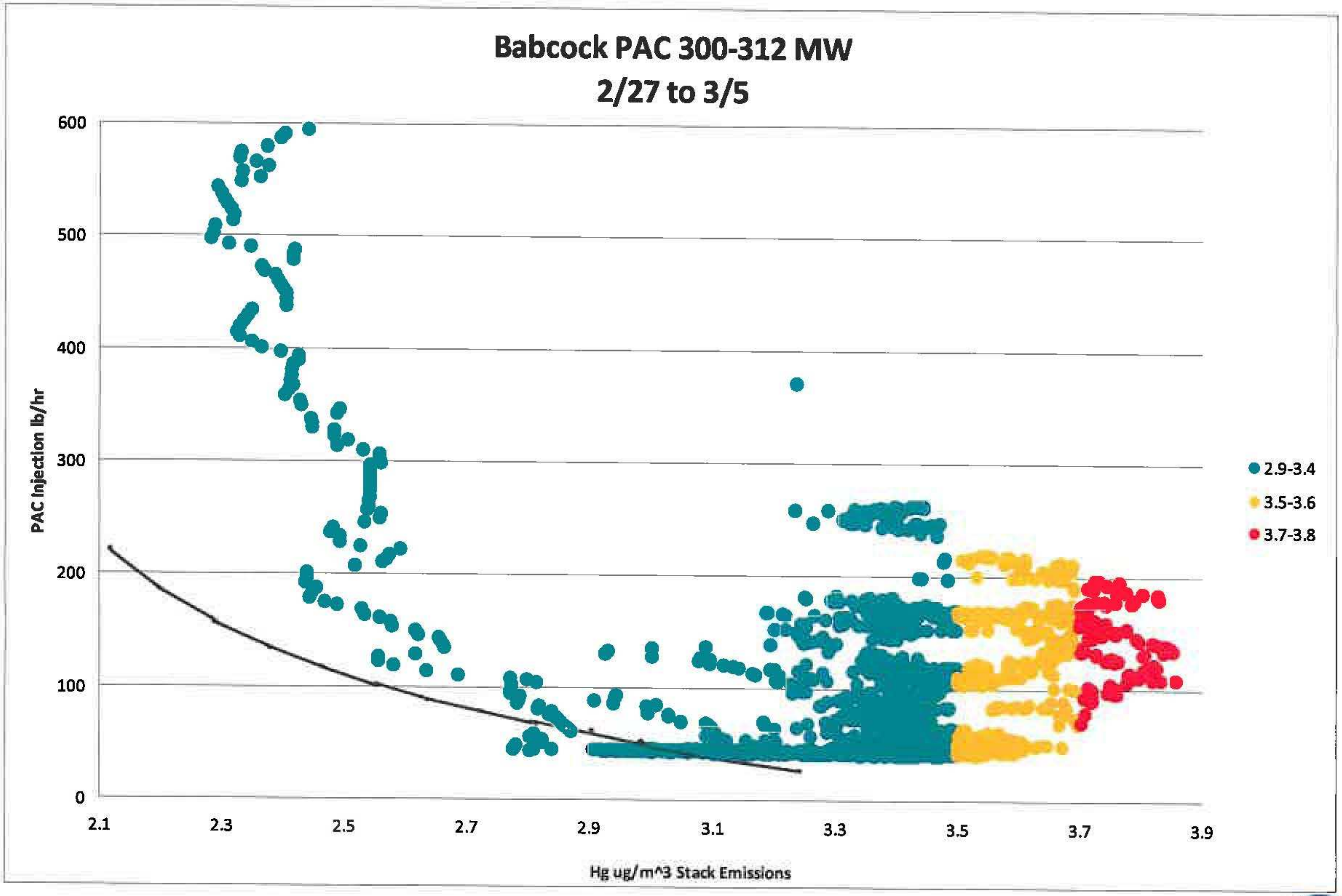
•Can relate RMS to NTUs completeness of mixing

•Improved mixing increases NTUs which allows system to maintain higher removals and relatively high utilization of sorbents

NTU vs. % Capture

NTU = - Ln (1-% removal)

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Hg ug/m^3 Stack Emissions
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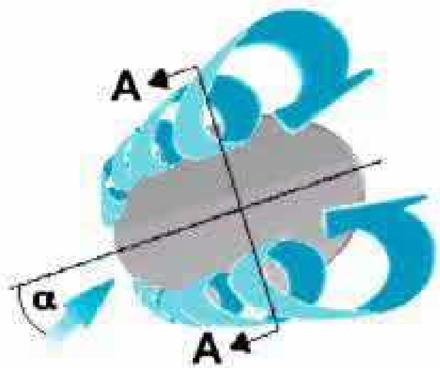
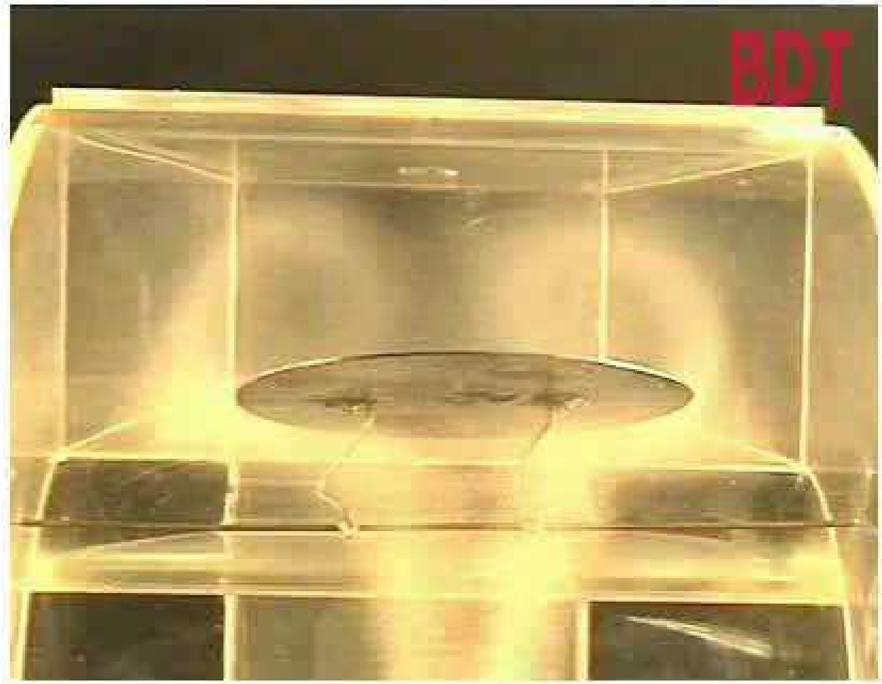
Static gas mixer

SGM for mixing of gas:

- concentrations
- temperatures
- volume flows





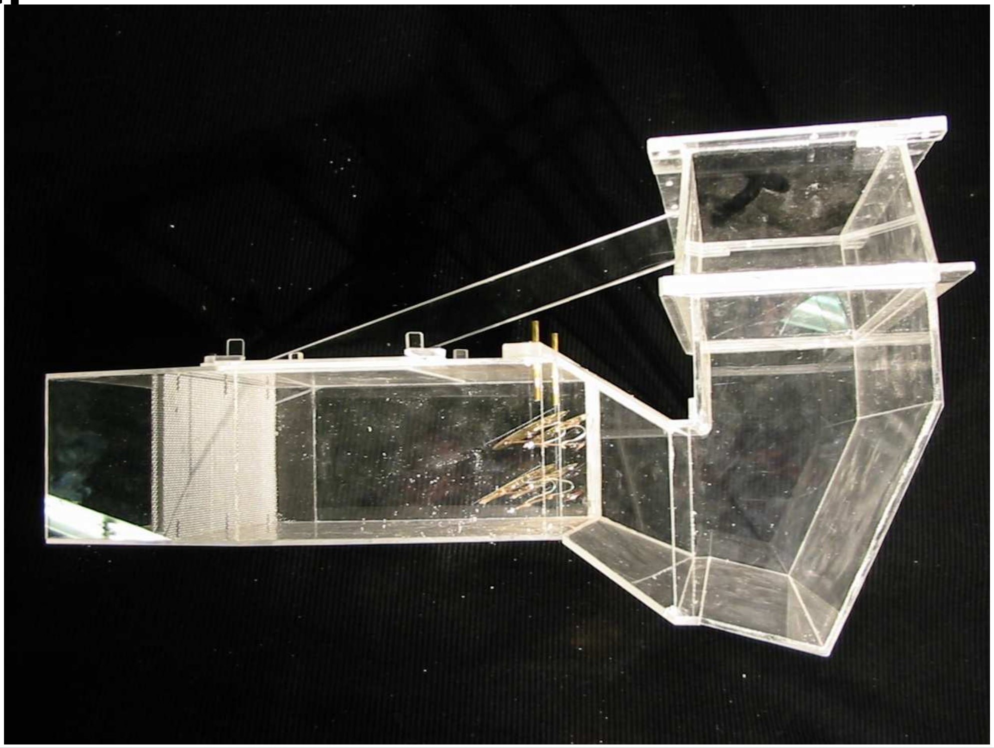
Section A - A
Vortices generated on plate edges

Working principle:

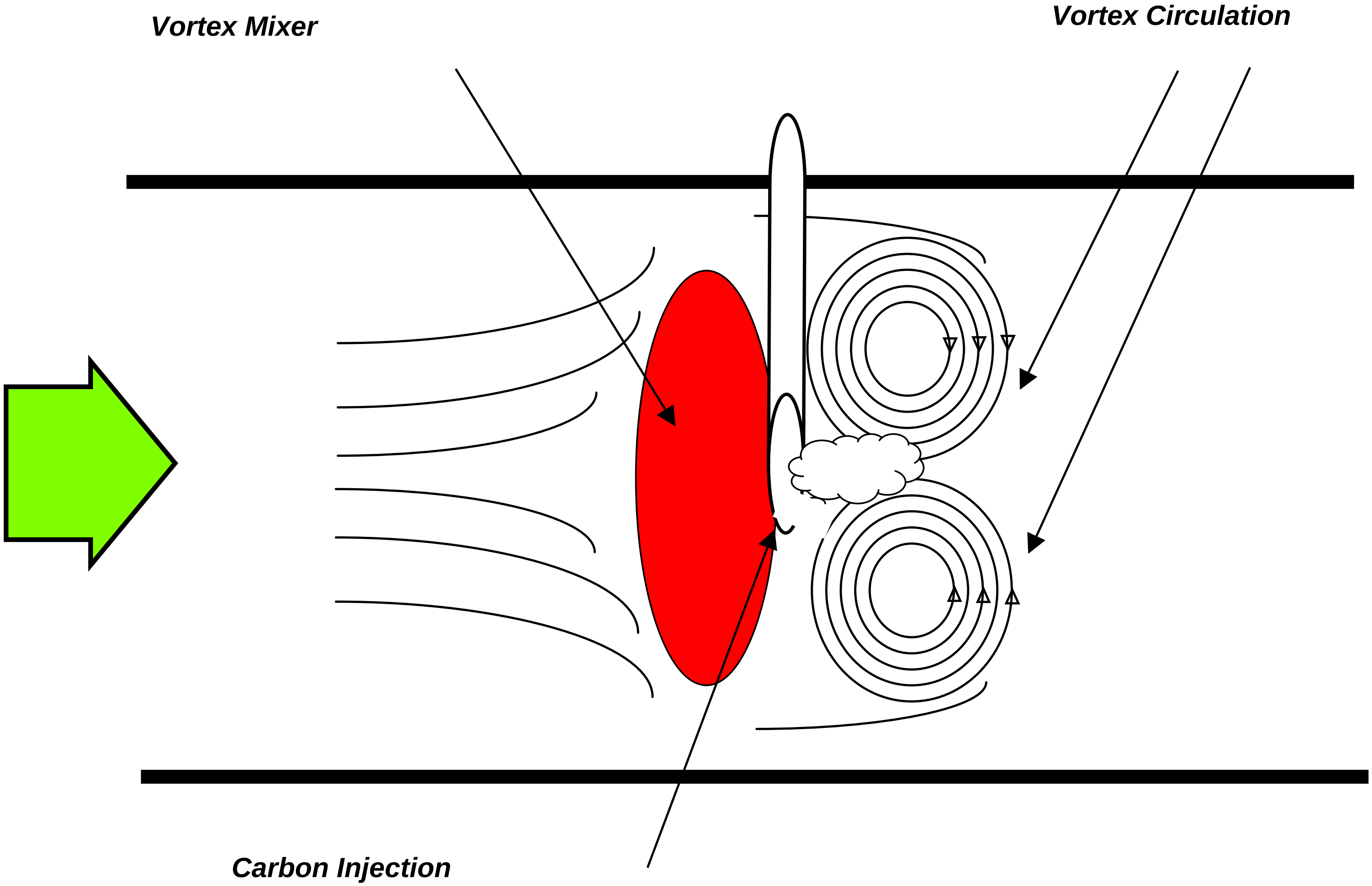
leading egde vortices created by gas flows arriving at shaped plates under an angle of attack generate turbulences for mixing purposes

Static Mixer

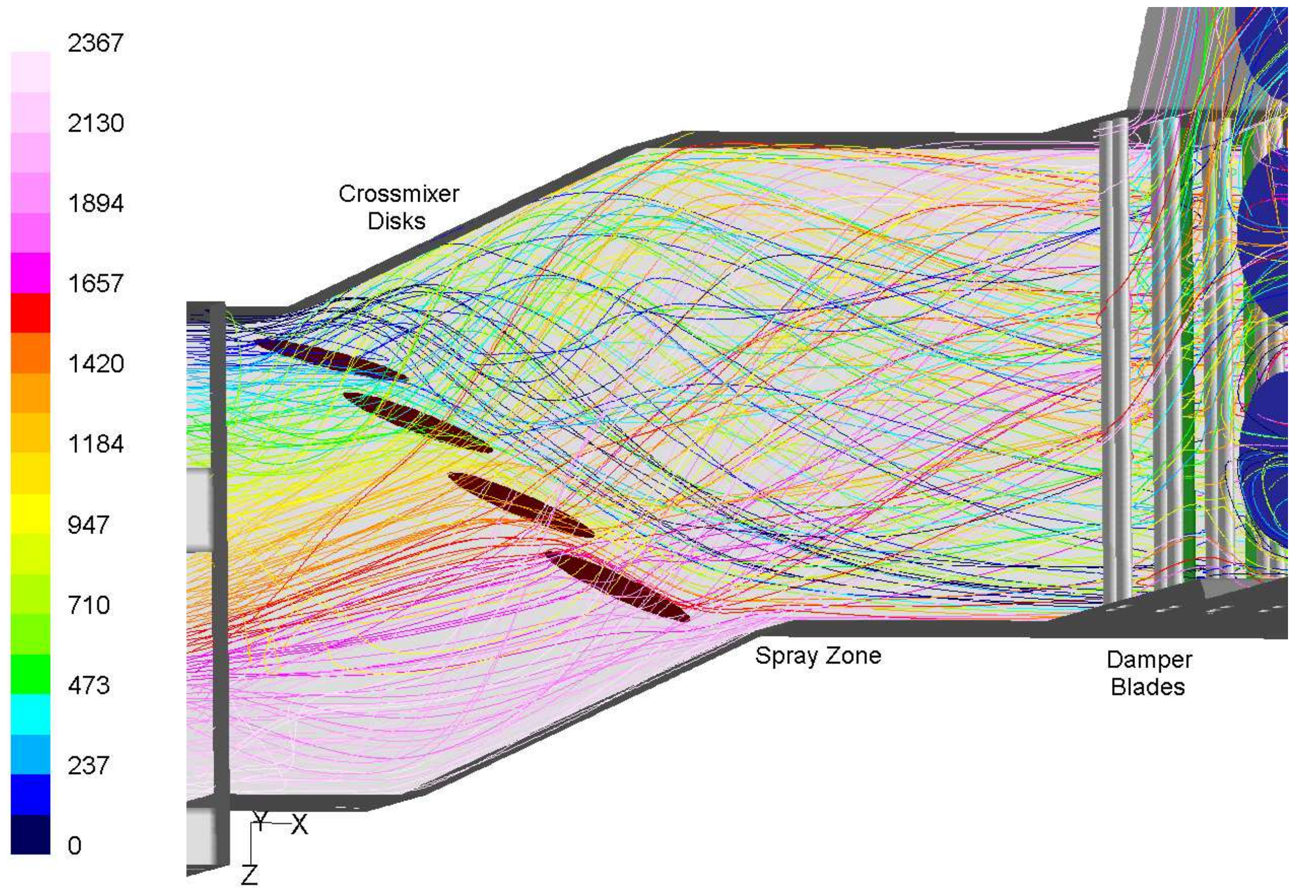
- Delta Wings Can either be used to direct inject sorbent or as cross mixers after injection to achieve optimum mass transfer



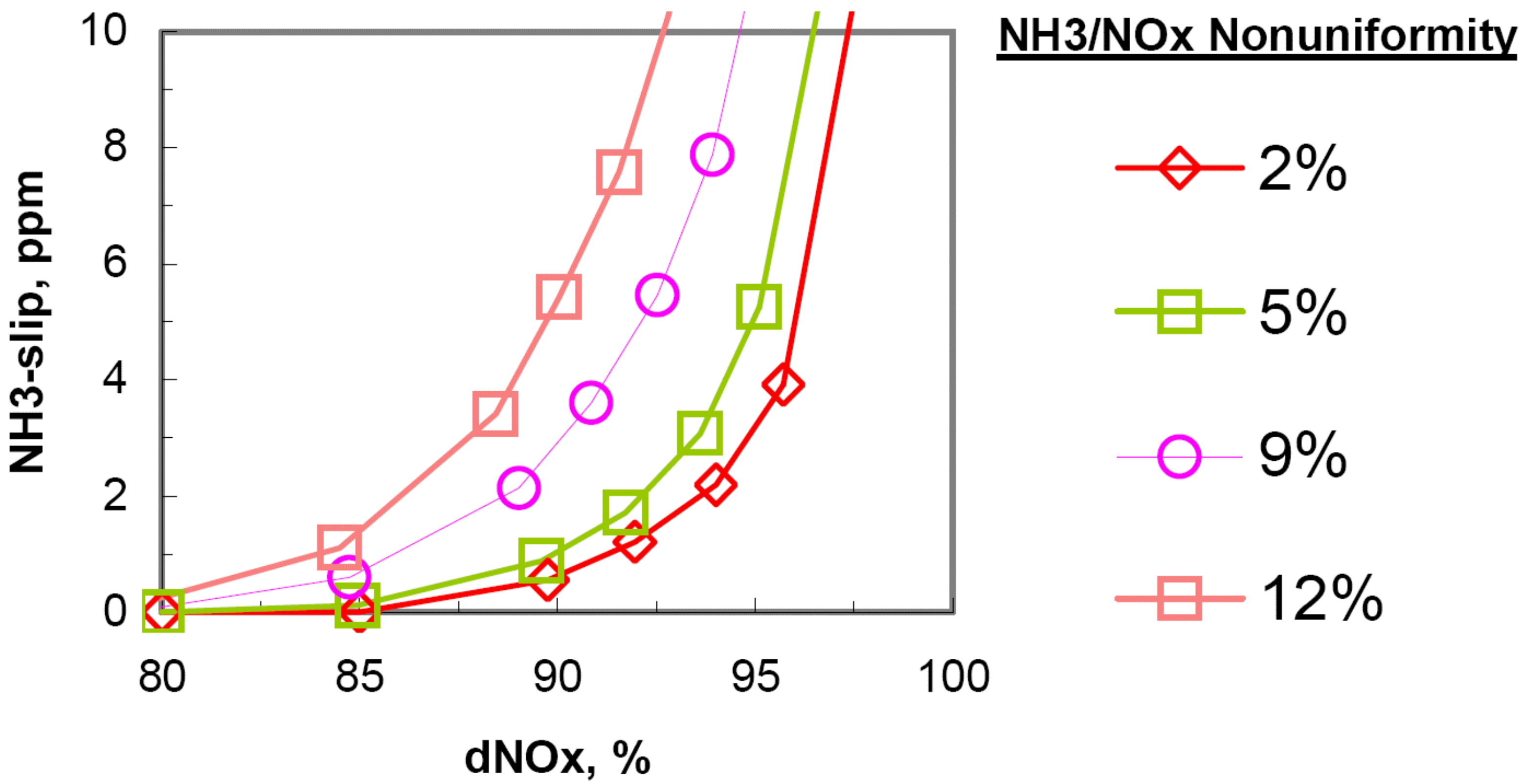
Direct Injection



Cross Mixers

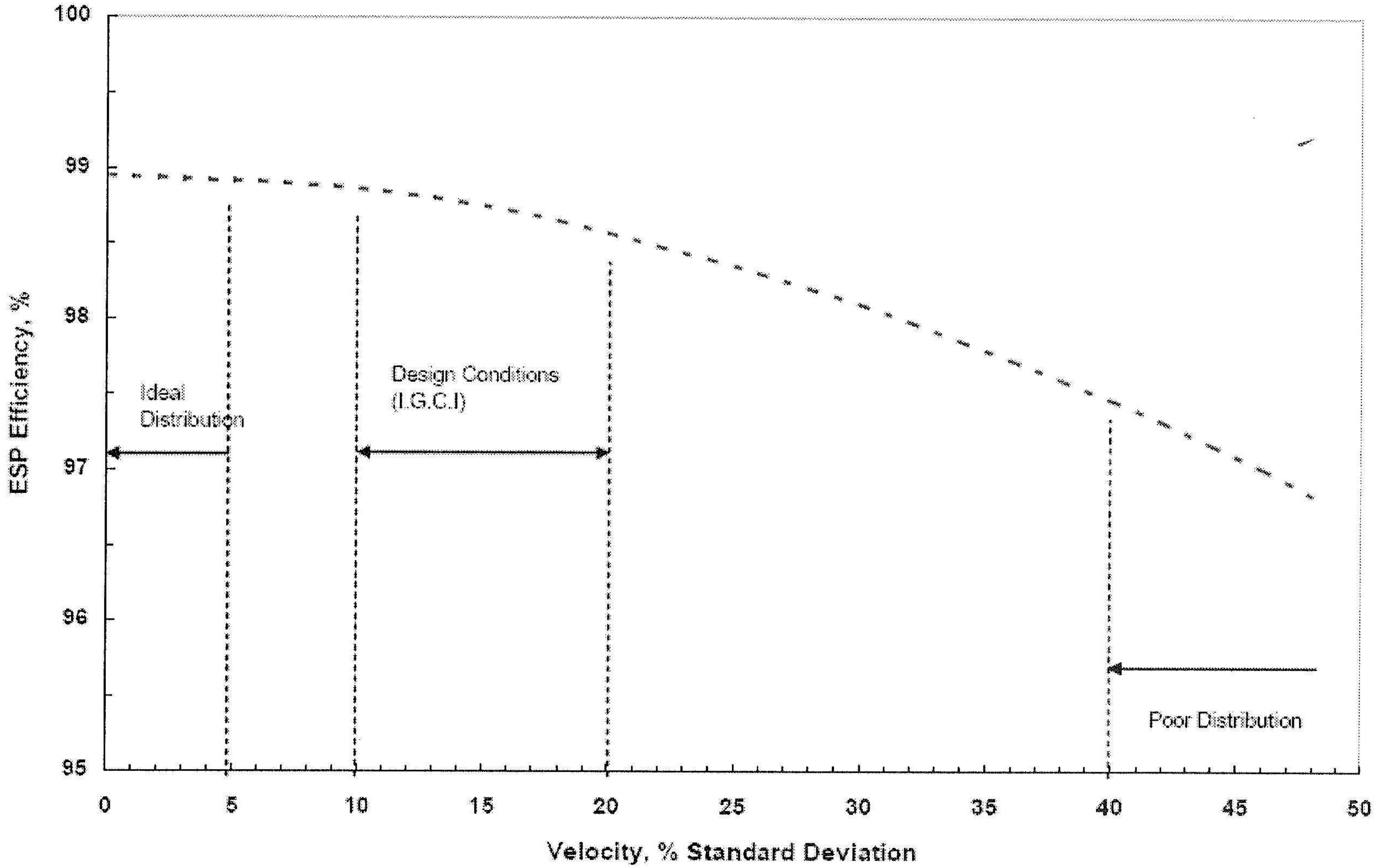


Impact of RMS on NH_3 Slip

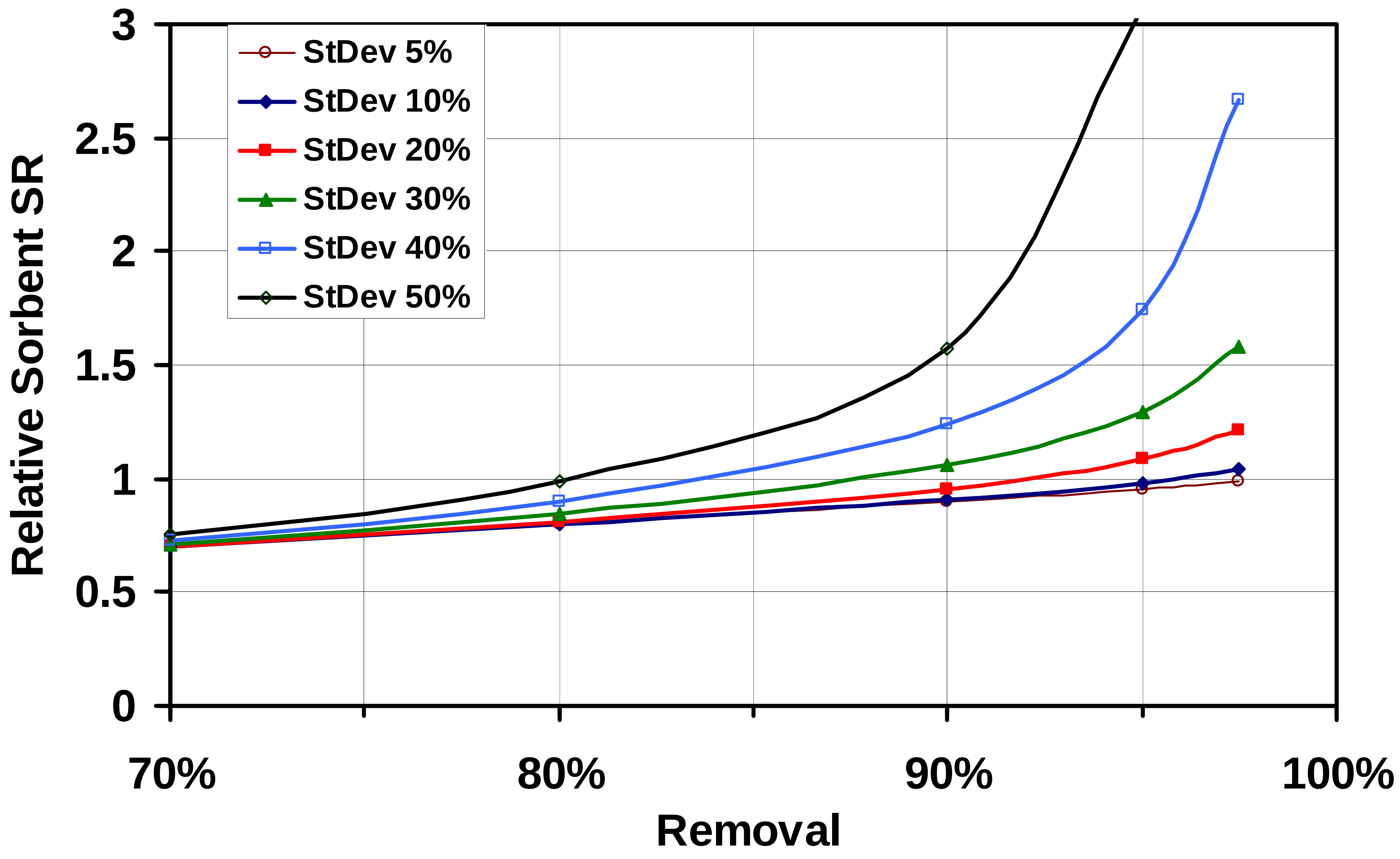


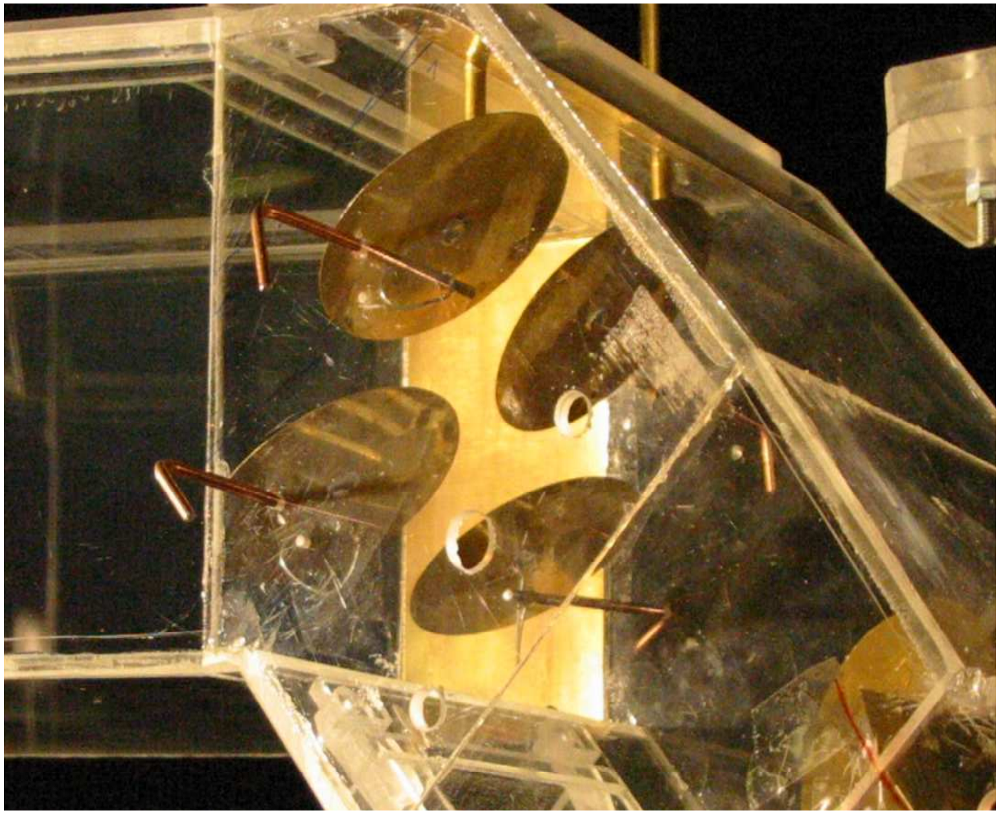
Source of data - FERCO Engineering

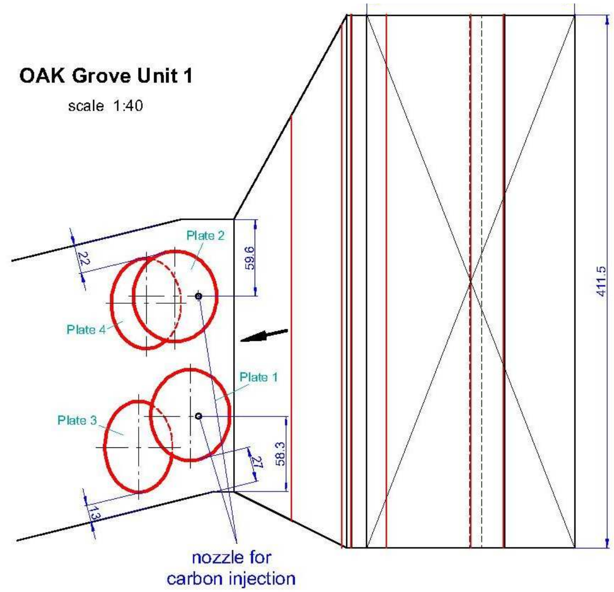
Impact of RMS on ESP Performance

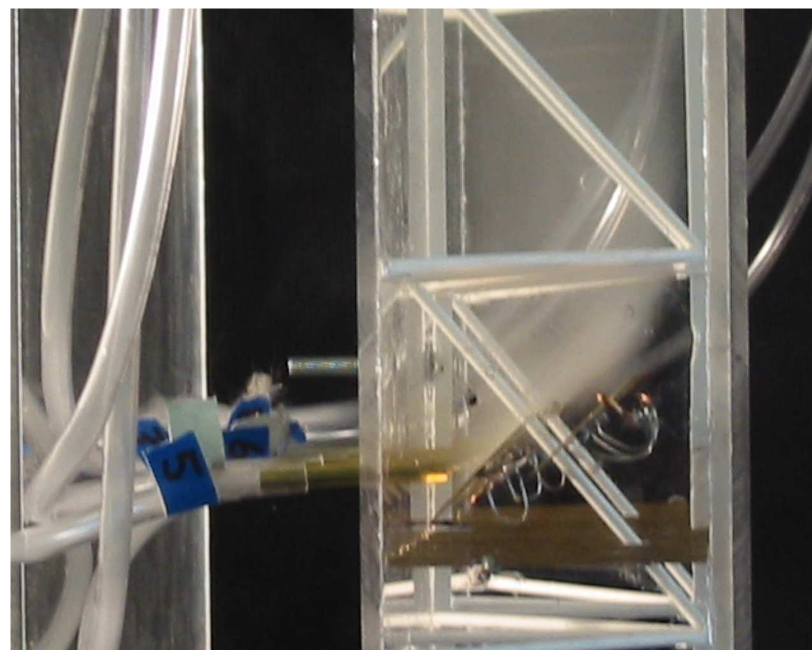


Mixing-Limited Sorbent Requirement






OAK Grove Unit 1
scale 1:40
Plate 2
Plate 4
Plate 1
Plate 3
22
59.6
411.5
27
58.3
13
nozzle for
carbon injection



Delta Wing® Modeling Case II Study

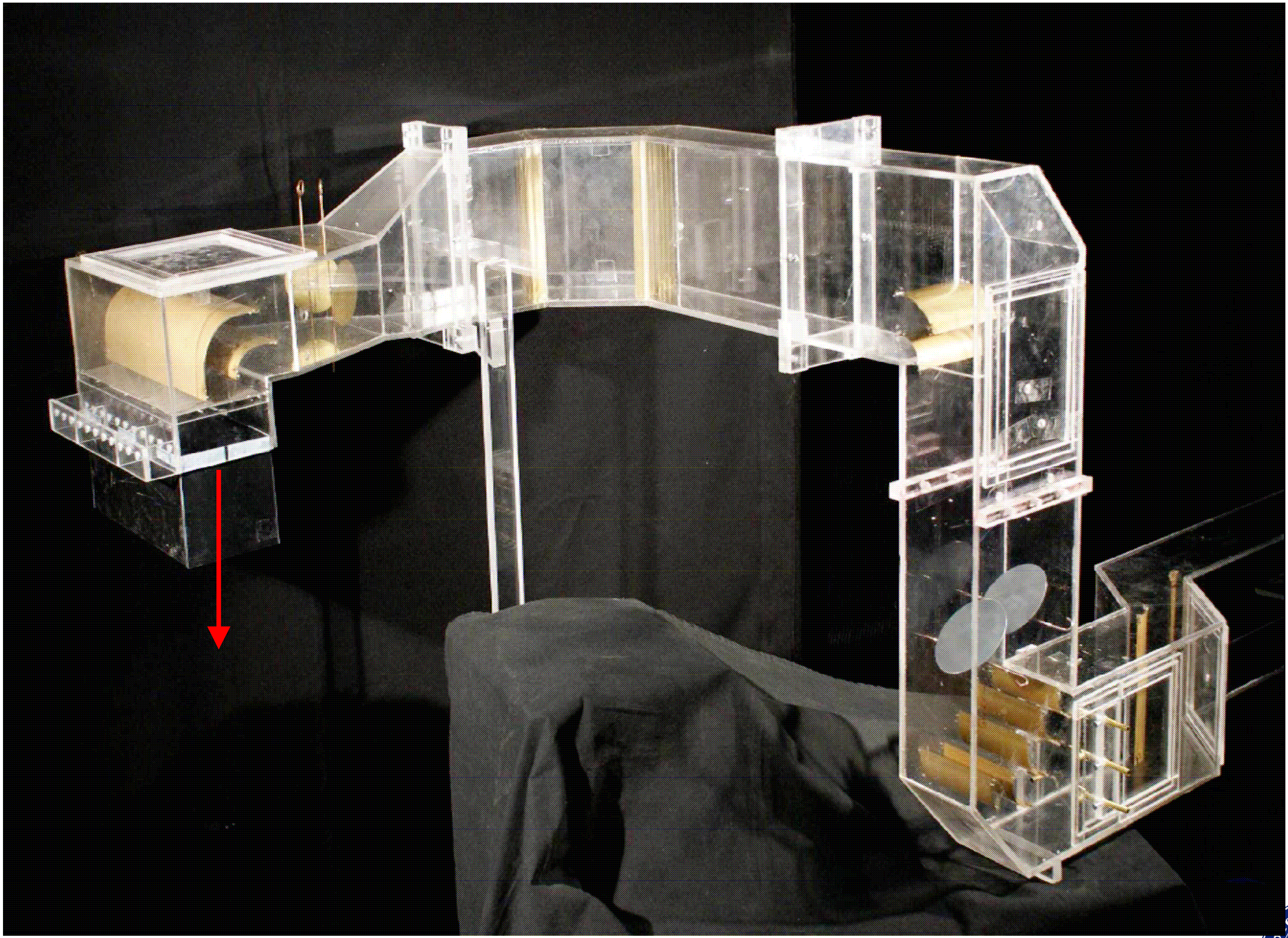
Description: Duct A sorbent injection upstream of hot ESP, long straight duct with 2 – 45° elbows and expansion section to ESP 6 injection nozzles

Without Delta Wing Mixers	With Delta Wing Mixers
RMS = 15.6%	RMS = 1.5%
Max. Deviation	Max. Deviation
+23.8%	+3.0%
-36.2%	-2.3%

Delta Wing® Modeling Case II Study

Description: Duct B Air heater outlet to ESP inlet, 8 injection nozzles, 3 - 90o elbows & 2 - 45o bends

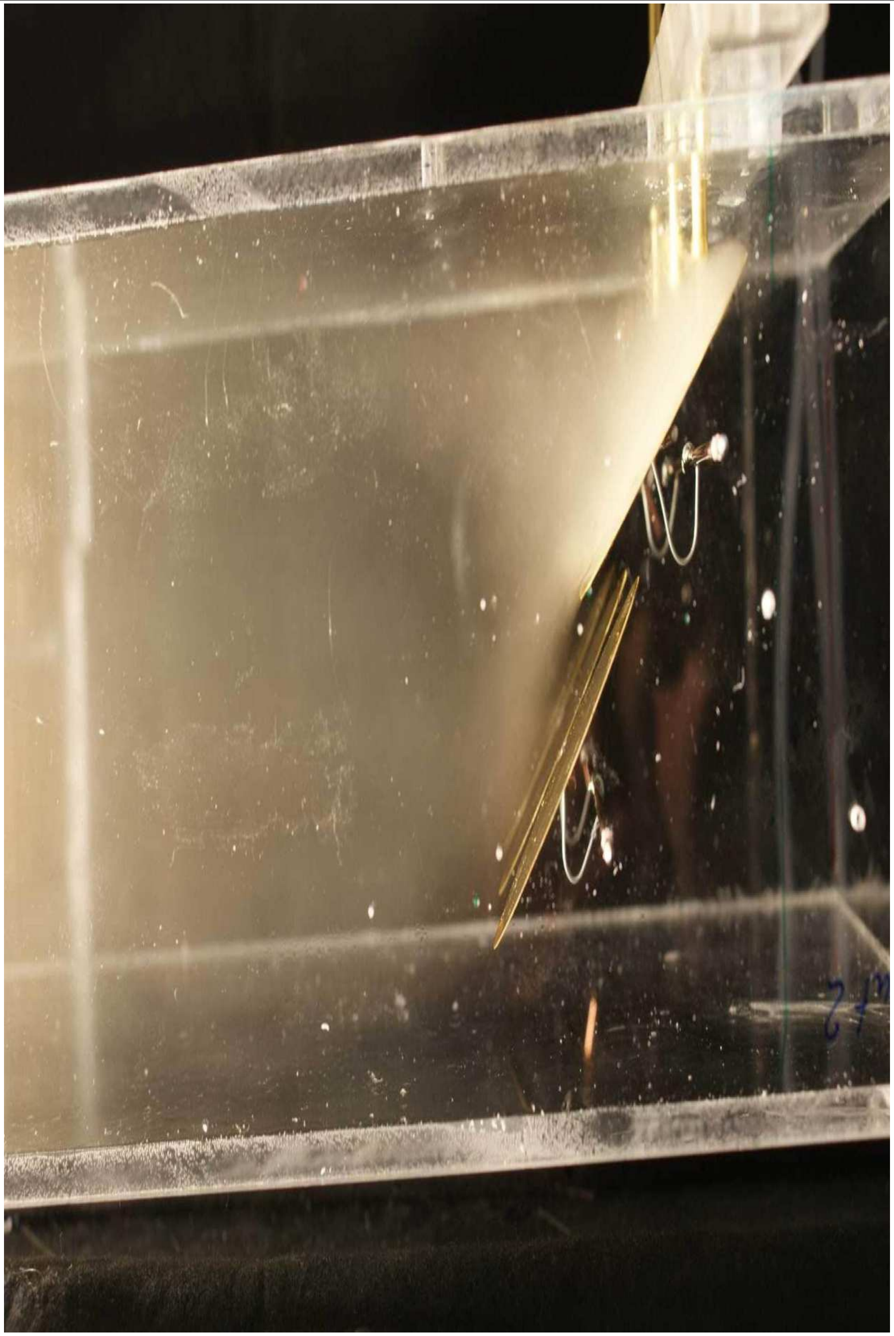
Without Delta Wing Mixers	With Delta Wing Mixers
RMS = 22.4%	RMS = 2.2%
Max. Deviation	Max. Deviation
+24.4%	+5.7%
- 58.5%	-2.7%



Delta Wing® Modeling Case III Study

Description; Air heater outlet with short duct to expanding ESP inlet

Without Delta Wing Mixers	With Delta Wing Mixers
RMS = 15.4%	RMS = 5.7%
Max. Deviation	Max. Deviation
+36.7%	+ 10.0%
-29.7%	- 12.0%

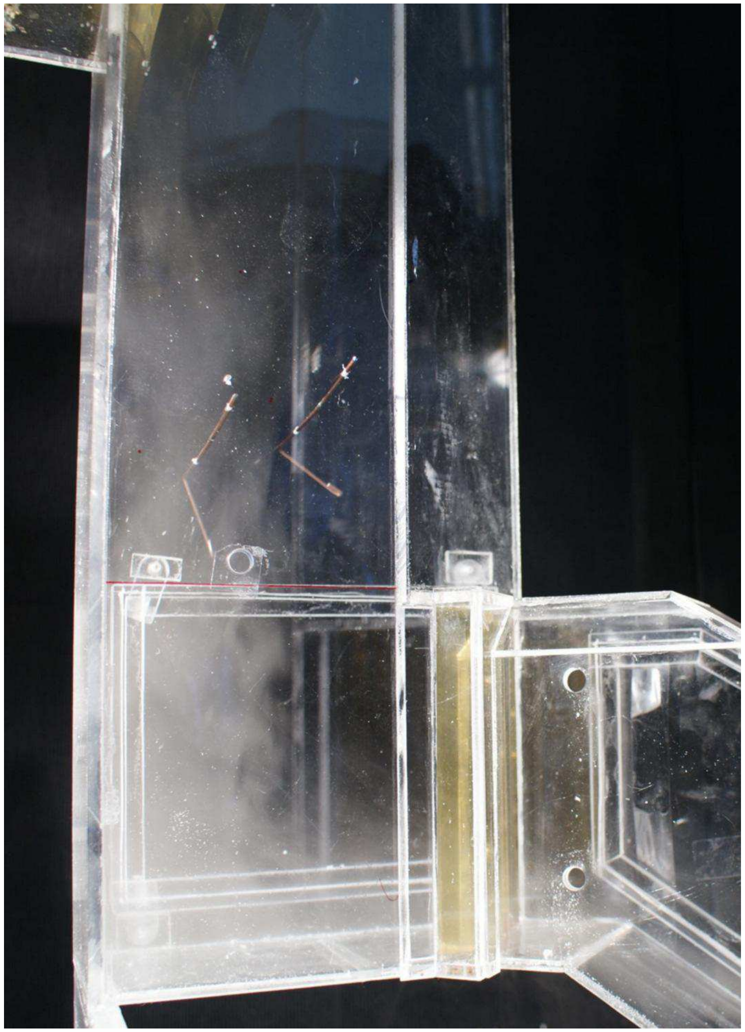


Full duct mixing with Delta Wing® cross mixer

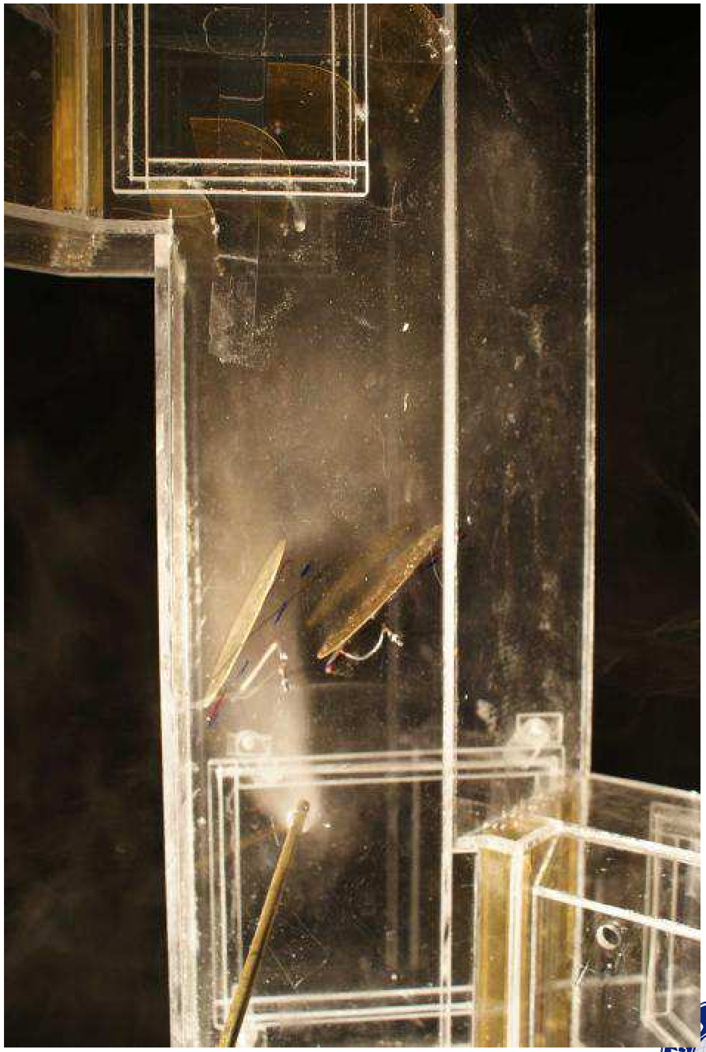
Delta Wing is a proprietary technology provided under license to Babcock Power from Balcke Dürr

Sorbent Injection

W/O Mixers



With Mixers



Observations

- Low RMS required to meet high performance levels
- Lowering RMS reduces sorbent usage
- RMS + (NTUs) predictive tool
- Physical modeling faster and more accurately predictive performance than CFD
- Delta Wing mixers can be used to lower RMS

Thank You

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