NETL 2003 Conference on SCR & SNCR for NOx Control

Mixing Performance Characterization for Optimization and Development on SCR Applications

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Efficient Design Optimization Requires Reliable Performance Predictions

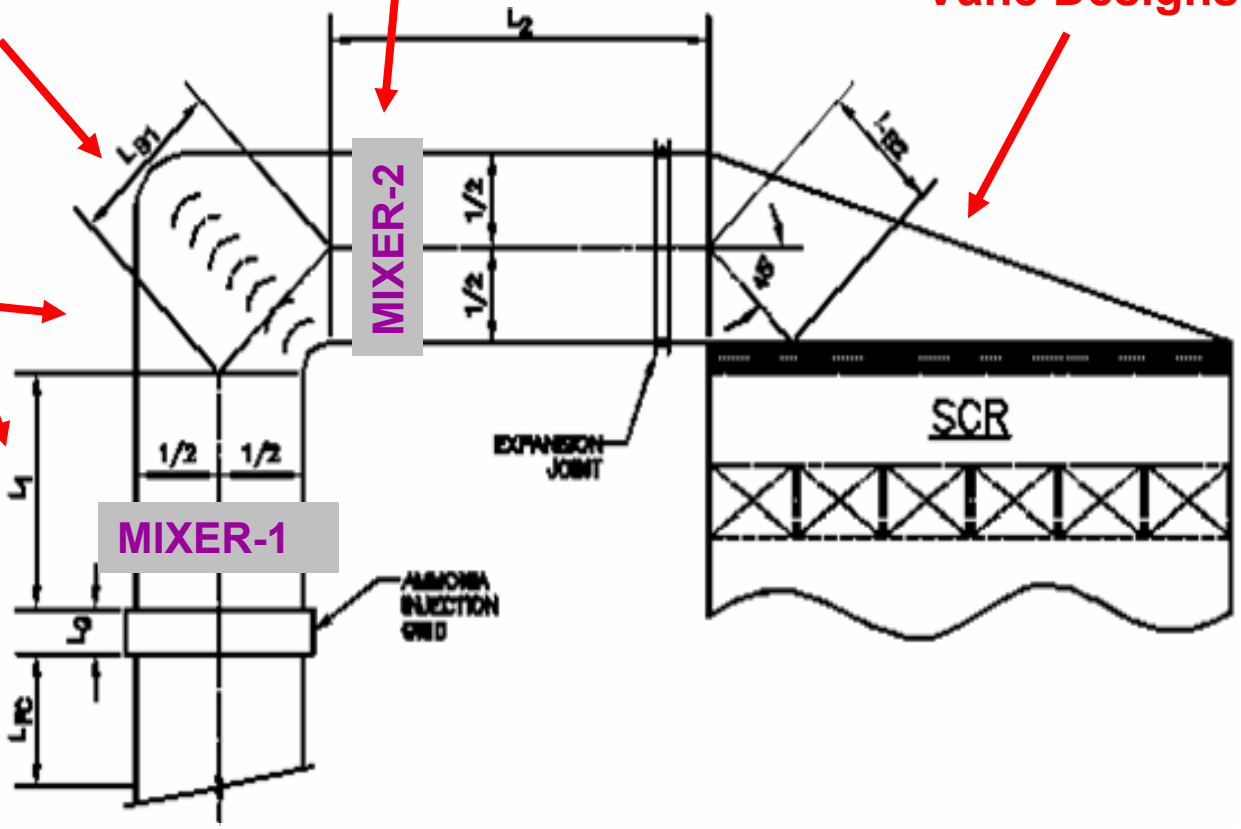
Influence of Bend and Vane Design

Need for Second Mixer ?

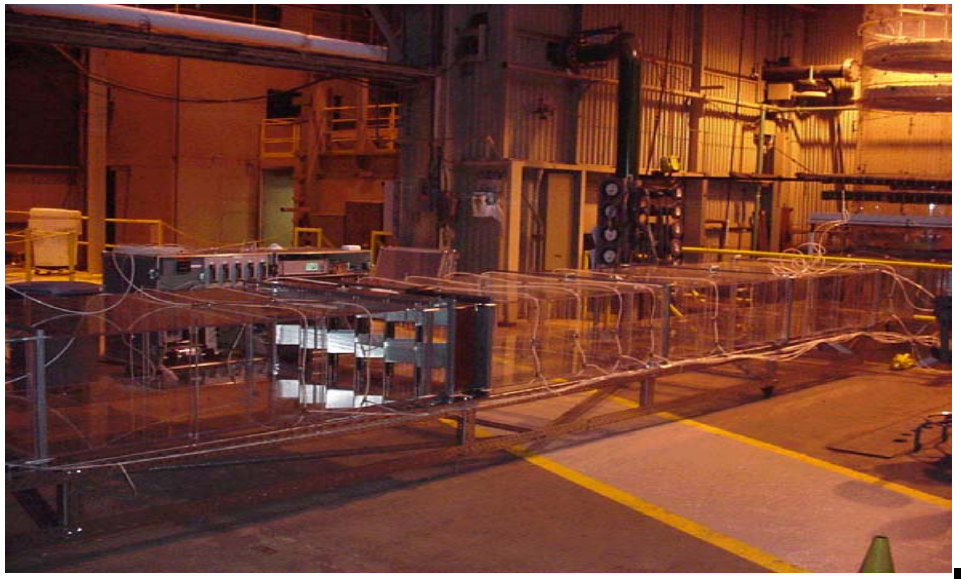
Influence of Hood and Hood Internal Vane Designs

Influence of Mixer Design & Proximity to Downstream Arrangement

Influence of AIG Design



Mixing Test Stands:



← Physical Test Stands:

Base Mixer Development

Performance Comparisons

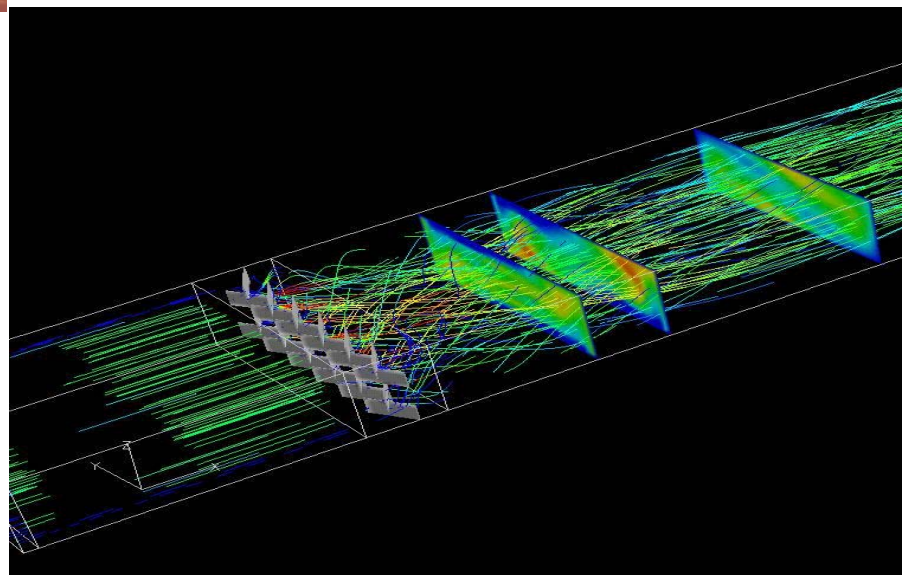
CFD Validation

Numerical Test Stands: →

Extended Mixer Development

Performance Comparisons

Multiple Scenario & Sensitivity Analyses



Mixing Effectiveness:

$$\xi_m = \frac{\sigma_1}{\sigma_0}$$

where,

ξ_m = Mixing Effectiveness

σ_0 = Standard Deviation Entering the Mixer

σ_1 = Standard Deviation at Downstream Assessment Plane

Modified Mixing Effectiveness :

(Provides an improved accounting for the length efficiency of the mixer design and the effect of its placement in a given arrangement)

$$\xi_m' = \frac{\sigma_1'}{\sigma_0'}$$

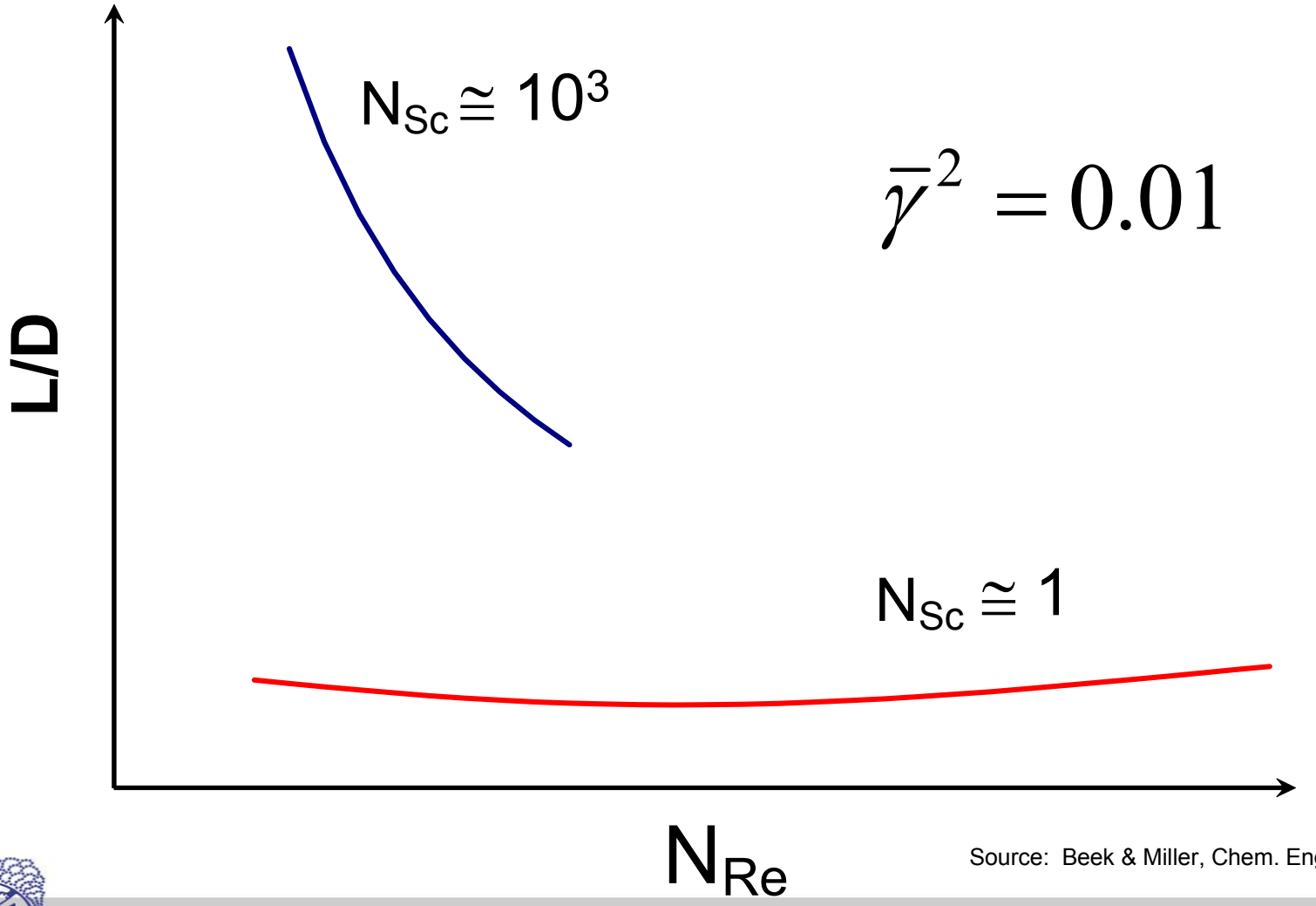
where,

ξ_m' = Modified Mixing Effectiveness

σ_0' = Std Deviation @ Assessment Plane w/o Mixer

σ_1' = Std Deviation @ Assessment Plane with Mixer

Theoretical Effect of Reynolds Number



Source: Beek & Miller, Chem. Eng. Prog. 1959

Mixing Efficiency :

Mixer Shock Loss Coefficient

$$\zeta_m = \frac{\Delta P_m}{\rho V^2 / 2}$$

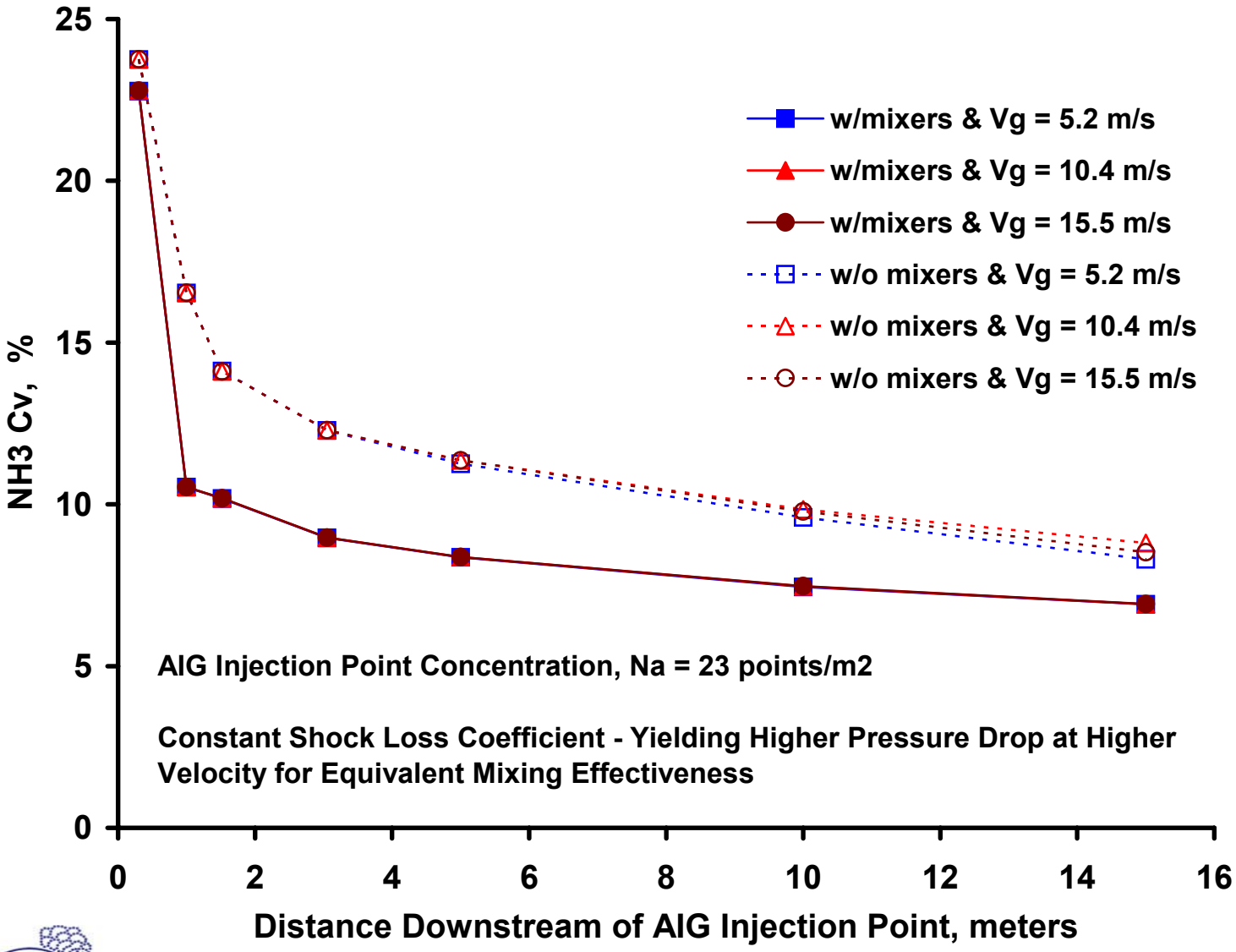
Mixing Effectiveness Parameter

$$\xi_m = \frac{\sigma_1}{\sigma_0}$$

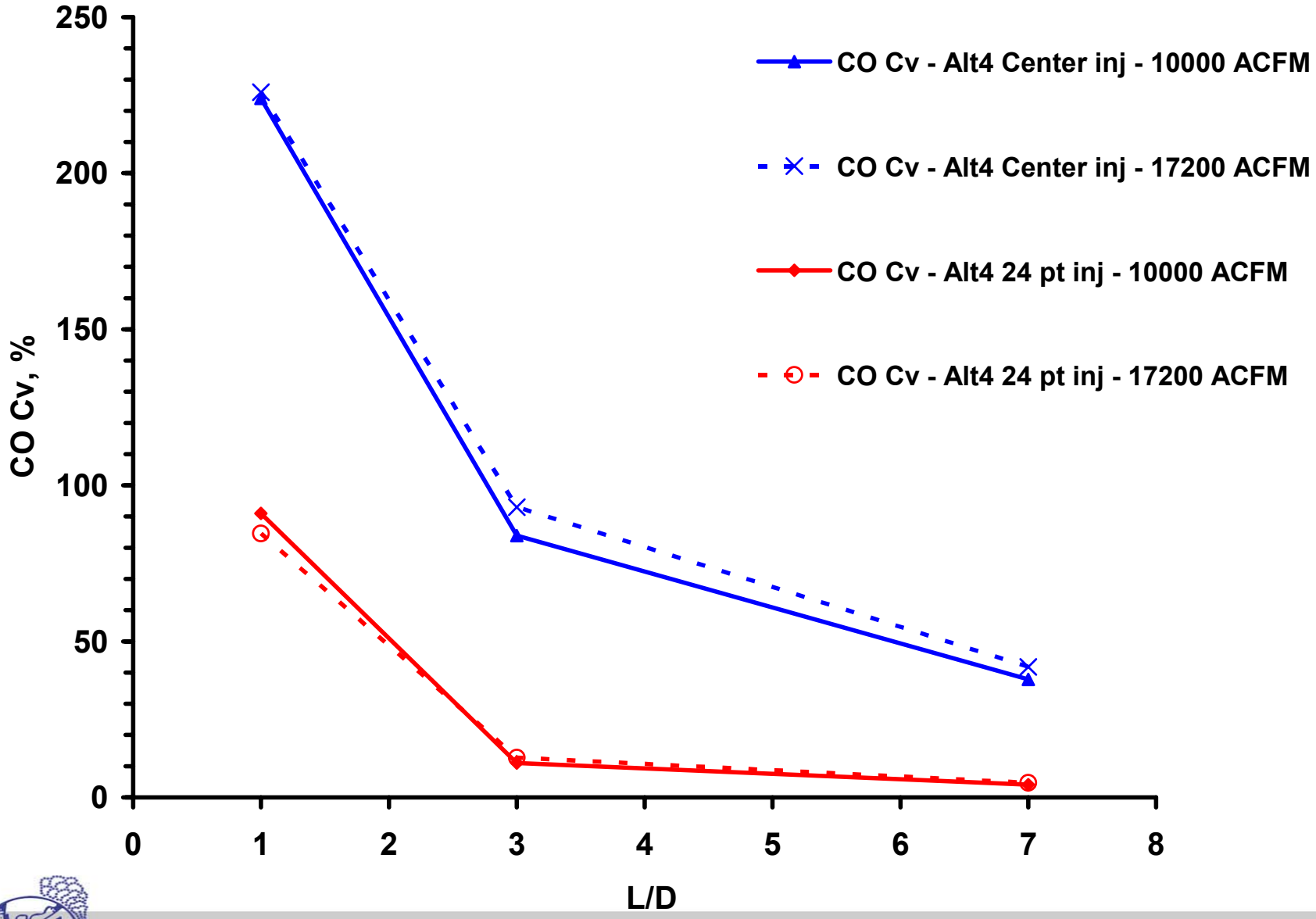
Dimensionless Mixing Efficiency

$$\eta_m = \frac{\xi_m}{\zeta_m}$$

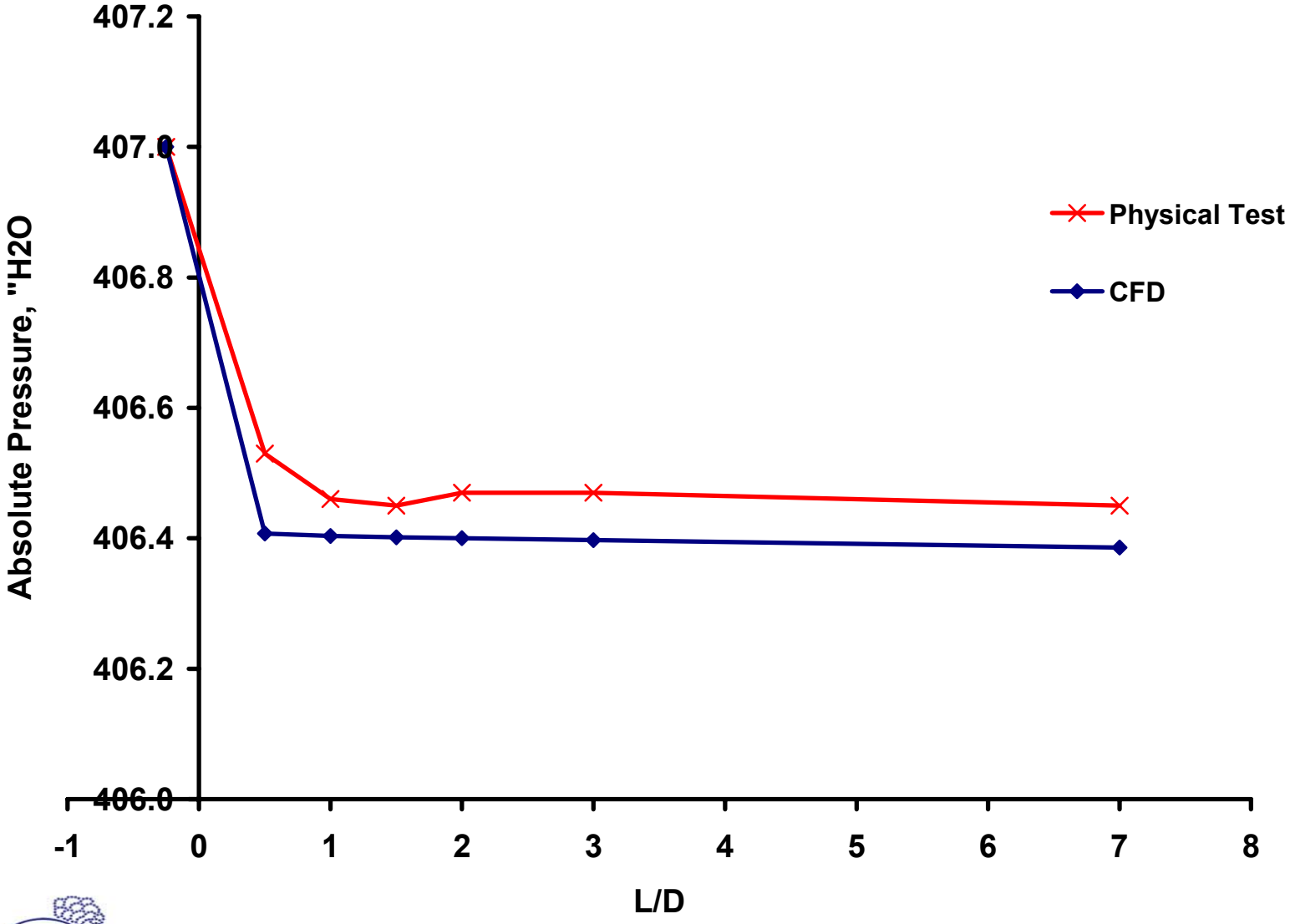
CFD Testing – Effect of Velocity



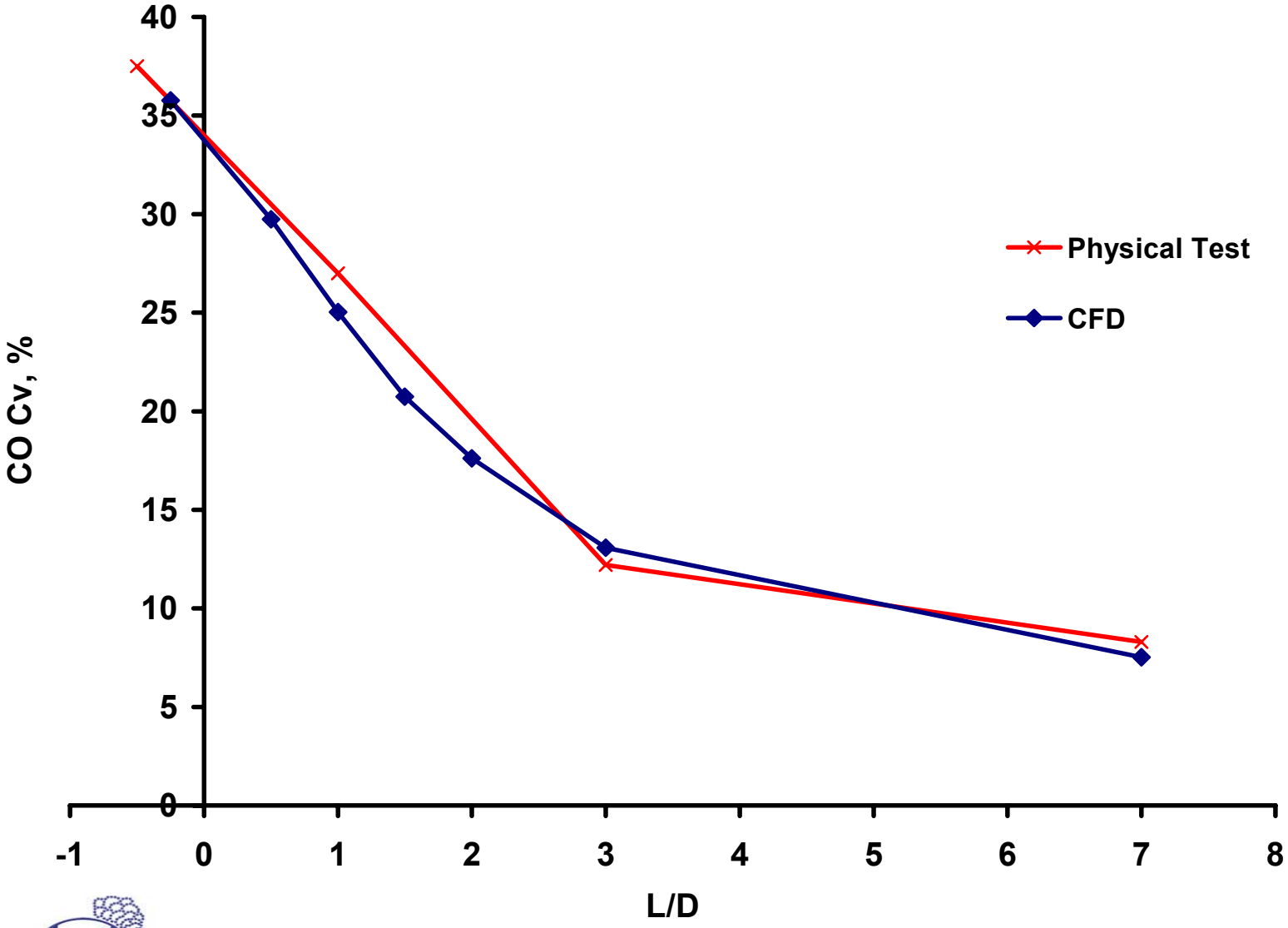
Physical Testing – Effect of Velocity



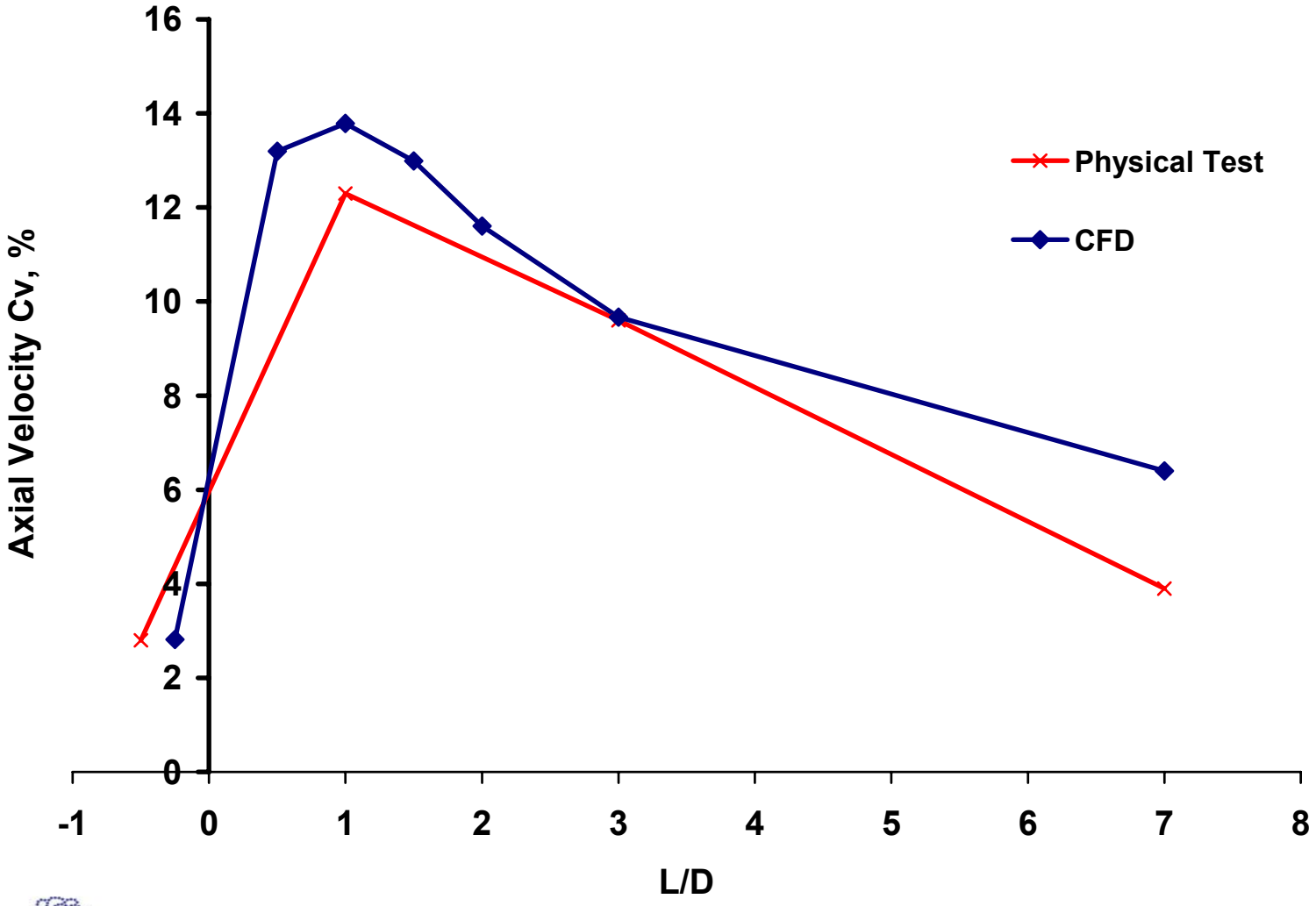
CFD Analysis vs Physical Tests



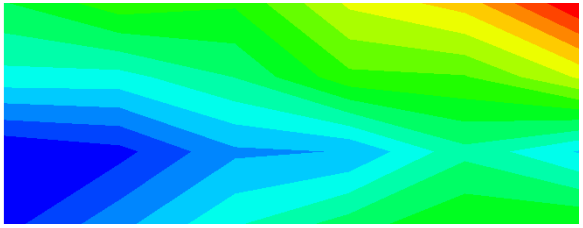
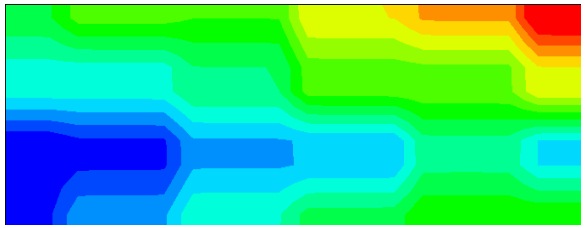
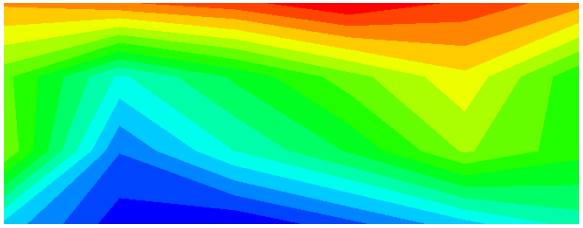
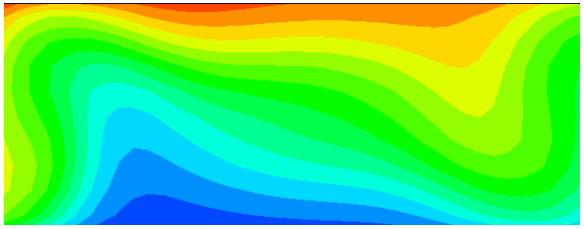
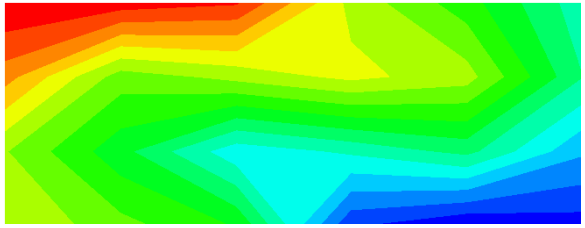
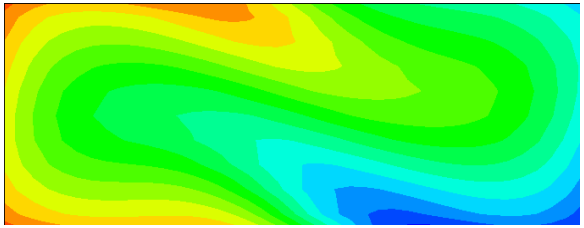
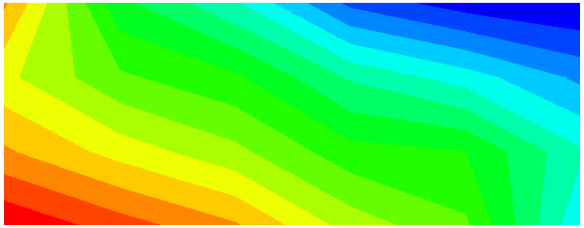
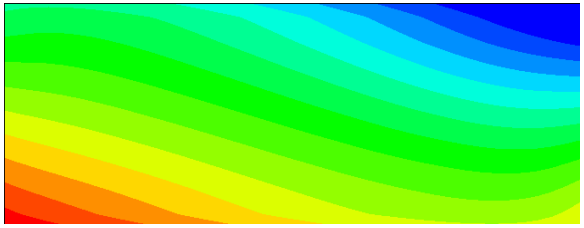
CFD Analysis vs Physical Tests



CFD Analysis vs Physical Tests

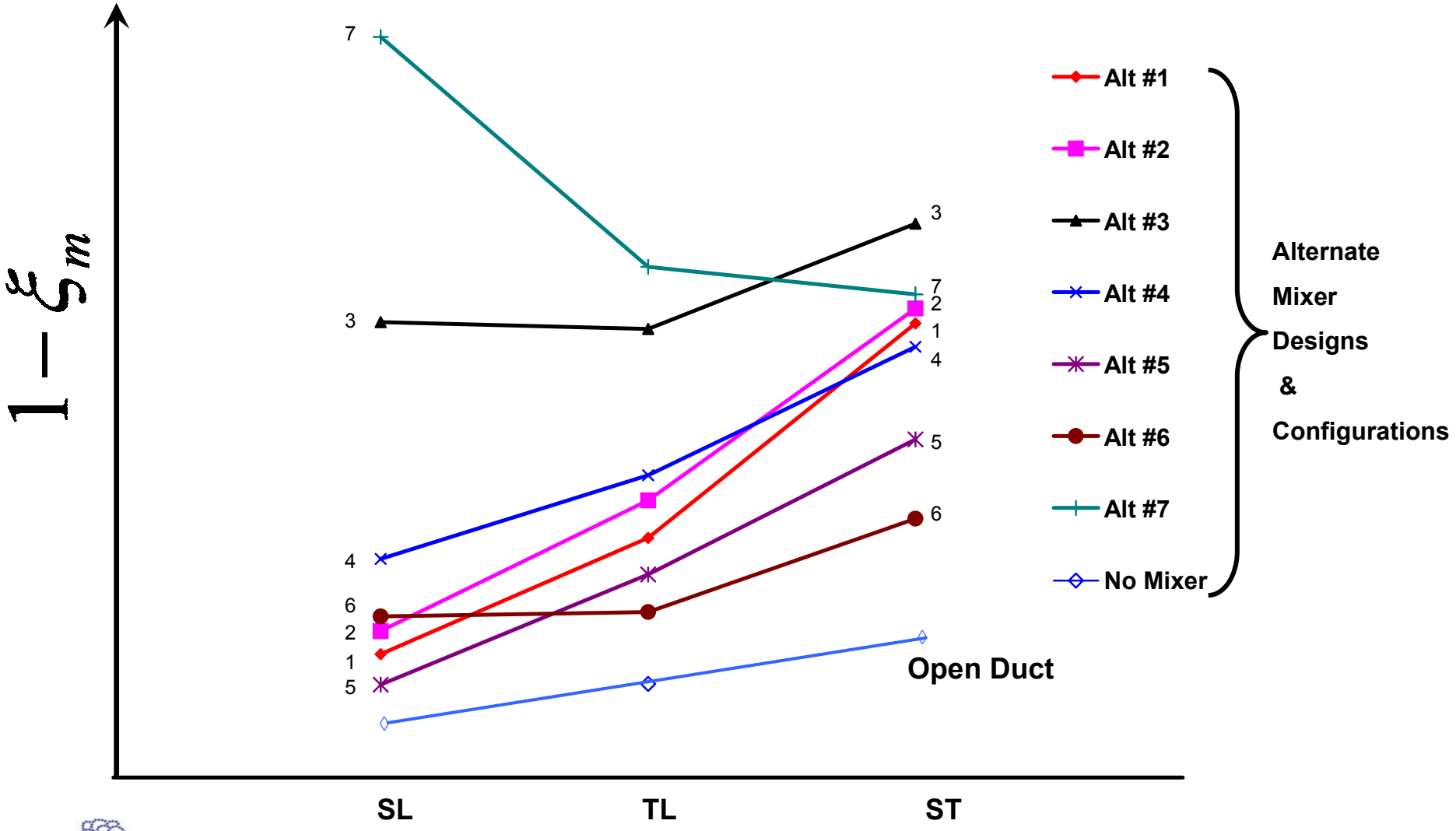


CFD Analysis vs Physical Tests

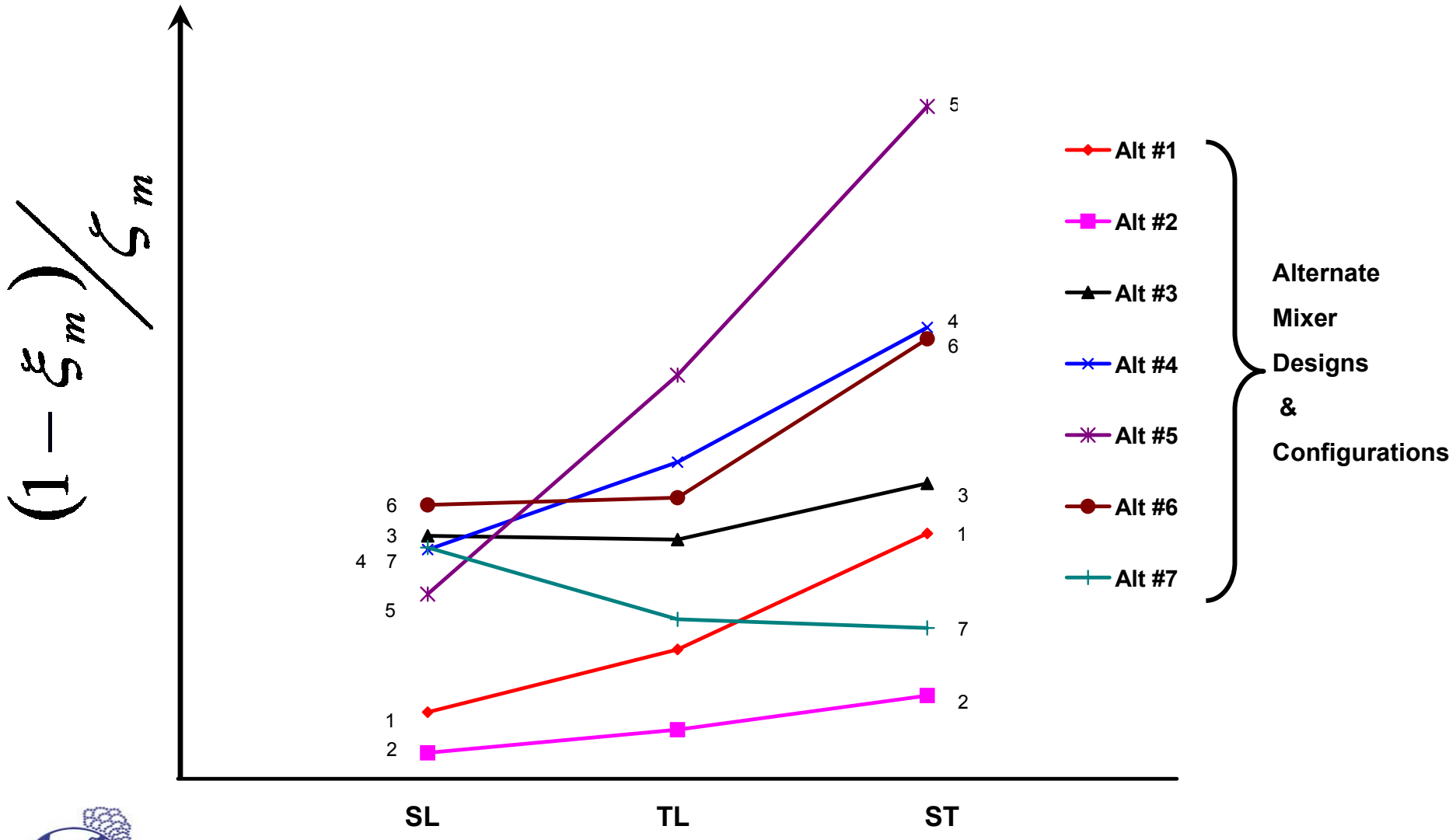
	Physical Test Contour*	Numerical Model Contour*
-0.5 Dh		
+1.0 Dh		
+3.0 Dh		
+7.0 Dh		

* Color Scale Not Constant. Scale Adjusted for Maximum Contrast in Each Frame

Mixer Design Effectiveness



Mixer Design Efficiency



Example Targeted Optimization Areas

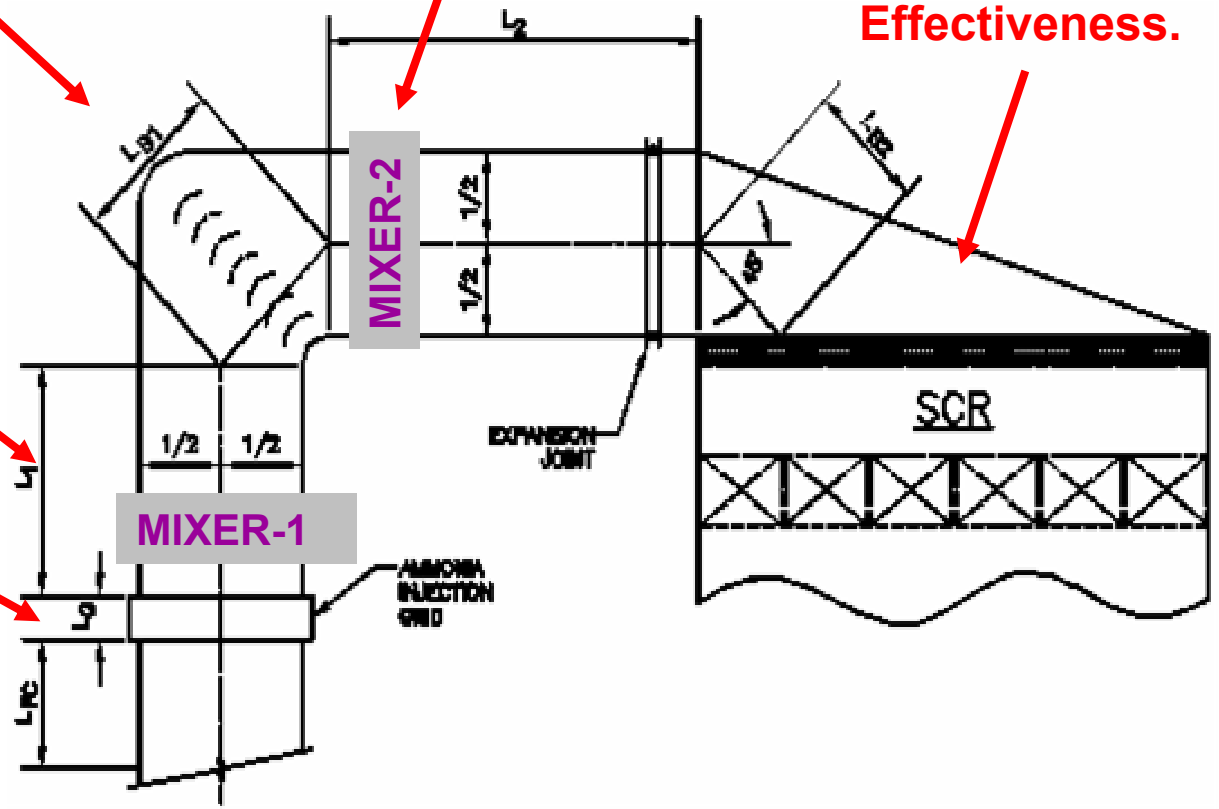
Bend Design Optimized to Propagate Mixing Effectiveness and/or Feed Second Mixer

If Needed, Second Mixer Optimized Against Upstream Mixer, Bend Design, and Proximity to Downstream Reactor Hood.

Optimize Hood and Internal Vanes to Correct Flow while Propagating Mixing Effectiveness.

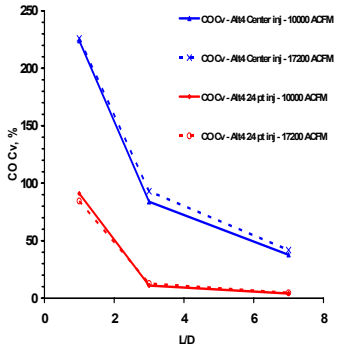
Mixer Optimized with AIG Design for Efficient Use of Energy and Downstream Length

AIG Optimized for Upstream Gas Flow Profiles; Controllable Zones vs Na vs Vcv, vs V Profile



Summary

Optimization requires a scorecard.



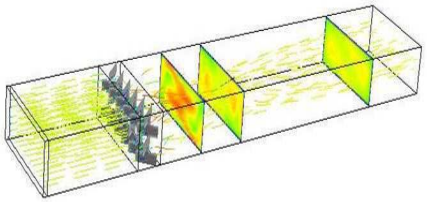
Standardized procedures and parameters that characterize performance with regard to energy and length efficiency is critical.

(Need to measure to be able to improve and manipulate a design)

η_m

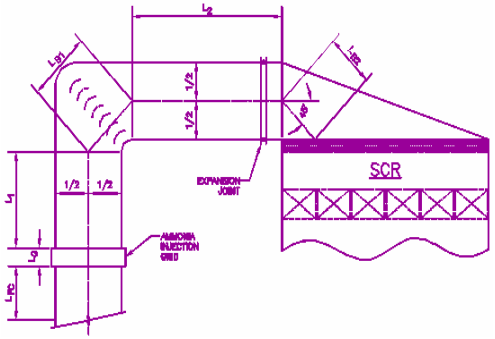
Consider dimensionless parameters where useful & practical.

Summary



Validated numerical models allow early optimization and facilitate the development of simplified formula.

Refine Validations against Field Measurements.



As practical, allow overall flue arrangement, bend, internal vane, damper, AIG, mixer and hood designs to compete with each other.

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