Pilot Evaluation of the Catalytic Oxidation of Mercury for Enhanced Removal in Wet FGD Systems

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Background

- **Oxidized forms of Hg are effectively removed in most wet scrubbers**
  - » **Hg^0 is not removed across wet scrubbers**
- **Hg^0 fraction in coal-derived flue gas can range from 5% to >90%**
  - » **Hg speciation affects emissions**
  - » **Removal difficult with Western fuels**
- **Oxidation of Hg^0 in flue gas can increase overall Hg removal in most wet FGD scrubbers**

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Background

Process: **Catalytic Oxidation of Flue Gas Mercury Upstream of a Wet FGD Absorber**

- **Initial concept development work by EPRI**
- **DOE NETL program**
  - » **MegaPRDA Project (95260)**
    - – **Phases 1 and 2 completed**
  - » **Cooperative Agreement (DE-FC26-01NT41185)**
    - – **Phase 3 underway**

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Phase 1 Summary

- Laboratory investigation of catalyst activity
- Short-term (~day long) proof of concept tests at pilot scale with pulse-jet fabric filter reactor
  - » Pilot-scale evaluation of Hg removal across FGD absorber, fate of absorbed Hg
    - – catalytic oxidation of Hg increased scrubber Hg removal
    - – Hg reported to FGD byproduct solids
- Field testing of bench-scale reactor (5 l/min) for evaluating catalyst life
  - » Catalysts capable of oxidizing Hg^0 in different flue gases

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Phase 2 Tests

- **Long-term (5-6 month) field testing of catalysts**
  - Five l/min reactor for evaluating catalyst life
  - Catalysts tested in powder form
- **Tests at three coal-fired facilities**
  - Texas lignite
  - Powder River Basin subbituminous
  - Eastern bituminous
- **Supporting studies**
  - Lab screening of candidate catalyst materials
  - Field tests (short term) with fixed catalyst structures
  - Regeneration of spent catalysts

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Phase 2 - Catalysts Tested

- **Carbons**
  - Coal- or lignite-derived AC
  - AC derived from biomass or waste materials
  - Impregnated AC (sulfur, iodine)
  - Activated carbon fibers
- **Metal-Based Catalysts**
  - Iron-based
  - Pd-based
  - SCR catalysts (Ti/V)
- **Fly Ash**
  - Derived from various coals

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Phase 2 Summary

- **High Hg^0 oxidation with several catalyst materials**
  - » **Over 90% oxidation of Hg^0 achieved**
  - » **Oxidation increased with catalyst loading**
- **Long-term oxidation with several catalysts**
  - » **Over 80% oxidation maintained for over 4000 hours**
    - – **consistent results with Pd-based sample in different flue gases**
  - » **Results dependent on catalyst and flue gas type**
  - » **Most ACs deactivated within 3000 hrs**
- **Catalysts tested as fixed structures**
  - » **High levels of Hg^0 oxidation at favorable area velocities**

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Phase 2 Summary

- **Deactivated catalyst samples easily regenerated**
  - » **Simple regeneration process**
  - » **Samples return to original activity**
  - » **Deactivation/regeneration associated with various flue gas components**
    - – **selenium**
    - – **sulfur**
- **Effective long-term samples not reactive toward flue gas species**
  - » **Chemical characterization indicates low uptake of flue gas components**

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Preliminary Engineering Analysis

- Hg mass transfer from flue gas to the catalyst surface limits oxidation rate
- Honeycomb cell pitch same as clean-gas SCR
  - » Assume 10-15 ft/sec gas velocity
- Four-inch catalyst depth at ESP outlet to achieve 81% Hg^0 oxidation
- Estimated costs favorable compared to AC injection upstream of fabric filter
  - » Three-year catalyst life, no regeneration
  - » Overall cost driven by catalyst costs

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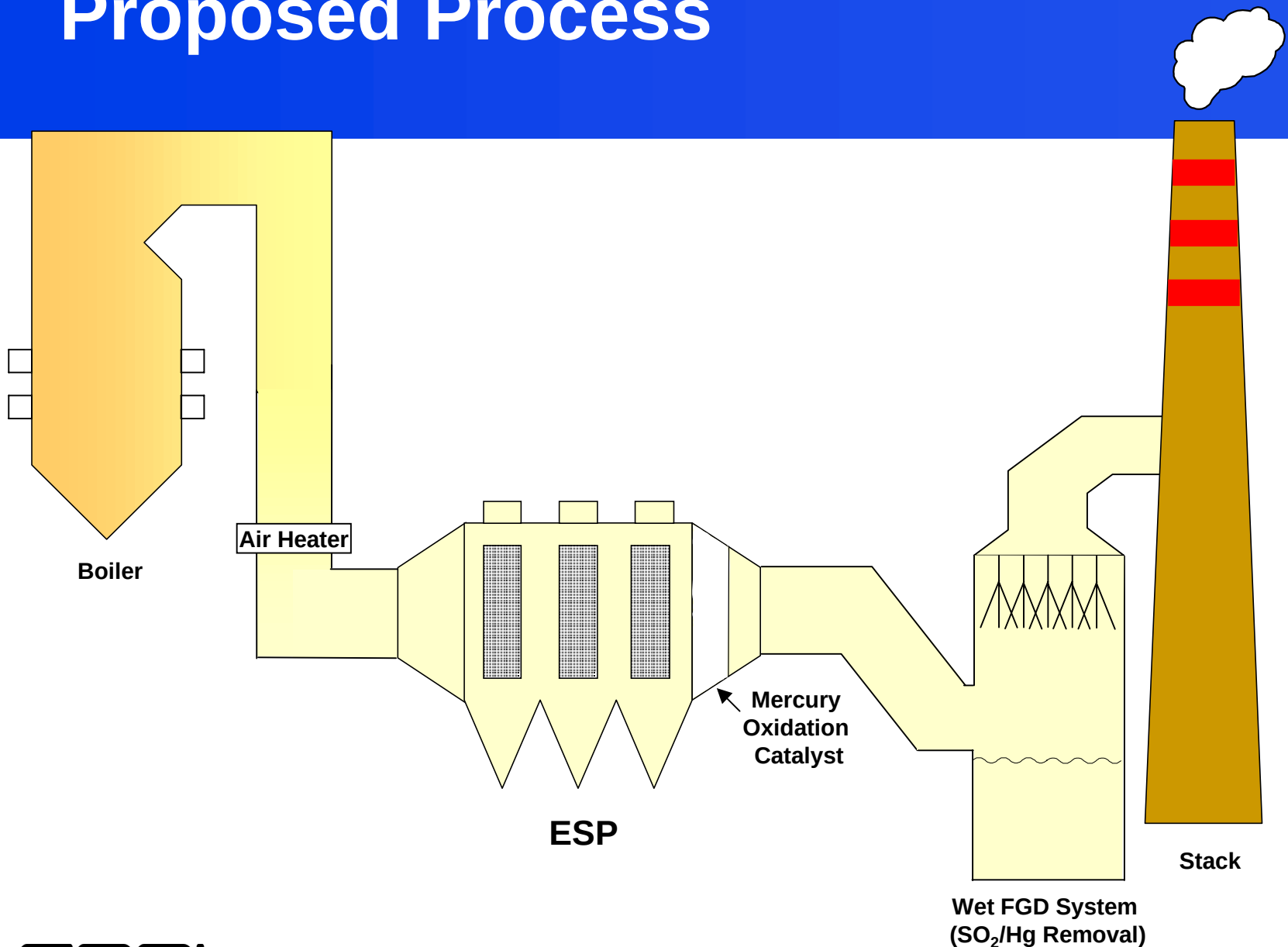
Proposed Process



Phase 3 Objective

Pilot-scale demonstration of low-temperature honeycomb catalysts to oxidize elemental mercury in flue gas for periods of 14 months at two sites

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Pilot Unit Design

- **Installs between particulate control and FGD on host plant**
  - » **Tests performed with clean flue gas**
- **Uses plant ID fan for motive force**
- **Evaluates four catalysts in parallel**
  - » **Each catalyst chamber is up to 1 meter x 1 meter**
- **Flue gas flow rate is about 2000 acfm/chamber**
  - » Area velocity range of 15 - 50 std ft/hr

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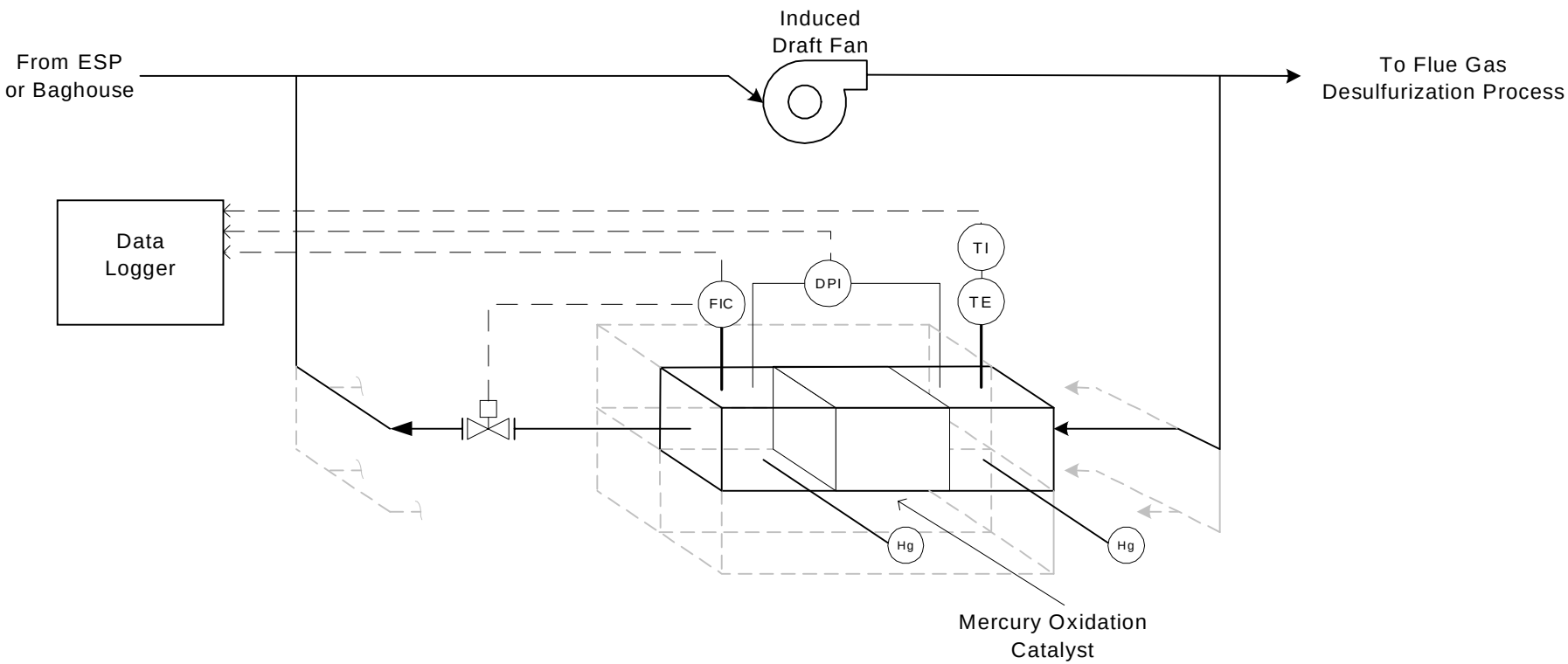
Pilot Unit Design



Pilot Unit Design

Pilot-Scale Testing

- **Evaluation of long-term catalyst activity**
  - » **Operate for 14 to 16 months**
    - – **mercury oxidation performance**
  - » **Parametric evaluation**
    - – **effect of flow rate (space velocity)**
- **Deactivation/regeneration mechanisms**
  - » **Regeneration of deactivated catalysts**
- **Effects on other flue gas species**
  - » **Oxidation of SO_2, NO**
  - » **Effect on flue gas trace metal concentrations**
  - » **HCl, HF**

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Mercury Measurements

- **Mercury measurements across catalyst unit**
  - » **Evaluate mercury concentration and speciation**
    - – **EPRI SCEM**
    - – **Ontario Hydro method**
    - – **EPA Method 29**
- **Full-scale measurements**
  - » **Mercury fate across wet FGD absorber**
    - – **Ontario Hydro method**
    - – **byproduct Hg distribution and stability**
  - » **Mercury balance across ESP + FGD scrubber**

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Phase 3 Host Sites

GREAT RIVER ENERGY

- **Site 1: Great River Energy Coal Creek Station**
- **Pilot unit installed on Unit 1**
  - » **550-MW unit**
  - » **Fires ND lignite**
  - » **Tangential boiler with low-NO_x burners**
  - » **ESP for particulate control (599 ft^2/kacf SCA)**
  - » **Alstom (was CE) FGD spray towers (4 per unit)**
    - – **lime reagent, natural oxidation**
- **Tests scheduled to start October 2002**

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Pilot Installation at Coal Creek Station

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Phase 3 Host Sites

- **Site 2: City Public Service J.K. Spruce Plant**
- **Pilot unit installed on Unit 1**
  - » **546-MW unit**
  - » **Fires PRB coal with Petcoke blend**
  - » **Tangential fired boiler**
  - » **Fabric filter for particulate control (2:1 A/C ratio)**
  - » **Alstom (was CE) FGD spray towers (3 per unit)**
    - – **limestone reagent, natural oxidation (100%)**
- **Tests scheduled to start March 2003**

Catalysts to be Tested - Site 1

Catalyst Type	Source	HC Pitch (mm)	Module Dimensions
Palladium on Alumina	Prototech	3.2 (64 spsi)	30”x30”x9”
SCR (Ti/V)	Ceramics GmbH & Co. (formally Siemens)	3.7 (46 cpsi)	35.4”x35.4” x19.7”
Waste-Derived AC	ISGS	3.2 (64 cpsi)	36”x36”x12”
Fly Ash	Subbituminous coal-derived	3.2 (64 cpsi)	36”x36”x12”

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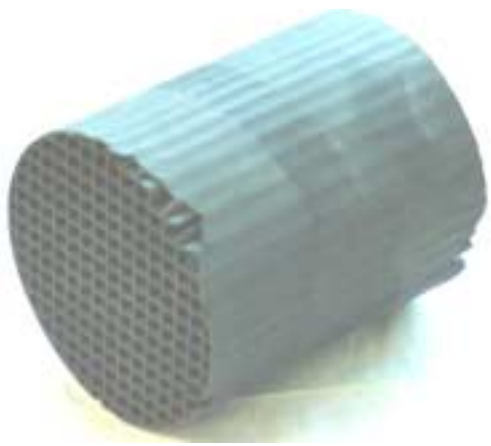
Ceramics GmbH Catalyst Module

Extruded Carbon & Fly Ash Honeycomb Structures

- **Small-scale preparations successful**
- **Methods for producing larger structures being determined**
  - » **Small pitch required**
  - » **Issues related to water content, drying time**



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Laboratory Testing

- Support pilot test program
- Screen catalyst materials at simulated Site 1 and Site 2 conditions
  - » Verify performance of actual honeycomb material
- Investigate deactivation mechanisms
- Investigate regeneration conditions
  - » Possible laboratory regeneration of pilot catalysts, if needed

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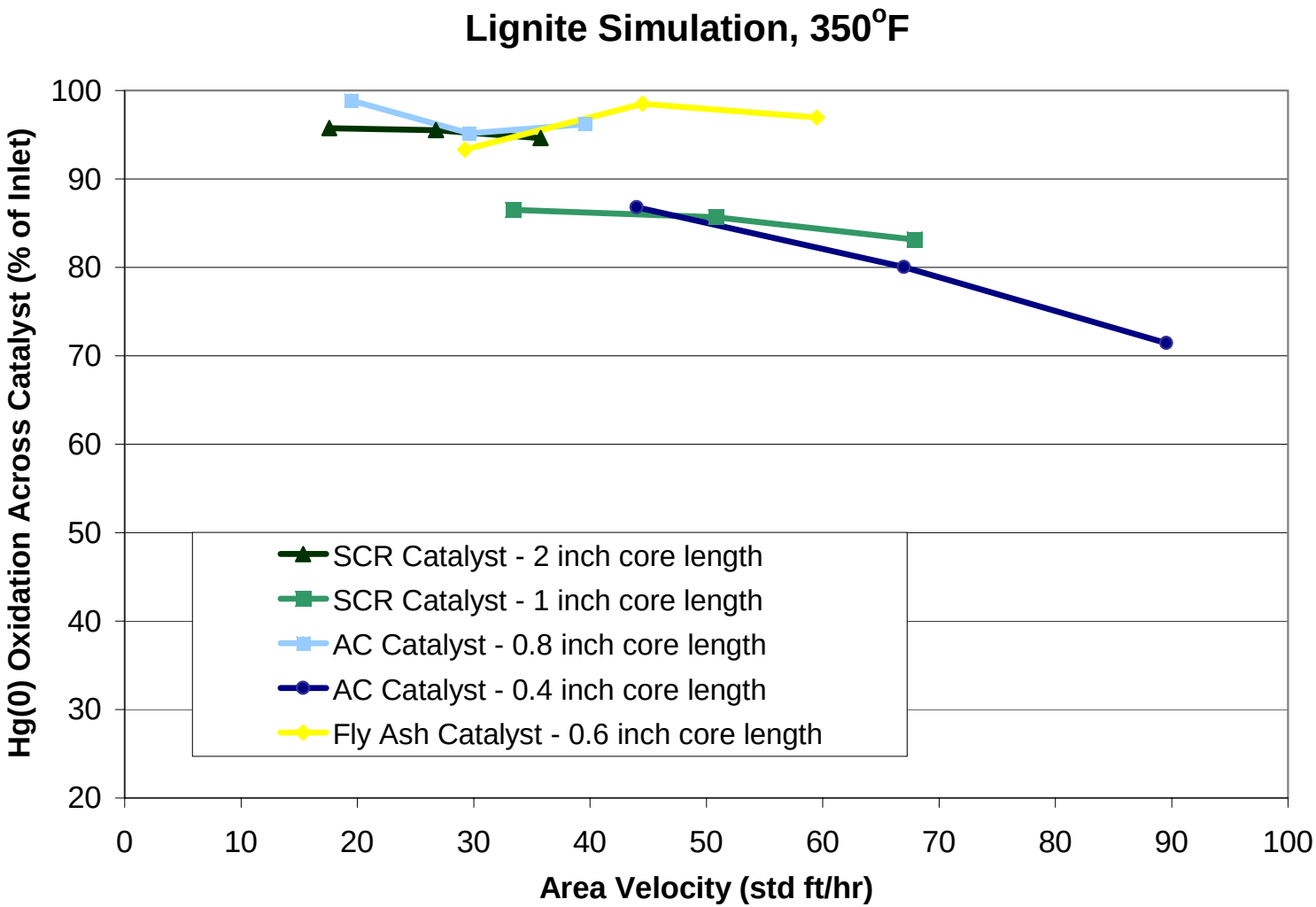
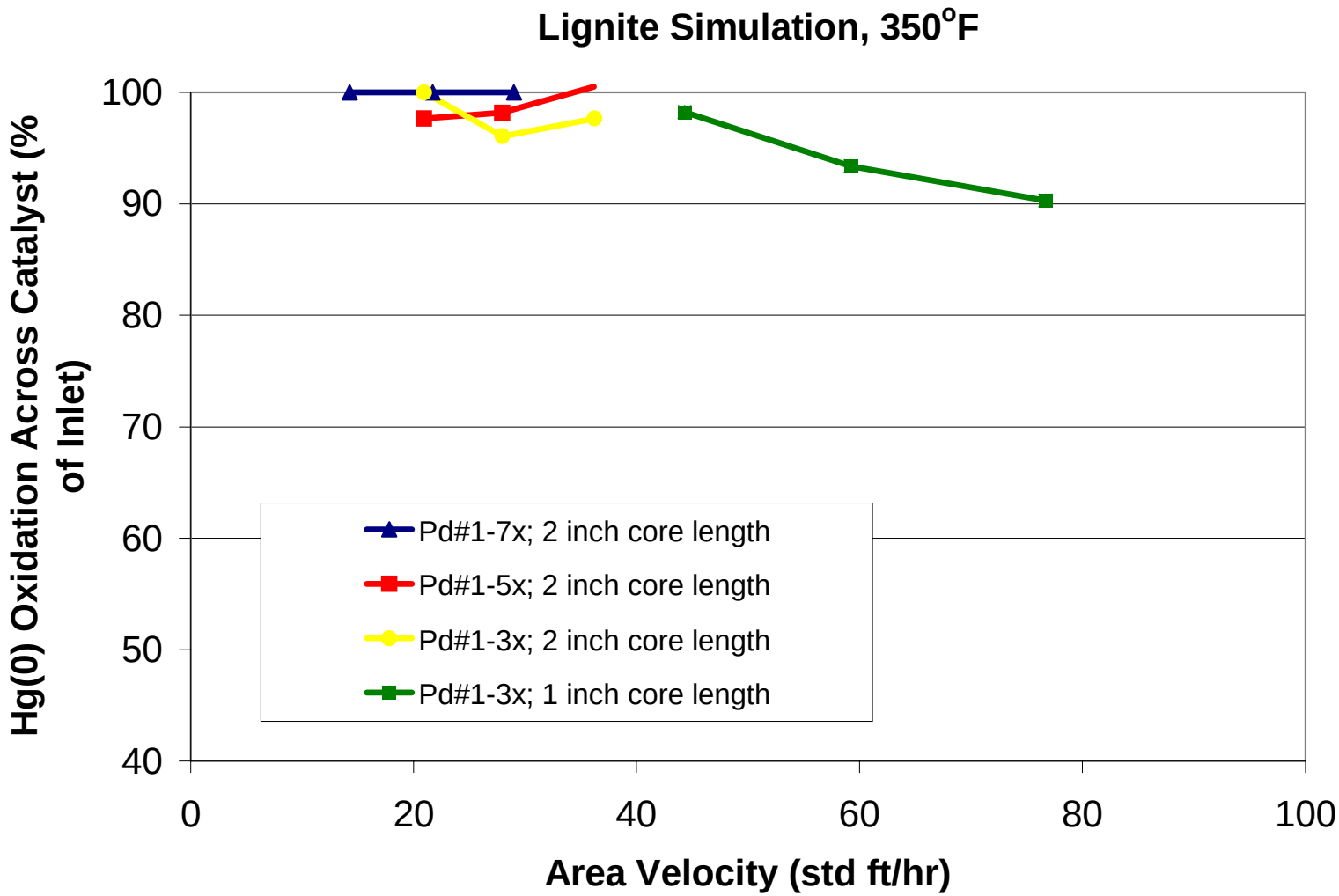
Lab Results - Catalyst Honeycomb Samples



Lab Results - Palladium Honeycomb Samples



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