SORBACAL® SPS - CHANGING PERCEPTIONS ON HYDRATED LIME FOR SO_2 REMOVAL AND ESP IMPACTS

APC-Wastewater Round Table/PCUG
July 2016

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Lhoist North America

AGENDA

LNA FGT Solutions Team

SO_2 Control Observed at Completed Trials

ESP Operations & Performance Data During Sorbacal® SPS Injection Trials

Trace Metal Capture with Hydrated Lime

Summary and Questions

LNA FGT Solutions Team

FGT Solutions Team Capabilities

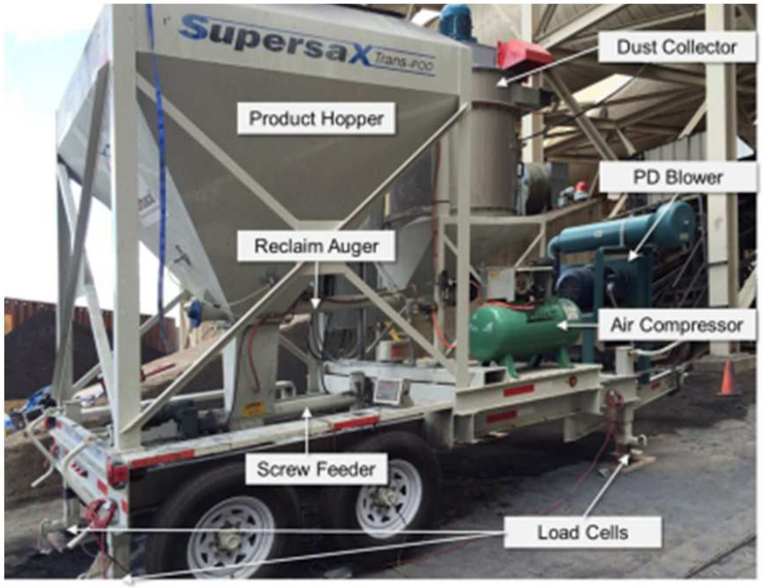
- **Five senior-level, technically-experienced DSI professionals**
  - ❑ Chemistry
  - ❑ Pneumatic Transport
  - ❑ Technology Applications Expertise
  - ❑ APC Systems Expertise
- **Support services for customers and applications**
  - Analytical laboratory
  - Inventory control - supply chain management
  - Process optimization - cost and performance improvements
- **R & D Laboratory support for calcium-based emission control solutions**
- **FGT Field Support Services**

FGT Field Support Services

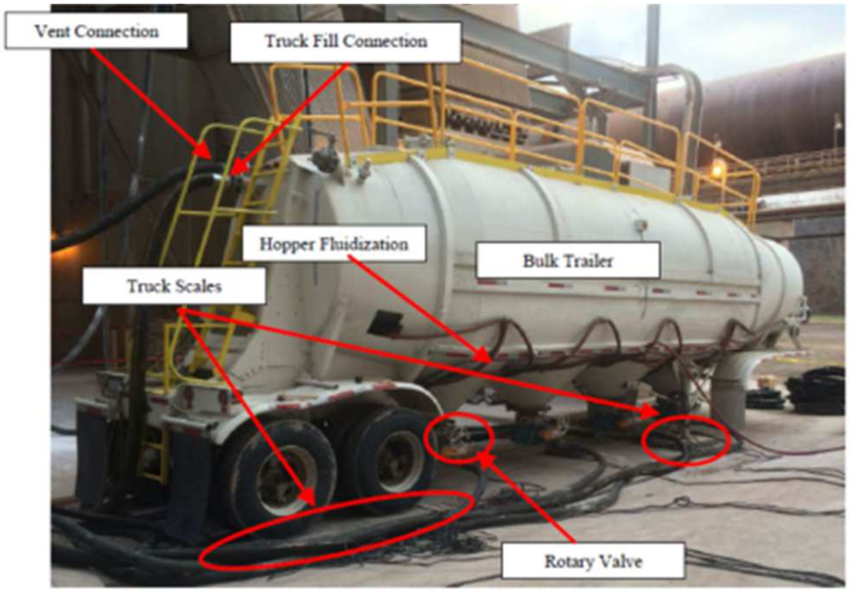
- **FTIR Flue Gas Analyzers**
  - LNA has a mobile lab
  - Two MKS FTIR flue gas analyzers
    - monitor emissions (SO_2, HCl, HF, flue gas moisture, etc.)
    - Experienced personnel to set-up, operate FTIR
- **Method 30B STM Console**

FGT Field Support Services

> ## Injection equipment
> - Supersax Trans POD System - 30 lb/hr to 1,000 lb/hr
> - Bulk Pneumatic Feed System – 1,600 lb/hr to 14,000 lb/hr



Supersax Feed System



DSI Bulk Feed System

LNA FGT Solutions Team

The LNA FGT Solutions Team works with customers to achieve the best DSI and to optimize sorbent consumption:

- Assistance with sorbent evaluation activities,
- Access to the analytical resources of our Irving, TX laboratory, and
- Offer emissions and system performance diagnostics and troubleshooting via two (2) in-house, field-deployable FTIRs

SO_2 Control Observed at Completed Trials

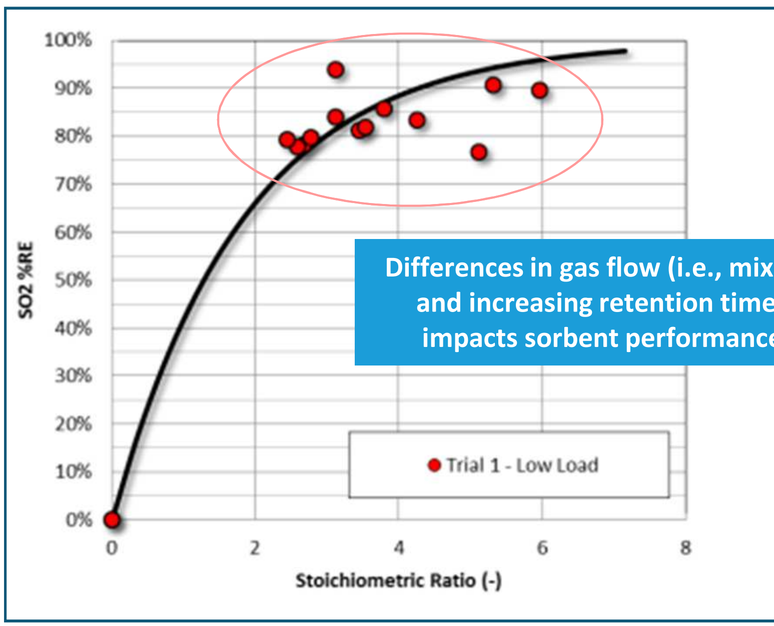
Sorbacal® SPS –
SO_2 Control at Recent Trials

- **SO_2 emissions control at PRB-fueled EGUs**
  - Three (3) recent tests, units configured with ESPs
  - Units capacity between 180Mw and 250Mw
  - Fuel load and Low load scenarios evaluated
- **Contrast low load v high load performance**
  - Variation in effectiveness as a function of unit load
  - Variations in gas flow (mixing) and increasing retention times
  - Meaningful cost savings/operational strategies
- **Inject Sorbacal® SPS upstream of the APH for SO_2 control**

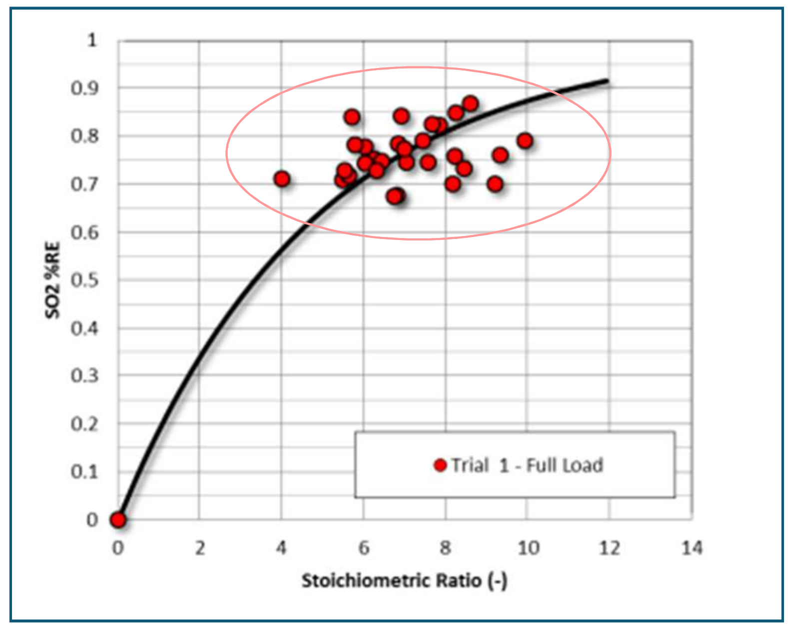
Utility EGU Trial 1

Unit Description

Unit Capacity (MWg)	190
Full Load Heat Input (MMBtu/hr)	1,800
Inlet SO2 (lb/MMBtu)	0.78
Target SO2 Removal	73%
Low Load Sorbent Usage (lb/hr)	1240
Full Load Sorbent Usage (lb/hr)	5864



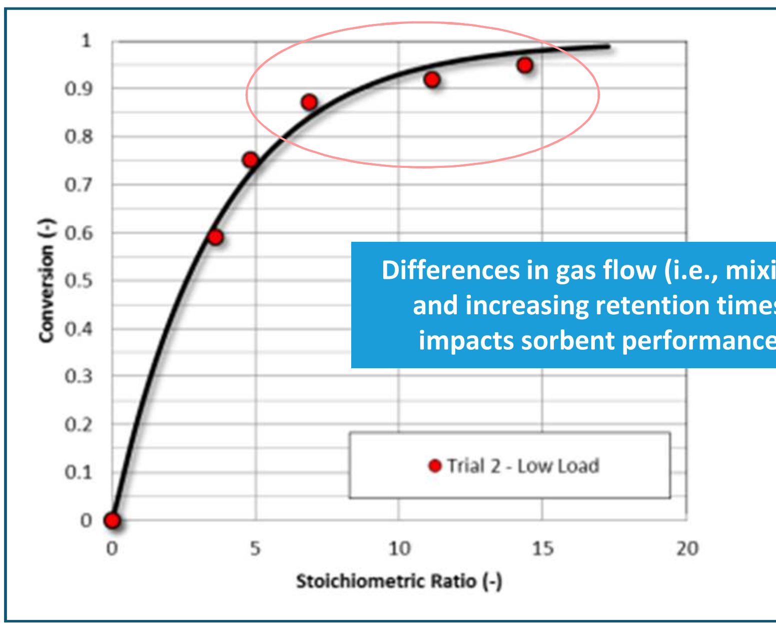
Differences in gas flow (i.e., mixing) and increasing retention times impacts sorbent performance



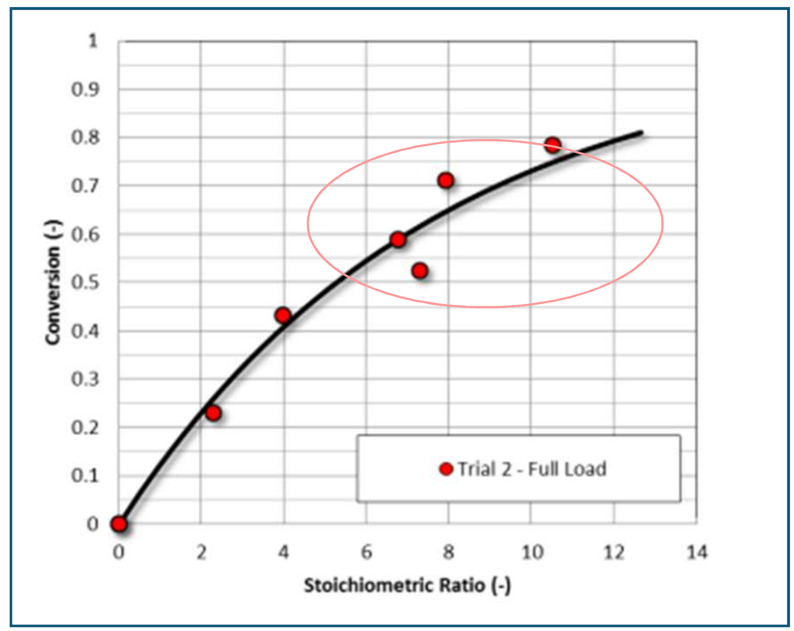
Utility EGU Trial 2

Unit Description

Unit Capacity (MWg)	**530**
Full Load Heat Input (MMBtu/hr)	**5,600**
Inlet SO2 (lb/MMBtu)	**0.41**
Target SO2 Removal	**62%**
Low Load Sorbent Usage (lb/hr)	**5,659**
Full Load Sorbent Usage (lb/hr)	**23,103**



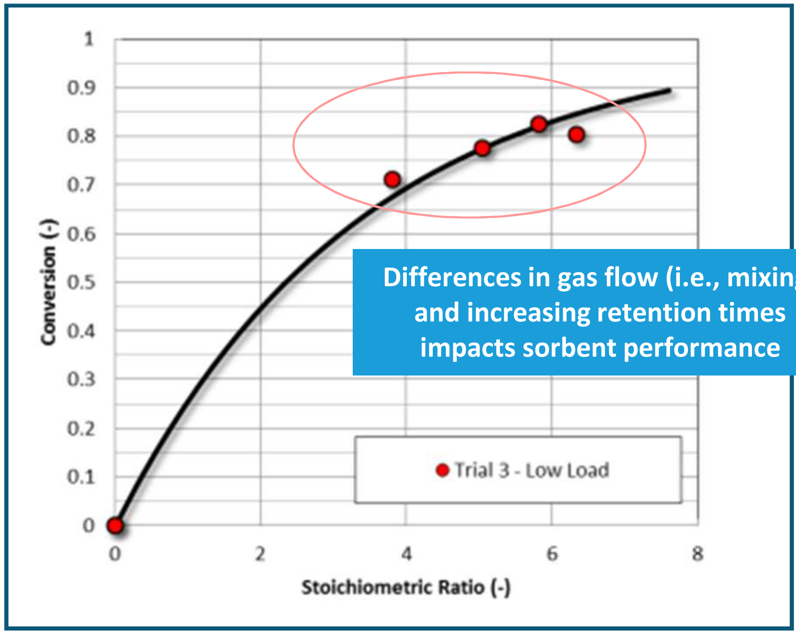
Differences in gas flow (i.e., mixing) and increasing retention times impacts sorbent performance



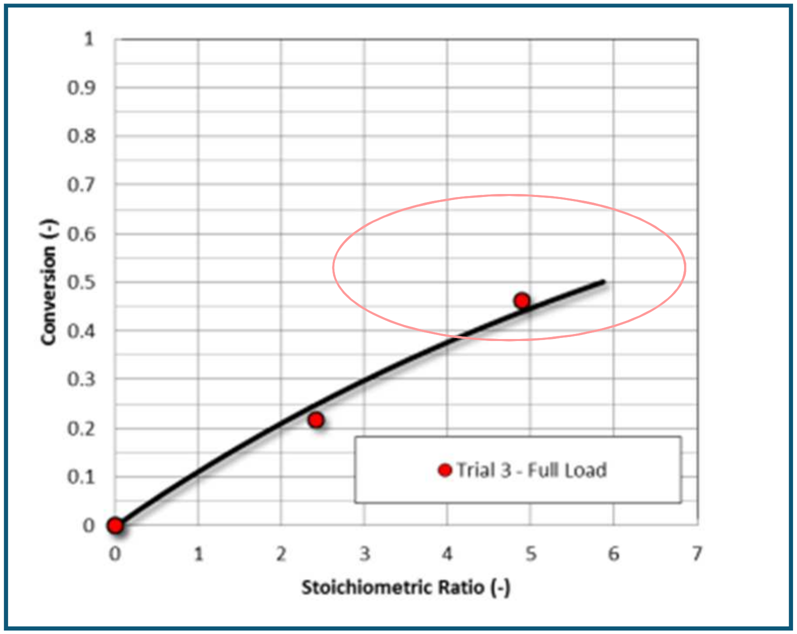
Utility EGU Trial 3

Unit Description

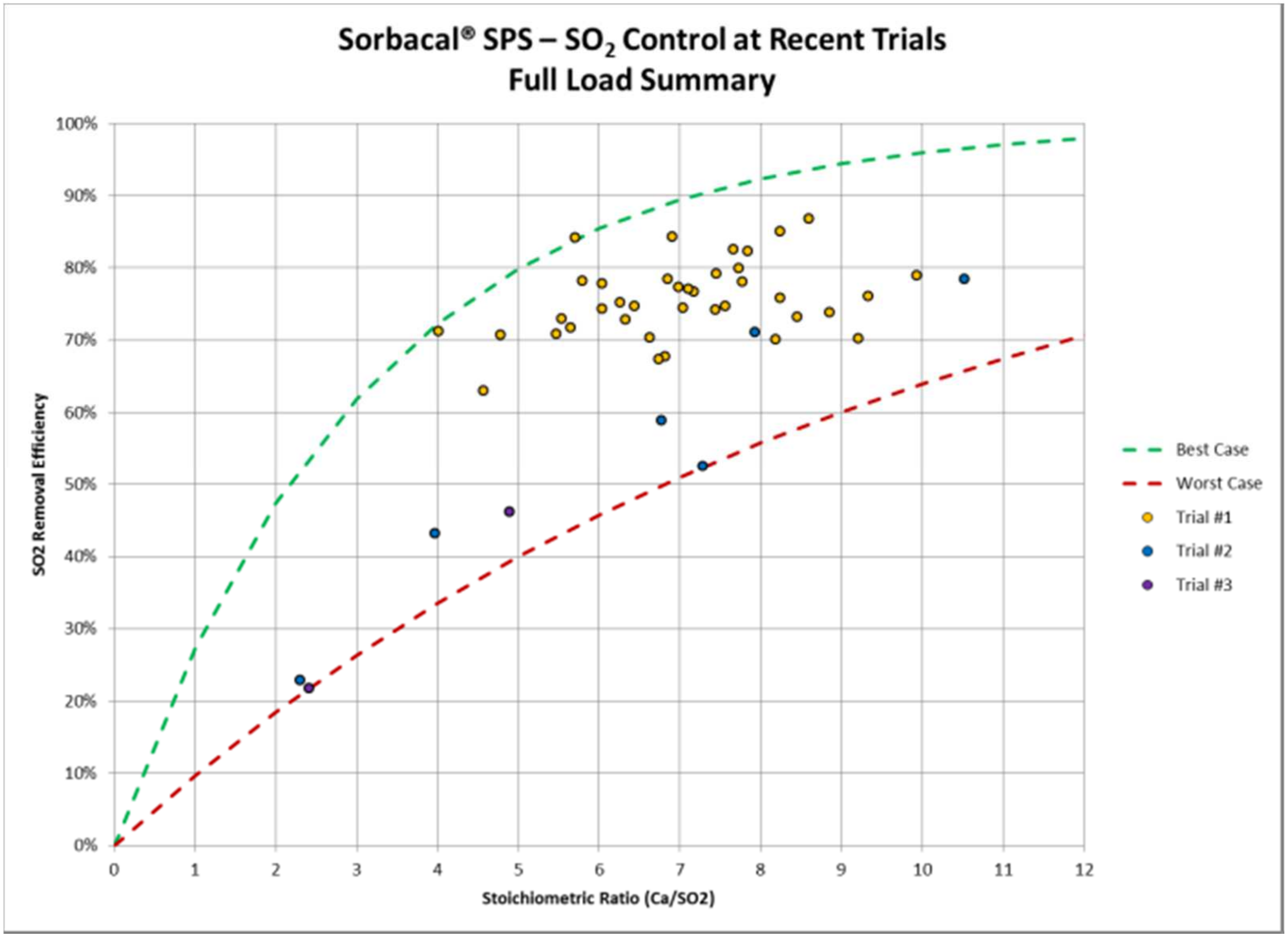
Unit Capacity (MWg)	185
Full Load Heat Input (MMBtu/hr)	1924
Inlet SO2 (lb/MMBtu)	0.35
Target SO2 Removal	54%
Low Load Sorbent Usage (lb/hr)	1,087
Full Load Sorbent Usage (lb/hr)	6,412



Differences in gas flow (i.e., mixing) and increasing retention times impacts sorbent performance



Sorbacal® SPS - Recent Trial Summary



Comparison to Trona??

Meaningful cost savings/operational strategies

Extracted from Trial 1 data

Unit Description

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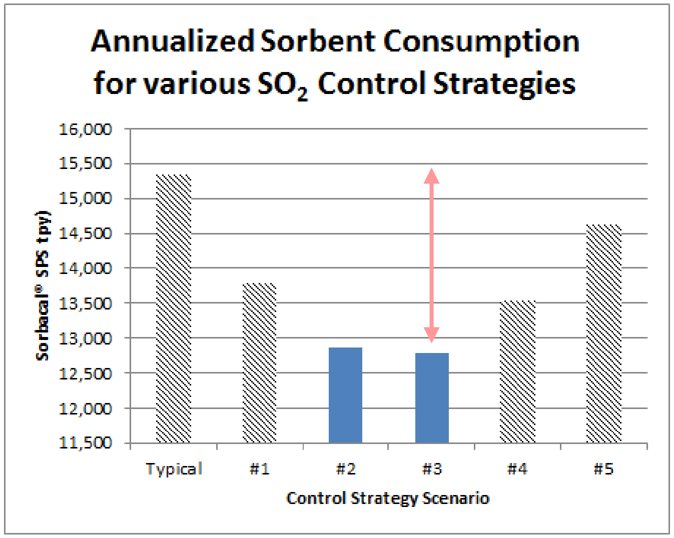
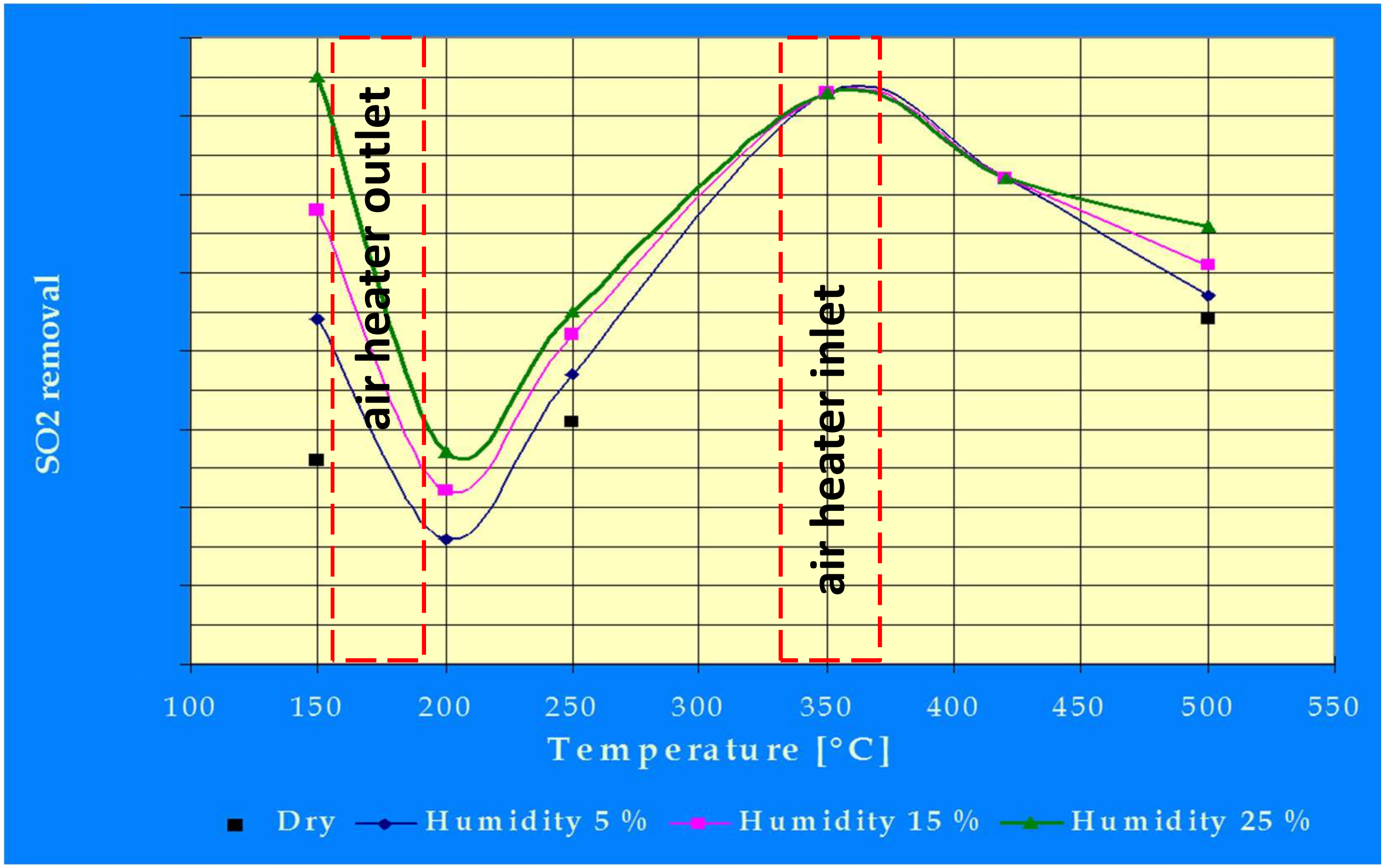
Control	Emissions Profile			Sorbent Injection Profile			
Strategy	Low Load SO2	Full Load SO2	Average SO2	Low Load MR	Full Load SPS	Annual Usage	Usage Reduction
Scenario	lb/MMBtu			lb/lb	lb/lb	tons	pct
Typical	0.16	0.16	0.16	2.93	7.82	15,346	-
#1	0.12	0.2	0.16	3.57	6.50	13,790	10.14%
#2	0.08	0.24	0.16	4.47	5.42	12,865	**16.17%**
#3	0.04	0.28	0.16	6.01	4.51	12,793	**16.64%**
#4	0.02	0.3	0.16	7.55	4.10	13,536	11.79%
#5	0.01	0.31	0.16	9.08	3.91	14,627	4.68%



The advantages presented at off-peak operations can yield significant cost savings

Sorbacal® SPS – The Importance of Injection Location for SO_2 control



ESP Operations & Performance with Sorbacal® SPS

Sorbacal® SPS Hydrated Lime

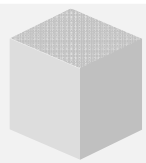
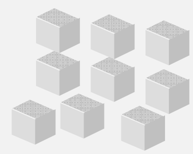
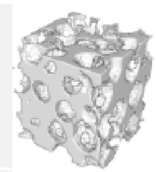
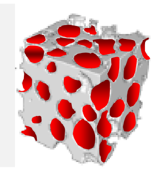
What makes **Sorbacal® SPS** products different?

Sorbacal® SPS	Standard Hydrated Lime
Specific Surface Area: ≥40 m^2/g	Specific Surface Area: 20 m^2/g
Porosity: ~0.23 cm^3/g	Porosity: ~0.07 cm^3/g
D_{50}: 8-12 µm	D_{50}: 3-6 µm

… the physical properties

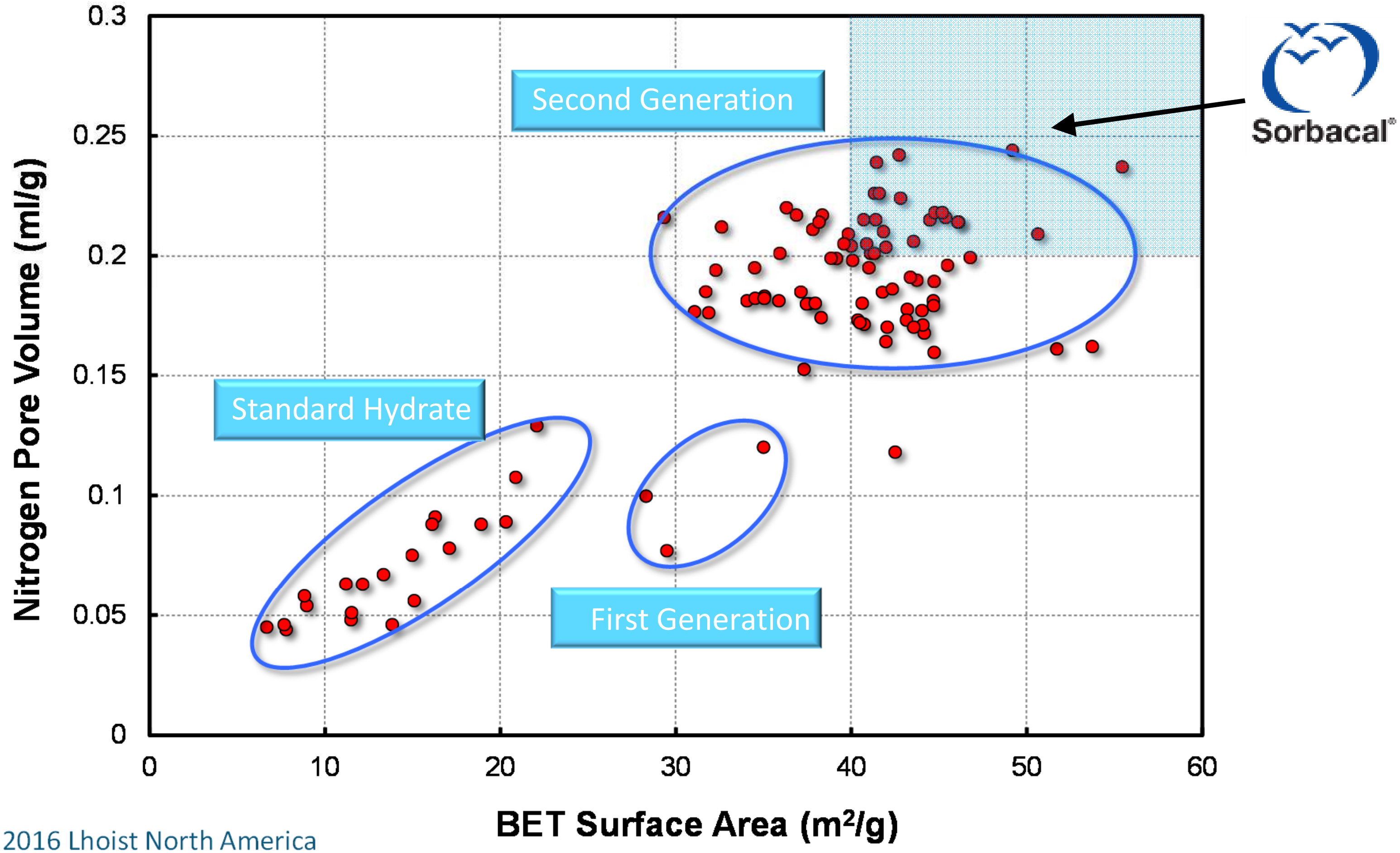
Sorbacal®

The Evolution of High Performance Products

Sorbent	Standard Hydrated Lime	Sorbacal® H	Sorbacal® SP	Sorbacal® SPS
Figure				
Typical Available $Ca(OH)_2$ [%]	92 – 95	93	93	93
Typical Surface Area [m^2/g]	14 – 18	> 20	~40	~40
Typical Pore Volume [cm^3/g]	~0.07	0.08	~0.20	~0.20

Sorbacal® -
Evolution of High Performance Products

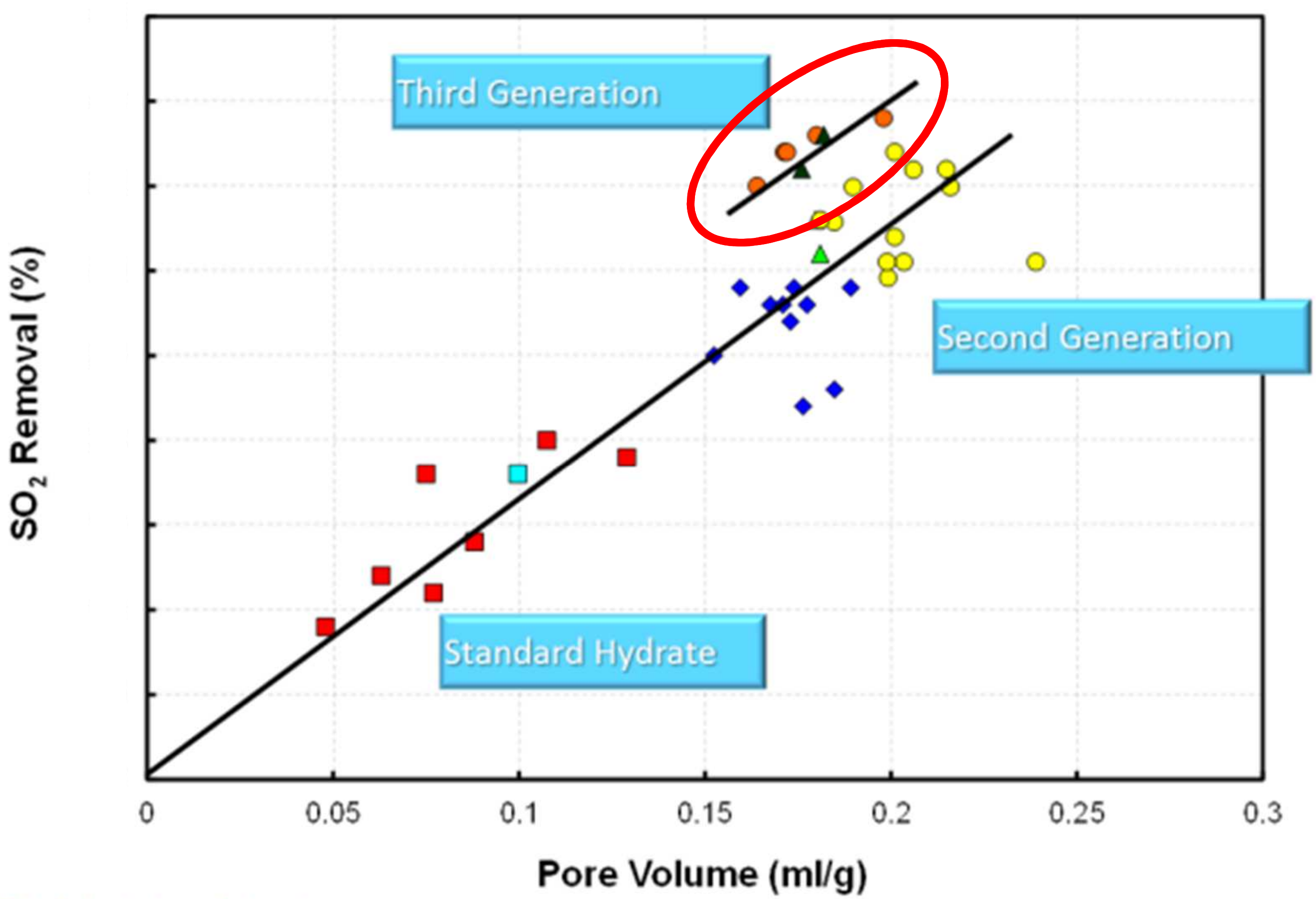
Surface Area and Pore Volume Development



Reactivity Property Relationships

Pore Volume and Lab Scale Activity Test

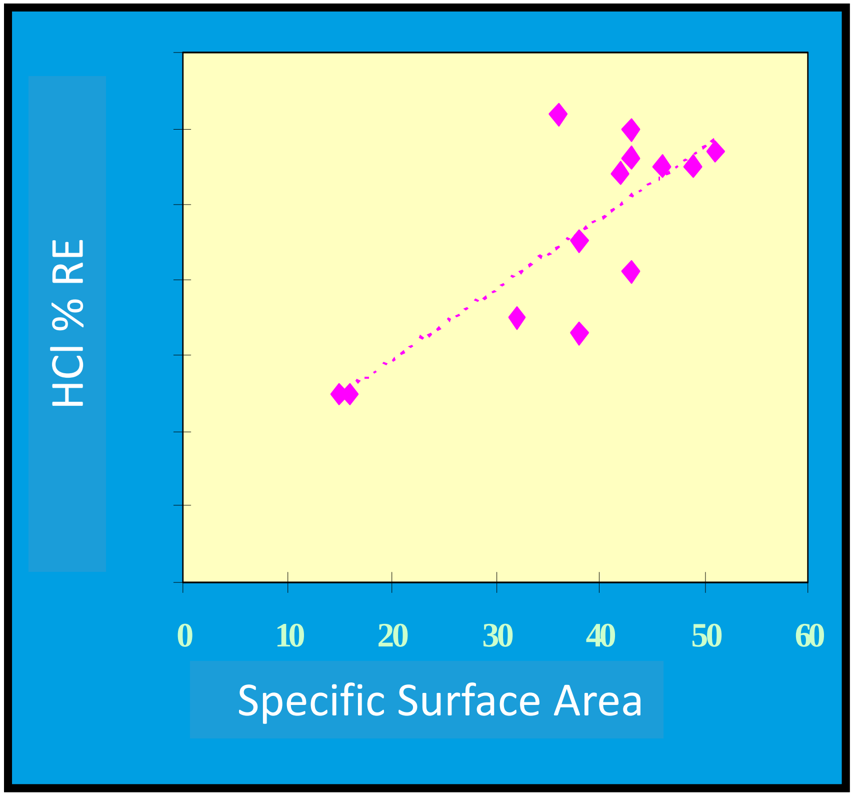
Linear relationship between activity and pore volume, SO_2 Basis



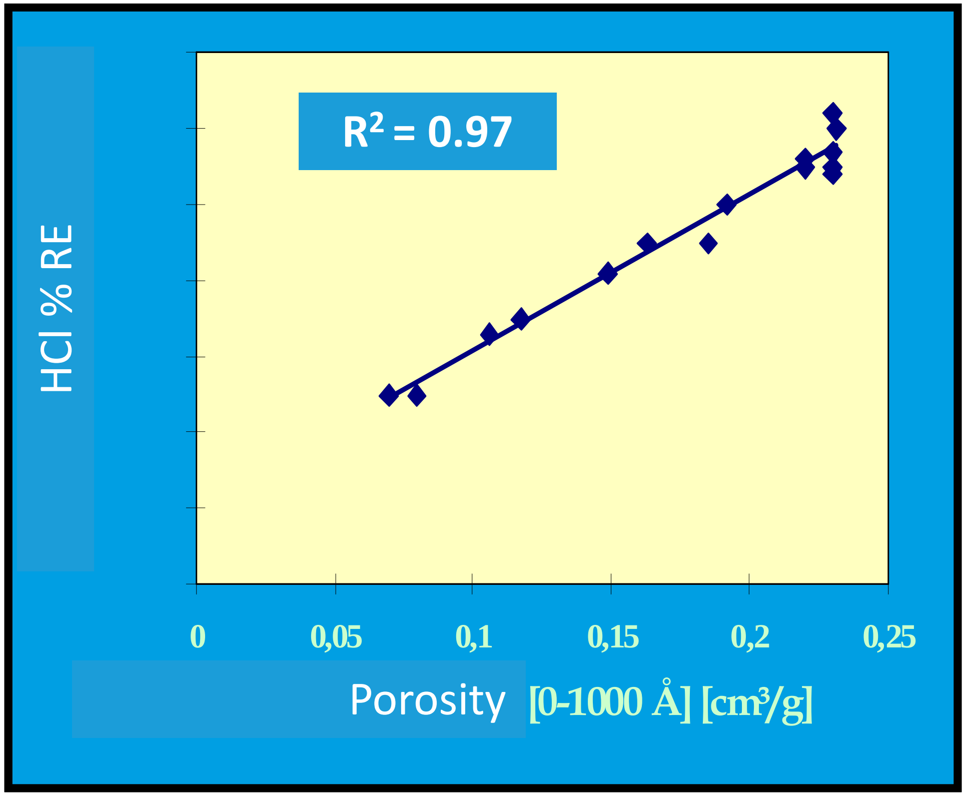
Reactivity Property Relationships

Laboratory Scale Study, HCl Basis

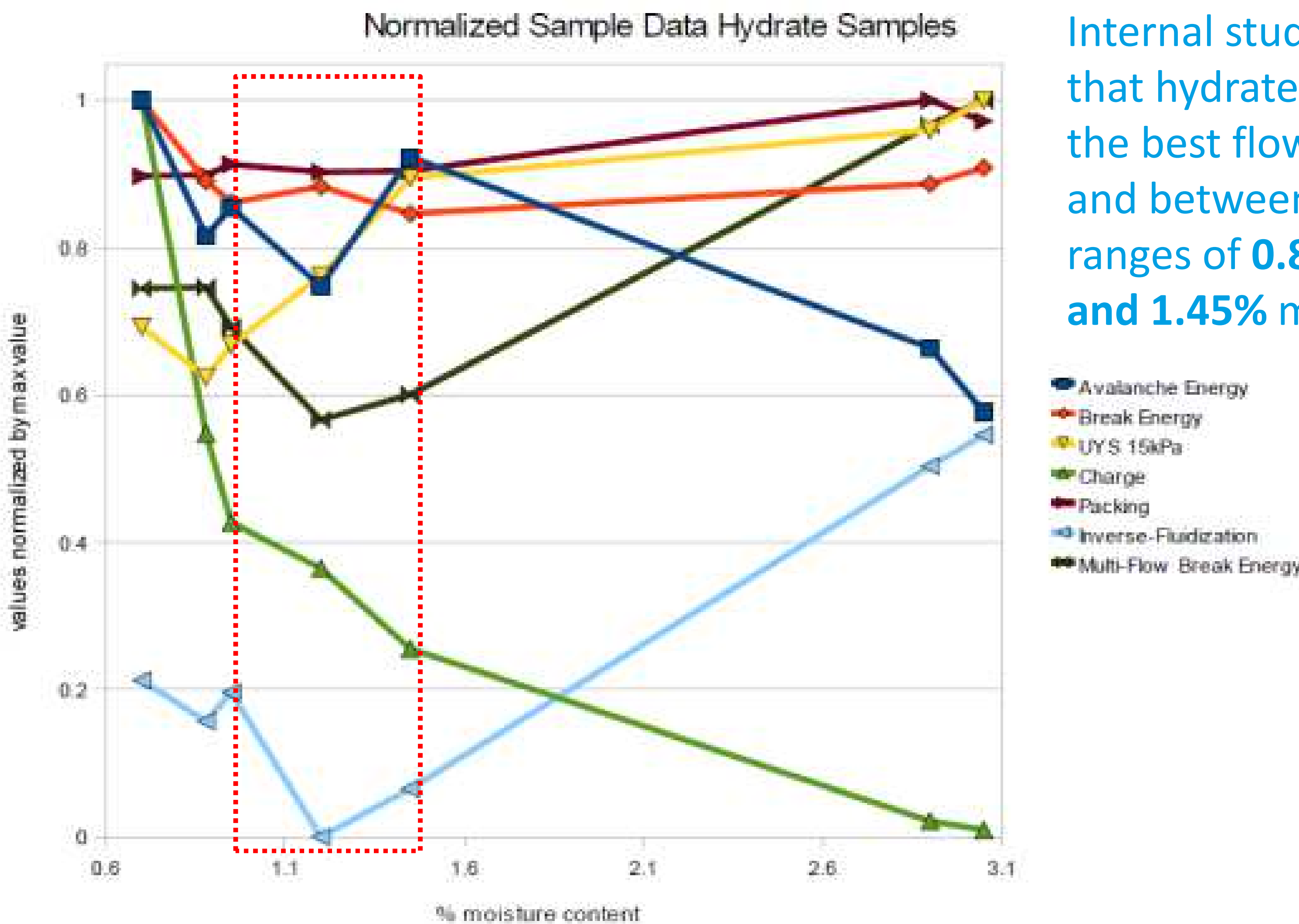
Importance of Surface Area



Importance of Pore Volume

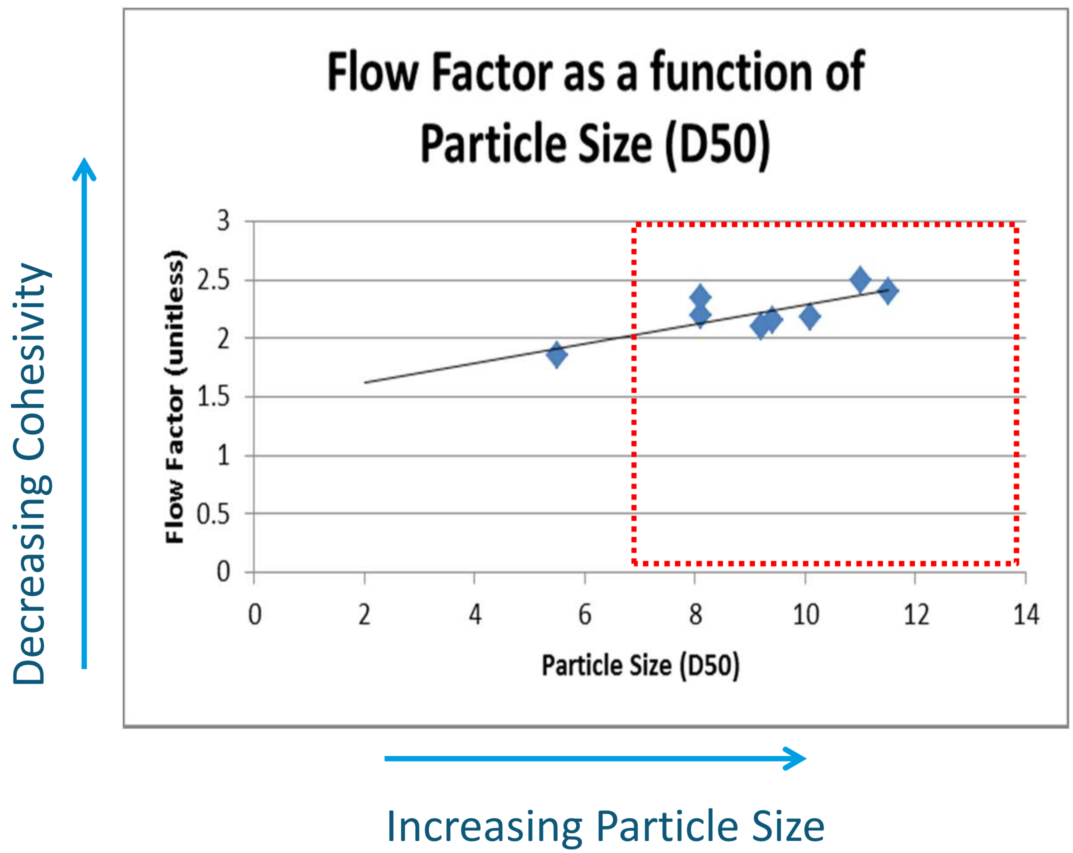


Effect of Moisture on Flowability



Internal studies indicated that hydrate samples have the best flow properties in and between the tested ranges of **0.88% moisture and 1.45%** moisture.

Effect of Particle Size on Flowability



- Flow study data indicate that Flow Factor improves with higher D_{50} PSD
- A 32% improvement in flow properties associated in size between a D_{50} = 2 µm and a D_{50} = 11 µm
- Effective superficial gas (saltation velocity) is a function of particle size
  - Set a limit for the D_{90}

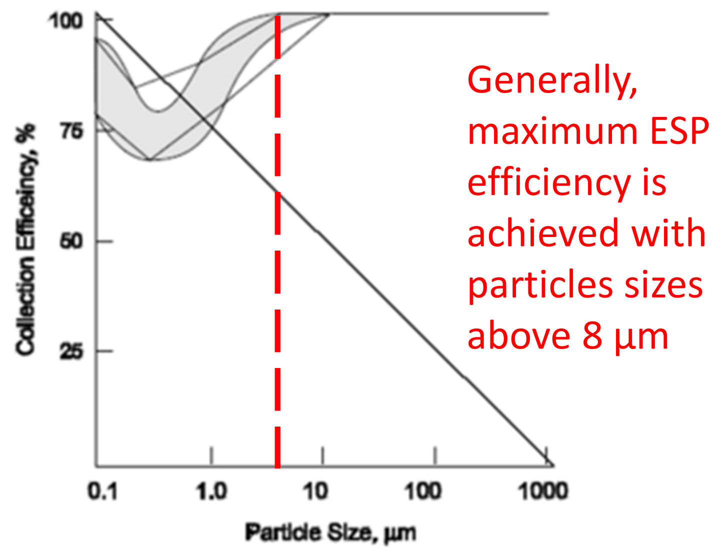
On-going Flowability Study in cooperation with current Utility Customers

ESP Collection Efficiency

For a given gas volume and sizing design, precipitator performance is dependent on the following:

- > Particle Size
- > Ash Loading
- > Ash Resistivity

Effect of particle size on ESP collection efficiency



Richards, J. R. Control of Particulate Matter Emissions Student Manual Control of Particulate Matter Emissions Student Manual. *APTI Course 413, Third Ed.* **2000**, 1–358

Particle Size & ESP Collection Efficiency

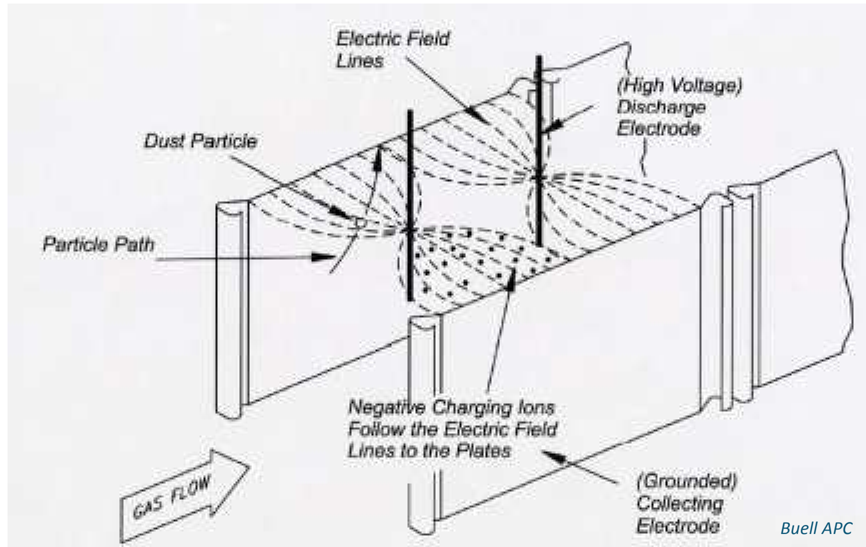
- **ESP efficiency is proportional to the particle drift velocity which is proportional to the particle size**

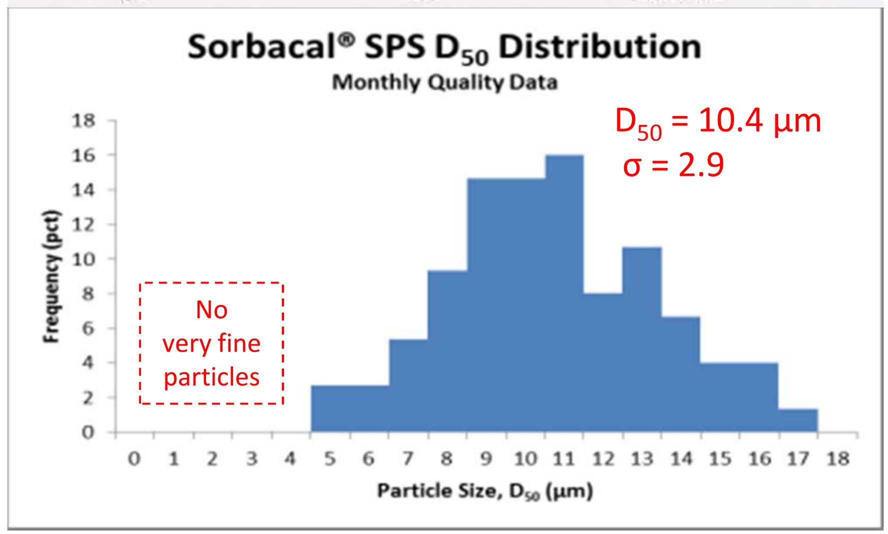
$$\eta \propto \omega \propto d$$

- **Collection efficiency of an ESP is better for particle sizes are greater than 2µm**
  - Very fine particles are more difficult to charge.
  - **Very fine particles require more treatment time** to charge adequately.
  - Very fine particles migrate to the plates in an indirect/random motion instead of a **more direct path as taken by larger particles.**

"Typical particle size for a utility pulverized-coal fired boiler would be a mass mean of 12 microns and a standard deviation of 3.8"

R. Mastropietro, "Fine Particulate Collection using Dry ESP"

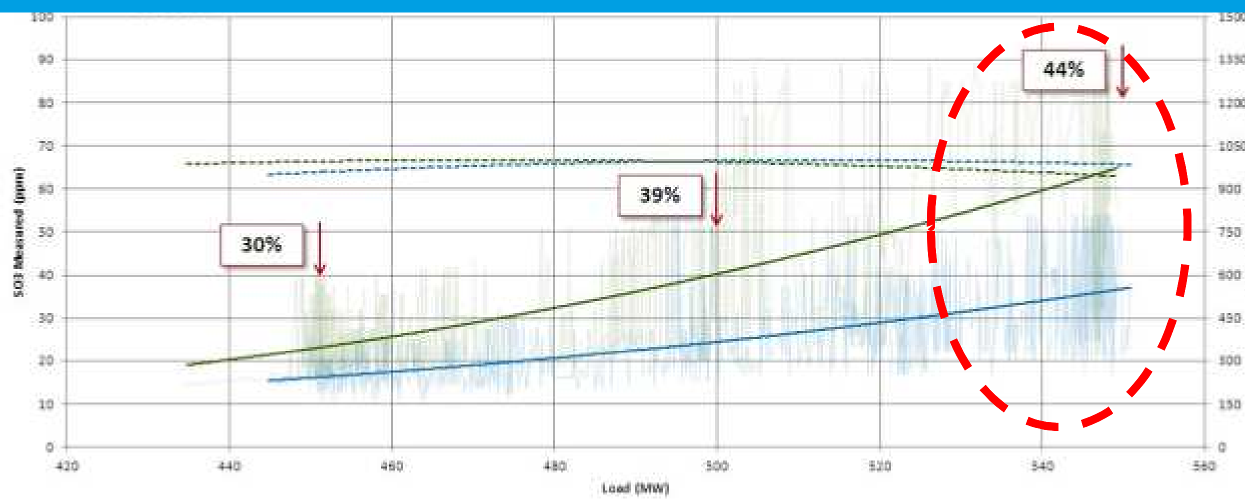




Ash Loading & ESP Collection Efficiency

- > **High ash loadings interfere with particle charging**
  - > Suppresses the corona
  - > Impedes the negative ions generated for charging.
- > **The effect of suppression becomes significant when higher ash loading has a large population of very fine particles (i.e., ≤ 2µm)**

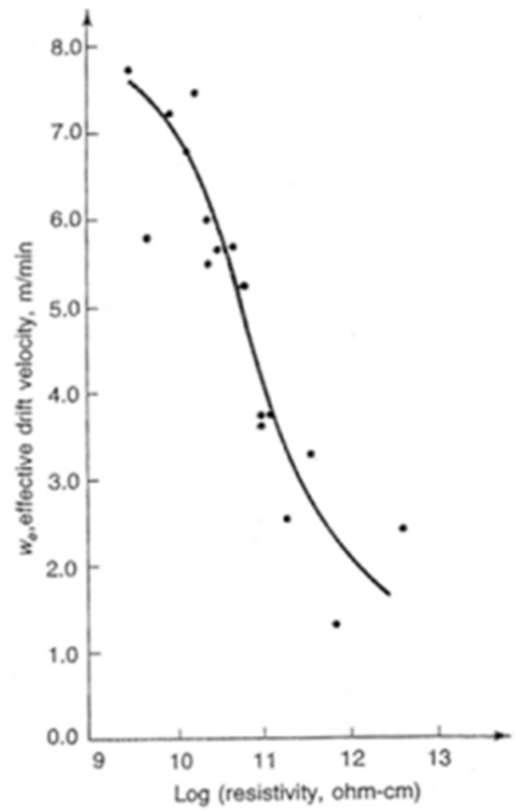
Trials indicated that significant reductions in the mass of hydrated injected can be realized with Sorbacal® SPS to achieve targeted outlet emissions



Highly reactive Sorbacal® SPS results in lower mass loading for equivalent performance

Ash Resistivity & ESP Collection Efficiency

- Fly ash resistivity impacts
  - Rate at which particles gain charge
  - Rate at which particles lose charge after contacting the collecting plate
- Effect of High Ash Resistivity, 10^{12} -10^{13} Ω-cm
  - Low power levels
  - Low voltage sparking,
  - Back corona formation
- Optimum Ash Resistivity, 10^{8} -10^{11} Ω-cm
  - Inhomogeneity of particle size broadens the effects optimum range



SOURCE: Adapted from White, "Control of Particulates by Electrostatic Precipitation," *Handbook of Air Pollution Technology*. Copyright © 1984 by John Wiley & Sons, Inc.

Sorbacal® SPS in ESP Applications

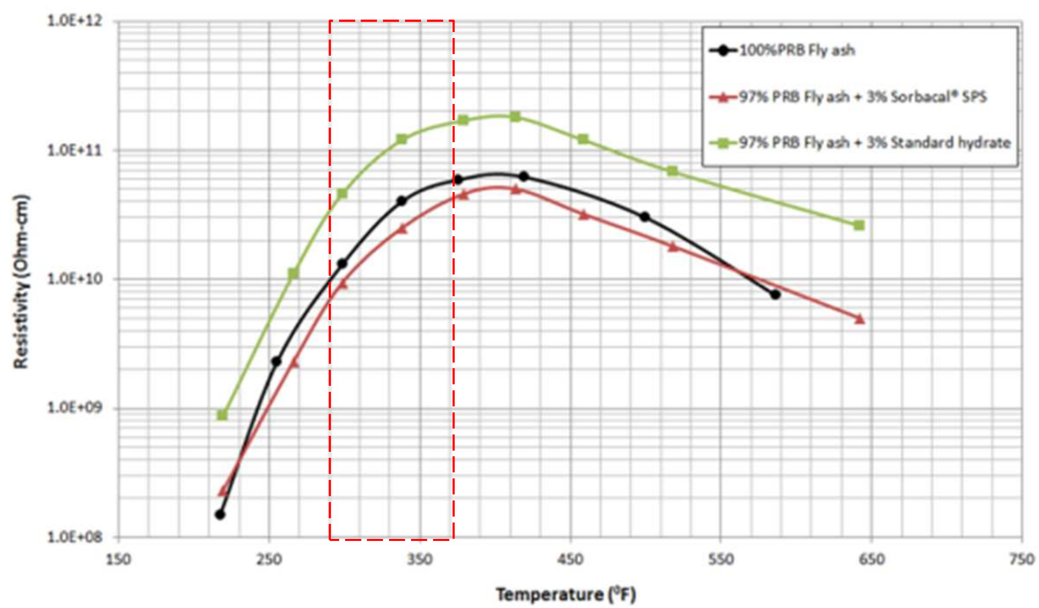
The key properties for determining compatibility of enhanced hydrated lime in ESP applications:

> High SO_2 removal efficiency

> Resistivity within the optimal range: 1E8 to 1E11 (Ω-cm)

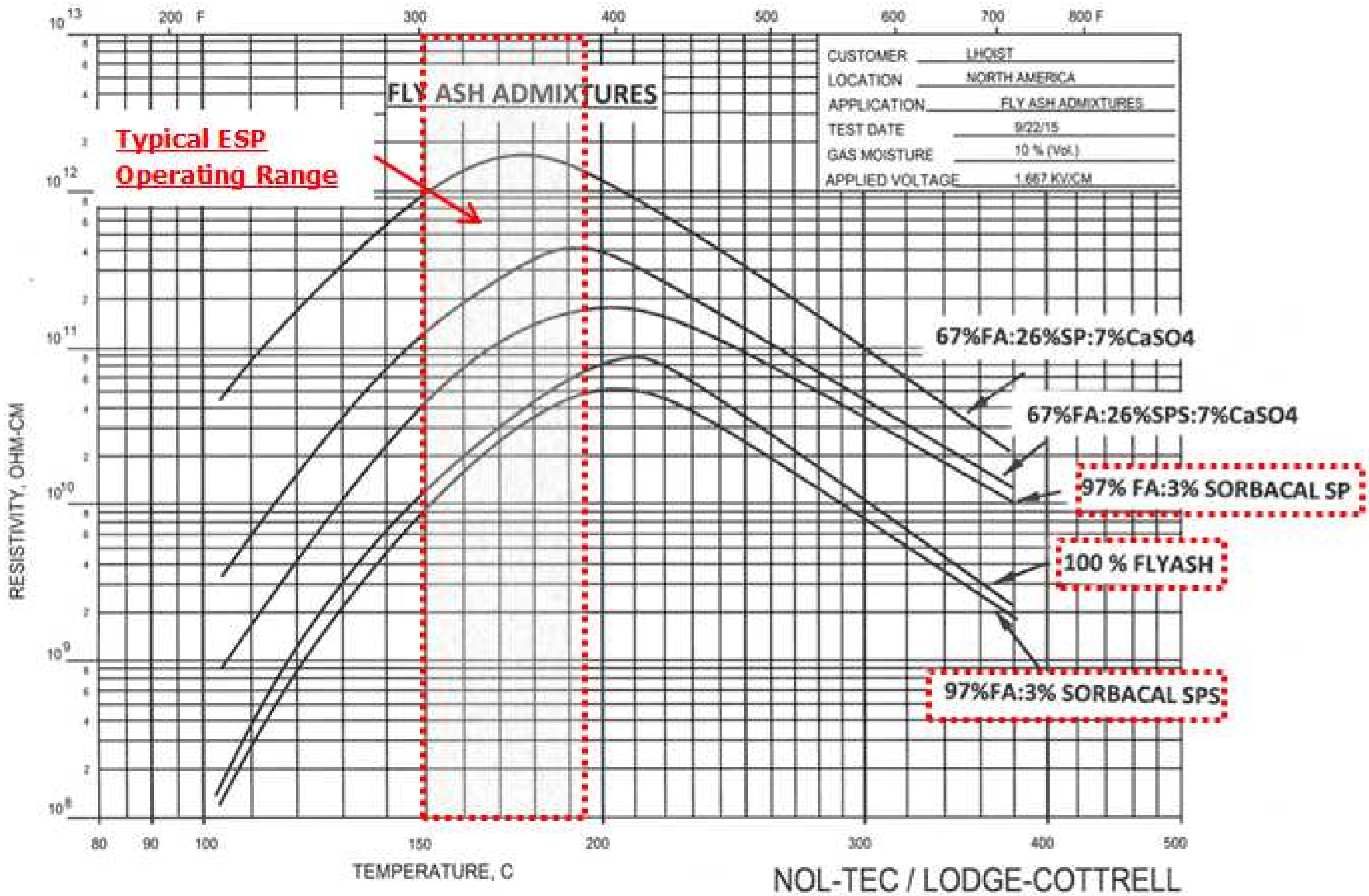
> Particle size that is suitable for efficient ESP capture

Laboratory resistivity measurements on fly ash mixtures



The impact of **Sorbacal® SPS** on ESP performance has been shown to be minimal in PRB applications

Sorbacal® SPS in ESP Applications



Sorbacal® SPS in ESP Applications

The D_{50} of Sorbacal® SPS is manufactured to be in a range of 8 µm < D_{50} < 12 µm which provides a good balance between:

- high SO_2 removal performance,
- particle dispersibility and mass transport,
- powder flow behavior and
- ESP compatibility.

Sorbacal® SPS Hydrated Lime Reactivity & SO_2

Dispelling that hydrate isn't reactive enough for SO2 (10 min, 6 slides)

> Trial reaction rate constants comparison for SPS – SO2 decay is a matter of time not potential

> Show that SPS can get (close) to the level of effectiveness for Sodium

> Reaction products are not noxious

  > Beneficial use of ash – maybe not use in concrete but also not hazardous

Trace Metal Capture with Sorbacal® Hydrated Lime Products

Trace Metal Capture with Sorbacal® Hydrated Lime Products

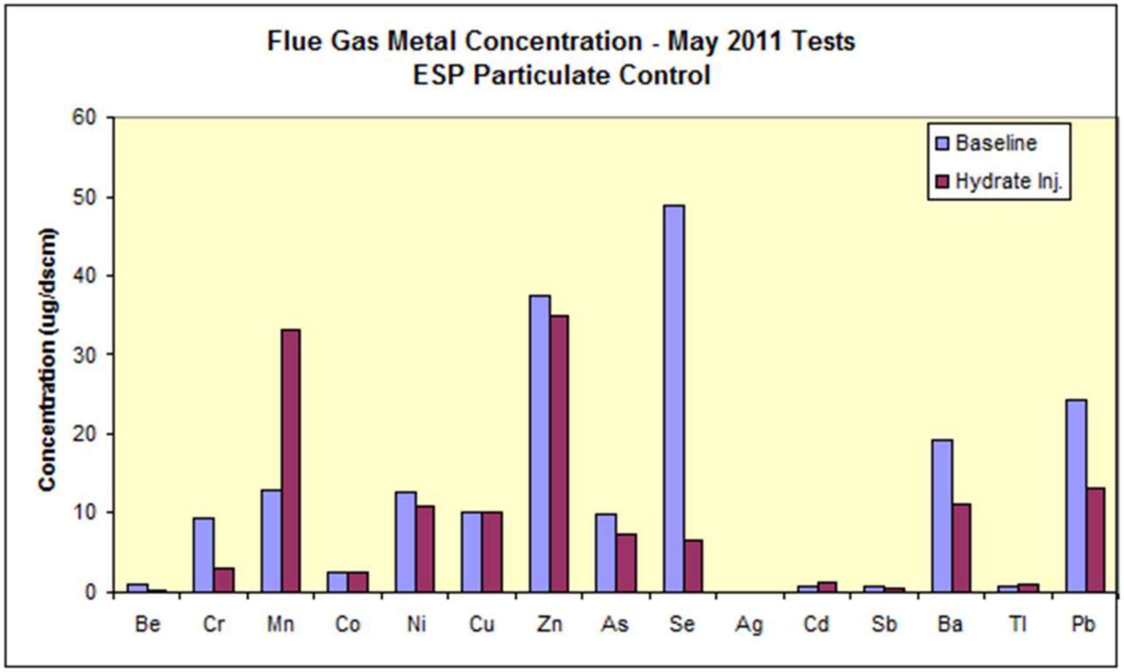
Secondary benefits that are present with a DSI system using Sorbacal® hydrated lime

(1) Reductions in gas phase trace metal emissions, and

(2) The production of a dry by-product that is basically non-leachable.

Removal of Trace Metal Emissions

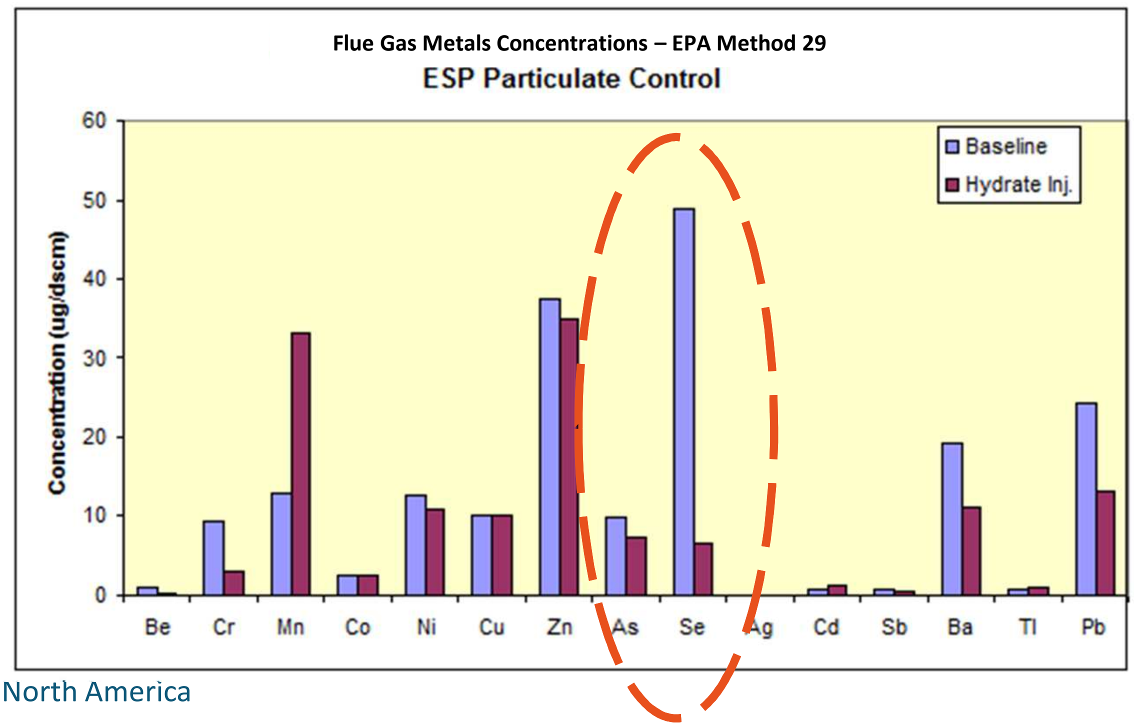
- Testing conducted at Southern Research Institute to evaluate the impact on the emissions of trace metals – specifically Selenium and Arsenic -in the flue gas.



Removal of Trace Metal Emissions

> Testing conducted at Southern Research Institute to evaluate the impact on the emissions of trace metals.

> Hydrated lime injection resulted in significant reduction is Selenium emissions



Removal of Trace Metal Emissions

> Tests conducted at Southern Research Institute in 2011 showed to fly ash containing hydrated lime from duct injection leached at an order of magnitude lower than the TCLP hazardous waste limits

> Selenium and Arsenic testing of ash is common practice on LNA trials – 2016 Sorbacal® SPS trials show strong performance on RCRA metals

> Hydrated lime injection resulted in significant reduction is Selenium leaching from the fly ash

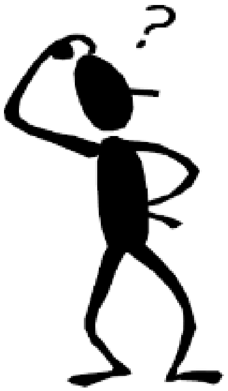
Flue Gas Metals Fly Ash Leaching Tests

Target Analyte	TCLP Hazardous Waste Limitation	2016 Sorbacal® SPS Test Results			
		Unit IL-1		Unit IL-2	
		Baseline Flyash	SPS Flyash	Baseline Flyash	SPS Flyash
		CST16-00612	CST16-00560	ENV16-01147	ENV16-01150
	ppm	ppm	ppm	ppm	ppm
Ag	5	<0.01	<0.01	<0.01	<0.01
As	5	0.04	0.01	<0.01	<0.01
Ba	100	1.31	15.12	4.4	14.5
Cd	1	<0.01	<0.01	<0.01	<0.01
Cr	5	<0.01	<0.01	0.136	<0.01
Pb	5	0.02	0.04	0.035	0.039
Se	1	0.10	<0.01	0.078	<0.01

Trace Metal Capture with Sorbacal® Hydrated Lime Products

The D_{50} of Sorbacal® SPS is manufactured in a range of 8 μm < D_{50} < 12 μm which provides a good balance between:

- Hydrated lime injection reduces vapor phase trace metals – particularly Se and As, and
- Metals removed from the flue gas using hydrated lime leached from the ash at an order of magnitude lower than TCLP limits



Discussion/Questions?

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