

REINHOLD ENVIRONMENTAL Ltd.



2016 APC-Wastewater Round Table & Expo Presentation

July 18 & 19, 2016 in Dearborn, MI / Hosted by DTE Energy

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SORBACAL[®] SPS - CHANGING PERCEPTIONS ON HYDRATED LIME FOR SO₂ REMOVAL AND ESP IMPACTS

**APC-Wastewater Round Table/PCUG
July 2016**

**Greg Filippelli, P.E.
Lhoist North America**

AGENDA

LNA FGT Solutions Team

SO₂ 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 Field Support Services



- > **FTIR Flue Gas Analyzers**
 - > LNA has a mobile lab
 - > Two MKS FTIR flue gas analyzers
 - > monitor emissions (SO₂, HCl, HF, flue gas moisture, etc.)
 - > Experienced personnel to set-up, operate FTIR
- > **Method 30B STM Console**



FGT Field Support Services



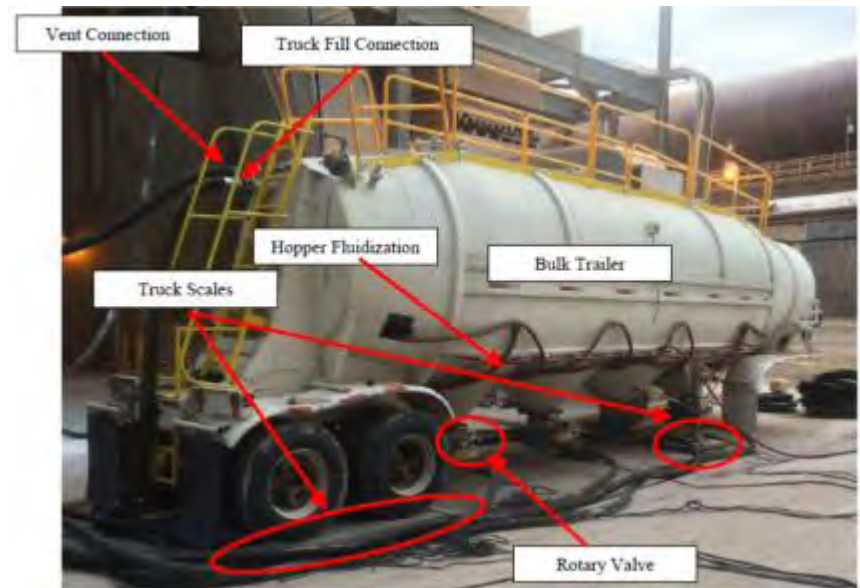
> Injection equipment

> 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 legitimate and useful applications data:

- 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

SO₂ Control Observed at Recently Completed Trials

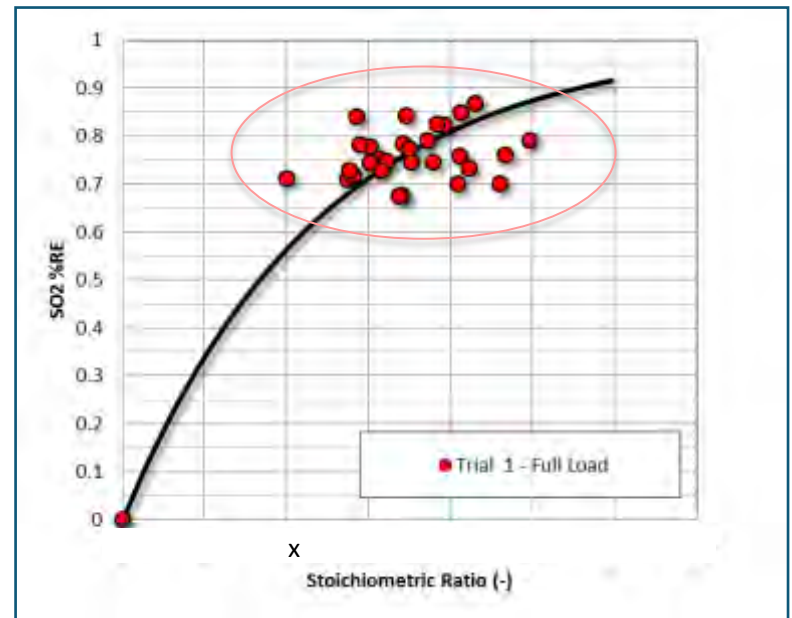
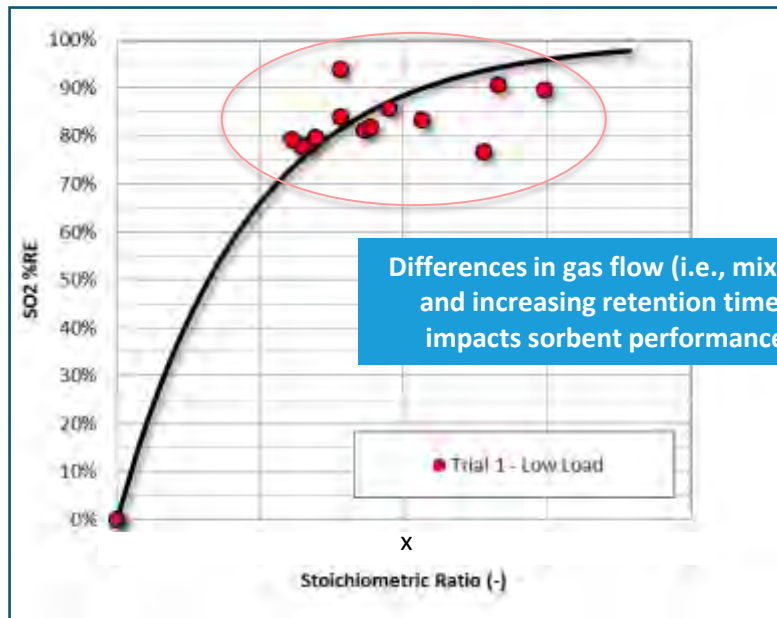
Sorbacal[®] SPS – SO₂ Control at Recent Trials

- > **SO₂ emissions control at PRB-fueled EGUs**
 - > Three (3) recent tests, units configured with ESPs
 - > Unit capacities between 180Mw and 550Mw
 - > Full load and low load scenarios evaluated
- > **Contrast low load v high load performance**
 - > Variation in effectiveness as a function of unit load
 - > Impacts of variations in gas flow (mixing) and increasing retention times
 - > Meaningful cost savings/operational strategies
- > **The importance of injection location for SO₂ control**

Utility EGU Trial 1

Unit Description

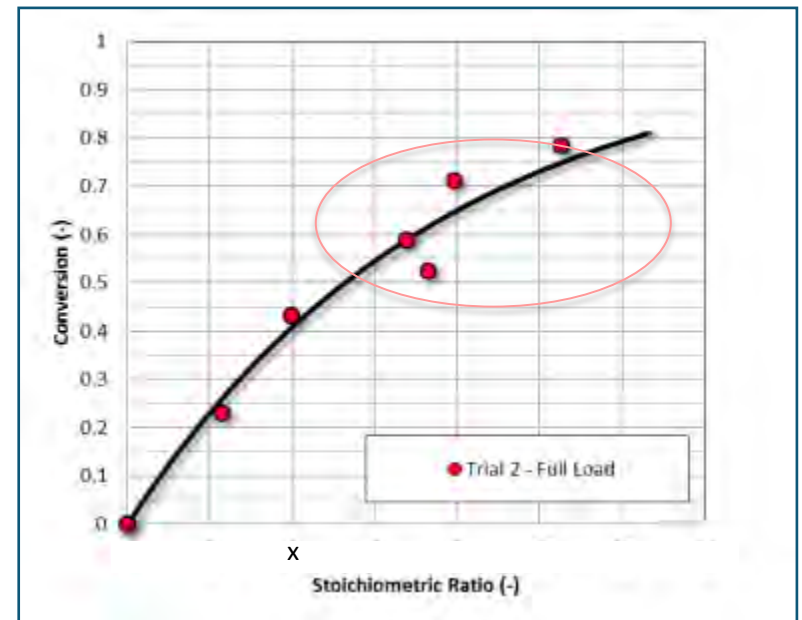
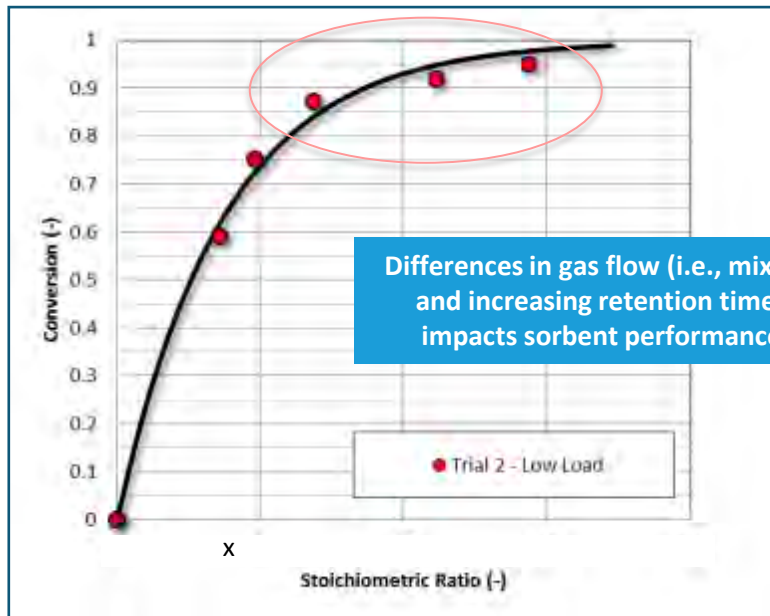
Unit Capacity (MWg)	190
Full Load Heat Input (MMBtu/hr)	1,800
Inlet SO ₂ (lb/MMBtu)	0.78
Target SO ₂ Removal	73%
Low Load Sorbent Usage (lb/hr)	1240
Full Load Sorbent Usage (lb/hr)	5864



Utility EGU Trial 2

Unit Description

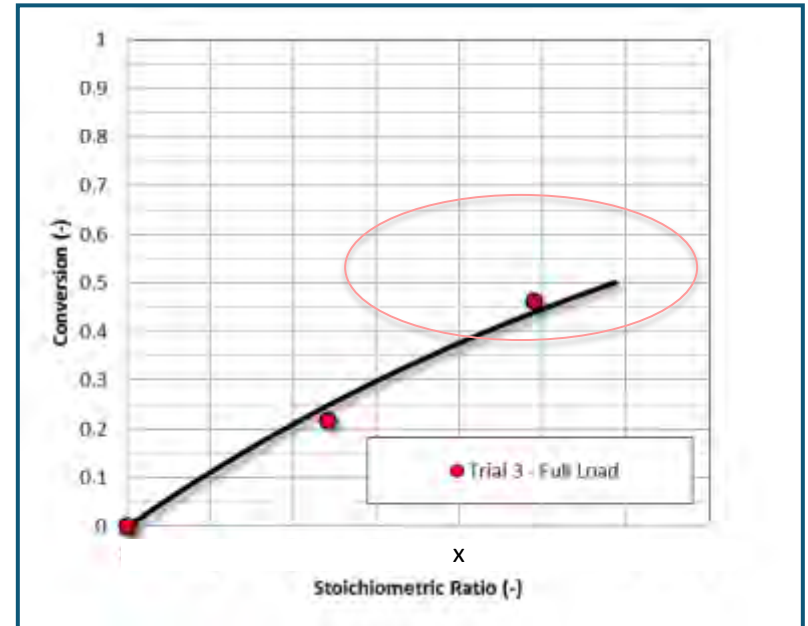
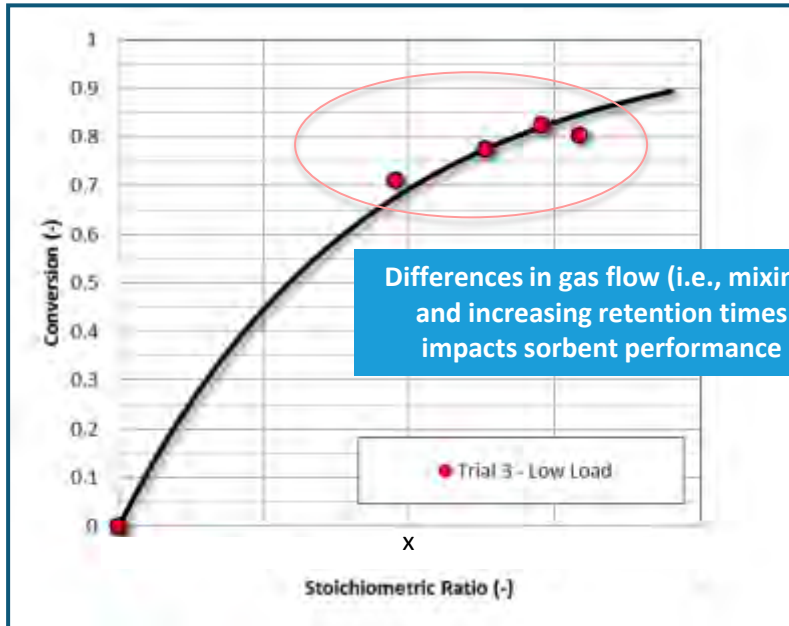
Unit Capacity (MWg)	530
Full Load Heat Input (MMBtu/hr)	5,600
Inlet SO ₂ (lb/MMBtu)	0.41
Target SO ₂ Removal	62%
Low Load Sorbent Usage (lb/hr)	5,659
Full Load Sorbent Usage (lb/hr)	23,103



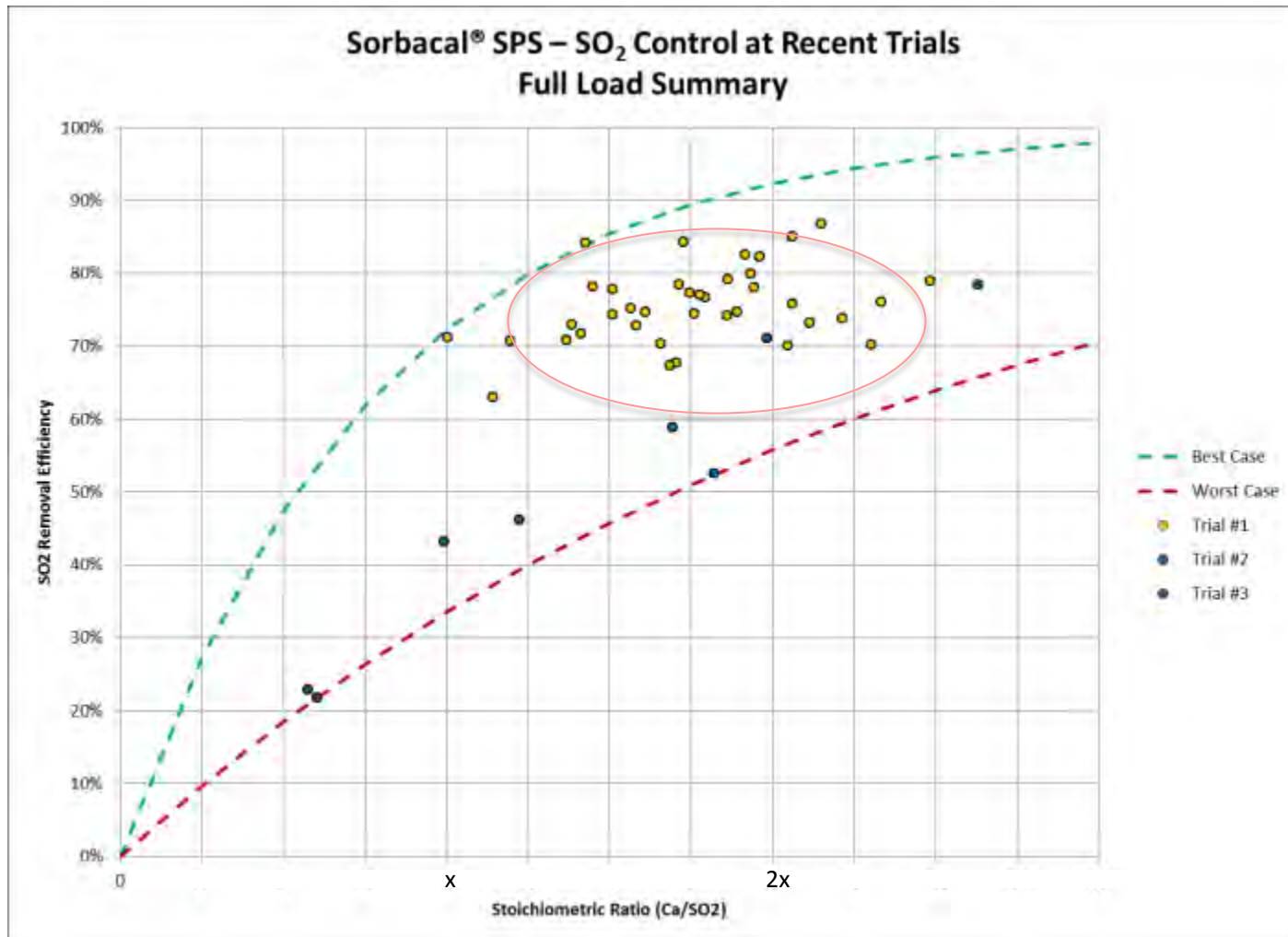
Utility EGU Trial 3

Unit Description

Unit Capacity (MWg)	185
Full Load Heat Input (MMBtu/hr)	1924
Inlet SO ₂ (lb/MMBtu)	0.35
Target SO ₂ Removal	54%
Low Load Sorbent Usage (lb/hr)	1,087
Full Load Sorbent Usage (lb/hr)	6,412



Sorbacal[®] SPS - Recent Trial Summary



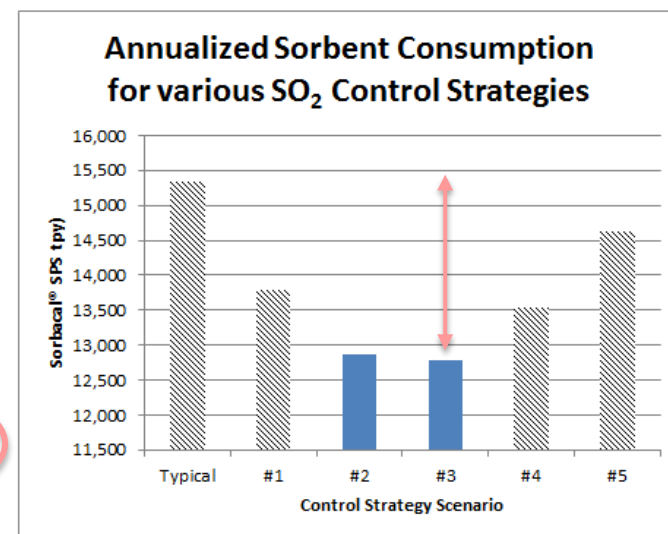
Meaningful cost savings/operational strategies

Extracted from Trial 1 data

Unit Description

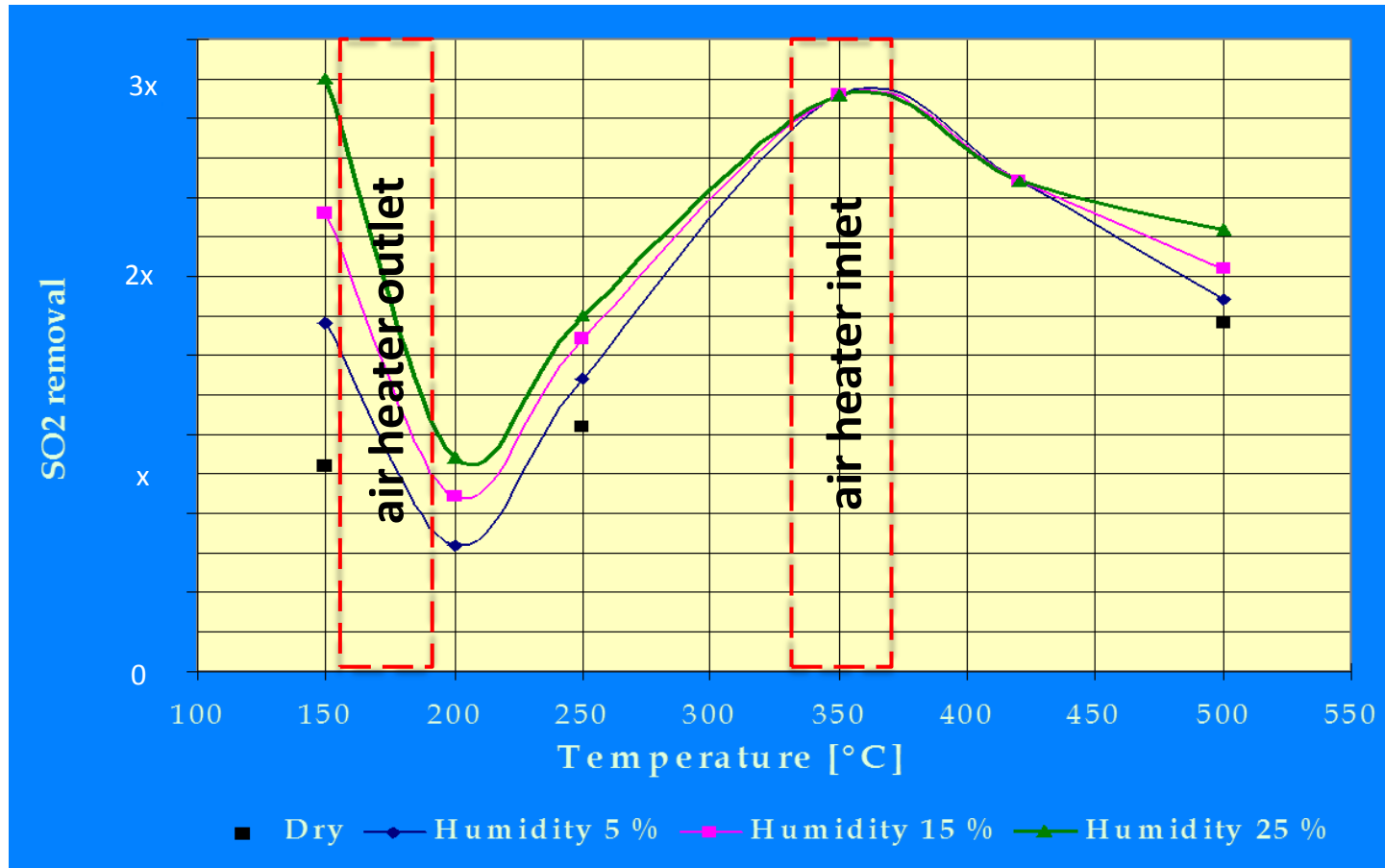
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Control Strategy Scenario	Emissions Profile			Sorbent Injection Profile			Usage Reduction pct
	Low Load SO ₂ lb/MMBtu	Full Load SO ₂ lb/MMBtu	Average SO ₂	Low Load MR lb/lb	Full Load SPS lb/lb	Annual Usage tons	
Typical	0.16	0.16	0.16	2.93	7.82	15,346	-
#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 SO₂ control



ESP Operations & Performance with Sorbacal[®] SPS

Sorbacal[®] SPS Hydrated Lime



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

Sorbacal[®] SPS

Specific Surface Area: $\geq 40 \text{ m}^2/\text{g}$

Porosity: $\sim 0.20 \text{ cm}^3/\text{g}$

D_{50} : 8-12 μm

Standard Hydrated Lime

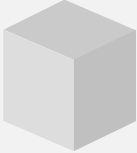

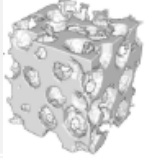
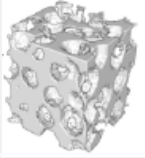
Specific Surface Area: $20 \text{ m}^2/\text{g}$

Porosity: $\sim 0.07 \text{ cm}^3/\text{g}$

D_{50} : 3-6 μm

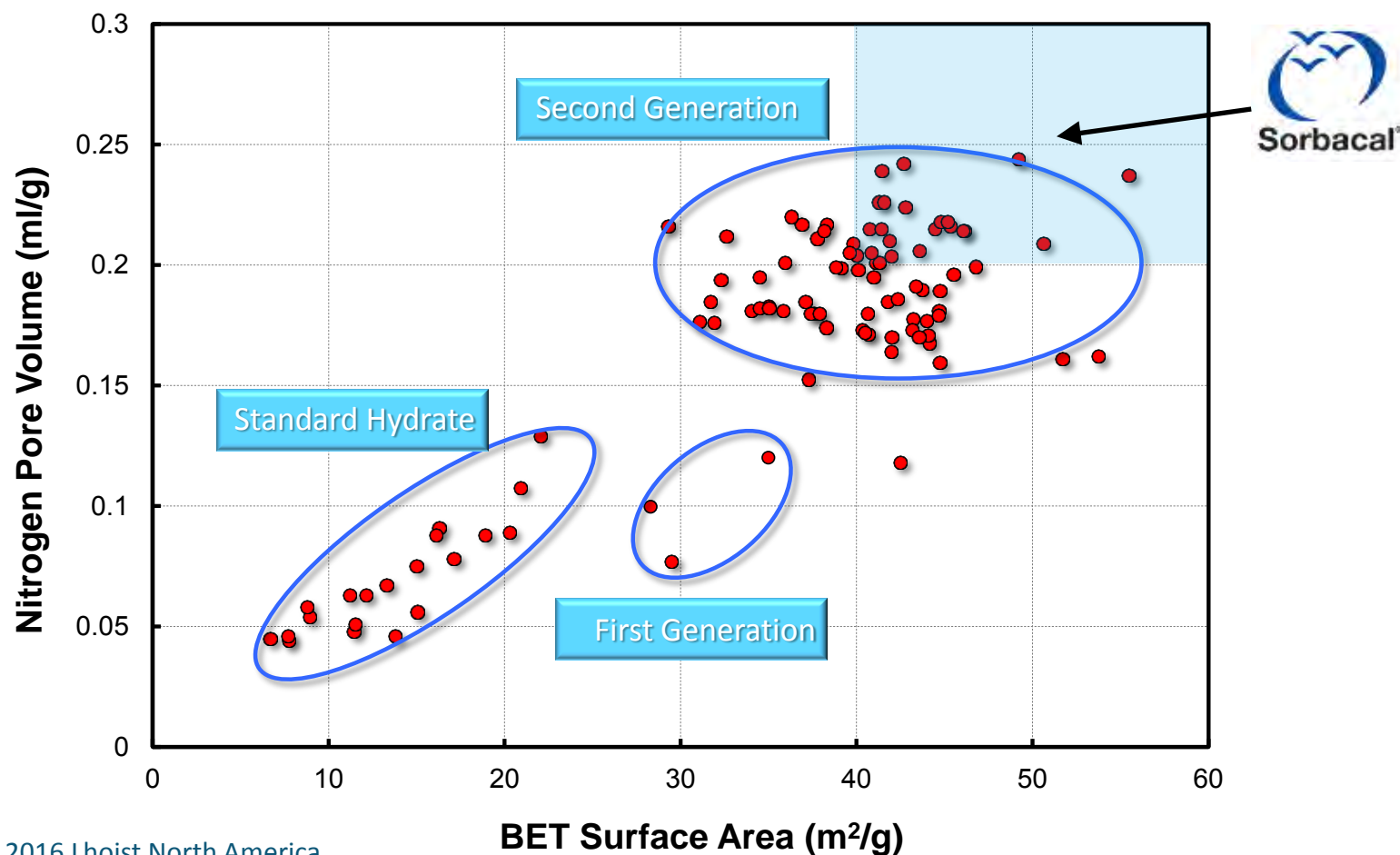
... the physical properties

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

Evolution of High Performance Products

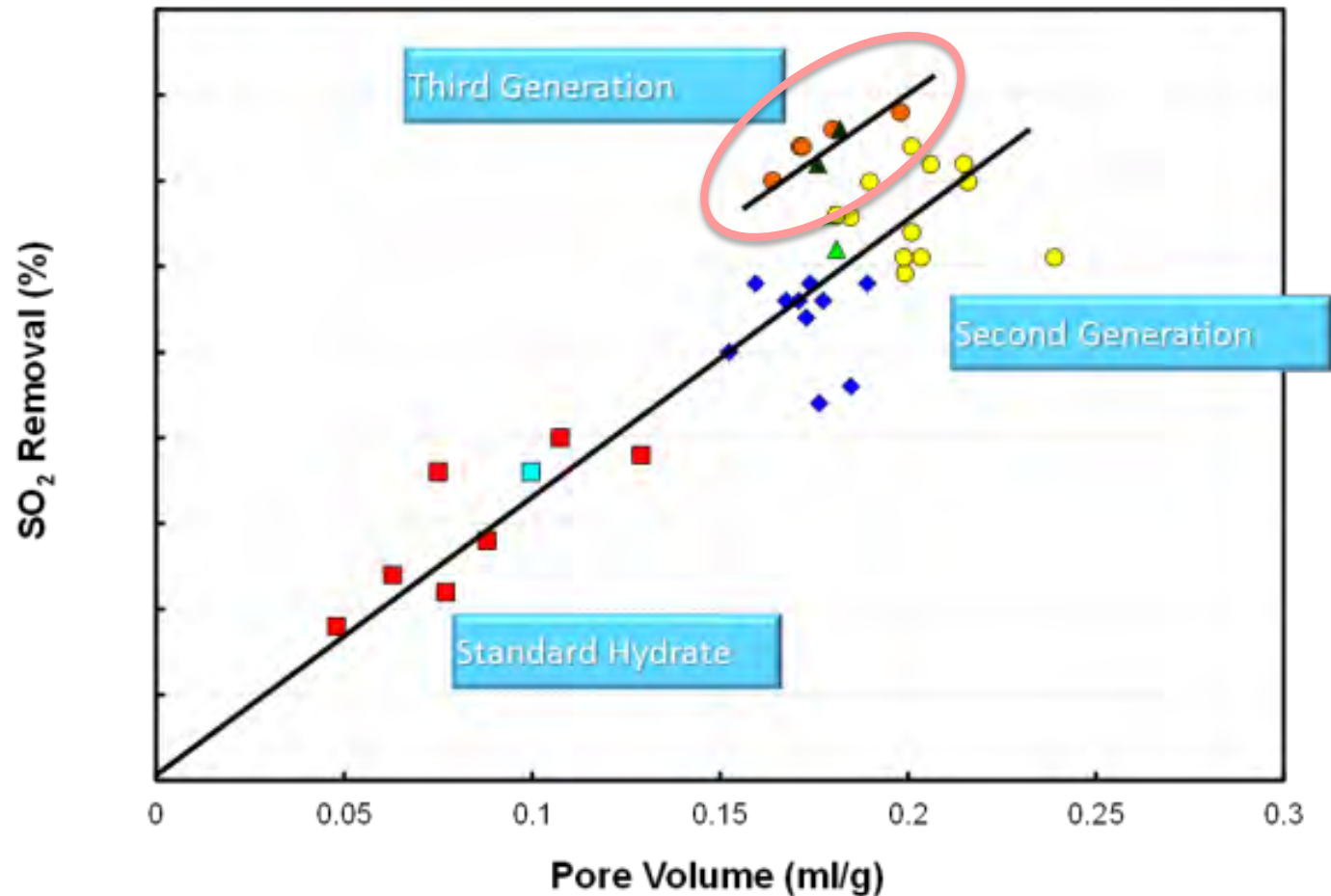
Surface Area and Pore Volume Development



Reactivity Property Relationships

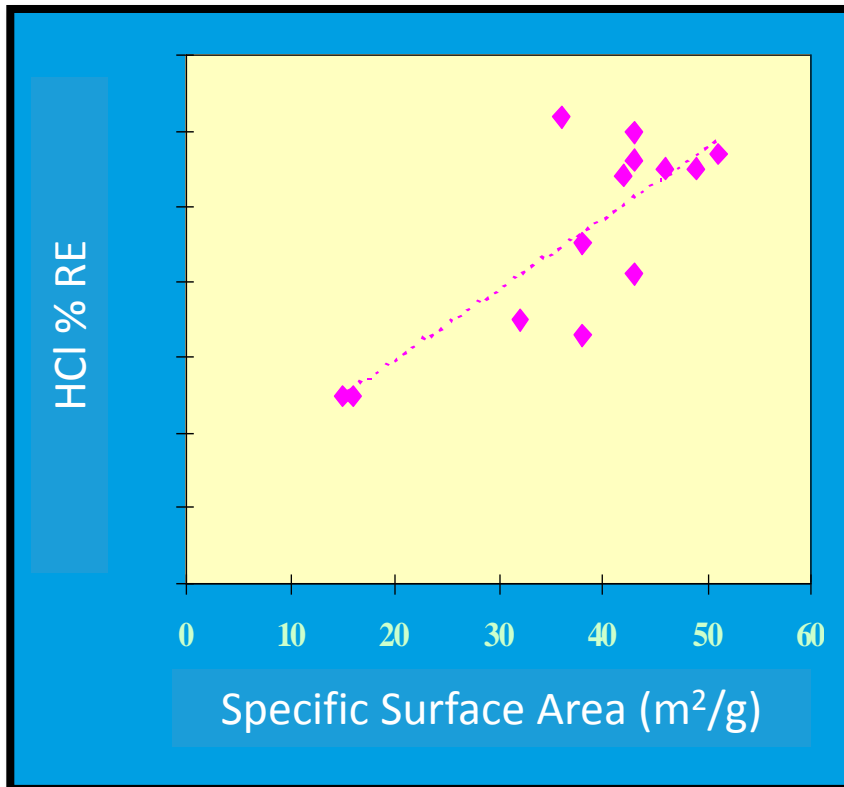
Pore Volume and Lab Scale Activity Test

Linear relationship between activity and pore volume, SO₂ Basis

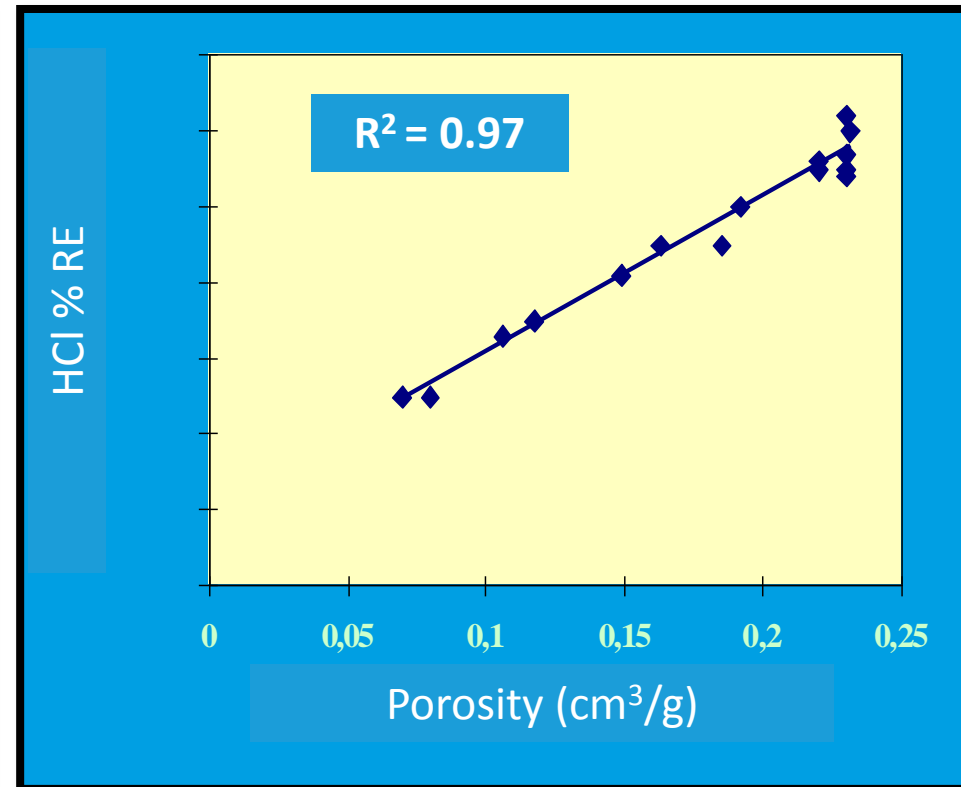


Laboratory Scale Study, HCl Basis

Importance of Surface Area



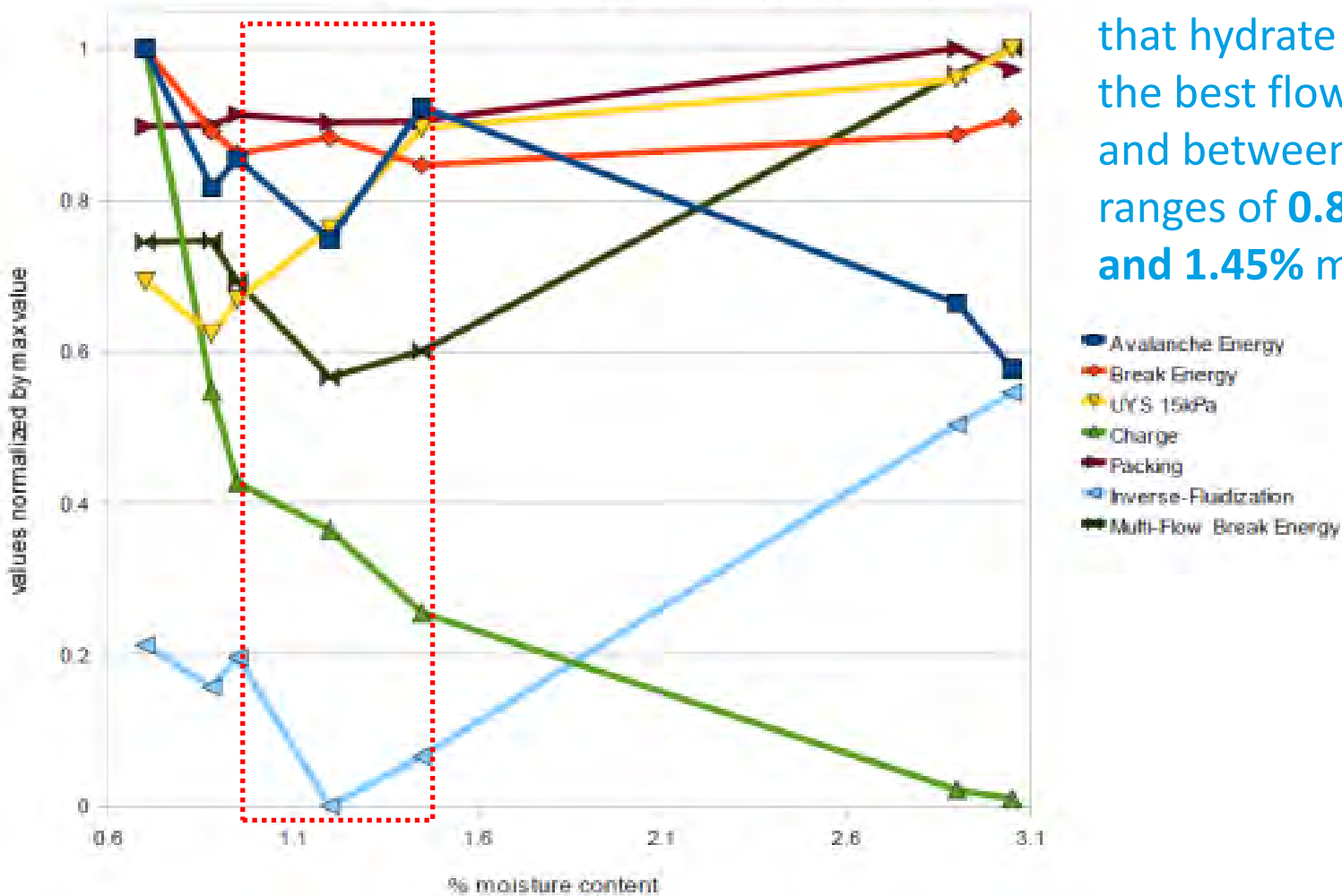
Importance of Pore Volume



Effect of Moisture on Flowability

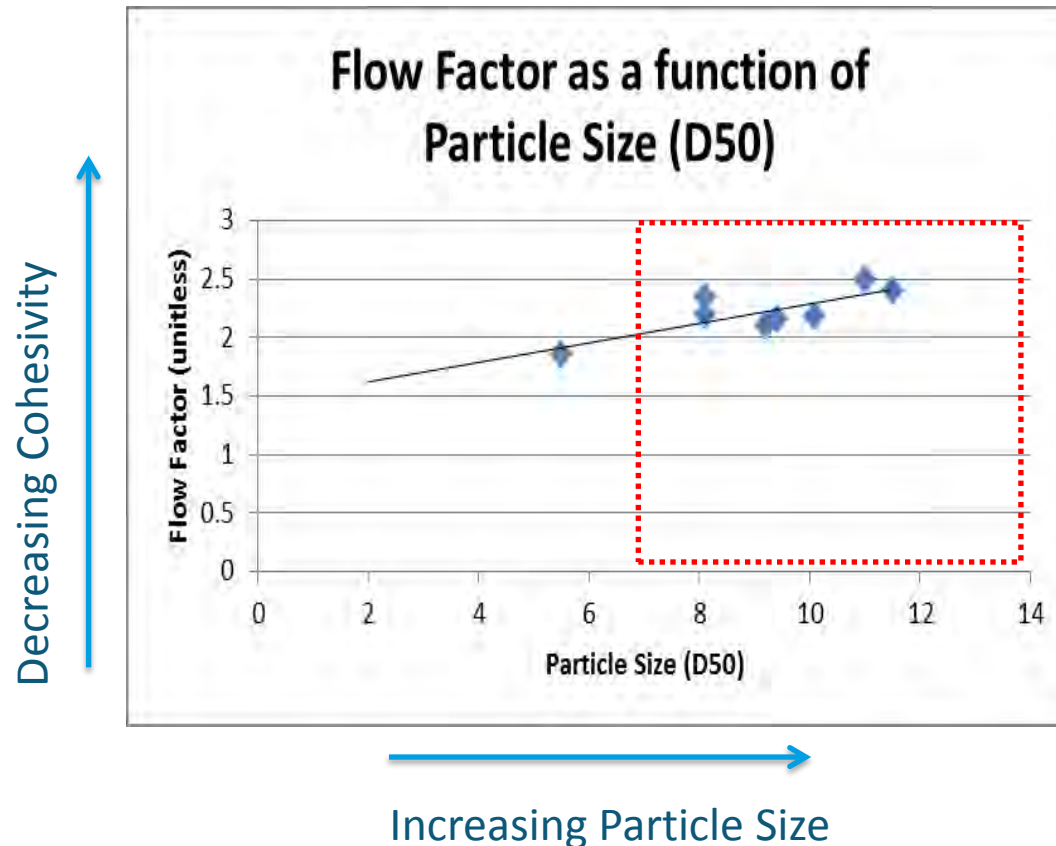


Normalized Sample Data Hydrate Samples



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 $D_{50} = 2 \mu\text{m}$ and a $D_{50} = 10.5 \mu\text{m}$

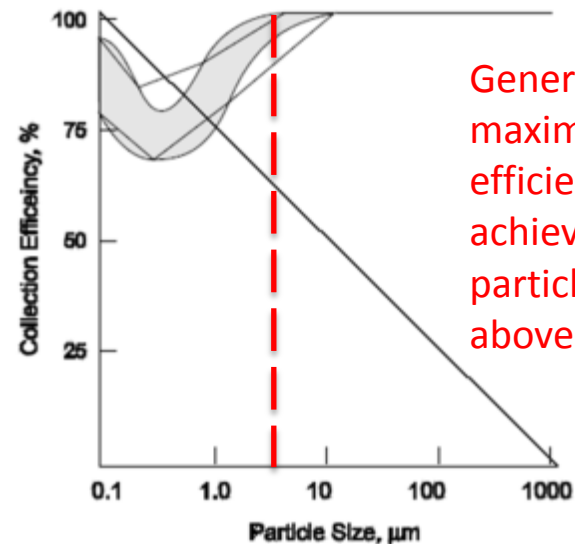
On-going Flowability Study in cooperation with current Utility Customers

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

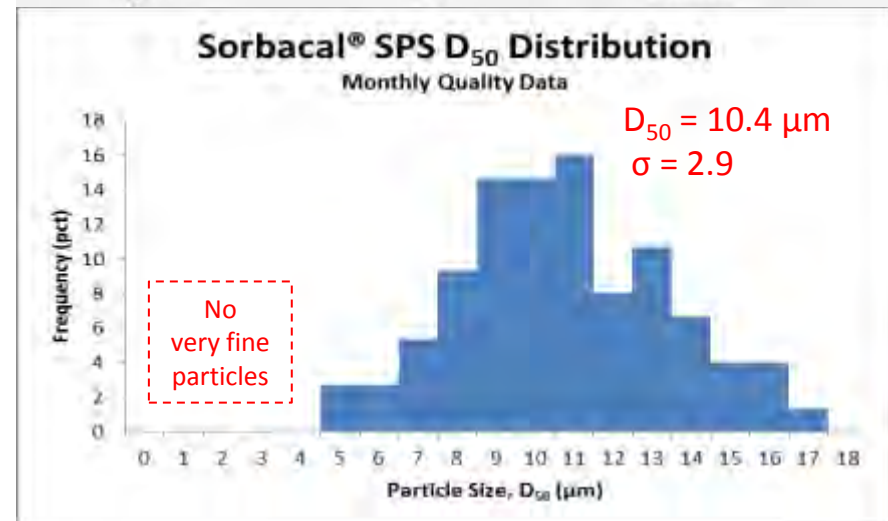
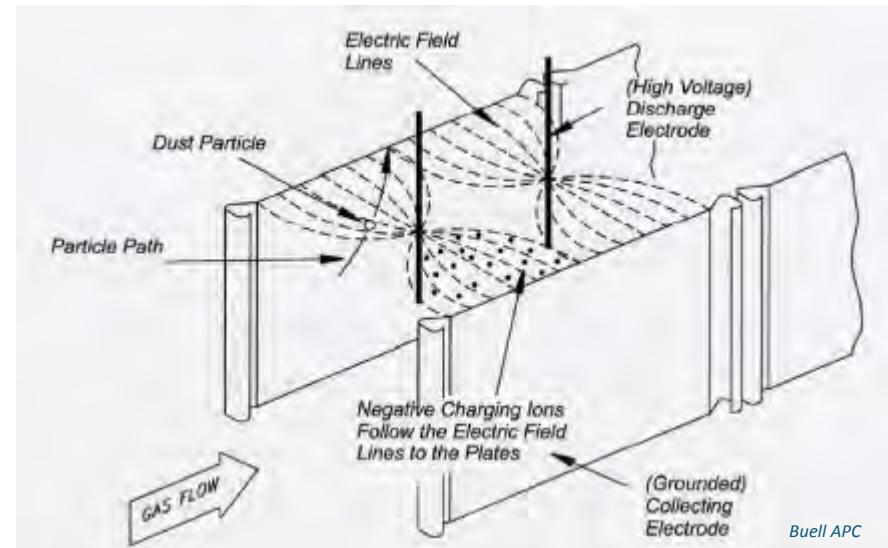
- > ESP efficiency is proportional to the particle drift velocity which is proportional to the particle size

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

- > Collection efficiency of an ESP is diminished for particle sizes are less than $5\mu\text{m}$
 - > 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”

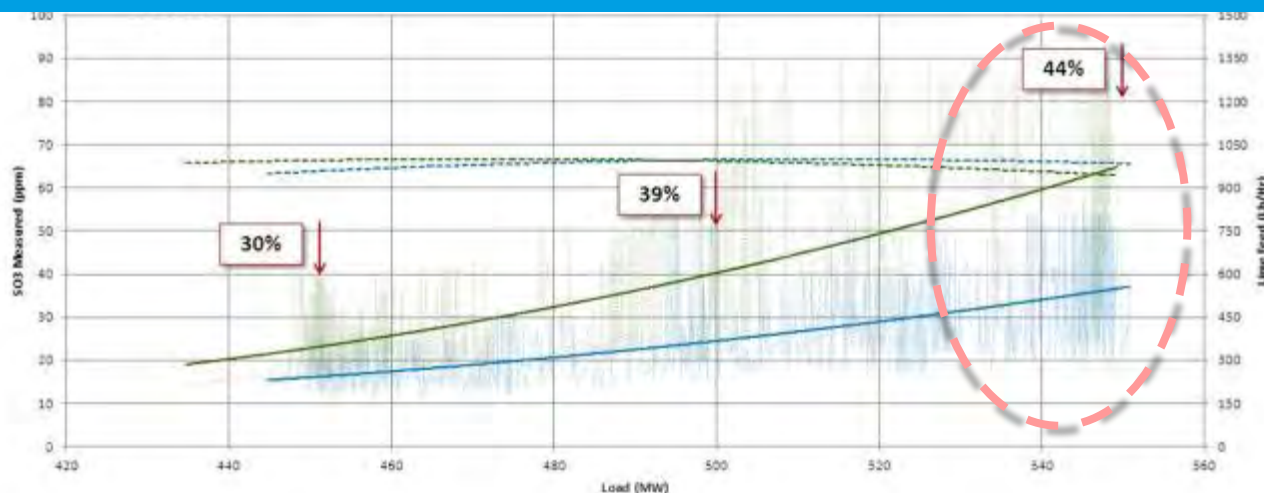


Ash Loading & ESP Collection Efficiency



- > 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., $\leq 2\mu\text{m}$)

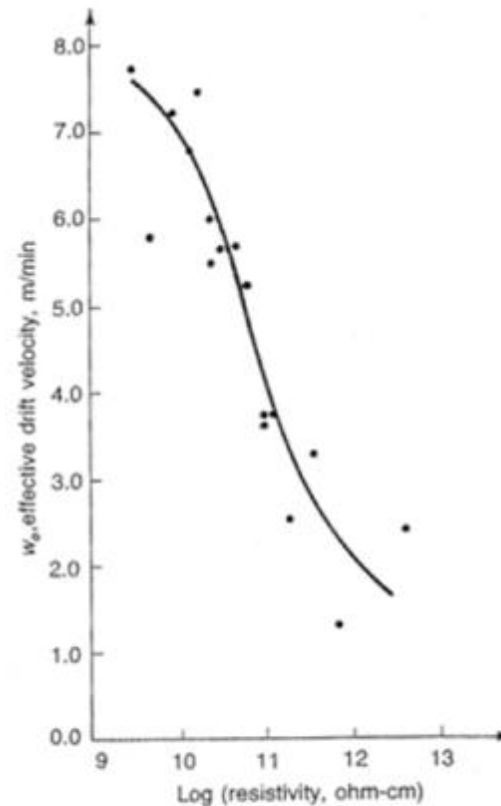
Trials indicated that significant reductions in the mass of hydrated injected can be realized with Sorbocal® SPS to achieve targeted outlet emissions



Highly reactive Sorbocal® 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 distinctly limits effects in the optimum range



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

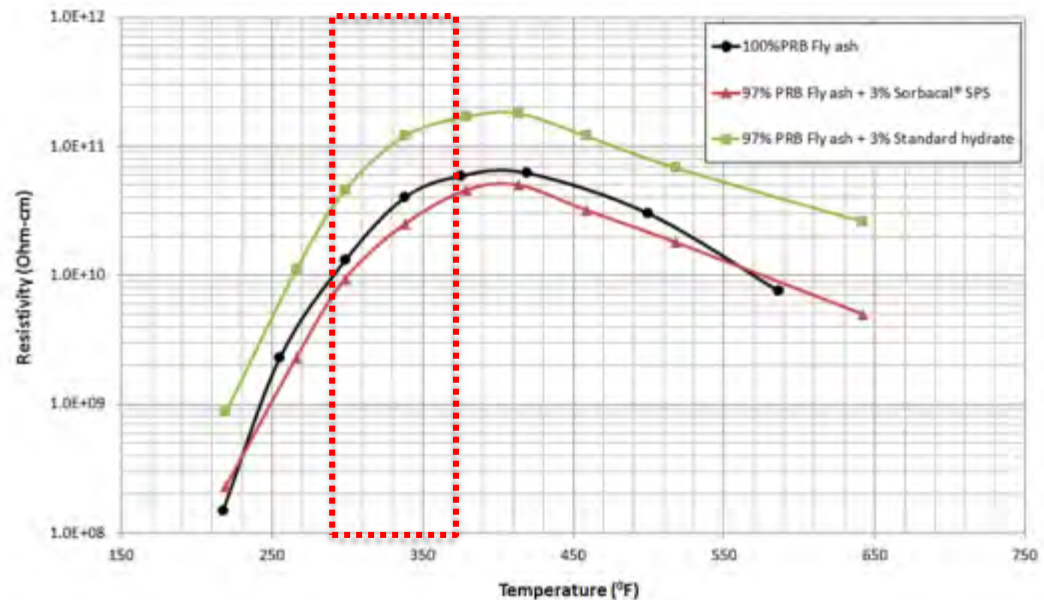
Sorbacal® SPS in ESP Applications



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

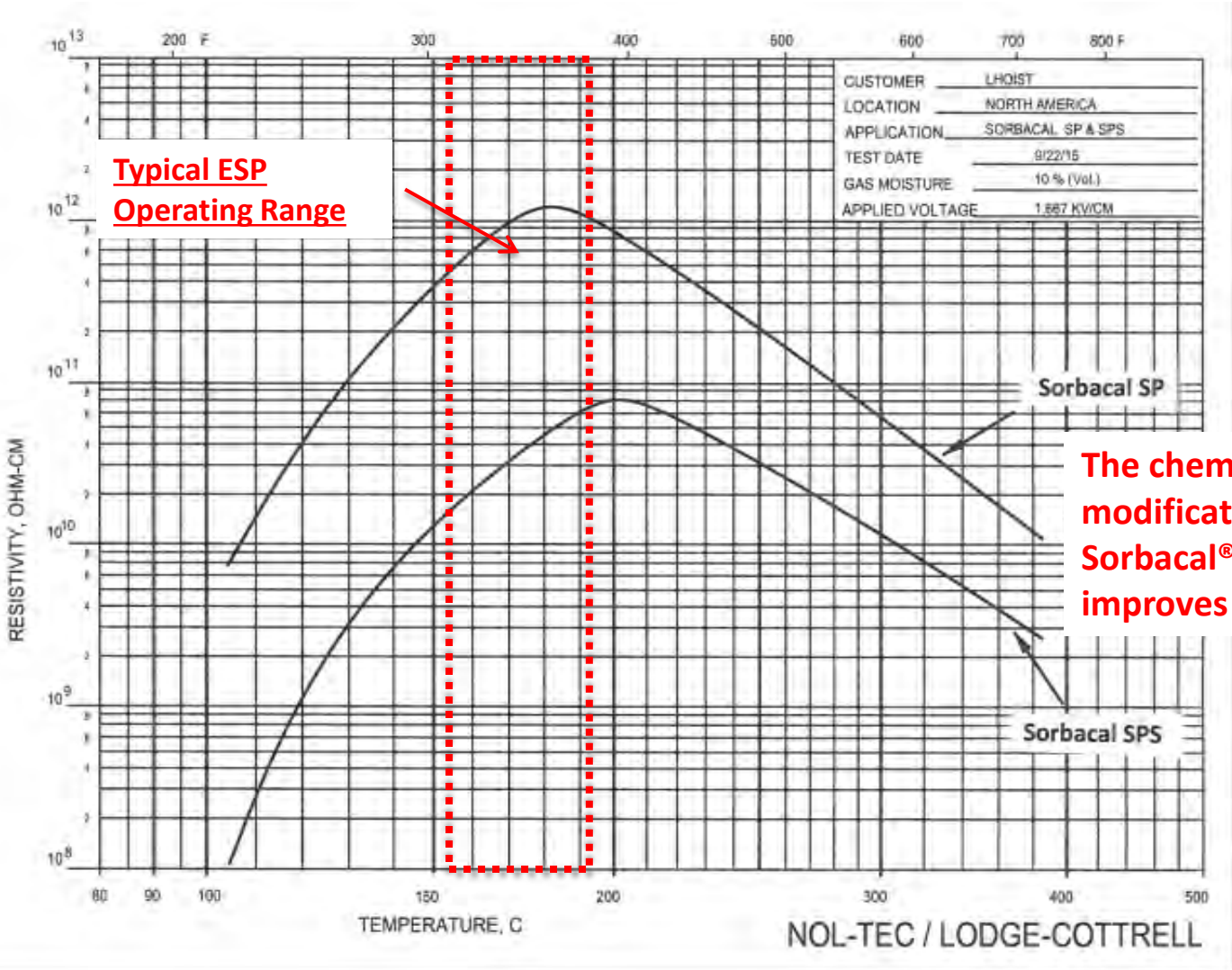
- > High SO₂ removal efficiency
- > Resistivity within the optimal range: 1E8 to 1E11 (Ω-cm)
- > Particle size that is suitable for efficient ESP capture

Laboratory resistivity measurements on fly ash mixtures

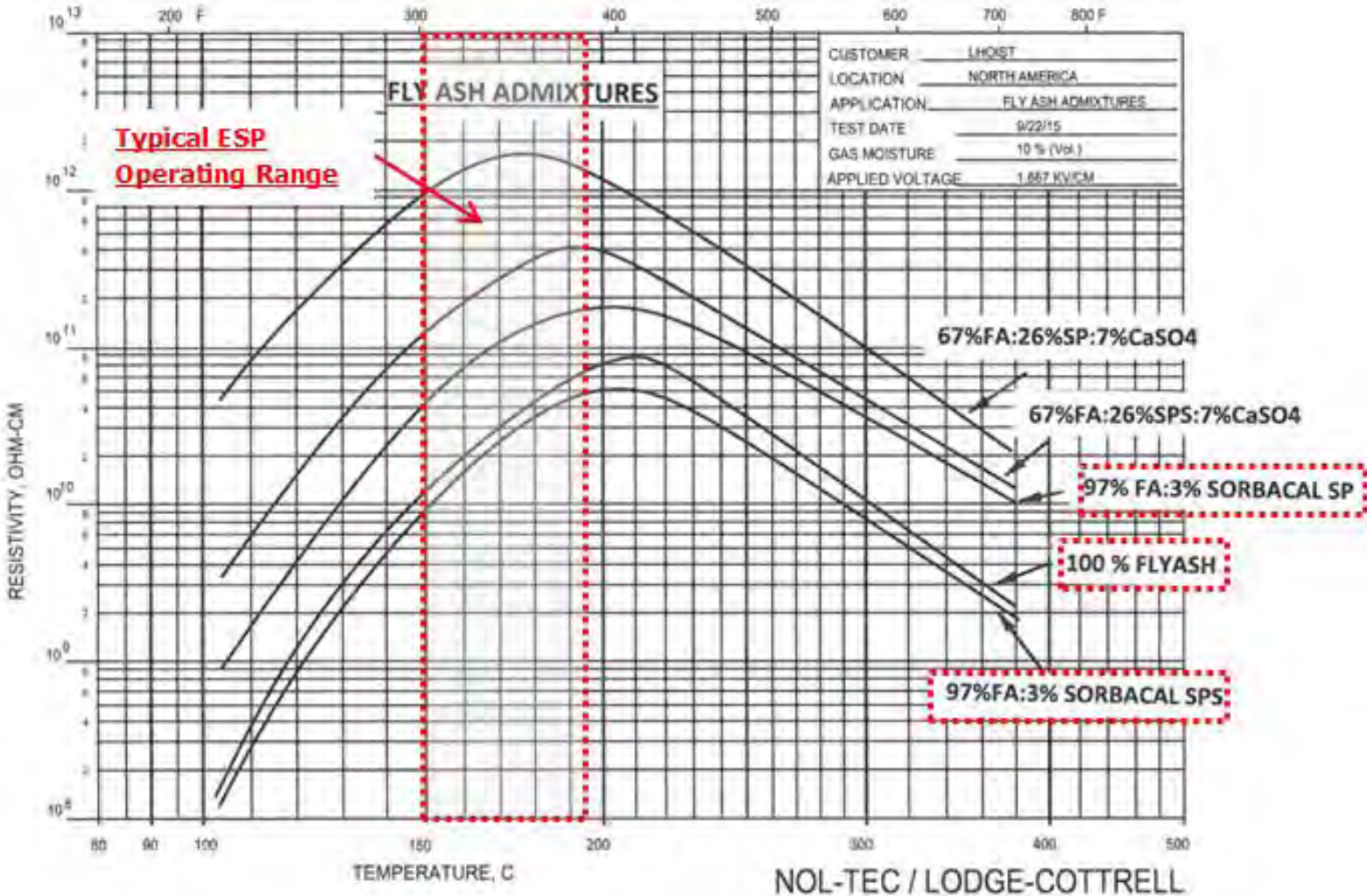


The impact of **Sorbacal® SPS** on ESP performance has been shown to be minimal in PRB applications

Sorbacal[®] in ESP Applications



Sorbacal® in ESP Applications



Sorbacal® SPS in ESP Applications



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

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

Trace Metal Capture with Sorbacal[®] Hydrated Lime Products

Trace Metal Capture with Sorbacal[®] Hydrated Lime Products

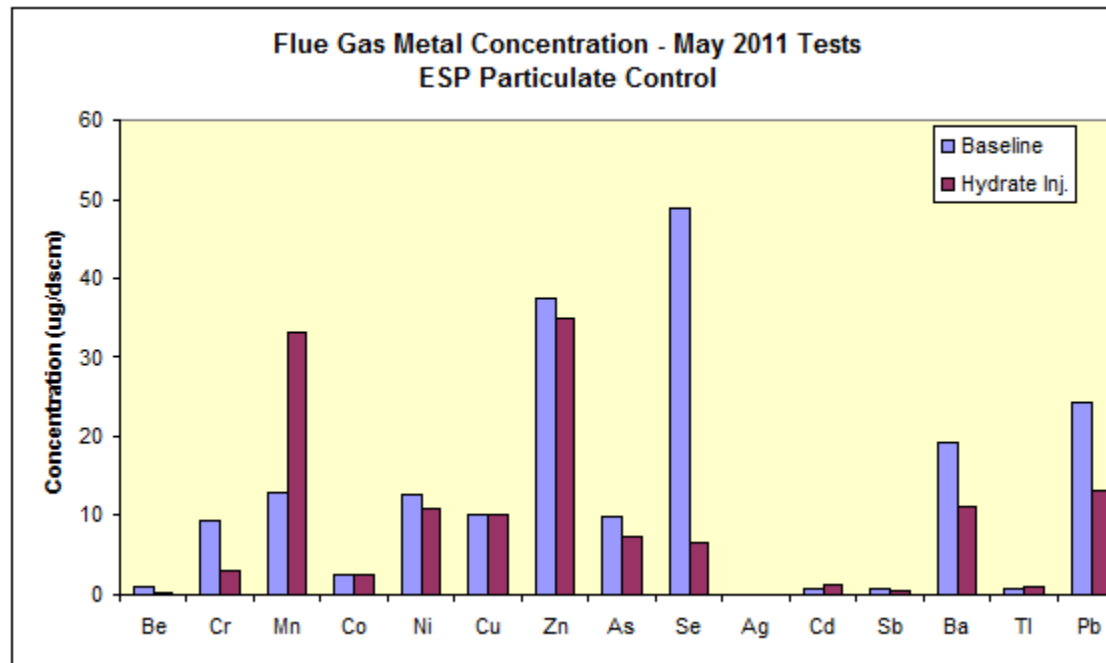


Secondary benefits that are present with a DSI system using Sorbacal[®] hydrated lime

- (1) Reductions in gas phase trace metal emissions, and
- (2) The production of a dry by-product that is basically non-leachable.

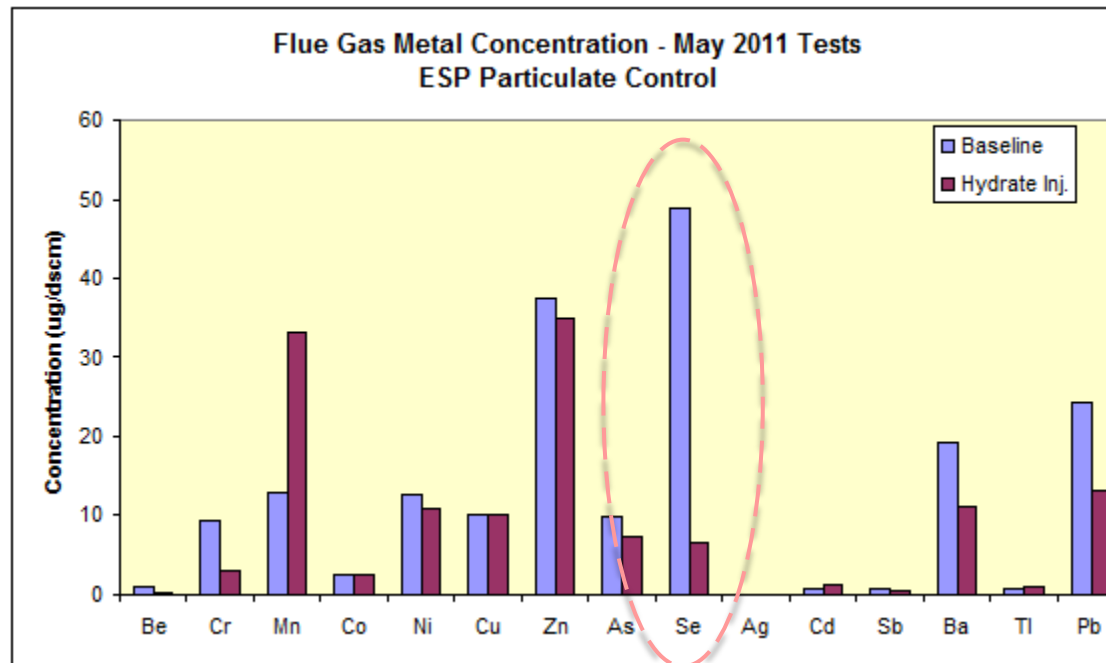
Removal of Trace Metal Emissions

- > 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 in 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 Sorbocal® SPS trials show strong performance on RCRA metals
- > Recent leachate testing during Sorbocal® SPS hydrated lime injection resulted in significant reduction in Selenium leaching from the fly ash

Flue Gas Metals Fly Ash Leaching Tests

Target Analyte	TCLP Hazardous Waste Limitation	2016 Sorbocal® 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 potential for disposal and use of coal combustion by-products can be directly related to the leaching of trace metals from the fly ash:

- Hydrated lime injection reduces vapor phase trace metals – particularly Se and As, and
- DSI with hydrated lime will not increase the leachability of metals from the ash over baseline
- 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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