Mercury Control In Wet FGD Systems on Coal-Fired Utility Boilers

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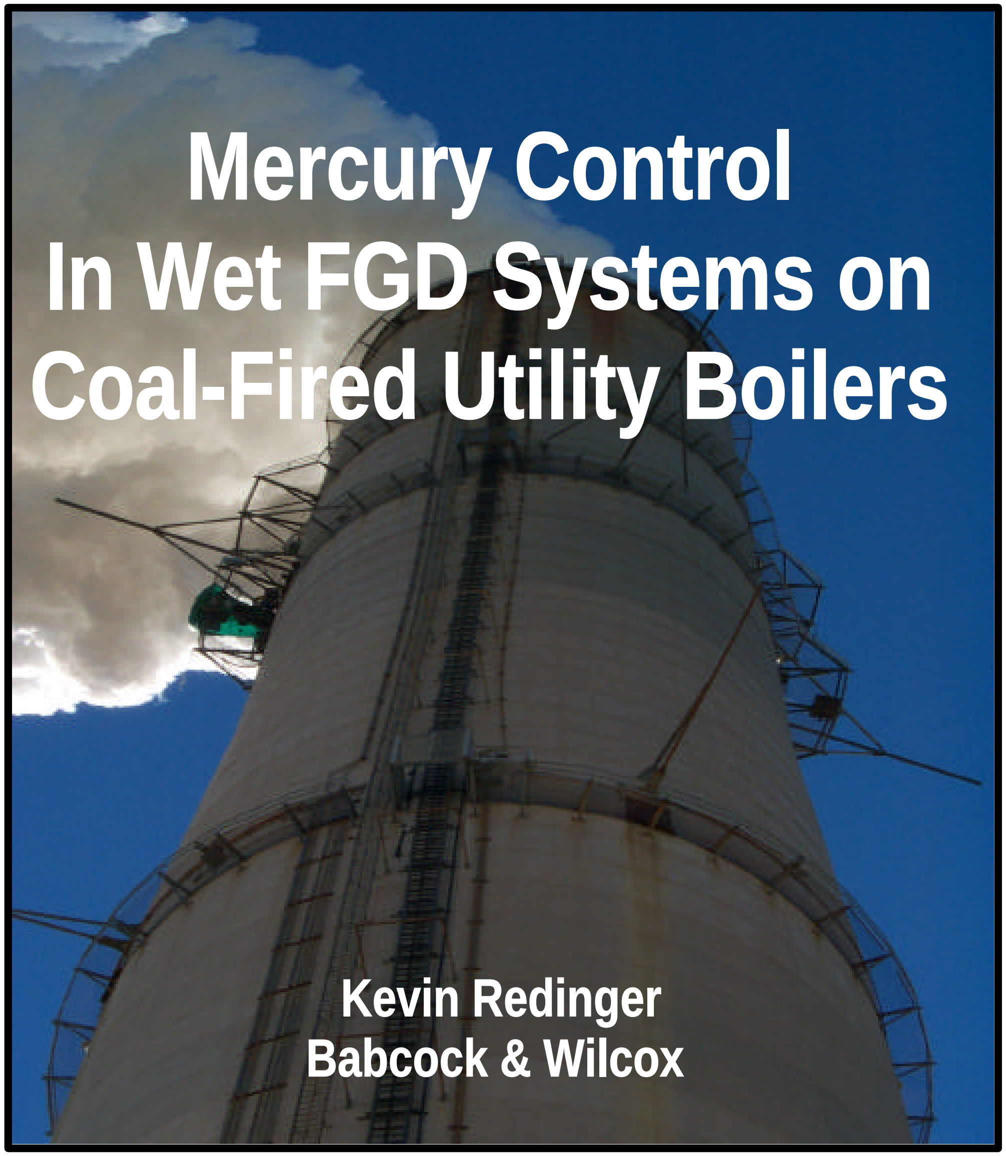
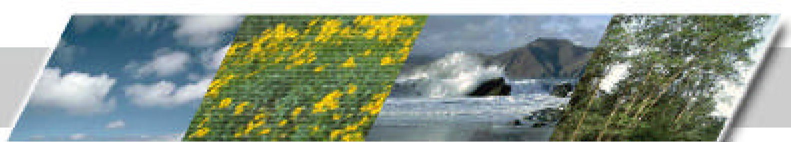
Babcock & Wilcox



Babcock & Wilcox



US Department of Energy / Ohio Coal Development Office

Babcock & Wilcox / McDermott Technology Inc

Wet FGD – Flue Gas Desulfurization

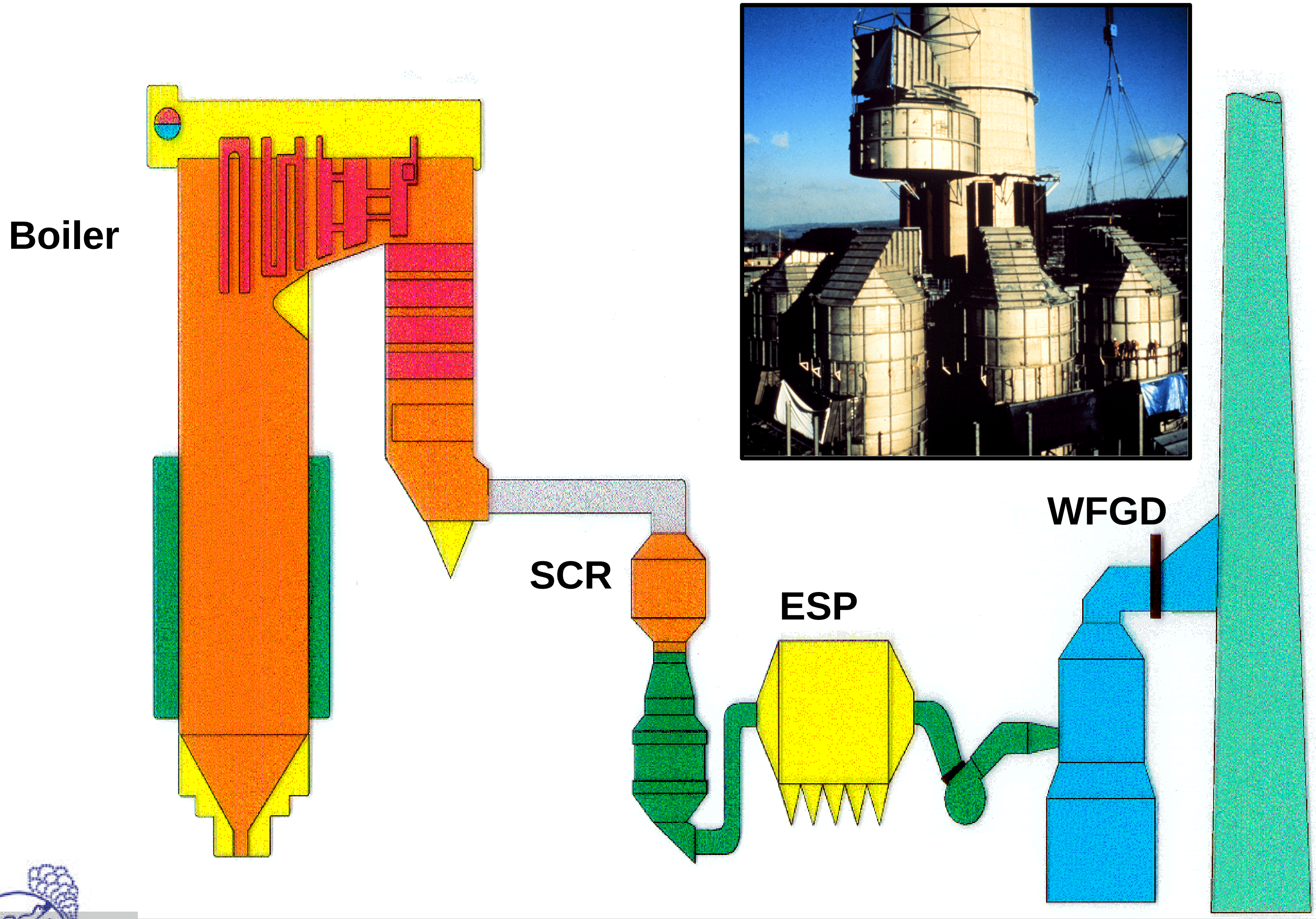
Primary SO_2 Control for US Utility Industry

- 95,000 MW or about 85% of all US FGD installations
- About 25% of US generating capacity (220 installations)
- Well proven technology – 30+ years
- Several major system suppliers

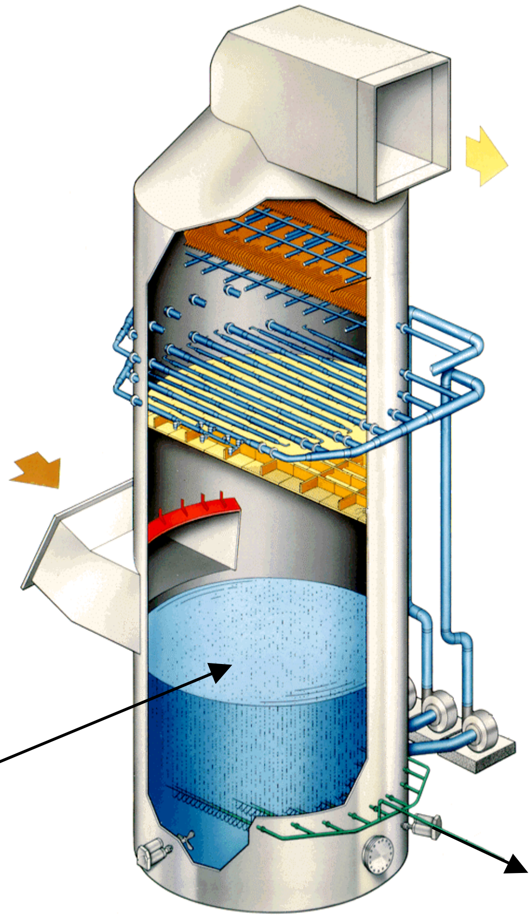
Co-control of mercury as a secondary benefit

- Control efficiency dependent on form of mercury
- System design and operation also play a role

Typical Wet FGD Installation



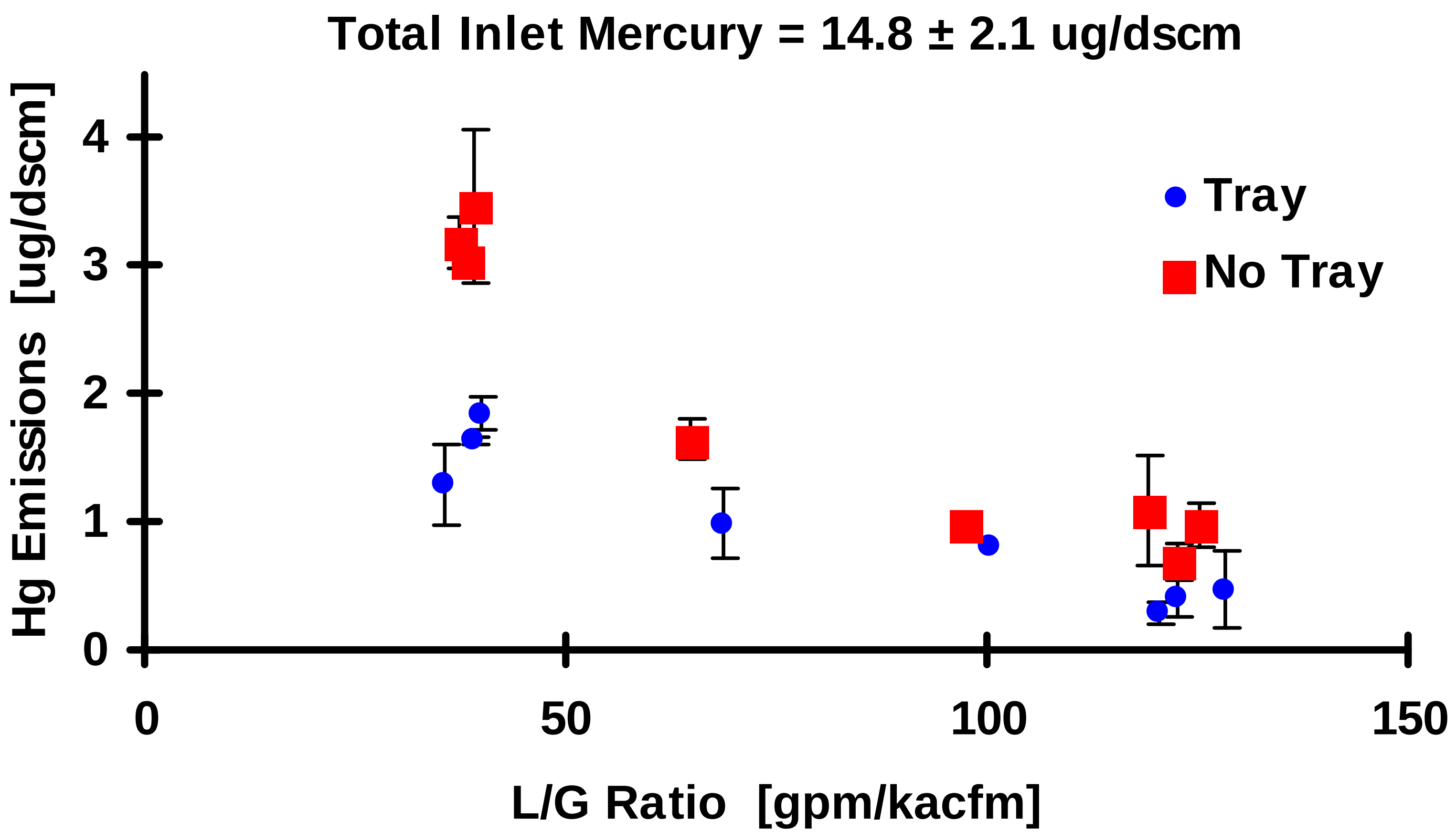
B&W Wet SO_2 Scrubber



B&W / MTI Pilot Tests Showed:

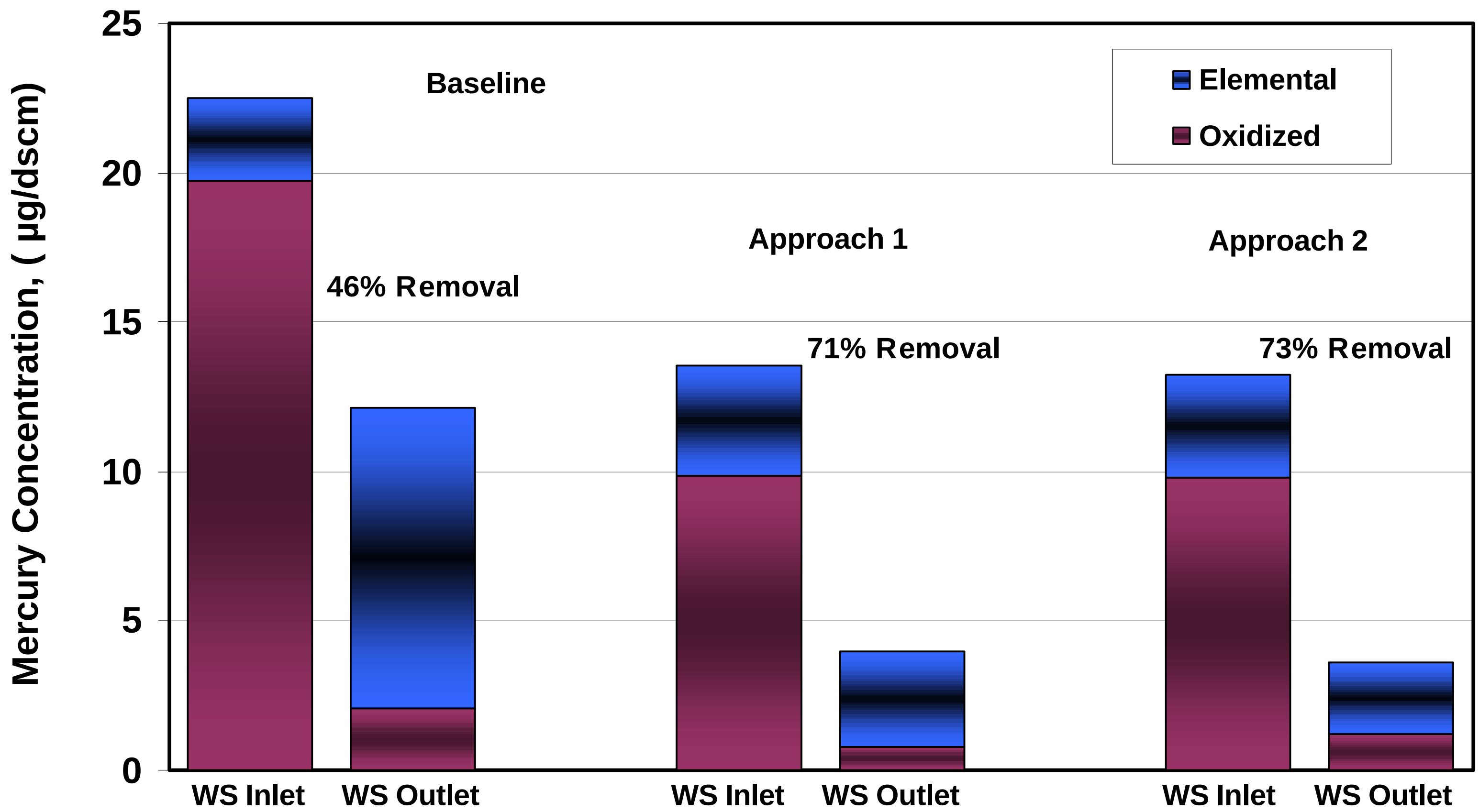
- System design and operation impacted mercury emissions control
  - 78% at L/G ratio of 40 vs. 94% at L/G of 120
  - Oxidized Hg removal of 85 to 98%
  - Limited impact on elemental Hg
  - Favorable Hg^{++} / Hg^0 does not assure high removal efficiency
- Additives effective in preventing reduction and release of Hg^0
  - Effective, convenient technique for addition
  - Safe, stable, low-cost reagents

B&W / MTI Pilot Testing - mid 1990's



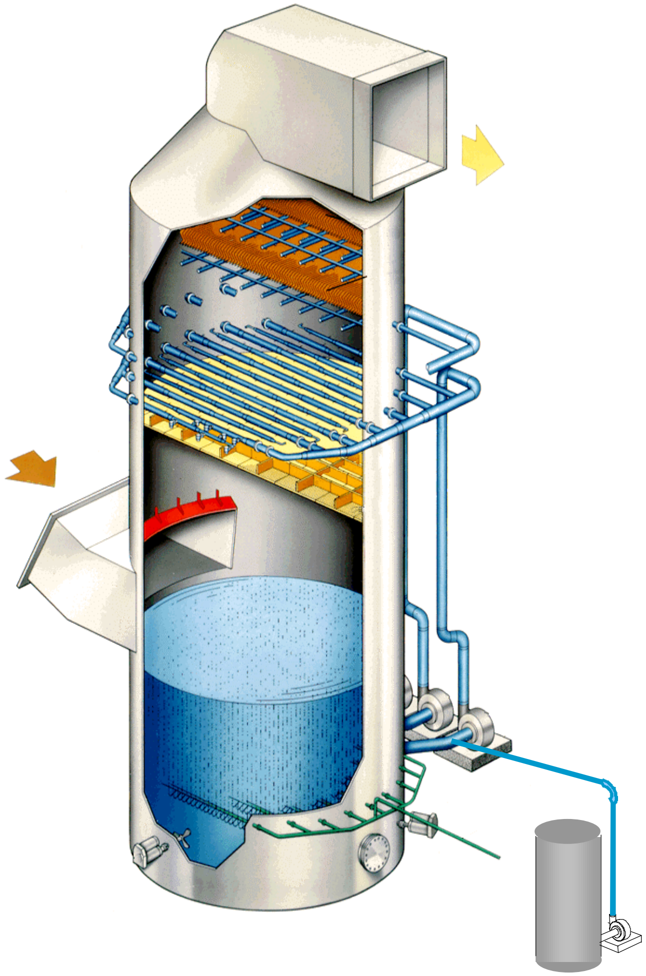
FGD Design and Operation Impacts Mercury Control

Additive to Control Release of Hg^0



Effective reagent / minimal FGD process impact

Full Scale Demonstration Tests

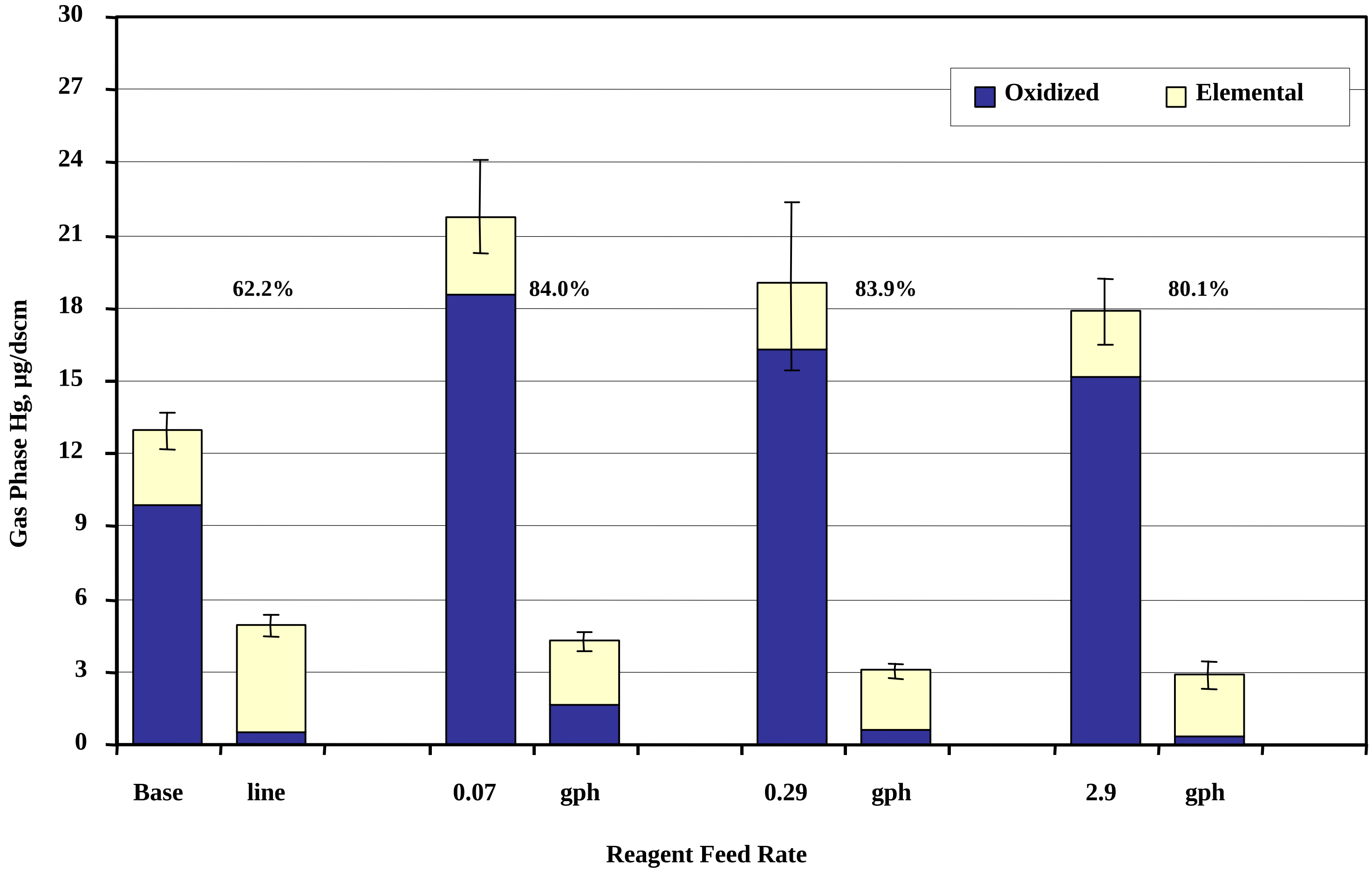


Mercury Removal Chemical Addition

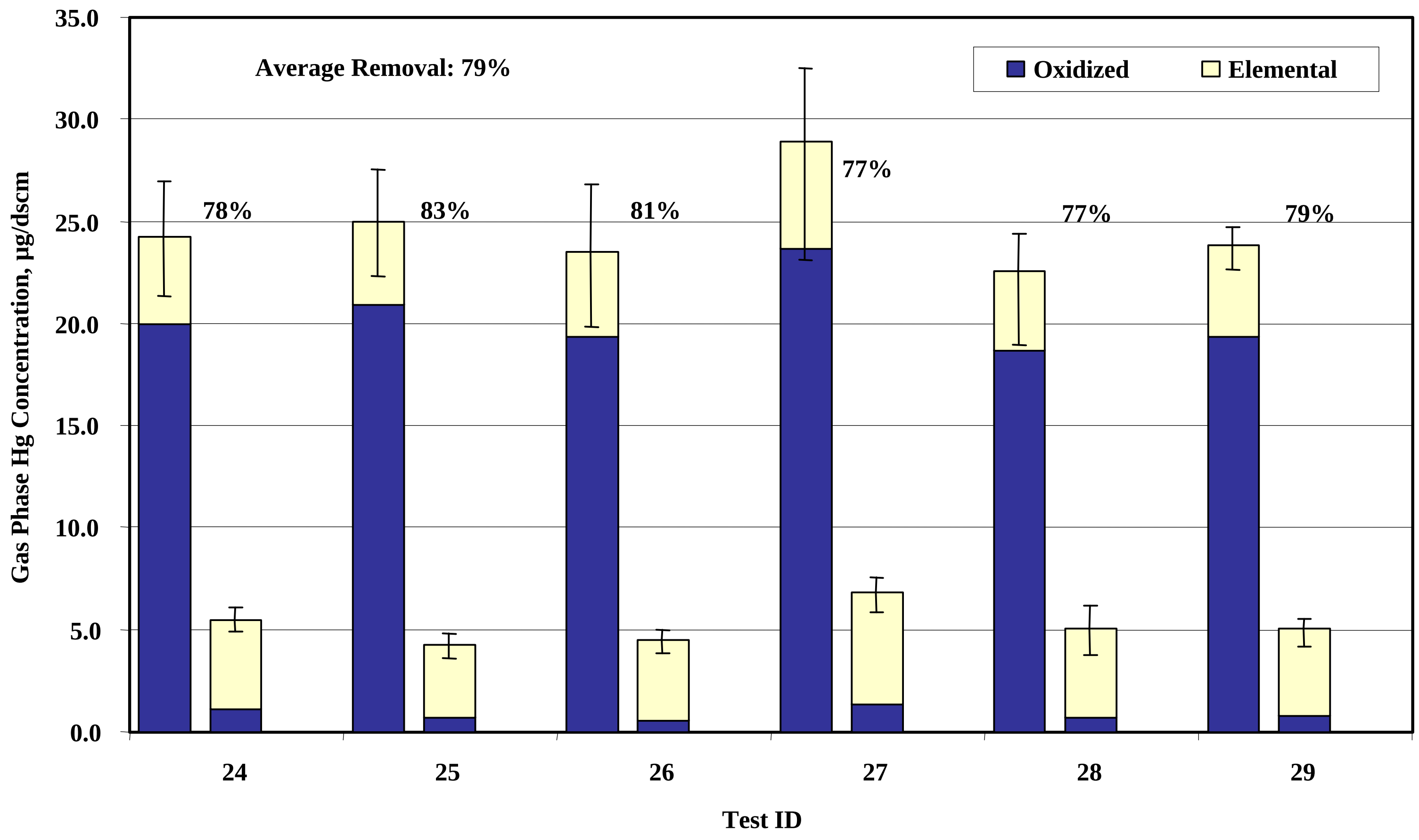
MSCPA Endicott - 55 MW / Limestone / In-situ oxidation

Design L/G ~ 80 gal/kacf, 90 to 93% SO_2 Removal

Endicott – Initial Tests



Endicott – Performance Over 4 Months



Cinergy Zimmer - 1300 MW / Thiosorbic Lime / Ex-situ oxidation

Design L/G ~ 20 gal/kacf, 90 to 92% SO_2 Removal

Zimmer Results

Mercury emissions reduction

- Total across FGD averaged 51%
- Oxidized mercury species averaged 87%
- Hg^0 at FGD outlet greater than inlet in each test

Reagent or approach was not effective at this site

- Different scrubber chemistry
- Different operating conditions

B&W Full-Scale Demonstration Summary

FGD System Gas Phase Hg Removal, %	Endicott	Zimmer
Average	79	51
Range	67 to 84	38 to 69
Average Coal Mercury, lb/10^{12} Btu	14	12
Stack Hg Emissions, lb/10^{12} Btu	1.1 to 5.3	3.6 to 8.4

Fate of Mercury - FGD Byproducts

Mercury found mainly in solid byproducts

- **Filtrate samples – ND (< 0.0005 mg/l)**
- **Byproduct solids**

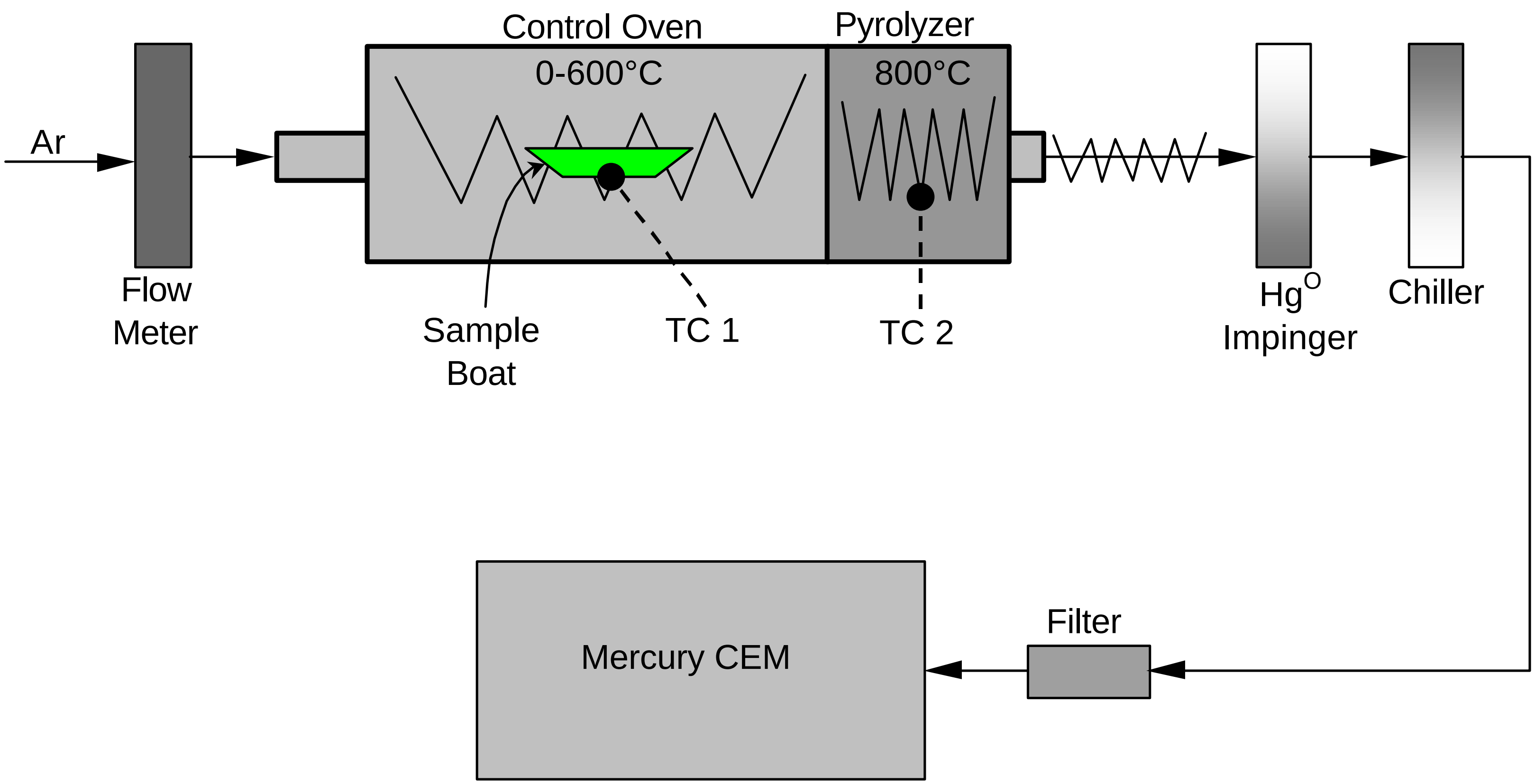
Byproduct solids	Endicott	Zimmer
Fly ash	0.2 – 0.4 ppmd	0.01 – 0.04
Gypsum	0.7 – 1.1 ppmd	0.05 – 0.07

- **Suggests mercury not in soluble form (not $HgCl_2$)**
- **Mercury concentrated in fine solids**

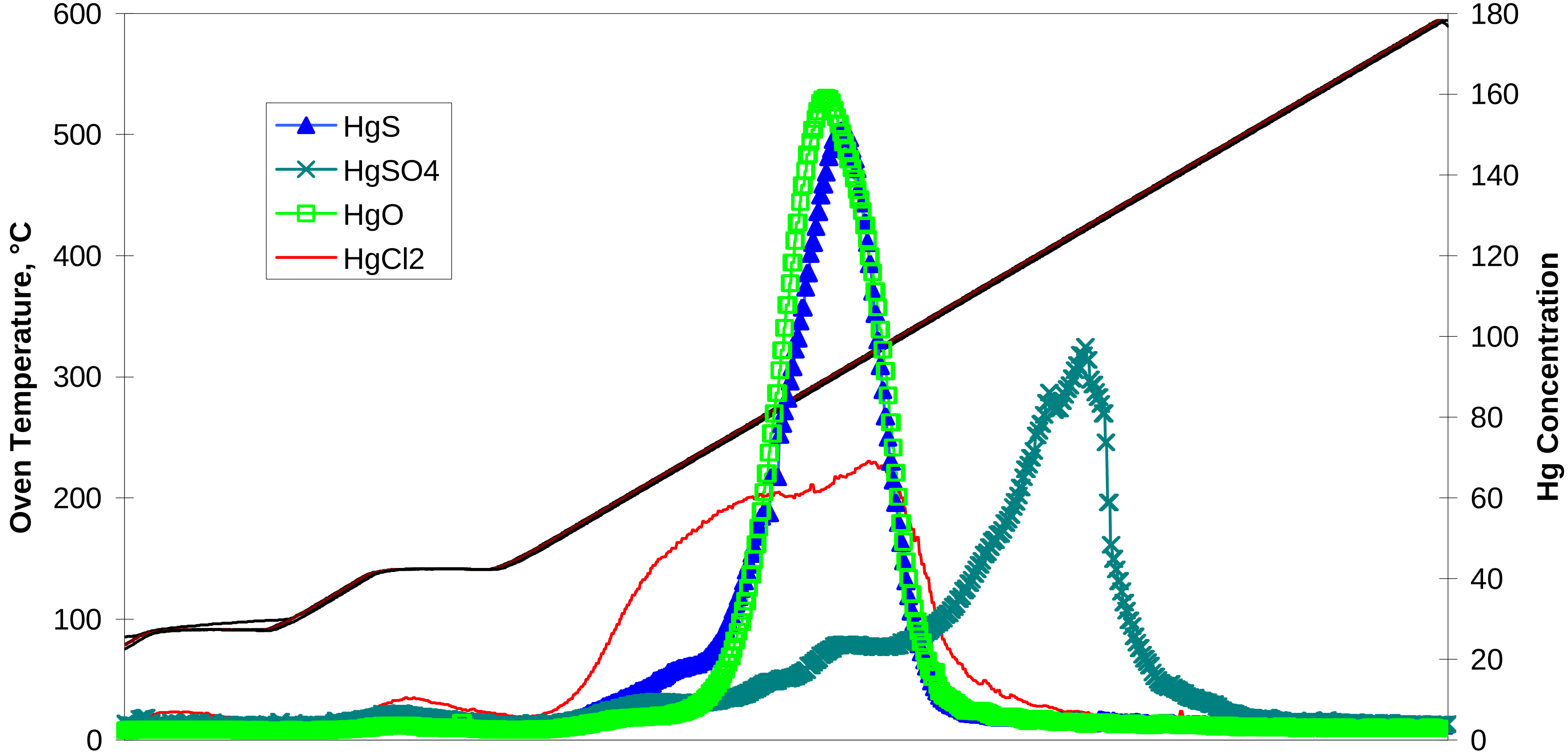
MTI Thermal Dissociation Tests

- **Possible mercury compounds in the byproduct include HgO, HgS and $HgSO_4$**

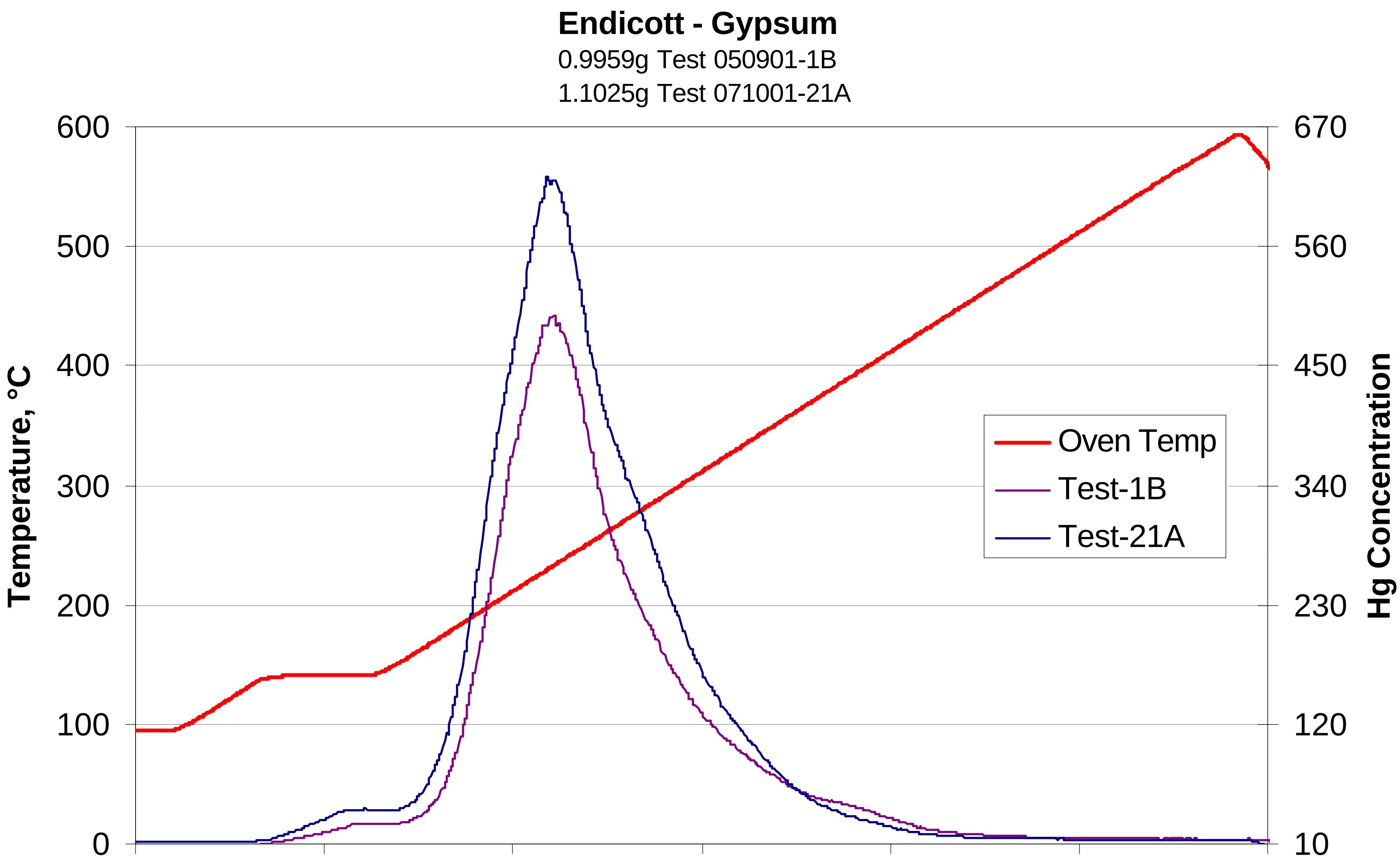
Thermal Dissociation Analysis



Thermal Dissociation Test (TDT) for Hg Standards



TDT for Endicott Gypsum Solids



EPA ICR Data – PC Boiler / Baghouse / WFGD

Bituminous Coal Sites	Clover	Intermountain Power
Tower Design	Open	Open
Reagent	Limestone	Limestone
Slurry Oxidation	Natural	Natural
L / G, gal/kacf	100	45 -70
pH	5.3 – 5.4	5.6 – 5.7
SO_2 Removal, %	96	90
Hg Removal, %	75 (58 – 86)	68 (59 – 76)
Inlet Speciation , % Hg^{++} / Hg^0	49 / 51	84 / 16

EPA ICR Data – PC Boiler / Cold ESP / WFGD

Bituminous Coal Site	Cayuga
Tower Design	Open
Reagent	Limestone / Formic Acid
Slurry Oxidation	Forced
L / G, gal/kacf	138
pH	NA
SO_2 Removal, %	92 - 94
Hg Removal, %	64 (62 – 68)
Inlet Speciation , % Hg^{++} / Hg^0	70 / 30

EPA ICR Data – PC Boiler / Hot ESP / WFGD

Bituminous Coal Site	RD Morrow
Tower Design	Venturi
Reagent	Limestone
Slurry Oxidation	Natural
L / G, gal/kacf	50
pH	5.4
SO_2 Removal, %	61
Hg Removal, %	49 (45 – 53)
Inlet Speciation , % Hg^{++} / Hg^0	69 / 31

EPA View of Wet FGD Mercury Control Potential

Current Level of Control (ICR Data)

	Bituminous	Sub-bituminous
ESP & WFGD	80	0
FF & WFGD	90	75

Near-Term Potential (2007 -2008)

	Bituminous	Sub-bituminous
ESP & WFGD	90	50
FF & WFGD	90	85

Source: Robert J. Wayland, US EPA, Northeast Midwest Institute/ECOS Meeting, July, 2001

OEM View of Wet FGD Mercury Control Potential

FGD mercury control variation reflects:

- Coal / mercury speciation differences
- System design differences (tower configuration, SO_2 removal, L/G)
- System chemistry (forced oxidation / natural / inhibited)

Enhanced FGD is cost effective approach for co-control

- Limited additional hardware
- Low reagent use rate

Mercury control efficiency

- 90% possible for bituminous coal – but it's a stretch currently
- 50 to 70% readily achievable for bituminous coal sites
- Integrated Hg^0 oxidation – catalytic or chemical?
- Must control re-emission of Hg^0

OEM Perspective –
Mercury Control Technology Application

Inherent performance variability

- Variable coal mercury and chlorine content
- Combustion system performance

Technical <u>and</u> commercial guarantee risks

- Risk exposure not yet established in the market – "best efforts" basis
- Mercury emissions measurement technique uncertainty
- Liquidated damages ?
- Performance fixes ?