New Developments in Power Plant Air Pollution Control – Advances in Dry Sorbent Injection (DSI) Reagents

Sorbacal®

Lhoist

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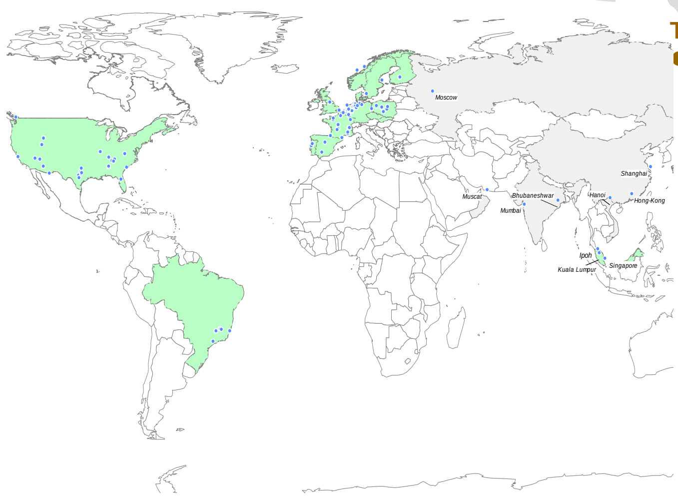
For McIlvaine Hot Topic Hour
July 11, 2013

Agenda

- Drivers for DSI
  - Regulatory
  - Operational
- DSI Basics
  - Chemistry
  - Effectiveness factors
  - Optimized $Ca(OH)_2$ DSI reagent results
- Other Impacts of DSI to consider
  - DSI reagent impacts on CCRs
  - DSI impacts on other air emissions

Lhoist Group and LNA Operations

Plants	15
Chem Limestone Plants	7
Clay Plant	1
Hydrating Plants	5
Stand alone Quarry	3
Terminals	34



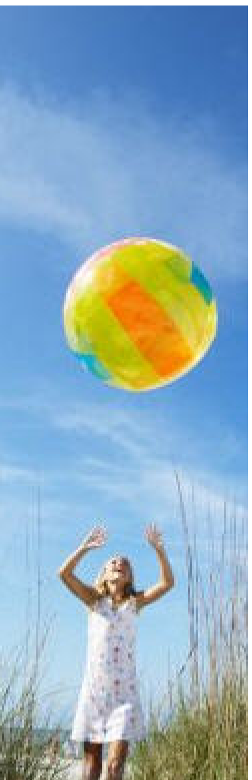
History of DSI

- Sodium and calcium dry injection testing done in 70's & 80's
- LIMB project – calcium products
  - Major R&D project from 1988 – 1992
  - Demonstrated SO_2 control capability of approx. 50%-60%
  - Too low to compete with FGD scrubbers
- LNA pioneered use of calcium DSI for utility SO_3 control at TVA Widows Creek in 2004
  - Much more effective for aggressive acid gases (SO_3, HCl, HF)
  - Demonstrated control capability in excess of 95%
  - Dry sodium injection also resurrected for SO_3 control
- Over 15 years of data on use of advanced hydrated lime for HCl control in Europe in MSW incineration applications
  - Demonstrated to capture over 98% of HCl in MSW acid gas control applications – gaining of data on utility HCl control
- Status of DSI for incremental SO_2 control
  - Perceived limits of calcium reagents overcome with optimized reagents and high temp injection

Current DSI Drivers

- Low capital cost acid gas control technology
- Advances in DSI reagents
  - Sodium based
  - Calcium based
- Both sodium and calcium now in wide use for SO_3
- Regulatory drivers evolving
  - SO_3
  - HCl for MATS
  - Incremental SO_2 control
  - Process water rule making efforts
- Use expected to expand as new rules come into play
- EPA 2011 IPM model estimates 56 GW of DSI for MATS
- Operational benefits now recognized
  - Duct corrosion minimized
  - ABS formation reduced

Basic DSI Reactions
Calcium and Sodium



Calcium Hydroxide acid gas capture reactions

$$Ca(OH)_2 + SO_2 + .5O_2 \longrightarrow CaSO_4 + H_2O$$

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

Trona acid gas capture reactions

$$2(Na_2CO_3\ .NaHCO_3.H_2O) + 3SO_2 \longrightarrow 3Na_2SO_3 + 4CO_2 + 5H_2O$$

Secondary sulfate capture reaction is as follows:

$$3Na_2SO_3 + 1.5O_2 \longrightarrow 3Na_2SO_4$$

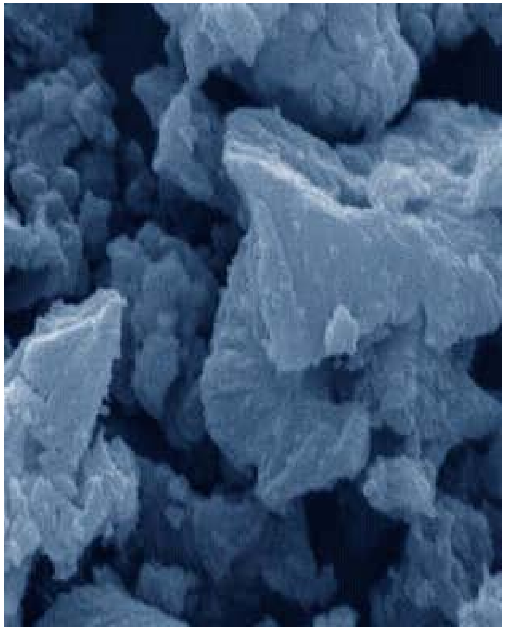
The basic chloride capture mechanism for sodium reagents is as follows [1]:

$$Na_2CO_3\ .NaHCO_3.H_2O + 3HCl \longrightarrow 3NaCl + 2CO_2 + 4H_2O$$

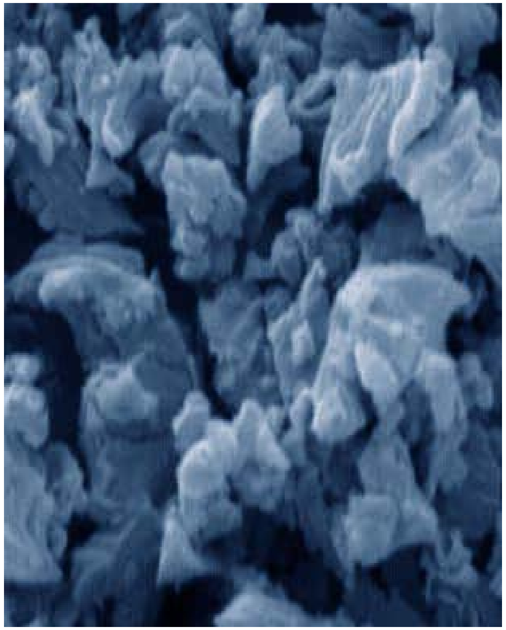
DSI System Effectiveness Factors

- Flue Gas Properties
  - Temperature
  - Flue gas moisture
  - Competing acid gases (SO_3, HCl, HF and SO_2)
- **Reagent Properties – physical and chemical**
  - Relative reagent reactivity
  - Reagent surface area
  - Reagent porosity
- Injection System Configuration
  - Particulate control device
  - In flight residence time
  - Reagent mixing
  - Injection location

Reagent reactivity considerations



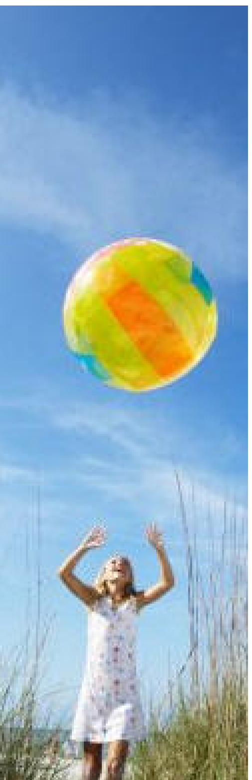
Standard
Hydrated lime

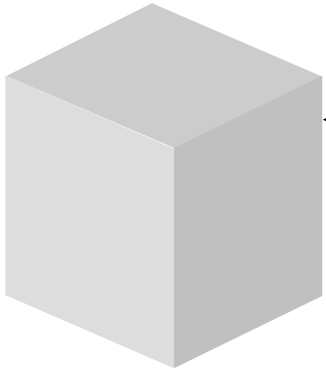


Sorbacal® H

Sorbacal® SP

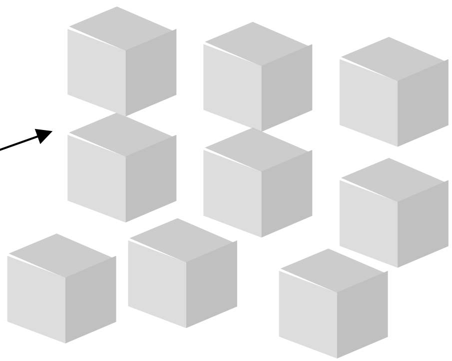
Calcium Hydroxide Physical Properties

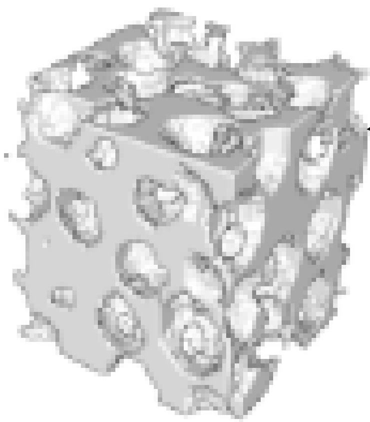




Standard Hydrate
- SSA 15 - 18 m²/g (BET)

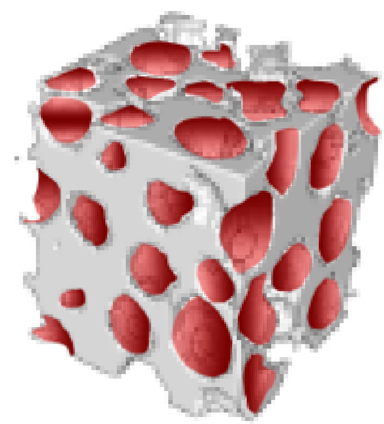
Sorbacal® H :
-SSA 17 - 22 m²/g (BET)



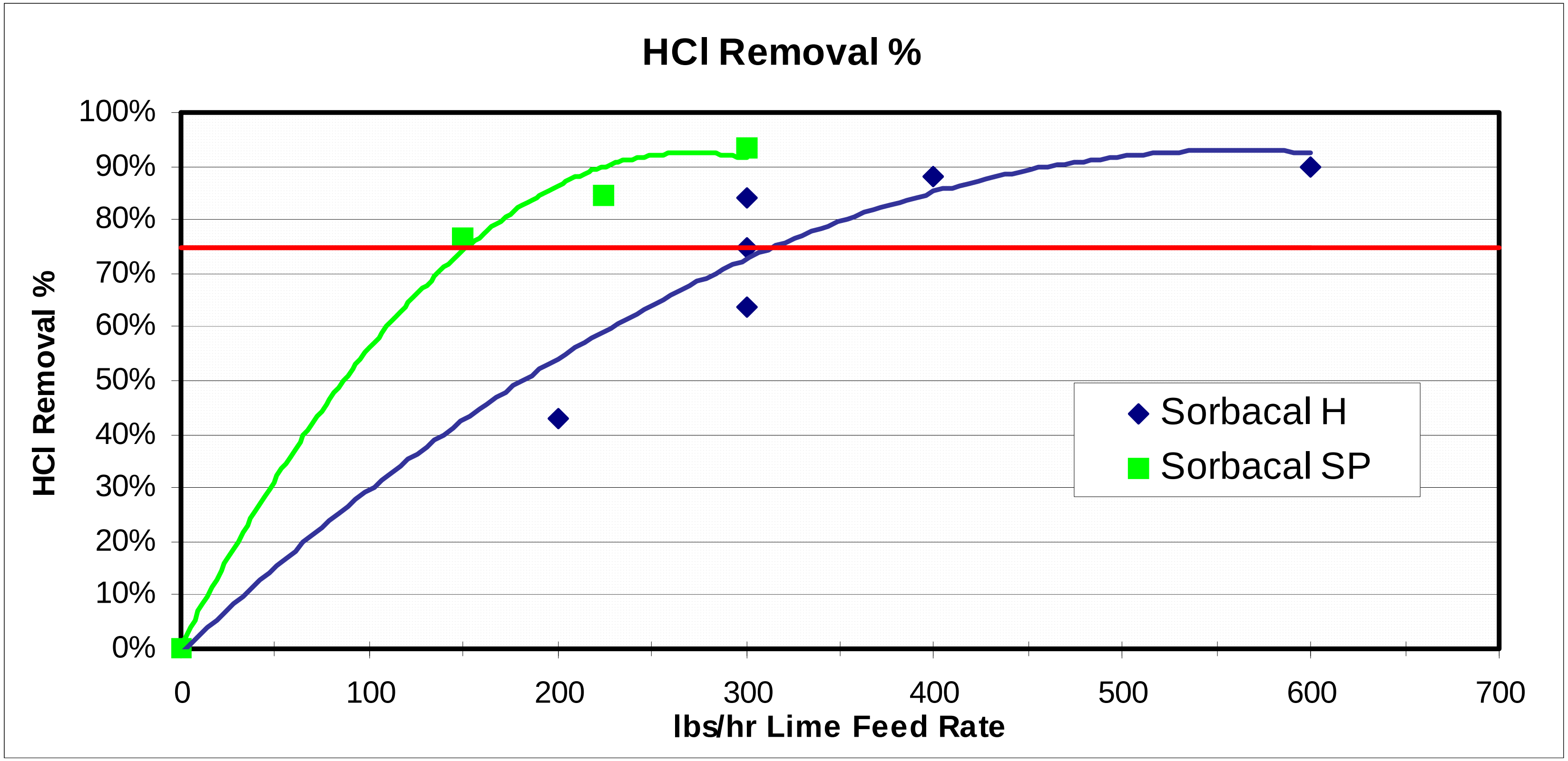


Sorbacal® SP :
- High SSA > 40 m²/g (BET)
- Large Pore Volume

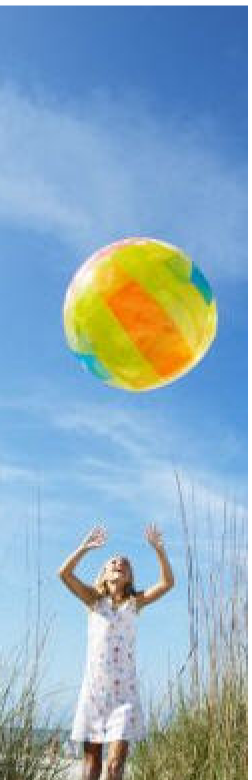
Sorbacal® SPS :
- Activated Sorbacal® SP to improve its SOx removal performances

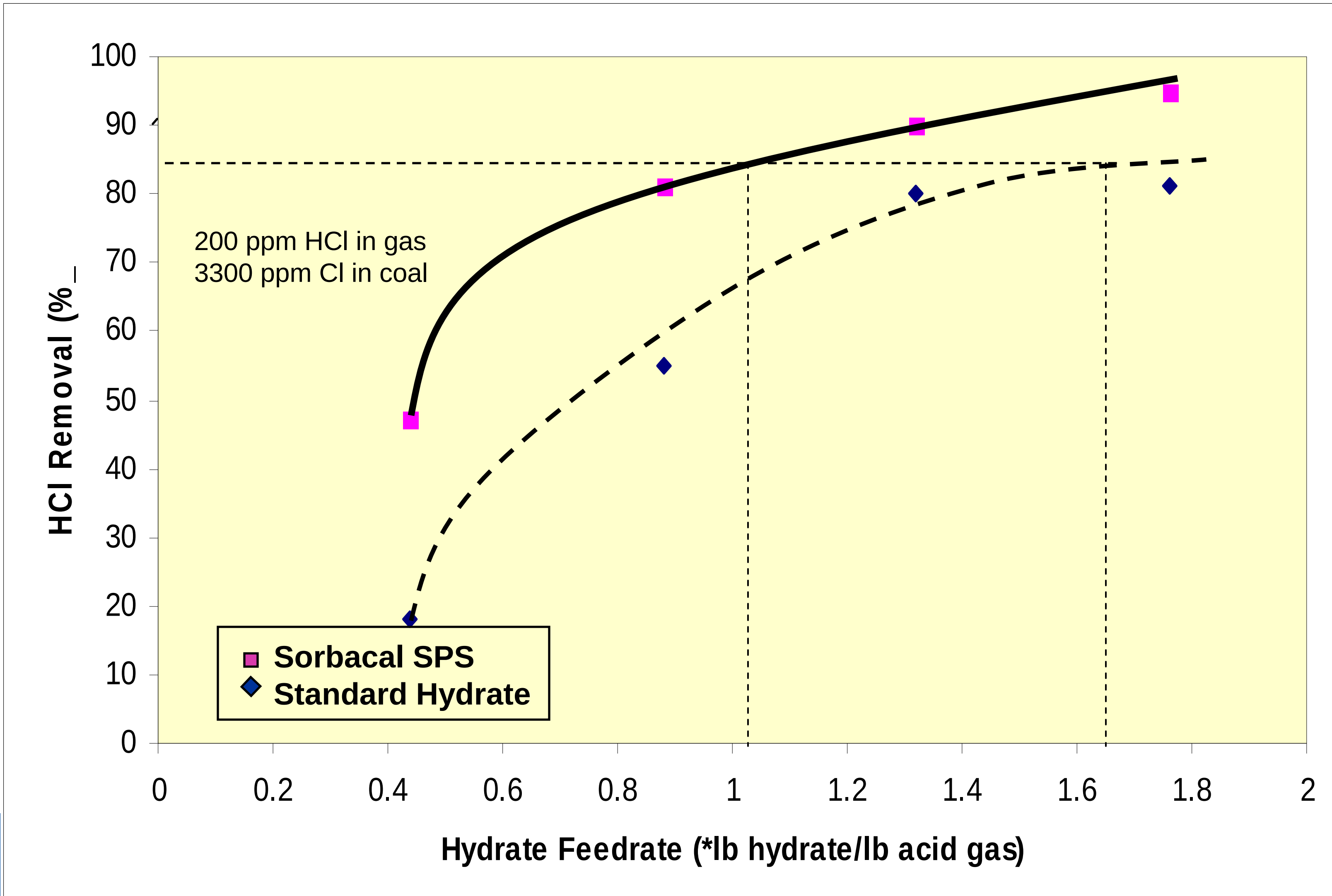


HCl Capture with baghouse (Industrial)

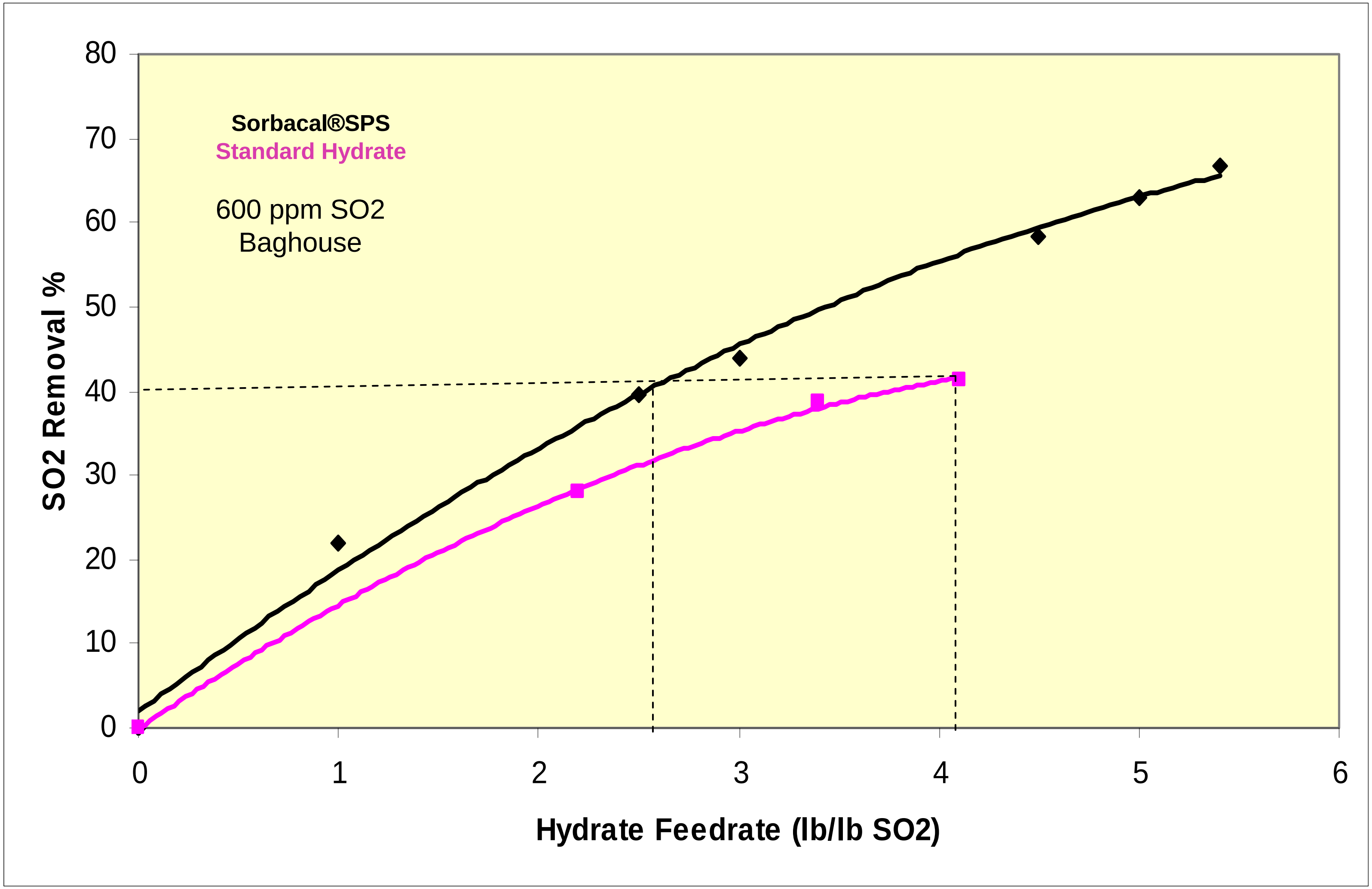


HCl Capture with ESP (utility)





SO_2 Removal
@ Air Heater Inlet T



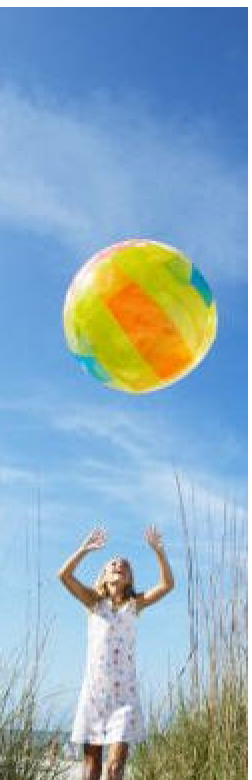
Ancillary DSI Considerations

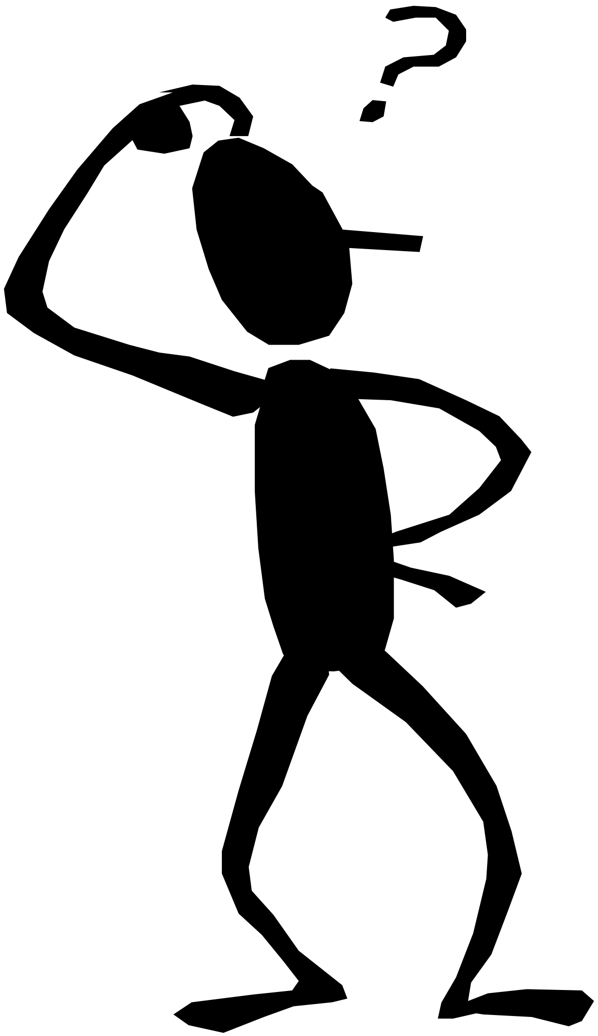
- Impact of DSI reagent on CCRs should be considered
  - Metals capture and leachability
  - Impact on total dissolved solids (TDS)
- Impact on other air pollutants
  - Generally accepted that removing SO_3 in advance of ACI injection can improve ACI performance
  - Sodium DSI reagents have potential to catalyze NOx compounds to NO_2, which can compete with Hg for ACI
  - Calcium hydroxide DSI reagents can negatively impact resistivity of ESP systems
- Especially important to understand ancillary impacts as more reagent is utilized to capture HCl and SO_2
  - Optimized reagents can minimize impacts

Conclusions

- DSI is relatively low capital option for addressing new air emissions rules
- Improvements in DSI reagent properties have dramatically improved acid gas capture capability of DSI reagents
- Ancillary impacts of DSI on CCRs and other air emissions must be considered
- Case by case DSI efficacy can vary dramatically therefore - field trials recommended

Questions?





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