Full-Scale Demonstration of a Mercury Oxidation Catalyst Upstream of a Wet FGD System

DOE-NETL Cooperative Agreement DE-FC26-06NT42778

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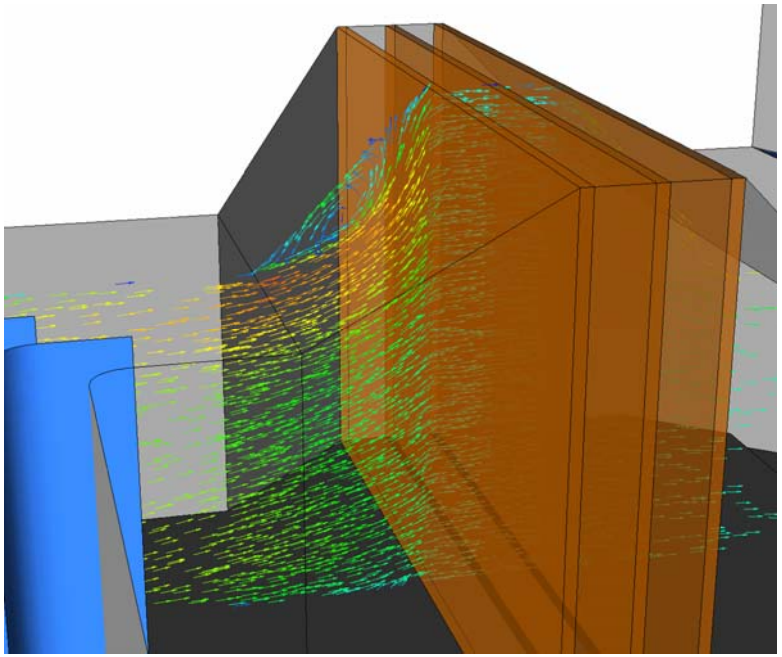

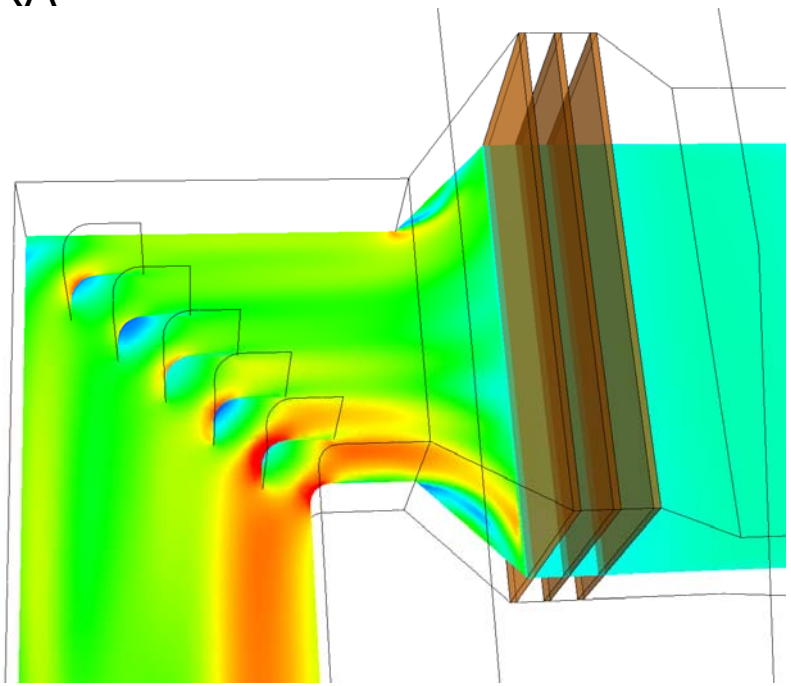

Presentation Outline

- Management summary for new project NT42778
- Background on mercury control process to be tested
- Results from previous pilot-scale evaluations
- Details of current project
- Results of modeling of new full-scale (200 MW) mercury oxidation catalytic reactor

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Current Project

- Cooperative Agreement DE-FC26-06NT42778
- Demonstrate gold catalyst upstream of a full-scale wet FGD module for oxidizing Hg^0, enhancing FGD removal of total Hg
- To be conducted at the Lower Colorado River Authority's (LCRA) Fayette Power Project Unit 3
  - Located near LaGrange, Texas
  - 460 MW
  - Fires PRB coal
  - Low NO_X burners, cold-side ESP, LSFO wet FGD
  - FGD has 3 absorbers, 2 operate at full unit load
  - Only Module C will have catalyst retrofitted

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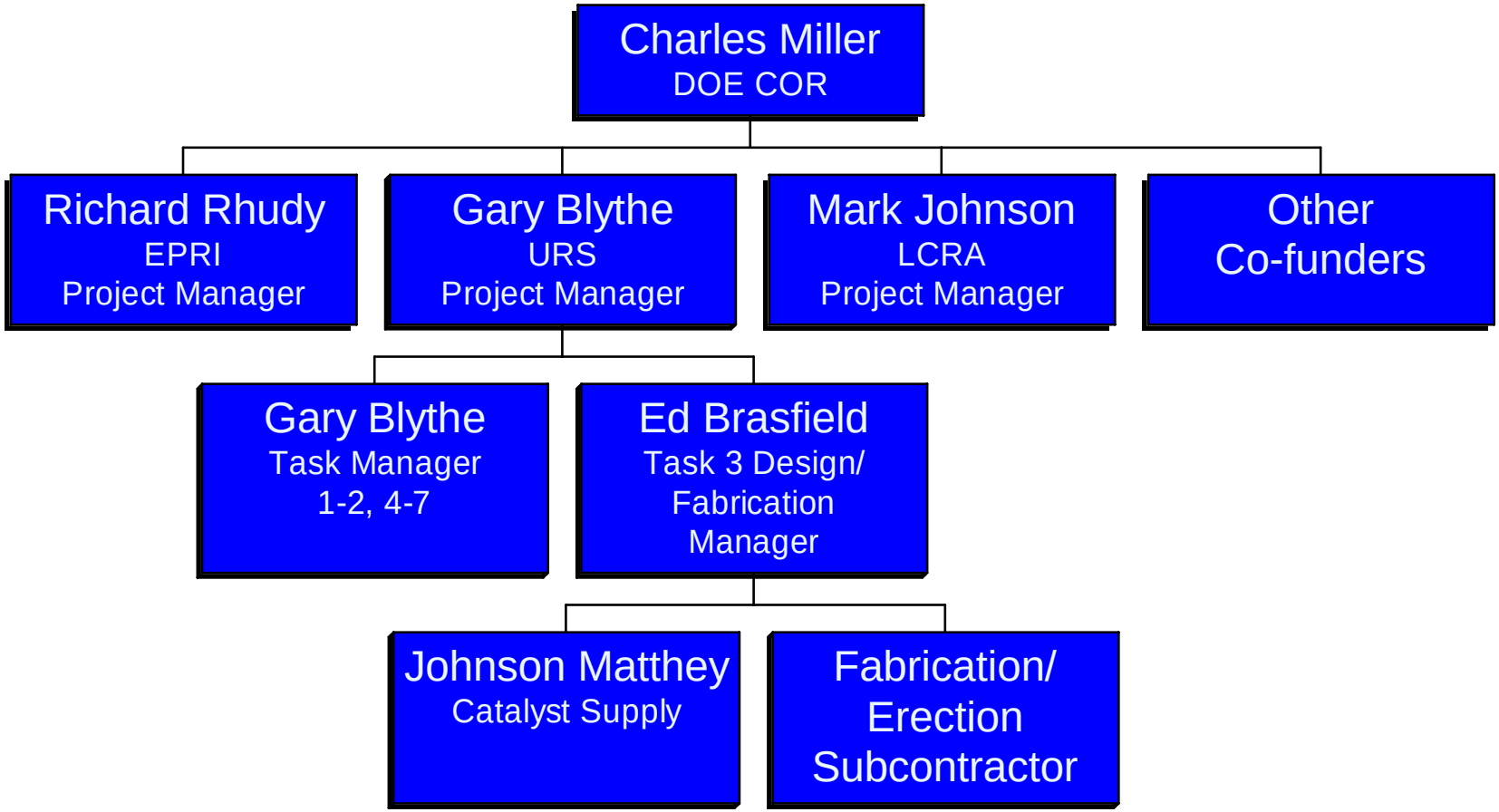
LCRA's Fayette Power Project

Project Description

- NETL Project Manager: Chuck Miller
- Total Value: $4.08 million ($2.5 million DOE share)
- Period of Performance: 7/24/06-7/23/09
- Project Participants/Co-funders (role):
  - LCRA (host)
  - EPRI
  - Great River Energy
  - Johnson Matthey (catalyst supplier)
  - Southern Company
  - SRP
  - TVA (patent holder)
  - URS (prime contractor)
  - Westar

Project Organization



Project Objectives

- Confirm catalyst quantities and life for achieving:
  - Average of ≥70% oxidation of Hg^0 in PRB flue gas over 24 mos.
  - Corresponding increase in FGD capture of Hg
- Meet or exceed solicitation objectives:
  - 50% to 70% Hg removal beyond baseline removal
  - Cost at least 50% lower than baseline of $60,000/lb of Hg removed

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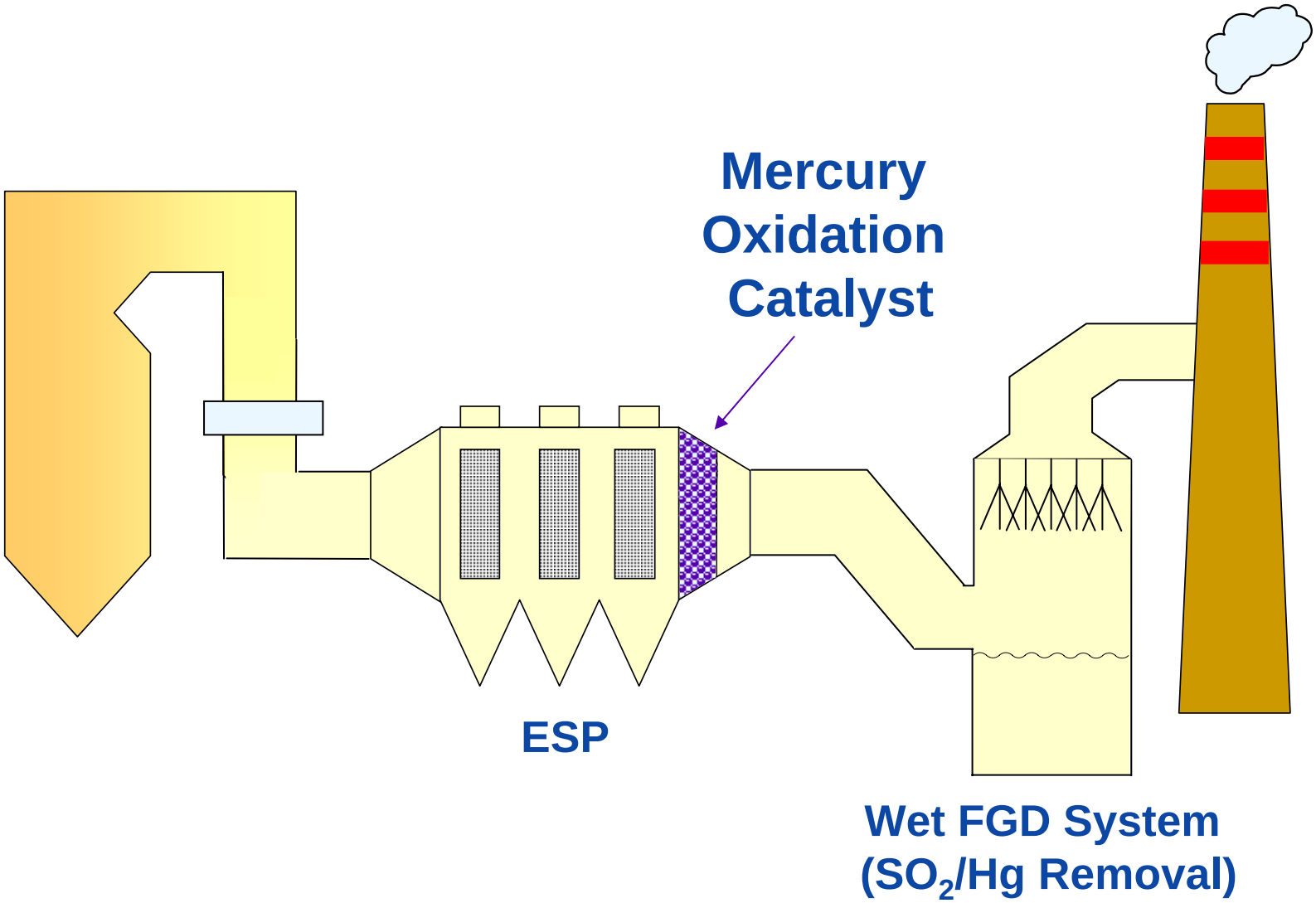
Illustration of Process Concept



Previous Projects

- Two DOE/EPRI projects (DE-FC26-01NT41185 and DE-FC26-04NT41992) conducted pilot-scale tests of low-temp Hg^0 oxidation catalysts at three sites
  - 2 to 4 catalysts tested in parallel (~2000 acfm each)
  - 12-20 months automated operation at each site
  - ~Bimonthly catalyst activity measurements
- Pilot wet FGD (~2000 acfm – one catalyst's flow) used to measure ability to scrub catalytically oxidized Hg

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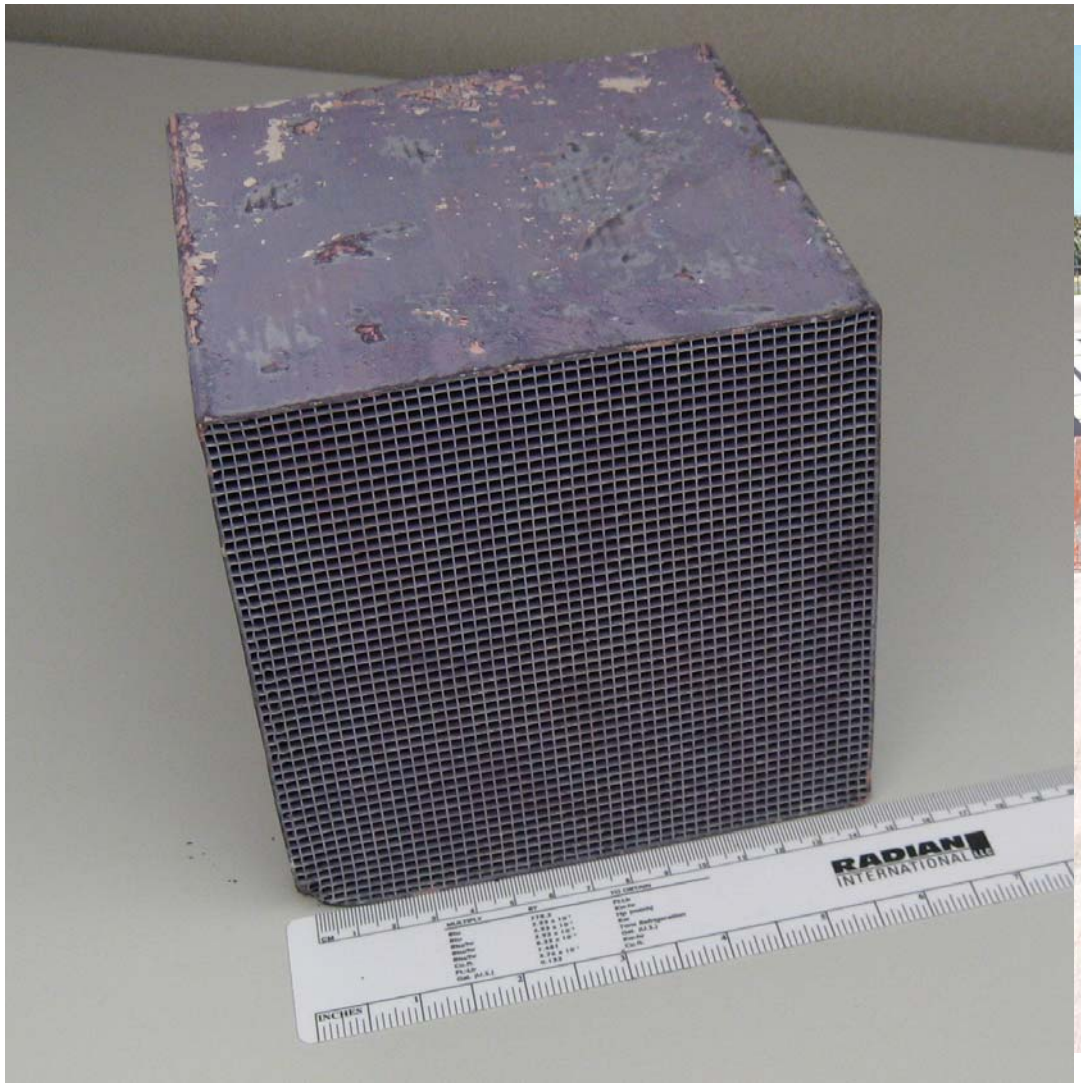
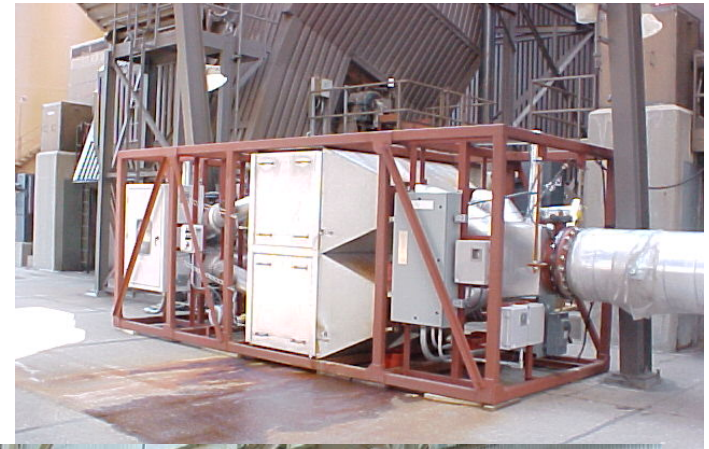
Catalyst Examples



41185 Project - Test Locations

- GRE's Coal Creek (ND lignite, ESP/wet FGD)
  - Pilot unit started up October 02
  - Long-term test completed June 04
- CPS' Spruce (PRB, FF/wet FGD)
  - Pilot unit started up August 03
  - Long-term test completed April 05



Summary from CCS Results

- Sonic horns required to prevent fly ash buildup
- Pd catalyst achieved 60-70% Hg^0 oxidation after 20+ months
- Pd catalyst restored to ~90% oxidation after regeneration with 600°F air
- Wet FGD pilot tests showed removal of oxidized Hg across wet scrubber limited only by Hg^0 re-emissions (79% overall Hg removal in LSFO mode with FGD inlet Hg 84% oxidized)
- Preliminary economics showed catalytic oxidation most cost effective relative to ACI when plant sells fly ash and when catalyst can be regenerated

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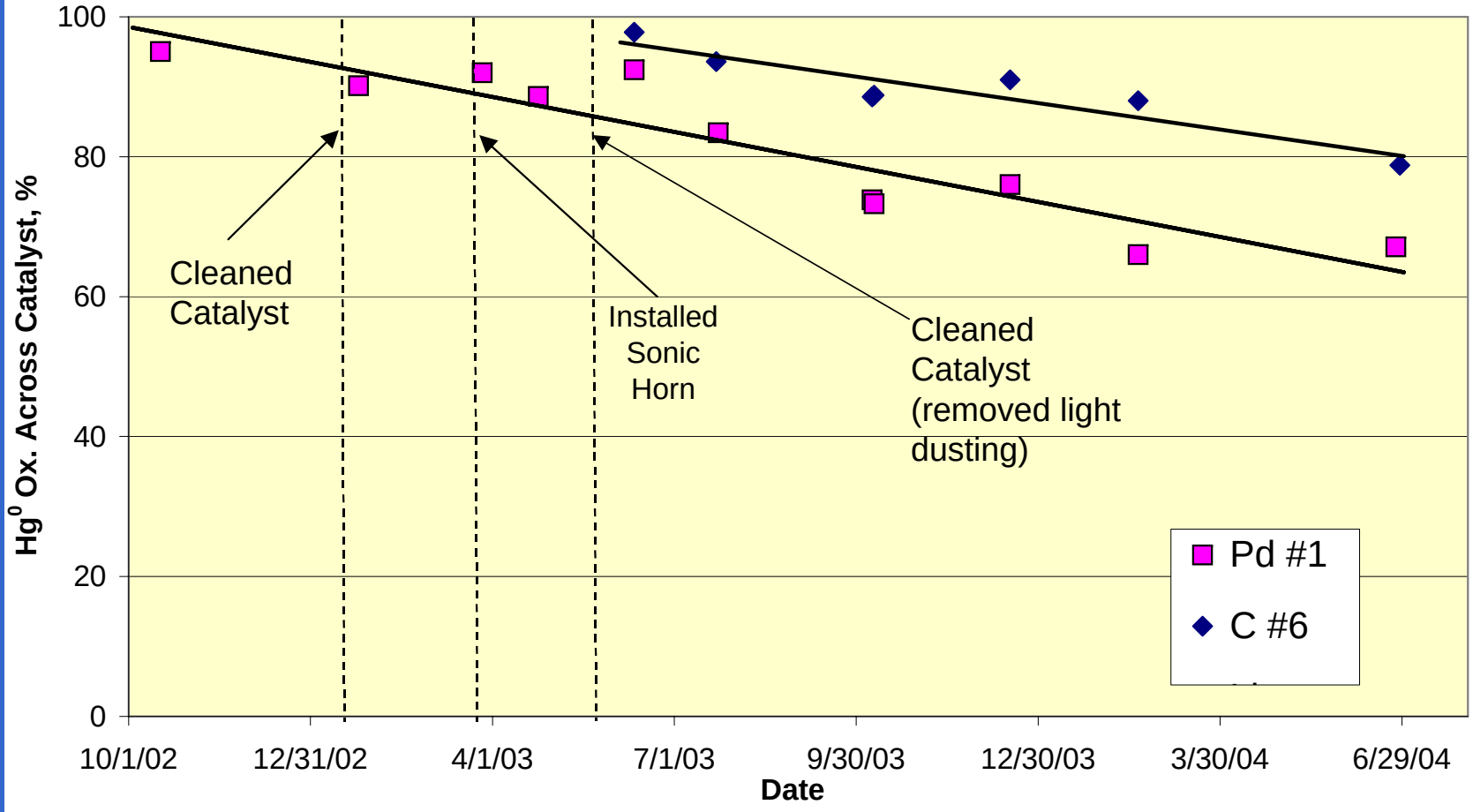
Catalyst Activity Trends over 20 Months at Coal Creek



Example Economics Based on CCS Results - $/lb of Hg Removed (55-70% Hg removal)

	Oxidation Catalyst Upstream of FGD	Conventional Activated Carbon Injection
2-yr Catalyst Life, Fly Ash Sales	$11,300	$17,900
2-yr Catalyst Life, No Fly Ash Sales	$11,300	$10,800
4-yr Catalyst Life, Regen. + Fly Ash Sales	$8,200	$17,900
4-yr Catalyst Life, Regen. + No Fly Ash Sales	$8,200	$10,800

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Summary from Spruce Results

- Sonic horns not required downstream of fabric filter (FF)
- High Hg % oxidation downstream of FF made it difficult to evaluate catalysts
  - Pd and Au catalysts achieved ~50% Hg^0 oxidation after ~17 months
  - Pd and Au catalysts restored to ~80% oxidation after regeneration with 600°F air
- Wet FGD pilot tests showed up to 93% total Hg removal when operating downstream of catalysts (FGD inlet Hg 96% oxidized)
- Preliminary economics showed catalytic oxidation not cost effective relative to ACI for PRB plant with FF (effect of high native Hg oxidation)

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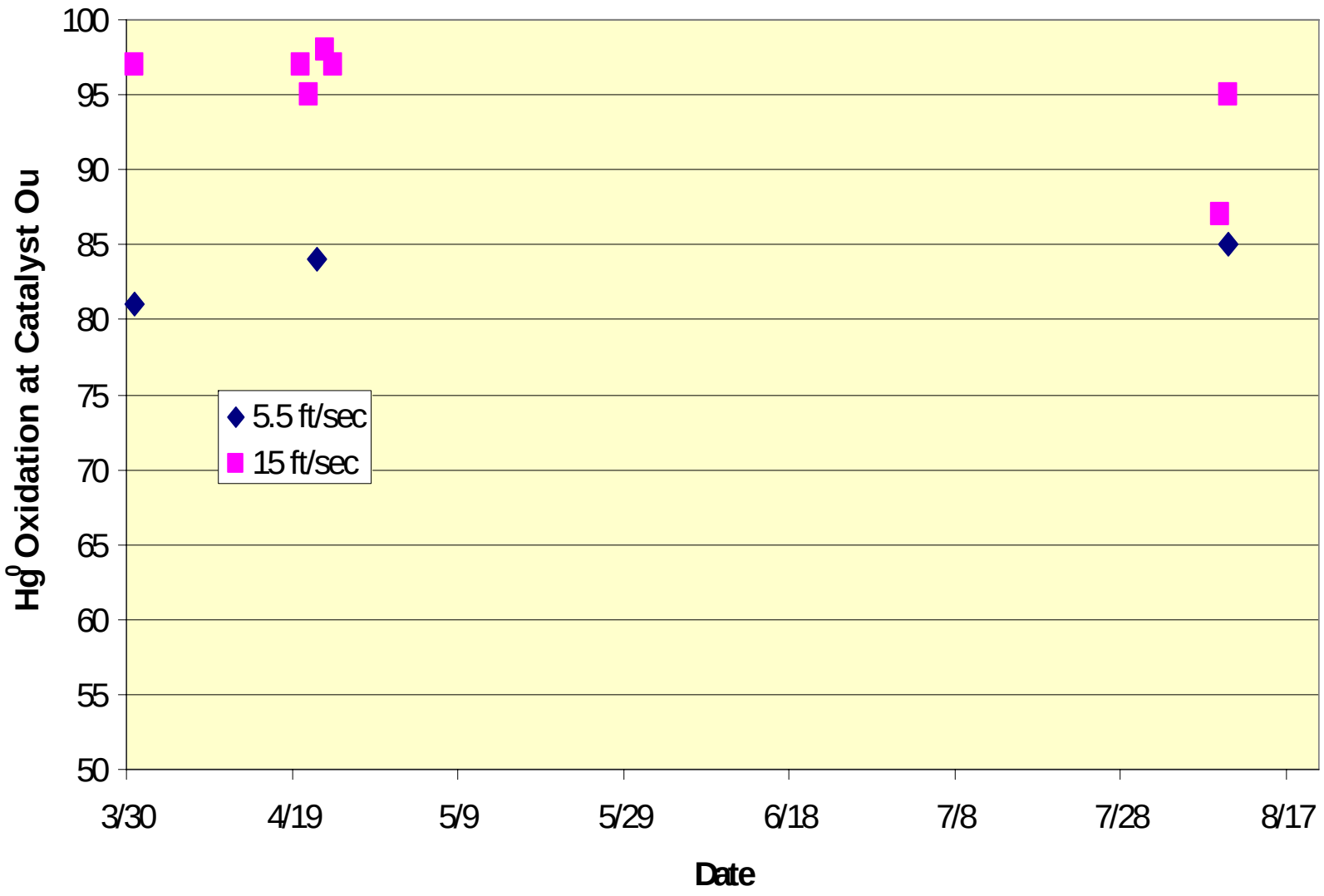
Results from Ongoing 41992 Project

- Testing at three sites
  - Texas lignite/PRB blend
  - Low sulfur eastern bituminous coal
  - PRB
- PRB site (SRP Coronado) results are most relevant to the current project

Activity vs. Time for Coronado Catalysts (Gold) by Hg SCEM



Wet FGD Pilot Unit at Coronado

Example Pilot Wet FGD Test Results (15 ft/sec Catalyst)

FGD Operating Mode	SO_2 Removal, %	Total Hg Oxidation at FGD Inlet	Total Hg Removal, %	Hg^{+2} Removal, %	Hg^0 Re-emissions, % of FGD Inlet Hg^{+2}
LS Natural Oxidation	93	88	**81**	96	4
LS Natural Oxidation with TMT Addition	94	89	**87**	97	0

Total Hg Oxidation at Catalyst Inlet – 8%

Expected Total Hg Removal Across FGD (w/o catalyst) - **<10%**

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Current Project - Major Project Tasks

- Design Module C duct modifications for catalyst retrofit (Aug-Dec 06)
  - Reduce gas velocity to ~15 ft/sec at catalyst
  - CFD modeling of gas flow distribution
  - Future application on entire unit would likely be installed at ESP outlet (~5 ft/sec)
- Construct duct modifications (Jan 06-July 07)
- Procure and install catalyst (Dec 06-July 07)
- Operate catalyst upstream of Module C (July 07-June 09)

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Long-term Catalyst Evaluation

- Up to 24 months duration
- Bimonthly SCEM measurements
  - Hg^0 oxidation across catalyst,
  - Net removal of Hg across FGD Module C
  - Compare to other FGD module in service
- Three sets of Ontario Hydro verification measurements over 20 mos. (each w/triplicate runs)
  - Catalyst inlet, catalyst outlet, Module C outlet
  - “Baseline” sampling across other FGD module
- Track catalyst pressure drop vs. time
- Other flue gas characterization (see next slide)

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Long-term Catalyst Evaluation (cont'd)

- Other flue gas characterization:
  - Catalyst inlet flue gas metals (Method 29)
  - Catalyst inlet flue gas halogens (Method 26a)
  - Catalyst inlet/outlet SO_3/sulfuric acid (Controlled Condensation Method)
  - Catalyst inlet/outlet NO and NO_2 concentration (CEM)

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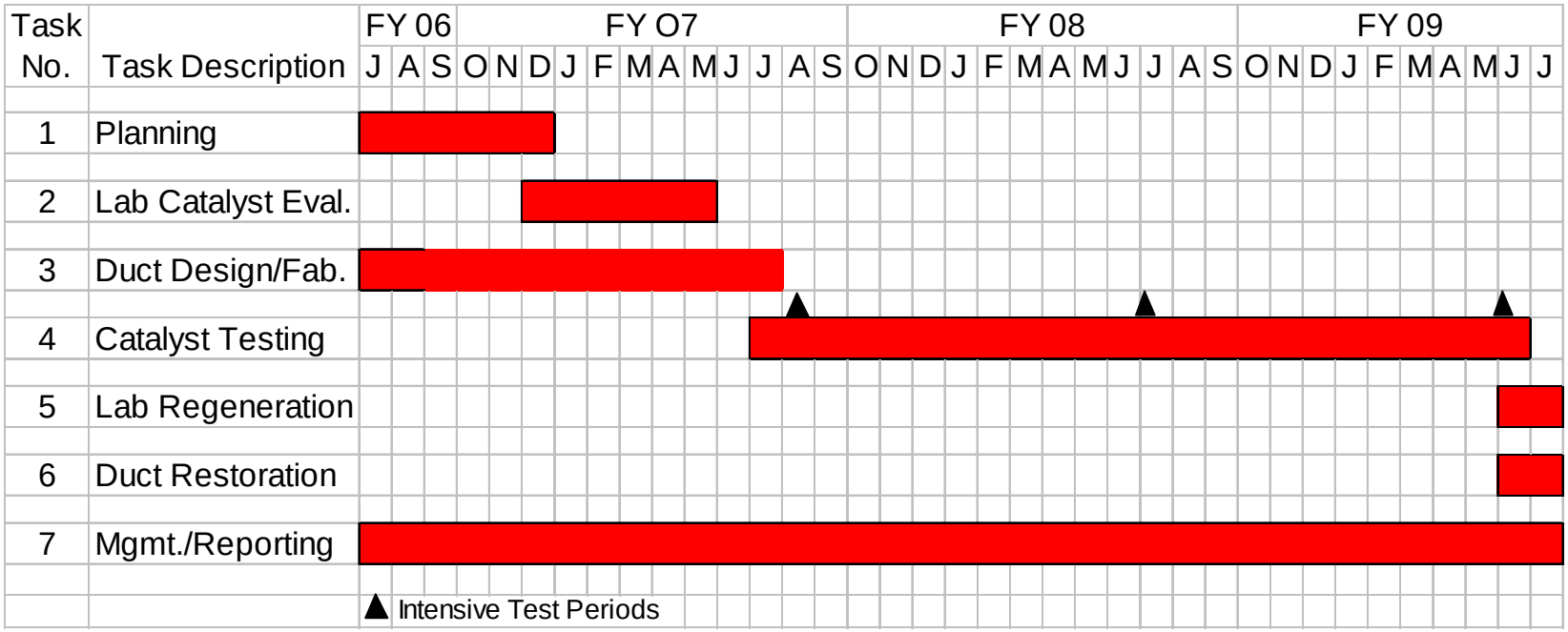
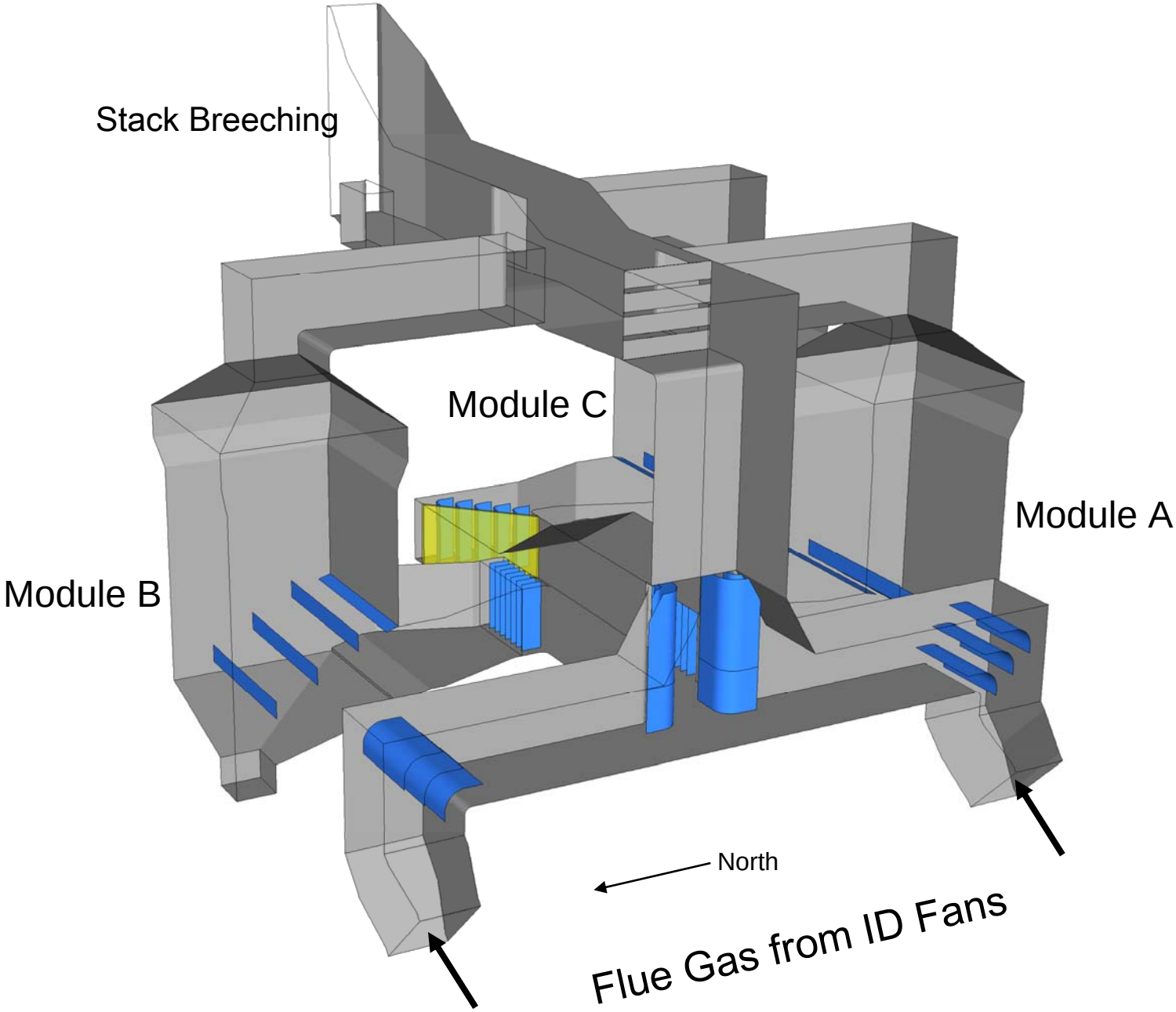
Project Schedule



CFD Modeling Results

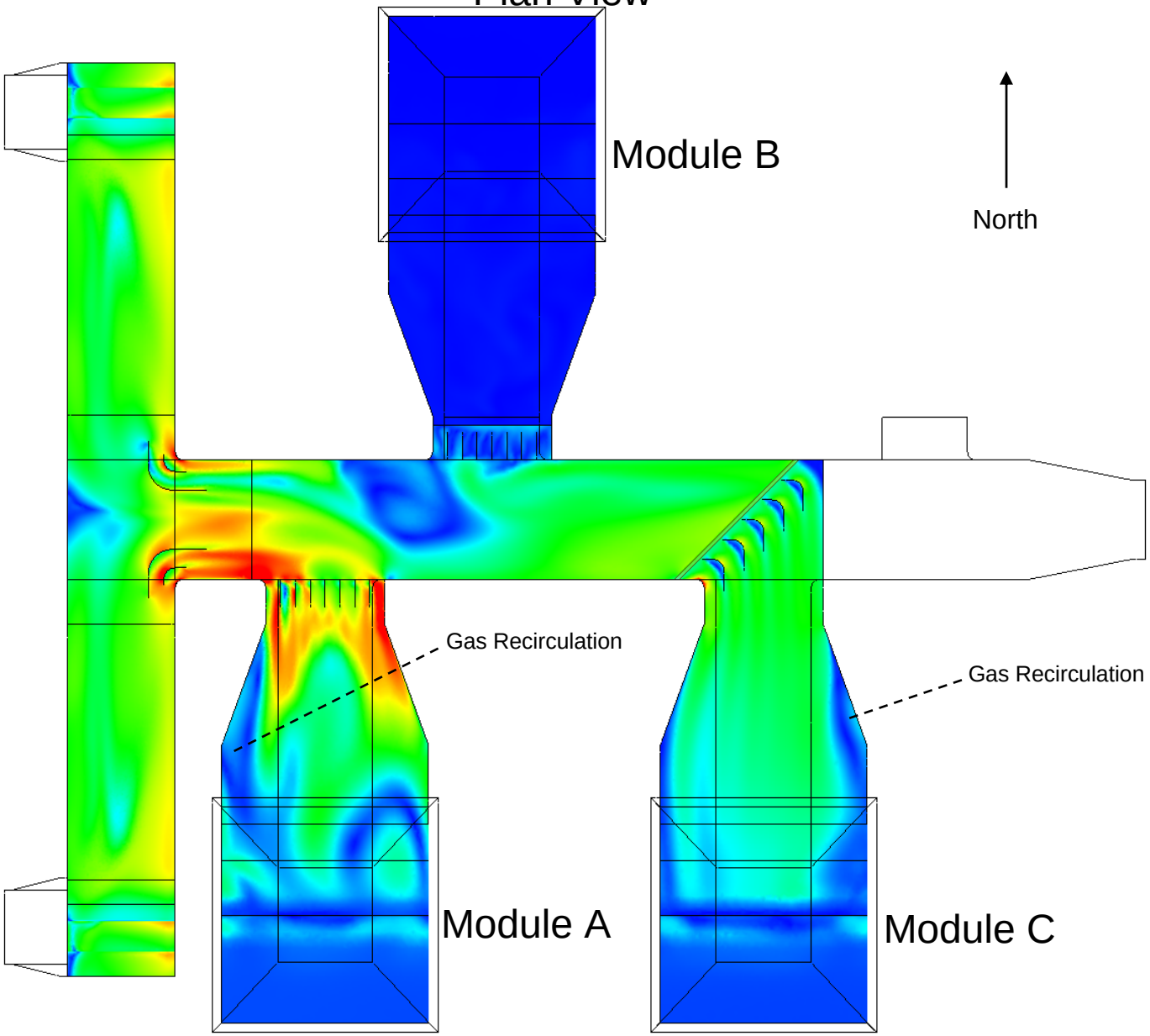
Existing Operation



Case 1:
Existing
Operation with
A&C In Service

Gas Velocity Magnitude

Plan View



75

37.5

0

ft/sec

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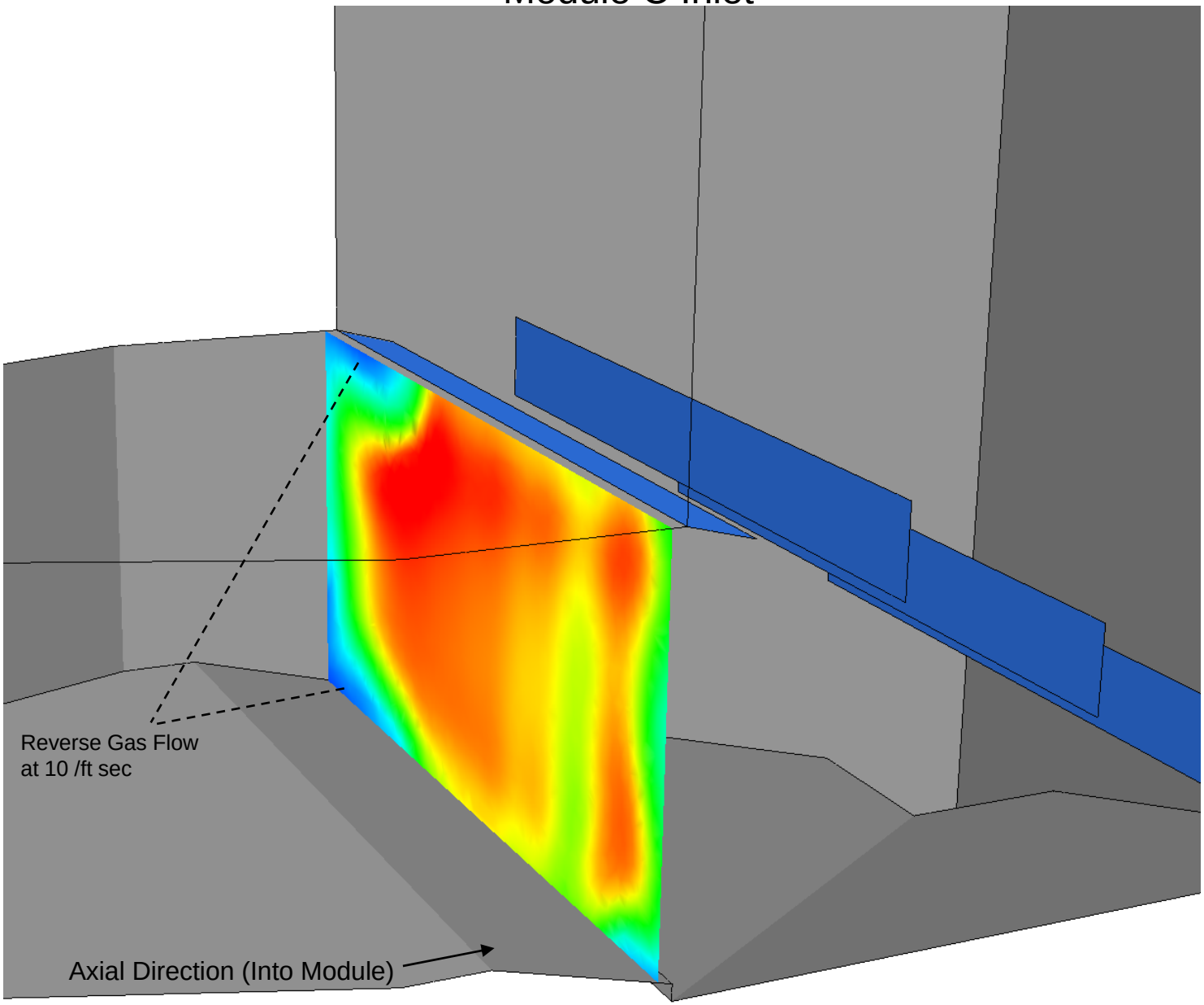
Case 1:
Existing
Operation with
A&C In Service

Axial Component of Gas Velocity

Module C Inlet



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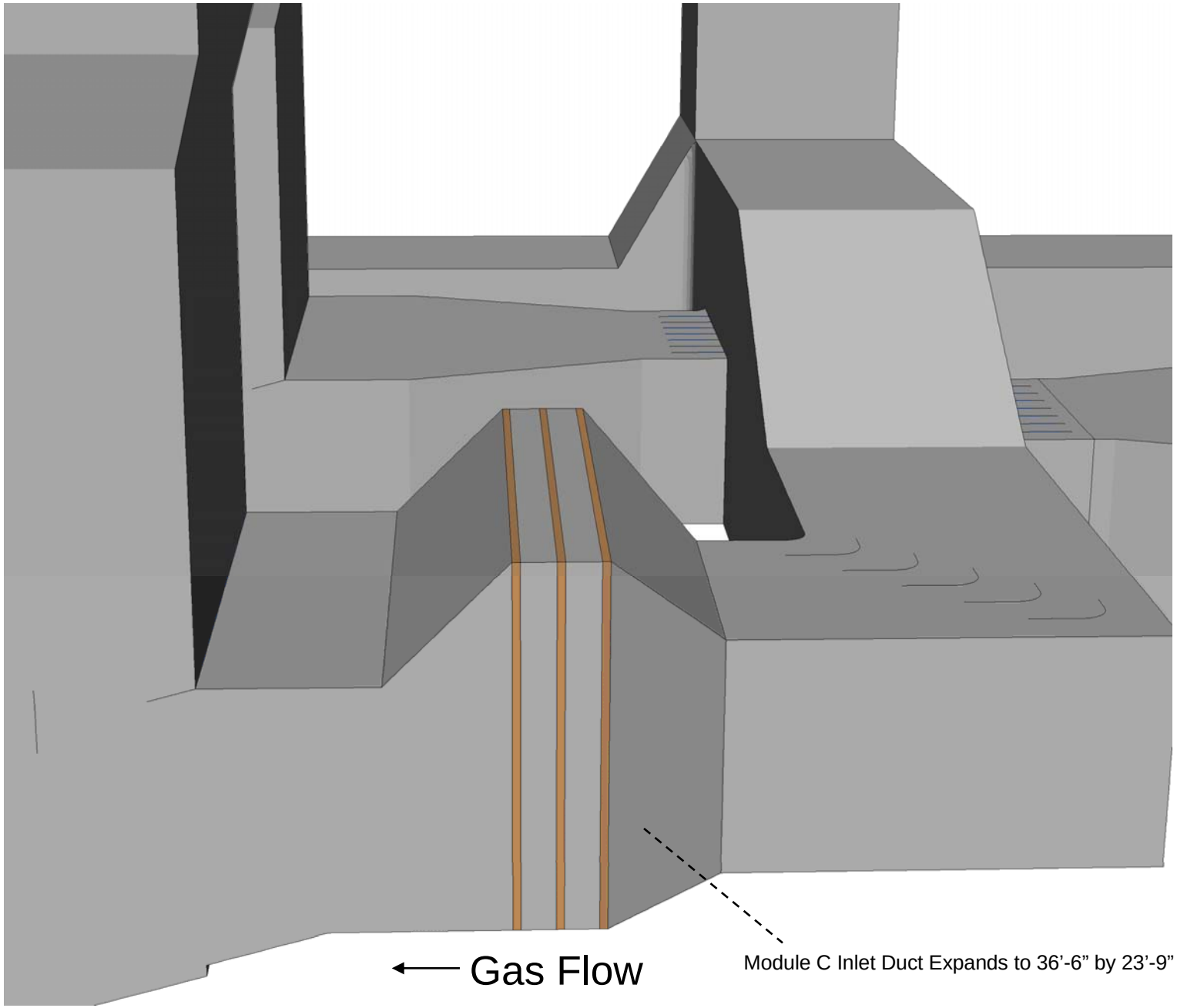
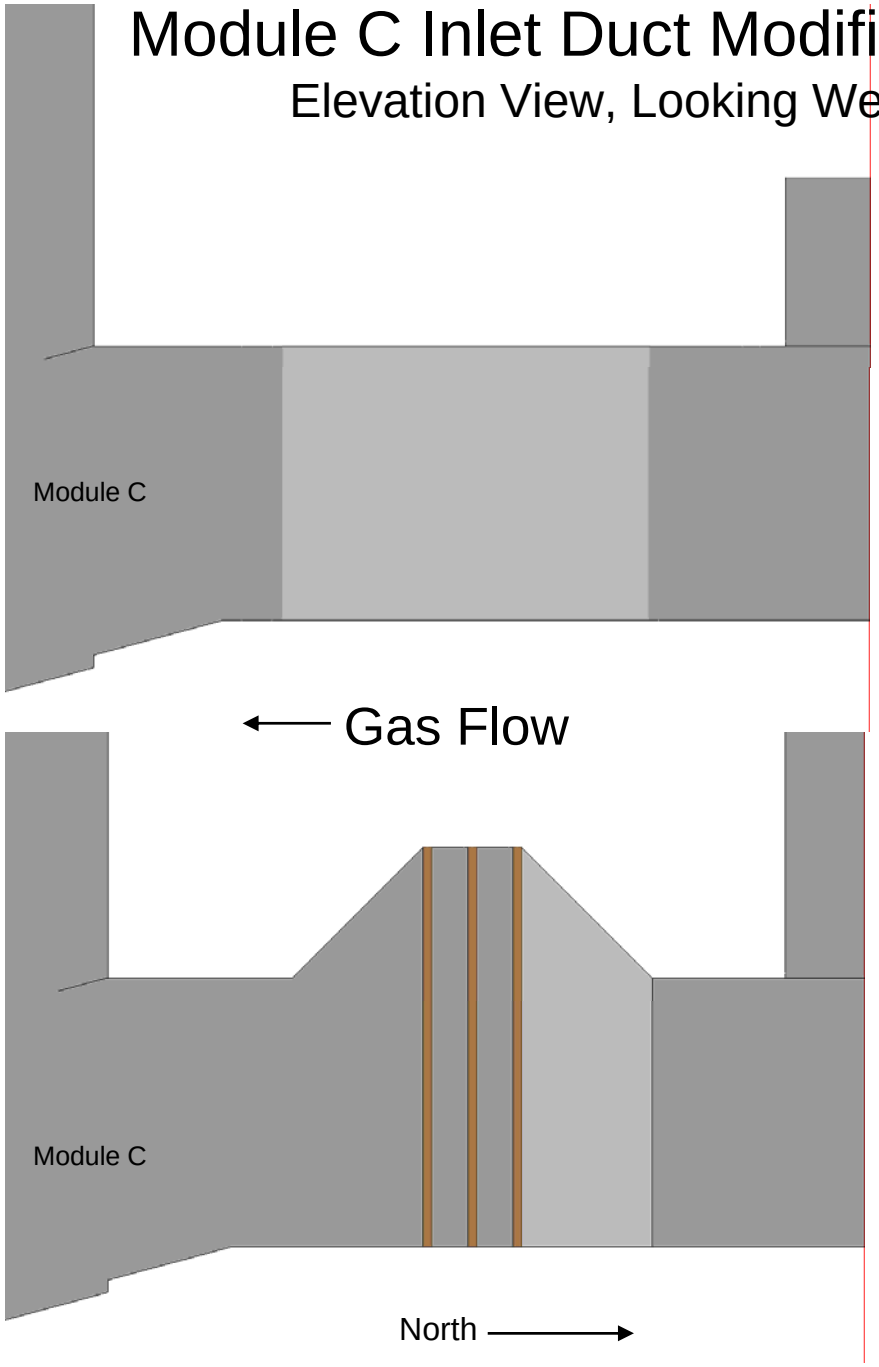
Module C Inlet Duct Modifications



Module C Inlet Duct Modifications

Elevation View, Looking West



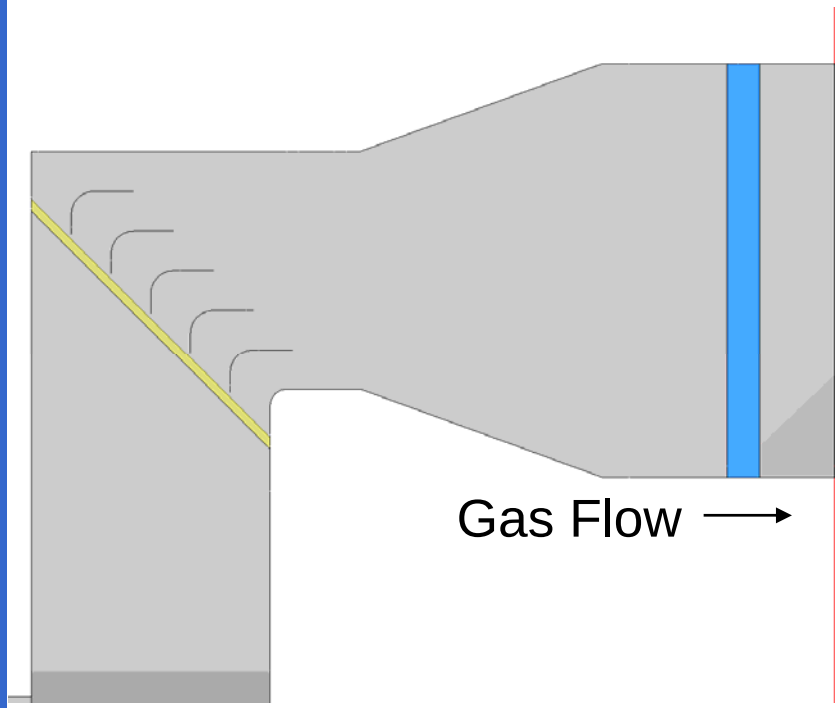
Existing Module C Inlet Duct

Modified Module C Inlet Duct

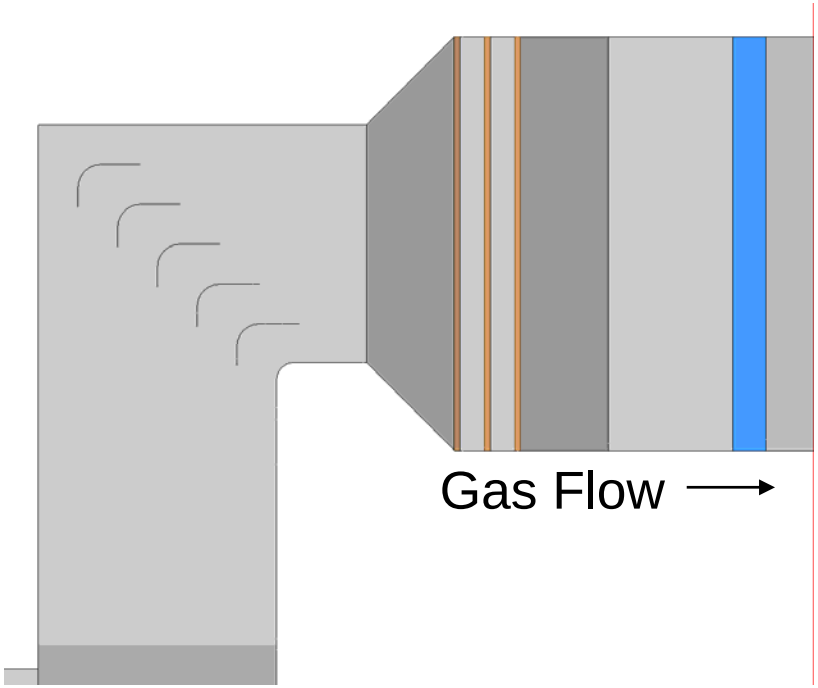
Module C Inlet Duct Modifications

Plan View

North



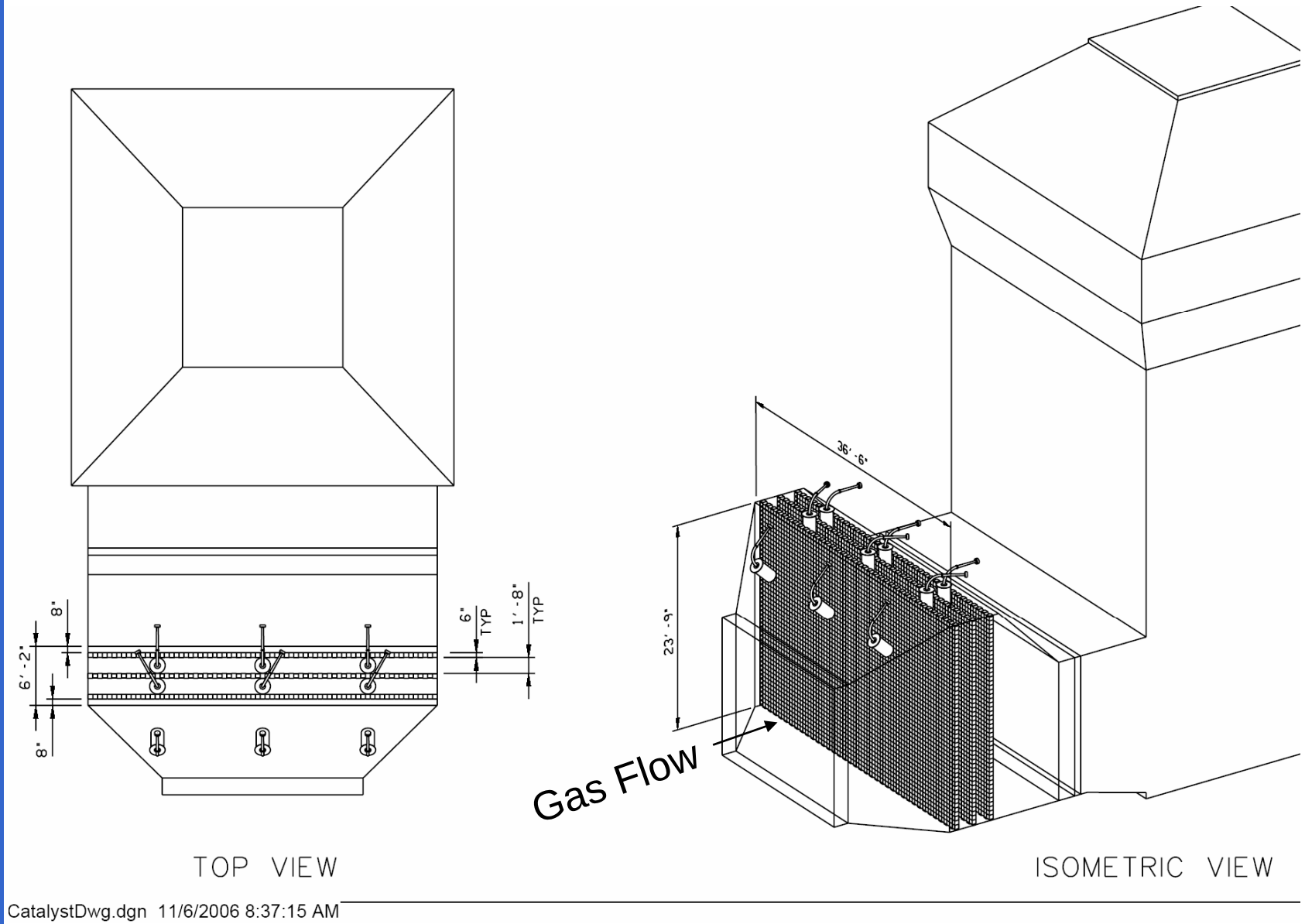
Existing Module C
Inlet Duct



Modified Module C
Inlet Duct

Module C Inlet Duct Modifications

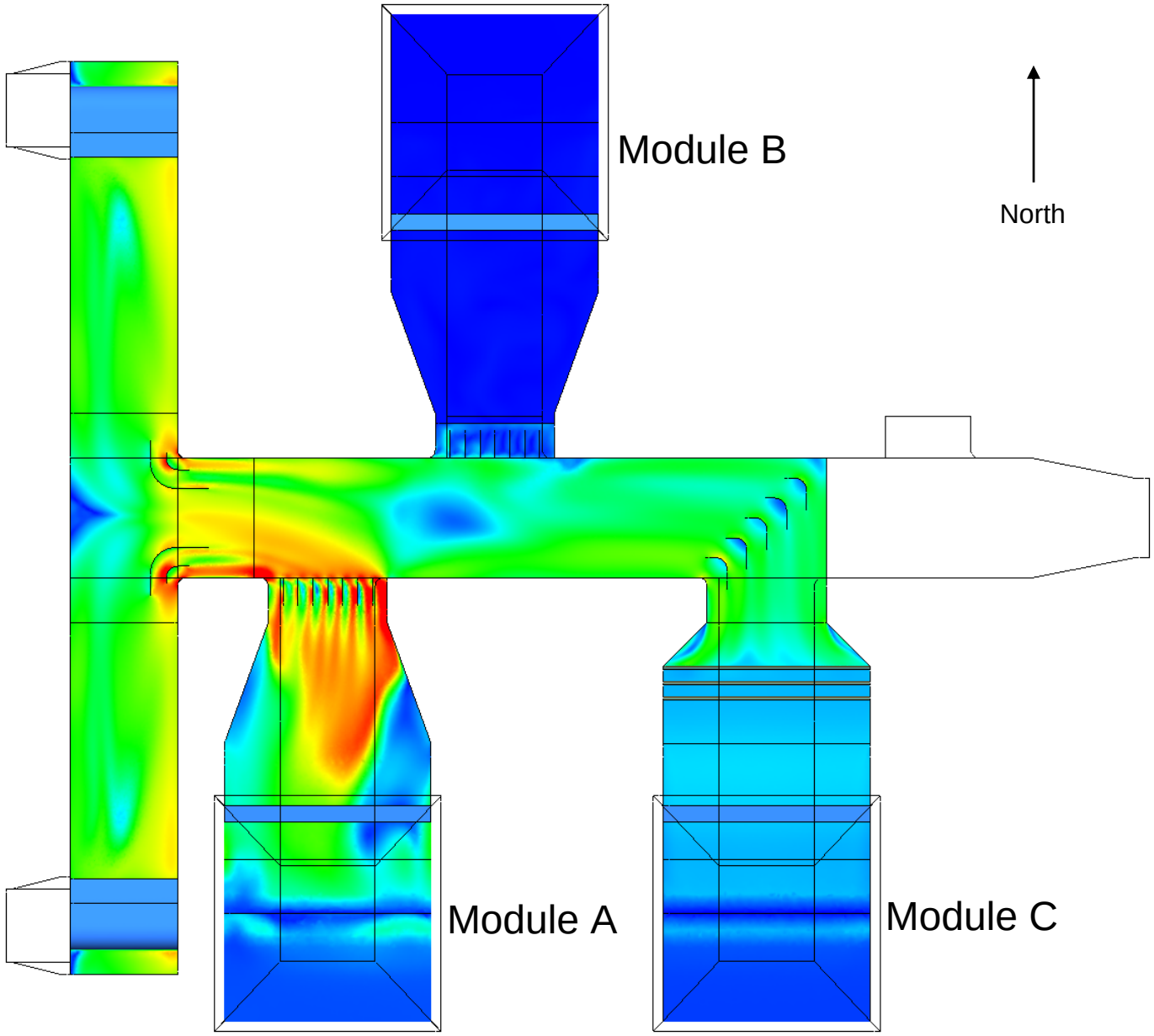
Sonic Horn Layout

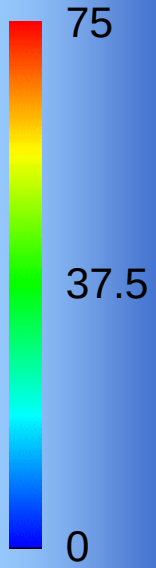


Case 9: Oxidation Catalyst, Perf Plate Removed, A&C In Service

Gas Velocity Magnitude

Plan View





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Case 9:
Oxidation
Catalyst,
Perf Plate
Removed,
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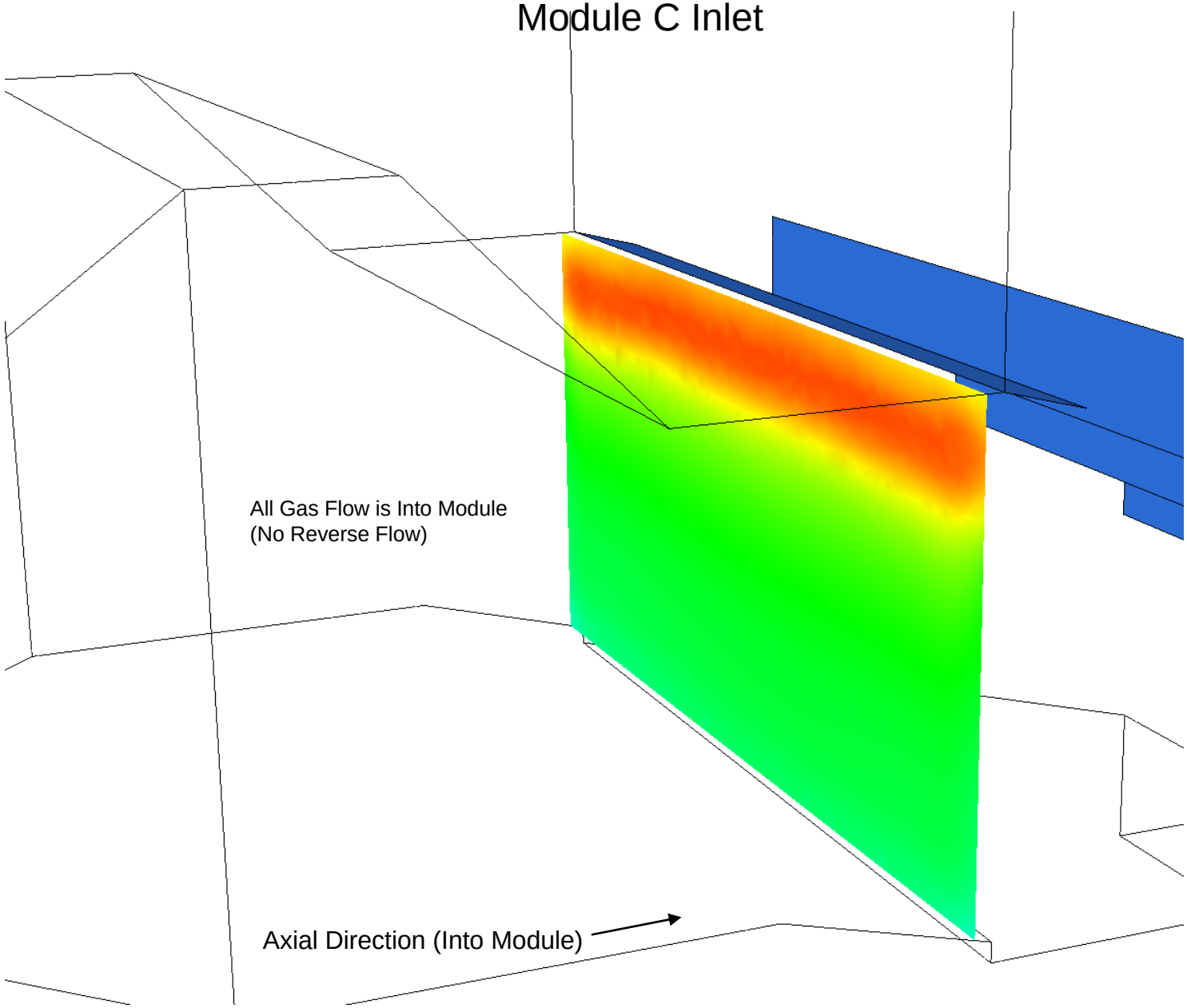
Axial Component of Gas Velocity

Module C Inlet



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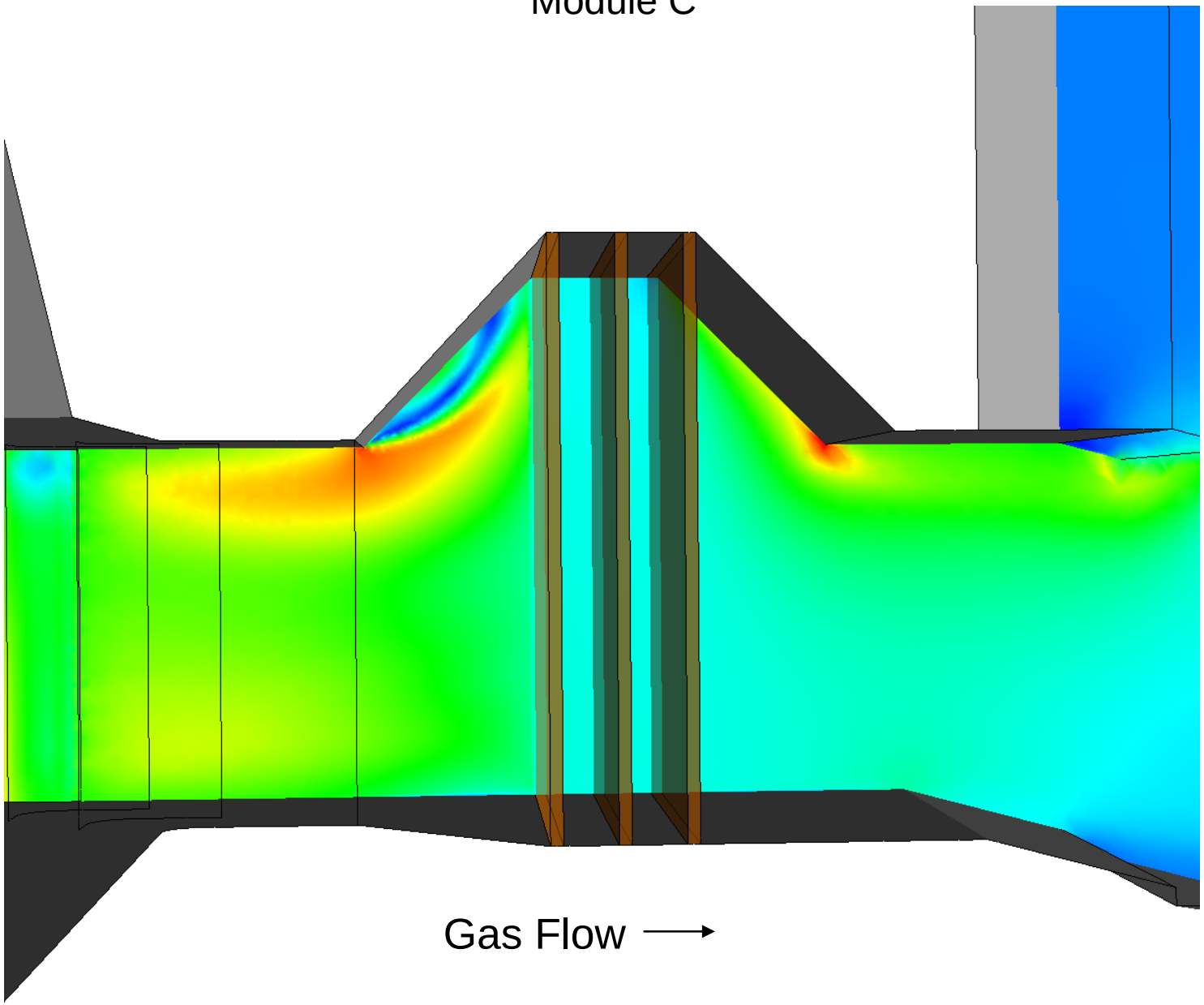
Case 9:
Oxidation
Catalyst,
Perf Plate
Removed,
A&C In Service

Gas Velocity Magnitude

Module C



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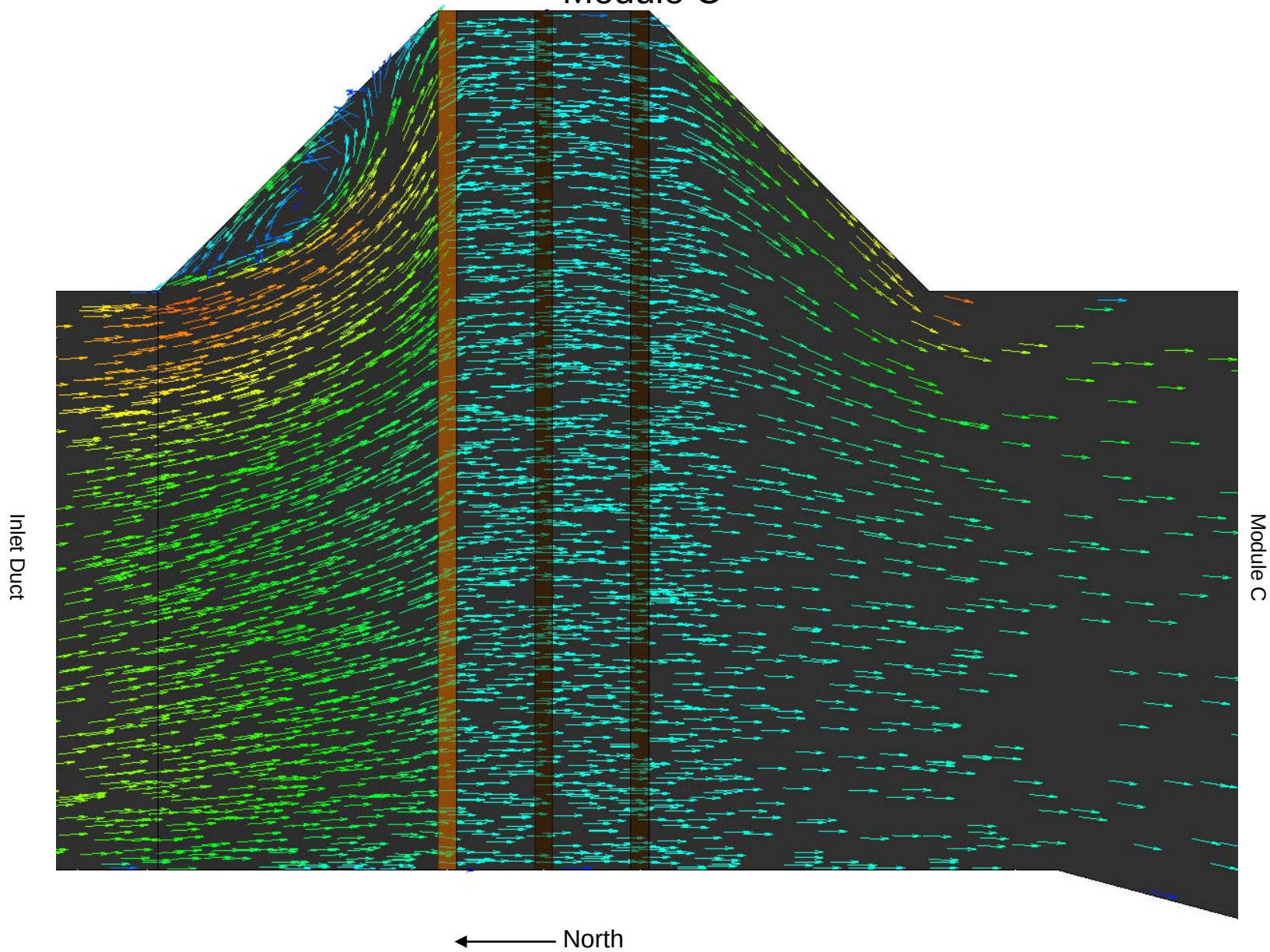
Case 9:
Oxidation
Catalyst,
Perf Plate
Removed,
A&C In Service

Gas Velocity Vectors

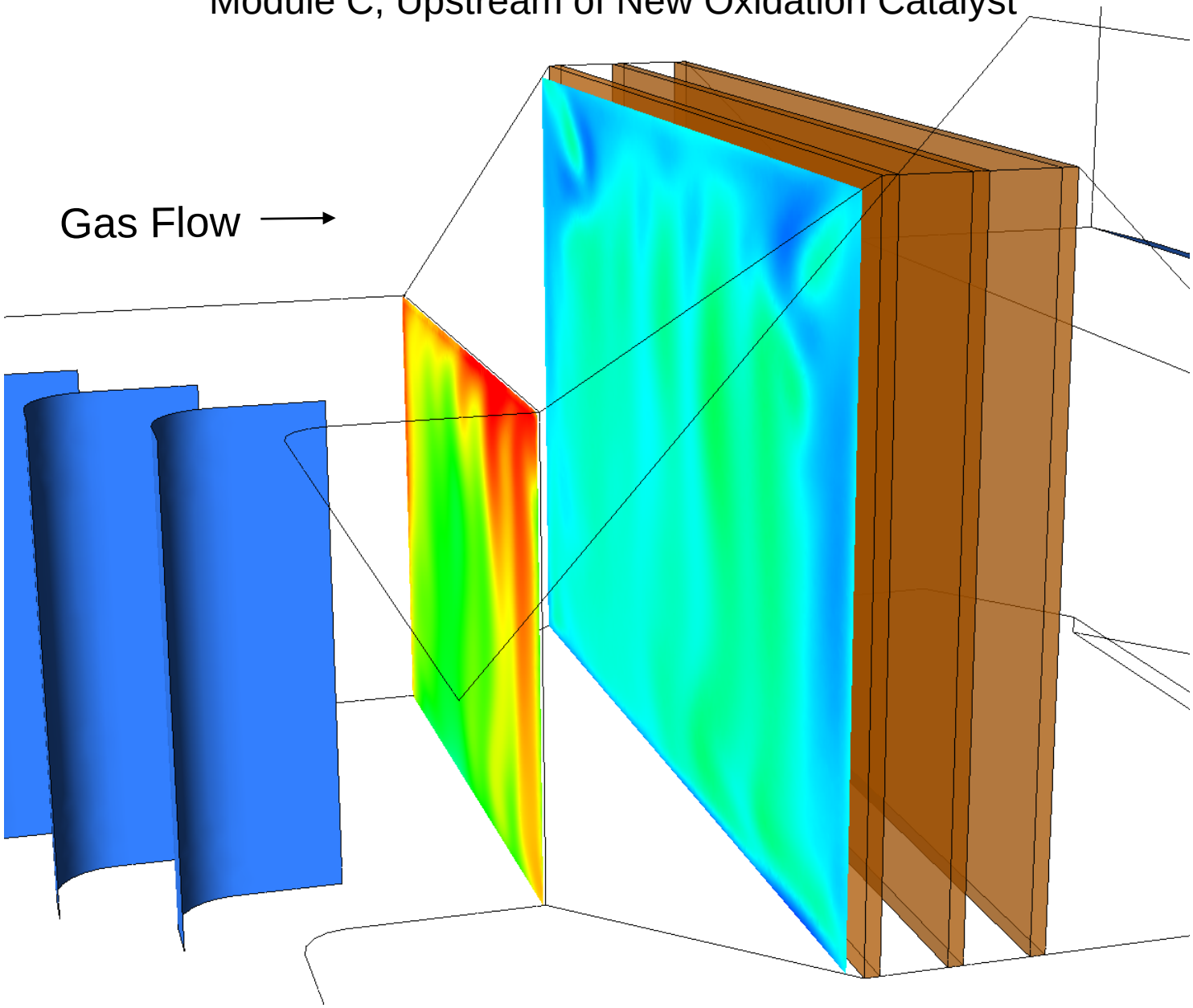
Module C



Case 9: Oxidation Catalyst, Perf Plate Removed, A&C In Service

Gas Velocity Magnitude

Module C, Upstream of New Oxidation Catalyst



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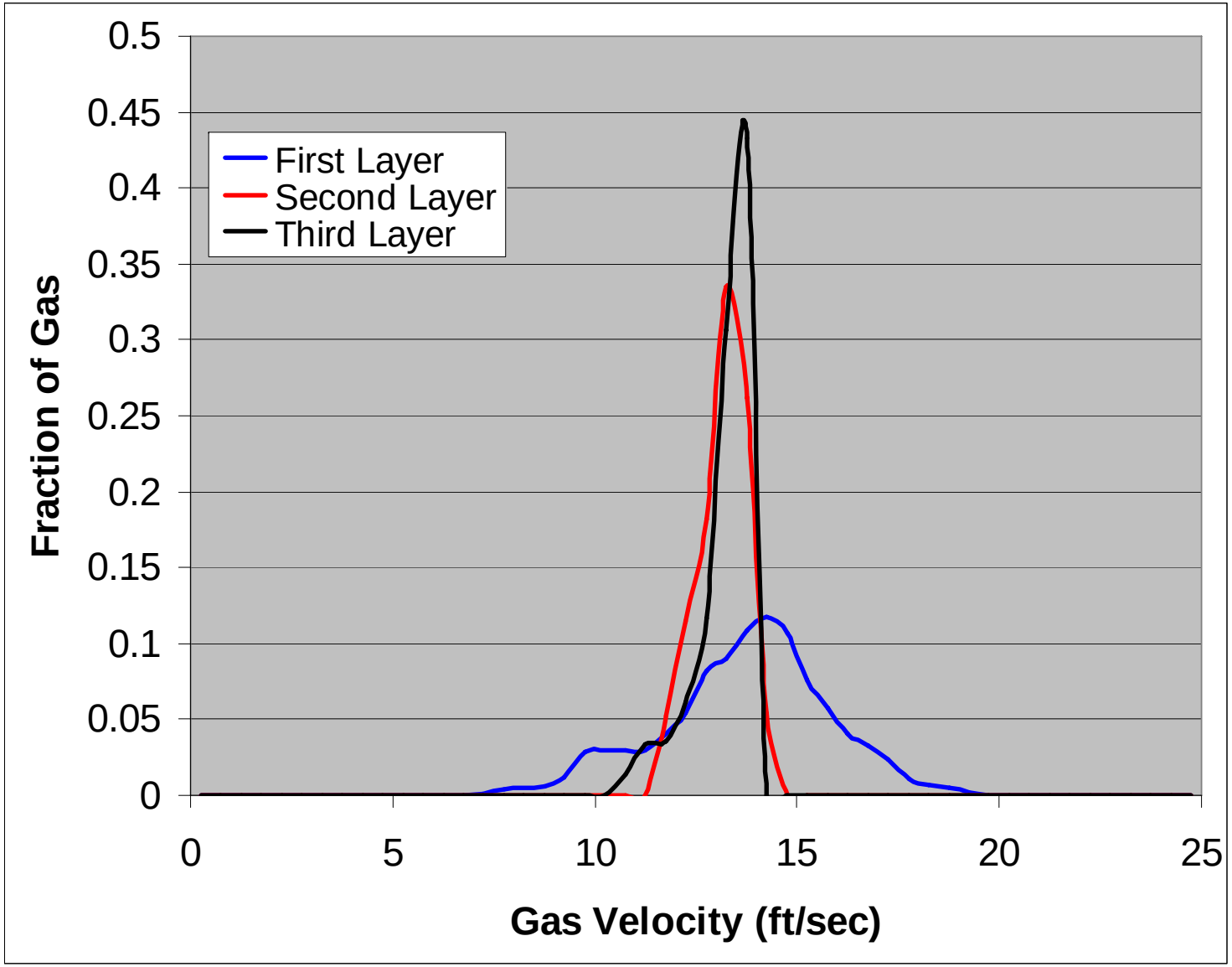
Case 9: Oxidation Catalyst, Perf Plate Removed, A&C In Service

Gas Velocity Distribution Upstream of Each Catalyst Layer



Summary of CFD Results

Case	Description	Gas Flow Split to FGD Modules			Perf Plate dP IWG	Catalyst dP IWG	Average Superficial Gas Velocity (ft/sec)
		A	B	C			
1	Existing Operation	50.5		49.5	0.80		
2	Existing Operation		51.0	49.0	0.80		
9	Catalyst	54.8		45.2		1.40	13.2
10	Catalyst		55.1	44.9		1.40	13.1

Conclusions:

- Existing perforated plate can be removed
- No gas flow straighteners required at catalyst chamber
- Predicted 0.6 IWG increase in pressure drop to module C will not significantly alter gas flow distribution among modules

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