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Hitachi Power Systems America, Inc.

Hitachi Advanced Hg Oxidation

TRAC® Catalyst

Hot Topic Hour
August 2, 2012

Kyle Neidig

MATS Hg Regulation & Compliance Strategy

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- New Hg Emission Limit – 1.2 lb/TBtu (for most existing units)
- Goal… Comply with New Regulations and in the Most Cost-Effective Way
  - Assuming Existing Coal Plant Remains in Operation
    - Retrofit unit with additional emissions control devices
    - Get more out of your Current Emissions Control Equipment when possible (SCR + FGD Co-Benefit)
- Hitachi Advanced TRAC® Catalyst Improves Hg Oxidation Across the SCR

Utilizing TRAC® in Units with Currently Installed SCR & FGD is a Cost-Effective Compliance Strategy.

Process of Hg Removal by SCR + FGD

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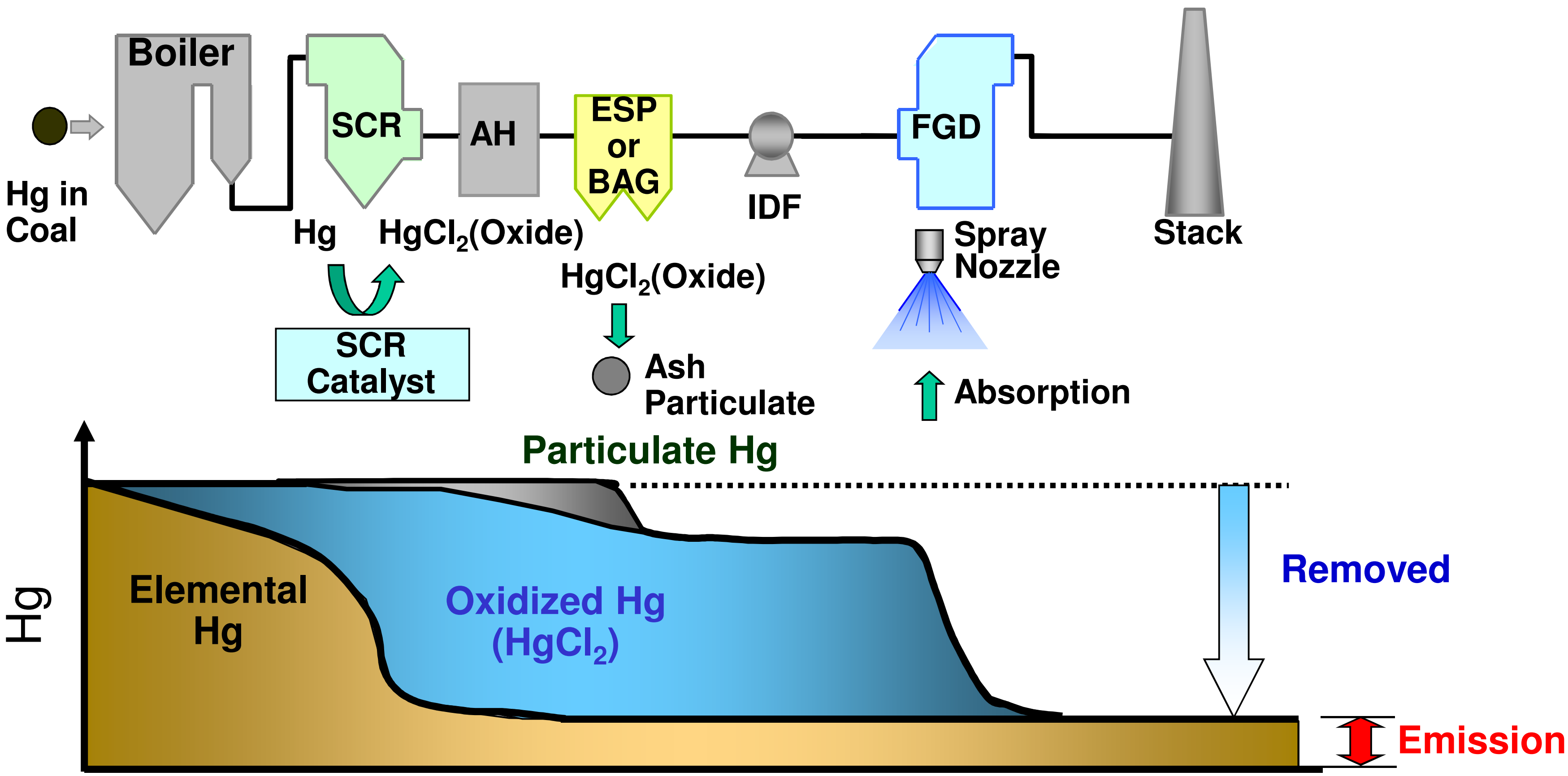

SCR Catalyst is a key component for mercury oxidation

Hitachi Hg Oxidizing Catalyst

TRAC®

Hitachi Technology Innovations

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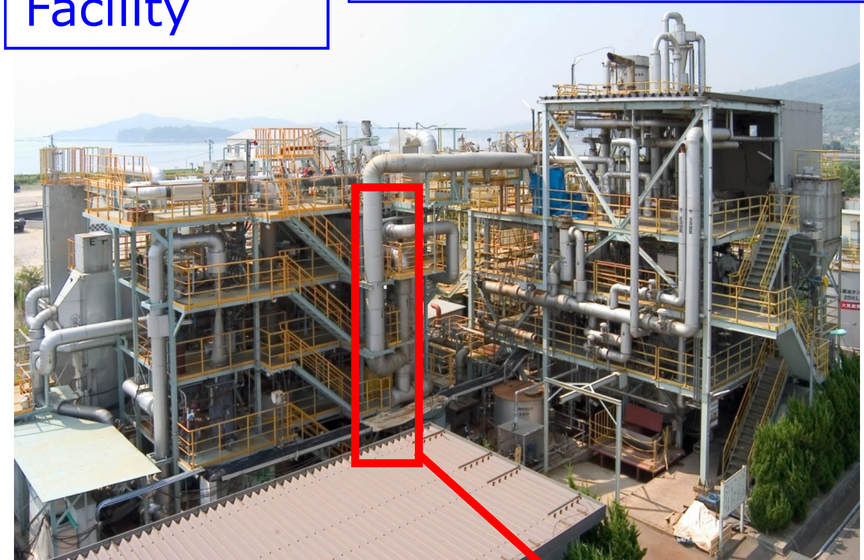
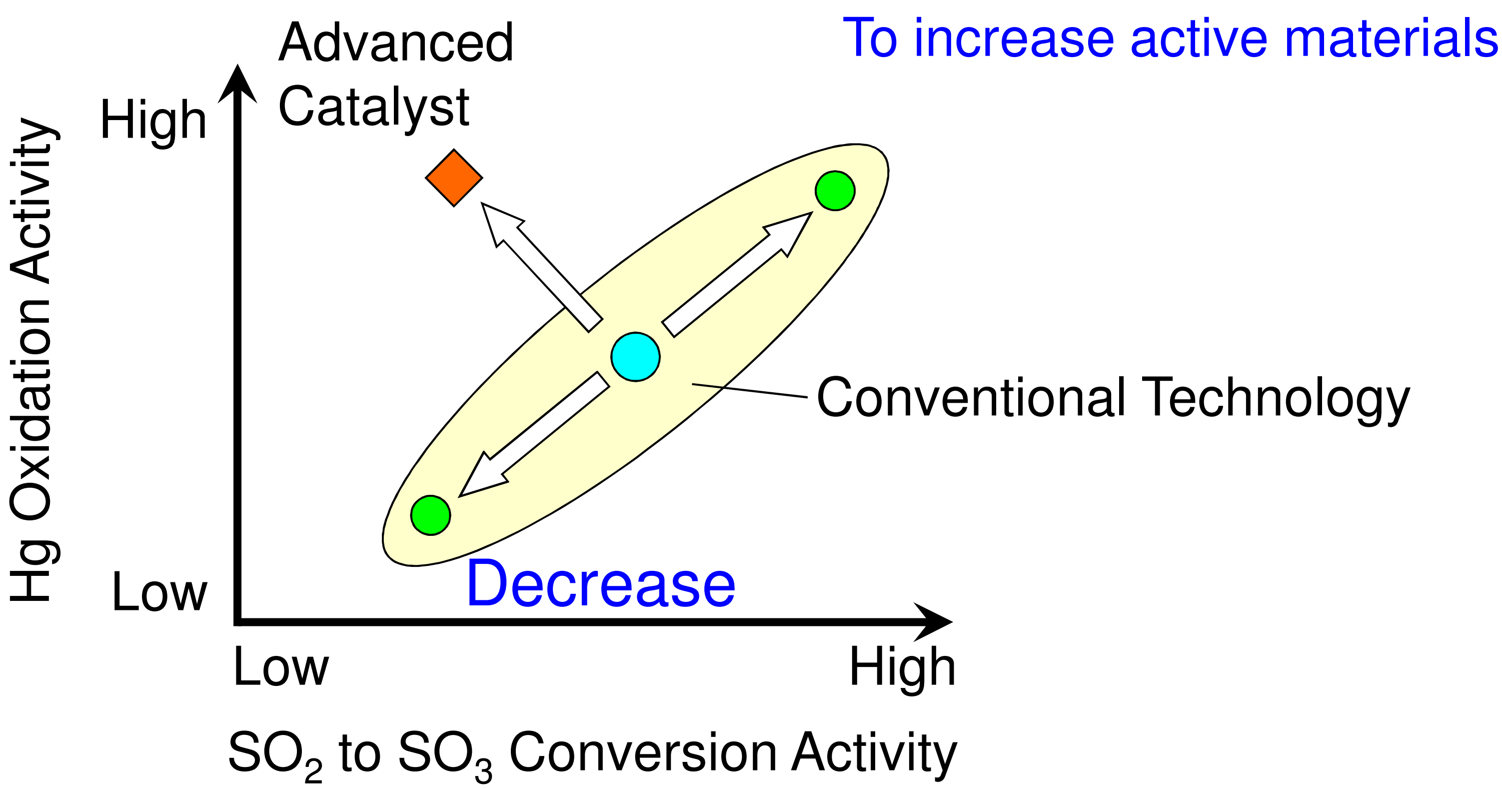
- Original co-developer of Ti02 in the 1960's with over 60 SCR patents.
- 1972 TiO_2/ V Series Catalyst for NO_x Reduction
- 1977 First Patent for Plate Type Catalyst
- 1987 Arsenic Resistant Catalyst
- 1991 Reactor Hood (Patented)
- 1993 Ammonia Injection Grid Nozzle Layout
- 1994 CU Plate Catalyst
- 2000 First Manufacturer to offer Low SO_2 to SO_3 Conversion Catalyst: CX Series
- ***2008 Advanced Mercury Oxidation catalyst: TRAC®***
- 2009 Extended Life Catalyst: CM Series



Research and Development is the cornerstone of success at Hitachi.

The Challenge in Catalyst Design

In order to increase Hg Oxidation in traditional catalyst SO_2 conversion inherently increases as well.



We have developed a new SCR catalyst with Higher Mercury (Hg) Oxidation while maintaining Low SO_2 Conversion

TRAC® – TRiple Action Catalyst

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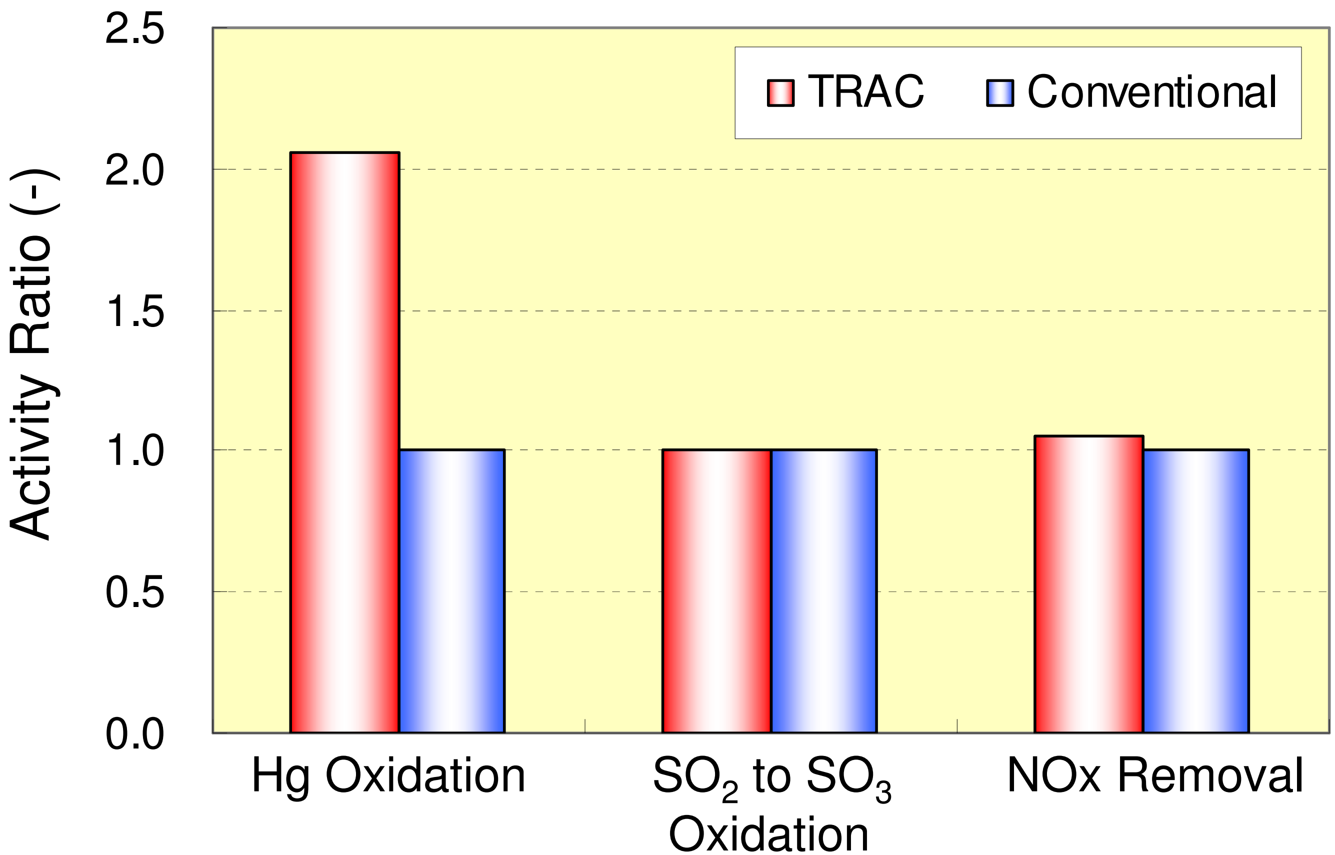
1st High Mercury Oxidation
2nd High DeNOx Performance
3rd Low SO_2 to SO_3 Oxidation



Process of Hg Removal by SCR + FGD

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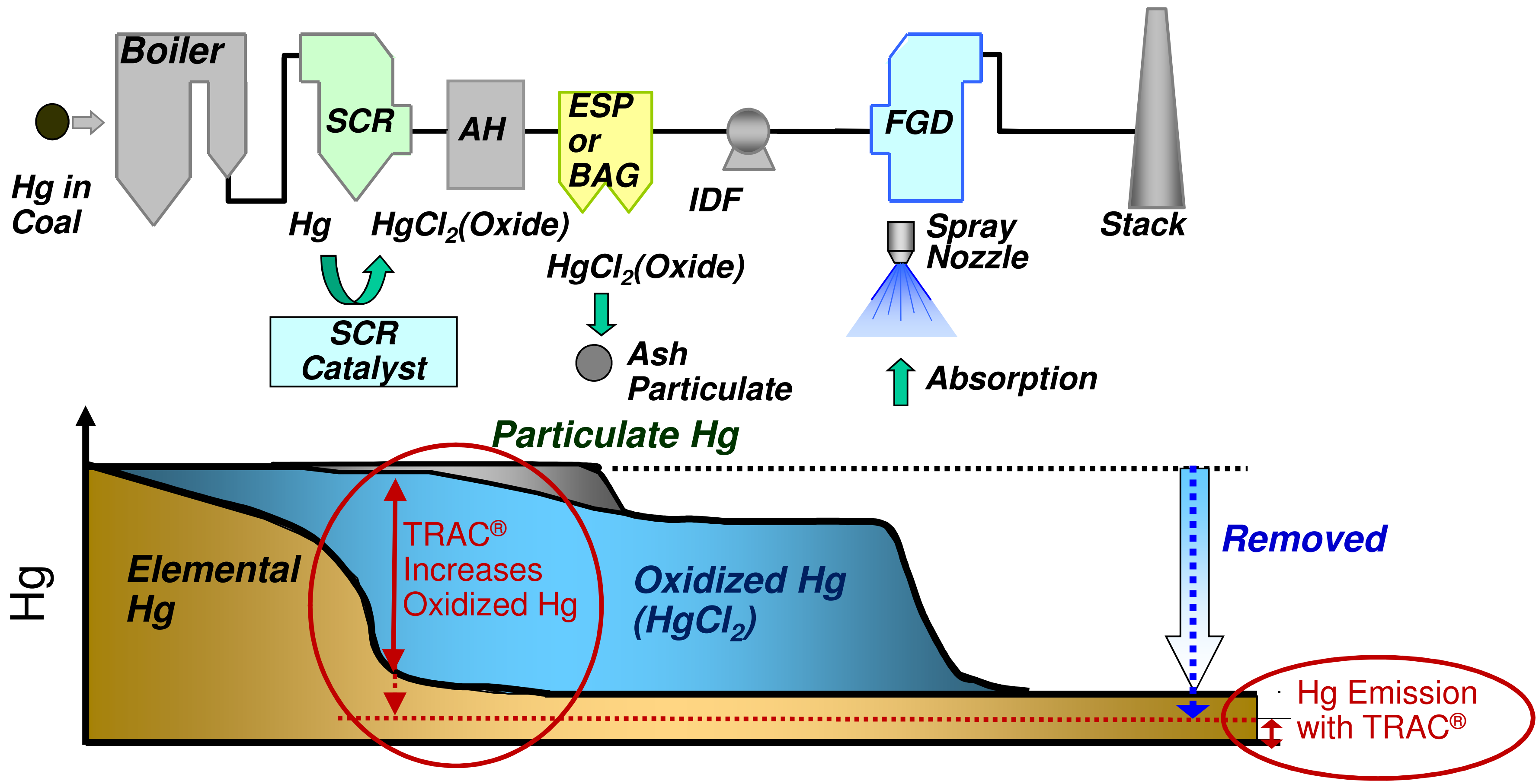

SCR Catalyst is a key component for mercury oxidation

Hitachi TRAC® Catalyst

R&D Testing

Pilot Test at MRC (Bituminous)

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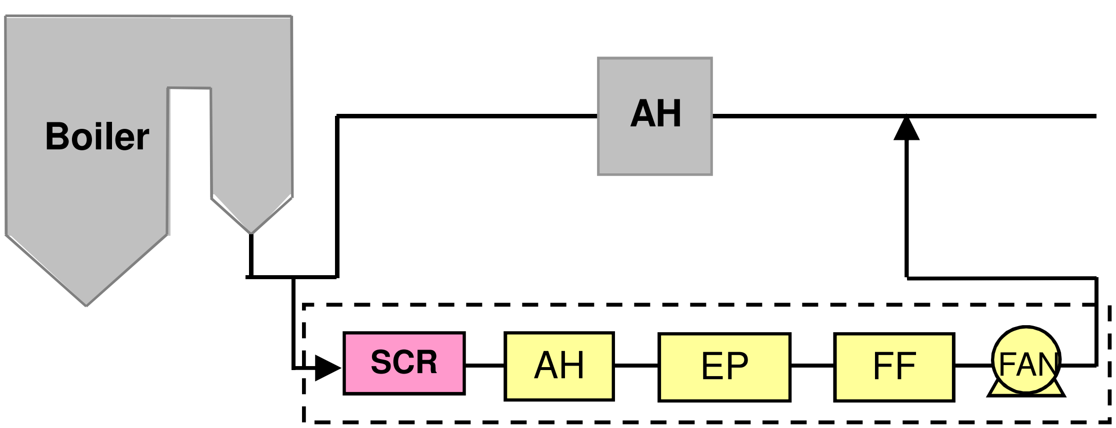
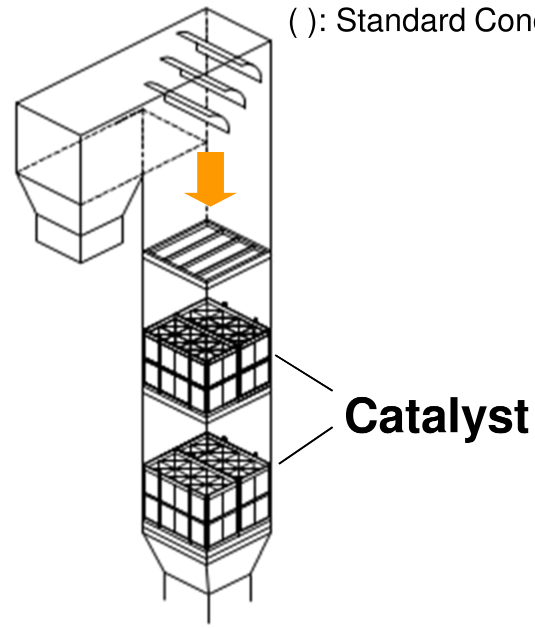
- MRC (Mercury Research Center)
- Host Unit - Gulf Power/Crist Unit5 (75MW)
- Coal - Low Sulfur Bituminous
- Slip Stream Reactor (SSR, 5MW equivalent)
  2 Layers SCR (cross section; 6.6' x 6.6')
- Parametric Testing of Hg Oxidation
  - Temperature
  - HCl
- Catalyst - TRAC® and Conventional Catalyst

Gas Flow Rate	10,705 - 17,842 m^3N/h
Temperature	626 - 752 (698) F
NOx	180 - 230 ppm
SO_2	600 - 900 ppm
HCl	110 - 350 (130) ppm
NOx Removal	90 %
Slip NH_3	2 ppm

( ): Standard Condition



Pilot Test Facility



SSR

Pilot Test at MRC (Bituminous)

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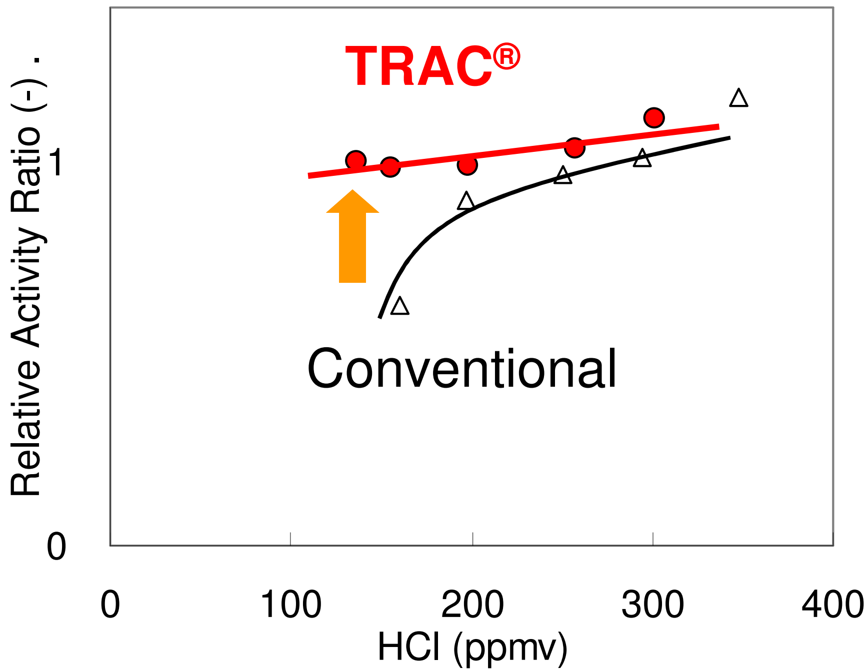
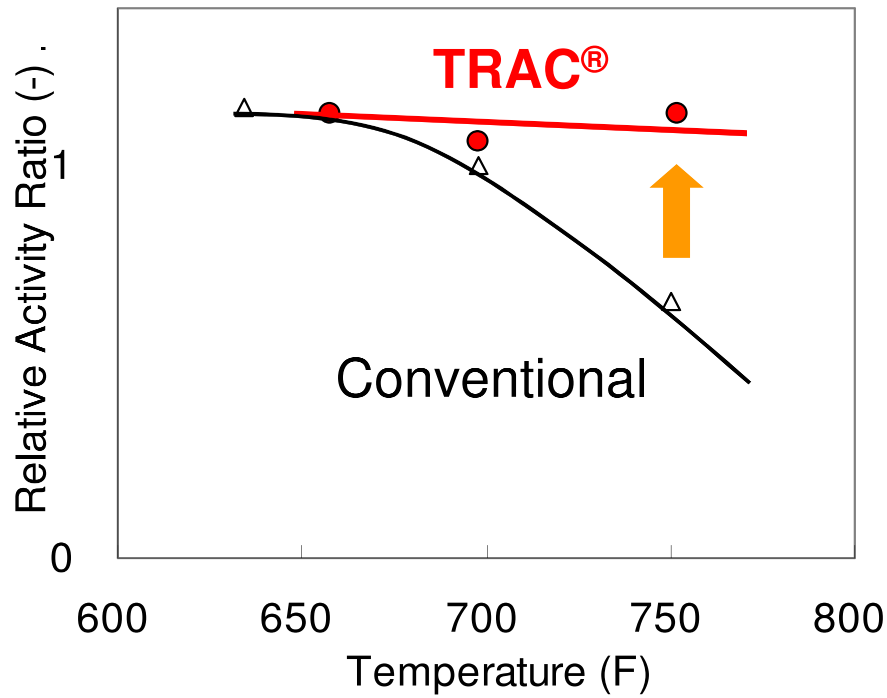
HCl Characteristics



Temperature Characteristics



TRAC® shows…

Higher Hg oxidation at lower HCl concentration

Higher Hg oxidation at higher temperature

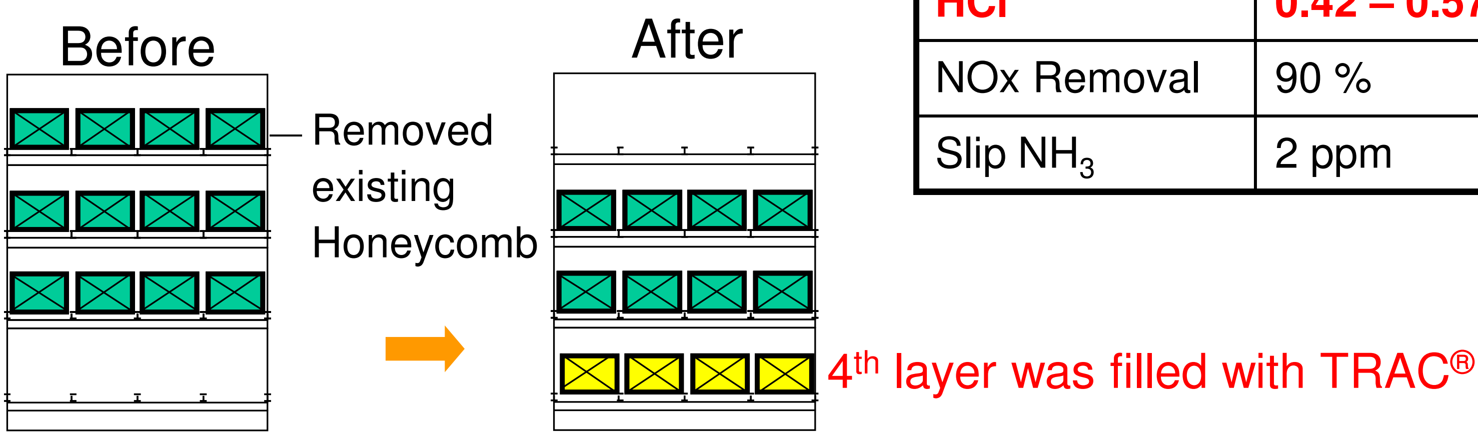
Hitachi TRAC® Catalyst

Full Scale Application

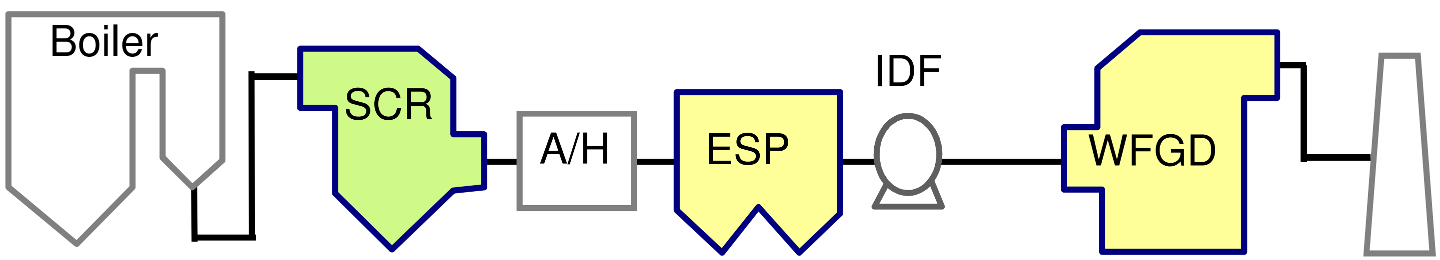
Full Scale Application at PRB Plant

- Northern US Power Plant (640MW)
- Coal - PRB
- TRAC® Supplied in 2008 at 4th Layer

Gas Flow Rate	1,198,652 Nm^3/hr
Temperature	730 F
NOx	372 ppm
SO_2	478 ppm
HCl	**0.42 – 0.57 ppm**
NOx Removal	90 %
Slip NH_3	2 ppm



Hg Removal: **35%** 70%



Full-Scale Result – Plant Miller

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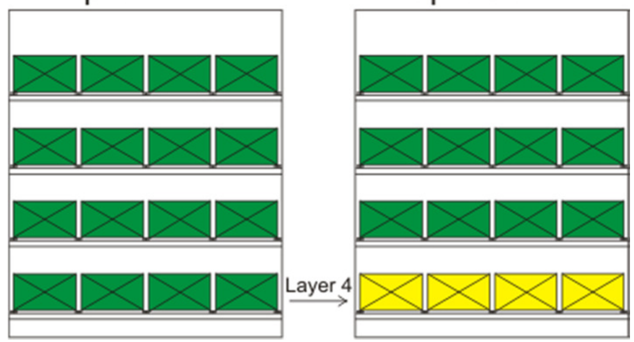
- Plant Miller Units 1 and 2 (720 MW)
- PRB Coal
- TRAC® Installed in spring 2011

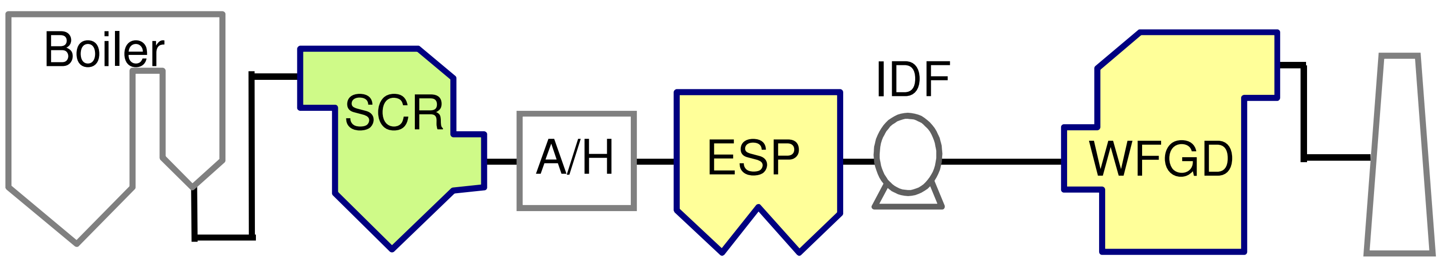
Stack Gas Flow Rate	3,397,200 m^3N/hr
Temperature	720 F
NOx	130-230 ppm
SO_2	125-325 ppm
HCl	1-7 ppm
NOx Removal	90 %
Slip NH_3	<2 ppm

Before Catalyst Replacement

After Catalyst Replacement



Hg Removal: **30%** Hg Removal: **60%**



Mercury CEMS Data – Plant Miller

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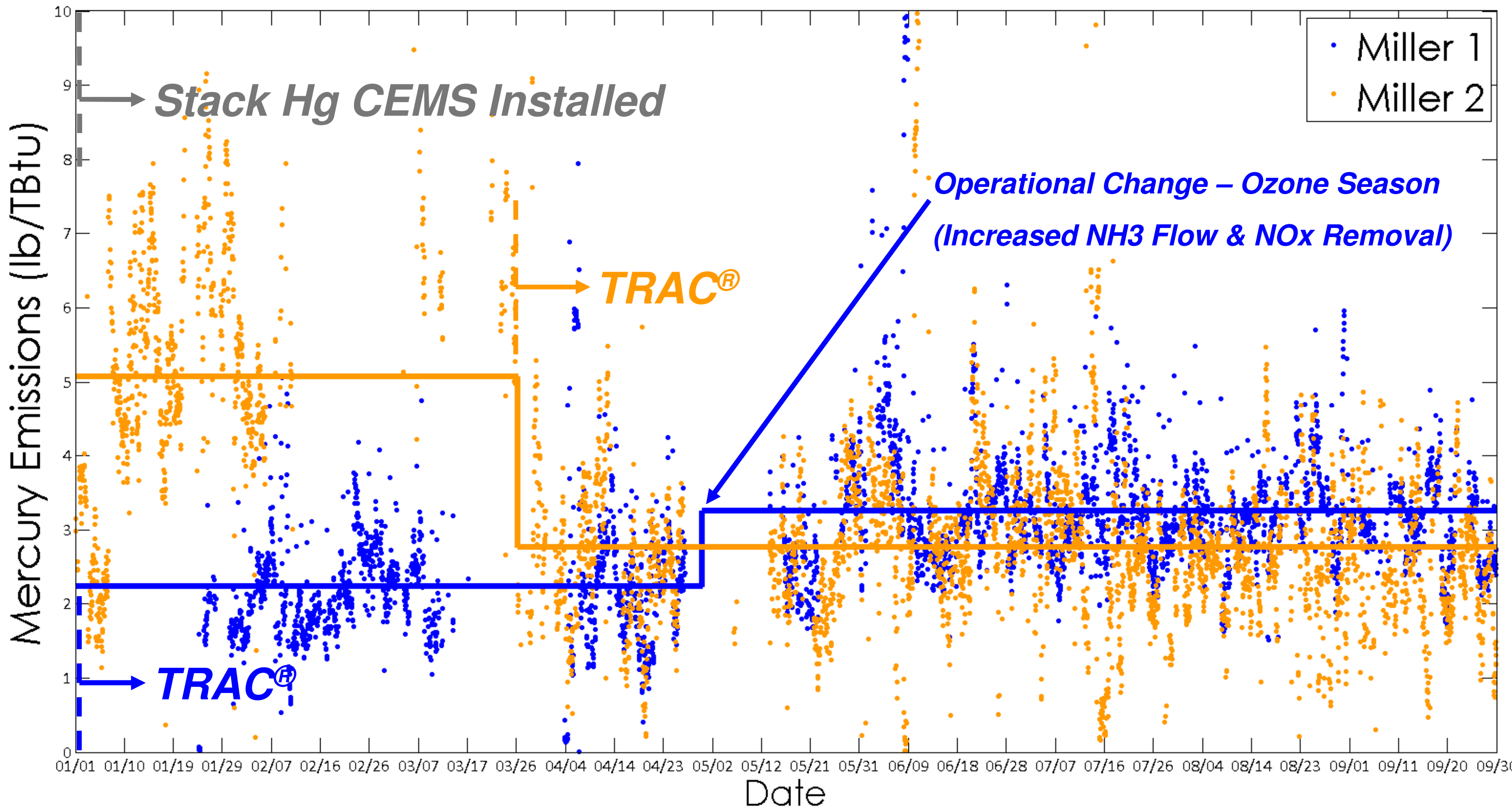

Miller Unit 2 mercury emissions dropped from 5.1 lb/Tbtu to 2.8 lb/Tbtu after installing one layer of TRAC. Miller Unit 1 mercury emissions were 3.3 lb/Tbtu after installing one layer of TRAC.

Cost Impact of an Advanced Hg Oxidation Catalyst

High Sulfur Bituminous Fuel

TRAC® Mercury Removal Study

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Base Case 1 - ACI + ESP (No FF)

- Installation Cost of ACI System
- Operation (AC Consumption) Cost
- High Carbon Content in Ash – Impact on Ash Sales

Base Case 2 - ACI + FF

- Installation Cost of FF + SCI System
- ***Operation (AC Consumption) Cost***
- ***High Carbon Content in Ash – Impact on Ash Sales***

TRAC (With and Without FF)

- Slightly higher cost than Conventional Catalyst (10-15%)
- No Additional Operation Cost
- 3rd Layer Addition (Lower Layer - Most effective for Hg oxidation)

TRAC® Mercury Removal Study - Assumptions

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Conditions

1) Eastern Bituminous Fuel
2) Flue gas temperature at SCR Inlet = 775F
3) 90% of NOx removal with 2 ppm of slip NH_3
4) TRAC® Hg oxidation is at end of catalyst life condition

Assumptions

1) Required total Hg removal = 90%
2) HCl in flue gas =100ppmvd 3%O_2
3) Elemental Hg / Oxidized Hg at SCR inlet = 70/30
4) AC (Untreated) cost = $0.50 / lb
5) Oxidized mercury removal across FF/ESP, WFGD = 95%
6) Hg Oxidation across APH = 50% of remaining elemental Hg

Note: The following evaluation result for Eastern Bituminous are based on the conditions and assumptions shown above. If the conditions and/or assumptions change, the results shall be re-evaluated.

TRAC® Economics – Eastern Bituminous

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TRAC with ESP (no FF) (for 550 MW unit)	1 Layer of Non-TRAC® Addition	1 Layer of TRAC® Addition	3 Layers of TRAC® (margin?)
HG Oxidation(@ APH outlet), (%)	85	95	>97
Hg Remove w/o ACI(@ Stack), (%)	77	90	92
AC injection, # / MMACF	8	0	0
AC Cost / year	$3.34M	$0	$0
Differential Cost of TRAC / year	$0	$20,000	$60,000
Cost of using AC and/or TRAC over an eight (8) year period	$26,700,000	$160,000	$480,000

TRAC® Saves… $26,000,000 (Operating Cost)
ACI System Capital Cost (~$5M)

TRAC® Economics – Eastern Bituminous

TRAC with FF (for 550 MW unit)	1 Layer of Non-TRAC® Addition	1 Layer of TRAC® Addition	3 Layers of TRAC® (margin?)
HG Oxidation(@ APH outlet), (%)	85	95	>97
Hg Remove w/o ACI(@ Stack), (%)	77	90	92
AC injection, # / MMACF	1.5	0	0
AC Cost / year	$630,000	$0	$0
Differential Cost of TRAC / year	$0	$20,000	$60,000
Cost of using AC and/or TRAC over an eight (8) year period	$5,040,000	$160,000	$480,000

TRAC® Saves… $4,800,000 (Operating Cost)
FF System Capital Cost (~$35M)
ACI System Capital Cost (~$5M)

Cost Impact of an Advanced Hg Oxidation Catalyst

Low Sulfur PRB Fuel

TRAC® Economics – PRB Coal w/ ESP

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PRB Application (with ACI)

TRAC with ESP (for 650 MW unit)	3 Layers of Conventional catalyst	2 Layers of conventional and 1 Layer of TRAC®	3 Layers of TRAC®
Hg Oxidation(@ APH outlet), (%)	30	65	80
AC injection, # / MMACF	4.5	2.5	1.5
AC Cost (per year)	$3.39M	$1.88M	$1.13M
Differential Cost of TRAC / year	$0	$25,000	$75,000
Cost of using AC + TRAC over an eight year period	$27.12M	$15.24M	$9.64M

Notes: Assumes $0.75/lb for untreated AC
Additional cost of TRAC is 10-20%

TRAC® Saves

$17,000,000

TRAC® Economics – PRB Coal w/ FF

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PRB Application (with ACI)

TRAC with FF (for 650 MW unit)	3 Layers of Conventional catalyst	2 Layers of conventional and 1 Layer of TRAC®	3 Layers of TRAC®
Hg Oxidation(@ APH outlet), (%)	30	65	80
AC injection, # / MMACF	1.5	1.0	0.5
AC Cost (per year)	\$1.13M	\$0.75M	\$0.38M
Differential Cost of TRAC / year	\$0	\$25,000	\$75,000
Cost of using AC + TRAC over an eight year period	\$9.04M	\$6.2M	\$3.64M

Notes: Assumes \$0.75/lb for untreated AC
Additional cost of TRAC is 10-20%

TRAC® Saves

\$5,400,000

TRAC® Record - Applications

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Owner	Plant	Load (MW)	Coal	Supply	Country
A	Plant A	640	PRB	2008	US
B	Plant B	550	Bituminous	2010	GR
Southern Company	Miller Unit 1	735	PRB	2011	US
Southern Company	Miller Unit 2	735	PRB	2011	US
Southern Company	Barry Unit 5	773	Bituminous	2011	US
AEP	Mountaineer Unit1	1,300	Bituminous	2011	US
Southern Company	Bowen Unit 3	950	Bituminous	2011	US
AEP	Cardinal Unit 2	600	Bituminous	2012	US

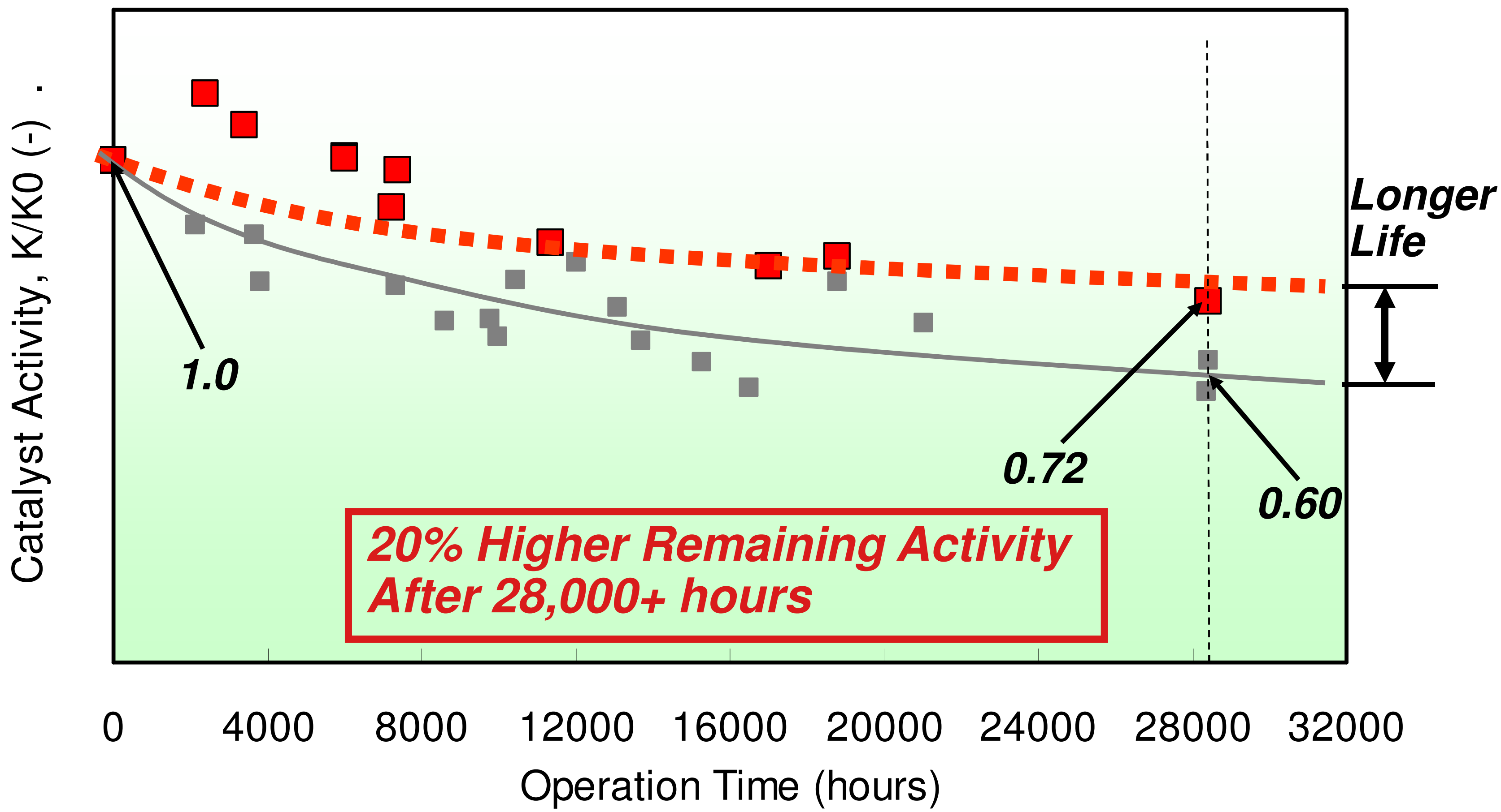
Eight Commercial Installations of TRAC® Catalyst

Additional Benefit of TRAC®

Long Life Catalyst (Slower Deactivation)

Longevity Test at Mitchell Unit 1 (Bituminous)

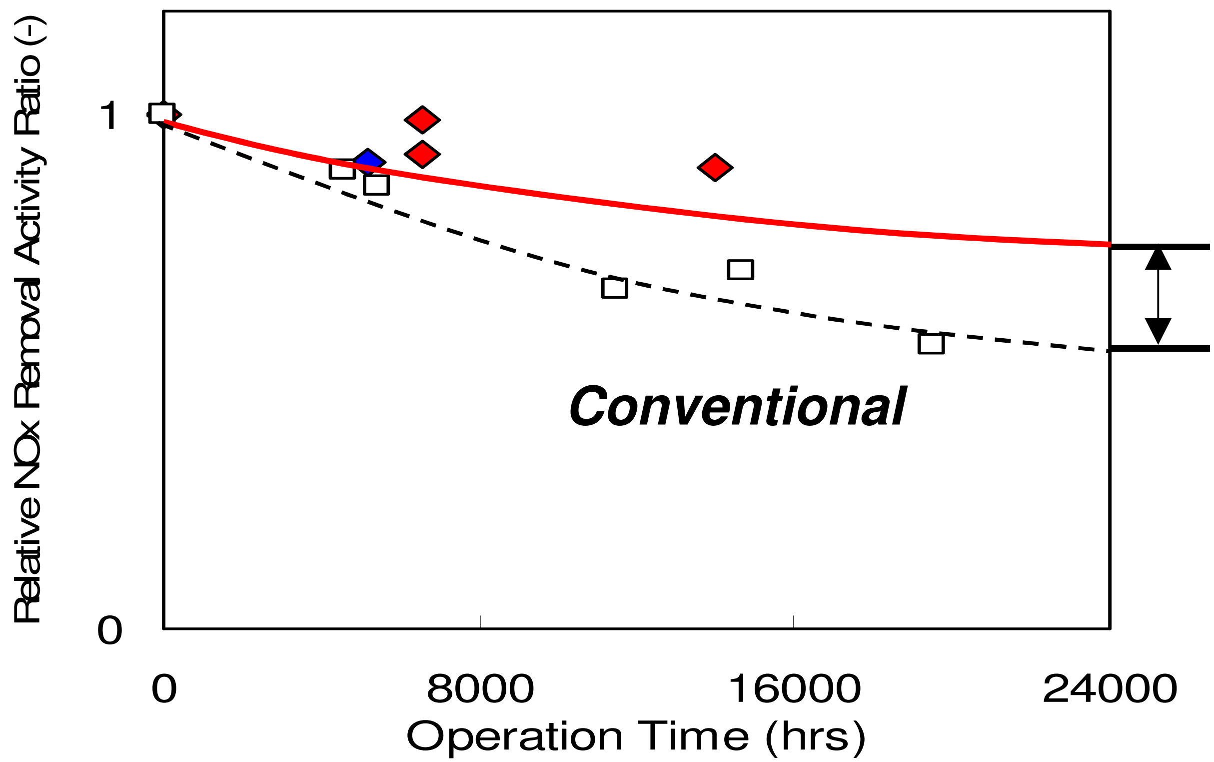
Durability of TRAC®/CM catalyst is extremely improved for longer life



TRAC®/CM catalyst has longer life compared with conventional. It is possible to save money for long term operation or reduce catalyst volume to be applied to actual plants.

TRAC®/CM Catalyst Deactivation Rate (PRB)

Durability of TRAC®/CM catalyst is extremely improved for longer life



TRAC®/CM catalyst has longer life compared with conventional. It is possible to save money for long term operation or reduce catalyst volume to be applied to actual plants.

Deactivation Rate – Test Results from 2012

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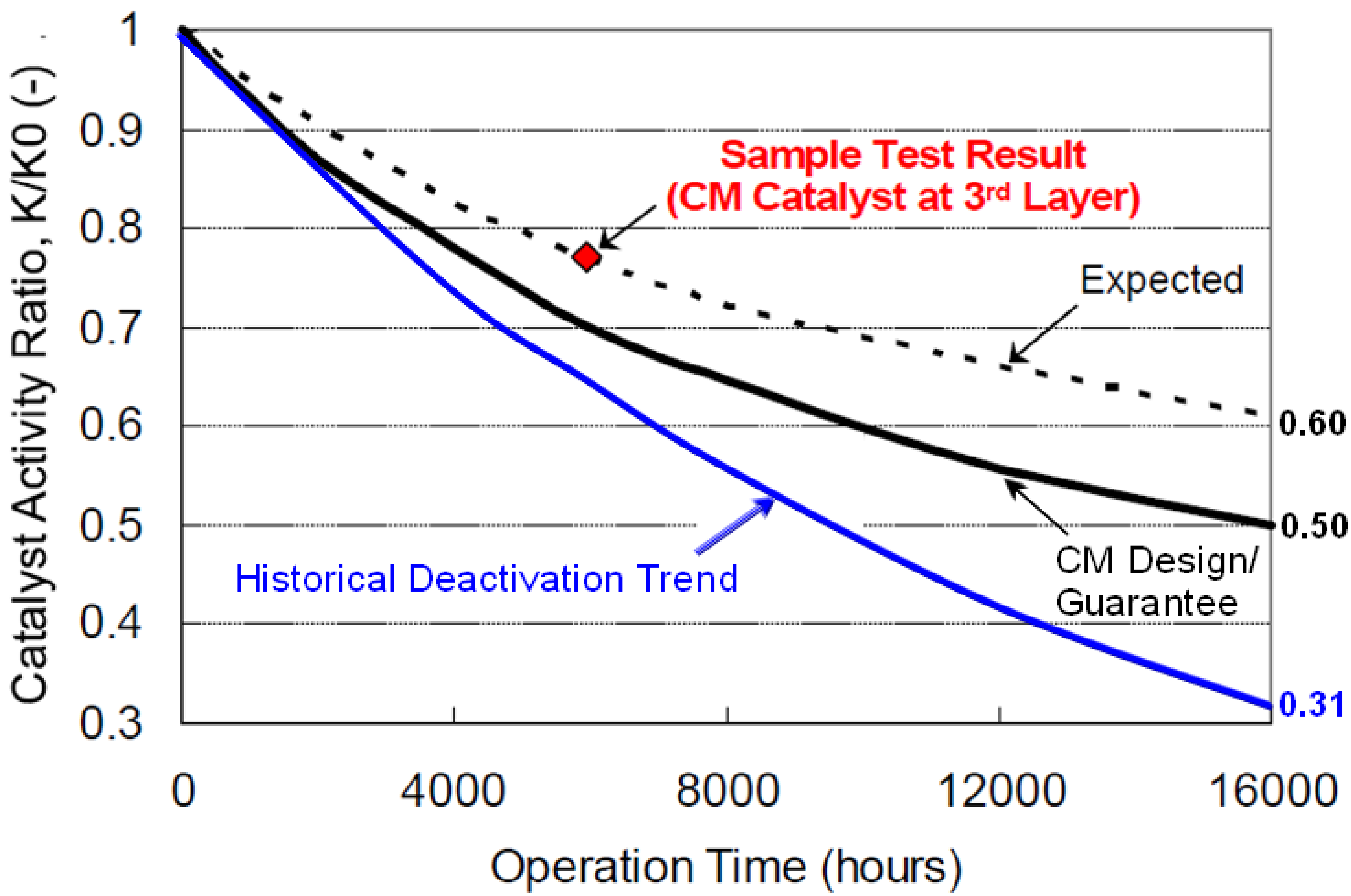

Cost Impact of a Longer Life Catalyst

Long Life Catalyst – CMP Economics – 700MW

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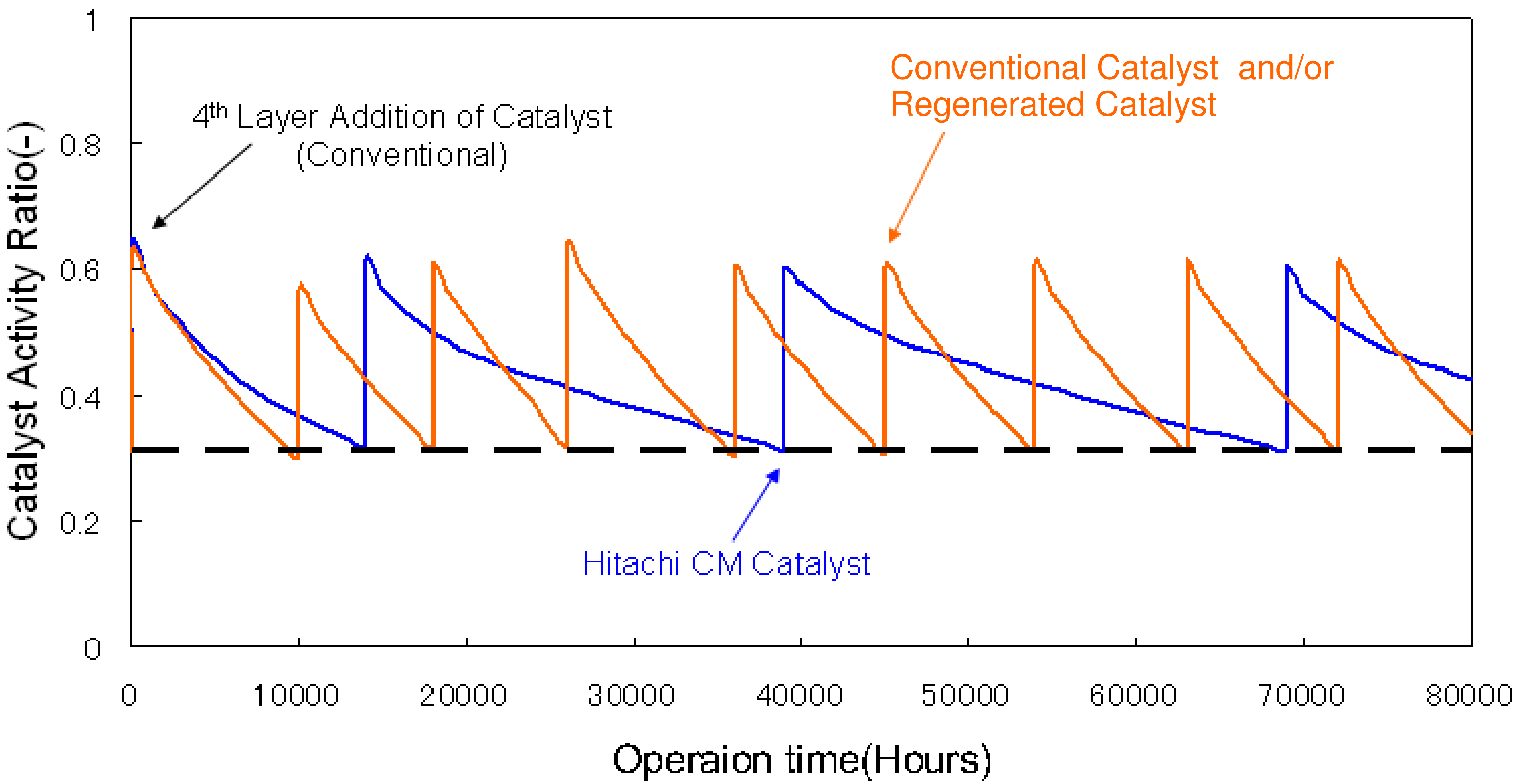

CM Reduces 9 Catalyst Replacement Outages to 4

Long Life Catalyst – CMP Economics – 700MW

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Hitachi Advanced Catalyst vs. Conventional and/or Regenerated Catalyst

Catalyst Type	Required number layers in next 10 years	Estimated Catalyst Material Cost (Per Layer)	Total Catalyst Material Cost (next 10 years)	Estimated Total Catalyst Loading Costs	10 Year Total Cost for Catalyst
Conventional Catalyst	9	$2,000,000	$18,000,000	$3,600,000 Assumes $400K / Layer	$21,600,000
Regenerated Catalyst	9	$1,200,000 Assumes 60% of New	$10,800,000	$3,600,000 Assumes $400K / Layer	$14,400,000
Hitachi	4	$2,000,000	$8,000,000	$1,600,000 Assumes $400K / Layer	$9,600,000

Hitachi Catalyst Saves $12M vs. Conventional Catalyst over a 10 year period

Hitachi Catalyst Saves $4.8M vs. Regenerated Catalyst over a 10 year period

Conclusion – Benefits of TRAC®

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- TRAC® & CM have the potential to save Millions
  - In some cases, TRAC® can eliminate the need for installation of ACI or halogen injection.
  - In other cases, TRAC® effectively reduces operating costs by decreasing the amount of AC or halogens required for mercury control on both bituminous and PRB units.
  - Longer catalyst life can be achieved with TRAC® & CM resulting in fewer catalyst replacement outages over the life of the SCR.
  - By maintaining low SO2 to SO3 conversion, TRAC® can reduce the amount of sorbent injection required for SO3 mitigation.

Development Continues to…

Further Enhance TRAC® & CM Catalyst Performance

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