

Mercury Emissions from Coal-Fired Facilities with SCR-FGD Systems



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**DOE/NETL's Mercury Control Technology Conference
December 12, 2006**

**DOE Cooperative Agreement No. DE - FC26 - 02NT41589
EPRI Contract No. EP - P - 13687/C6820**

Outline

- **Project Description**
- **Project Results**
- **Comparison with Other Programs**



Background

- Typical mercury concentration in coal is 0.08 to 0.20 $\mu\text{g/g}$
- Volatilized during combustion, exits boiler in flue gas
 - Particulate mercury (Hg^{Part})
 - Oxidized mercury (Hg^{++})
 - Elemental mercury (Hg^0)
- Particulate matter control + SO_2 control devices mainly remove particle-bound and oxidized mercury



Current Program

- Evaluate the mercury removal co-benefits achieved by the SCR-FGD combination
- 10 SCR / FGD equipped units:
 - 2 SCR-SDA-baghouse units
 - 5 SCR-ESP-wet limestone FGD units
 - 3 SCR-ESP-wet lime FGD units
- Units fire bituminous coal
- 7 ozone-season and 3 year-round units
- Four units without SCR for comparison



Objectives

- Evaluate the effects of:
 - SCR / air preheater system on Hg speciation
 - SCR / FGD system on Hg capture
- Collect data to provide insights into:
 - The nature of Hg chemistry in flue gas,
 - The effect of SCR / air heater systems on Hg speciation, and
 - The capture of Hg by different FGD technologies.

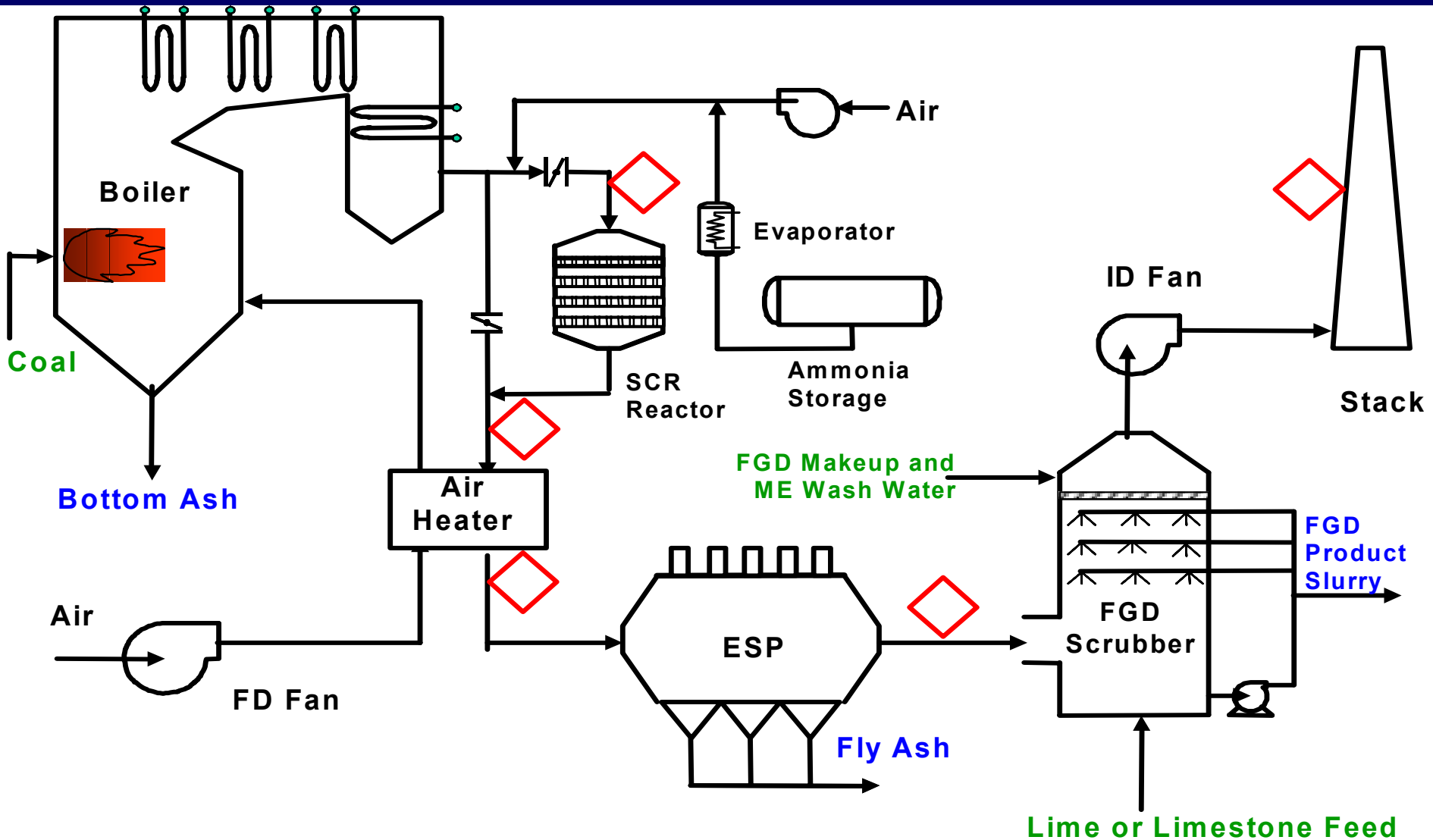


Host Site Information

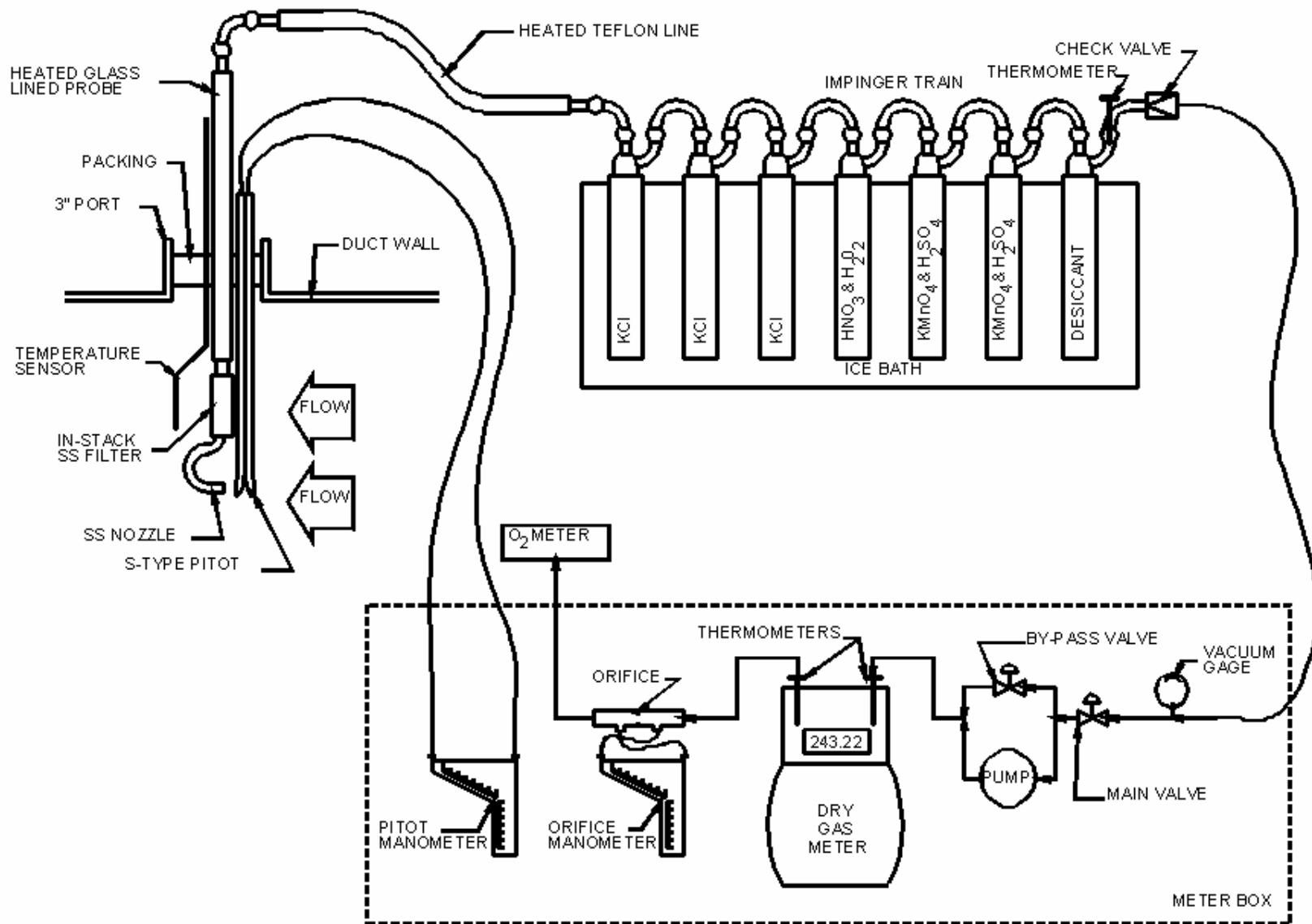
Plant No.	SCR Type	Particulate Control	FGD Type	MW
1	Siemens Plate + Hitachi Plate	Fabric Filter	Lime Spray Dryer	210
2	IHI Corp. Honeycomb	Fabric Filter	Lime Spray Dryer	140
3	KWH Plate	ESP	Limestone, Natural Oxidation	560
4*	Siemens Plate	ESP	Limestone, Natural Oxidation	470
5*	Cormetech Honeycomb	ESP	Limestone, In-Situ Oxidation	1,300
6*	Hitachi Plate	ESP	Limestone, Ex-Situ Oxidation	545
7*	Hitachi Plate	ESP	Limestone, Ex-Situ Oxidation	520
8	Haldor-Topsoe Corrugated Plate	ESP	Mg-Lime, Ex-Situ Oxidation	645
9	Haldor-Topsoe Corrugated Plate	ESP	Mg-Lime, Inhibited Oxidation	660
10	Siemens Plate	ESP	Mg-Lime, Inhibited Oxidation	1,300

* Units tested with and without SCR in operation

Sampling Locations



Ontario-Hydro Hg Sampling Train



Locations Tested

Plant	SCR Inlet (Economizer Outlet)	SCR Outlet (Air Heater Inlet)	Air Heater Outlet (ESP Inlet)	ESP Outlet (FGD Inlet)	Stack (FGD Outlet)
1	X		X		X
2	X		X		X
3	X	X	X	X	X
4	X	X	X		X
5	X	X	X	X	X
6	X	X	X	X	X
7	X	X	X	X	X
8	X		X		X
9	X		X		X
10	X	X	X		X



Coal Properties

Plant	Mercury, ppm as determined	Chlorine, wt. % dry basis	Sulfur, wt. % dry basis
1	0.09 ± 0.02	0.104 ± 0.023	1.0 ± 0.2
2	0.11 ± 0.01	0.100 ± 0.005	1.9 ± 0.0
3	0.11 ± 0.01	0.039 ± 0.014	3.6 ± 0.1
4	0.14 ± 0.03	0.141 ± 0.010	1.5 ± 0.1
5	0.09 ± 0.01	0.136 ± 0.009	3.0 ± 0.2
6	0.11 ± 0.01	0.013 ± 0.005	3.6 ± 0.2
7	0.13 ± 0.01	0.110 ± 0.034	3.7 ± 0.1
8	0.10 ± 0.01	0.046 ± 0.006	4.7 ± 0.2
9	0.11 ± 0.01	0.050 ± 0.001	3.7 ± 0.1
10	0.12 ± 0.01	0.063 ± 0.005	3.7 ± 0.1



Flue Gas Conditions

Plant	Temperature, °F			% Oxygen	
	SCR Inlet	Air Heater Exit	Stack	SCR Inlet	Air Heater Exit
1	628	256	191	5.0	7.0
2	758	349	182	4.0	5.1
3	729	357	136	4.2	6.5
4	679	285	125	3.8	5.2
5	642	315	124	4.7	5.0
6	660	327	137	3.2	3.9
7	696	329	132	3.6	5.1
8	678	333	151	3.1	5.3
9	654	267	125	4.2	5.5
10	639	357	130	4.1	4.3



Distribution of Hg Species (%)

Plant No.	SCR Type	Coal Chlorine, wt % dry	Flue Gas Temperature, °F		% Elemental Mercury	
			SCR Inlet	AH Outlet	SCR Inlet	AH Outlet
1	Siemens Plate + Hitachi Plate	0.104	628	256	54	5
2	IHI Corp. Honeycomb	0.100	758	349	82	3
3	KWH Honeycomb	0.039	731	358	37	9
4	Siemens Plate	0.142	679	285	42	3
5	Cormetech Honeycomb	0.136	642	315	61	2
6	Hitachi Plate	0.013	660	327	14	2
7	Hitachi Plate	0.110	696	329	49	2
8	Haldor-Topsoe Corrugated Plate	0.046	678	333	86	6
9	Haldor-Topsoe Corrugated Plate	0.050	654	267	78	4
10	Siemens Plate	0.063	639	357	54	2



Hg Removal

Plant No.	FGD Type	Mercury Flow Rate, mg/sec			Mercury Emissions, lb/10 ¹² Btu	% Hg Removal, Coal to Stack	Mercury Balances	
		Coal Feed	AH Outlet	Stack			AH Out vs. Coal Feed	Total Mass Balance
1	Lime Spray Dryer	1.8	2.0	0.22	0.84	87	116%	100%
2	Lime Spray Dryer	1.8	1.6	0.09	0.44	95	90%	99%
3	Limestone, Inhibited Ox.	5.1	6.5	1.81	3.05	65	128%	96%
4	Limestone, Natural Ox., Adipic Acid Enhanced	6.0	3.4	0.17	0.31	97	57%	104%
5	Limestone, In-Situ Ox.	10.7	12.2	1.52	0.93	86	114%	105%
6	Limestone, Ex-Situ Ox.	6.5	6.8	0.76	1.11	88	104%	96%
7	Limestone, Ex-Situ Ox.	7.0	7.0	1.15	1.77	84	100%	99%
8	Mg-Lime, Ex-Situ Ox.	5.7	6.0	1.61	1.96 (1.11)	72 (84)	104%	110%
9	Mg-Lime, Inhibited Ox.	6.6	7.4	0.88	1.13	87	111%	99%
10	Mg-Lime, Inhibited Ox.	16.9	14.2	1.81	1.01	89	84%	88%

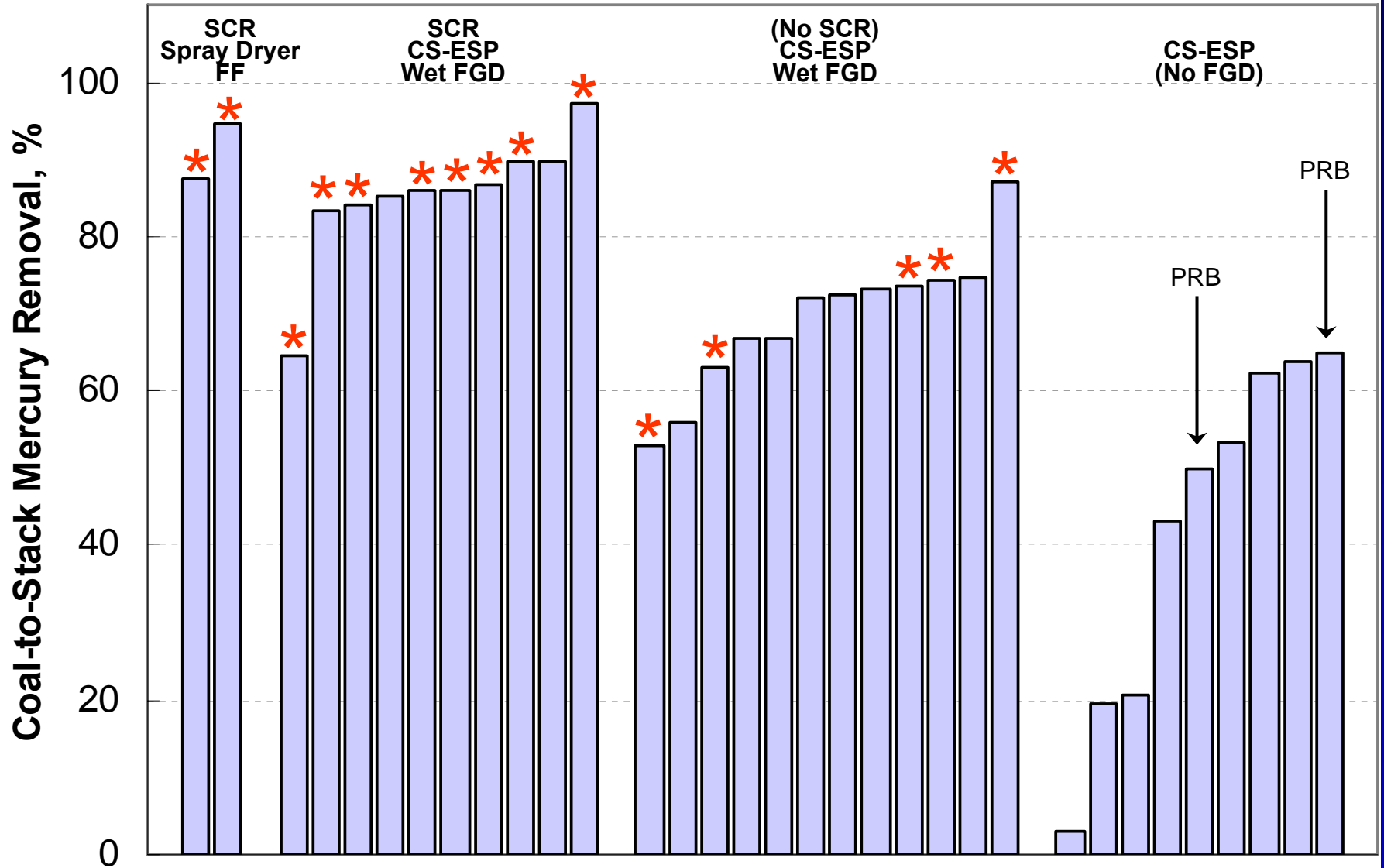


SCR/Non-SCR Comparison

Plant No.	SCR Type	FGD Type	% Elemental Mercury		% Hg Removal, Coal to Stack
			Econ. Outlet (SCR Inlet)	AH Outlet (ESP Inlet)	
4, Unit 1	(none)	Limestone, Natural Ox.	39	9	87
4, Unit 2	Siemens Plate		42	3	97
5, Unit 2	(none)	Limestone, In-Situ Ox.	(NM)	34	51
5, Unit 1	Cormetech Honeycomb		61	2	86
6, Unit 1	(bypassed)	Limestone, Ex-Situ Ox.	(NM)	7	75
6, Unit 1	Hitachi Plate		14	2	88
7, Unit 4	(bypassed)	Limestone, Ex-Situ Ox.	(NM)	12	70
7, Unit 4	Hitachi Plate		49	2	84
10, Unit 1	(none)	Mg-Lime, Inhibited Ox.	(NM)	28	61
10, Unit 2	Siemens Plate		54	2	89



Hg Removal - Comparison with Other Tests

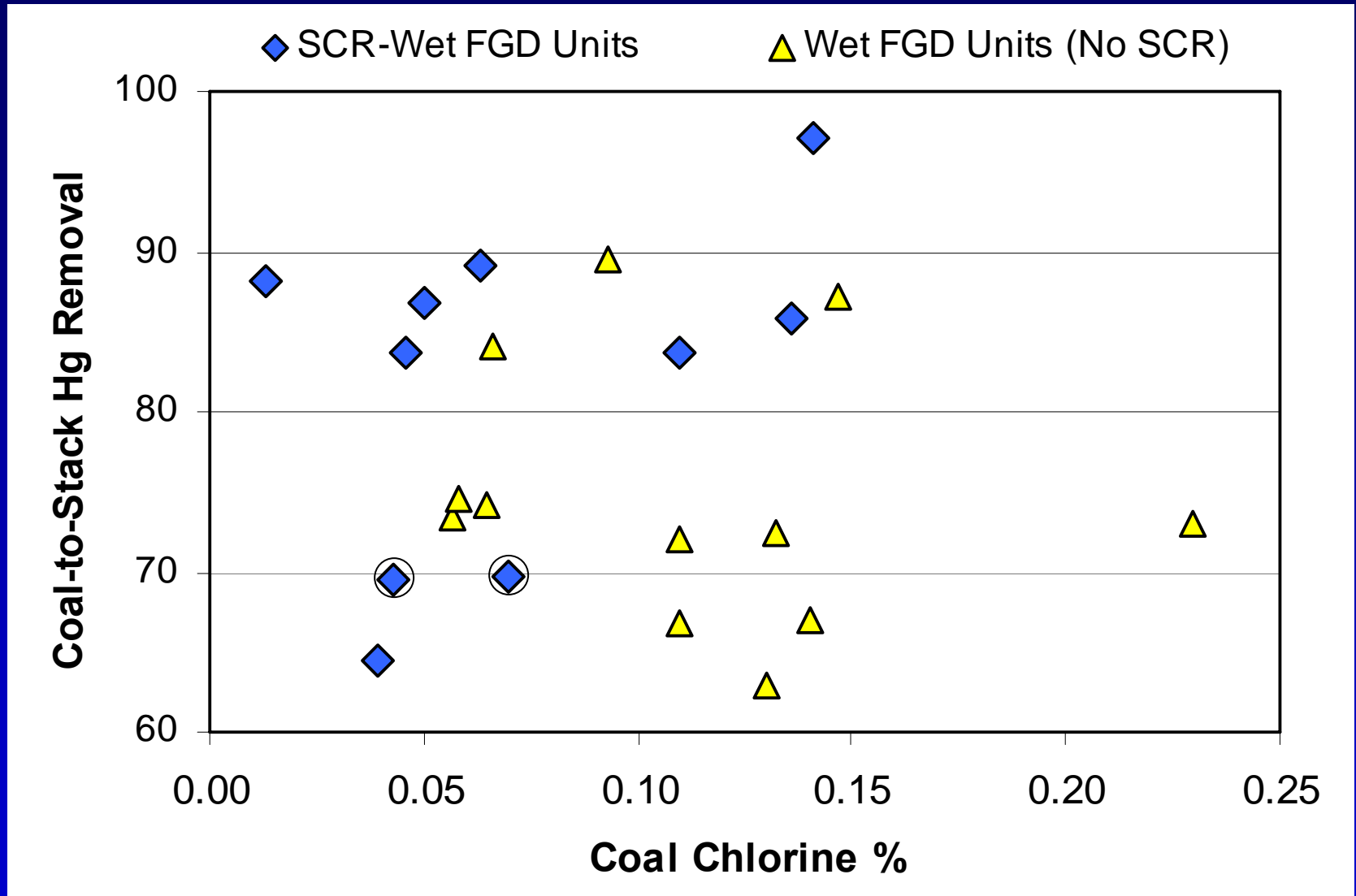


Hg Removal

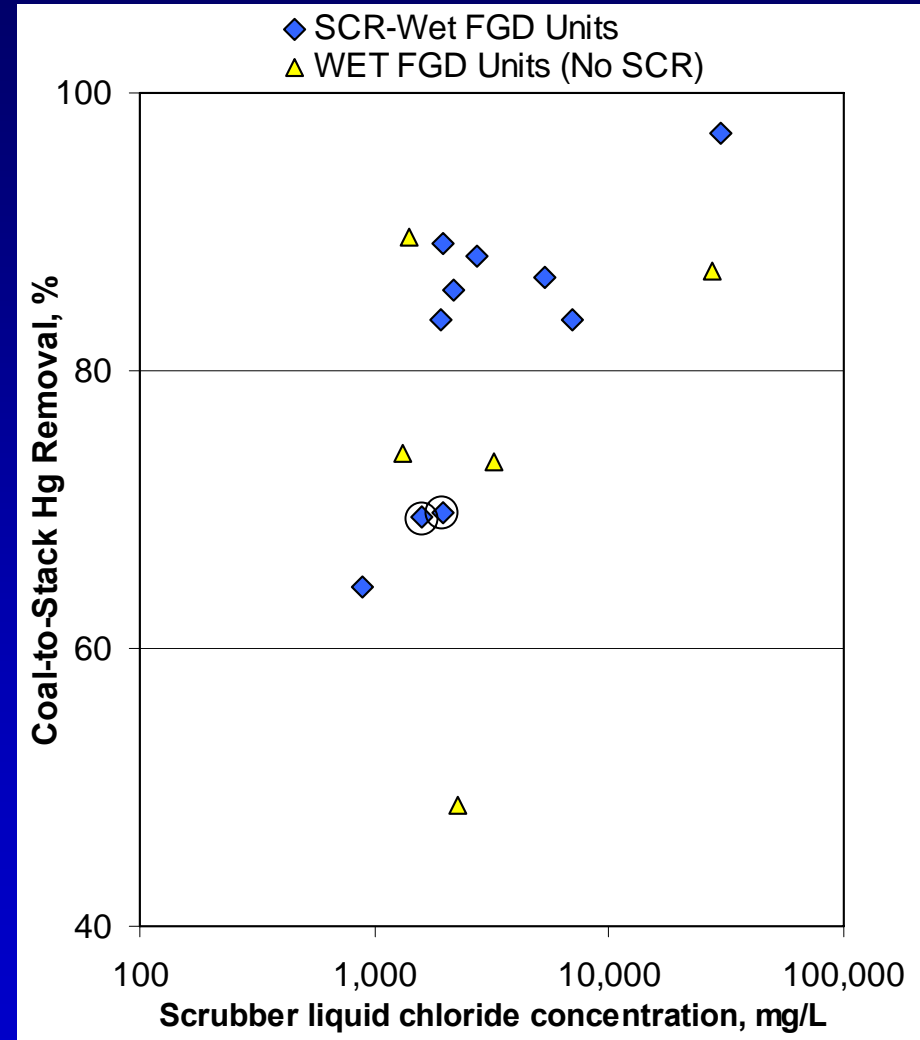
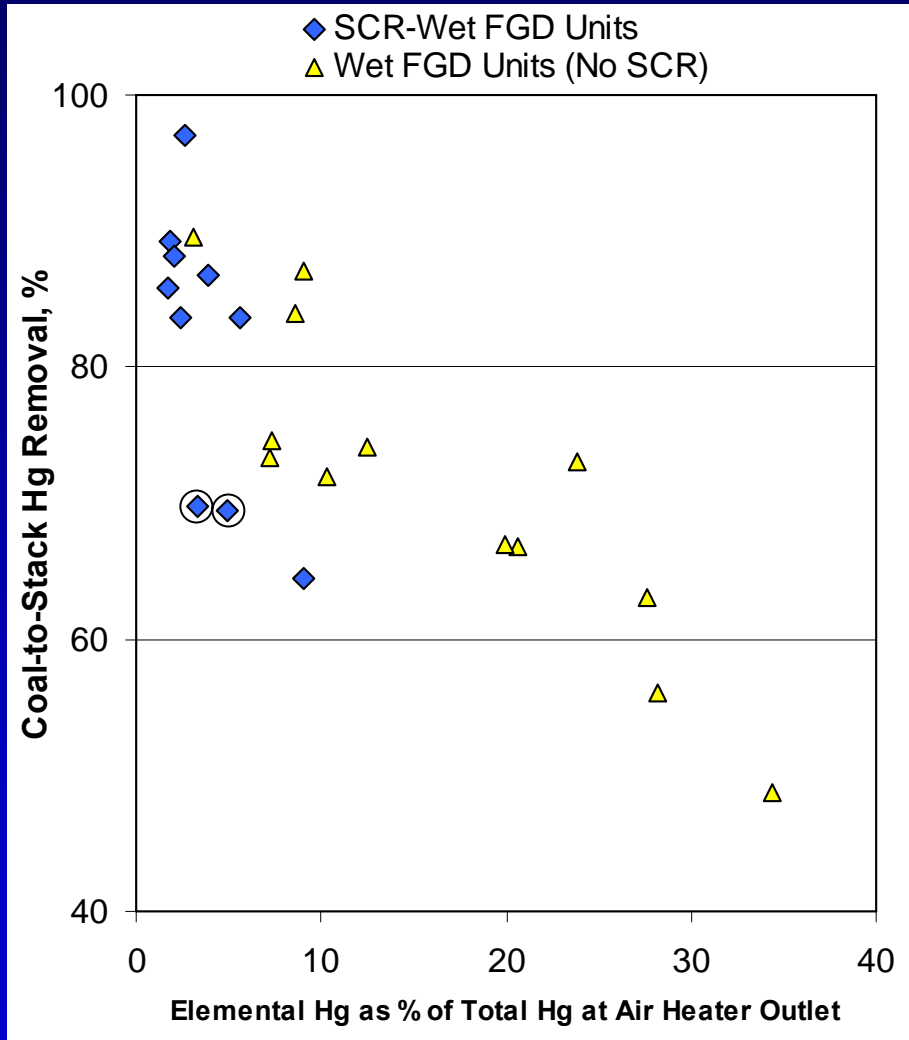
	% Hg Removal Across ESP or FF	% Hg Removal Coal-to-Stack	Mercury Mass Balance, Out/In, %
Units with SCR/Spray Dryer/FF (2 Units)	N.A.	91.0 ± 5.2	99.5 ± 0.7
Units with SCR/CS-ESP/Wet FGD (10 Units)	11.1 ± 15.5	85.2 ± 8.3	97.9 ± 10.4
Units with CS-ESP/Wet FGD (no SCR) (12 Units)	12.4 ± 9.6	69.4 ± 9.1	97.3 ± 8.9
Units with CS-ESP (no FGD) (9 Units)	43.6 ± 26.2	42.3 ± 22.5	100.3 ± 11.2



Hg Removal in Wet Scrubbers



Hg Removal in Wet Scrubbers



Conclusions

- **The SCR/air heater combination effectively oxidized Hg**
- **On a coal-feed basis, Hg removals were:**
 - **91% average for 2 lime spray dryer units**
 - **85% average for 10 wet scrubber units with SCR**
 - **69% average for 12 wet scrubbed units without SCR**
- **Mercury speciation did not correlate with coal chlorine content**
- **Scrubber chloride content might affect mercury removal**



Acknowledgement

- Funding for this project
 - U.S. Department of Energy National Energy Technology Laboratory via DOE Cooperative Agreement No. DE-FC26-02NT41589.
 - Lynn Brickett – COR
 - Electric Power Research Institute via Contract No. EP-P-13687/C6820.
 - Paul Chu – Project Manager
 - CONSOL Energy Inc.
- Participation and the assistance of the host sites

