

REINHOLD ENVIRONMENTAL Ltd.



2014 NO_x-Combustion Round Table & Expo Presentations

February 10 & 11, 2014, in Charlotte, NC / Hosted by Duke Energy

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Performance Gains with Hydrated Lime DSI FGD Purgewater and CCPs



Reinhold NOx Conference –
February 10, 2014
Howard Fitzgerald
Lhoist North America



History and Drivers for DSI Technology

✓ DSI History

- Sodium and calcium dry injection testing done in 70's & 80's
- LIMB project – calcium products
- Rebirth of DSI for utility SO_3 control in 2000s
- Increasing interest for MATS compliance
- Additional interest in Fuel Flexibility and other performance gains

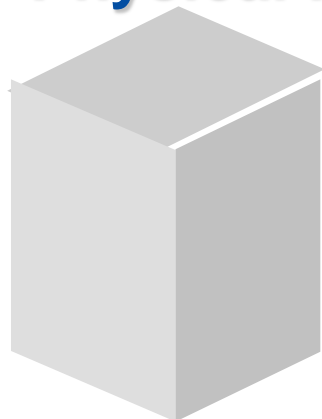
✓ DSI Drivers

- Low capital cost
- Low process water demands
- Evolution of HAPS rules
- Operational benefits now recognized
- Technological advancements lead to higher effectiveness

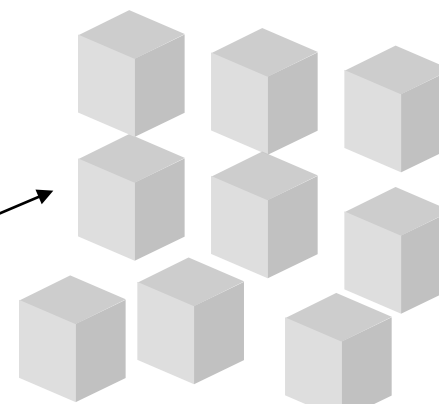




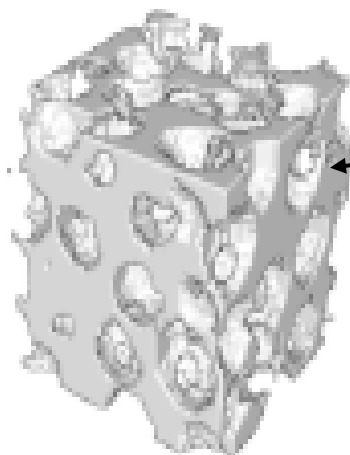
Calcium Hydroxide Physical Properties



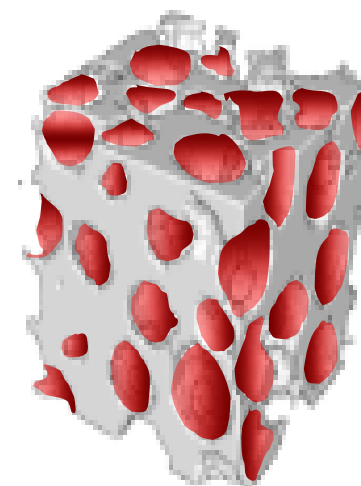
Standard Hydrate
- SSA 15 - 18 m²/g (BET)



Sorbacal[®] H :
-SSA 17 - 22 m²/g (BET)



Sorbacal[®] SP :
- High SSA > 40 m²/g (BET)
-High Pore Volume



Sorbacal[®] SPS :
- Activated Sorbacal[®] SP to
improve its SO_x removal
performances

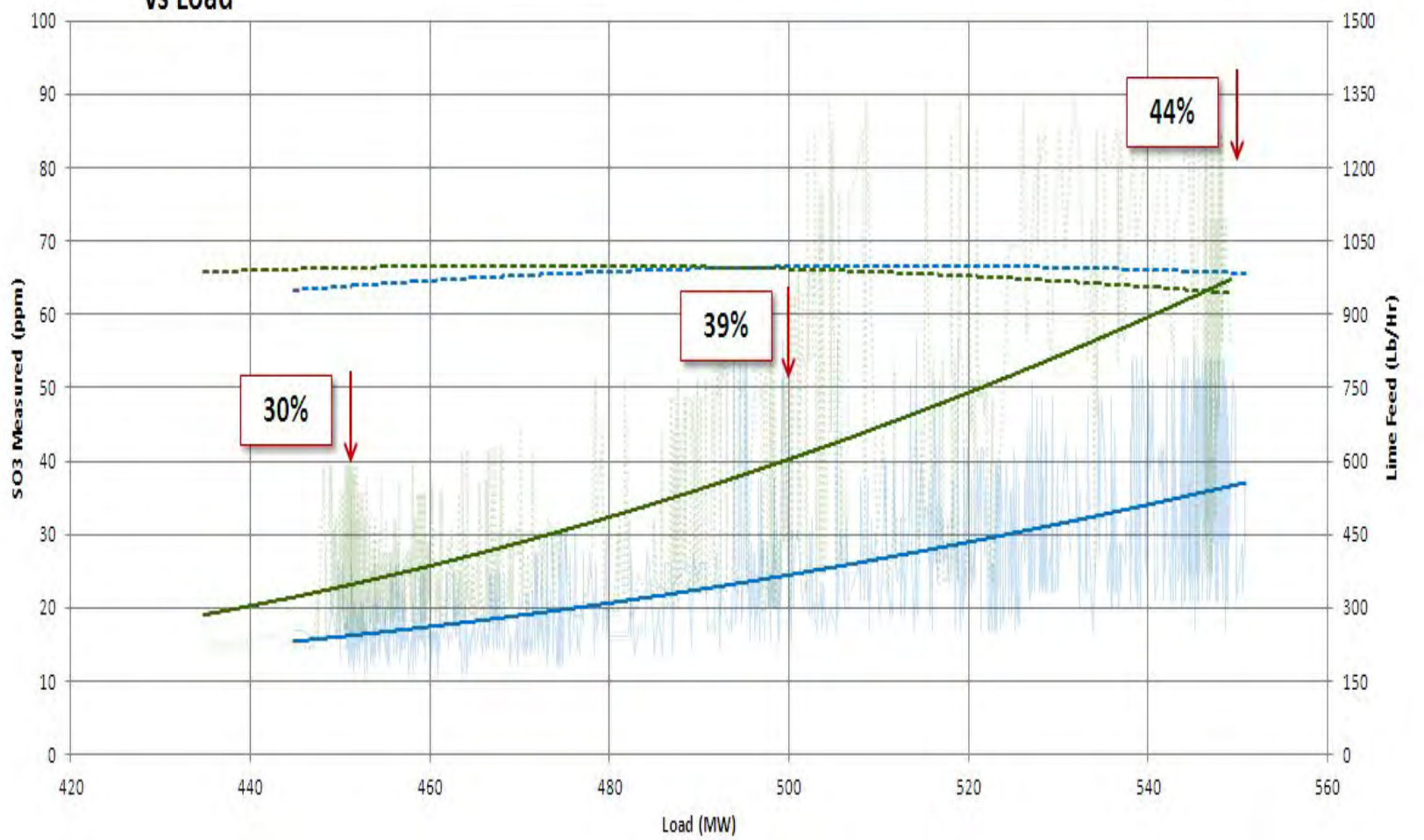




SO₃ Emissions Coal-fired Boiler Air Heater Inlet Injection

Measured SO₃
vs Load

— SPSO3m — H SO3m — SP Lime — H Lime — Poly. (SPSO3m) — Poly. (H SO3m) — Poly. (SP Lime) — Poly. (H Lime)





Issue of the Day

Can Hydrate DSI be used effectively for controlling acid gas emissions and reducing the effects on FGD purgewater?





Emission Control Demonstration Tests

✓ Drivers

- MATS
- Consent Decrees
- 316 Water Rules
- CCP regulations
- Better FGD Performance

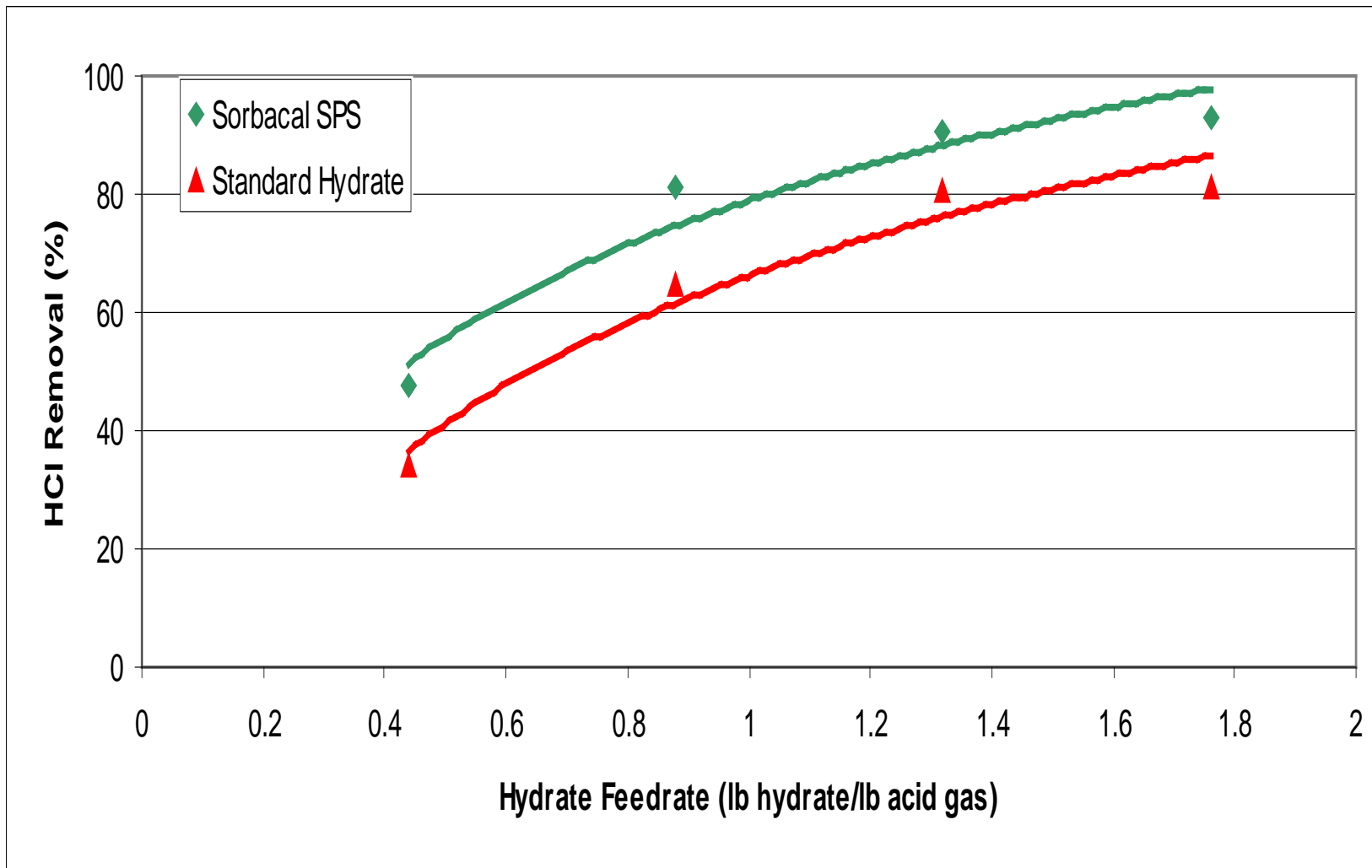
✓ Acid Gases Tested

- SO_3
- HCl
- HF
- As
- Se



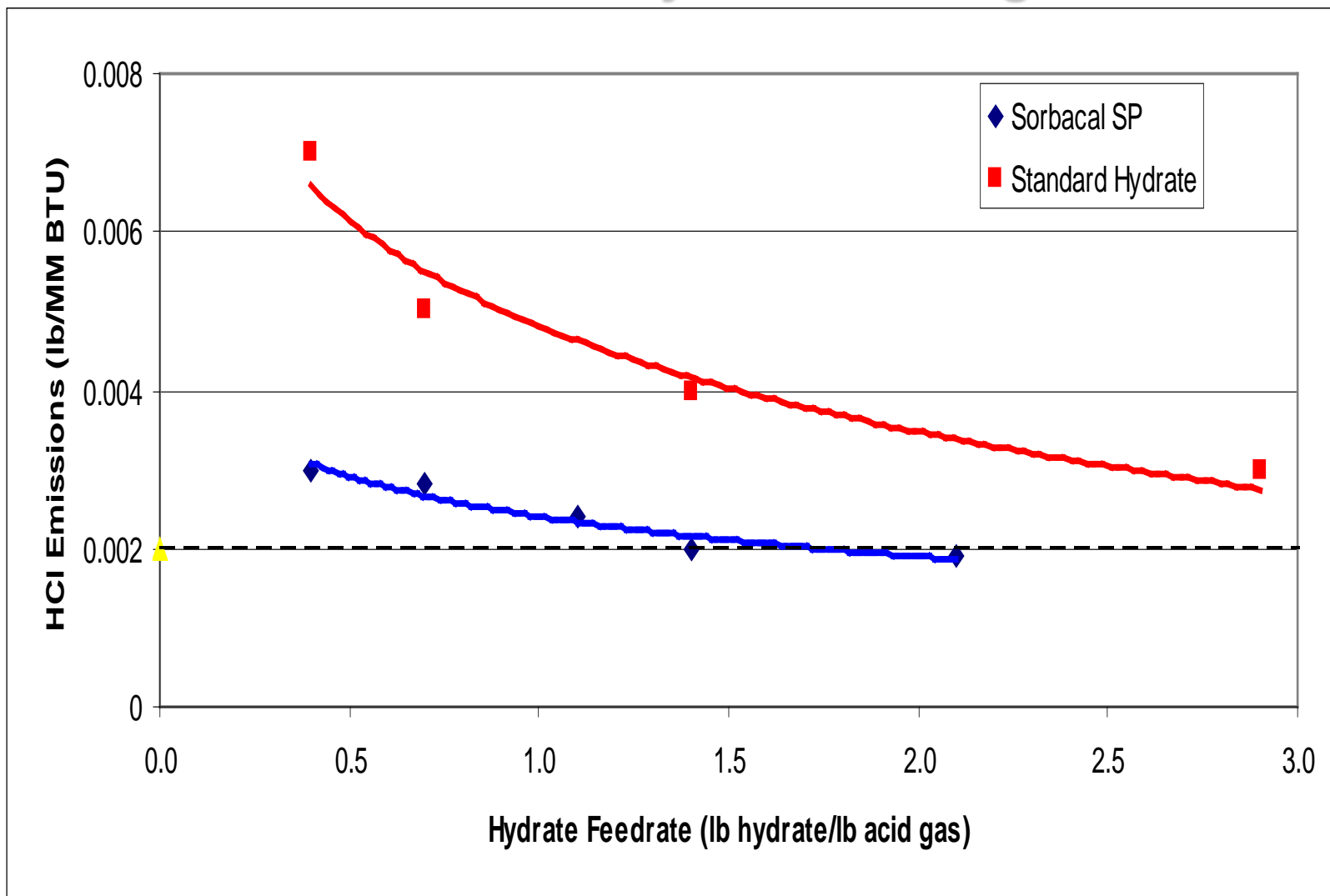


HCl Removal Coal Fired Boiler High Cl Coal - 650°F Injection T - ESP





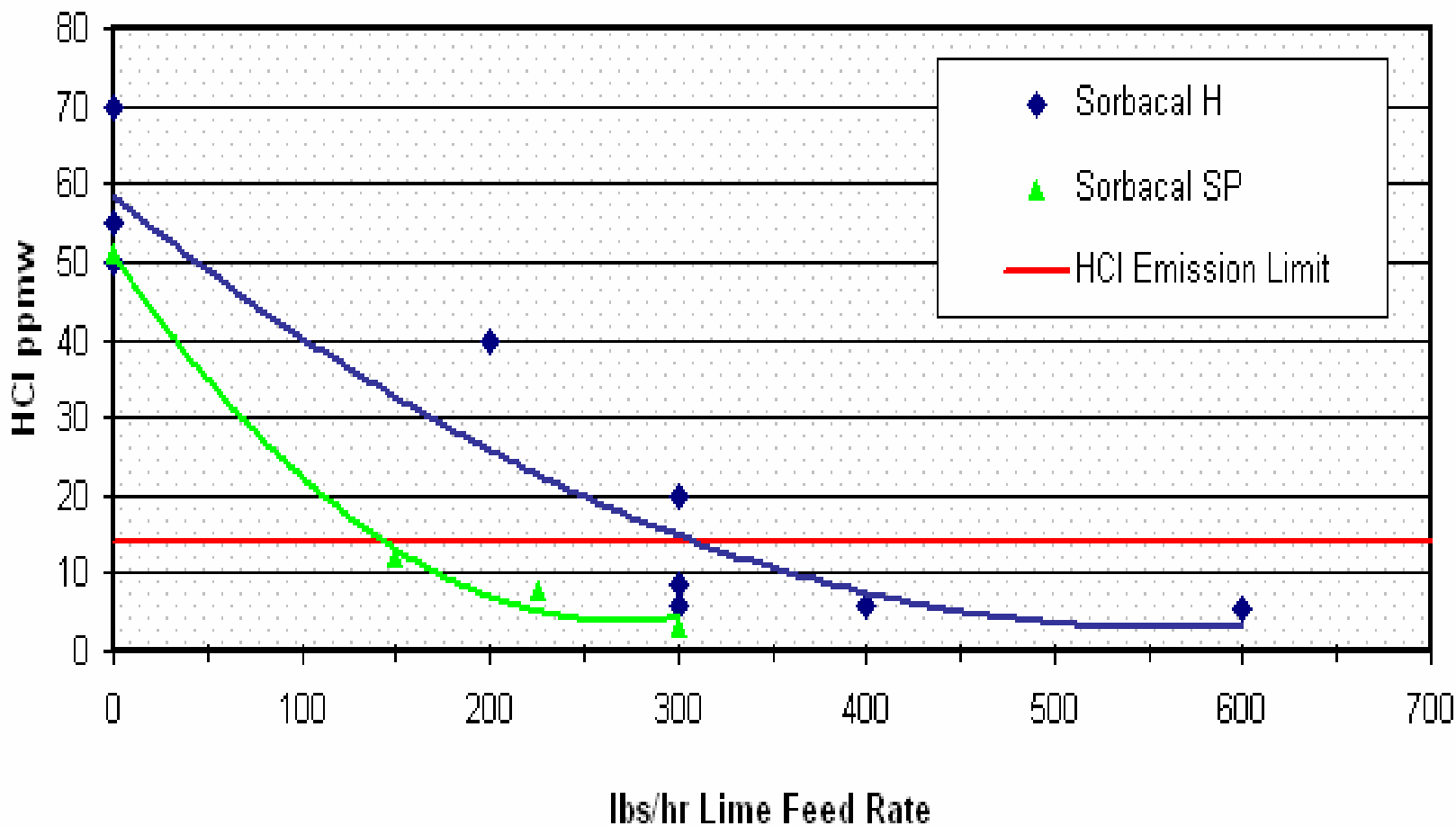
HCl Emissions Coal Fired Boiler Medium CI Coal – 650°F Injection T - Baghouse





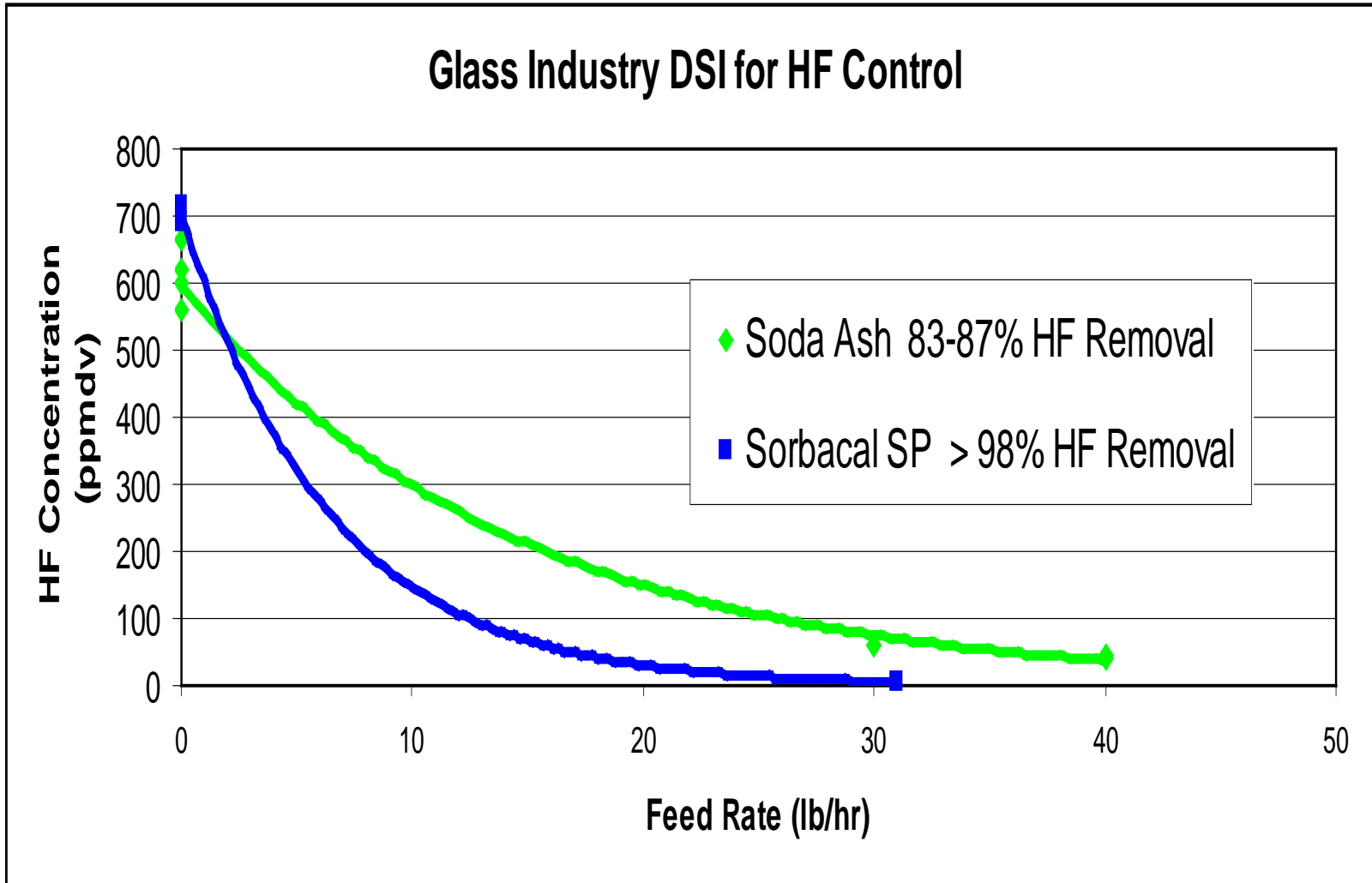
HCl Emissions Industrial Boiler 380°F Injection T - Baghouse

HCl Emissions



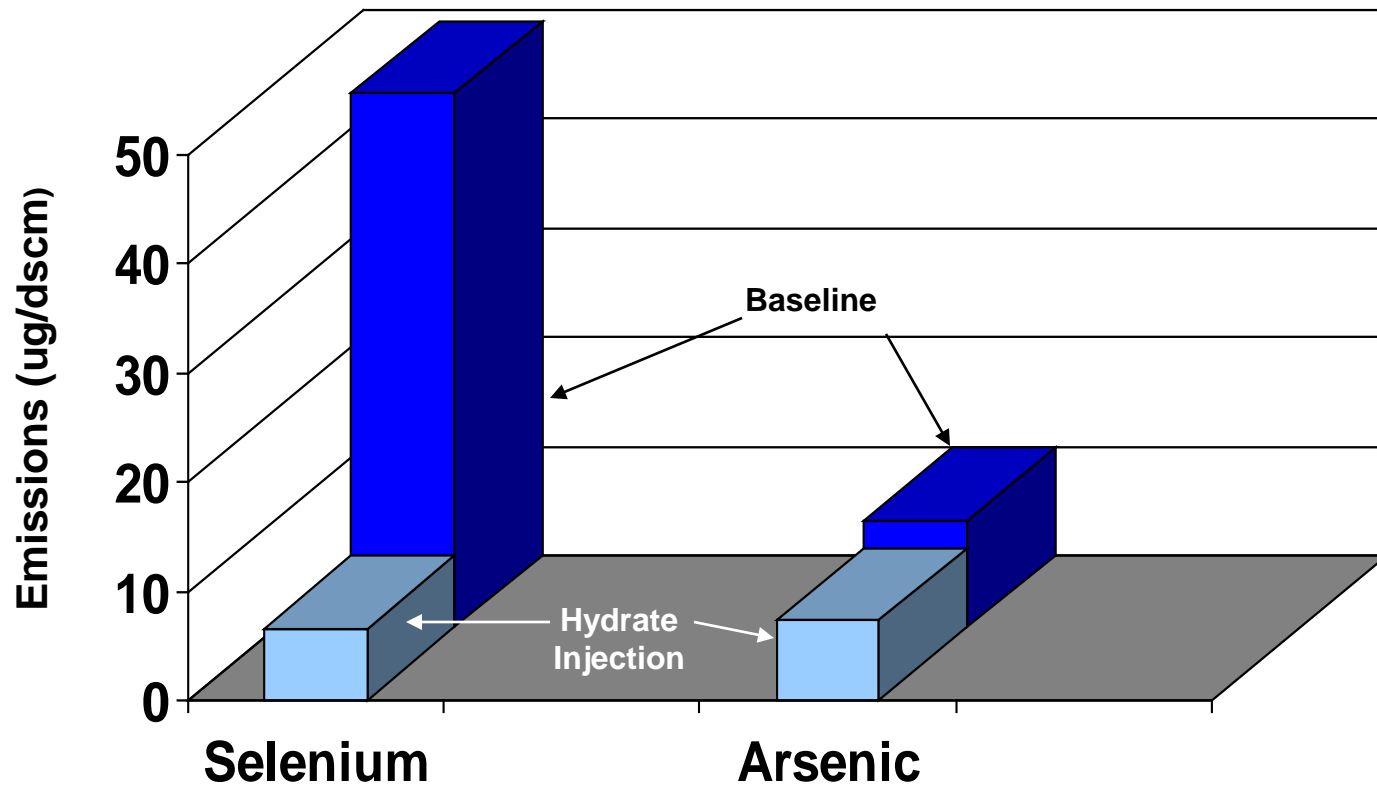


HF Emissions Glass Industry Comparison with Soda Ash





Selenium and Arsenic Vapor Emissions Sorbacal® SP DSI at APH Outlet for HCl



Arsenic Vapor Emissions at 600°C with Hydrated Lime DSI

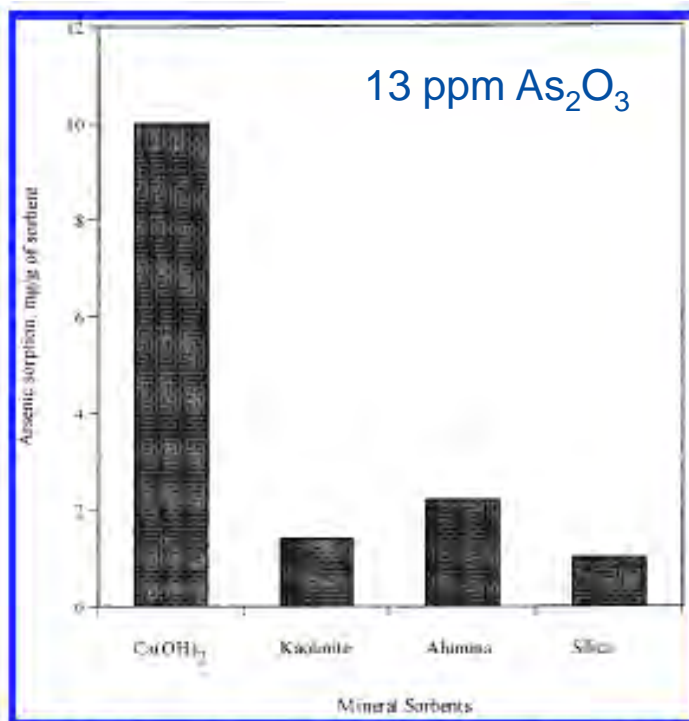


FIGURE 2. Amount of arsenic captured by various sorbents. As_2O_3 gas-phase concentration, 13 ppm; sorption temperature, 600 °C; sorption time, 1 h.

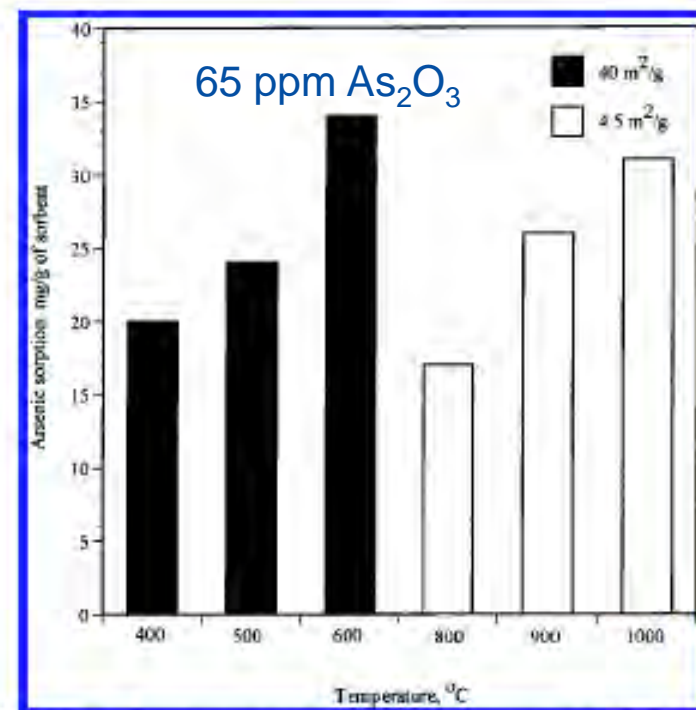


FIGURE 3. Arsenic uptake by $Ca(OH)_2$ sorbent in 1 h. As_2O_3 gas-phase concentration, 65 ppm.

Mechanism of Arsenic Sorption by Hydrated Lime, S. Mahuli, R. Agnihotri, S. Chaulk, A. Ghosh-Dastidar, and L. S. Fan, Dept. of Chemical Eng, Ohio State Univ., Environ. Sci. Technol. 1997, 31, 3226-3231



Effects of Hydrated Lime DSI on the Fly Ash





Method 29 – Collected Flue Gas Metals

Metal Species	Baseline (ug/dscm)	Hydrate Injection (ug/dscm)	Change (ug/dscm)	Change (%)
Beryllium	1.031	0.318	0.713	69.16
Chromium	9.31	2.898	6.412	68.87
Manganese	12.91	33.07	-20.16	-156.16
Cobalt	2.538	2.583	-0.045	-1.77
Nickel	12.57	10.72	1.85	14.72
Copper	10.1	10.01	0.09	0.89
Zinc	37.45	34.73	2.72	7.26
Arsenic	9.956	7.305	2.651	26.63
Selenium	49.03	6.653	42.377	86.43
Silver	0.062	0.075	-0.013	-20.97
Cadmium	0.692	1.232	-0.54	-78.03
Antimony	0.719	0.63	0.089	12.38
Barium	19.23	11.02	8.21	42.69
Thallium	0.812	1.045	-0.233	-28.69
Lead	24.17	13.18	10.99	45.47





Collected Ash Metals Data

Metal Species	Baseline (ug/g)	Injection (ug/g)	Change (ug/g)	Change (%)
Beryllium	9.7	5.2	4.5	46.39
Chromium	123	96.5	26.5	21.54
Manganese	185	264	-79	-42.70
Cobalt	28.5	26.5	2	7.02
Nickel	110.5	105	5.5	4.98
Copper	70.5	75.5	-5	-7.09
Zinc	197.5	172	25.5	12.91
Arsenic	37	46	-9	-24.32
Selenium	12.1	18	-5.9	-48.76
Silver	0.34	0.3	0.04	11.76
Cadmium	1.68	1.26	0.42	25.00
Antimony	4.26	4.52	-0.26	-6.10
Barium	11.7	fault	n/a	n/a
Mercury	0.27	0.21	0.06	22.22
Thallim	5.37	3.9	1.47	27.37
Lead	145	61	84	57.93





Leached Metals by TCLP Analysis

Leached Metal	Reg. Limit (ppm)	Baseline (ppm)	w/ Hydrate (ppm)
Chromium	5	0.024	<0.005
Arsenic	5	<0.005	0.008
Selenium	1	0.054	0.096
Silver	5	<0.005	<0.005
Cadmium	1	<0.005	<0.005
Barium	100	0.477	0.225
Mercury	0.2	0.011	0.013
Lead	5	0.07	<0.005

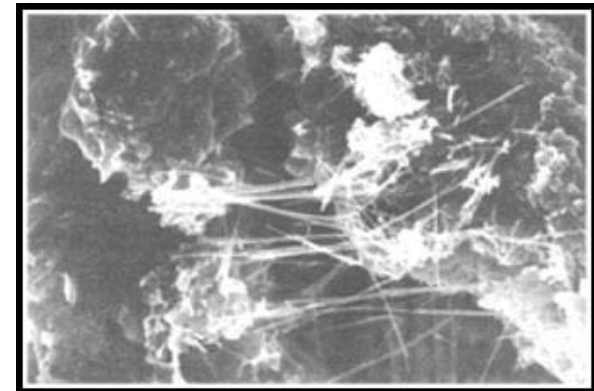
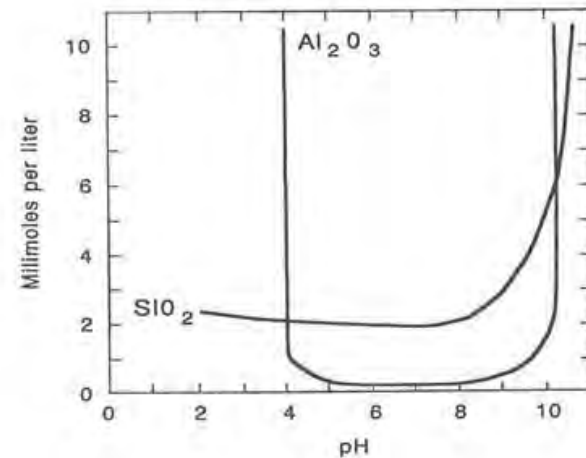




Chemical Reactions for Lime Stabilization of Fly Ash

CaO from the Lime combines with the SiO_2 and Al_2O_3 in coal ash and water (H_2O) to form cementitious C-S-H and C-A-H compounds.

- Hydroxyl ions (OH^-) elevate pH to range of 11 to 12
- SiO_2 and Al_2O_3 become soluble above pH 10
 - SiO_2 reacts with Ca to form C-S-H
 - Al_2O_3 reacts with Ca to form C-A-H
- Cementitious products agglomerate to form stable matrices
 - Strength continues to increase for months/years



Growth of cementitious crystals in stabilized clay sample





Conclusions

- ✓ Advances in DSI technology and reagent properties are driving acid gas performance to levels previously never imagined
 - SO₂ removals of >95% were demonstrated
 - HCl removals of ~99% were demonstrated
 - SO₃ performance improved by ~30%
 - HF emission reductions >98% were demonstrated
 - Gas phase Se and As can be captured
- ✓ Ancillary impacts of DSI technology must be considered
- ✓ Effects of Hydrate Lime DSI on fly ash can be positive
- ✓ Adoption of DSI technology as primary compliance strategy is likely to continue





Sorbacal®

Solutions for AIR, LAND, and WATER

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