Reinhold Environmental Ltd.

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Mercury Oxidation by SCR Catalyst

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Outline

- Mercury Speciation
- PRB Testing
  - US Test Plant
- Eastern Bituminous Testing
  - US Test Plant
  - BHK Test Facility
- Summary and Further Development

Mercury Speciation

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Form of vapor phase mercury (Speciation)

Elemental Mercury - Hg^0

Oxidized or ionic mercury - Hg^{++}

The form of mercury in the flue gas is critical to performance of emissions control systems.

- Elemental Mercury: Hard to remove from flue gas
- Oxidized or ionic Mercury: Easier to remove from flue gas (downstream ESP, FGD)

To achieve higher Hg removal, Hg oxidation is indispensable.

US Coal Speciation

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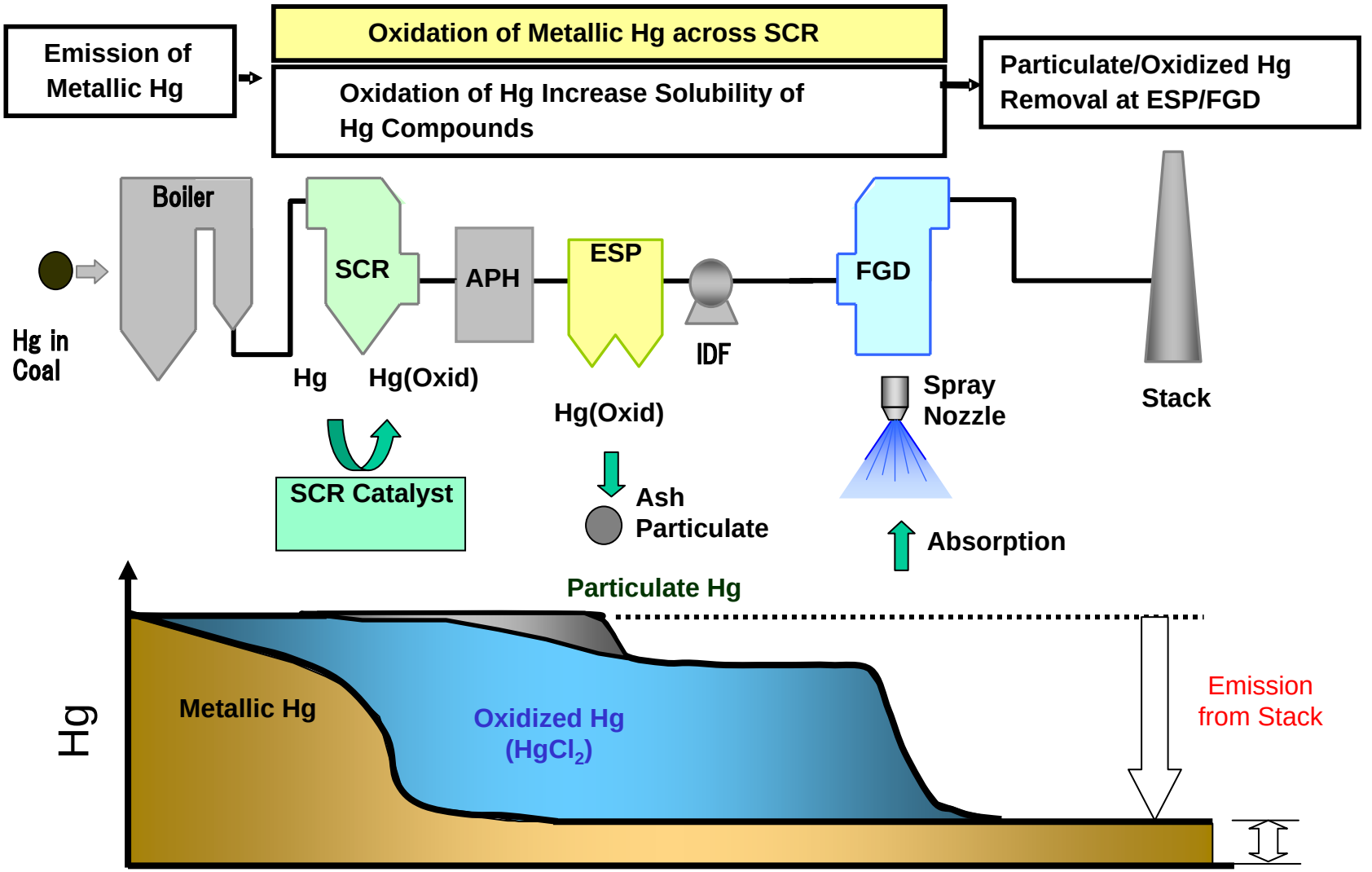
	% Coal-Fired Installations	Relative Content		% Elemental Mercury in Flue Gas
		Cl	Hg	
Lignite	5	Low	High	>90
Sub-bituminous	38	Low	Low	80-90
Bituminous (Western)	7	Int	Low	NA
Bituminous (Eastern)	50	High	Int	30-40

Typical Behavior of Mercury



Hitachi R&D History for Mercury Oxidation catalyst

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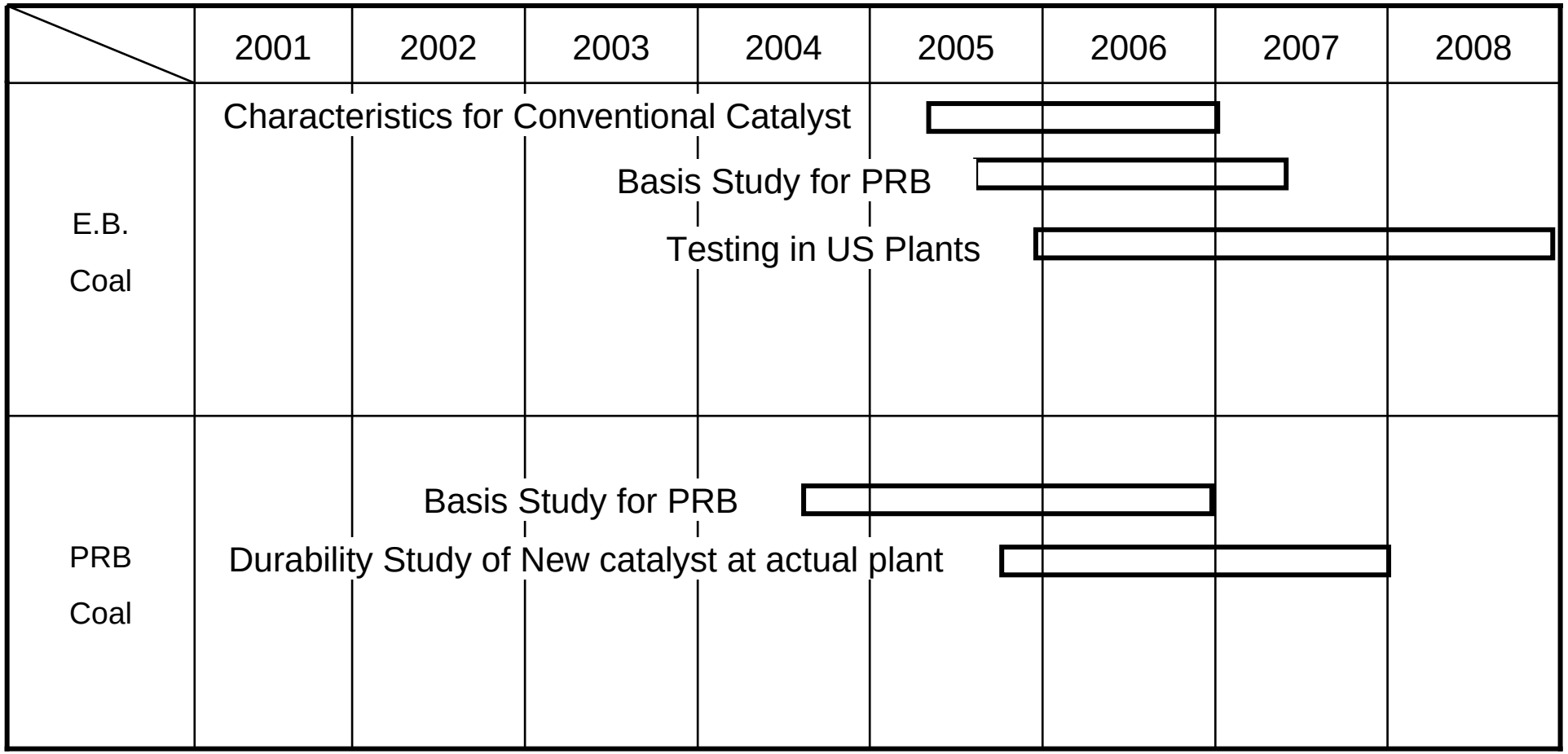
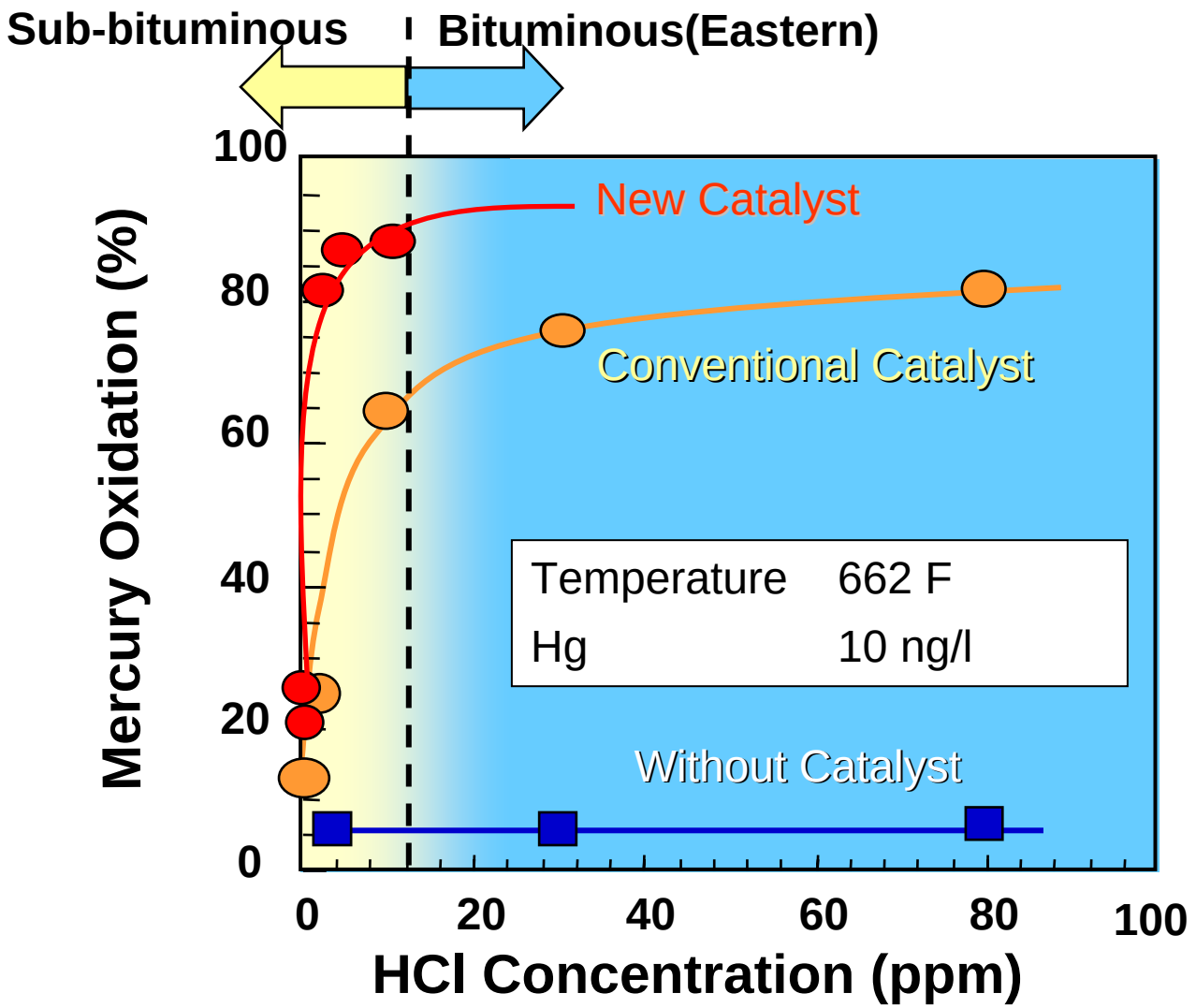


Mercury Oxidation Catalyst for PRB Coal

New Hitachi Hg Oxidation Catalyst



Test Site – Slip Stream Reactor

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- 620 MWg
- Fires 100% PRB
- SCR System began operation in 2003

Test Objectives

- Install a Slipstream Reactor for catalyst exposure in **actual** operating conditions
- Allow for periodic sampling of catalyst performance and extraction of samples for laboratory analysis
- Utilize results to optimize catalyst design for commercial applications

Slipstream Reactor - SSR

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- Installed next to full-scale operating SCR
- Takes flue gas from just above the 1st layer of catalyst
  - Flue gas contains NH_3
- Used to expose catalyst to flue gas for:
  - Ongoing periodic performance testing
  - Periodic catalyst sample extraction for laboratory analysis

Slipstream Reactor - SSR

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- SSR equipped with:
  - Four (4) layers of catalyst
  - Sootblowers at each catalyst level
  - I.D. fan
  - Control valve for flow adjustment
  - Heaters
  - Instrumentation for measurement of flow, temperature and pressure drop throughout SSR
  - Local control panel and PLC with communication to DCS and remote monitoring (via modem)
- Measurement ports for onsite testing of:
  - Hg (Ontario Hydro Method)
  - NH3 (wet chemistry)
  - NOx
  - Gas Flow

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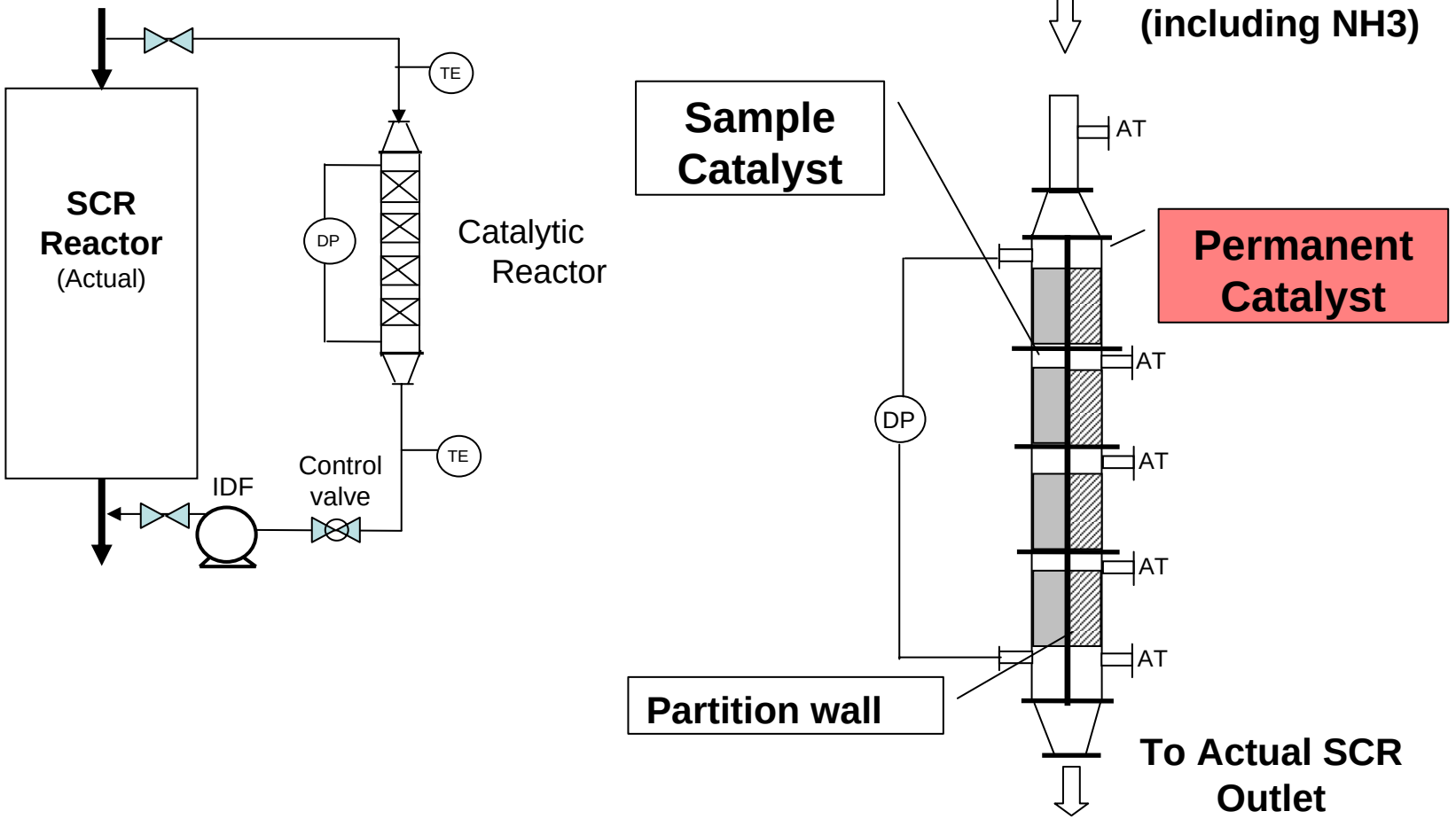
Outline of SSR



Started operation December,'2005

SSR Reactor (One Catalyst Layer)

Mercury Speciation at Each Sampling Point

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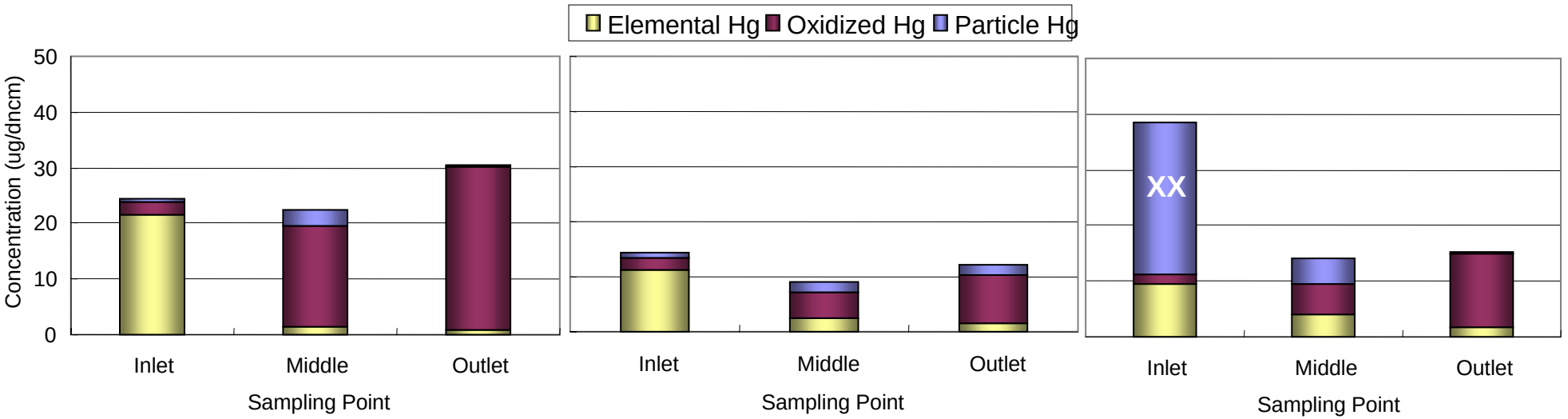
1st sampling Date:Jan.10,'06

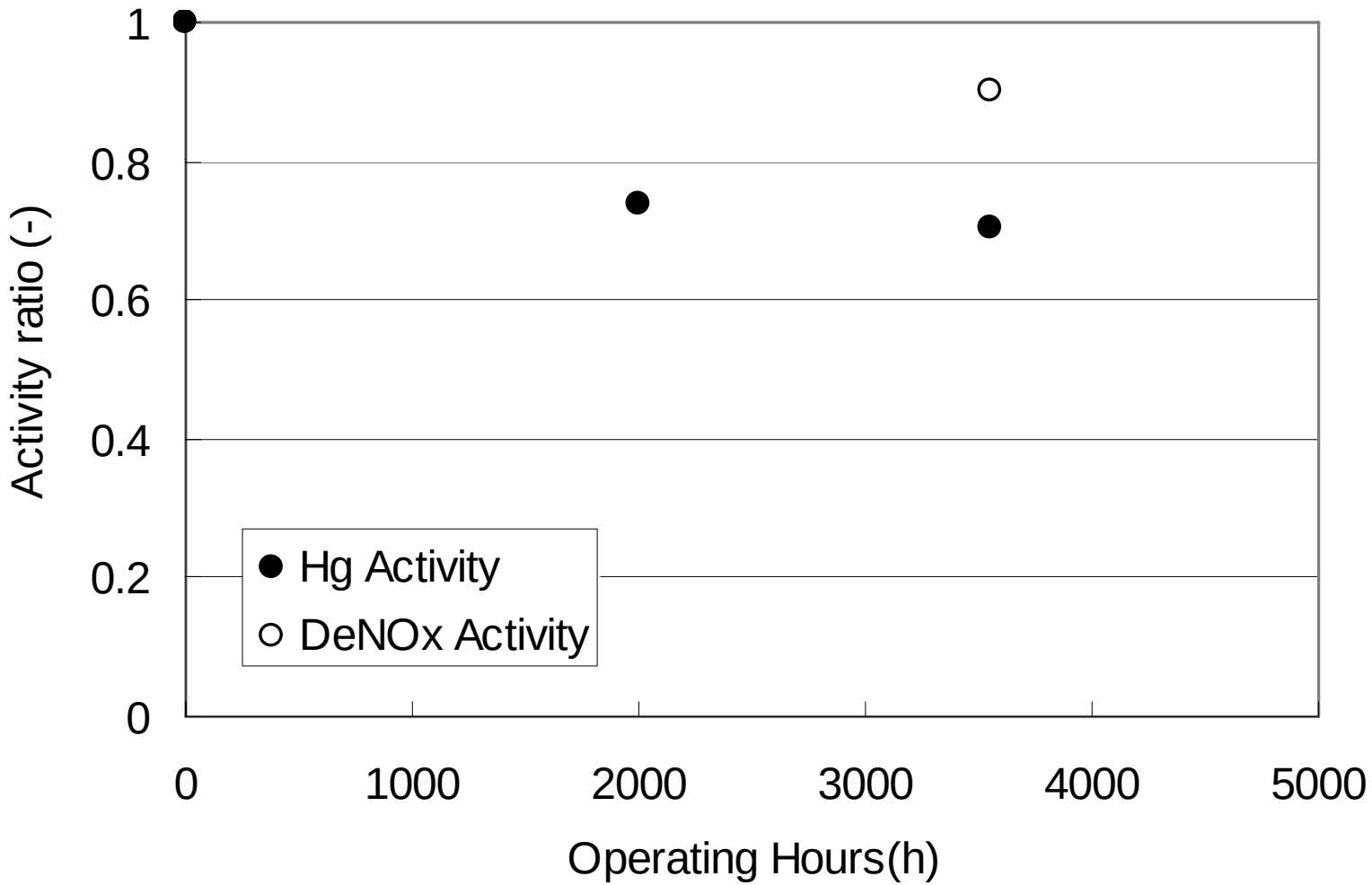
2nd sampling Date:Apr.24,'06

3rd sampling Date:Jul. 6,'06



XX:Particle bound mercury was extremely high among a series of trials

Mercury Oxidation Performance Over Time



Schedule for SSR Test Program

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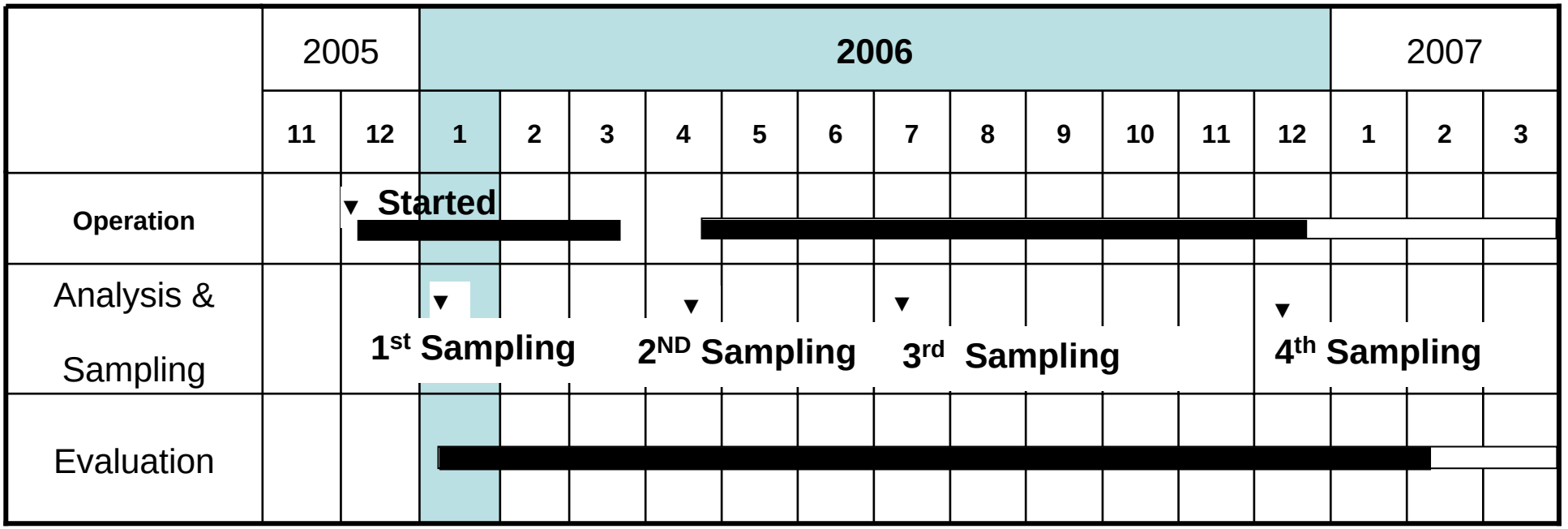

Mercury Oxidation Catalyst for E.B. Coal

Test Site – Eastern Bituminous Plant

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- 550 MWg
- Burns High Sulfur Eastern Bituminous Coal
- SCR placed in Service in 2002 Ozone Season
- All SCR catalyst supplied by Babcock-Hitachi K.K.

Test Objectives

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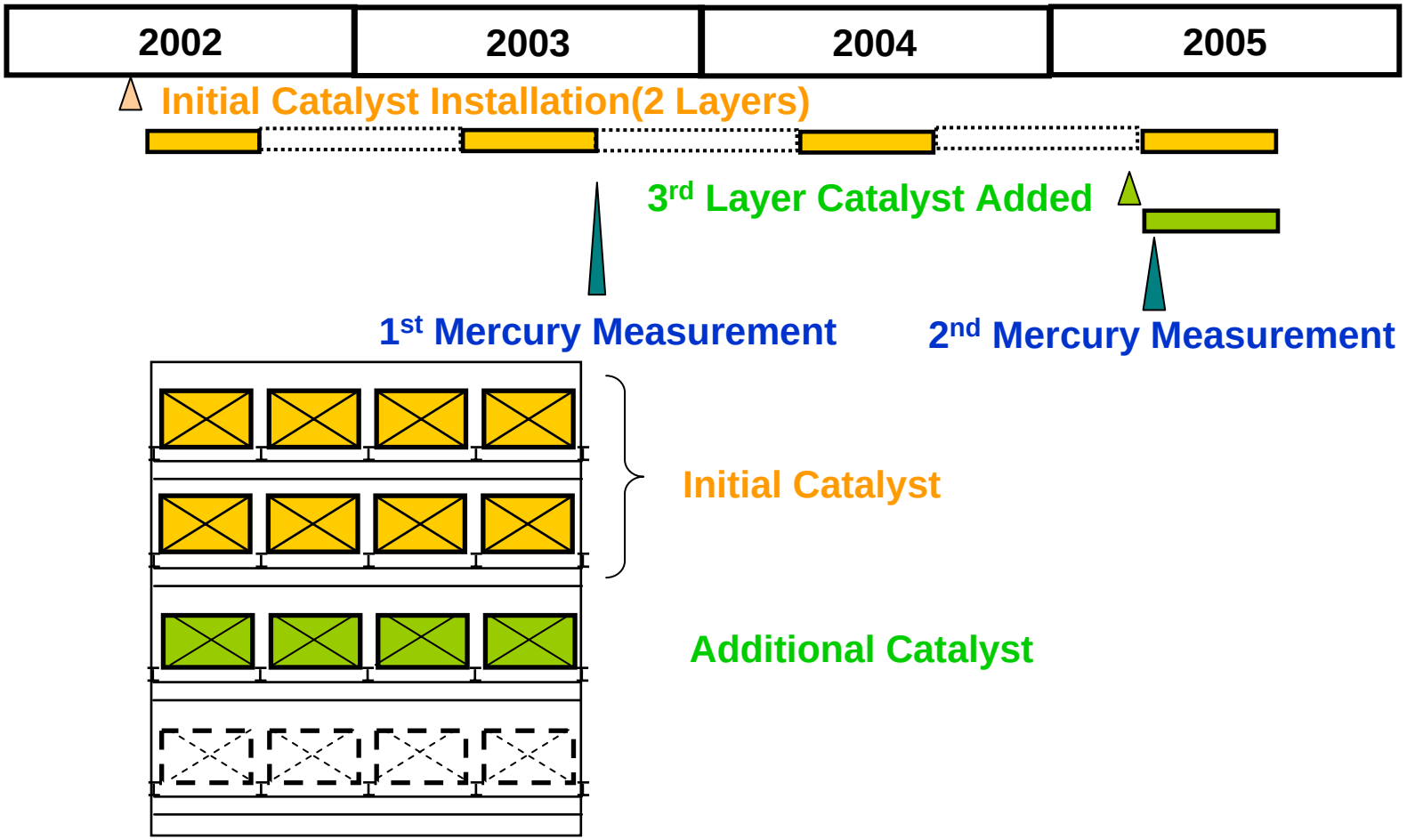
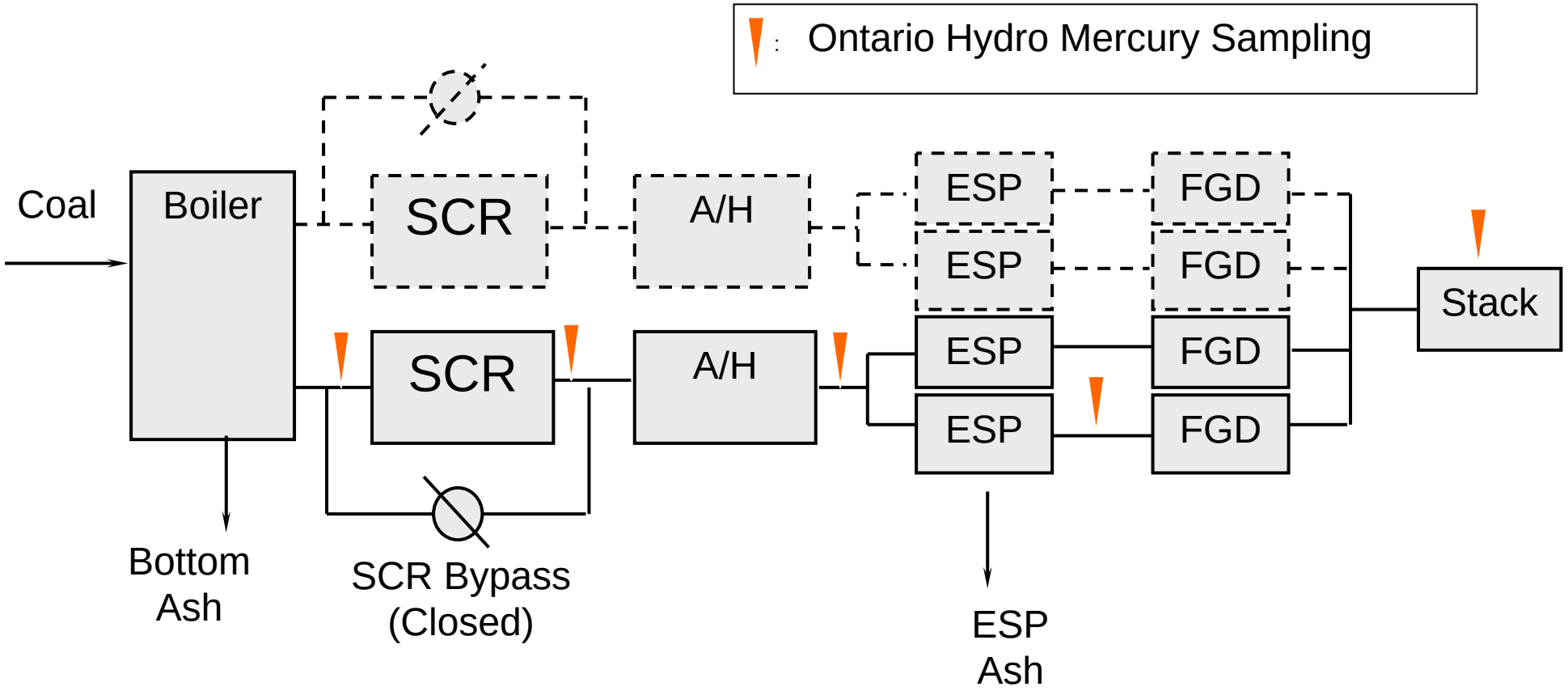
- Perform Hg Speciation Tests through the system to ascertain Hg Oxidation and Removal
- Ascertain SCR Catalyst Hg Oxidation for:
  - Performance Over Time
  - Performance with Additional Catalyst Layer
- Utilize results to optimize catalyst design for commercial applications

SCR Catalyst Management History



Flue Gas Mercury Sampling Locations



Note: Mercury sampling at both 2nd layer SCR catalyst outlet and 3rd layer SCR catalyst outlet was performed during the 2nd Mercury testing.

Operating Time vs Hg^0 Content at SCR Outlet

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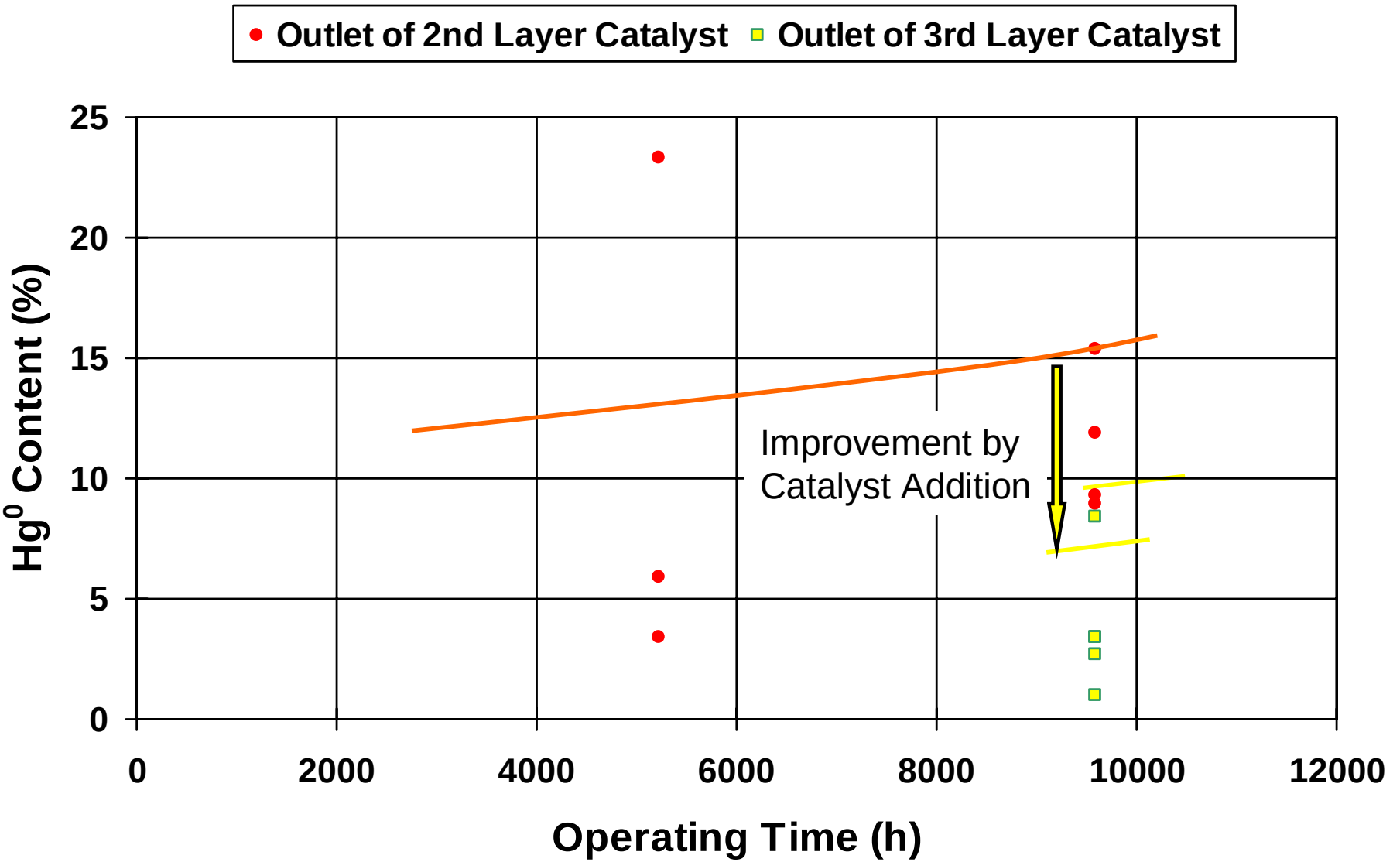
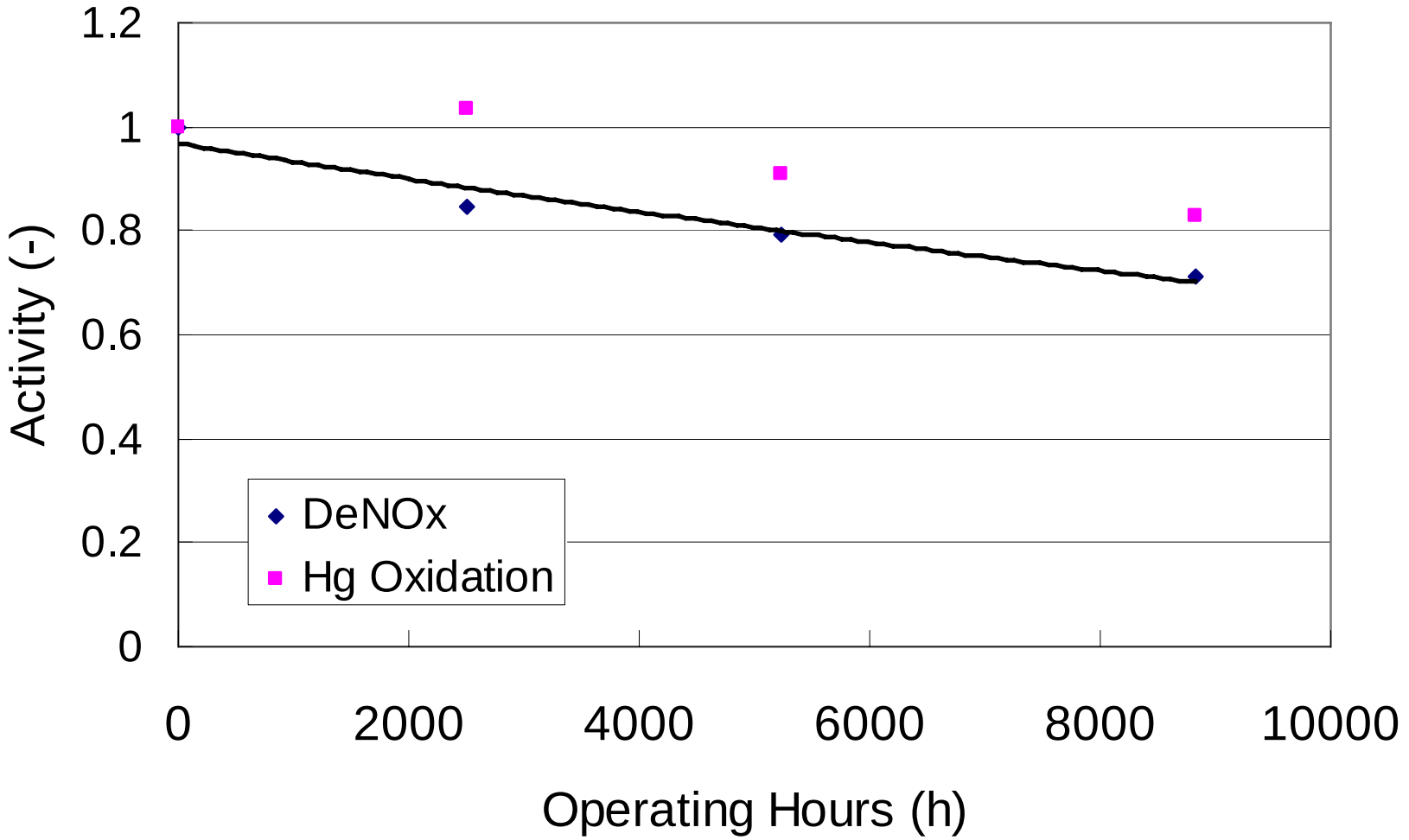
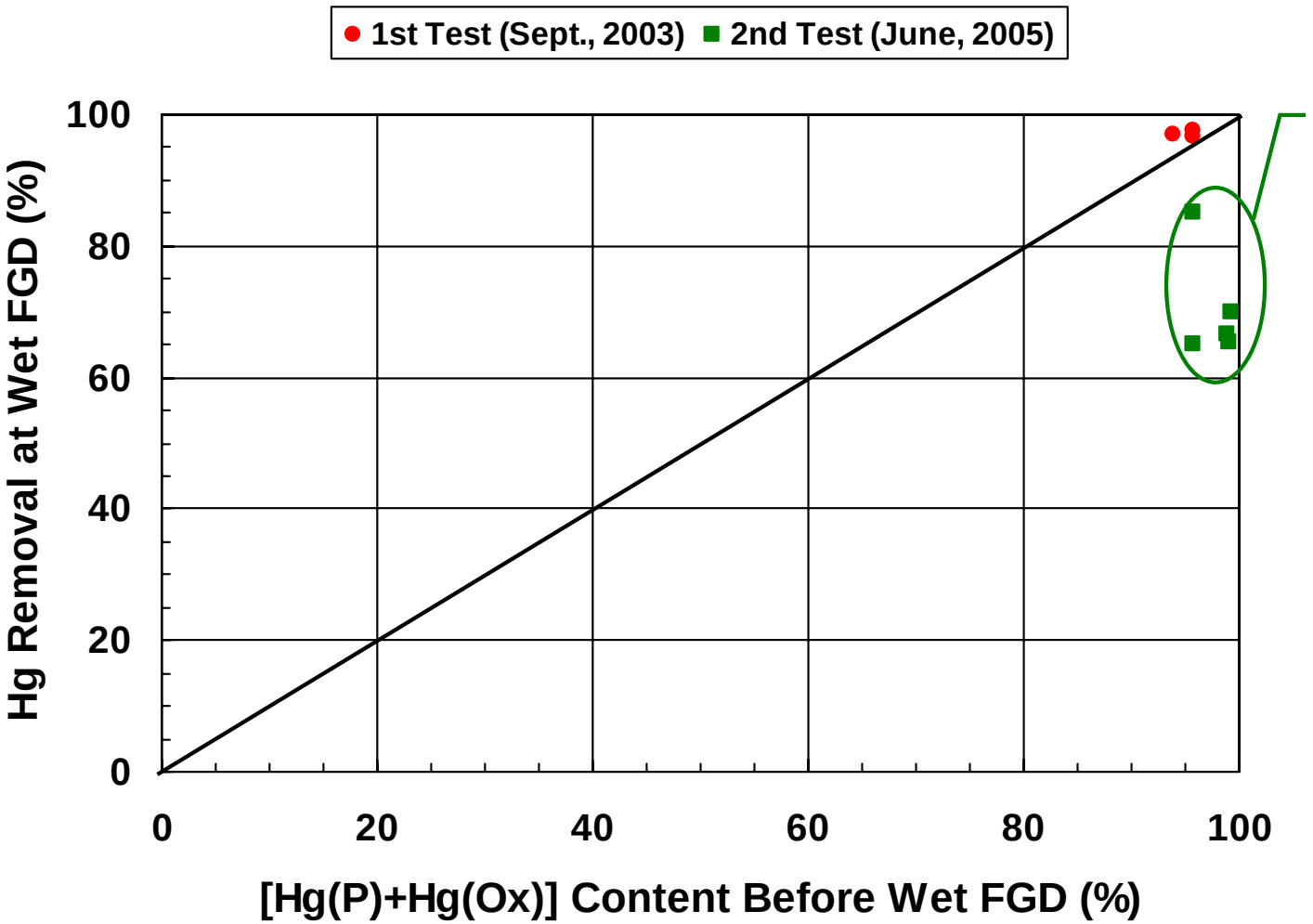


Hg Oxidation Activity* of Samples



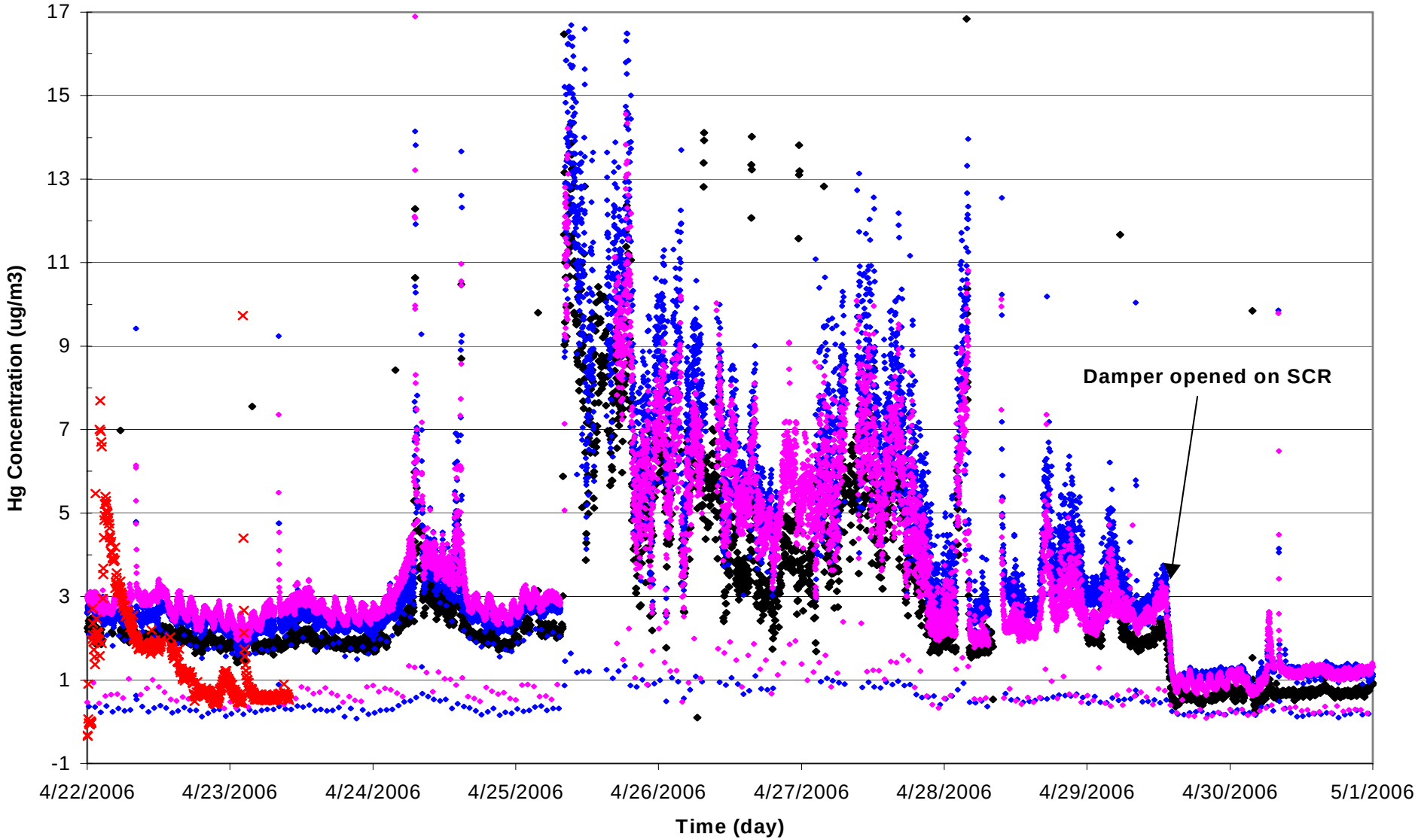
* Laboratory Analysis

Mercury Capture at Wet FGD



FGD system had nozzle plugging problem and pH control difficulty during test

EPA Mercury Stack CEMS Data



Eastern Bituminous Mercury Oxidation Catalyst

Higher Mercury Oxidation Catalyst

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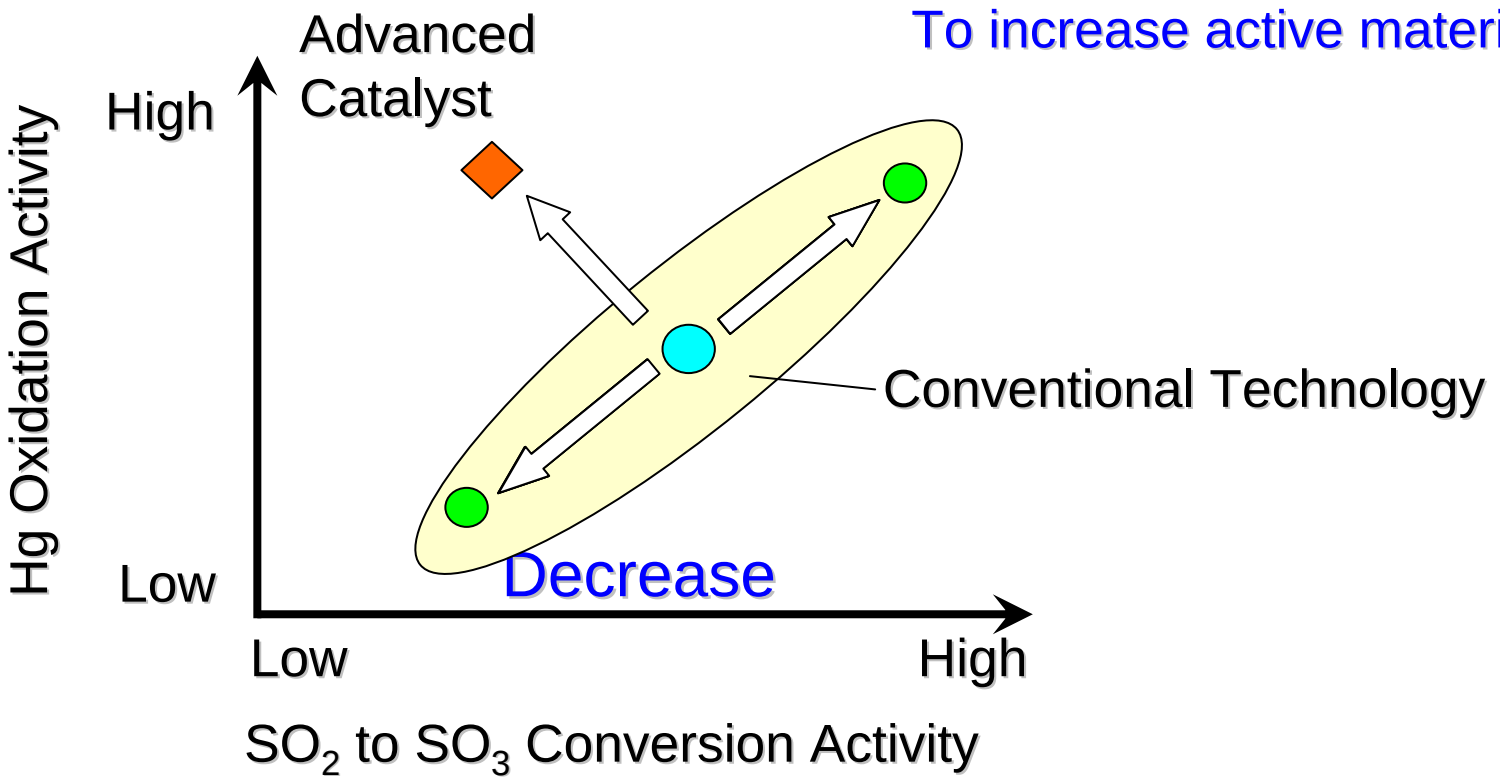
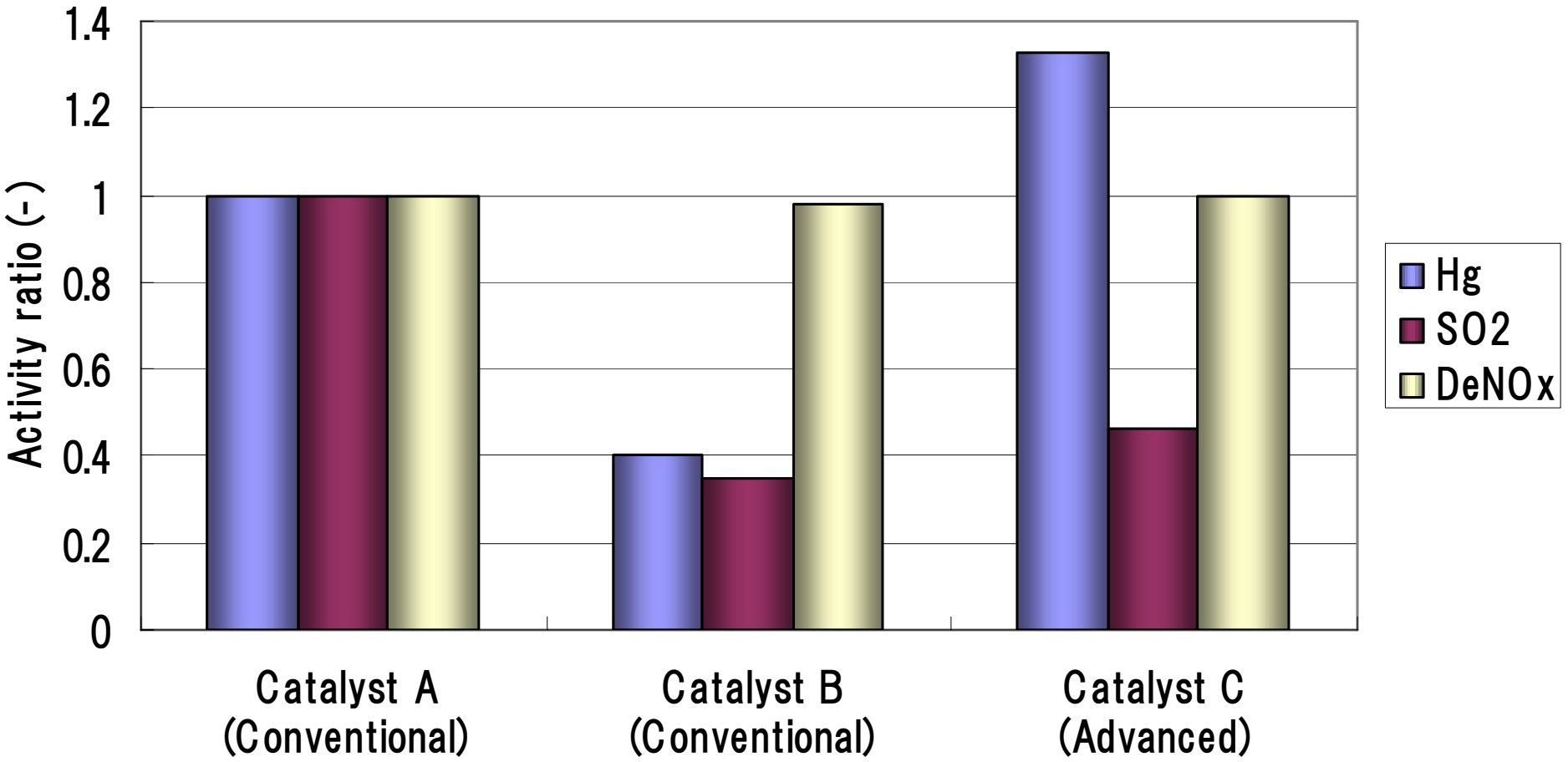
Lower SO_2 conversion is required while keeping higher Hg oxidation.



We started development of a new SCR catalyst with
Higher Hg Oxidation & Lower SO_2 Conversion

Mercury vs. SO_2 Oxidation Activity



Test Facility at Akitsu Works

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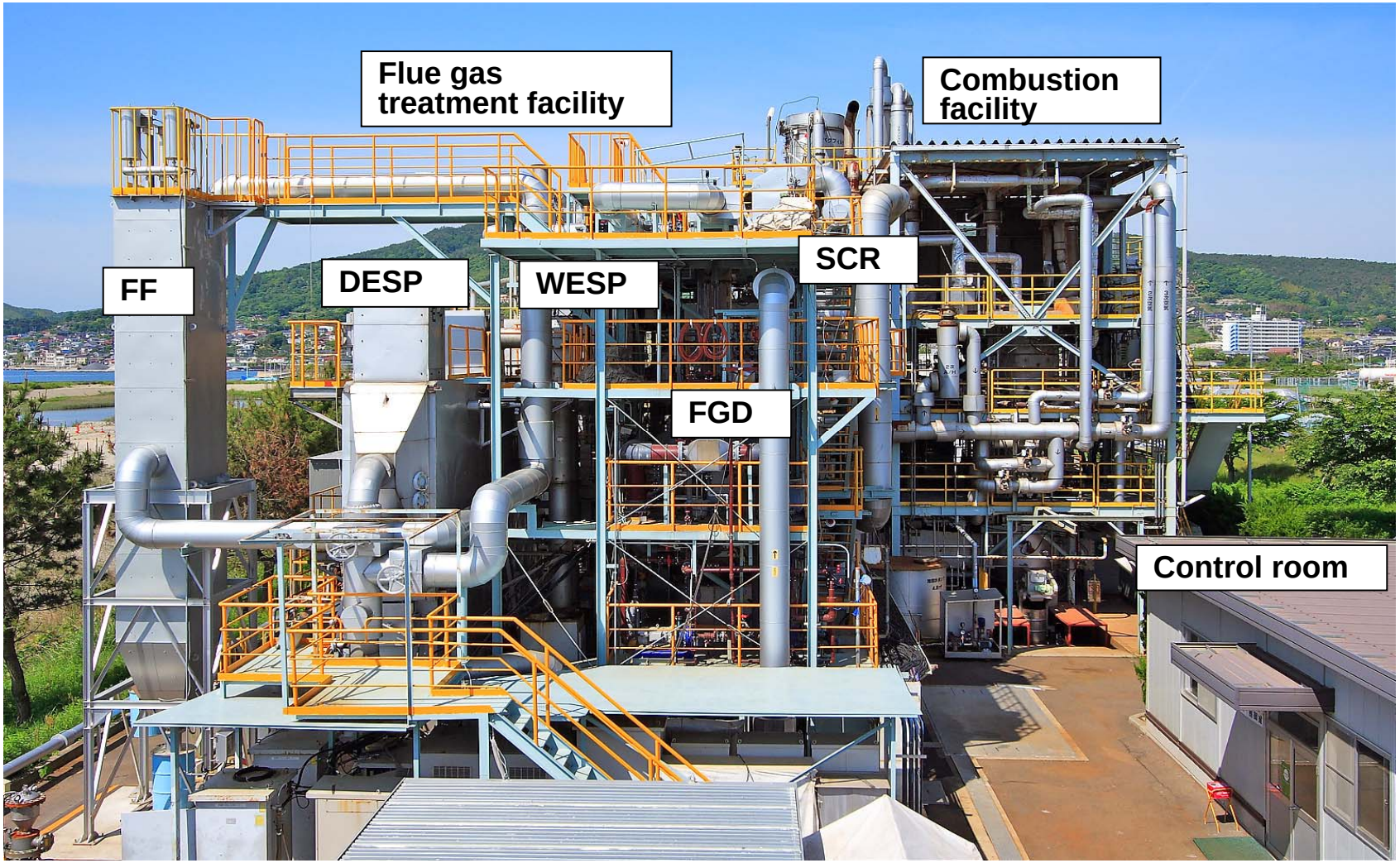
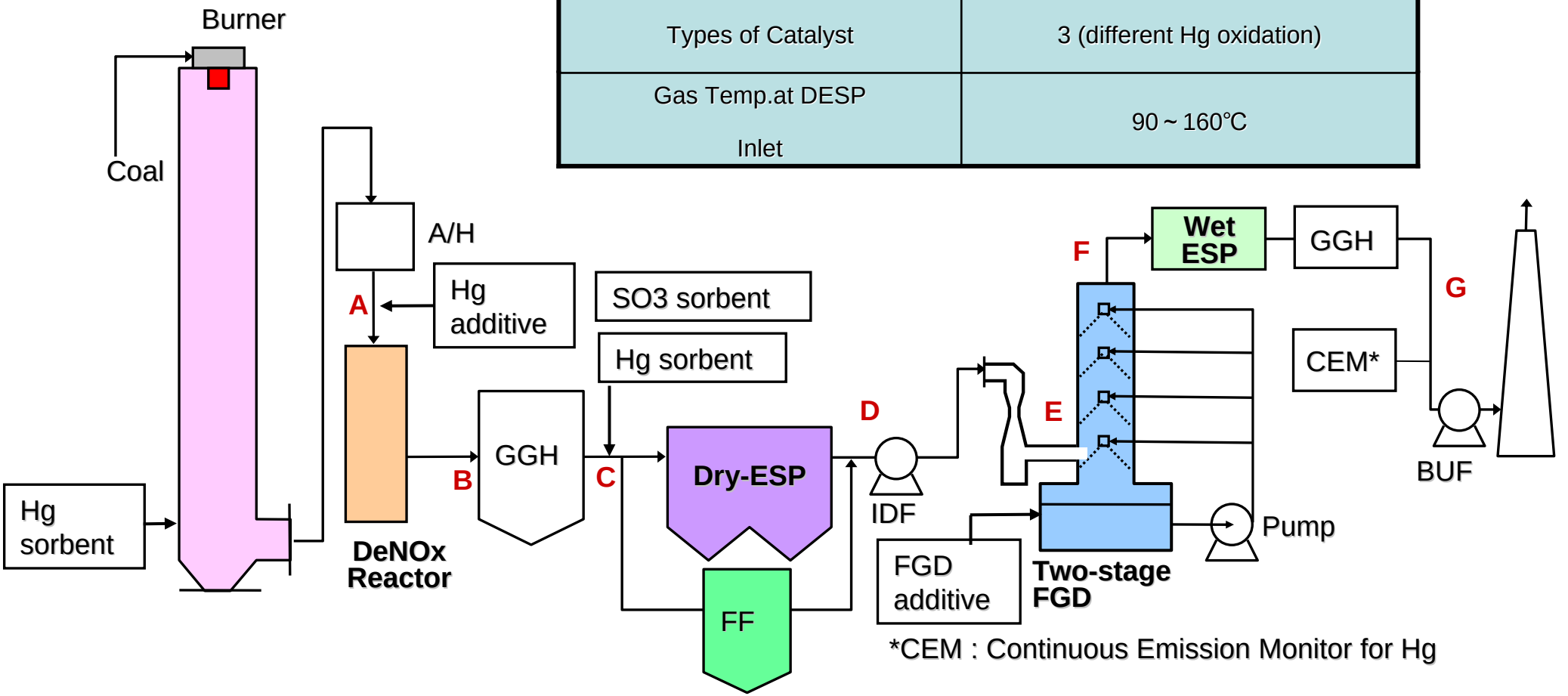


Schematic Flow and Test Conditions

Item	Condition
Coal Feed Rate	100 ~ 150 kg/h
Gas Flow Rate	1000 ~ 1500 m^3/h
Types of Coal	3 (Eastern Bituminous Coal)
Types of Catalyst	3 (different Hg oxidation)
Gas Temp.at DESP Inlet	90 ~ 160℃

A ~ G : Hg Sampling Points



*CEM : Continuous Emission Monitor for Hg

Test Coals

Coal Type	A	B
Proximate Analysis, wt %		
Moisture	7.16	1.32
Volatiles	40.62	37.11
Fixed Carbon	48.70	55.68
Ash	10.68	7.21
High Heating Value (MJ/kg, dry)	27.88	32.48
Elemental Analysis, dry, wt %		
Ash	10.61	7.13
C	71.32	78.48
H	5.14	5.03
O	8.45	6.41
N	1.58	1.35
S	2.90	1.60
Trace Elements, dry, mg/kg		
Hg	0.10	0.06
Cl	300	650

Mercury Oxidation Performance vs. Temperature

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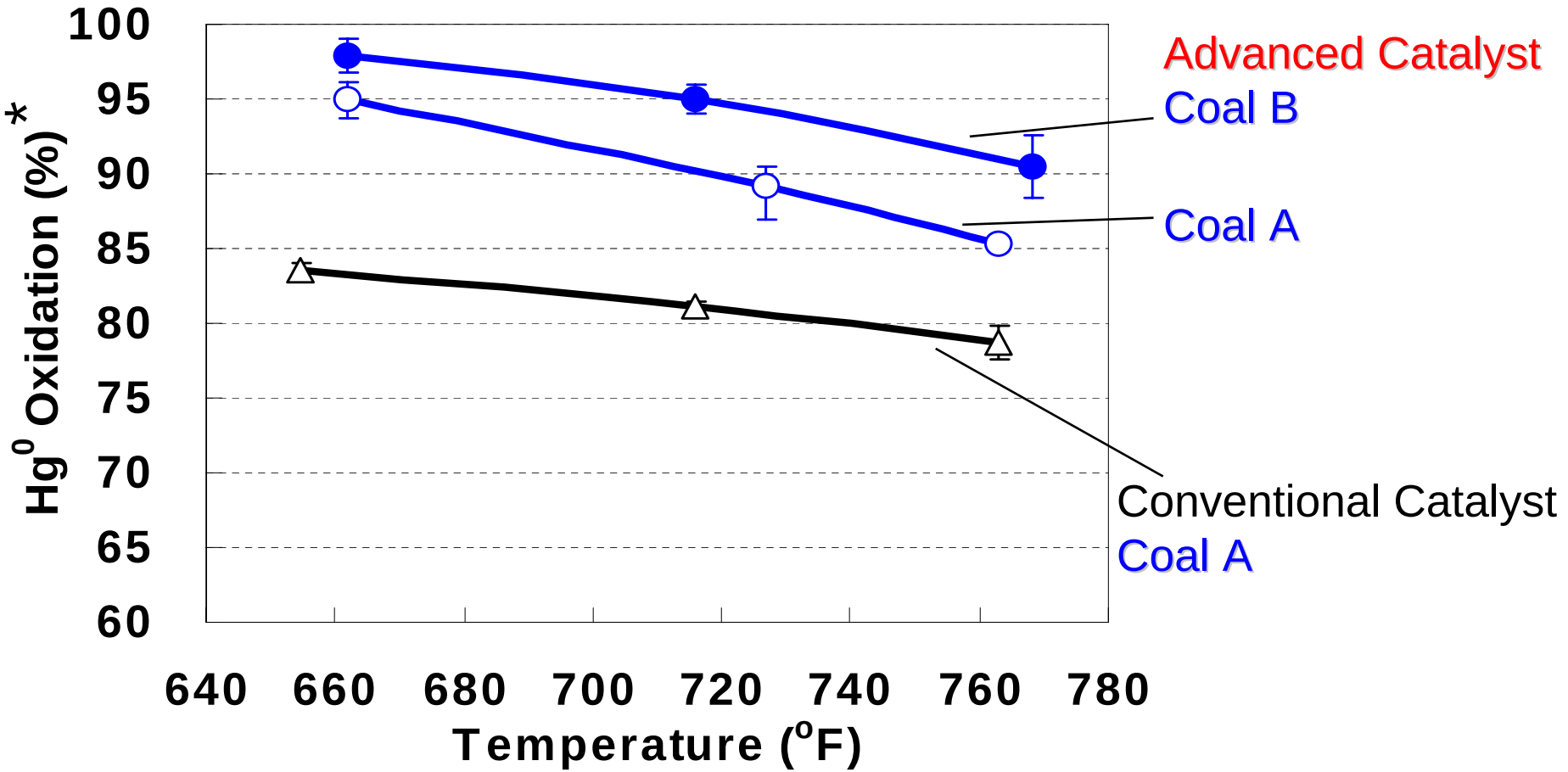
* corrected moisture volume, approximately 10 vol%



Hg Oxidation : > 95% below 716°F(380°C)

SO2 to SO3 Conversion Rate vs. Temperature

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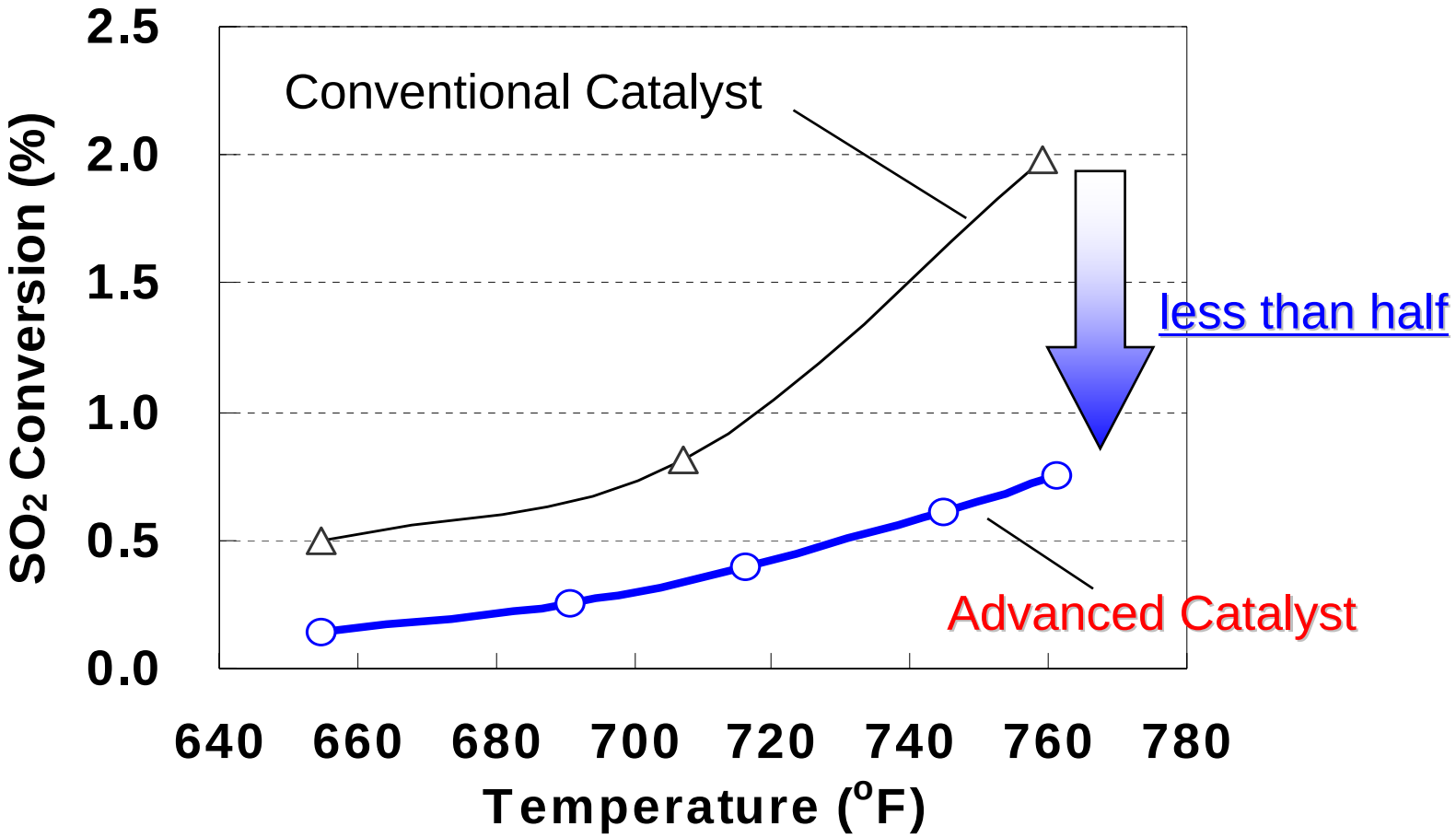

SO_2 to SO_3 Conversion : < 0.5% below 734^{o}F(390^{o}C)

Summary

Mercury Oxidation for PRB Coal

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- Mercury oxidation more than 80% across the catalyst was obtained at SSR after 3,500 hours, although HCl concentration in flue gas for PRB firing was very low.
- Additional SSR testing will continue for further reliability check…

Mercury Oxidation for Eastern Bituminous Coal

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- A new-plate-type catalyst is developed which can achieve high Hg oxidation and low SO2 to SO3 conversion for power plants burning bituminous coal.
- This catalyst can meet Hg oxidation up to 95% at a temperature of 716ºF while keeping SO2 to SO3 conversion less than half that of a conventional catalyst. (below 0.5% at below 734ºF).
- Durability testing at actual plant in the U.S. is underway.