



Fireside Corrosion Environments in Coal-Fired Utility Boilers

DE-FC26-07NT43097

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Project Objectives

- Determine the effects of coal impurities on fireside corrosion in advanced coal-fired utility boilers with staged combustion
- Generate a fireside corrosion database from long-term laboratory tests simulating advanced coal-fired boiler environments
- Develop corrosion models with predictive equations for corrosion rates on lower furnace walls and superheaters

Project Tasks

Task 1 – Coal Selection, Procurement, and Handling

- 2009 milestone complete

➤ **Task 2 – Pilot Scale Combustion Testing**

- 2009 milestone complete

➤ **Task 3 – In-Furnace Gas and Deposit Sampling**

- 2009 milestone complete

Task 4 – Laboratory Corrosion Testing

- No 2009 milestone; task in progress

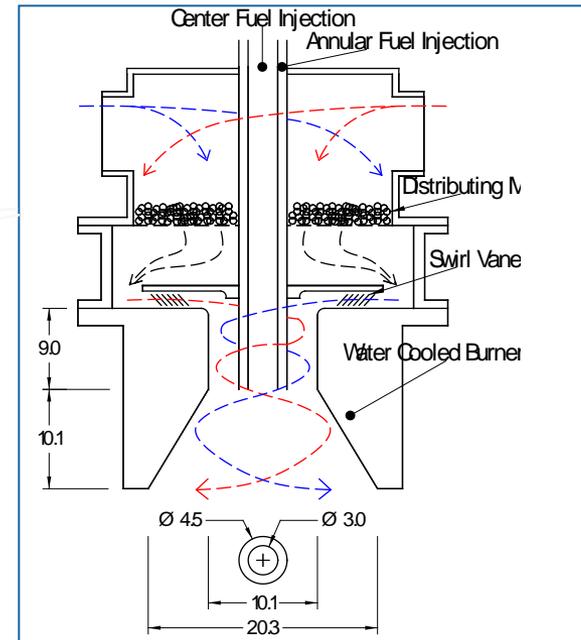
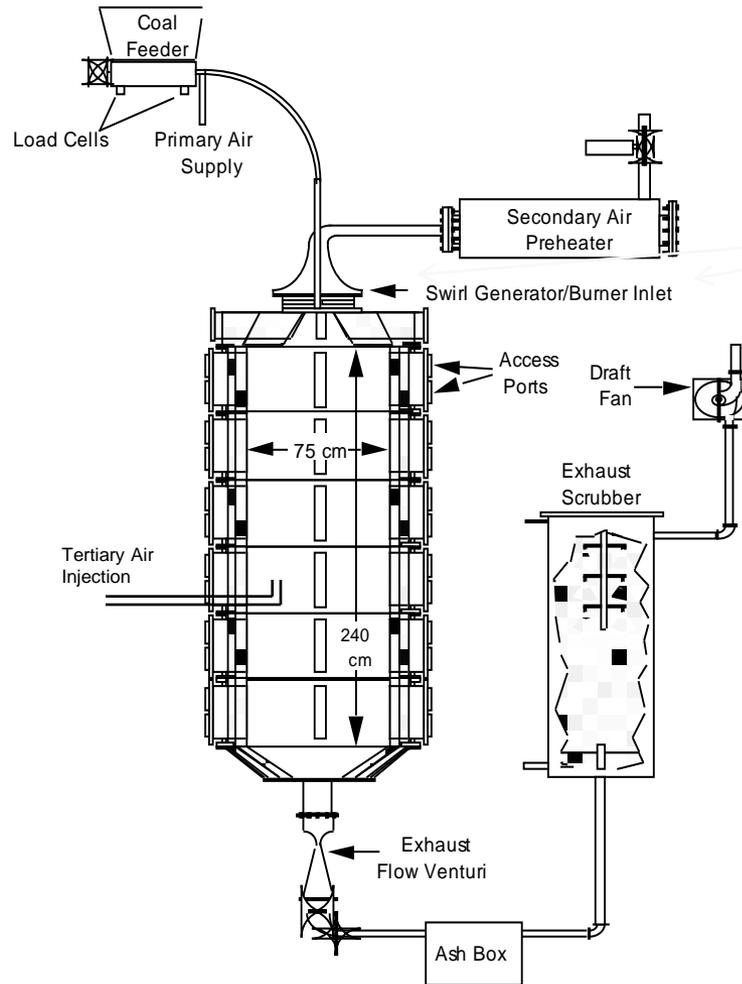
Task 5 – Corrosion Model Development

- No 2009 milestone

Task 6 – Management and Reporting

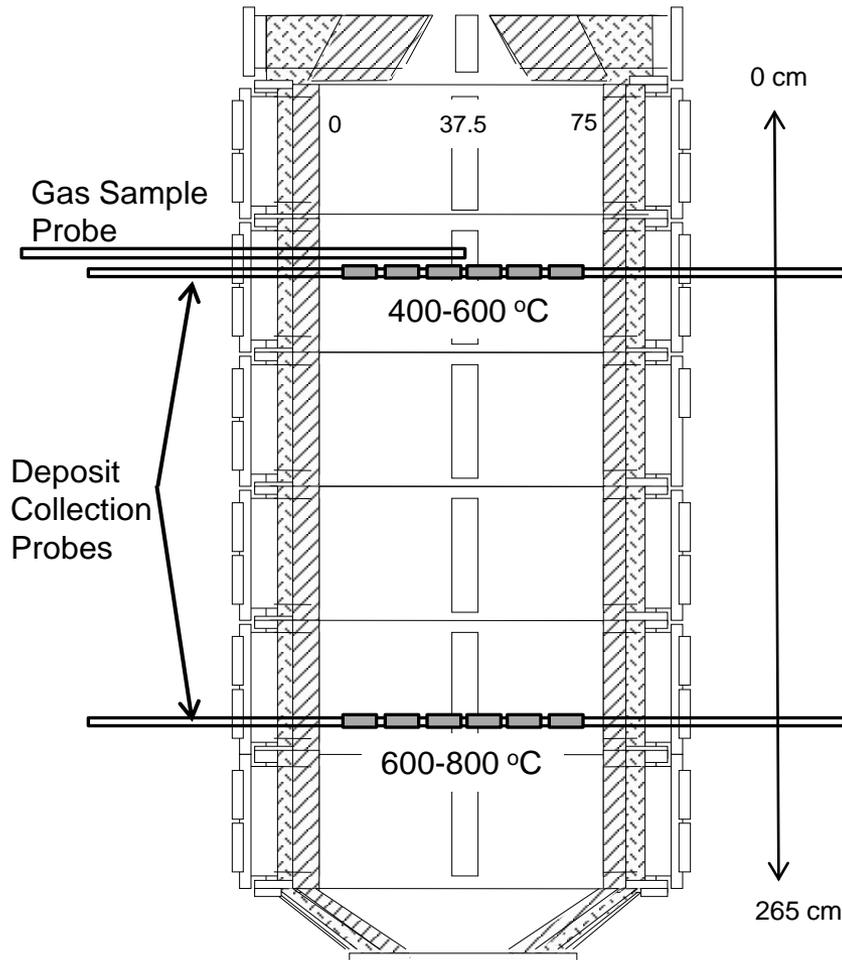
- No 2009 milestone

Pilot-Scale Combustion Facility with Variable Swirl Burner



- Pulverized coal
- Downfired
- Variable swirl stabilized flame
- Staged air injection

Gas and Deposit Sampling



Gas Sampling

- Water cooled outer jacket is
- Heated Inner tube (180°C)
- Heated line (180°C) from furnace to analyzers

Deposit Sampling

- Water cooled in burner zone
- Air cooled in oxidizing zone
- Half-sleeves clamped onto probes

Coal Feed System Delivering PC to Burner



Bulk Bag

Massage Paddles

Agitator Hopper

Slide Gate

Feeder Hopper

Twin Screw Feeder

Scale



Feeder Motor

Twin Screw Auger

Scale

Eductor

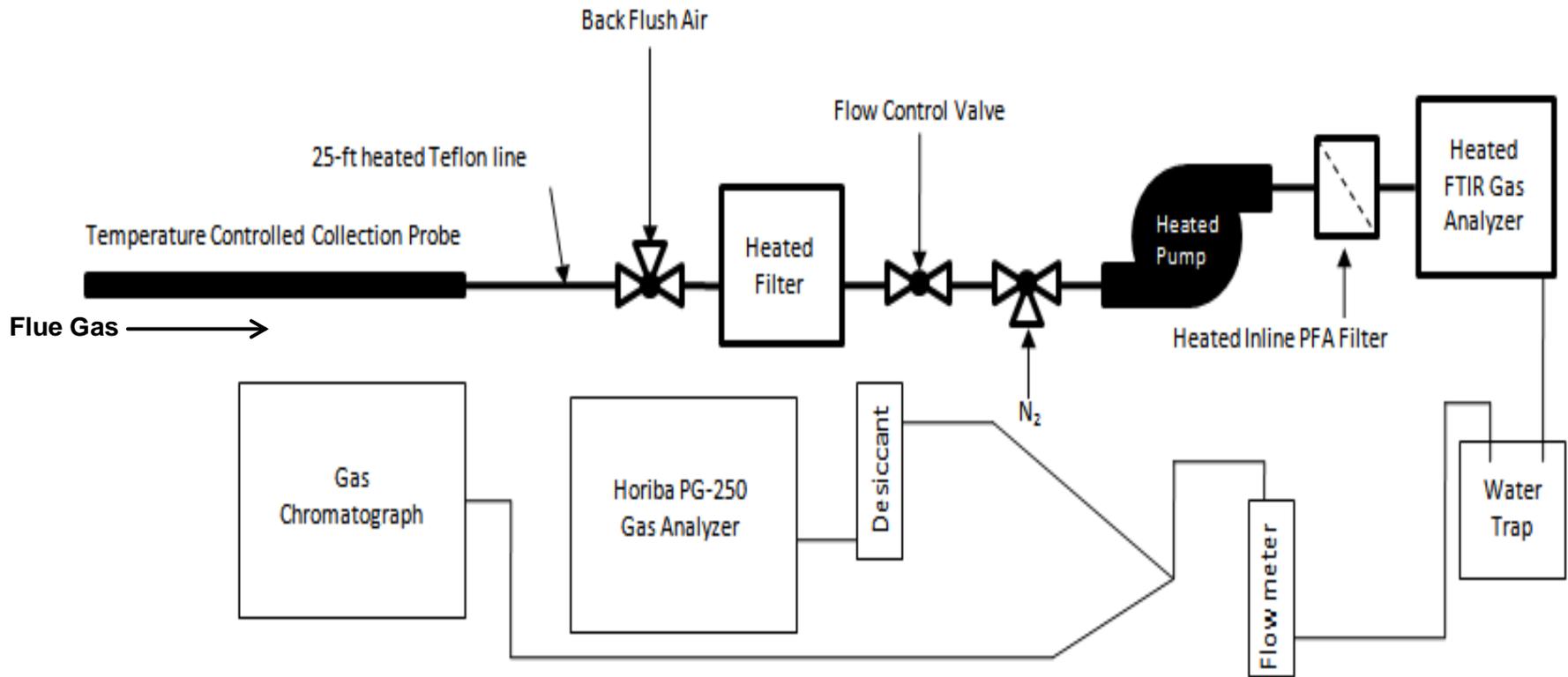
Approximate Mine Locations of Five Coals Tested



Chemistry of Five U.S. Coals Tested

Proximate	PRB	Beulah Zap	Indiana #6	Ill. #6 Galatia	Gatling
Moisture	24.59	27.33	7.25	3.68	3.77
Ash	5.14	8.66	7.20	10.45	11.34
Vol.	37.00	33.77	30.87	33.70	40.73
Carbon	33.27	30.24	54.68	52.17	44.16
Total	100.00	100.00	100.00	100.00	100.00
Ultimate					
Moisture	24.59	27.33	7.25	3.68	3.77
H	2.55	2.03	4.02	3.14	4.07
C	54.75	46.56	69.48	67.66	67.11
N	0.83	0.86	1.36	0.95	0.94
S	0.25	0.67	1.14	2.96	4.31
O	11.89	13.89	9.55	11.16	8.46
Ash	5.14	8.66	7.20	10.45	11.34
Cl (%dry)	0.0012	0.0010	0.2121	0.2830	0.0387
HHV (Btu/lb)	9,156	7,792	12,400	12,464	12,191

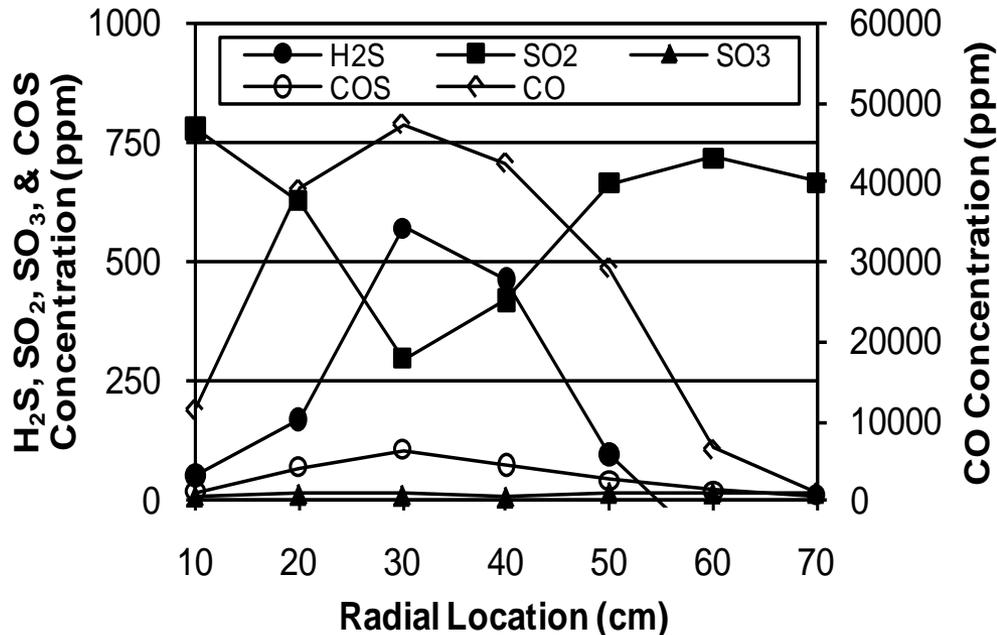
Online Sampling Train for In-Furnace Gas Measurement



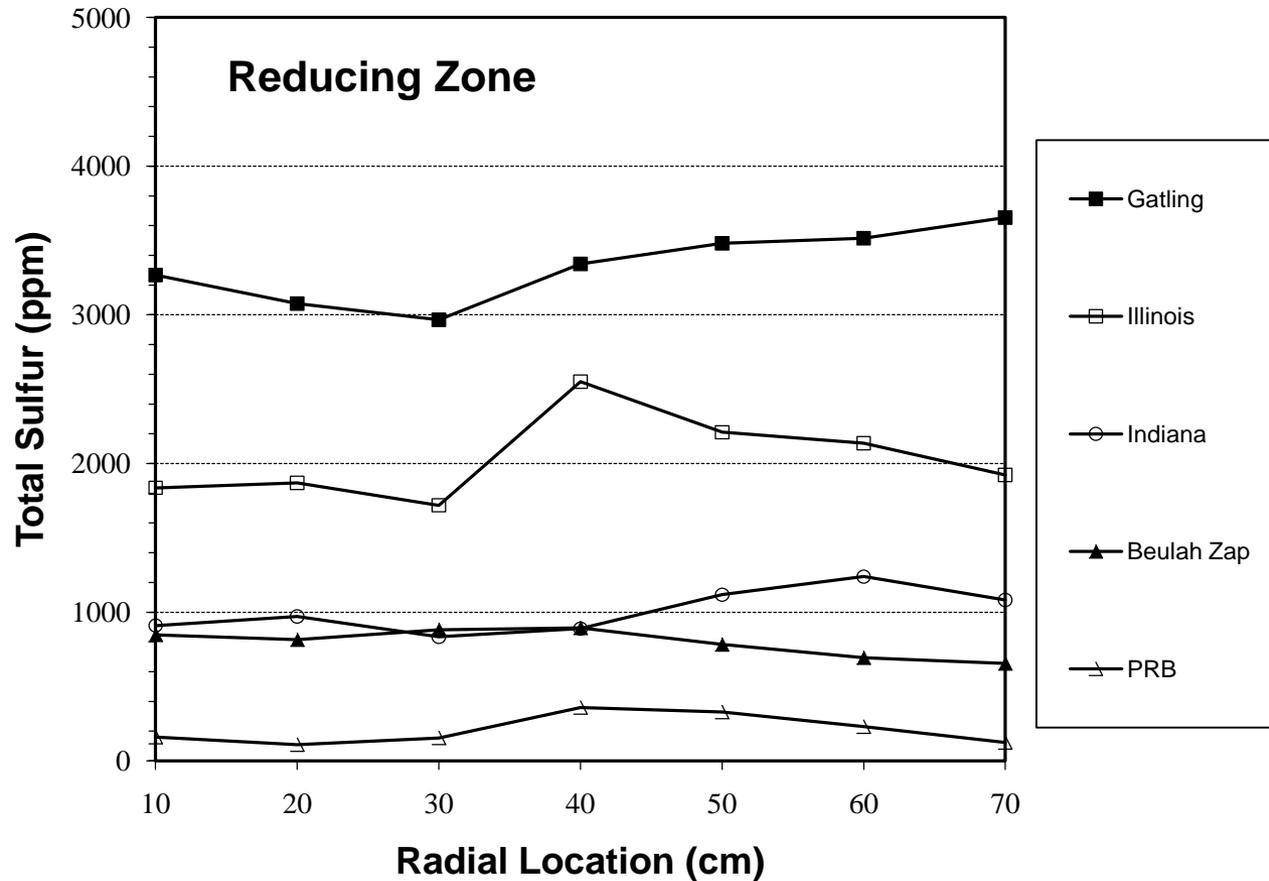
Concentrations of CO and Sulfur-Bearing Species

Beulah Zap Lignite, Burner Zone

Rad. (cm)	CO (ppm)	H ₂ S (ppm)	SO ₂ (ppm)	SO ₃ (ppm)	COS (ppm)	O ₂ (%)
10	11617	54	781	12	20	2.89
20	39181	170	629	15	71	0.90
30	47406	571	298	13	108	0.96
40	42536	465	419	10	75	0.86
50	29380	98	666	19	45	1.26
60	6640	-107	719	18	21	3.01
70	1030	-91	668	19	11	3.36



Concentrations of All Sulfur-Bearing Species (H₂S, SO₂, SO₃, and COS) - Beulah Zap Lignite

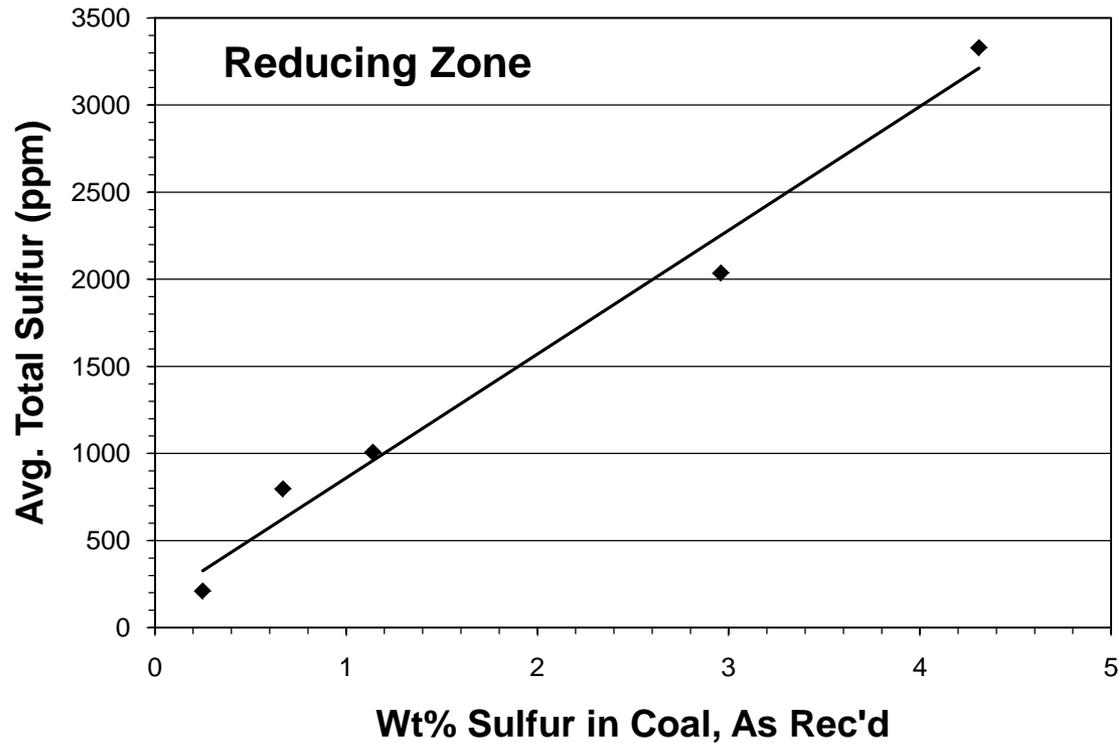


Coal Sulfur vs. Measured Gaseous Sulfur

Burner Zone

Coal	Total Sulfur in Coal As Received (wt.%)	Avg. Total Sulfur Measured (ppm)
PRB	0.25	200
Beulah Zap	0.67	765
Indiana #6	1.14	862
Illinois #6	2.96	1743
Gatling	4.31	2851

Coal Sulfur vs. Measured Gaseous Sulfur Burner Zone



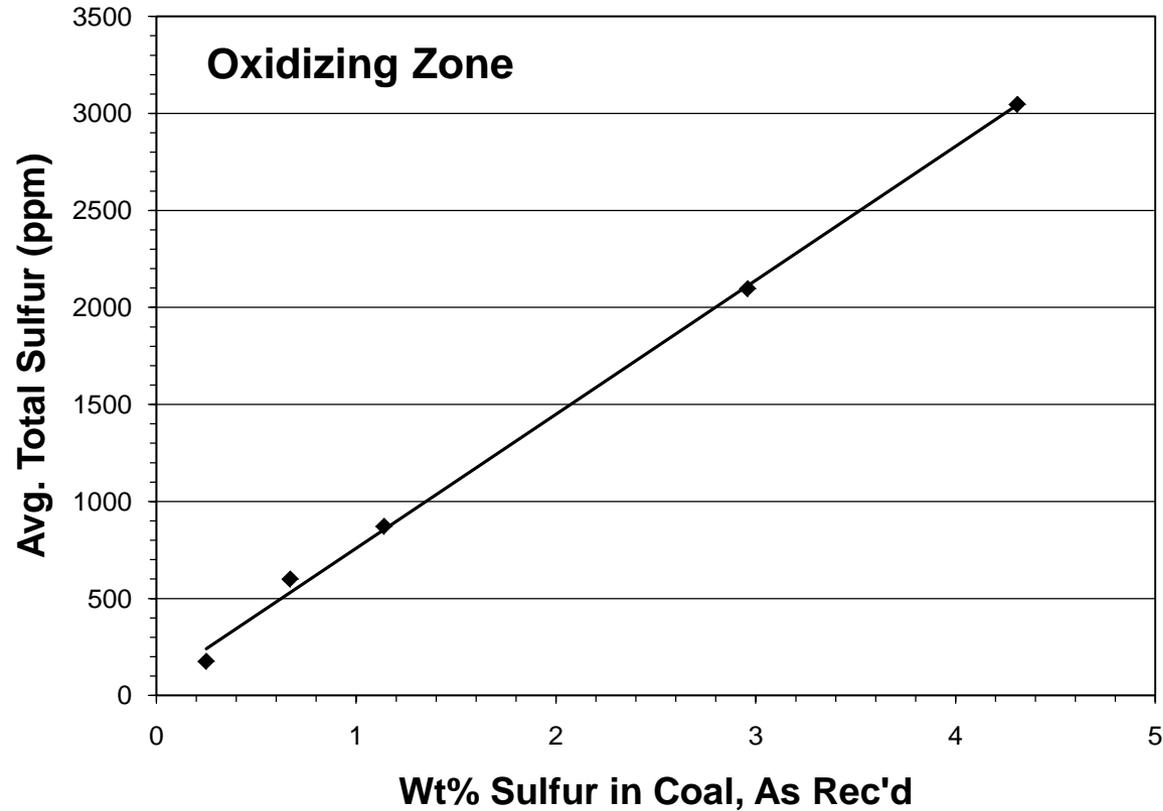
Measured vs. Predicted Gaseous Sulfur

Burner Zone, 1400K

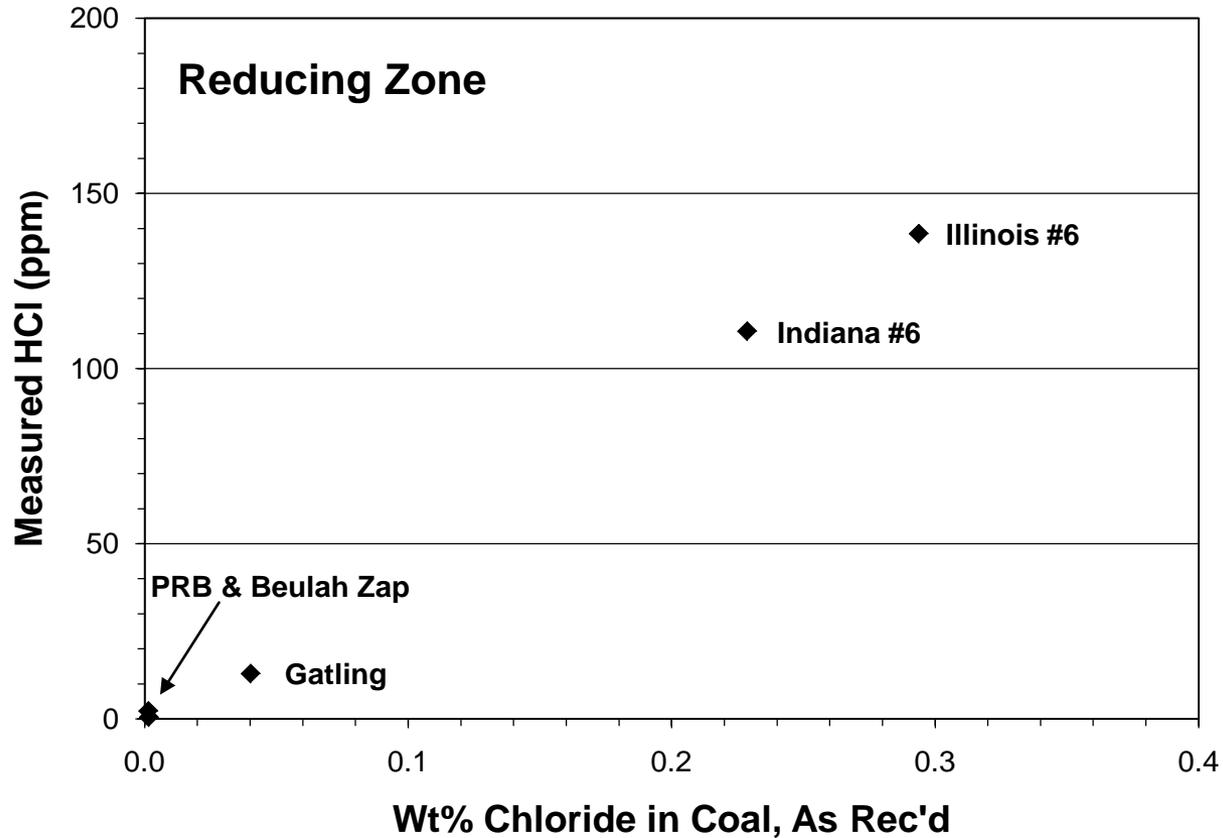
Coal	Total Sulfur Species (Measured ppm)	Total Sulfur Species (Equilibrium ppm)
PRB	200	325
Illinois #6	2047	2300
Gatling	2851	3400

- Thermodynamic calculations overestimate total sulfur in gas phase!

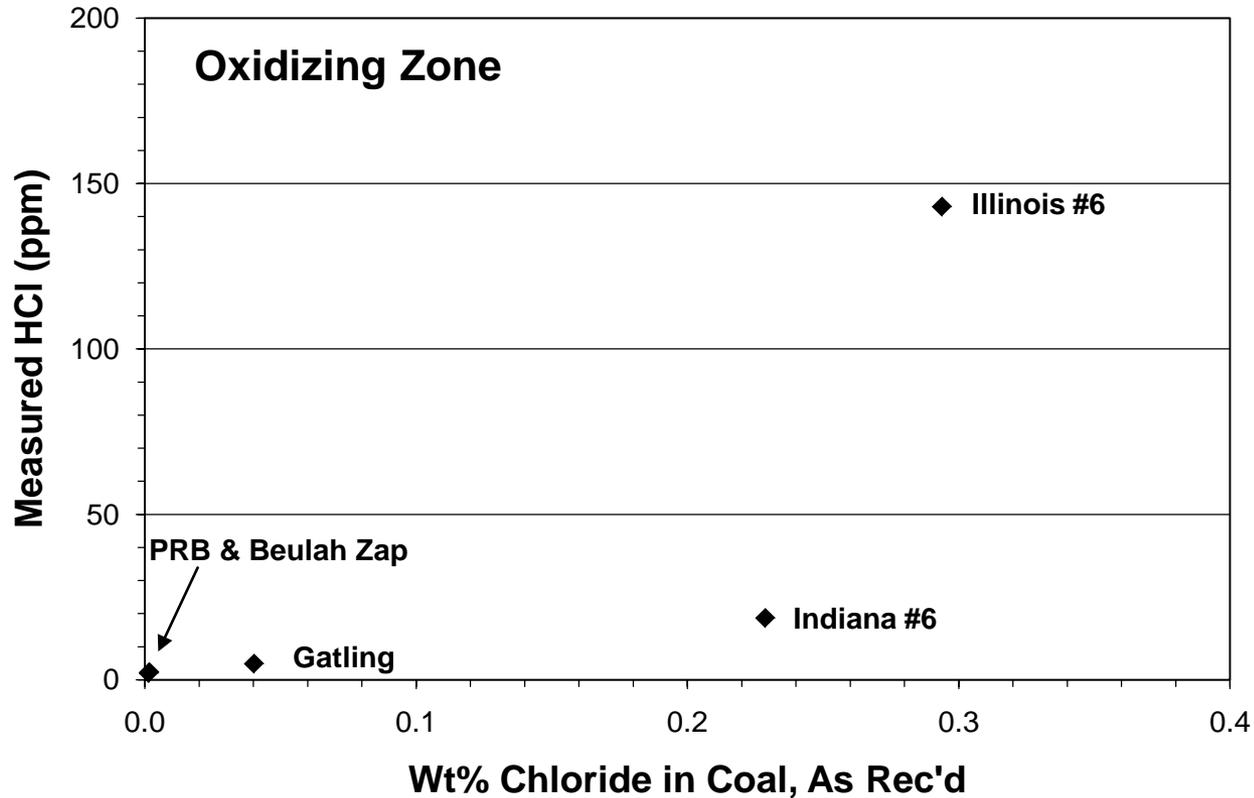
Coal Sulfur vs. Measured Gaseous Sulfur Oxidizing Zone



Coal Chlorine vs. Measured Gaseous Chlorine Burner Zone



Coal Chlorine vs. Measured Gaseous Chlorine Oxidizing Zone



Summary

- Online gas measurements have been performed on five U.S. coals to date
- Uniform distribution of fuel was achieved
- Coexistence of reducing and oxidizing gaseous species was revealed → non-equilibrium nature of combustion gases
- Amount of total sulfur-containing gaseous species was proportional to sulfur in coal for both reducing and oxidizing zones → independent of original sulfur forms
- A critical chlorine concentration in coal appeared to exist, beyond which the HCl concentration would increase significantly → to be further investigated

Acknowledgement

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