REINHOLD ENVIRONMENTAL Ltd.

2012 APC Round Table
& Expo Presentation

July 16-17, 2012, in Baltimore, MD / Hosted by Duke Energy, Entergy, FirstEnergy, Southern Company & TVA

The Effects of Hydrated Lime Properties on Acid Gas Removal with DSI

Sorbacal®

Lhoist

Megasymposium
August 2012

Jim Dickerman – Lhoist North America

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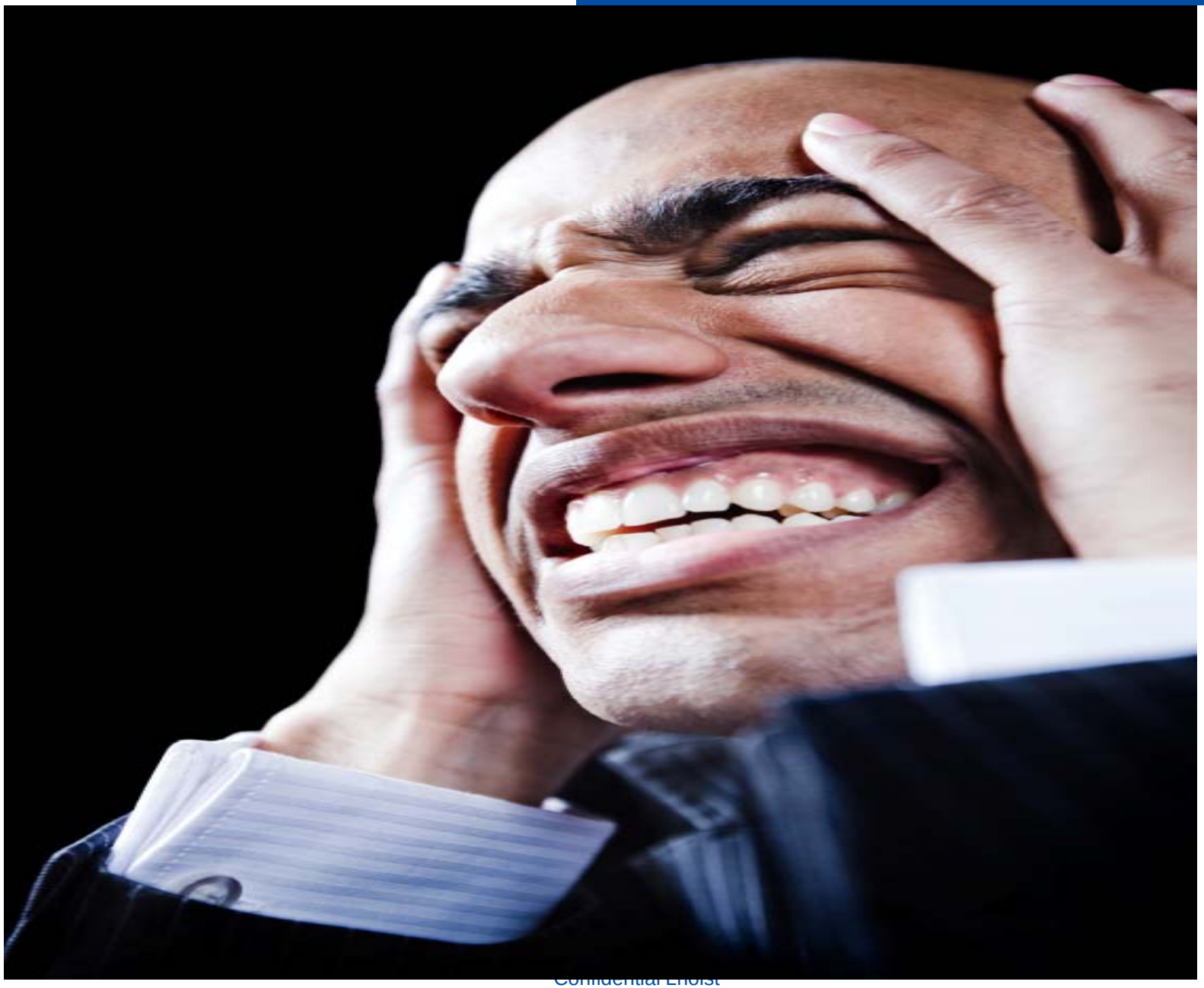


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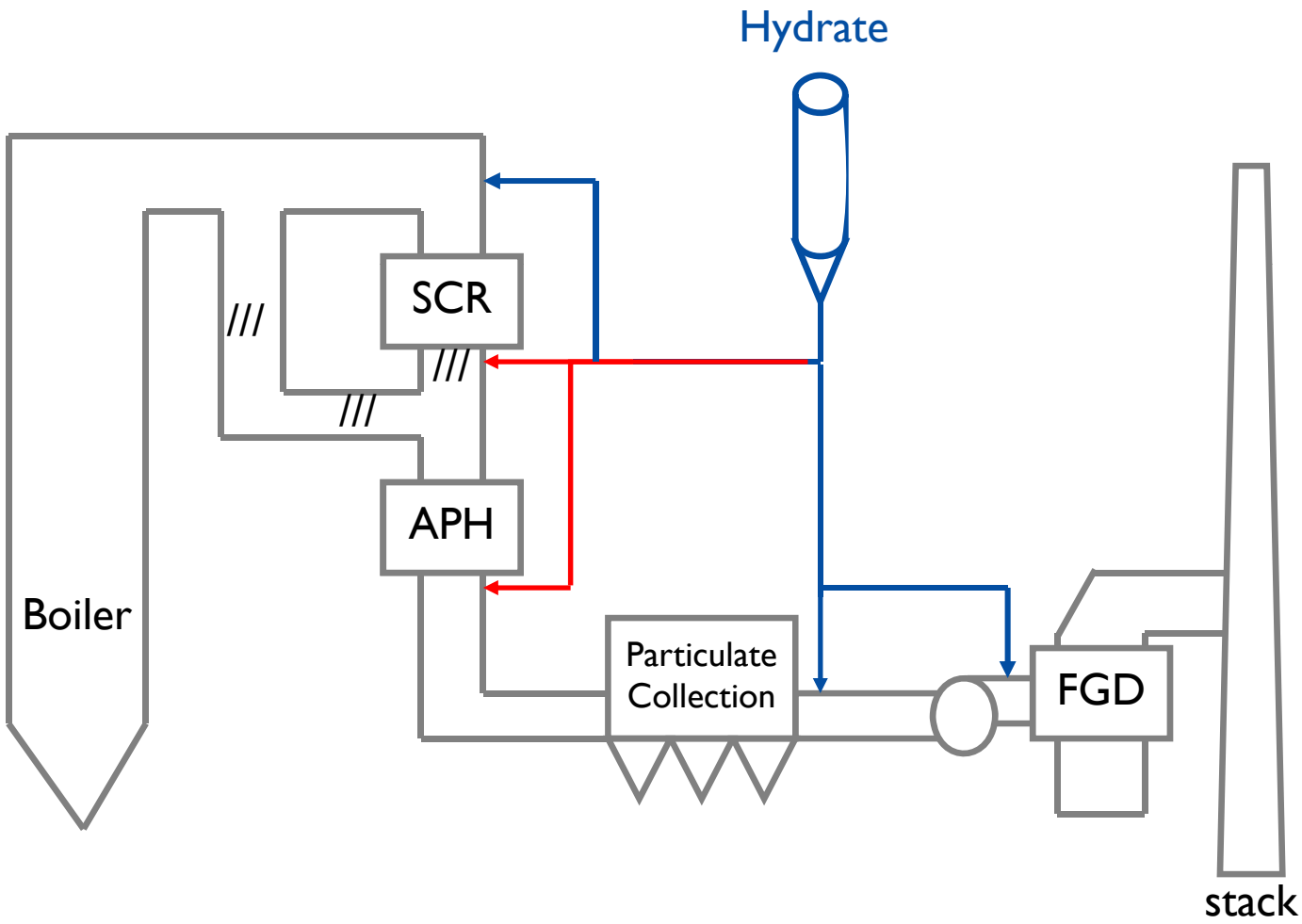
DSI – What Is It?



DSI – Background

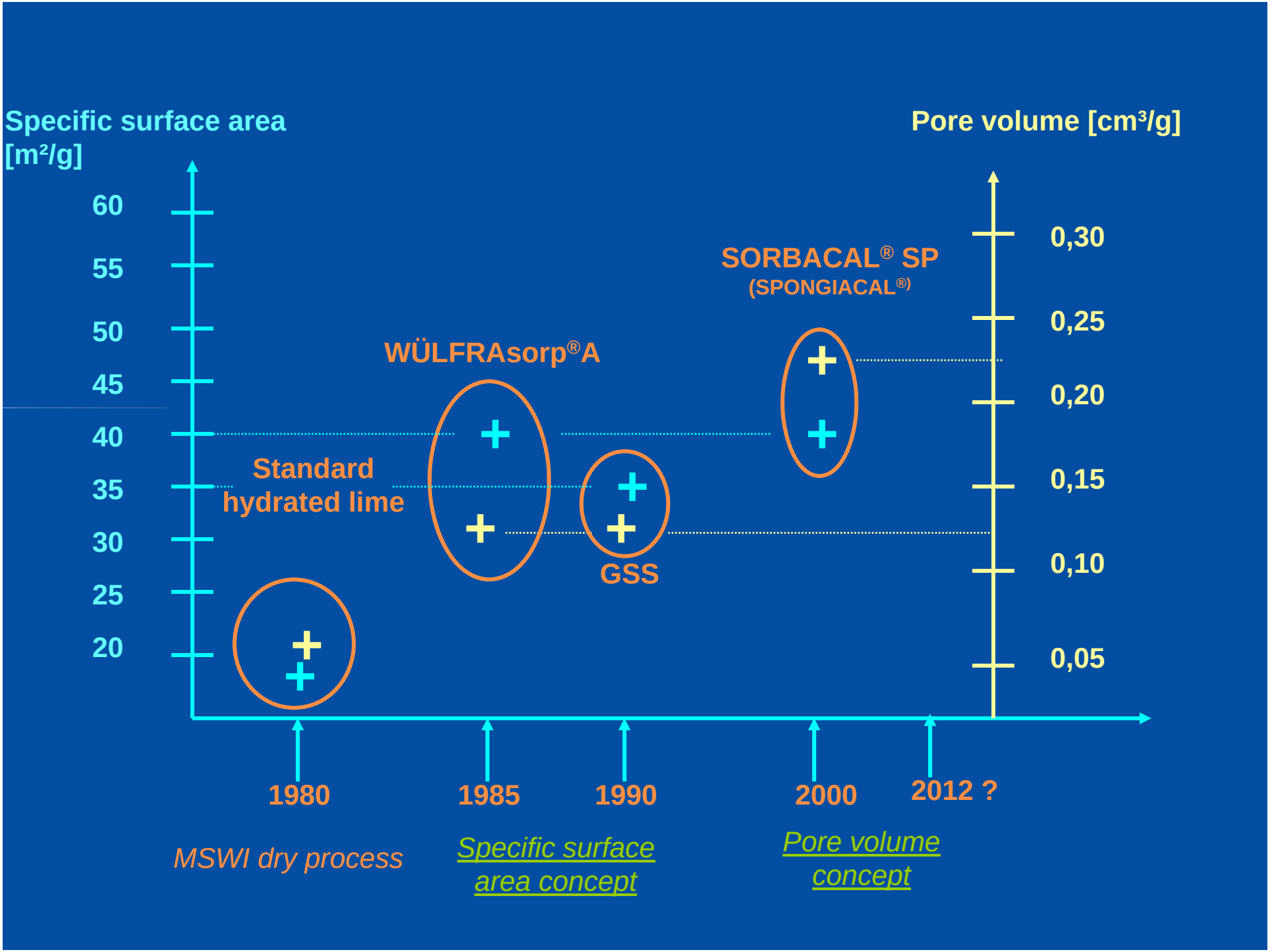
- Late 60's – TVA experimented with limestone boiler injection
- 1984 – 1991 LIMB Project sponsored by EPA & DOE
  - ✓ Technology basically abandoned due to no commercial interest
- 2004 – The need for SO_3 control revived interest in duct injection
  - ✓ Early technology concerns/issues
    - Fouling of utility ducts/downstream equipment
    - Injection equipment issues
  - ✓ Technology concerns have basically been resolved and DSI is widely used commercially for SO_3 mitigation
- MATS has resulted in need for HCl control data
- CSAPR has renewed interest in SO_2 control
- European and Asian MSW experience has shown high removal levels for both HCl and SO_2
- US coal-fired data is needed

Presentation Objectives

- Present a summary of coal-fired boiler test data to show the performance of DSI using hydrated lime as an effective emission control option
  - ✓ HCl
  - ✓ Trace metals
- Show how coal properties, sorbent composition, and particulate collection devices impact DSI performance

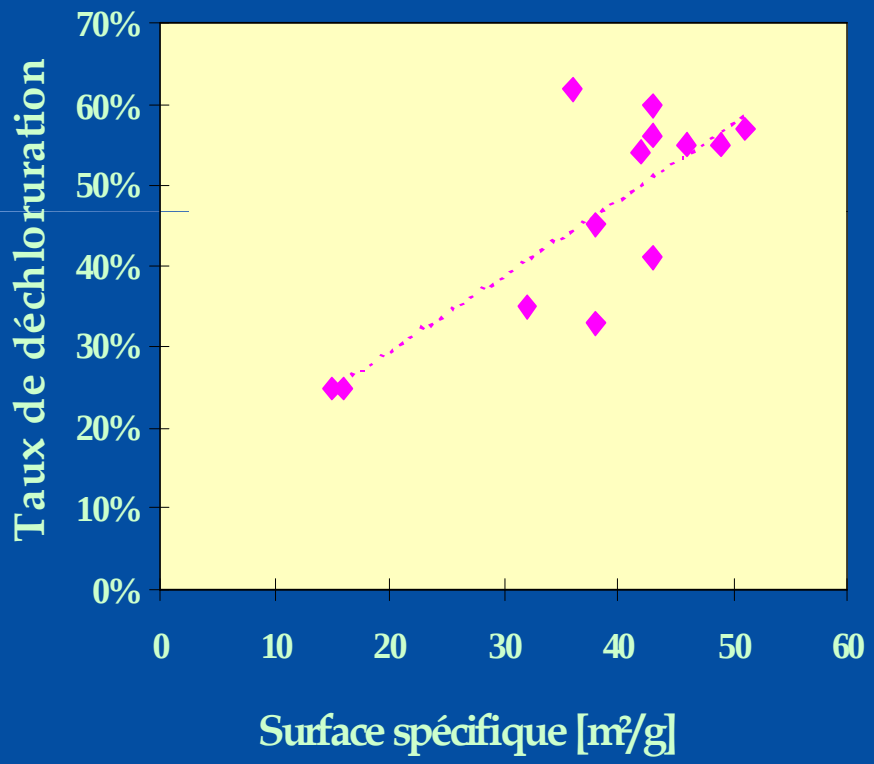
Hydrated Lime Characteristics

What's Important

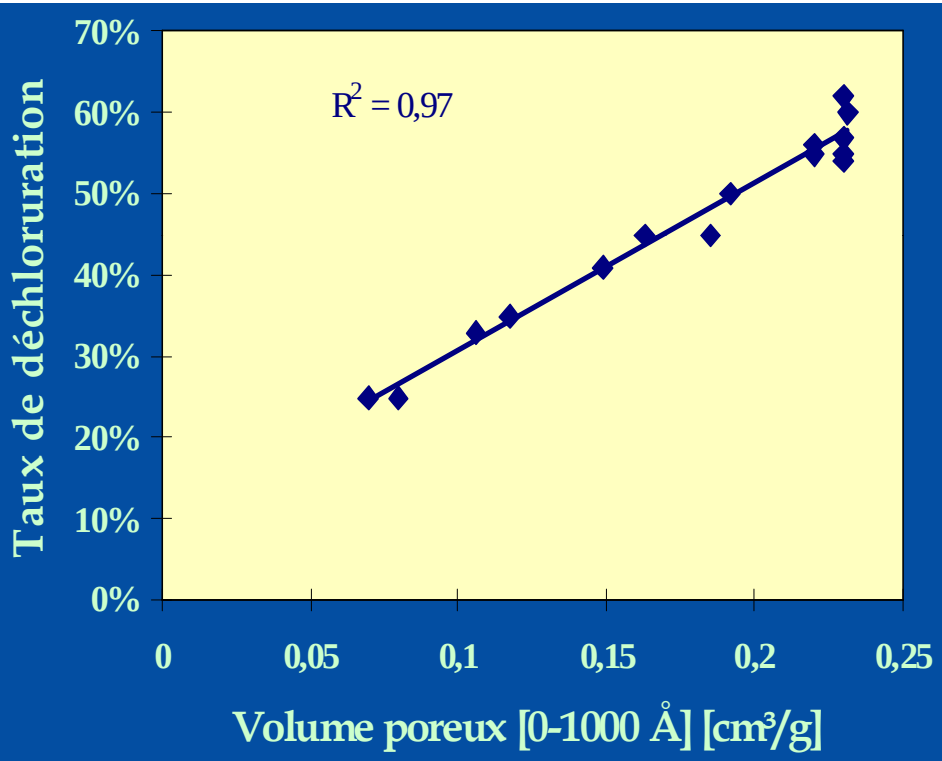

Specific surface area [m²/g]
60
55
50
45
40
35
30
25
20
Pore volume [cm³/g]
0,30
0,25
0,20
0,15
0,10
0,05
SORBACAL® SP
(SPONGIACAL®)
WÜLFRAsorp® A
Standard hydrated lime
GSS
1980
1985
1990
2000
2012 ?
MSWI dry process
Specific surface area concept
Pore volume concept

Laboratory scale study
HCl removal vs hydrated lime properties

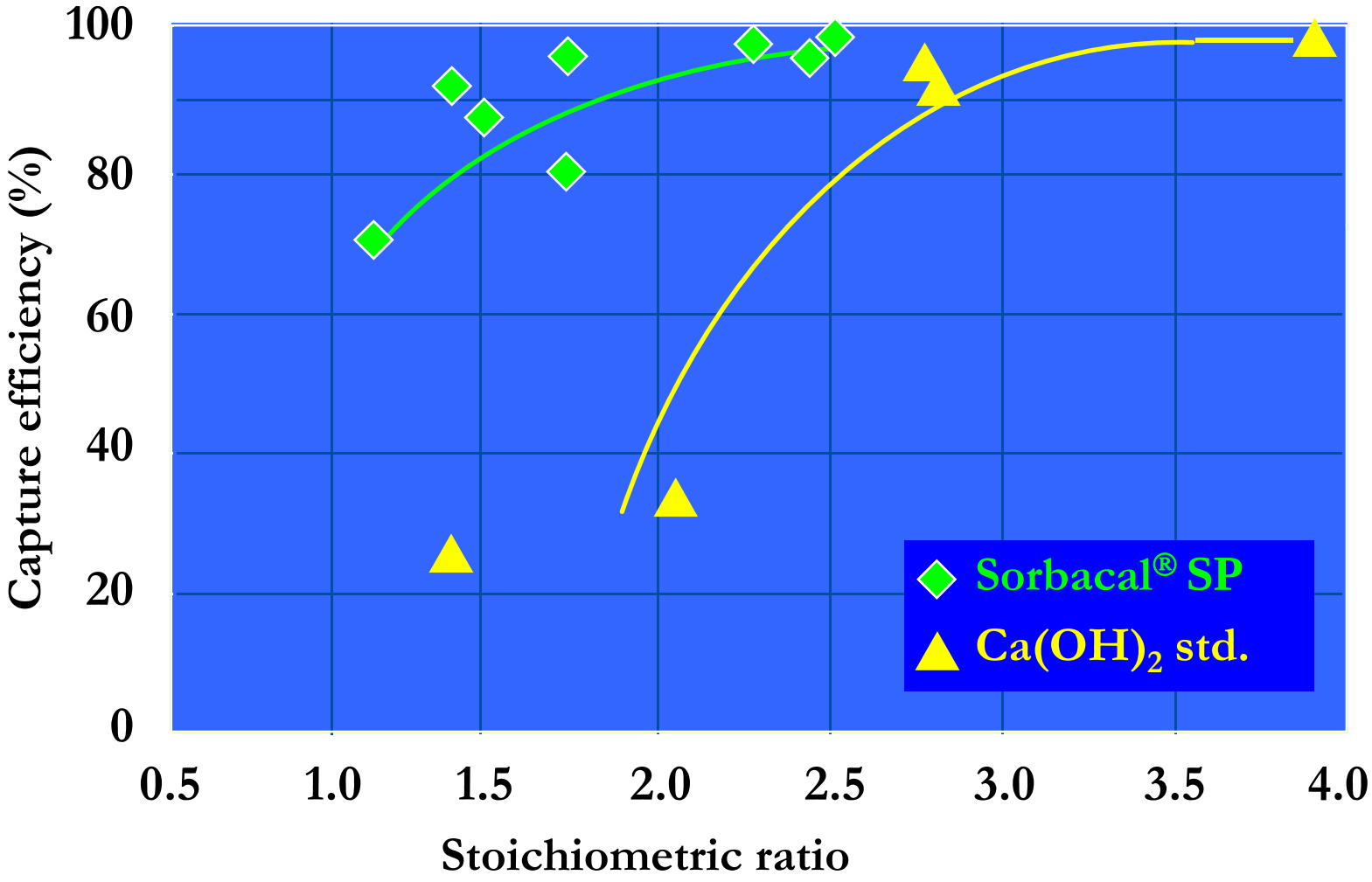
SSA / HCl removal rate



Pore volume / HCl removal rate



HCl CAPTURE EFFICIENCY



Properties of Test Hydrates

- Chemically the hydrated limes evaluated are basically the same
- Their difference lies in their physical properties

Sorbacal®SP	Standard Hydrate
SSA - 40+ m^2/g	SSA - ~20 m^2/g
Porosity - ~.23 cm^3/g	Porosity - ~.07 cm^3/g

HCl Data Summary

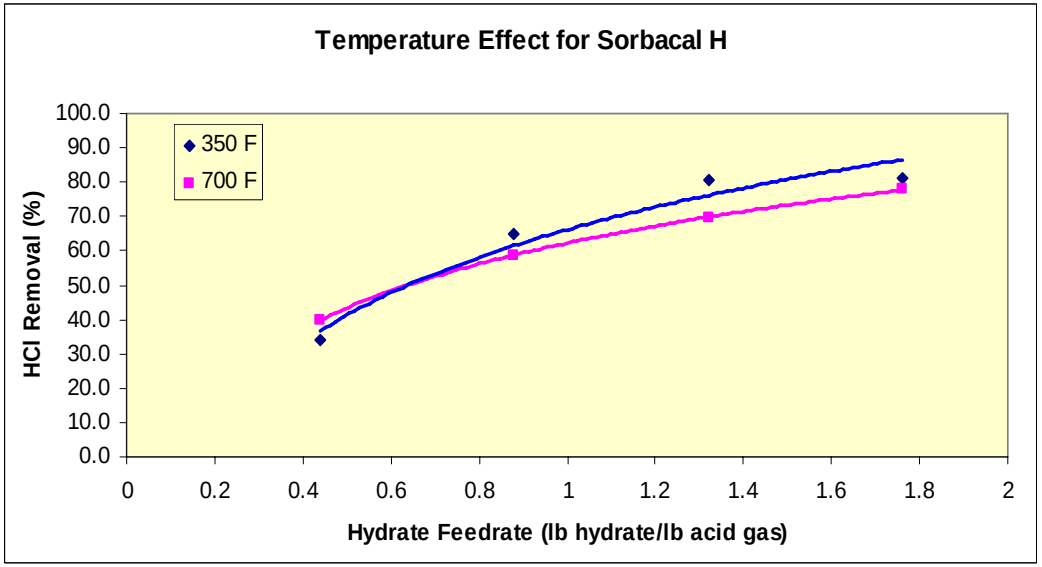
High Cl Tests
(3300 ppm Cl in Coal, 200 ppm HCl in flue gas)

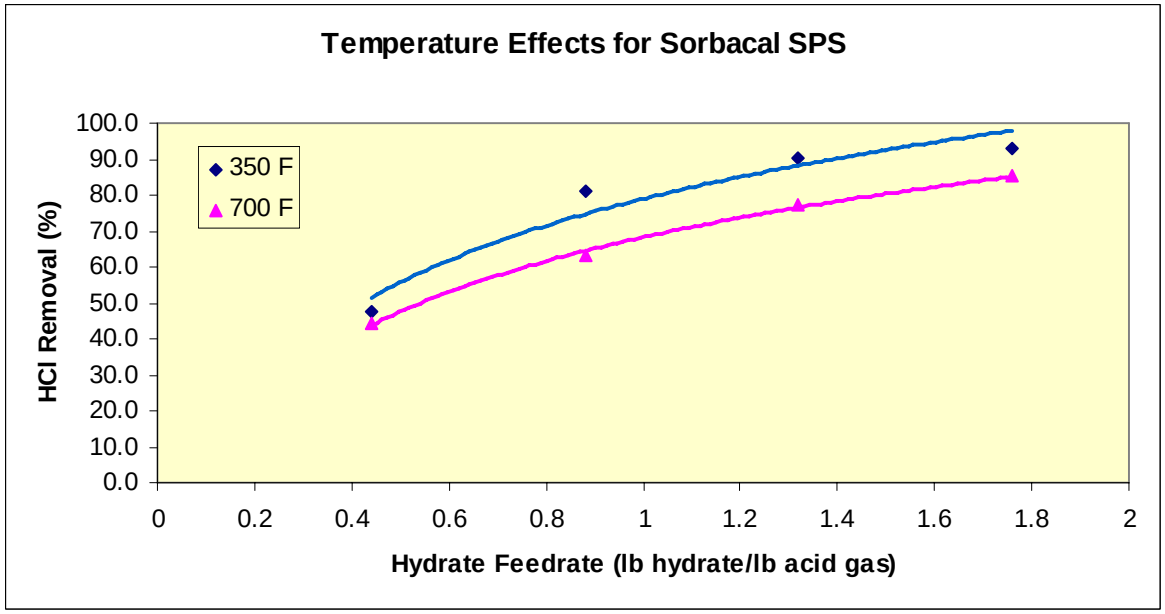
Moderate Cl Tests
(~800 – 1000 ppm in coal, 63 ppm in flue gas)

Temperature Impacts on Removal

ESP Operations for High Cl Coal
(~3300 ppm in coal –
200 ppm HCl in flue gas)

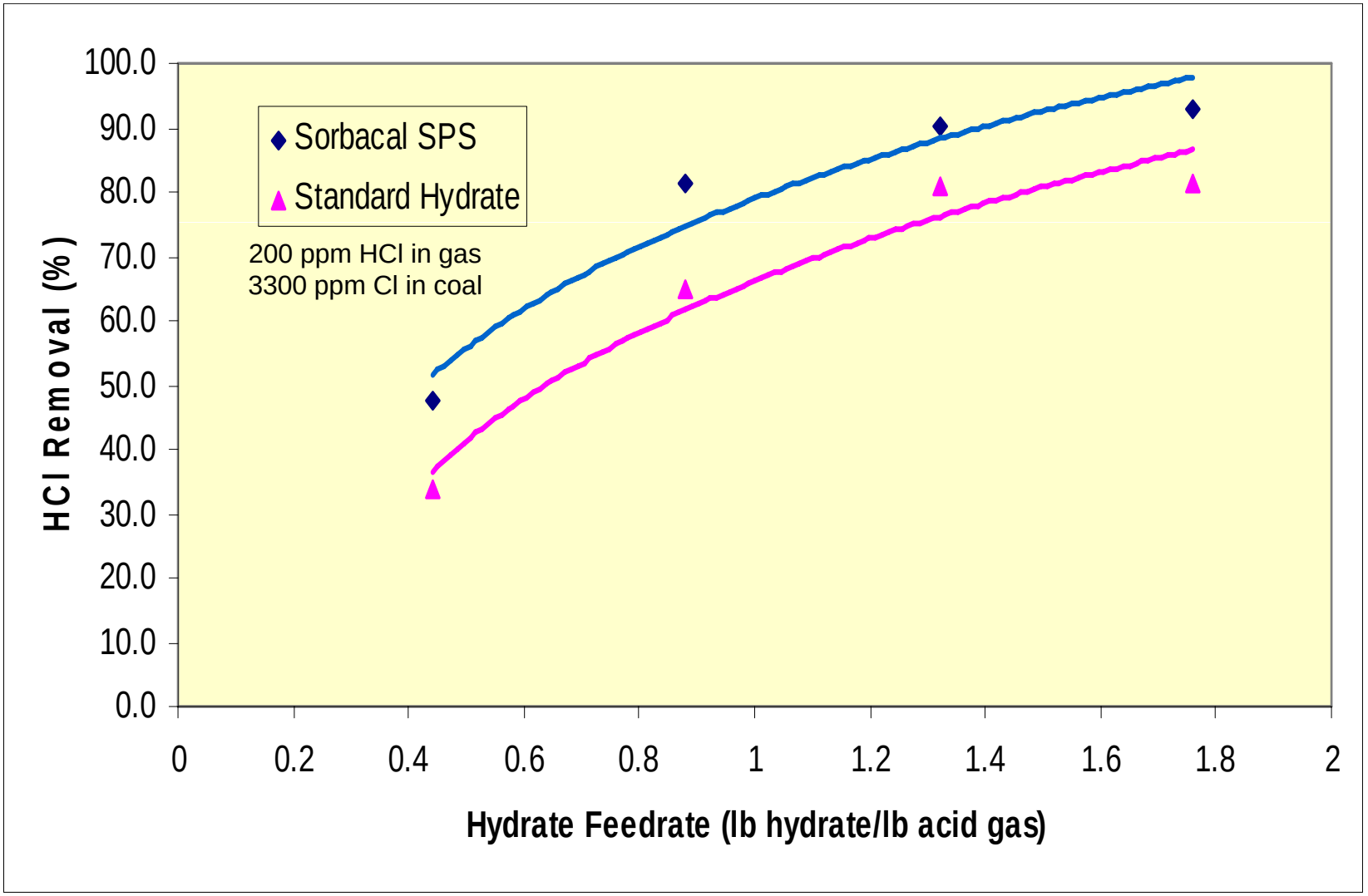
HCl Removal Better at Low T





Sorbacal®SPS vs. Standard Hydrate

ESP Operations @ 350°F



Sorbacal®SPS vs. Standard Hydrate

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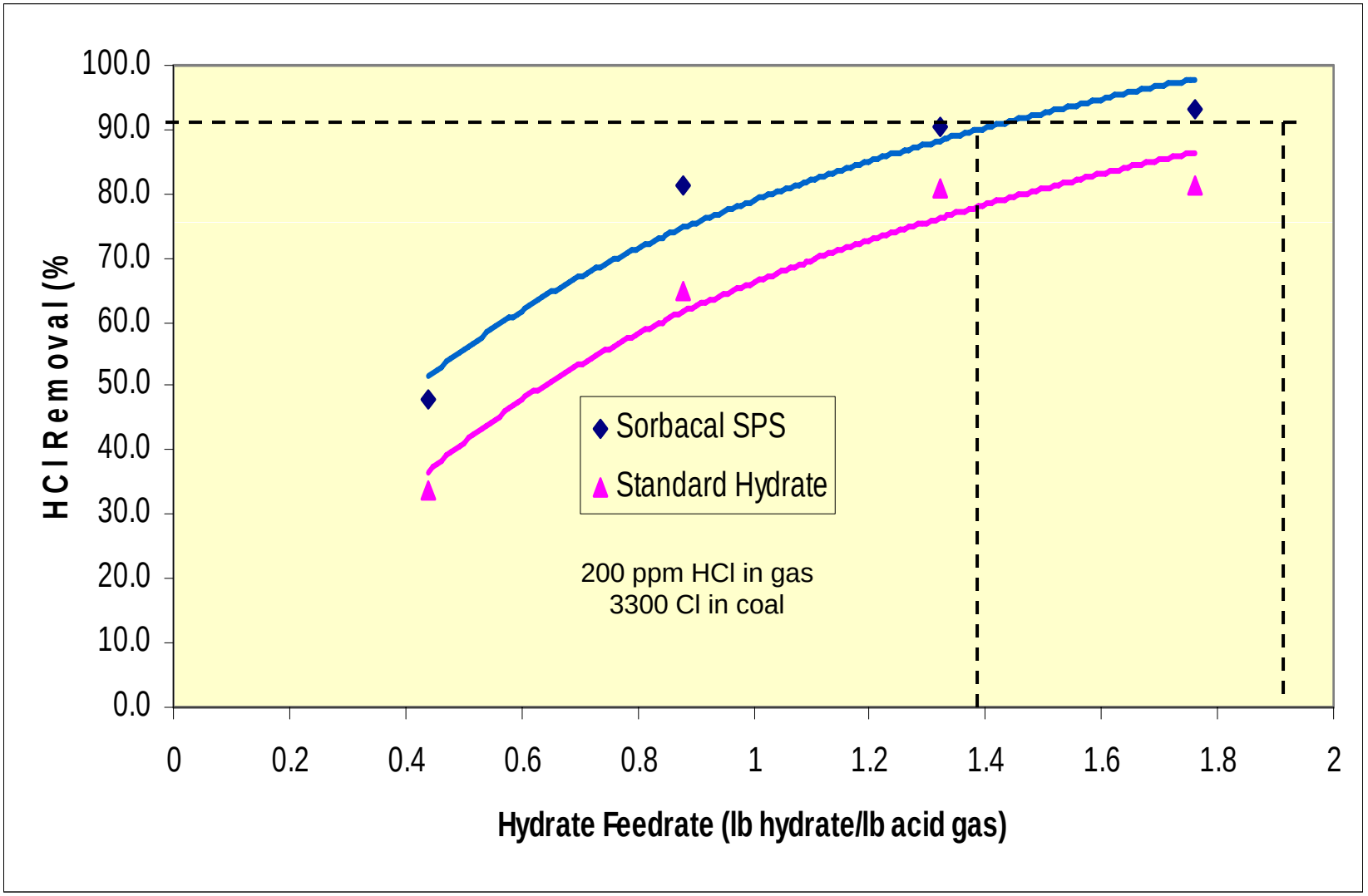

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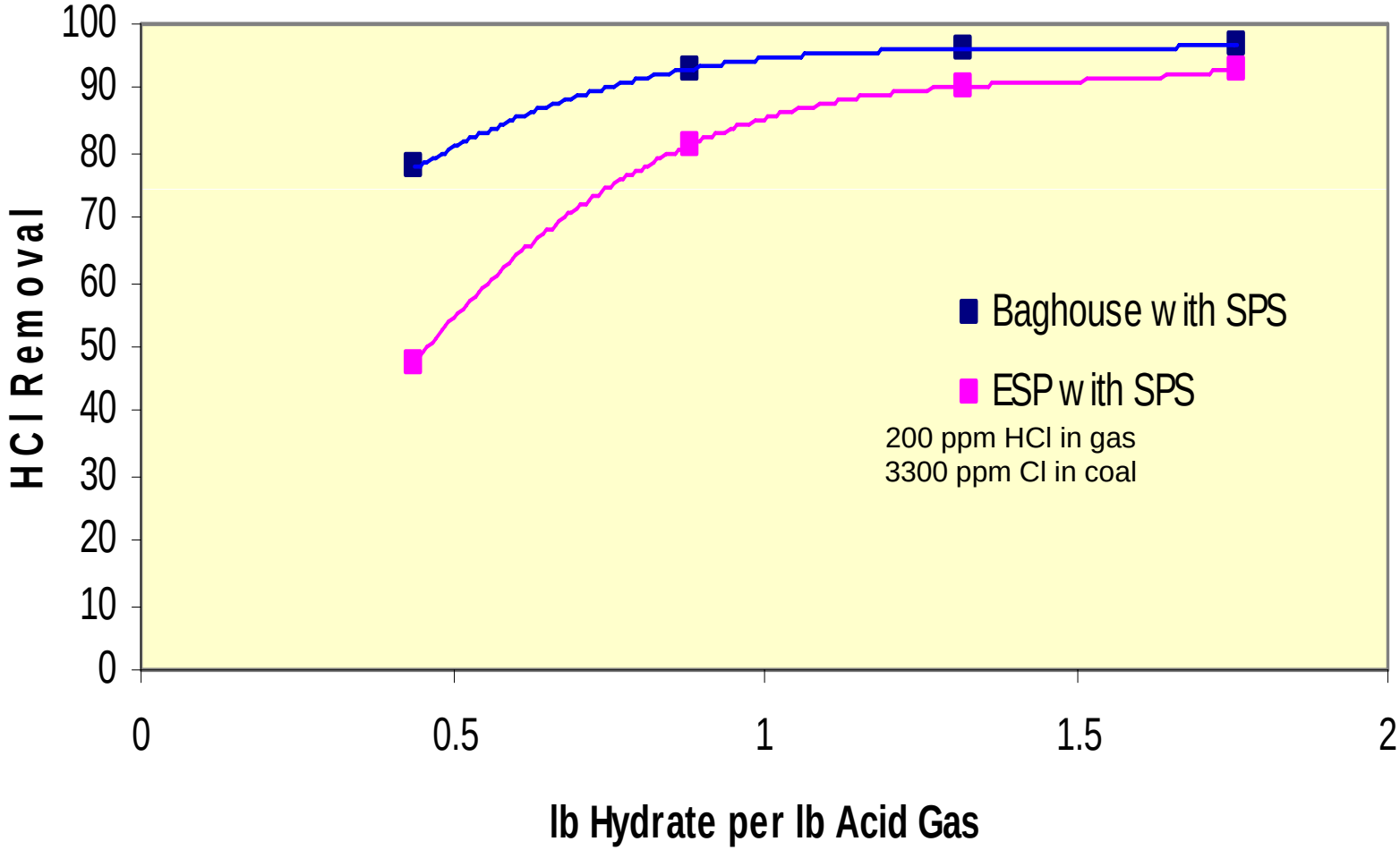
HCl Removal - Baghouse vs. ESP

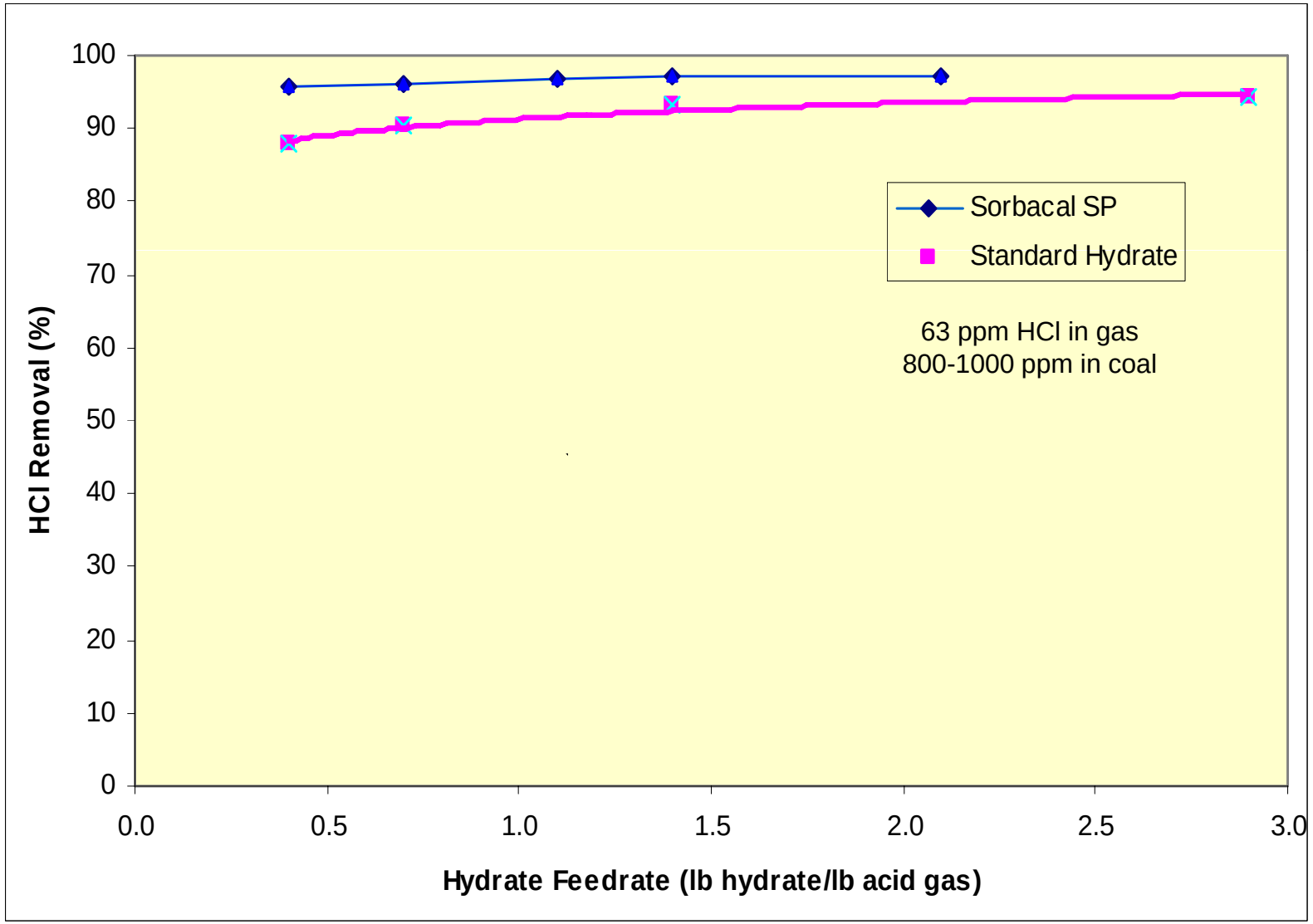


High S, High Cl Test Summary

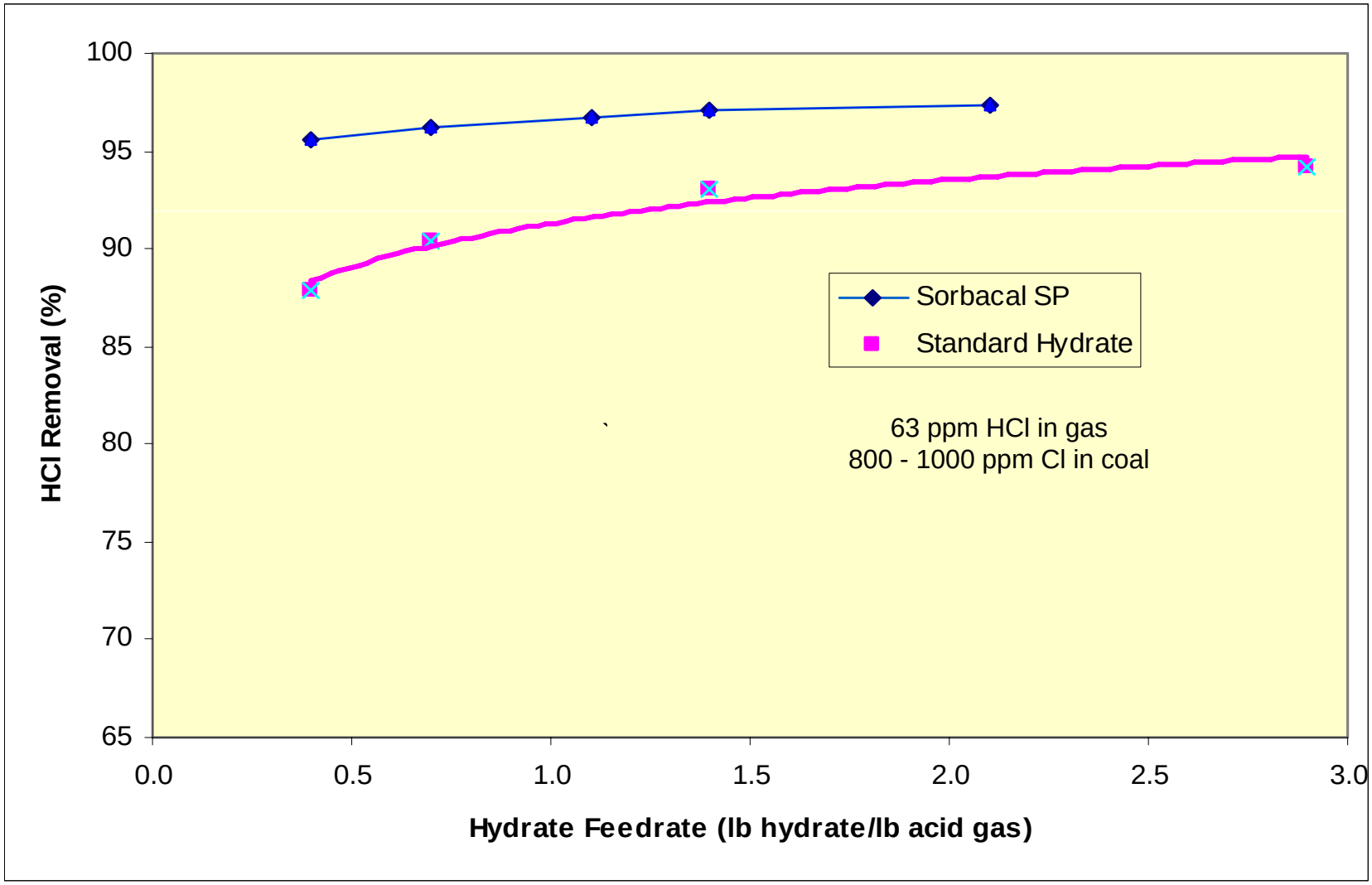
- Sorbacal®SPS performed better than the standard hydrate
- Better performance was shown at the air heater outlet temperature(300 - 350°F) than the inlet temperature (650 - 700°F)
- ~90% HCl removal was achieved with an ESP and 97% removal with a baghouse
- The utility MATS limit of 0.002 lb/MM Btu was not achieved with this high Cl coal

DSI can be an effective way to limit Cl corrosion in FGD systems and also reduce waste water treatment costs.

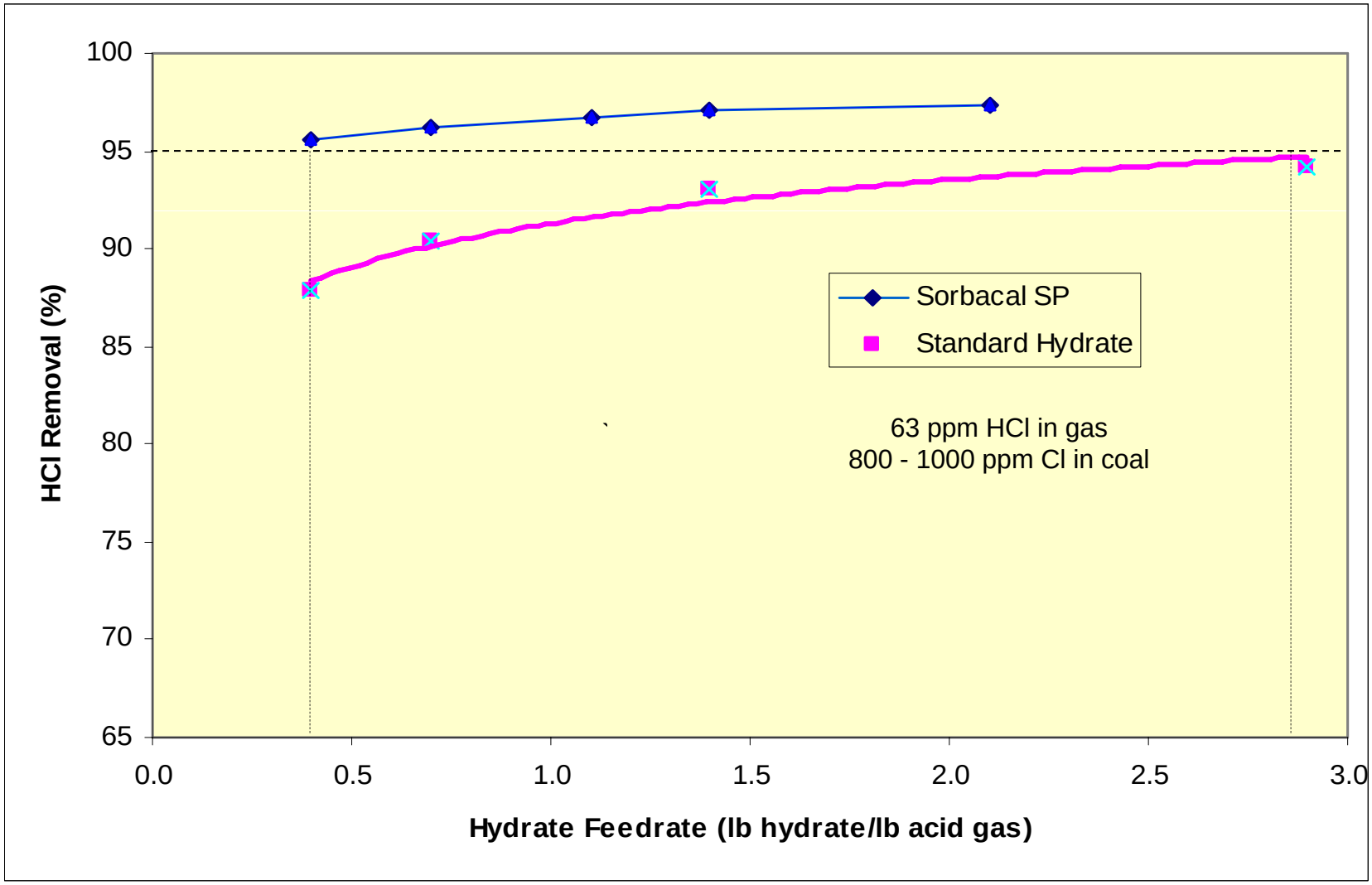
HCl Removal Across Baghouse



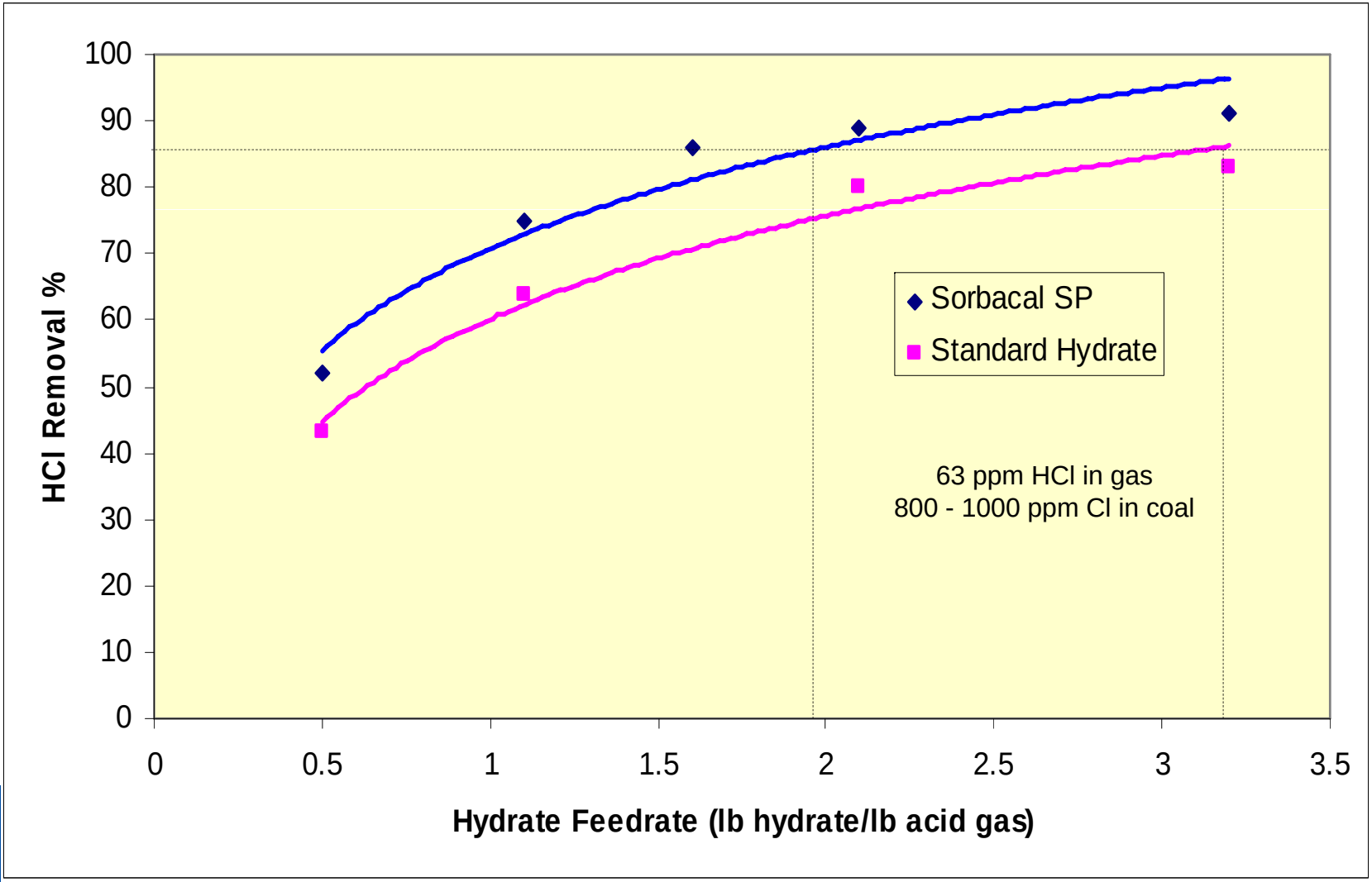
HCl Removal Across Baghouse



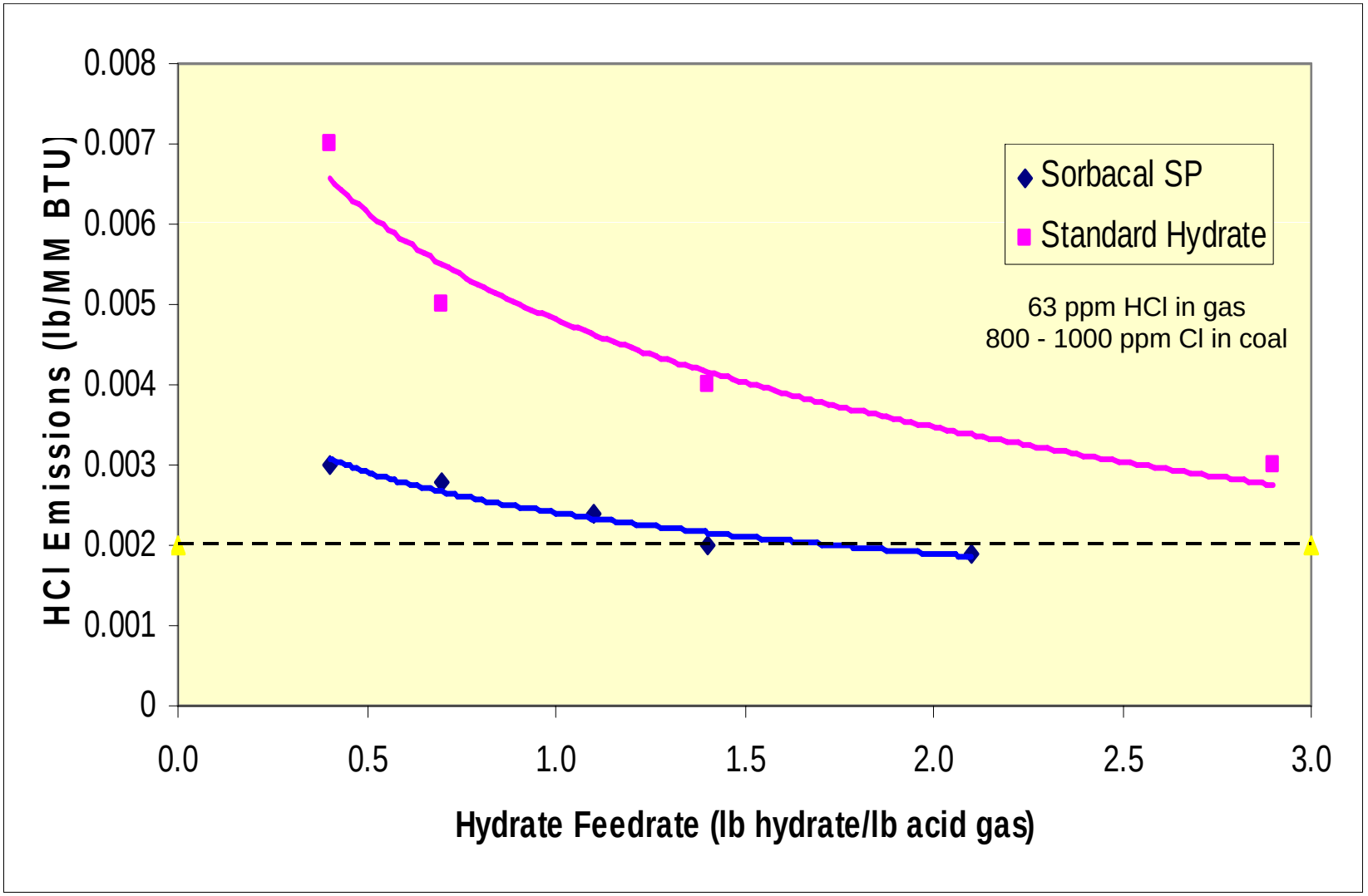
HCl Removal Across Baghouse



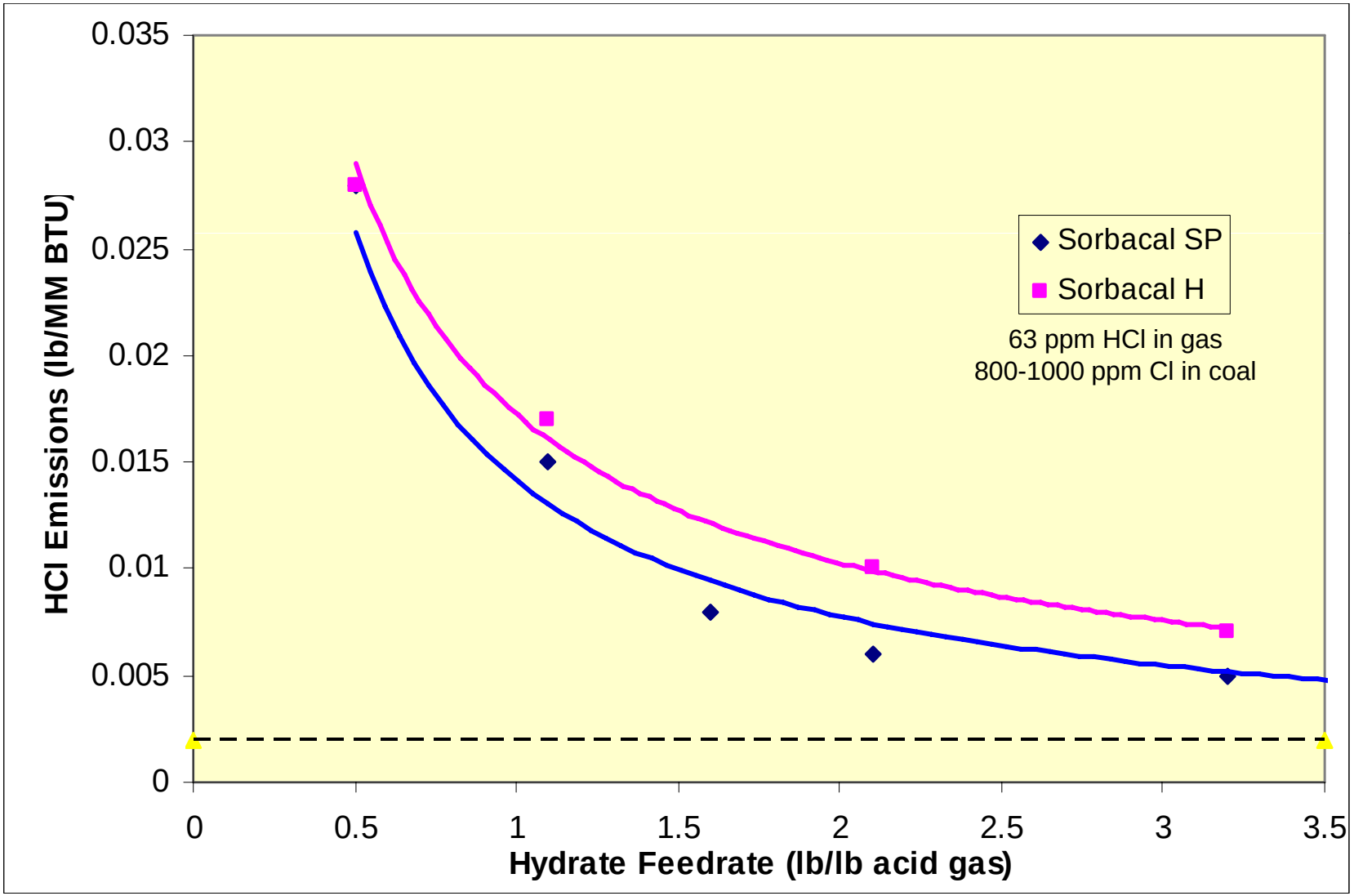
HCl Removal Across ESP



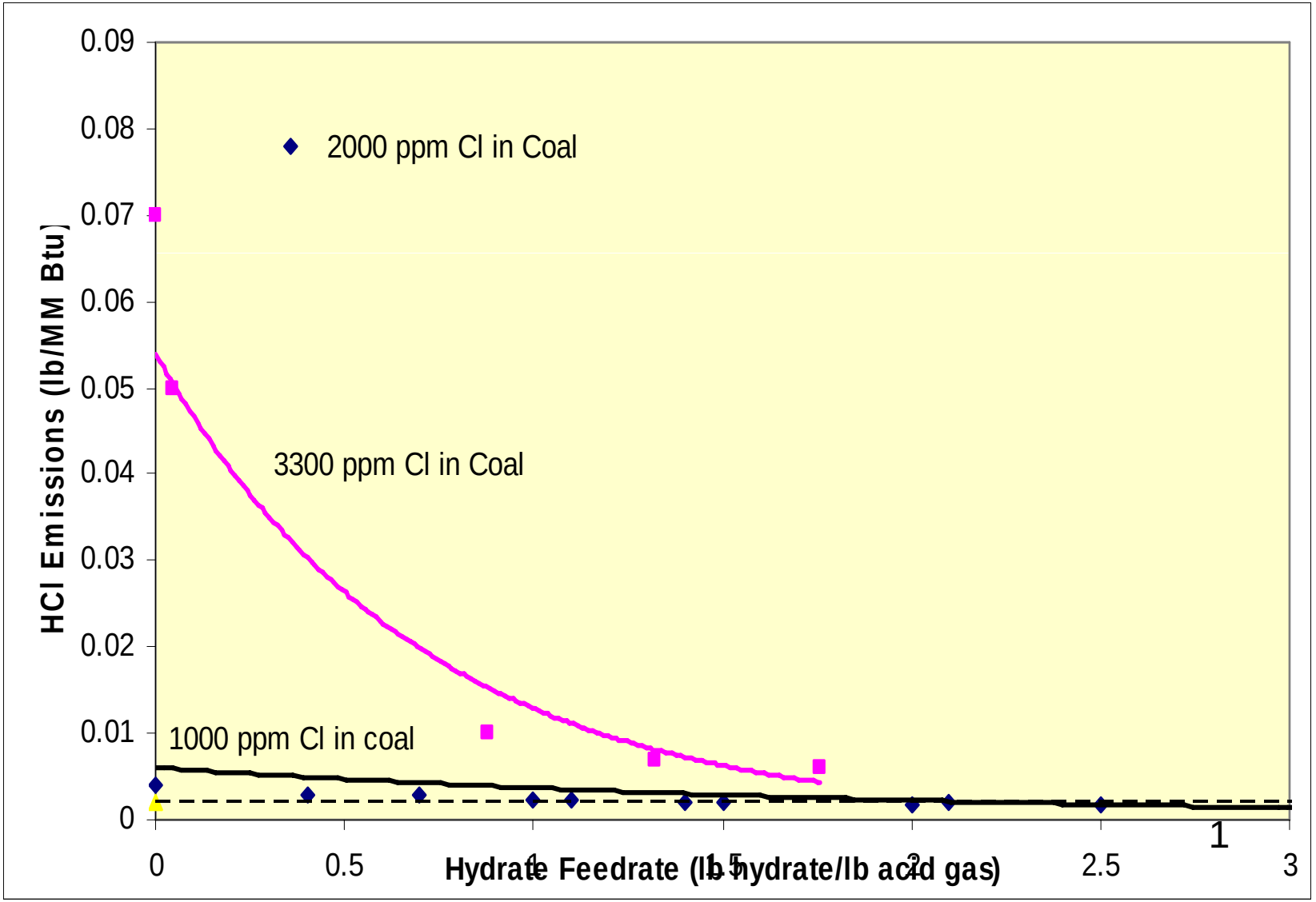
HCl Emissions Across Baghouse



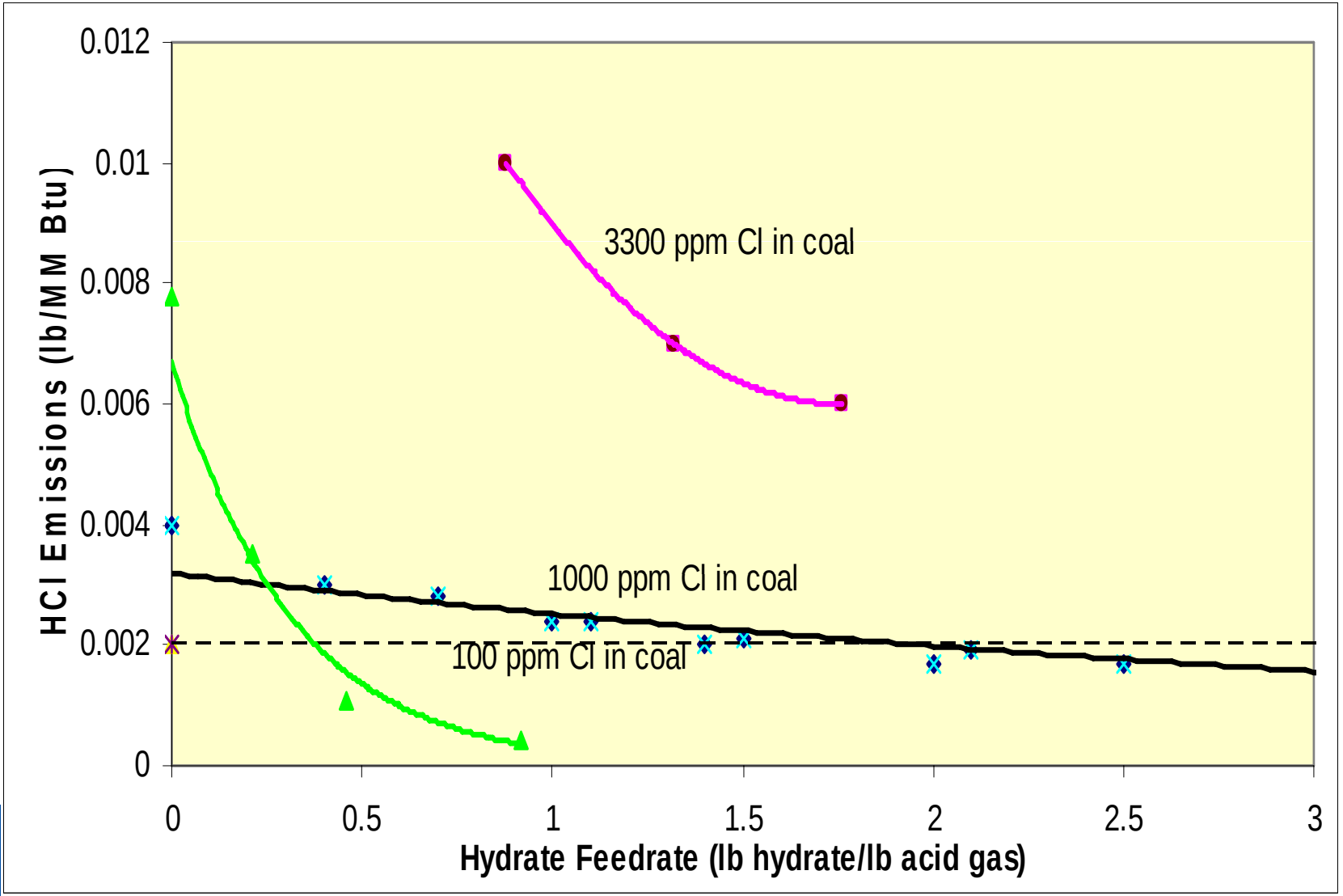
HCl Emissions from ESP (lb/MM BTU)



HCl Emissions Vs. Coal Cl Content



HCl Emissions vs. Coal Cl content



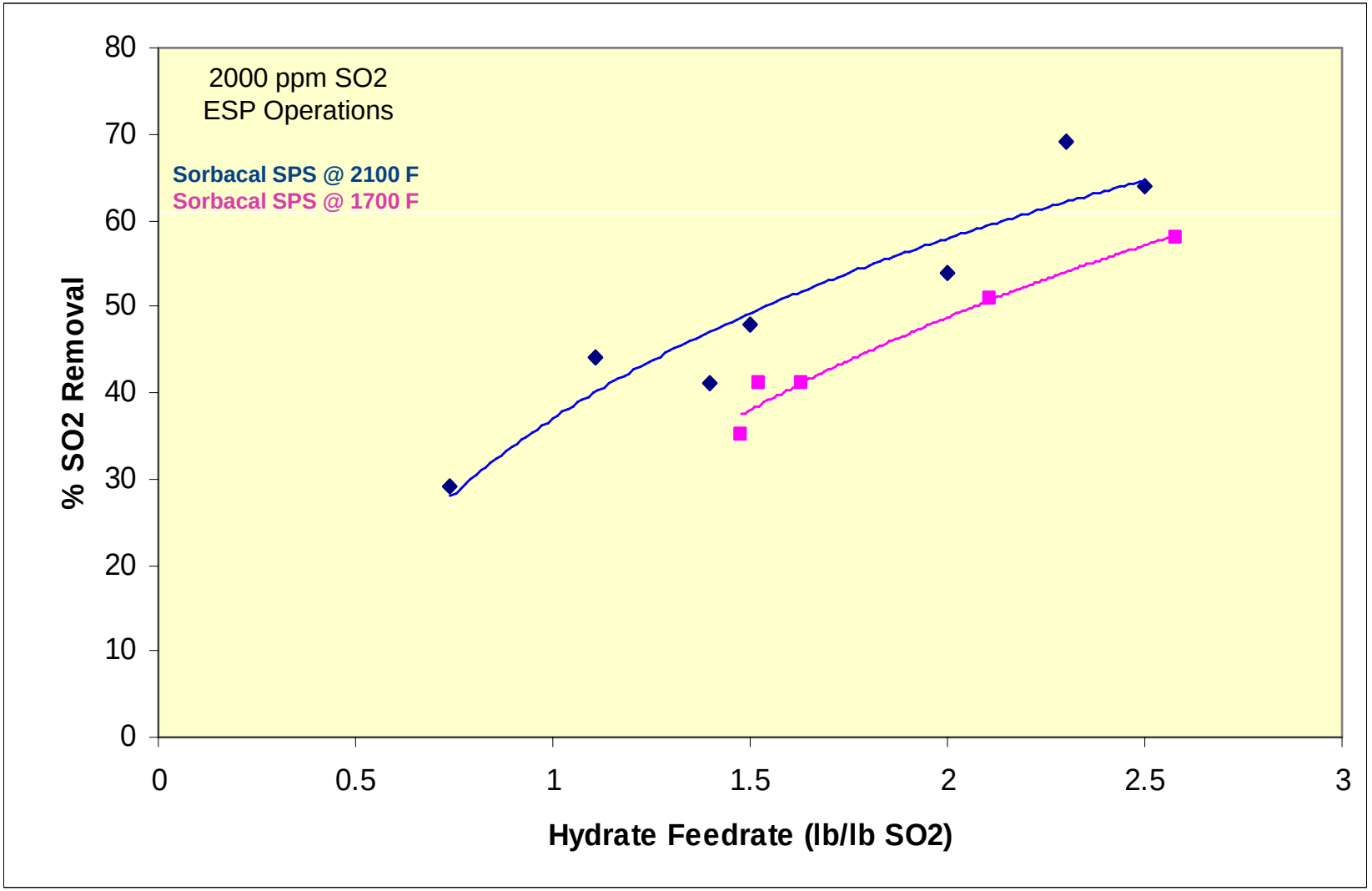
HCl Test Summary

- Sorbacal®SP performed better than the standard hydrate
- Utility MATS emission level (0.002 lb/MM Btu) was achieved with Sorbacal®SP and a baghouse with 1000 ppm Cl in coal
- Utility MATS emission level was not achieved with an ESP particulate collection device
- Utility MATS emission level was not achieved with the standard hydrate at all
- The coal Cl level vastly impacts the ability to achieve the MATS emission level

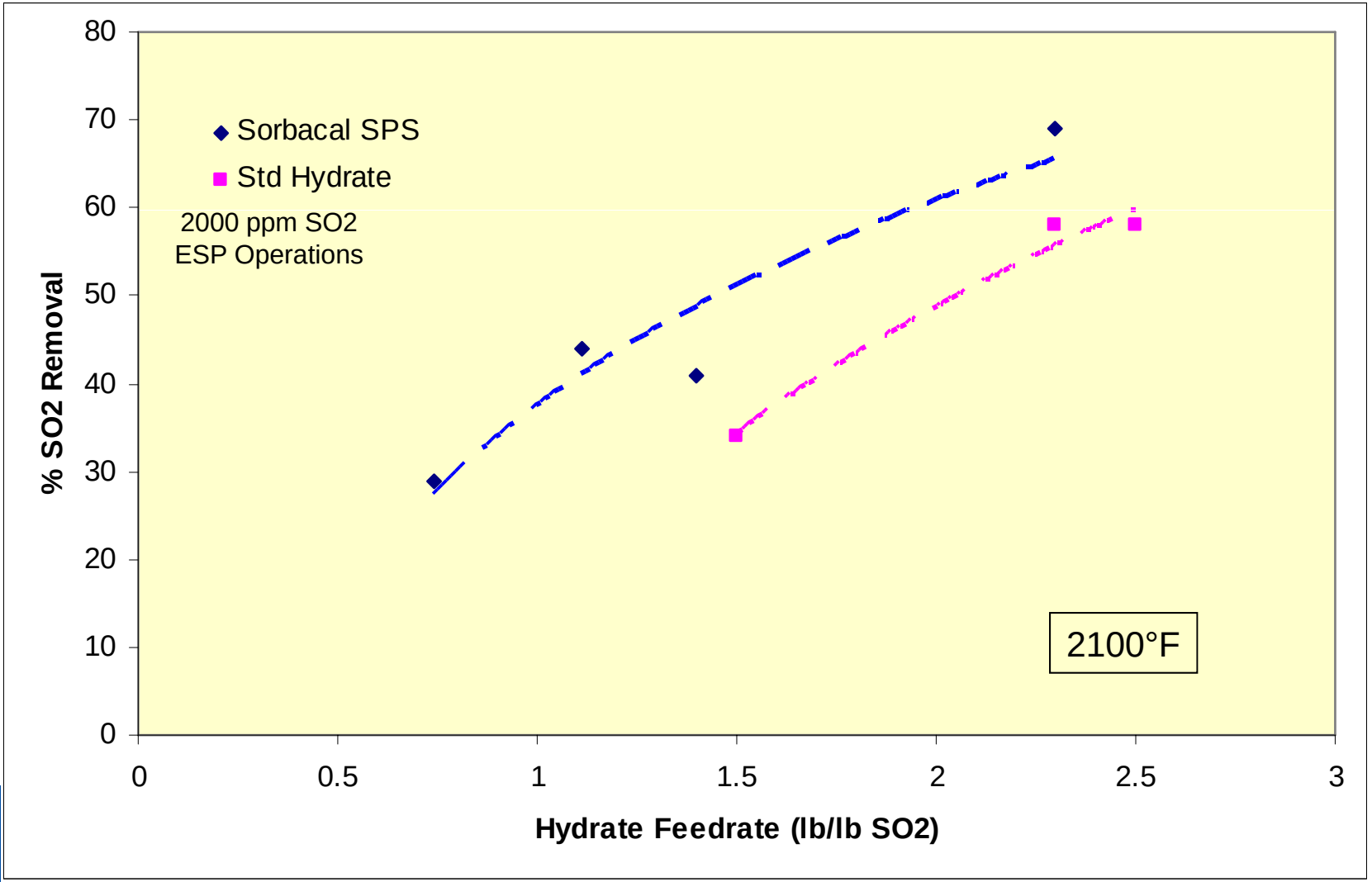
SO_2 Data Summary

High S - ~2000 ppm in flue gas (furnace injection)
Low S - ~600 ppm in flue gas (duct injection)

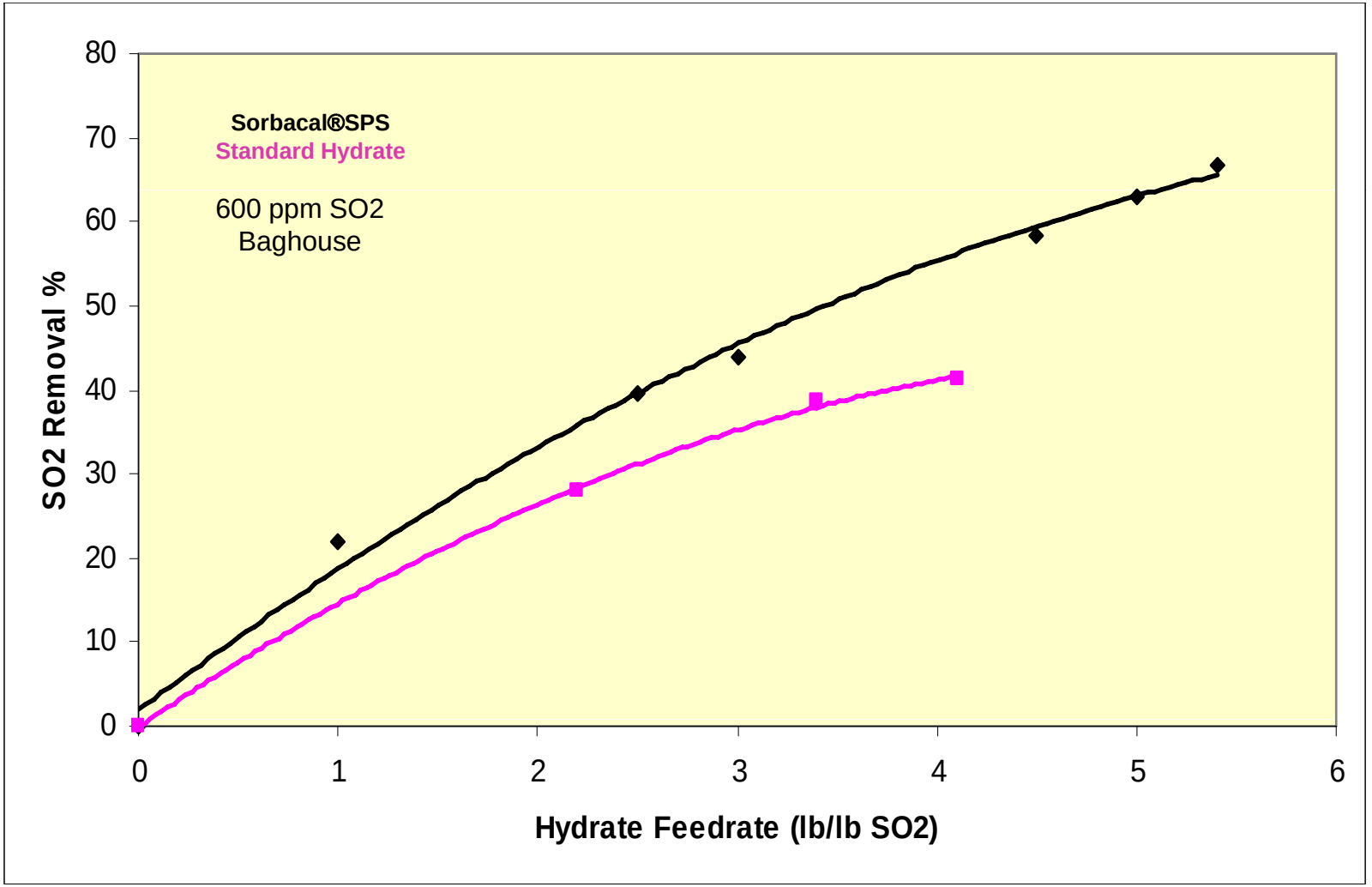
Temperature Impact on SO_2 Removal



SO_2 Removal – Sorbacal SPS vs. Standard Hydrate



SO_2 Removal @ Air Heater Inlet T



SO_2 Test Conclusions

- Higher Temperatures are better for SO_2 removal
- Sorbacal®SPS performs better than standard hydrate by ~30%
- 70+% removal is achievable with Sorbacal®SPS at a feedrate of ~2 lbs Sorbacal®SPS/lb SO_2 with in furnace injection with an ESP. A baghouse should perform better.
- ~ 50% removal is achievable with Sorbacal®SPS at the air heater inlet temperature
- <20% removal can be expected at the air heater outlet temperature

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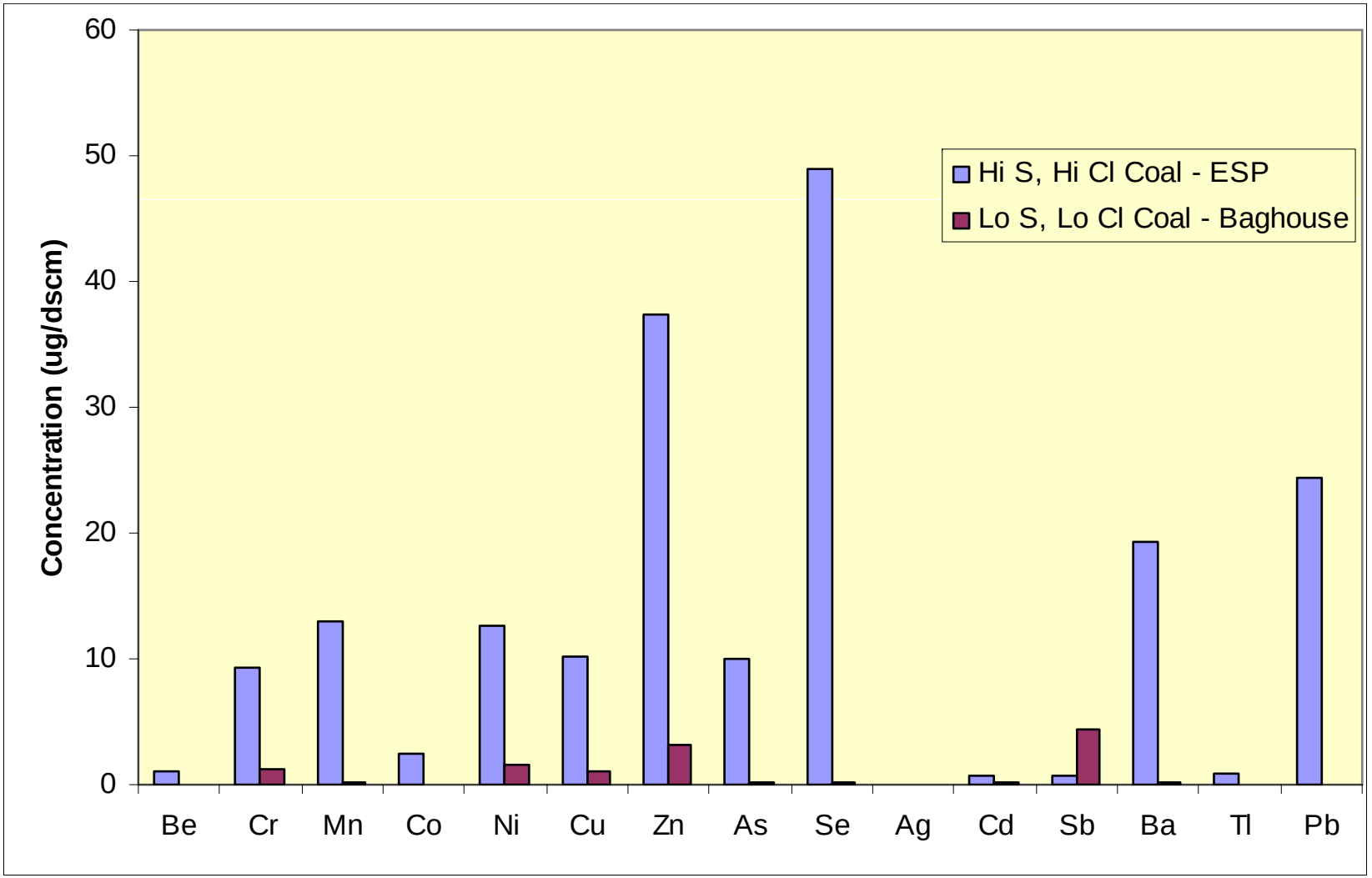
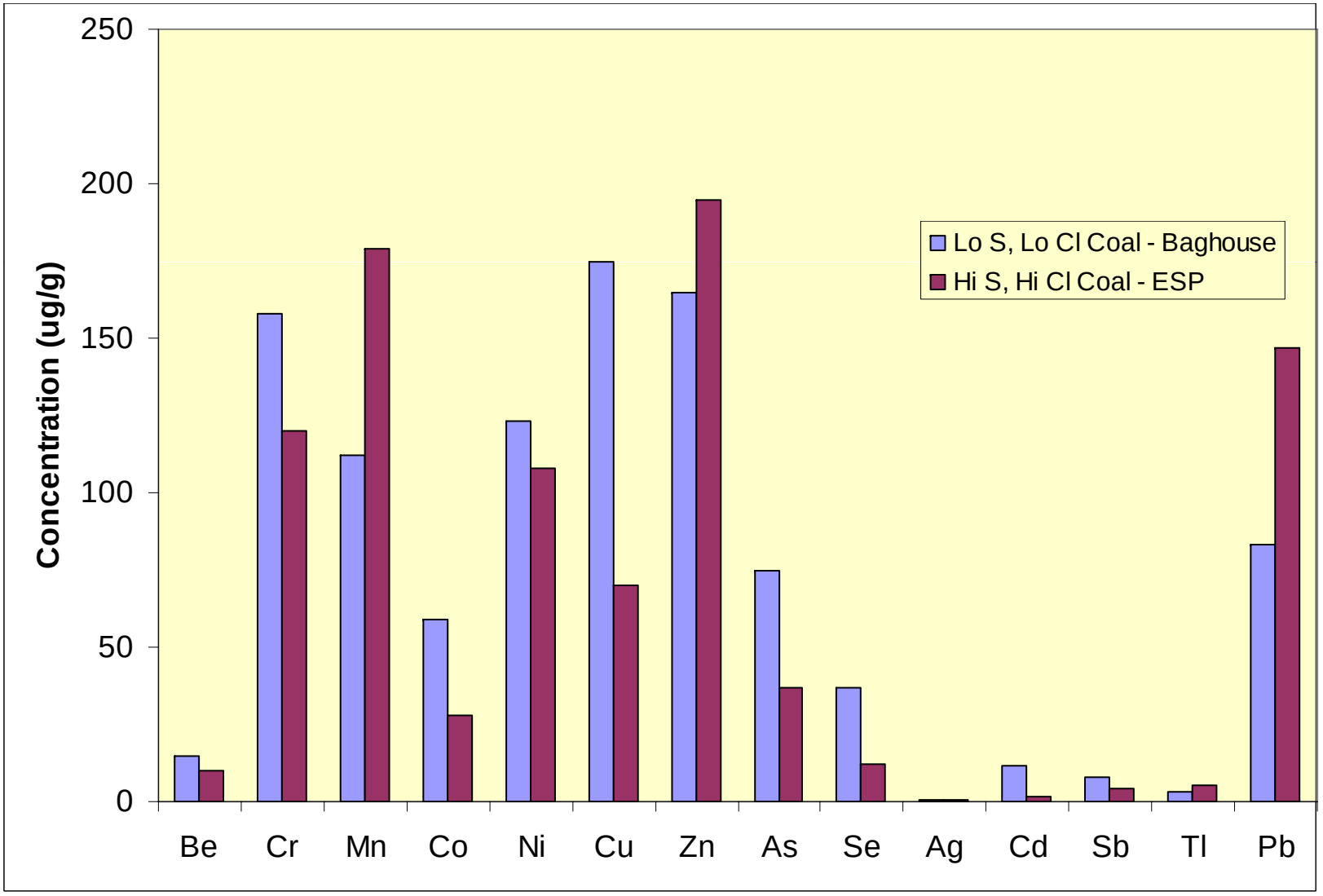
Trace Metal Capture

Baseline Comparison of Flue Gas Trace Metals

EPA Method 29 Analysis

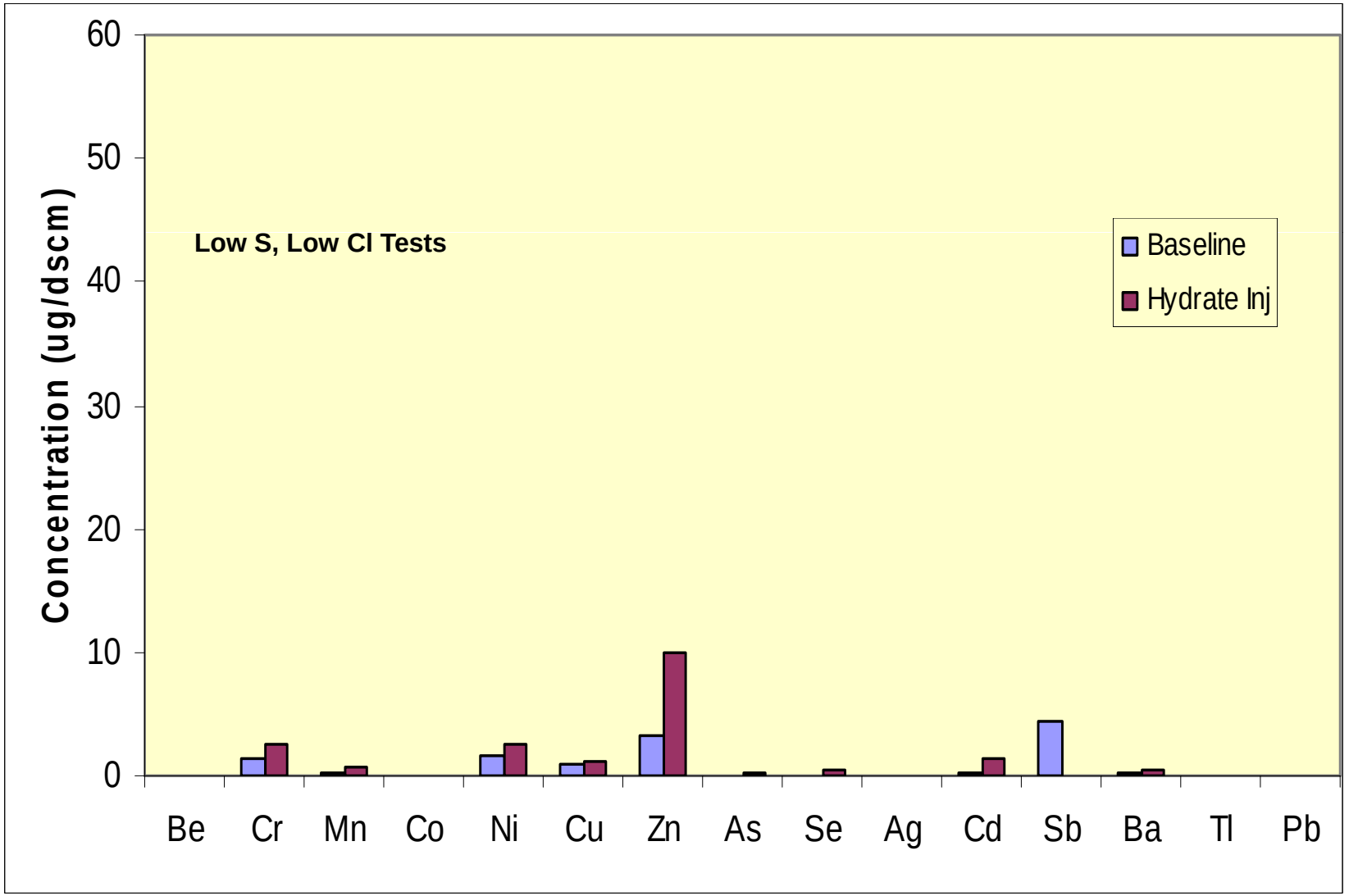


Comparison of Baseline Flyash



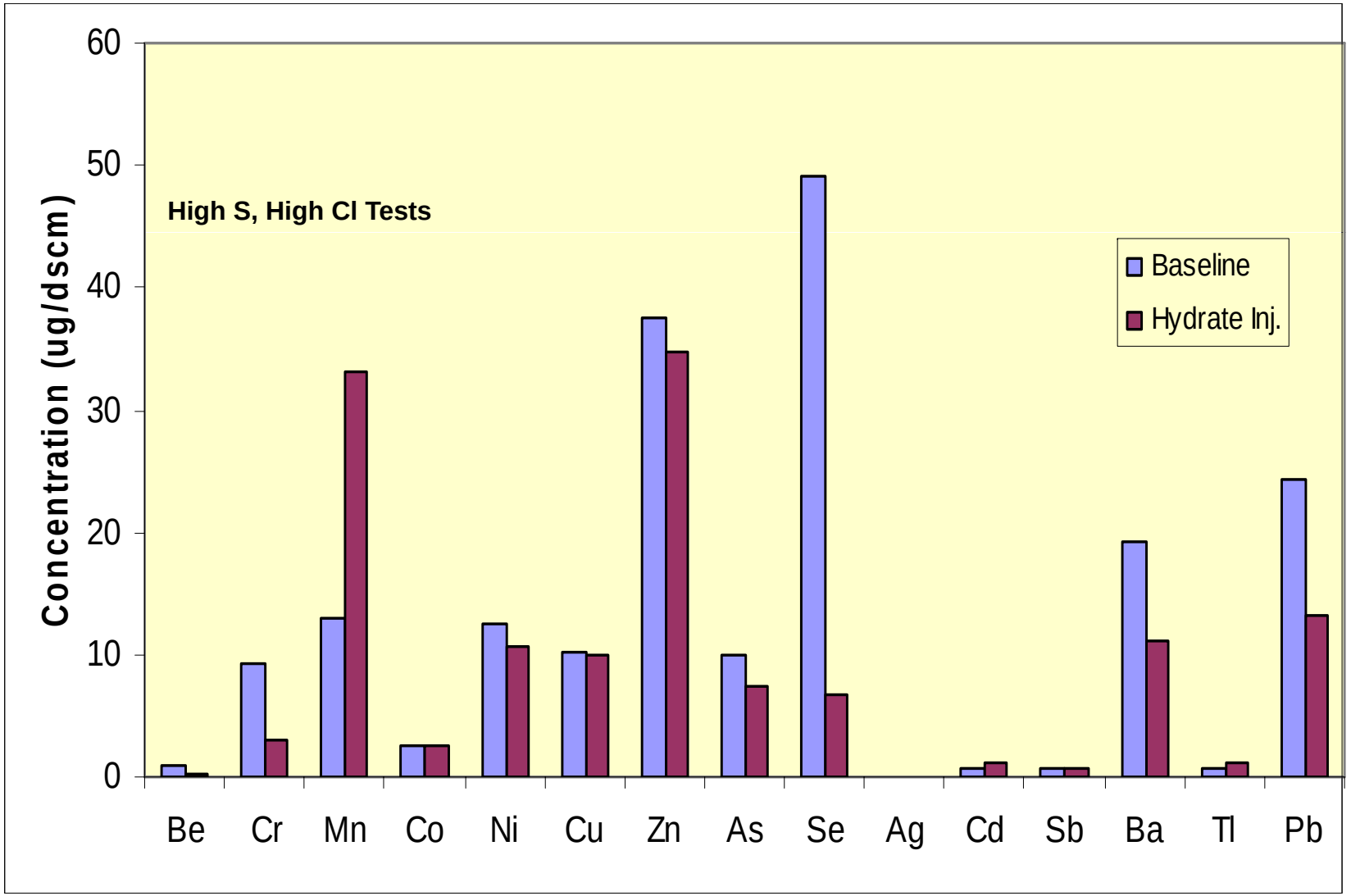
Flue Gas Trace Metals – October 2011 Tests

Baghouse Particulate Collection



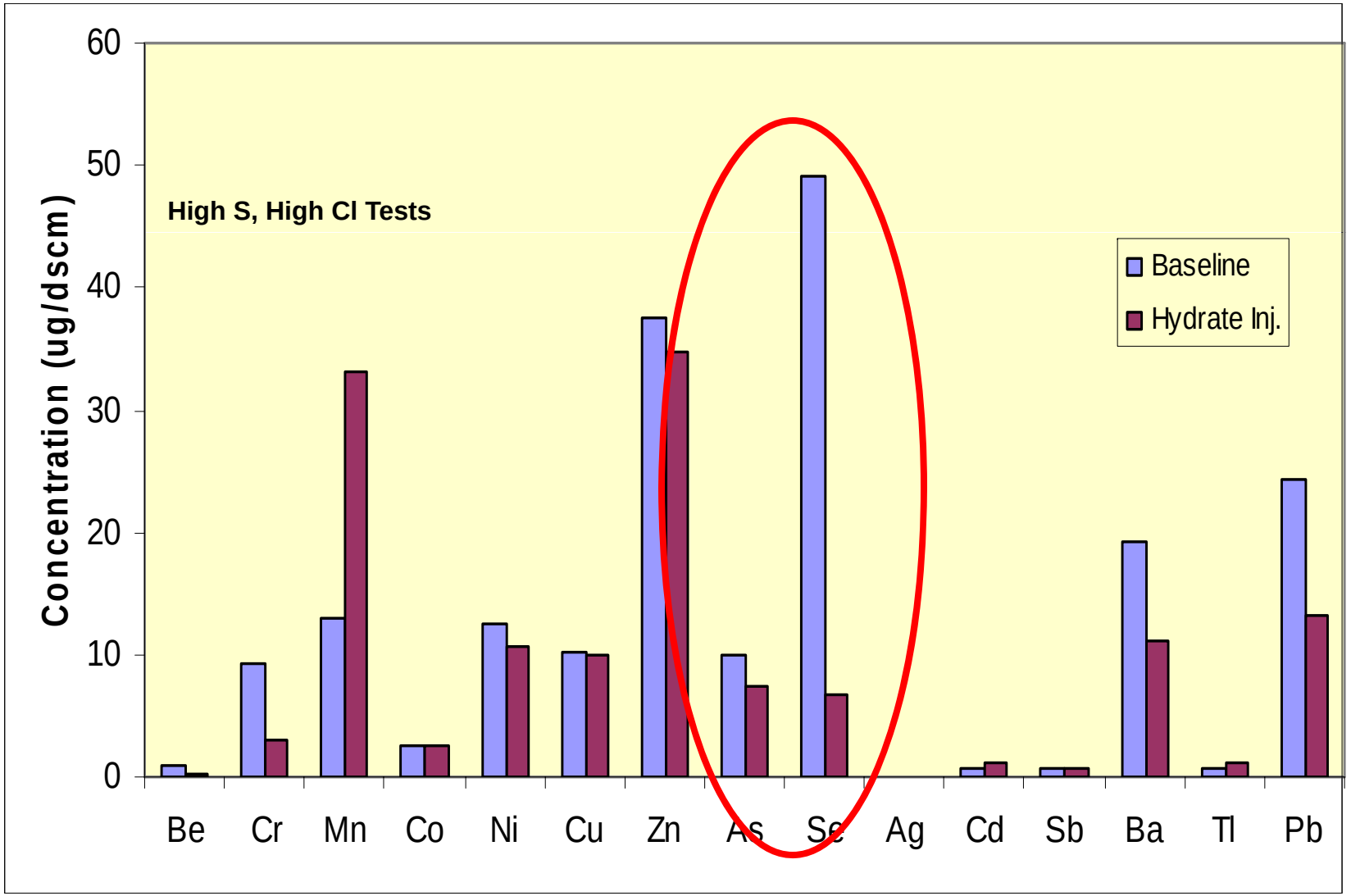
Flue Gas Trace Metals – May 2011 Tests

ESP Particulate Collector



Flue Gas Trace Metals – May 2011 Tests

ESP Particulate Collector



Leaching Tests

Leached Metal	TCLP Haz Waste Reg. Limit (ppm)	Primary Drinking Water (ppm)	Baseline (ppm)	Hydrate Injection (ppm)
Chromium	5	0.1	0.024	<0.005
Arsenic	5	0.05	<0.005	0.008
Selenium	1	0.05	0.054	0.096
Silver	5	0.1	<0.005	<0.005
Cadmium	1	0.005	<0.005	<0.005
Barium	100	2	0.477	0.225
Mercury	0.2	0.002	0.011	0.013
Lead	5	0.015	0.07	<0.005

Overall Test Results/Observations

- Sorbacal®SP performs better than the standard hydrate under all conditions
- SO_2 removal is better at high temperatures
- HCl removal is better at lower temperatures
- HCl MATS emission level can be achieved with Sorbacal®SP and a baghouse at a moderate Cl coal
- HCl performance significantly impacted by coal Cl content
- DSI can be an effective means of limiting HCl corrosion and waste water impacts
- DSI with hydrated lime reduced vapor phase trace metals – particularly Se and As
- Metals from DSI flyash leached at an order of magnitude lower than the TCLP hazardous waste limits

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DSI with hydrated lime can be a viable low capital incremental emission control option for coal-fired boilers

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