Worldwide Pollution Control Association

WPCA/TVA

Coal & Gas Seminar

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Mixing Issues and Lessons Learned

Robert Mudry, P.E.
Airflow Sciences Corporation
rmudry@airflowsciences.com
734-525-0300

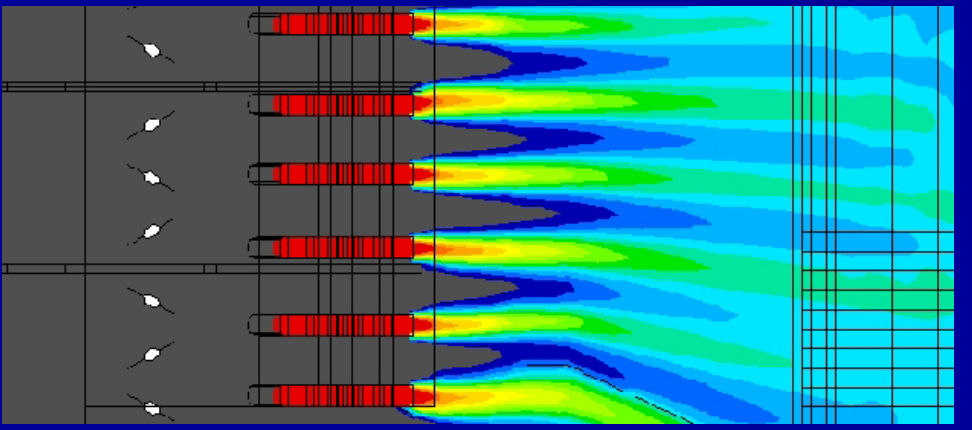
From Webster's Dictionary

Mix (verb):

(1) : to combine or blend into one mass
(2) : to combine with another
(3) : to bring into close association
(4) : to form by mixing components
(5) : to confuse -- often used with *up*

How Do You Mix?

- Control the flow streams at the merger location
  - Multi-point injection
  - Layered injection
- Churn up the flow after the merger
  - Induce turbulence
  - Create shear forces
  - Generate swirl or vortices



Ammonia-to-NOx Ratio

- Ammonia-to-NOx ratio at the catalyst inlet plane should be “uniform”
- Typical goal is %RMS < 5%
- Allows optimal NOx reduction with minimum NH3 slip

NOx Stratification

- NOx is not necessarily uniform at the boiler exit; it is a function of
  - Boiler design
  - Burner air flow balance
  - Coal pipe balance
  - Mills out-of-service
- Solutions
  - Mix the NOx prior to the NH3 injection
  - Mix the NOx and the NH3
  - Tune the NH3 to the NOx profile

Ammonia Injection

- Two basic strategies are used for ammonia injection in SCRs
  - Dense grid of injection pipes
  - Coarse grid of injection pipes with mixers

Dense Grid Ammonia Injection

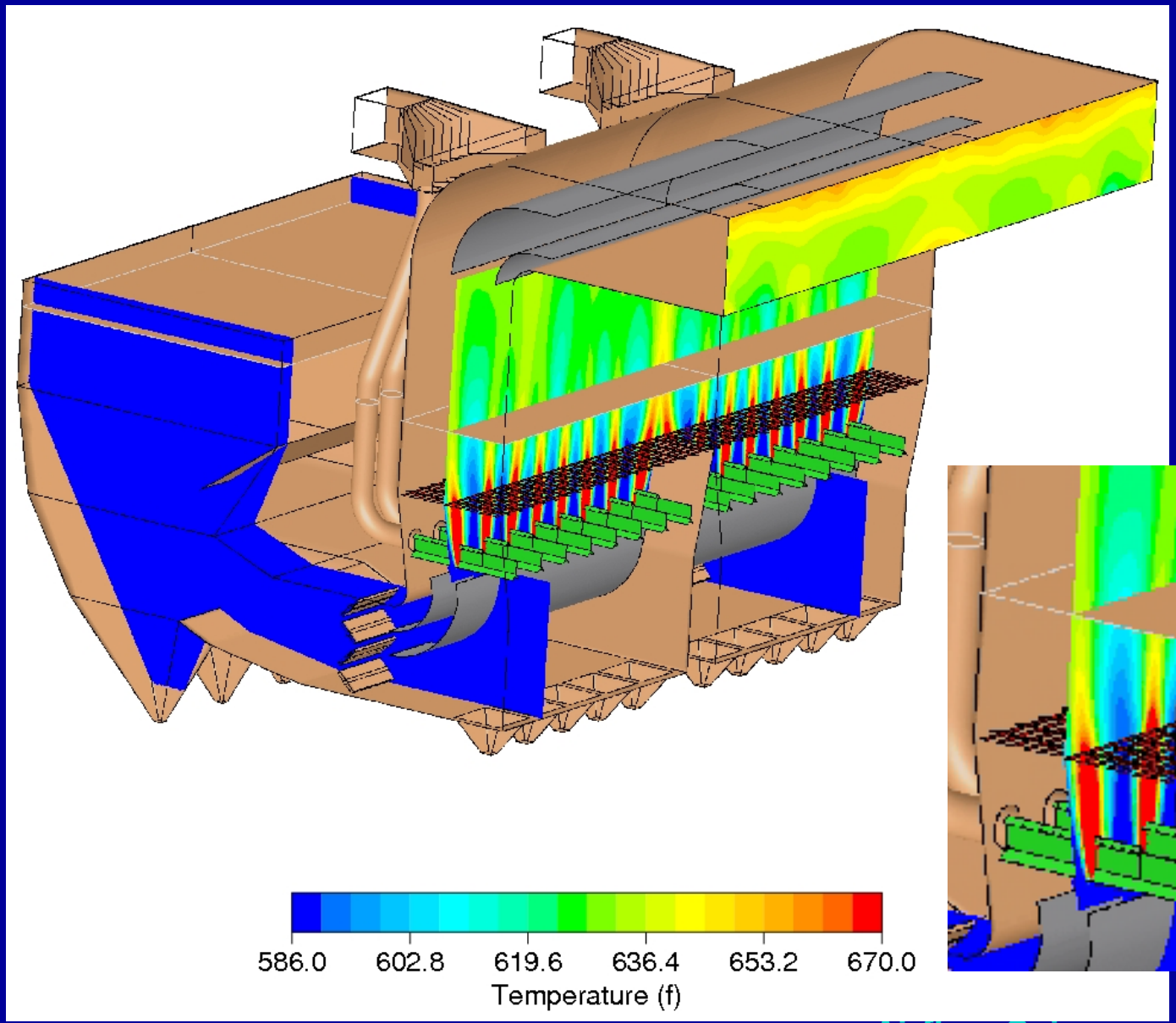
- Many injection lances with multiple nozzles per lance
  - Depending on SCR size, could have 50-200 lances per reactor inlet duct
  - Typically 6-10 nozzles per lance
  - Hundreds of discrete injection points
- Lances grouped into zones for tuning

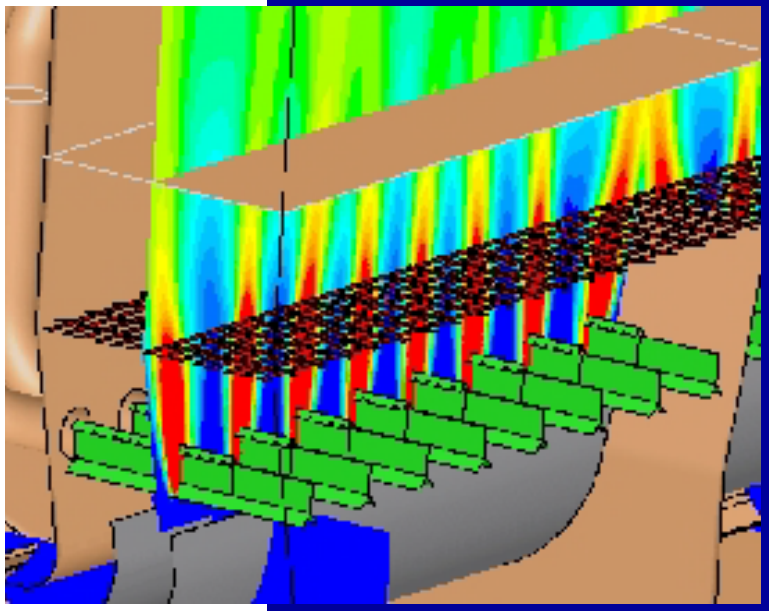
Coarse Grid Ammonia Injection

- Few injection lances with multiple nozzles per lance
  - Depending on SCR size, could have 5-30 lances per reactor
  - Typically 6-10 injection nozzles per lance
- Lances located immediately upstream of a static mixer
- Often multiple stages of static mixers
- Tuning possible but not as straight-forward due to purposeful creation of turbulence

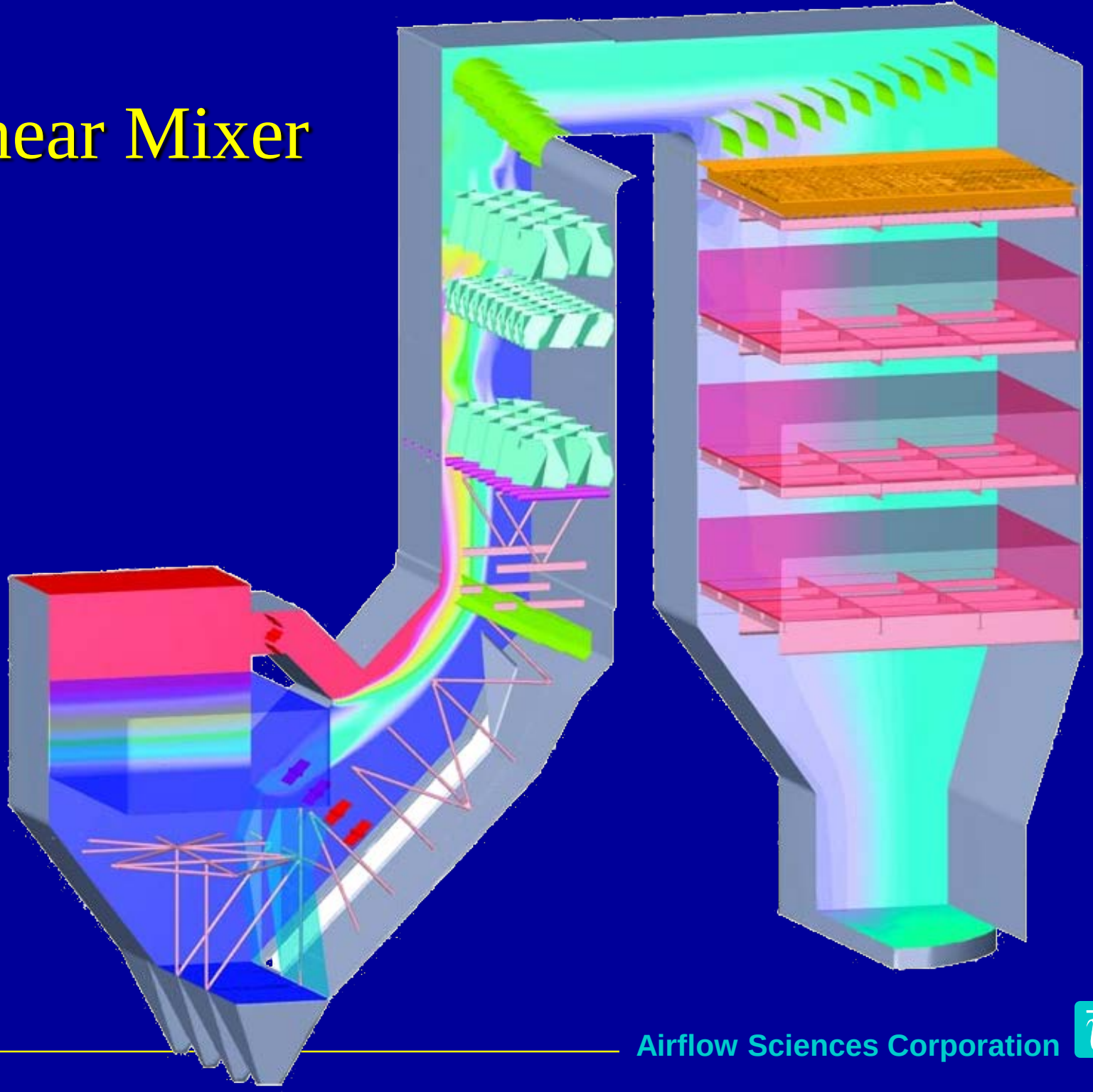
Shear Mixer

Shear Mixer

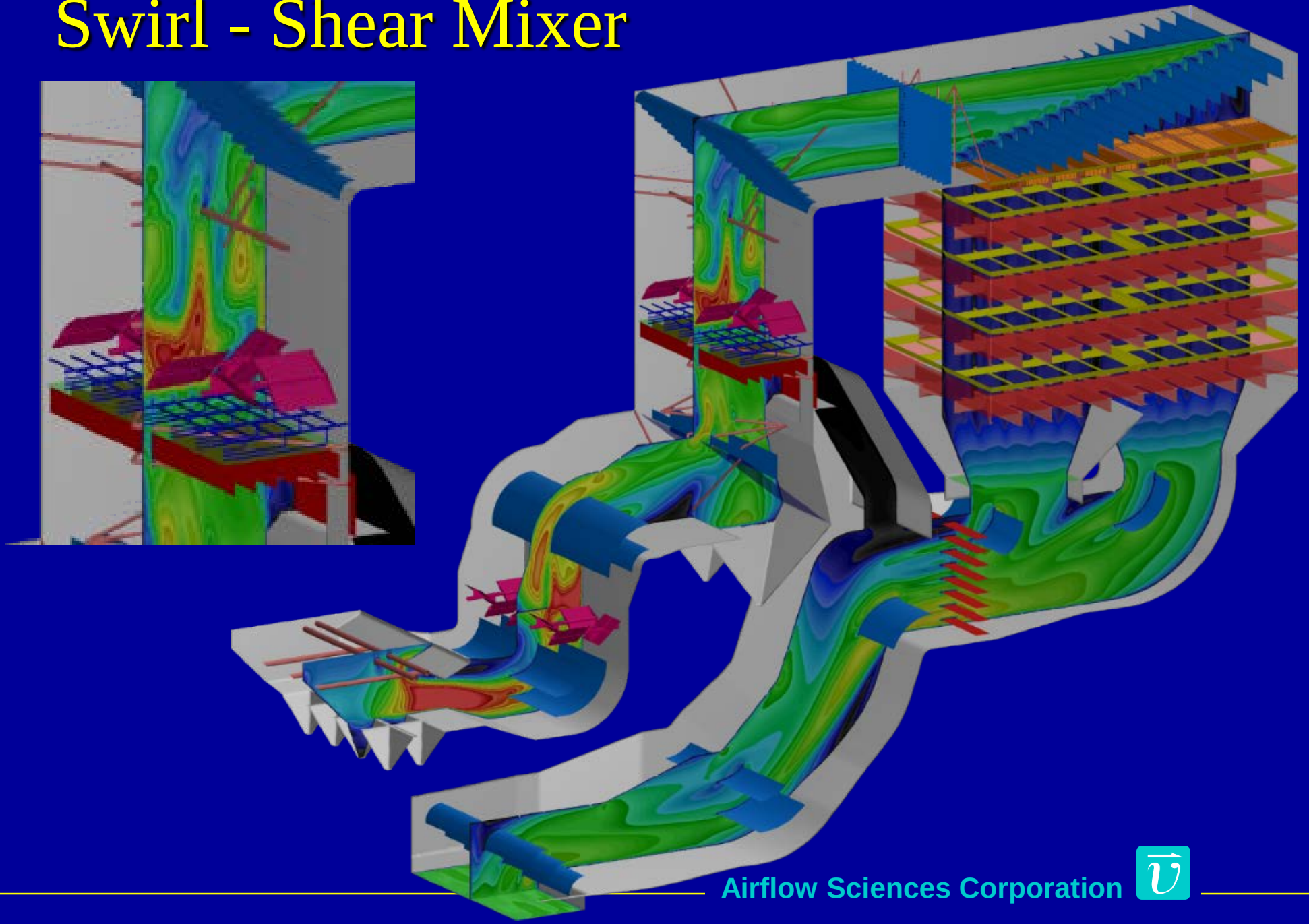




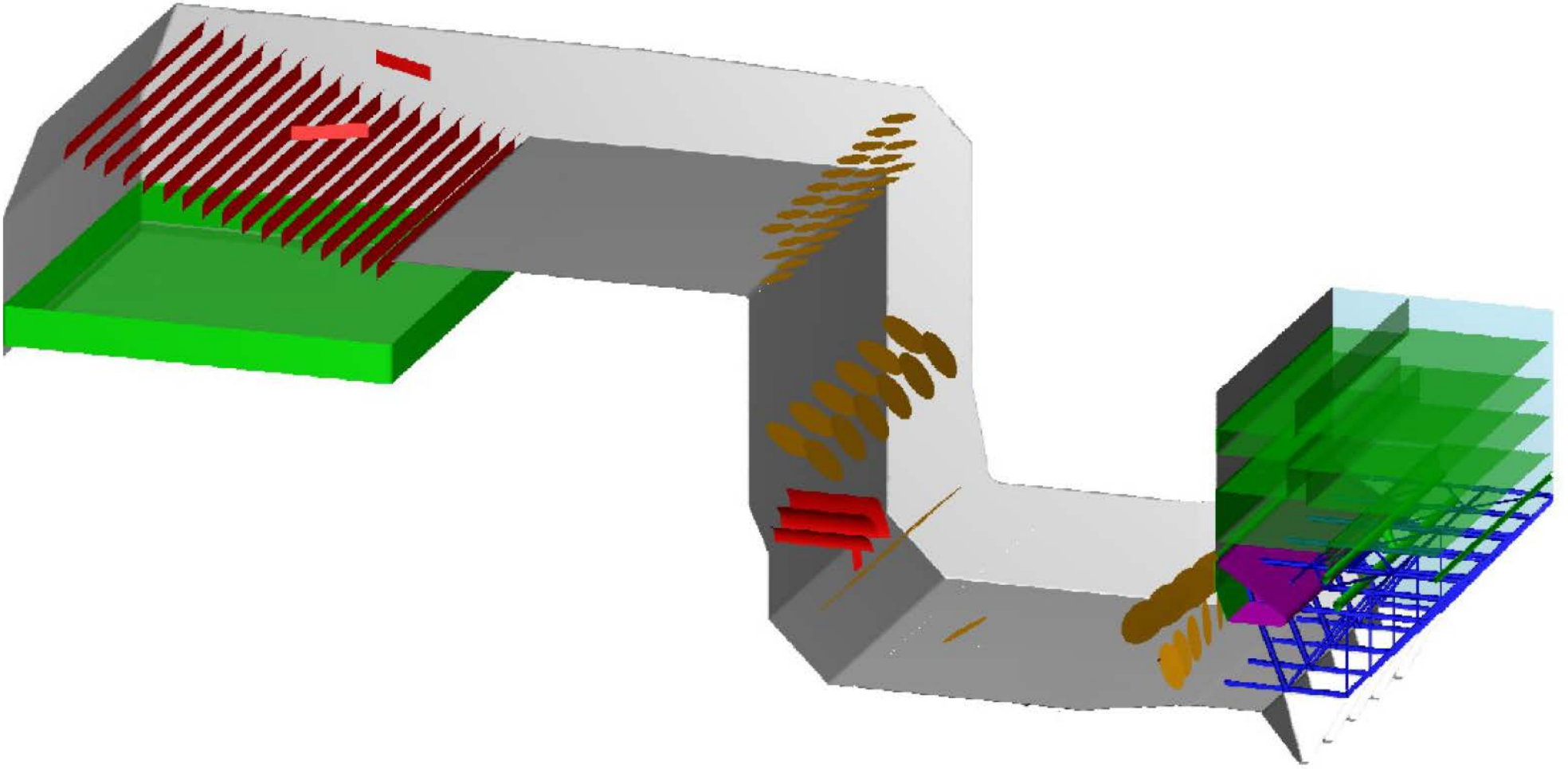
Shear Mixer



Swirl - Shear Mixer



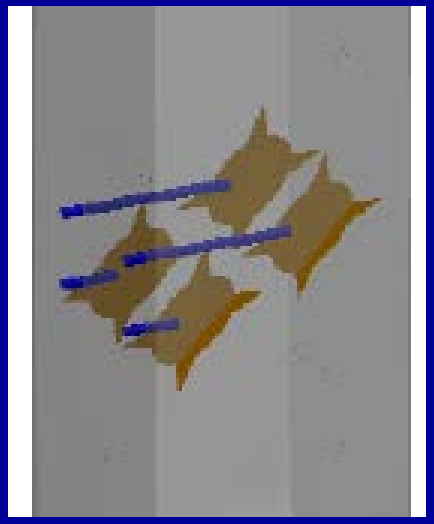
Vortex Mixer

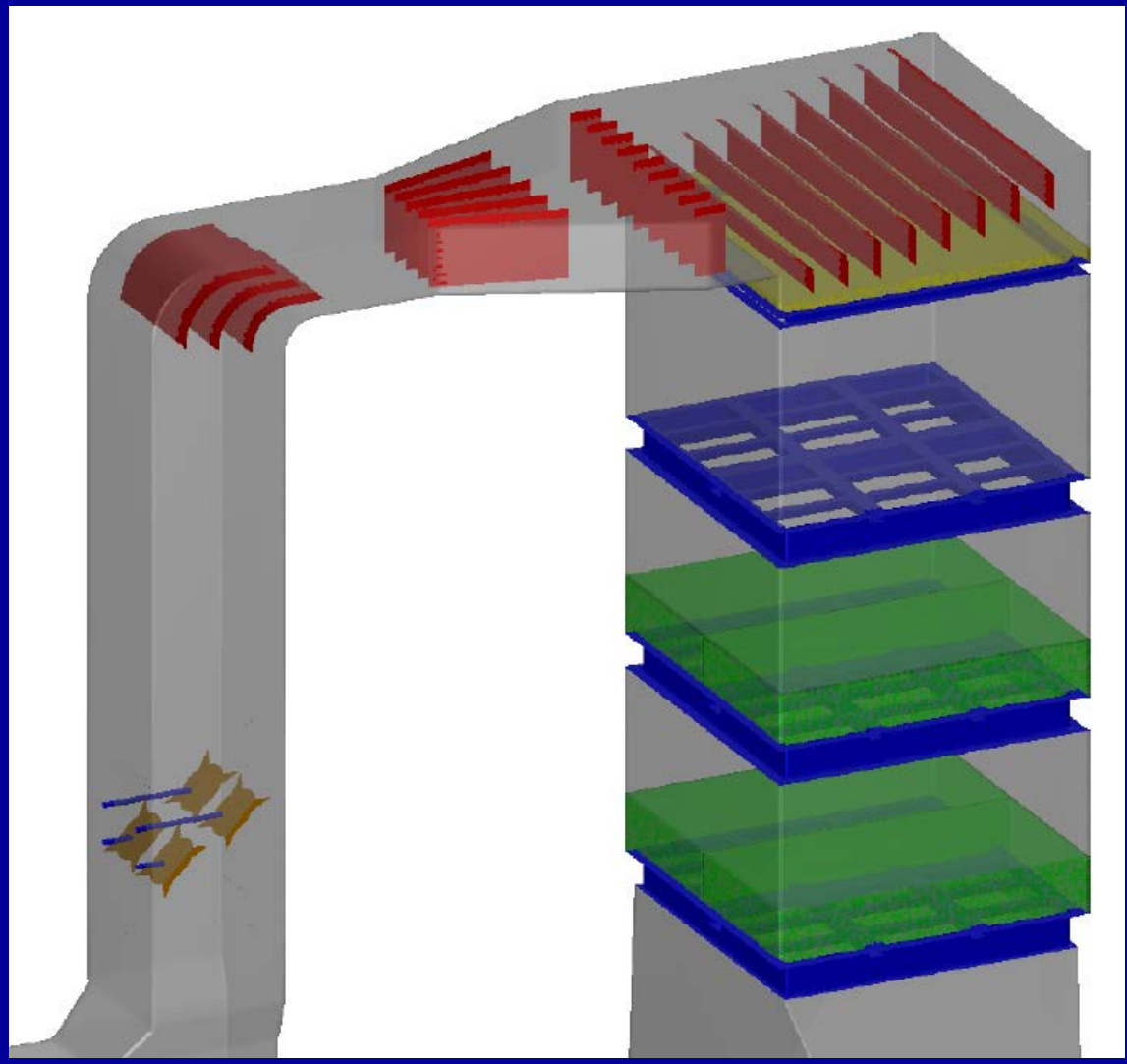


Vortex Mixer

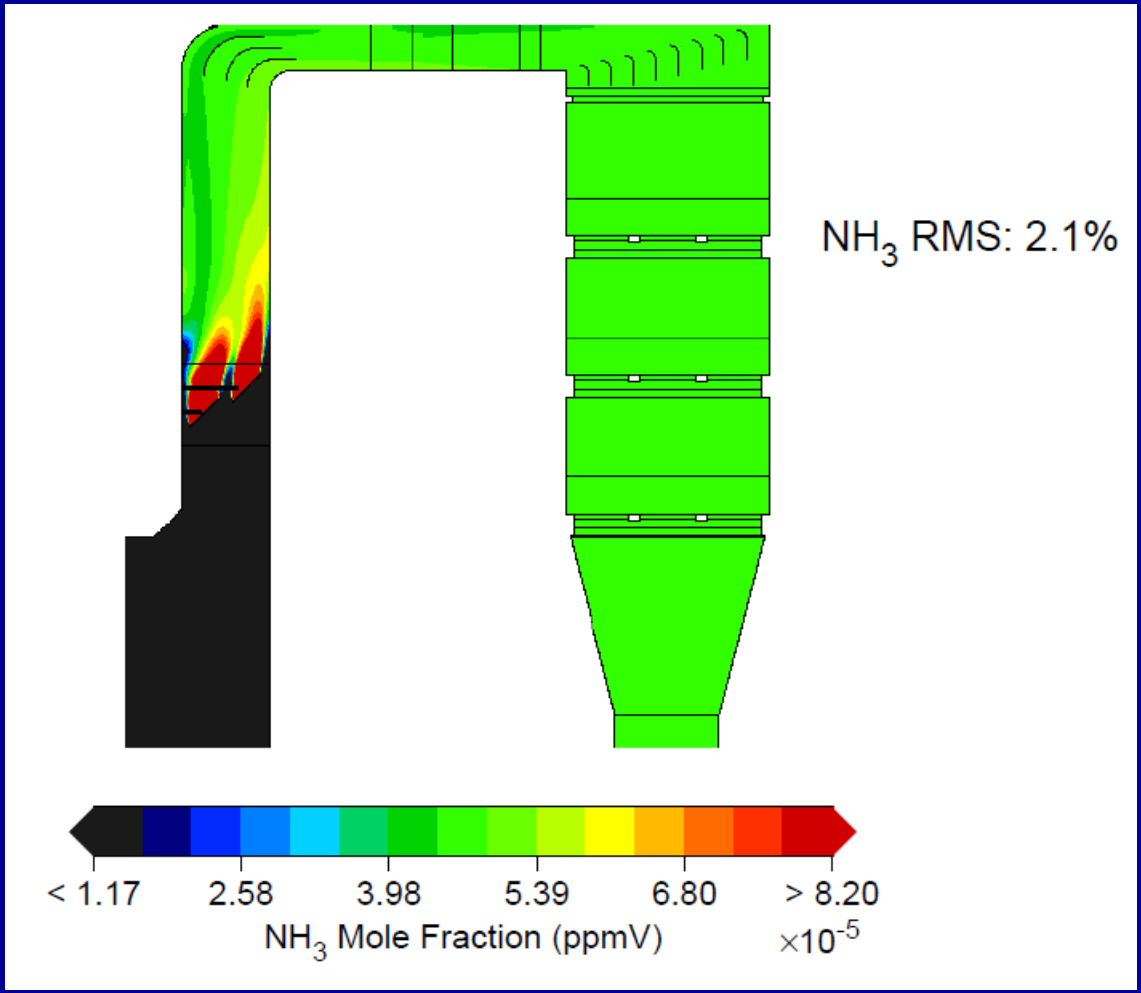
Economizer outlet,
compilation photo of mixer plates
(flow is into page)

Vortex Mixer





Vortex Mixer



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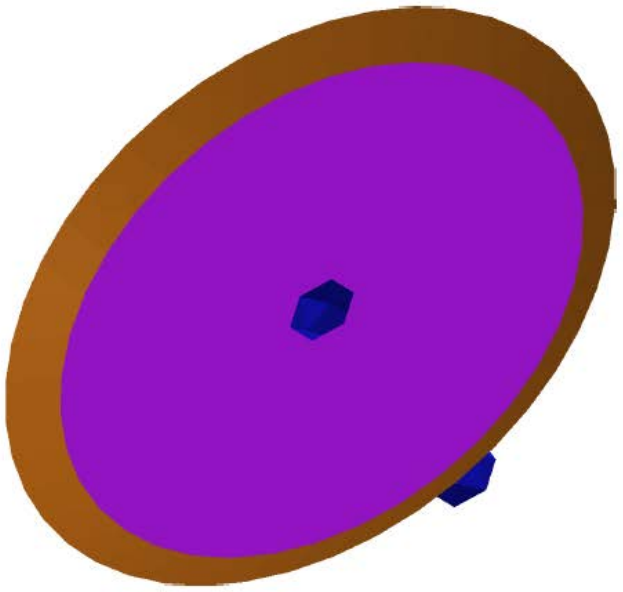
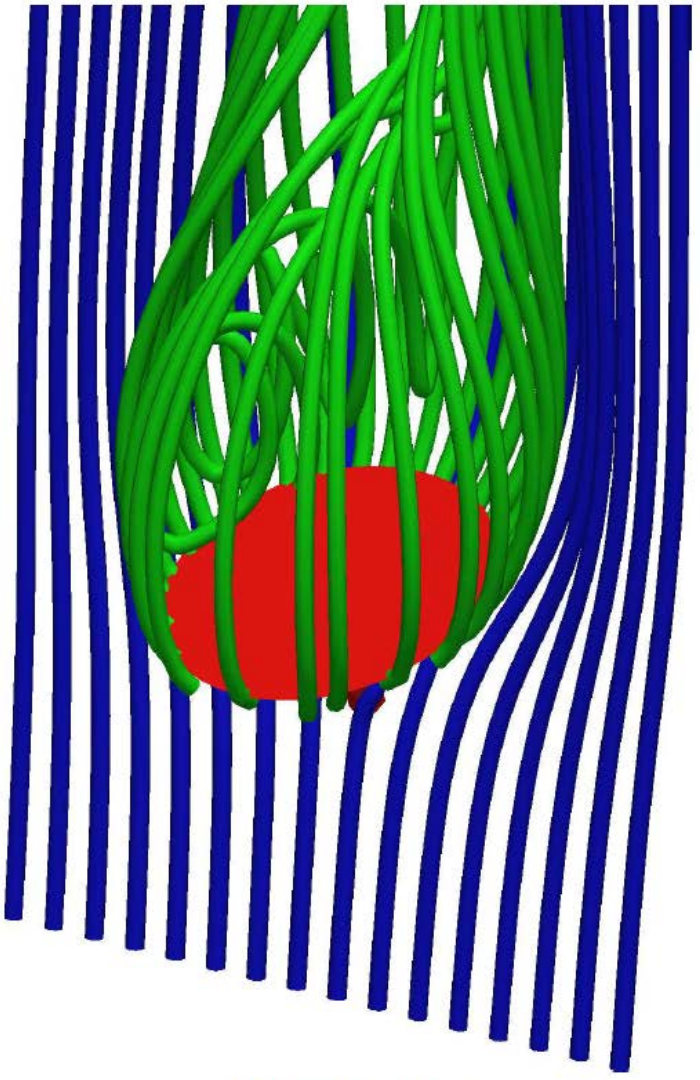


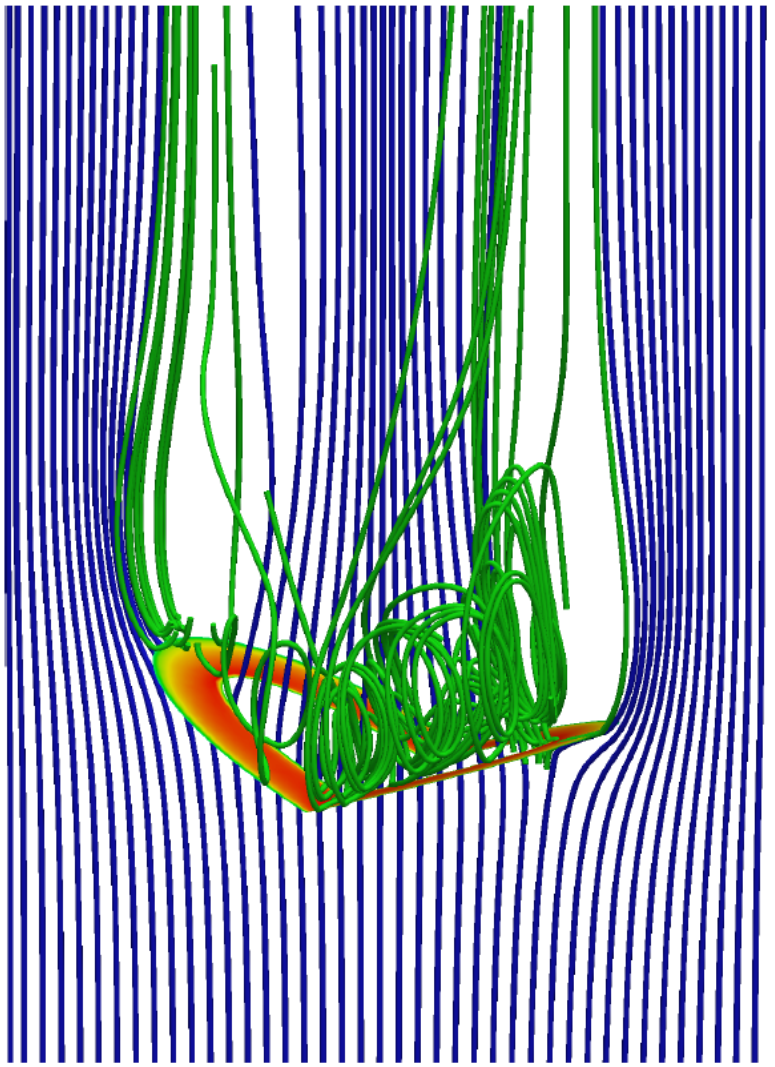
Geometry



Fluid path lines

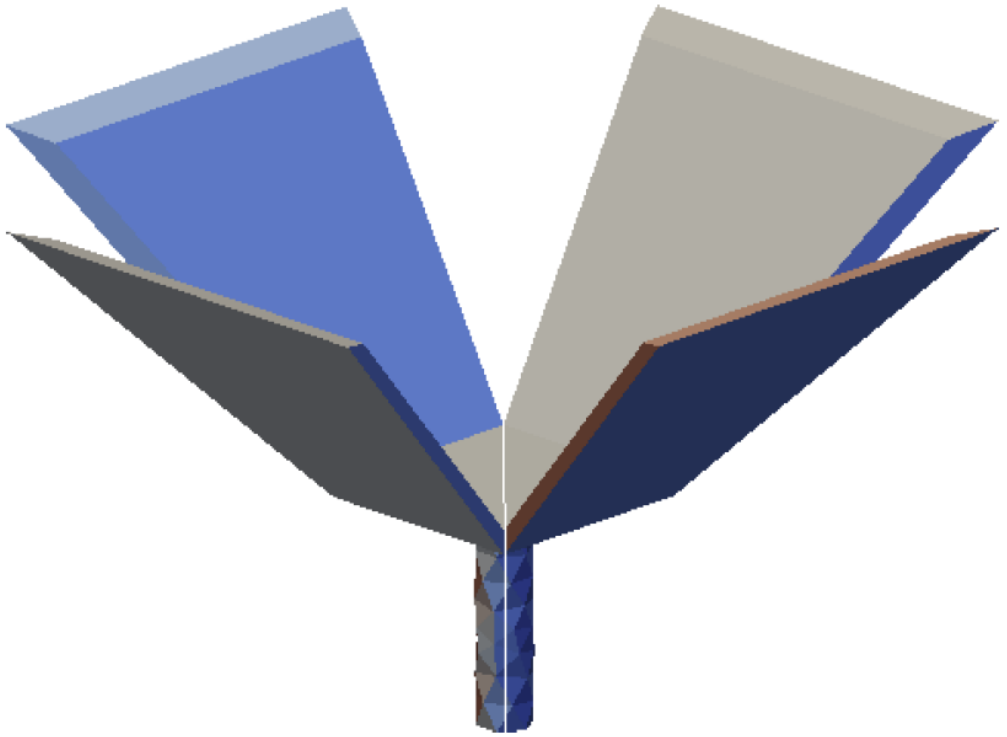
Vortex Mixer

Geometry



Fluid path lines

Vortex Mixer



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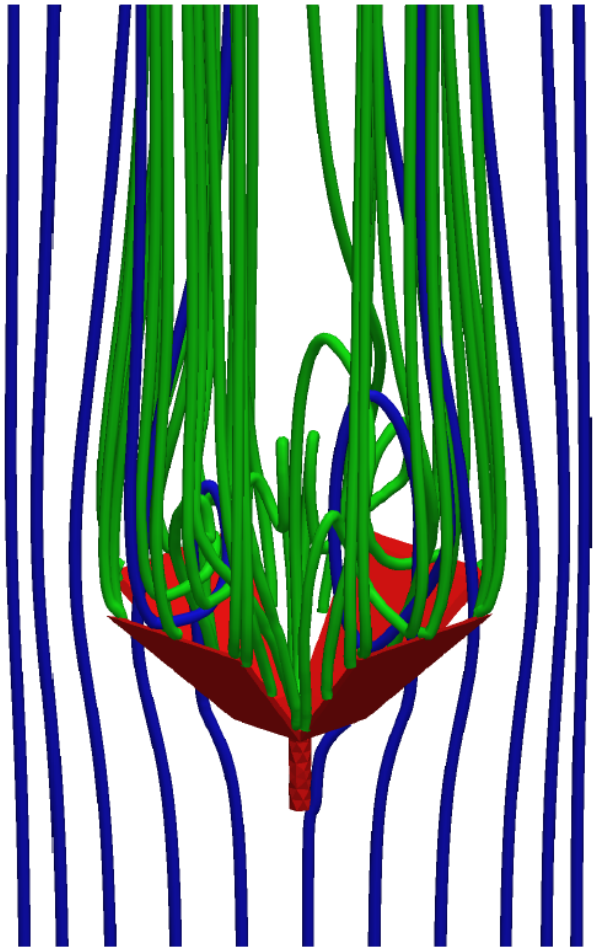
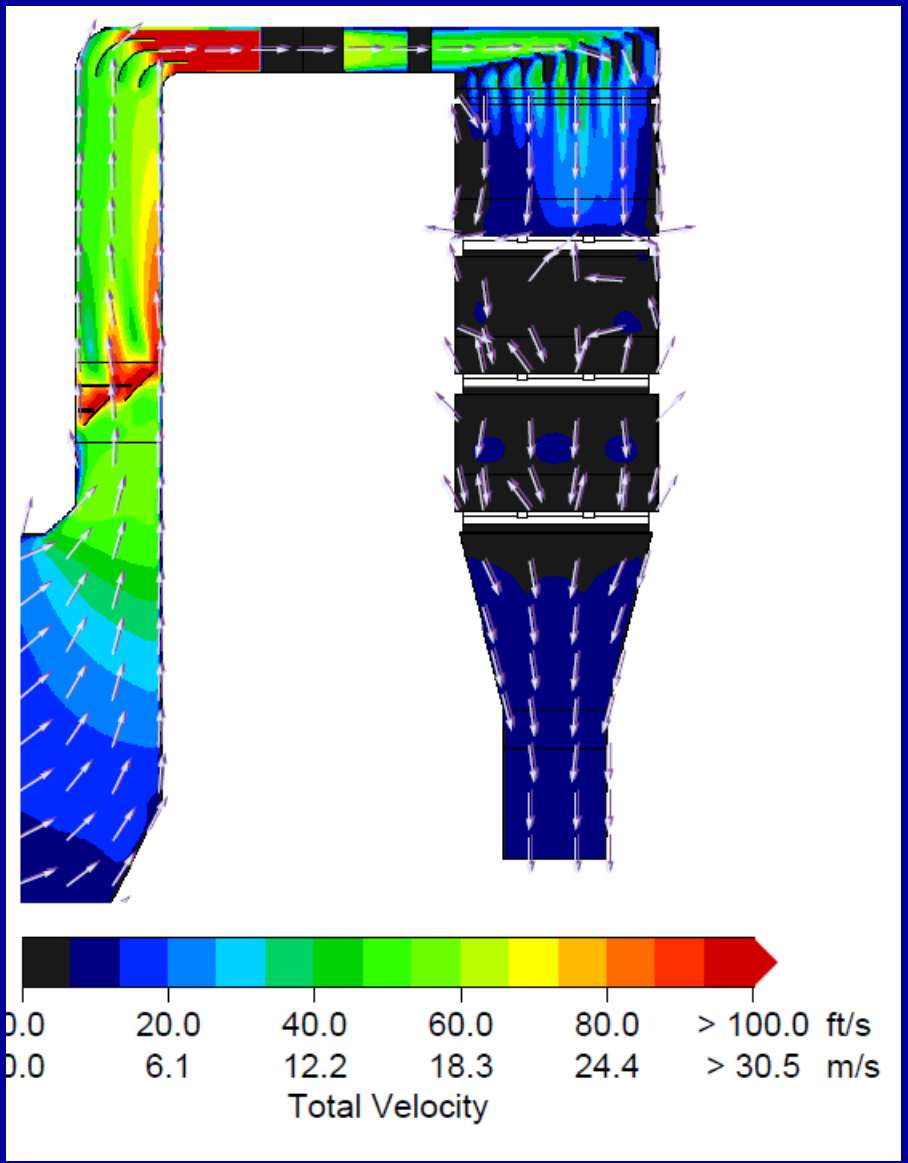


Fluid path lines

Vortex - Shear Mixer

Mixer Issues - Erosion



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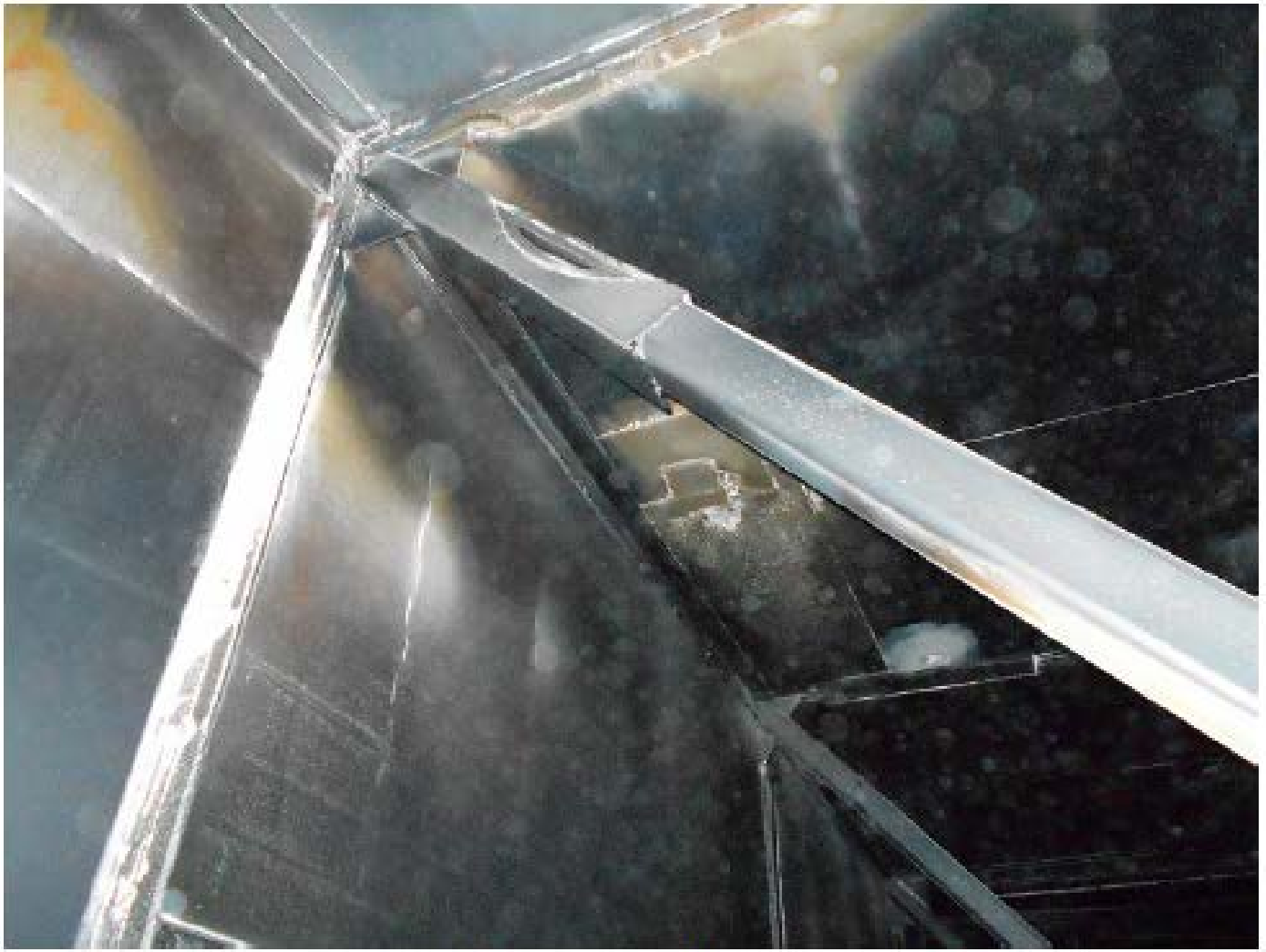
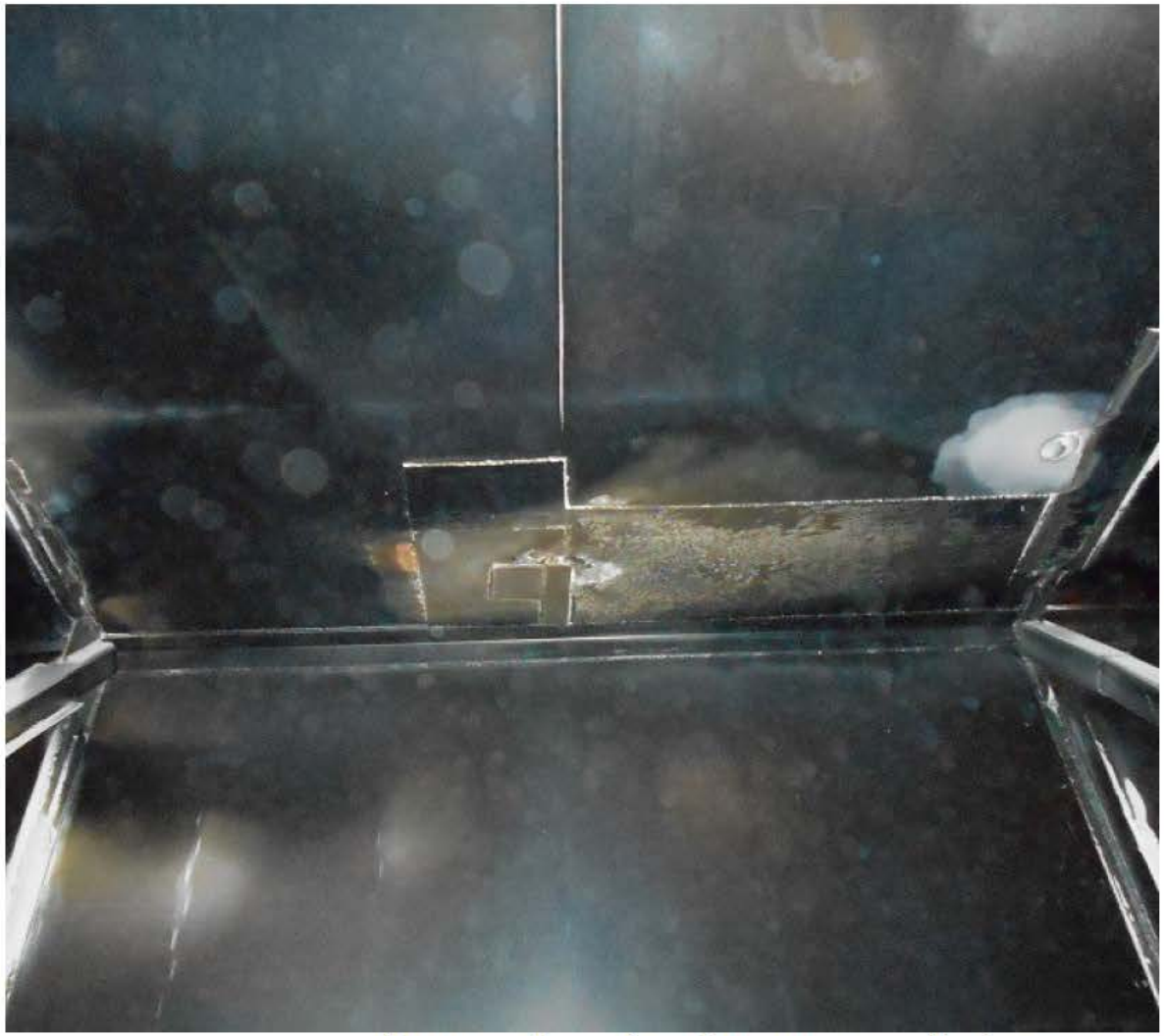


Internal truss erosion downstream of mixers
(zoomed view at right)

Mixer Issues - Erosion



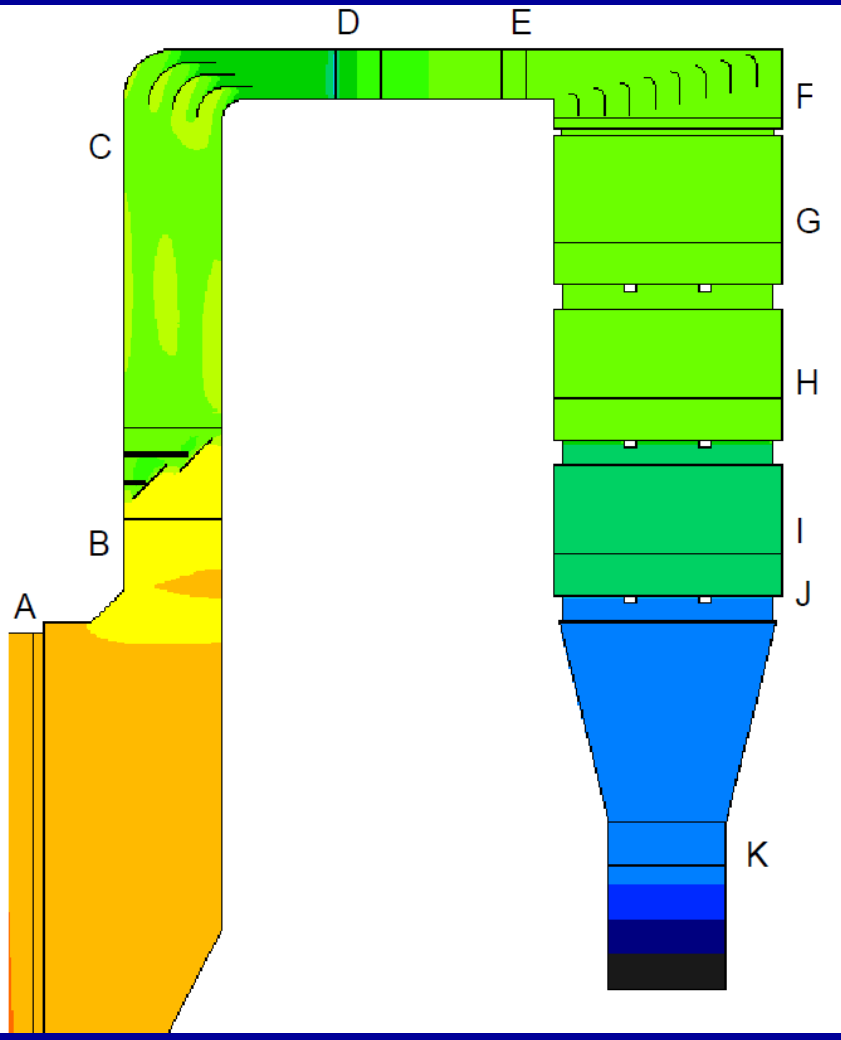
Duct roof erosion downstream of mixers, near unit centerline (flow is left to right)
(zoomed view at right; repair patches evident)

Mixers– Pressure Drop

	Location	Total Pressure Loss (inH2O)	Total Pressure Loss (mmH2O)
A	Evaporator Outlet	0	0
B	Upstream AIG	-0.03	-0.8
C	Downstream AIG	-0.75	-19.1
D	Upstream SCR Duct Expansion	-0.95	-24.1
E	Downstream SCR Duct Expansion	-1.07	-27.1
F	Upstream Flow Rectifier	-1.23	-31.2
G	Upstream (Future) 1st Catalyst Layer	-1.26	-32.1
H	Upstream 2nd Catalyst Layer	-1.29	-32.7
I	Upstream 3rd Catalyst Layer	-2.30	-58.3
J	Downstream 3rd Catalyst Layer	-3.29	-83.7
K	Economizer Inlet	-3.31	-84.0
A-K	**Total DP, Evaporator Outlet to Economizer Inlet**	**3.31**	84.0
A-K	**Total DP, Excluding Catalyst Layers**	**1.27**	32.3

DP = 0.72 IWC

Typical mixer stage
DP = 0.3 to 0.8 IWC



Summary

- Many power plant systems require adequate mixing of flow streams to perform optimally
- For SCRs: NH3, NOx, and temperature are key players
- For other APC equipment: chemical species, sorbent distribution, and temperature are important
- For combustion: air and coal balancing are key
- Mixer design involves many competing criteria which must be understood and optimized

Questions