

# Reinhold Environmental Ltd.

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2008 NO<sub>x</sub>-Combustion Round  
Table & Expo Presentation

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*February 4-5, 2008 in Richmond, VA*

# ***New SCR Catalyst With Improved Mercury Oxidation Activity***

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Hitachi Power Systems America, Ltd.  
Basking Ridge, NJ

*Presented at the  
2008 NOx Round Table  
Richmond, VA  
February 5, 2008*

- ❖ Mercury Speciation
- ❖ Summary of U.S. Test Programs
- ❖ PRB Catalyst
- ❖ Eastern Bituminous Catalyst
- ❖ Summary and Further Development

## Form of vapor phase mercury (Speciation)

Elemental Mercury -  $\text{Hg}^0$

Oxidized or ionic mercury -  $\text{Hg}^{++}$

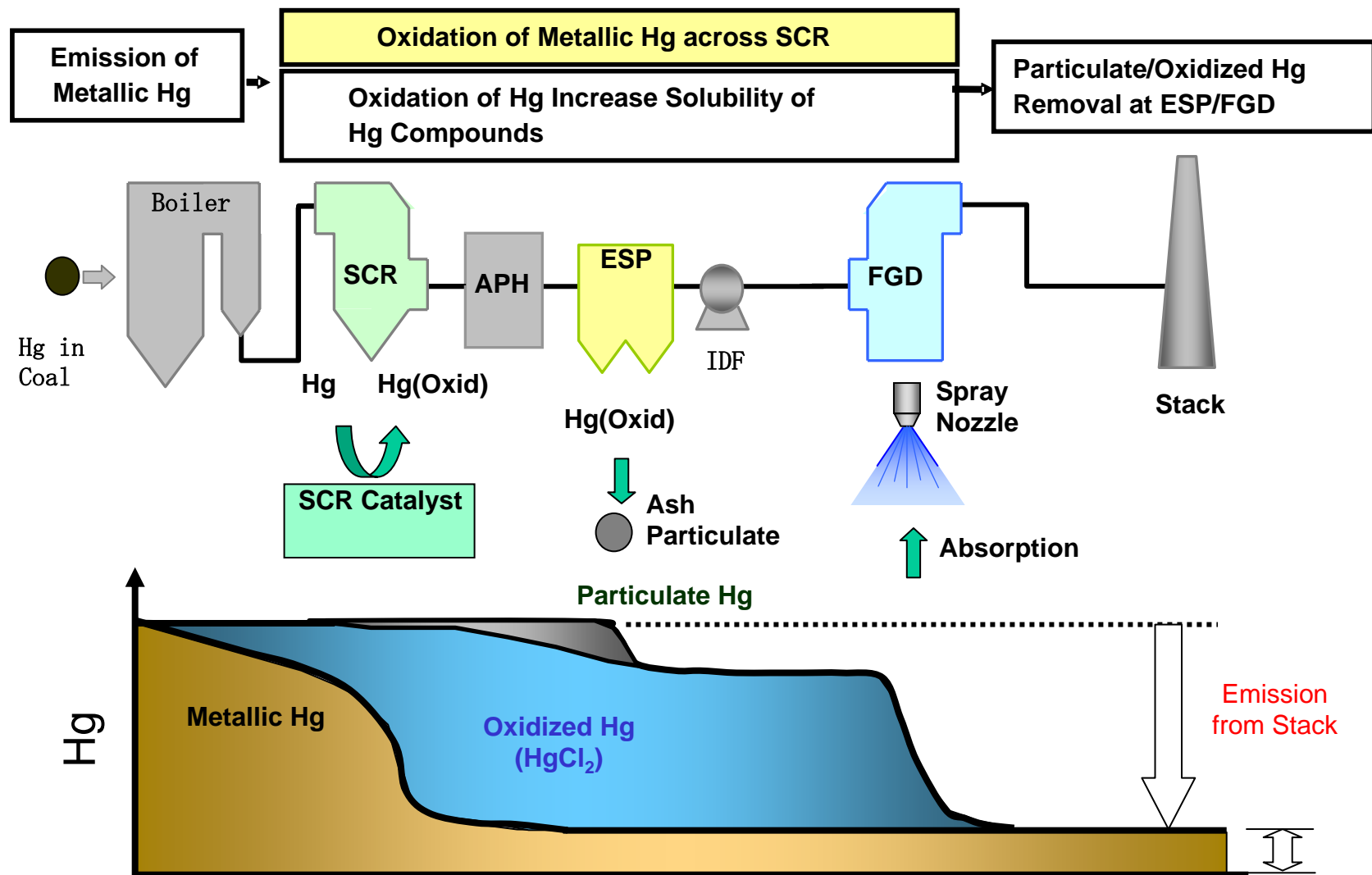
The form of mercury in the flue gas is critical to performance of emissions control systems.

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

# US Coal Speciation

	% 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

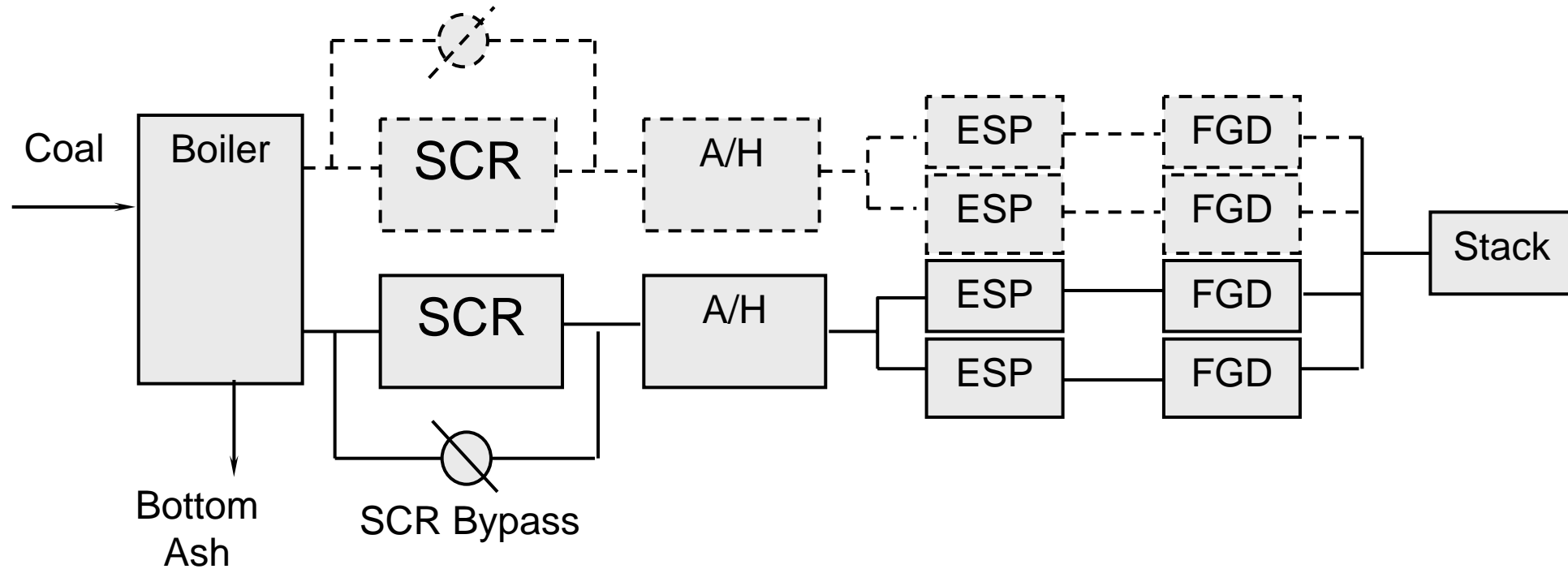
# Behavior of Mercury in Coal-Fired Applications



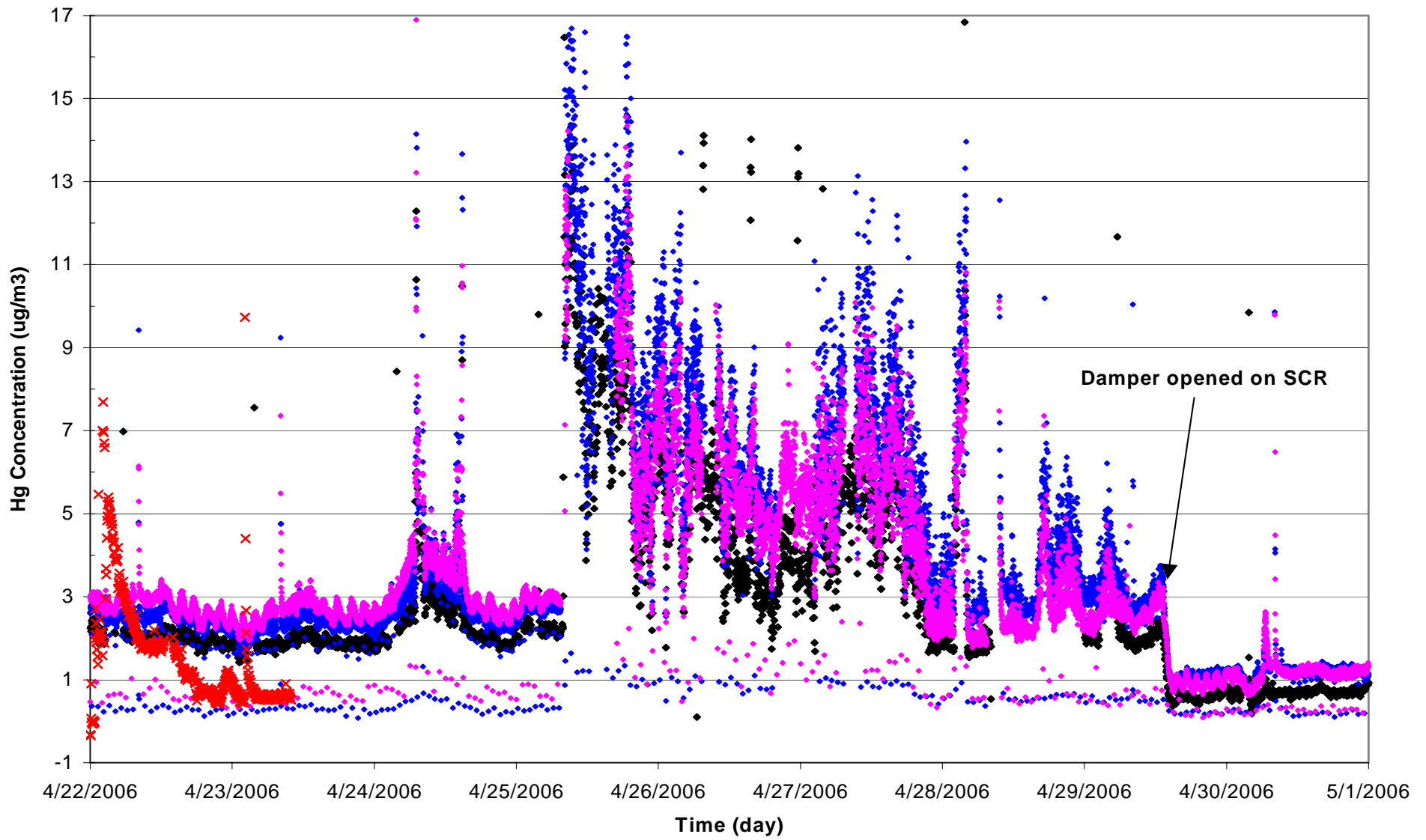
## Why Oxidize Mercury in the SCR?

- With downstream equipment (i.e. WFGD), removal of 90+% of the oxidized mercury can be achieved
- Co-Benefit...Utilization of existing SCR to reduce NOx and oxidize Hg
- Additional remedies such as ACI can be reduced or eliminated

# Existing US Coal Plant with SCR



# EPA Mercury Stack CEMS Data

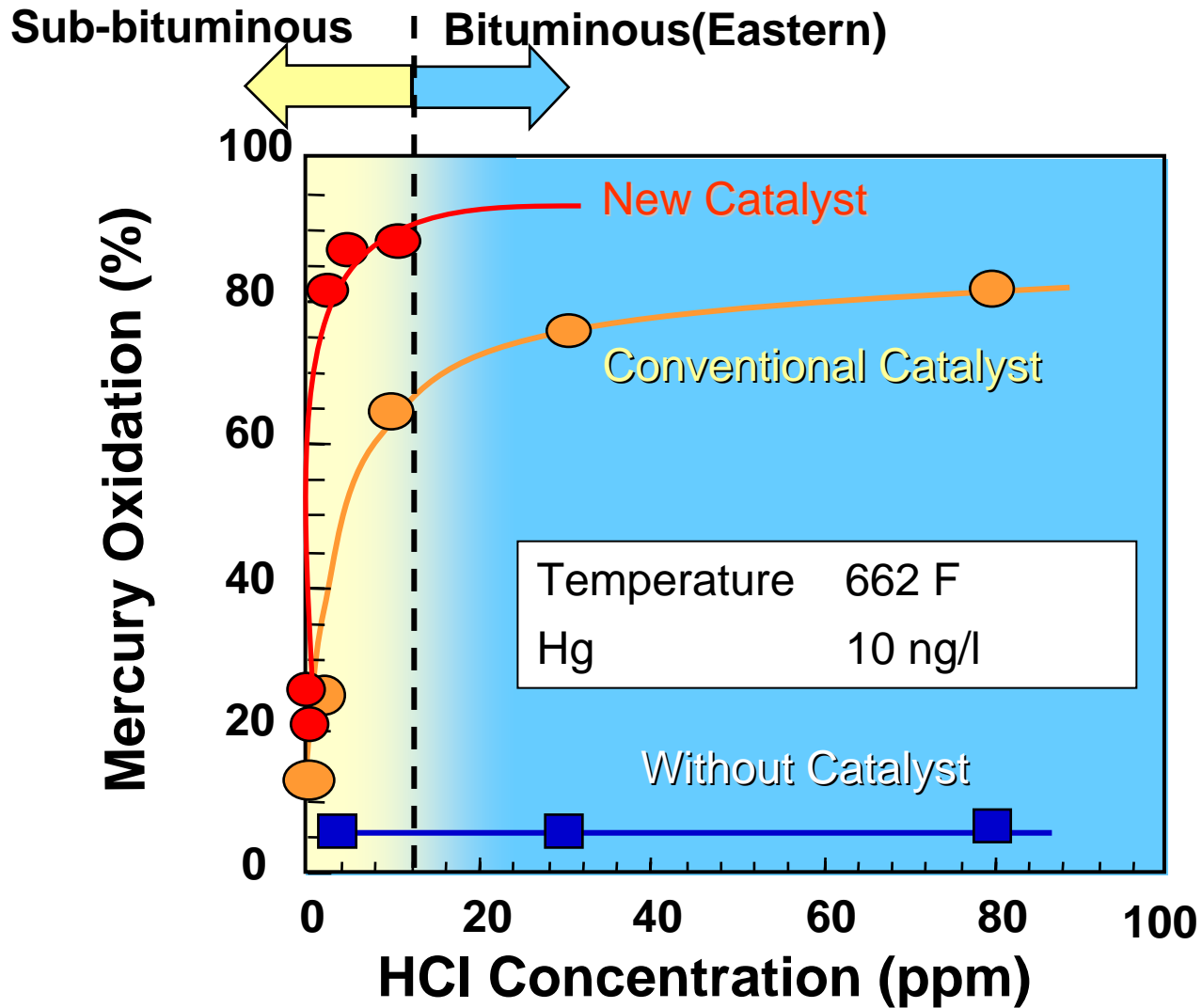


# Hitachi R&D History for Mercury Oxidation Catalyst

Test	Contents	Coal	2003	2004	2005	2006	2007	2008	
<b>BHK laboratory test</b>	Screening of catalyst materials	-	High DeNOx & Hg oxidation activity					Low SO <sub>2</sub> oxidation rate	
			-		-		-		-
<b>BHK pilot scale test</b>	Characteristics for coal-firing flue gas	Eastern Bituminous(EB) & PRB coals	-		-		-		
<b>U.S. Field Testing in Coal-Fired Boilers</b>	Trace element analysis across actual AQCS (Speciation)	E.B coal	Plant A		A	B C A		D	
		PRB coal		Plant E				F	
	Characteristic test of catalyst using slipstream reactor	E.B.coal					Plant AA		
		PRB coal			Plant BB				
		Lignite coal				Plant CC			
	Durability test of catalyst	E.B.coal					Plant AA		
		PRB coal				Plant BB			
		Lignite coal					Plant DD		
<b>Design progress</b>				F/S Design					
		Design Data Collection						Start of Commercial Pant Design	

# ***Mercury Oxidation Catalyst for PRB Coal***

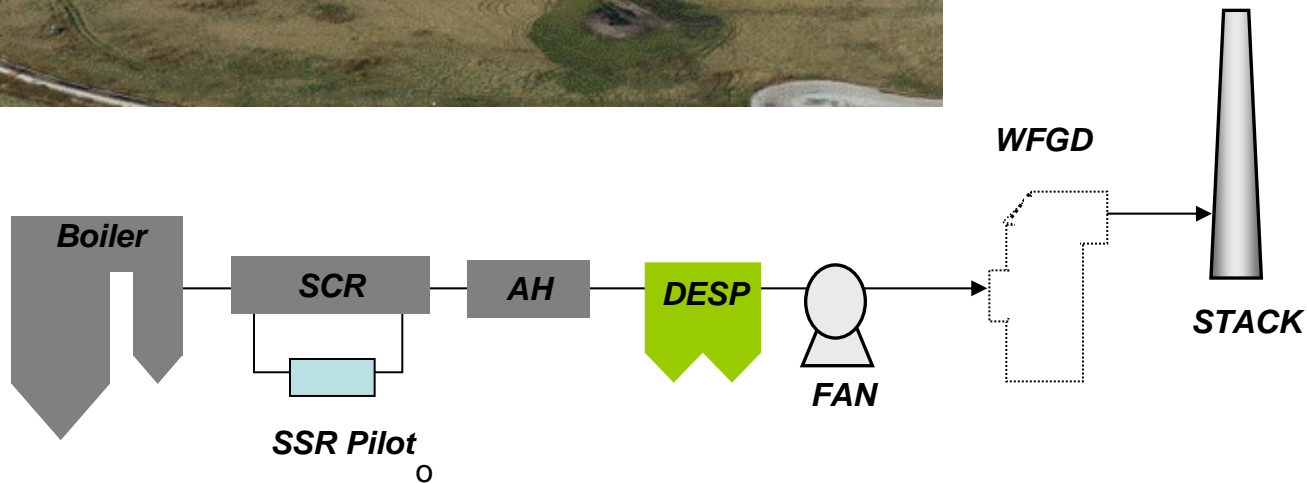
# New Hitachi Hg Oxidation Catalyst



# Demonstration at PRB Plant



- 620 MWg
- 100% PRB Firing
- Boiler Started Operation in 1986
- SCR Installed in 2003
- Slipstream Reactor (SSR) Installed in 2005



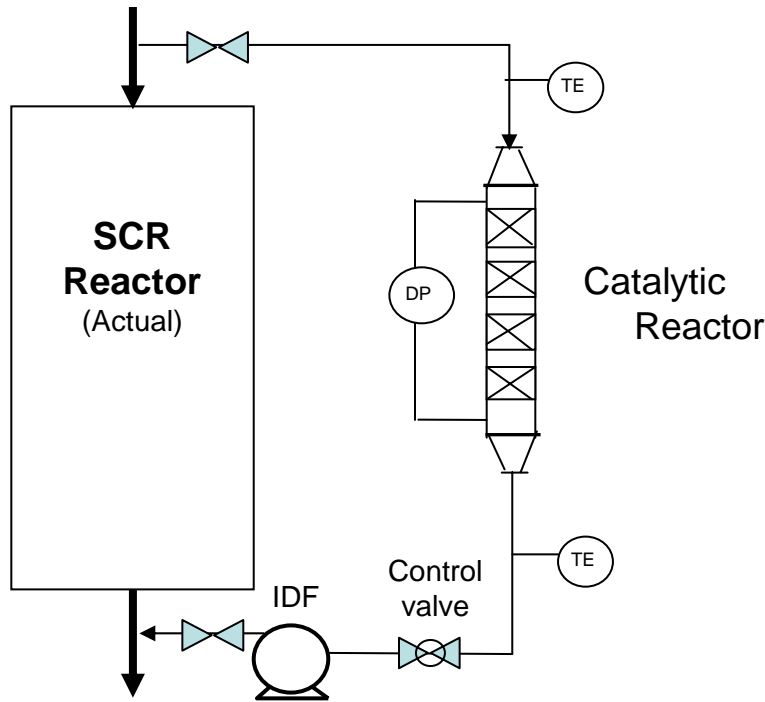
- Install a Slipstream Reactor for catalyst exposure in **actual** operating conditions
- Allow for periodic sampling of catalyst performance and extraction of samples for laboratory analysis
- Utilize results to optimize catalyst design for commercial applications

- Installed next to full-scale operating SCR
- Takes flue gas from just above the 1<sup>st</sup> layer of catalyst
  - ◆ Flue gas contains  $\text{NH}_3$
- Used to expose catalyst to flue gas for:
  - ◆ Ongoing periodic performance testing
  - ◆ Periodic catalyst sample extraction for laboratory analysis

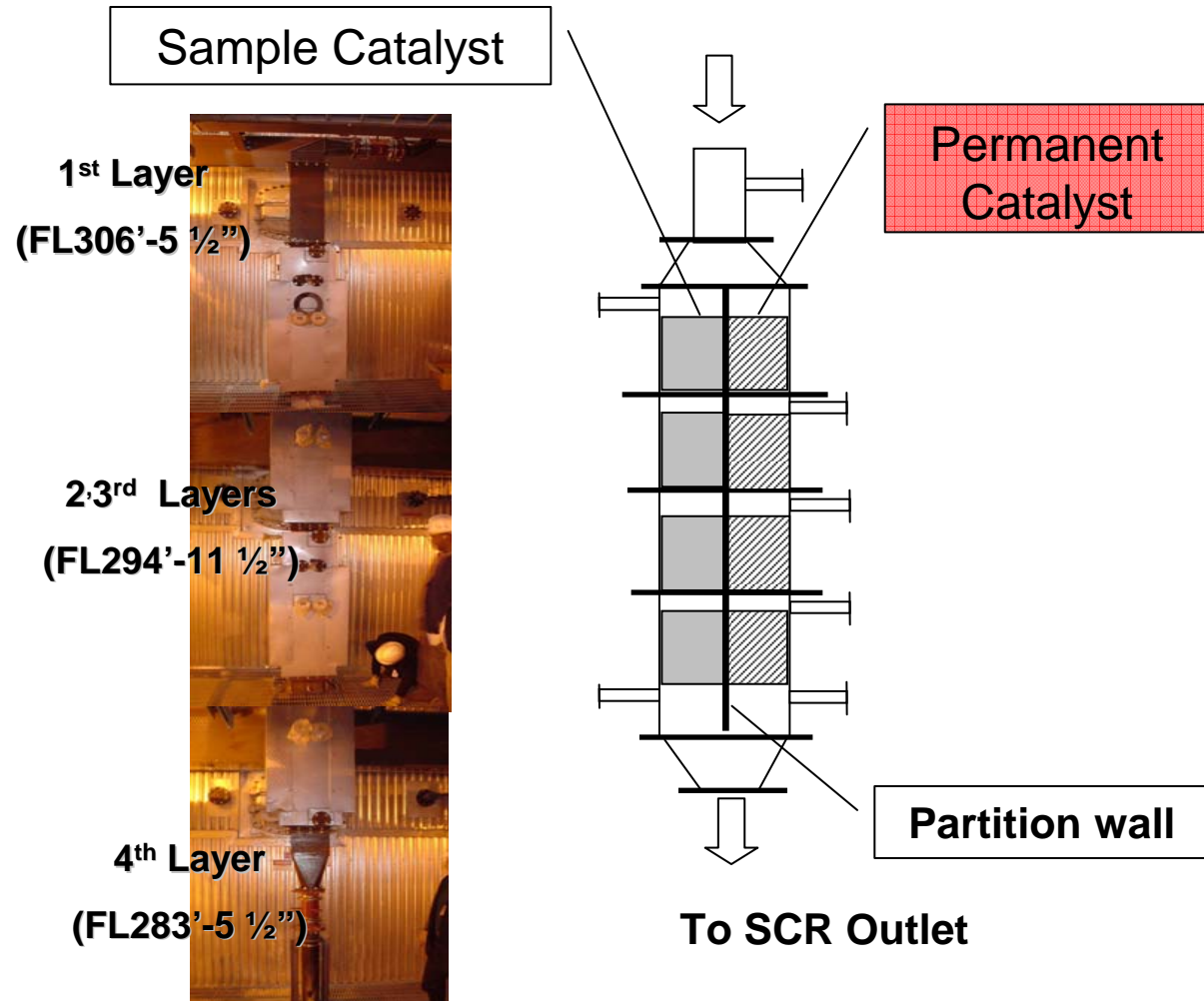
- SSR equipped with:
  - ◆ Four (4) layers of catalyst
  - ◆ Sootblowers at each catalyst level
  - ◆ I.D. fan
  - ◆ Control valve for flow adjustment
  - ◆ Heaters
  - ◆ Instrumentation for measurement of flow, temperature and pressure drop throughout SSR
  - ◆ Local control panel and PLC with communication to DCS and remote monitoring (via modem)
  
- Measurement ports for onsite testing of:
  - ◆ Hg (Ontario Hydro Method)
  - ◆ NH<sub>3</sub> (wet chemistry)
  - ◆ NO<sub>x</sub>
  - ◆ Gas Flow

# SSR Setup

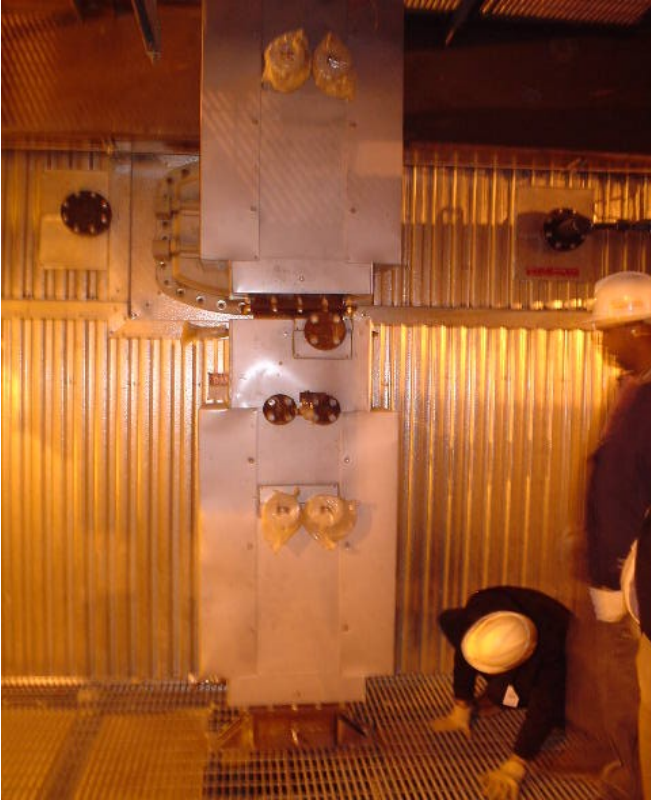
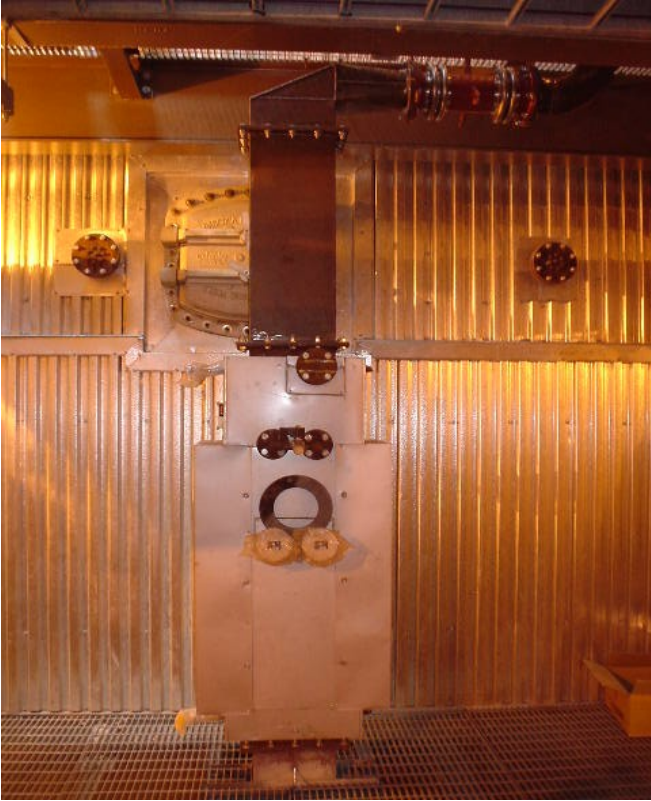
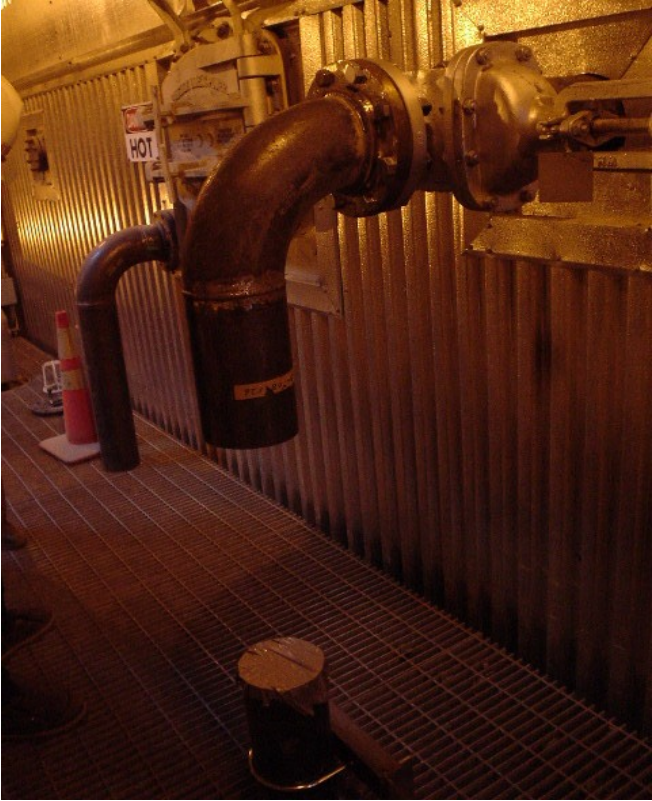
## Outline of SSR at P4U2



Flue Gas from Actual SCR Inlet  
(including NH<sub>3</sub>)



# SSR Setup

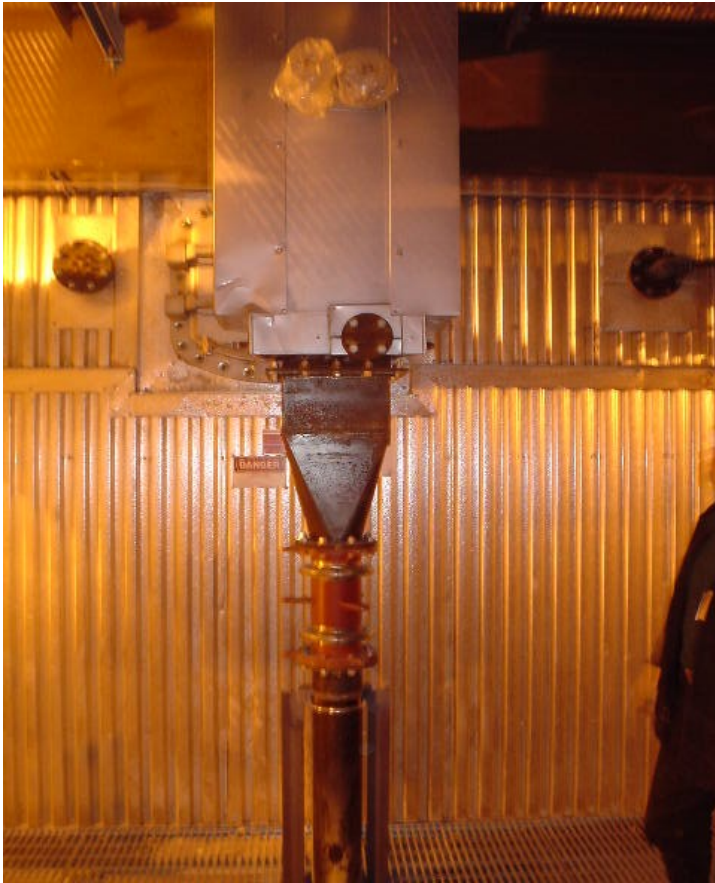


Extraction Point of Flue Gas

1<sup>st</sup> Reactor

2<sup>nd</sup> and 3<sup>rd</sup> Reactor

# SSR Setup

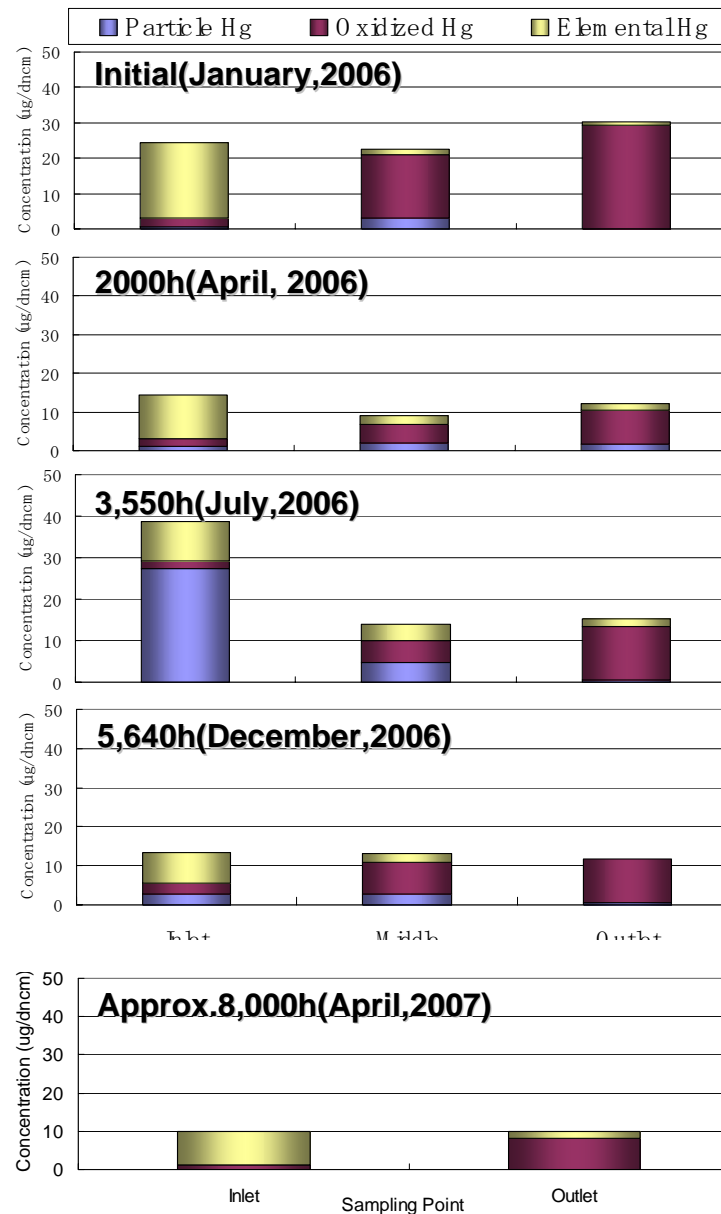


**4<sup>th</sup> Reactor**



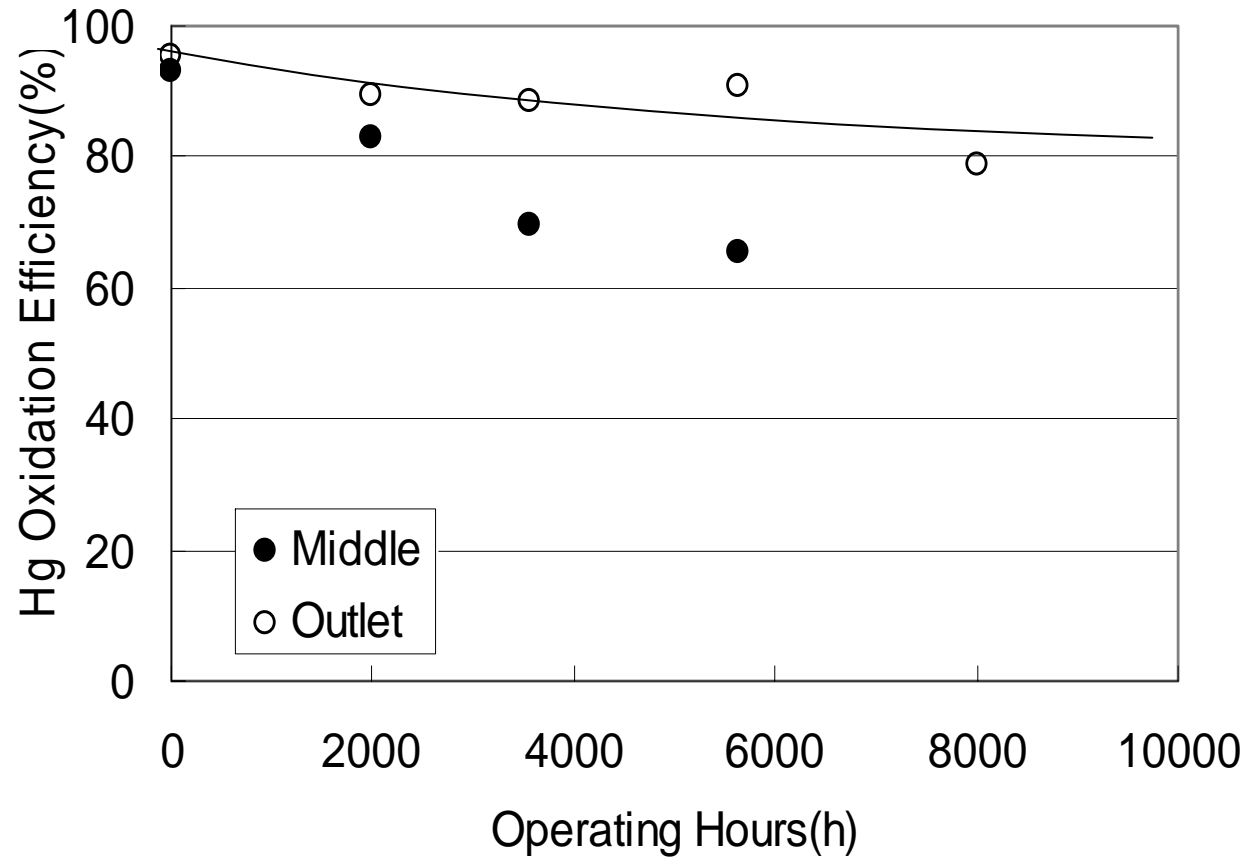
**Venturi, IDF**

# PRB - Summary of Mercury Oxidation Results



# PRB - Summary of Mercury Oxidation Results

Temp:572-662°F, HCl:1-4 ppm, SV(Mid):4084,(Out)2042)

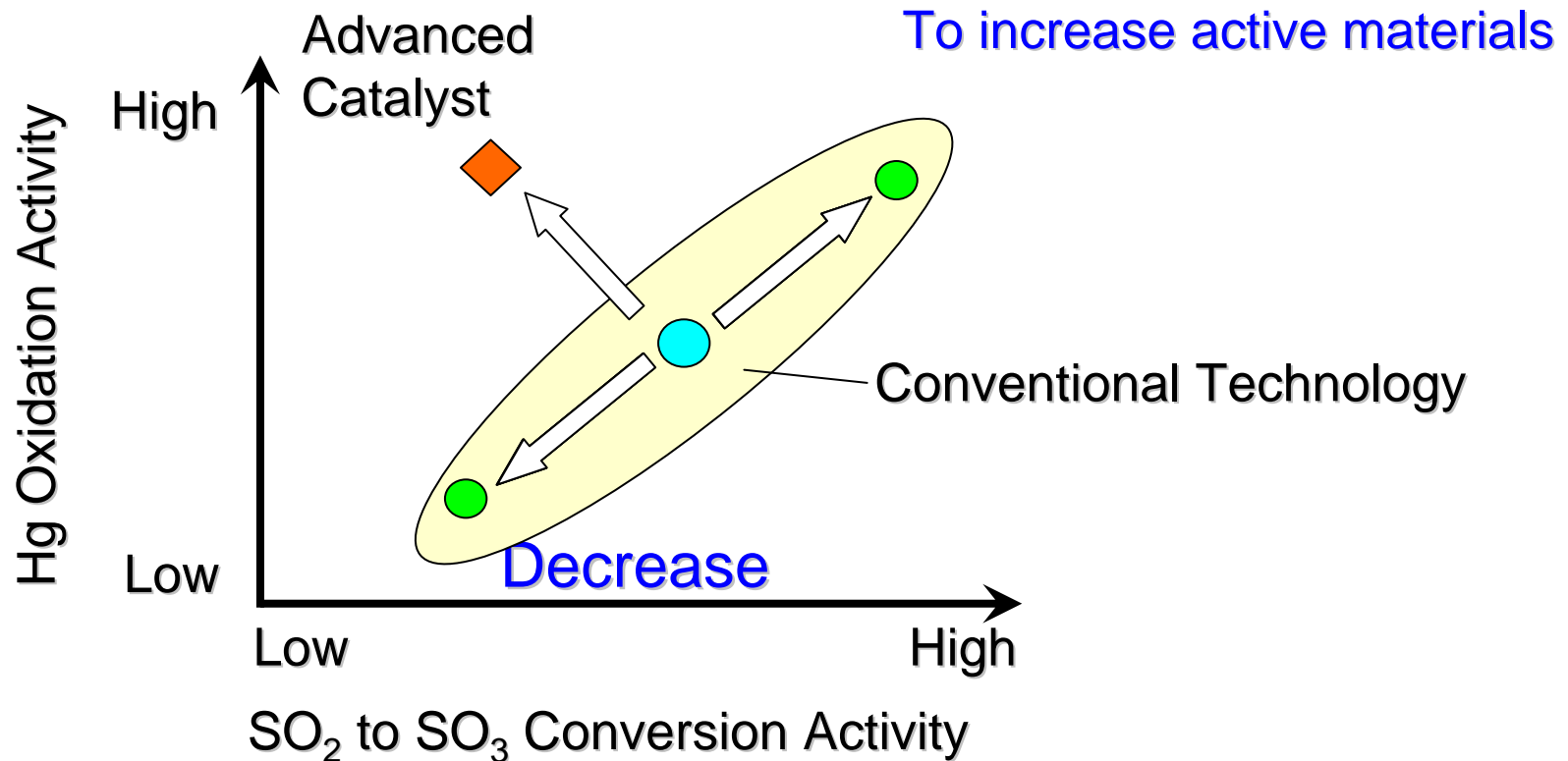


- For PRB (<100 ppm Cl) – results from SSR demonstration test showed very good mercury oxidation, as predicted.
- Durability of Mercury Oxidation Catalyst was confirmed
- Mercury oxidation more than 80% across the catalyst was obtained in the SSR after 8,000 hours, although HCl concentration in flue gas for PRB firing was very low.
- Based on these results, along with laboratory testing, deterioration factors can be applied for full-scale applications
- Commercial guarantees are being applied

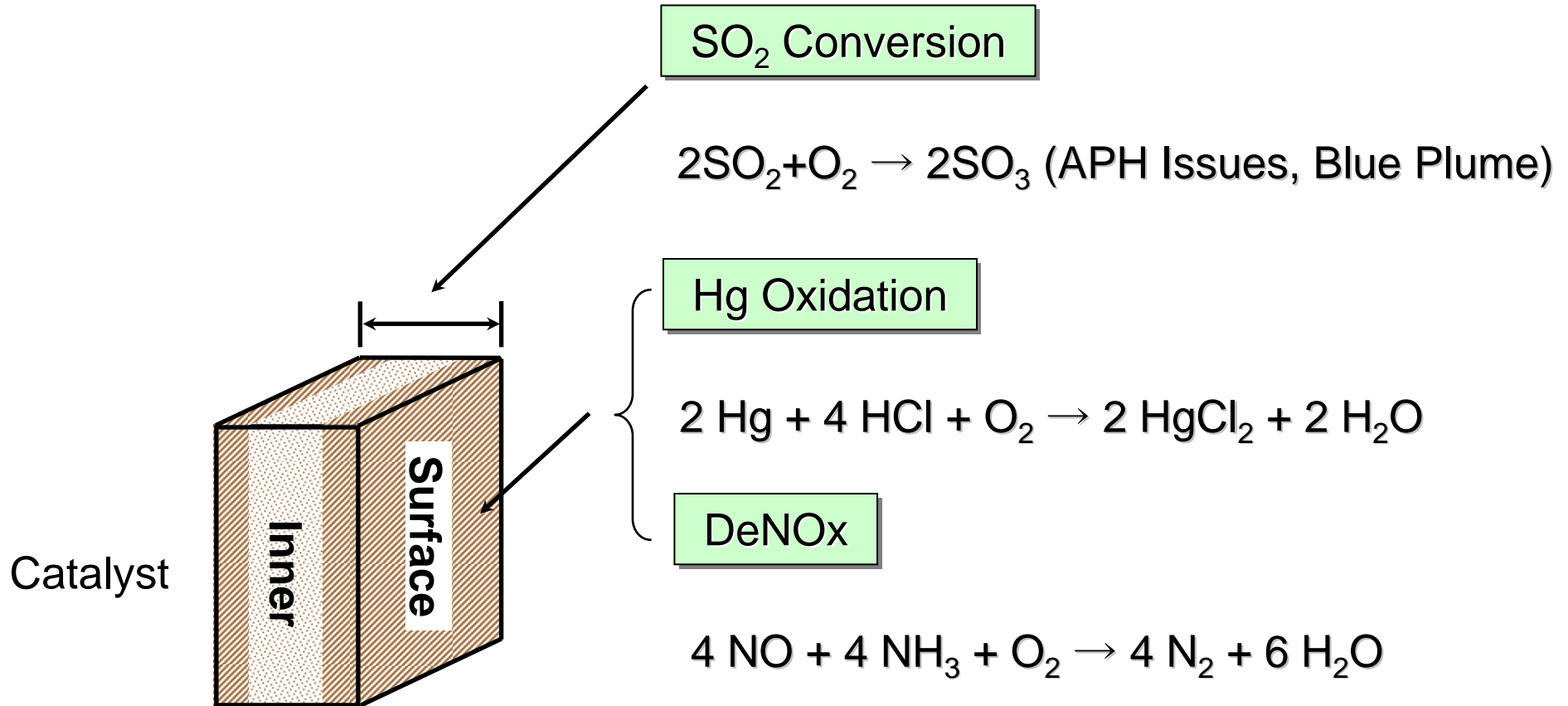
# ***Eastern Bituminous Mercury Oxidation Catalyst***

# Higher Mercury Oxidation Catalyst

Lower SO<sub>2</sub> conversion is required while keeping higher Hg oxidation.



# Comparison of Reaction Speeds

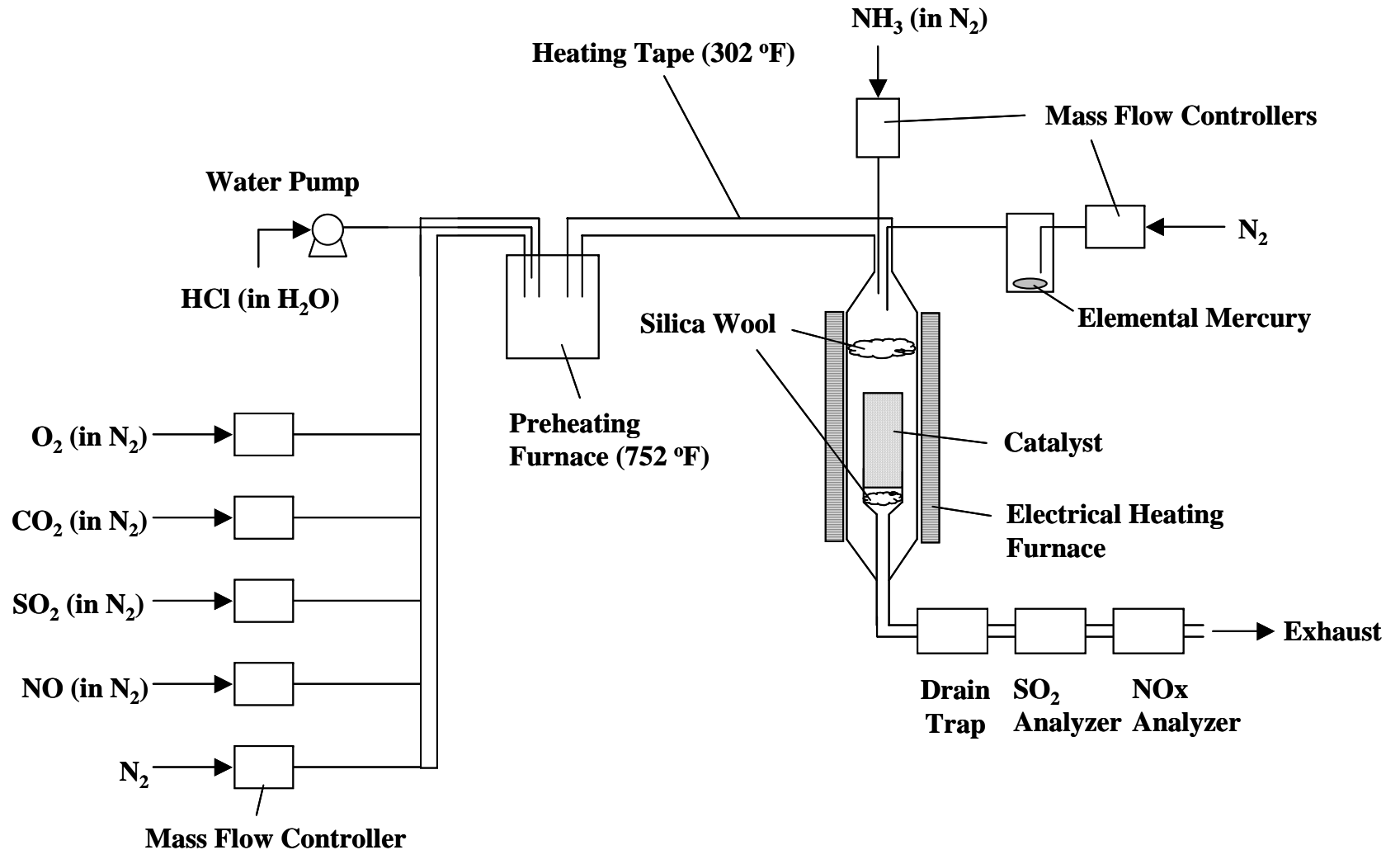


Reaction Speed ; Hg Oxidation, DeNOx >>SO2 Conversion

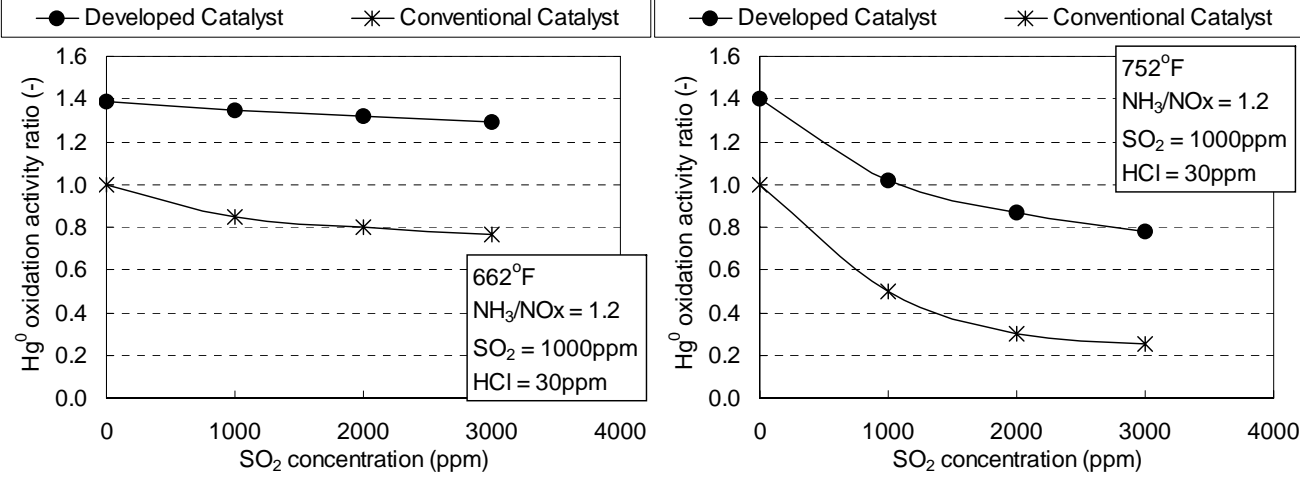
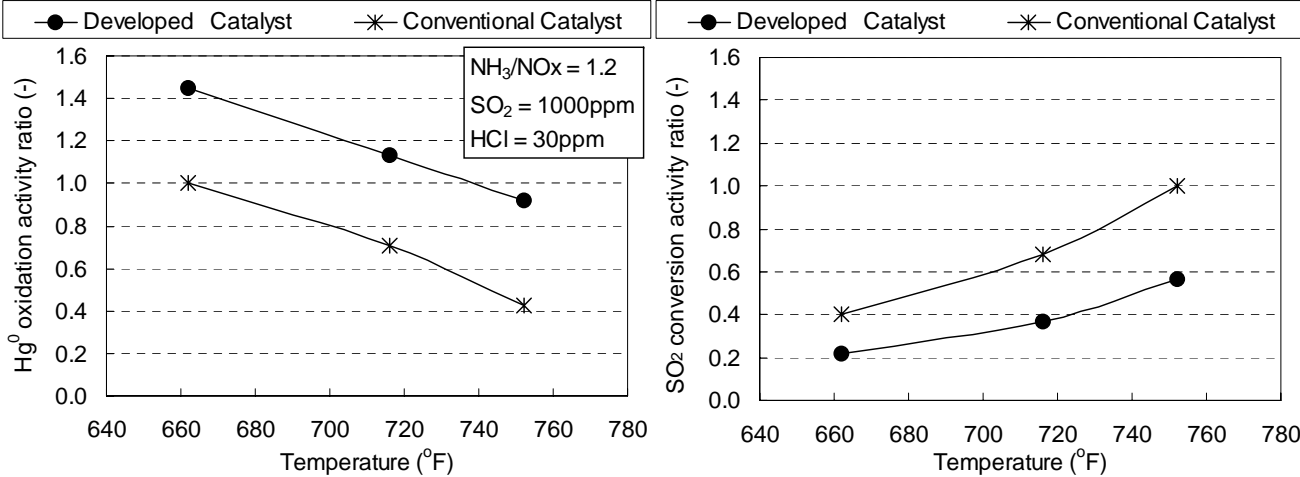
DeNOx/Hg Oxidation reaction takes place exclusively on the surface

SO2 Conversion rate is very slow and thus may increase with total active materials

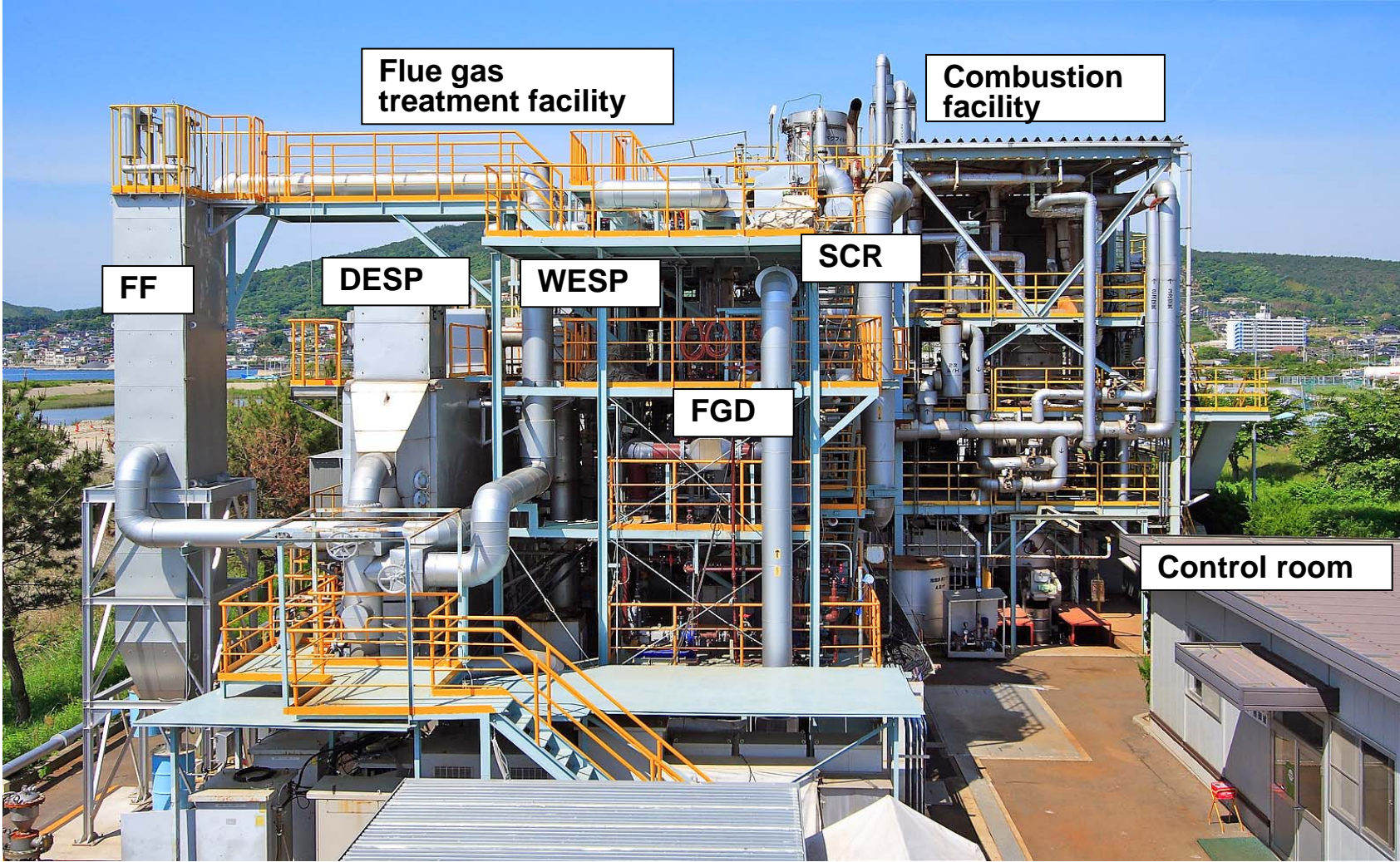
# Laboratory Testing



# Laboratory Testing



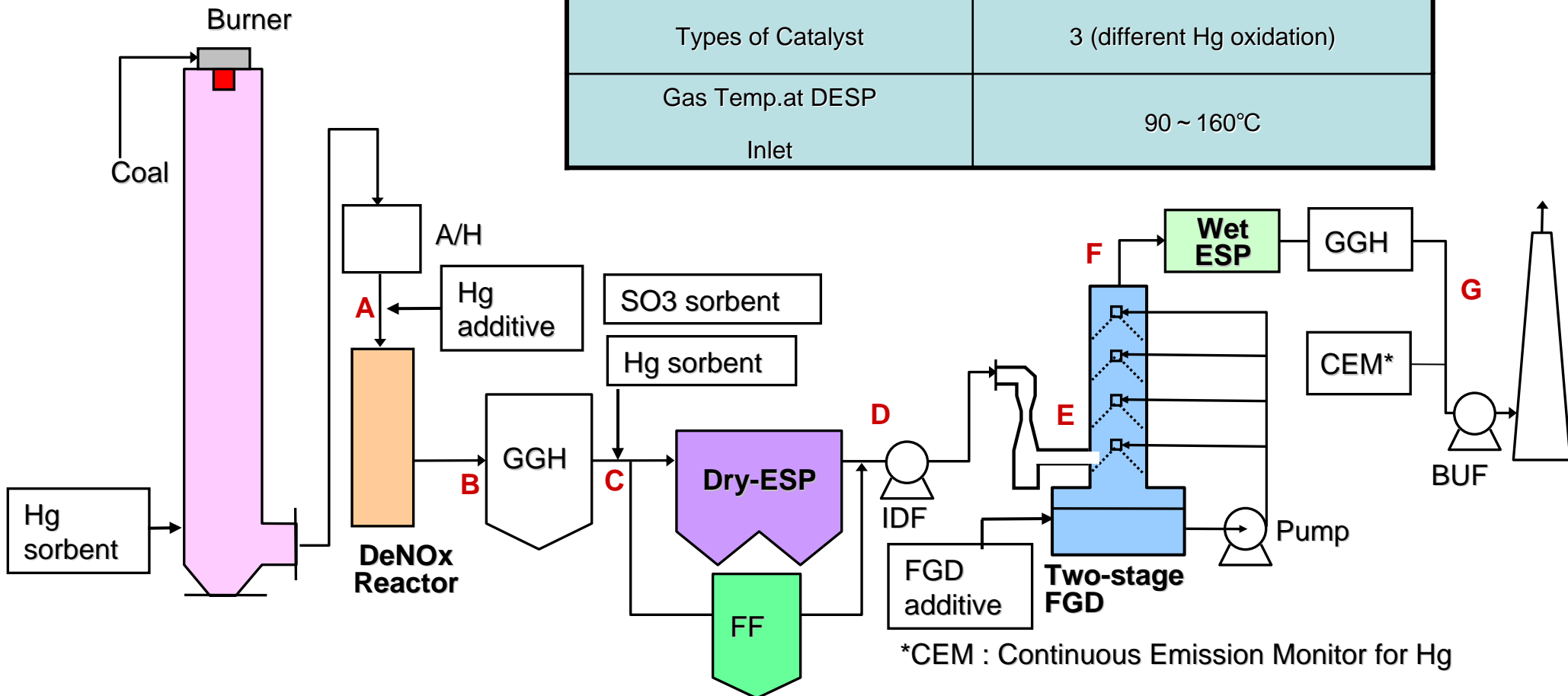
# Pilot Test Facility at Akitsu Works



# Pilot Facility - Schematic Flow and Test Conditions

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

## A ~ G : Hg Sampling Points

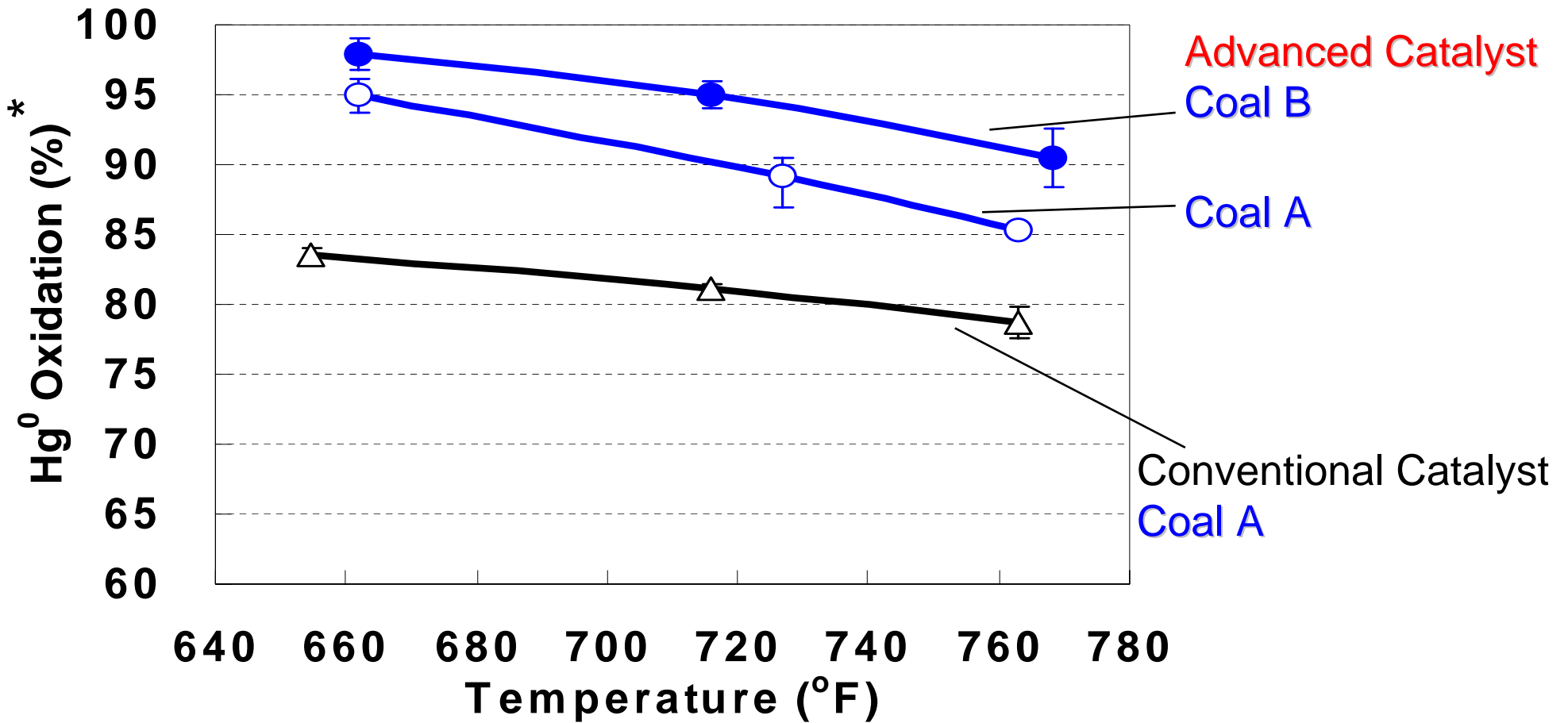


# Test Coals

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

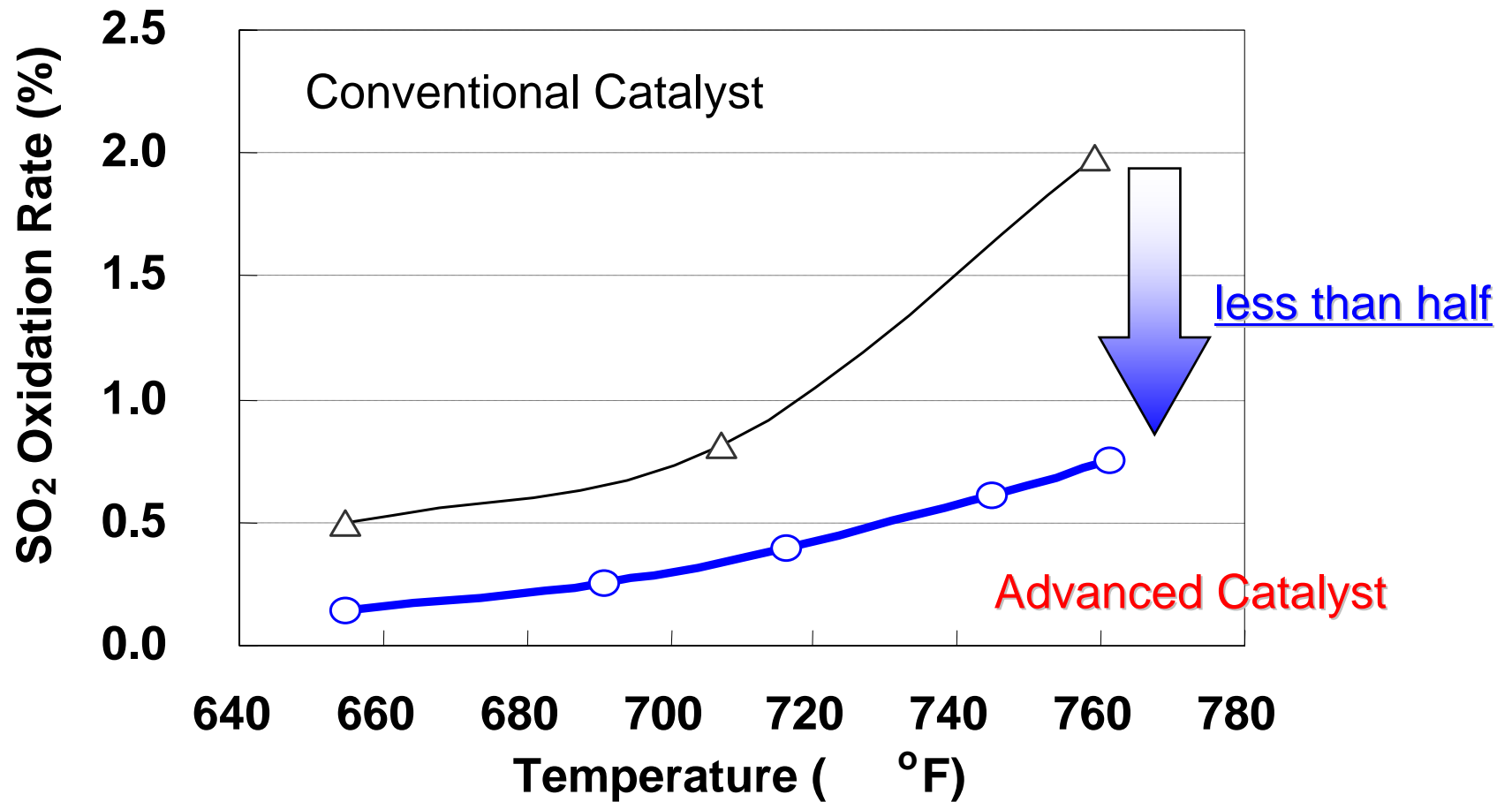
# Pilot Testing: Mercury Oxidation vs. Temperature

\* corrected moisture volume, approximately 10 vol%



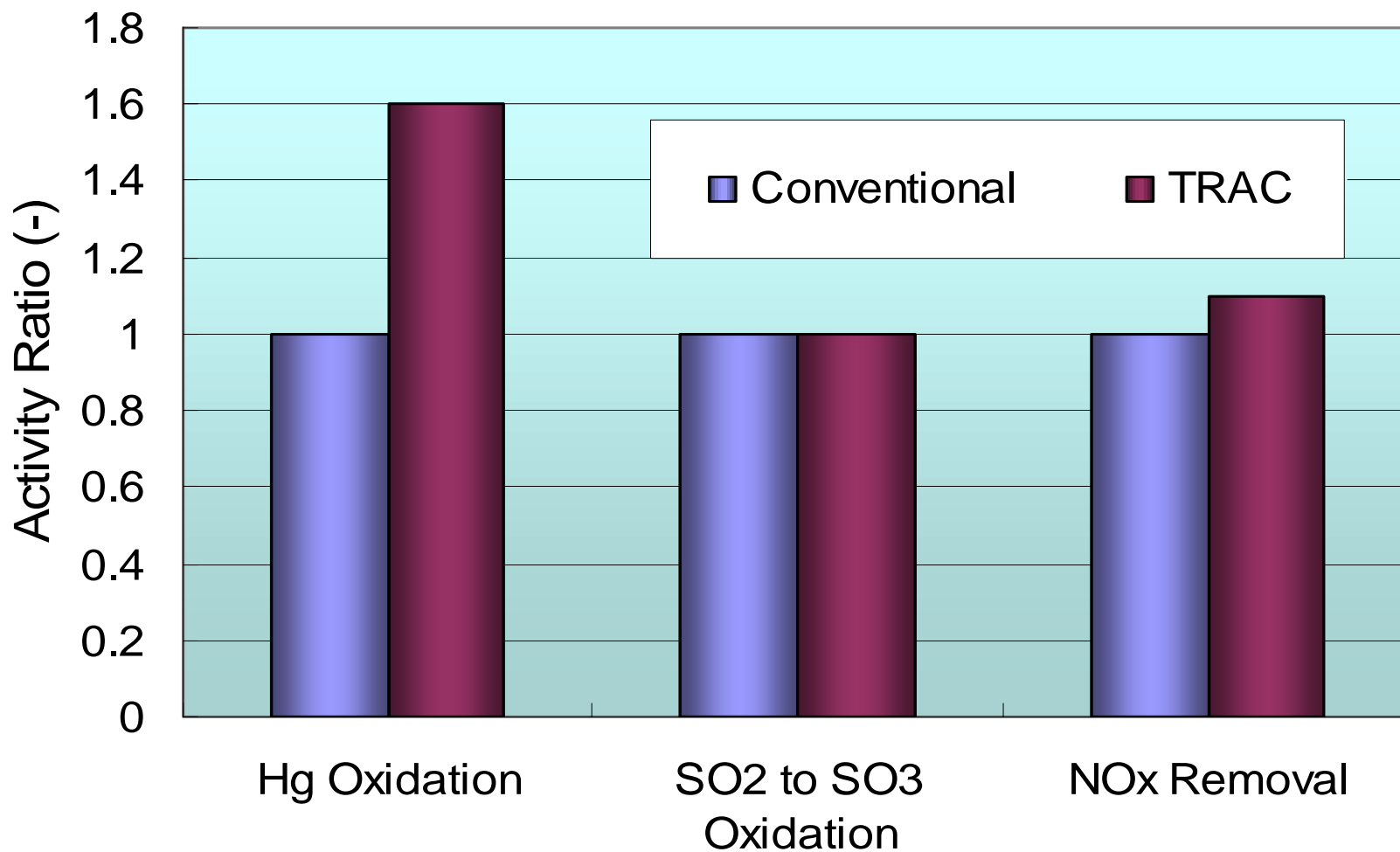
Hg Oxidation : > 95% below 716°F(380°C)

# Pilot Testing: SO<sub>2</sub> Oxidation Rate vs. Temperature

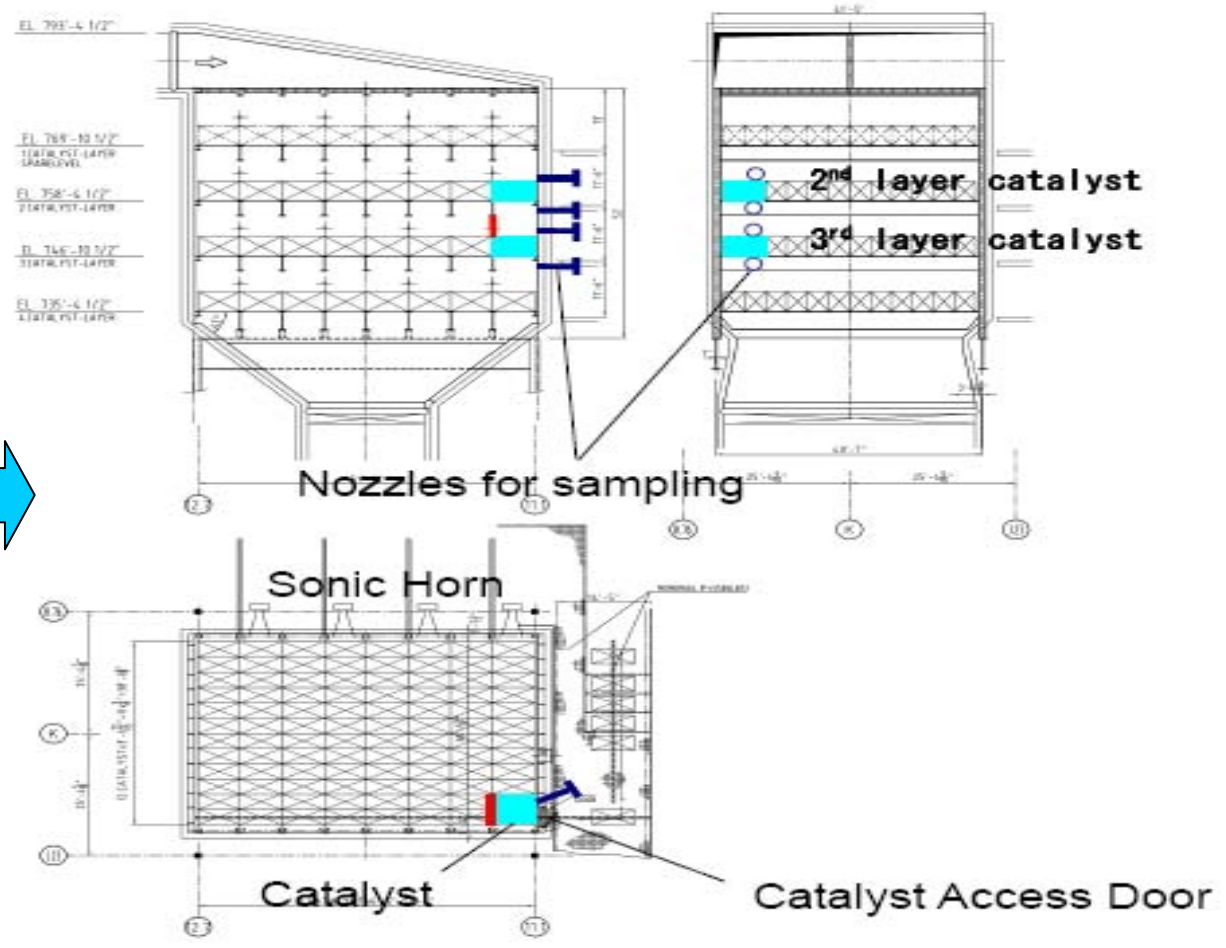
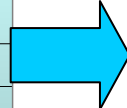
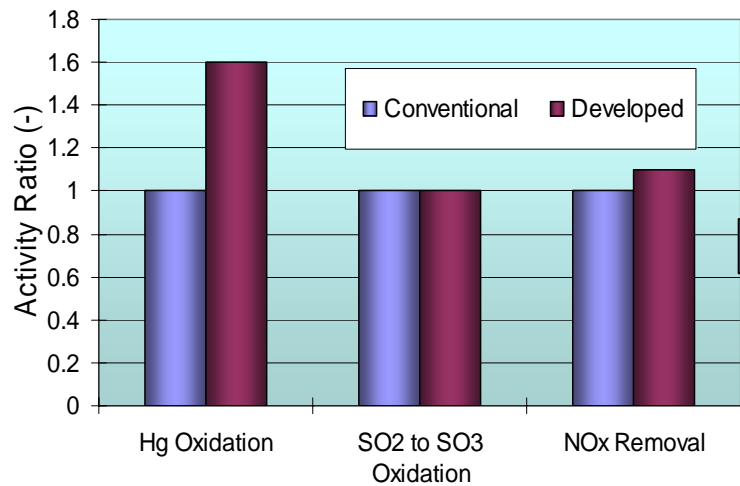


SO<sub>2</sub> Oxidation Rate: < 0.5% below 734°F(390°C)

TRAC™ – TRiple Action Catalyst



# Durability Demonstration Test – Underway at U.S. Plant



**Performance confirmed in pilot scale – entered long term field demonstration**

- A new-plate-type catalyst is developed which can achieve high Hg oxidation and low SO<sub>2</sub> oxidation for plants burning bituminous coal.
- This catalyst can meet Hg oxidation up to 95% at a temperature of 716F while keeping SO<sub>2</sub> oxidation rate less than half that of a conventional catalyst. (below 0.5% at below 734°F).
- Durability testing at actual plant in the U.S. is underway.
- For conventional catalyst, Hg oxidation rate after Air Pre-heater can be kept higher than 95% even after 17000 hours.

# Questions?