THE McILVAINE COMPANY

Hydrated Lime for HCl Mitigation

Benefits of High Reactivity Hydrate

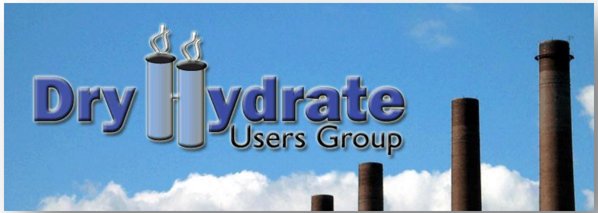
MISSISSIPPI® LIME

Discovering what's possible with calcium

July 18, 2013

Utility Focus - Support of Technical Advancement

- Support of key industry events
  - WPCA member
  - Sponsor of 2013 APC Conference in St. Louis
  - Dry Hydrate Users Group
- Continued funding of test programs
  - SO_3 & HCl mitigation
  - 2015 MACT/MATS requirements
- Technical Service and R&D organization
  - Equipment for field tests
  - Additional personnel
  - Focus on new product development



Hydrated Lime DSI (SO_3, HCl, SO_2)

Known

- Works well for acid gases
  - Good quality hydrate
- Works with hot or cold side injection
- On-site treatment unnecessary – ready to use as delivered
- Simple feed systems
- Ash-friendly

Challenges, new and old

- Tighter regulations for acid gases
- More in-flight capture
- Very marginal ESPs

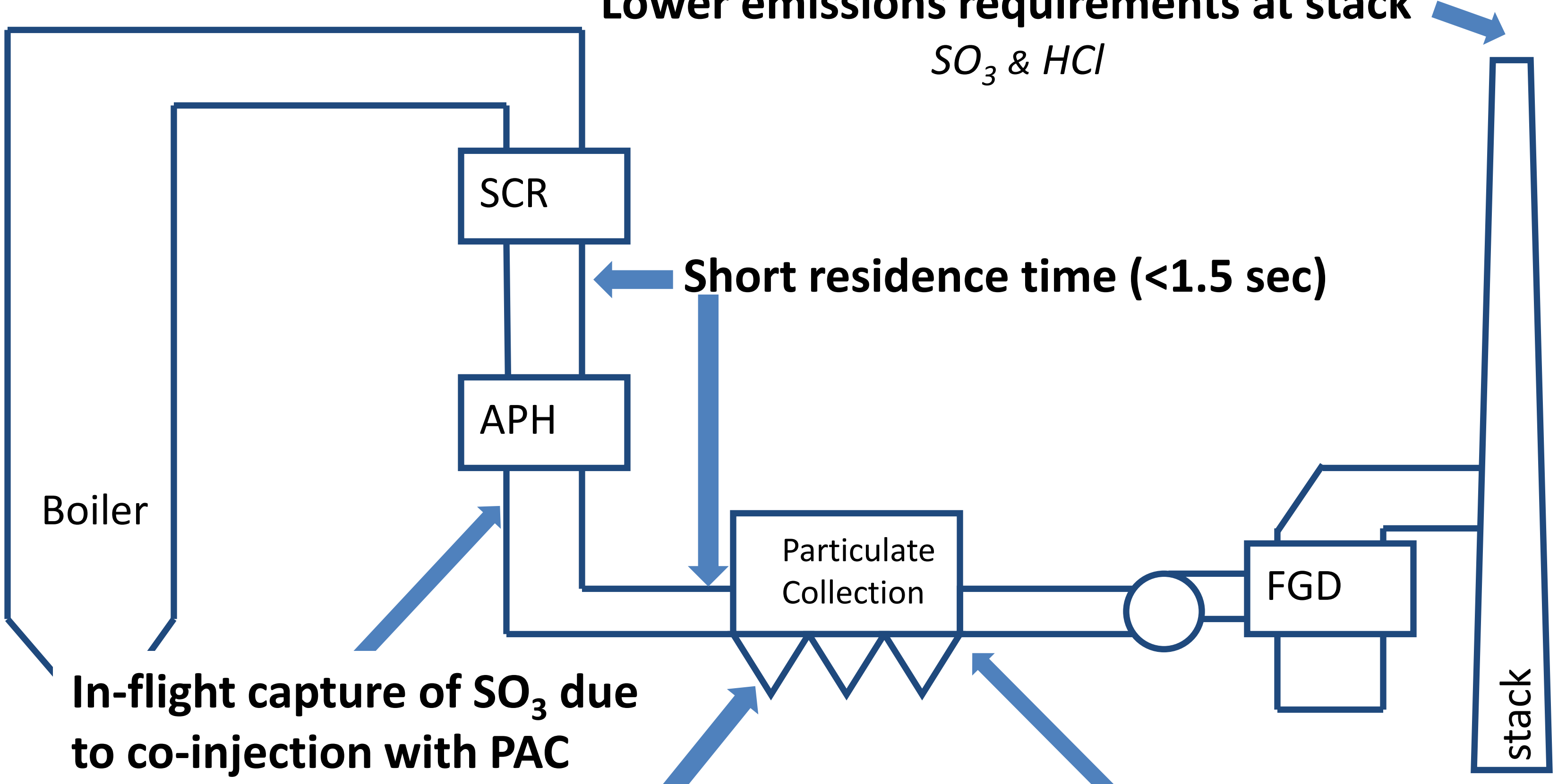
Factors Affecting Removal Rate

- Hydrated lime quality
  - Purity & reactivity
- Injection system efficiency
  - Feed system
  - Flow splitting
  - Flue gas coverage
- Residence time
- Levels of HCl

Market Needs for Higher Reactivity Hydrate

Lower emissions requirements at stack

SO_3 & HCl



Short residence time (<1.5 sec)

In-flight capture of SO_3 due to co-injection with PAC

Marginal ESP limits particulate

Desire to use less hydrate
Freight savings & less truck traffic

Performance Improvement

Qualify High Reactive Hydrate

- Lab data
  - Internal reactivity test
    - HR Hydrate >> FGT Hydrate >> Industrial Hydrate
  - TGA
- Pilot Studies
  - Southern Research Institute
  - B&W
- Full Scale Field Results
  - HCl removal chart
  - Other testing

General Properties – FGT Hydrate

Property	Guaranteed	Comment
Available $Ca(OH)_2$	$\geq$ 94% wt	High purity improves utilization, minimizes byproduct.
- 325 mesh	$\geq$ 92% wt	Fine power product
Moisture	$\leq$ 1.0% wt	As shipped, good for handling
BET Surface Area	$\geq$ 20.0 m^2/g	High surface area improves acid gas capture. Major hydrate DSI systems use material with >20 BET material
SiO_2	$\leq$ 2.0% wt	Low quantity of inert material Reduced wear on equipment

Reactivity Test Comparison

Identified potential laboratory screening method for hydrated lime reactivity

	Reactivity	**Surface Area**	**Pore Volume**
Construction Hydrate	50+ sec	15	0.050
High SA/PV Hydrate	42 sec	31.5	0.206
Hydrated Lime FGT	27 sec	21.5	0.089
High Reactivity Hydrate	4 sec	21.3	0.097

Determined that HR Hydrate was worthy of additional evaluation at pilot and full scale

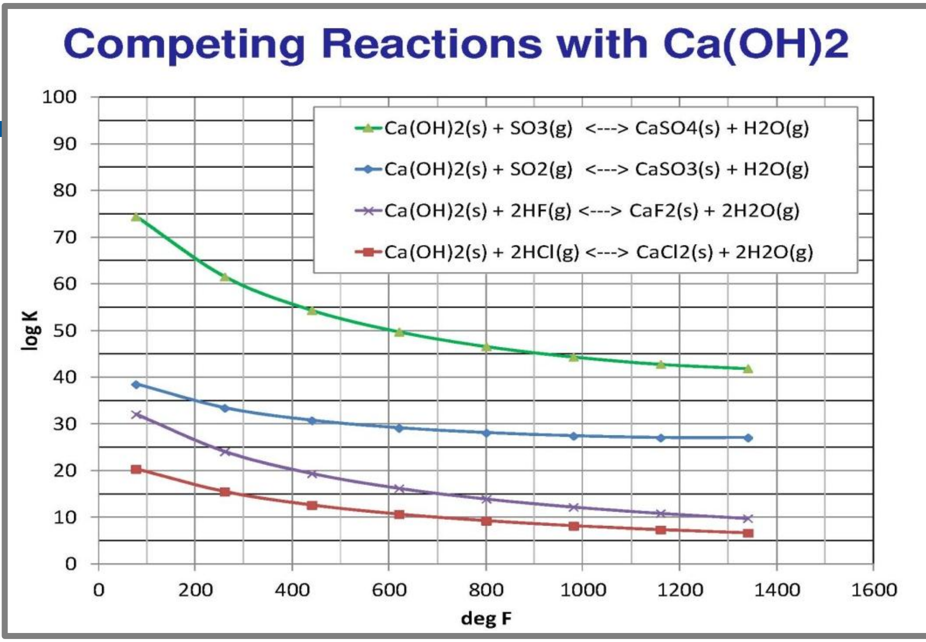
Reactivity & Removal

Thermodynamic

- $SO_3 > SO_2 > HF > HCl$

Kinetic

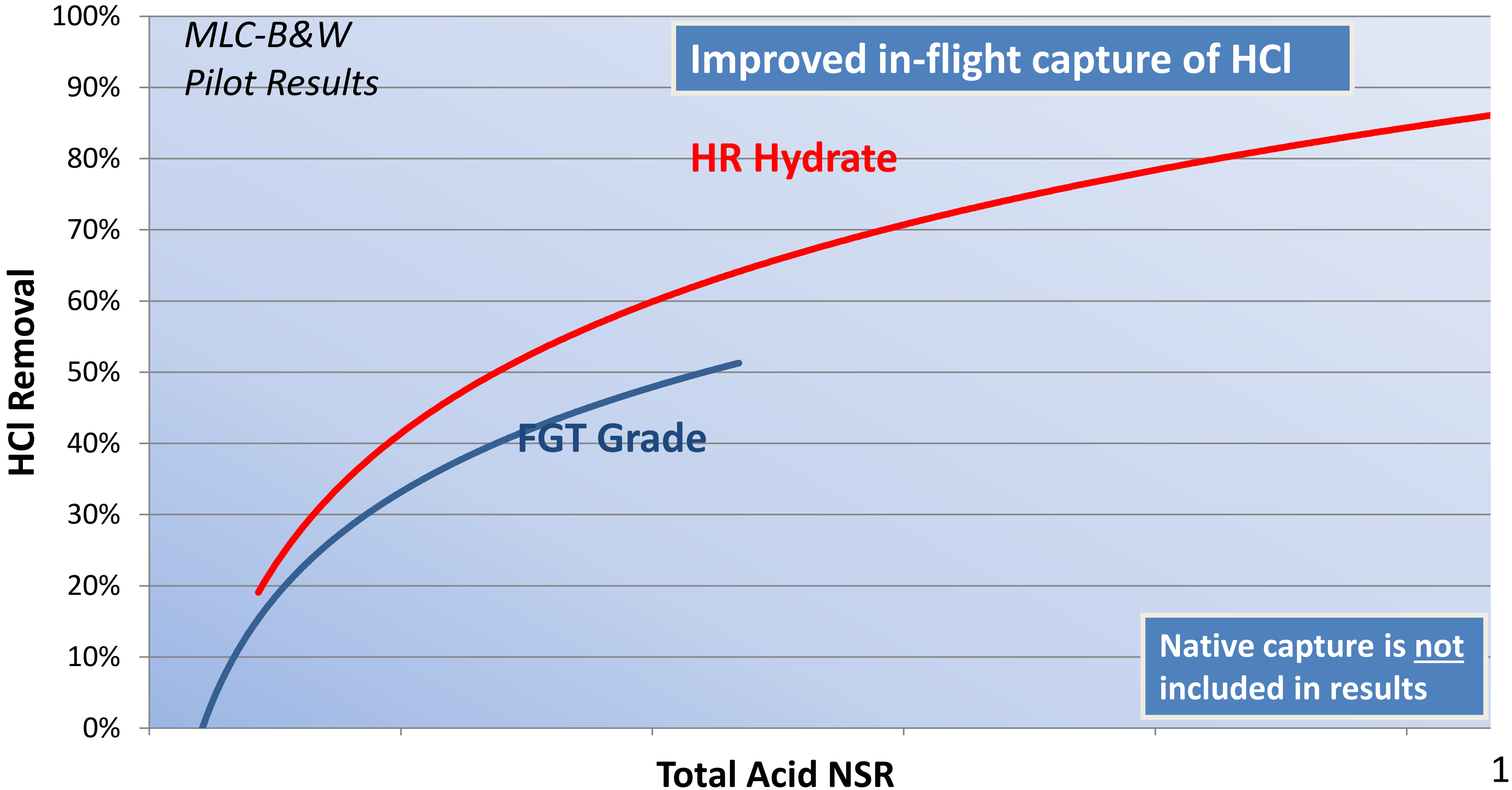
- Maximize collisions
- Hydrate D_{50} ~ 2-4 μm
- Gas particles ~ 0.0003 μm



Benson, 2012 DHUG

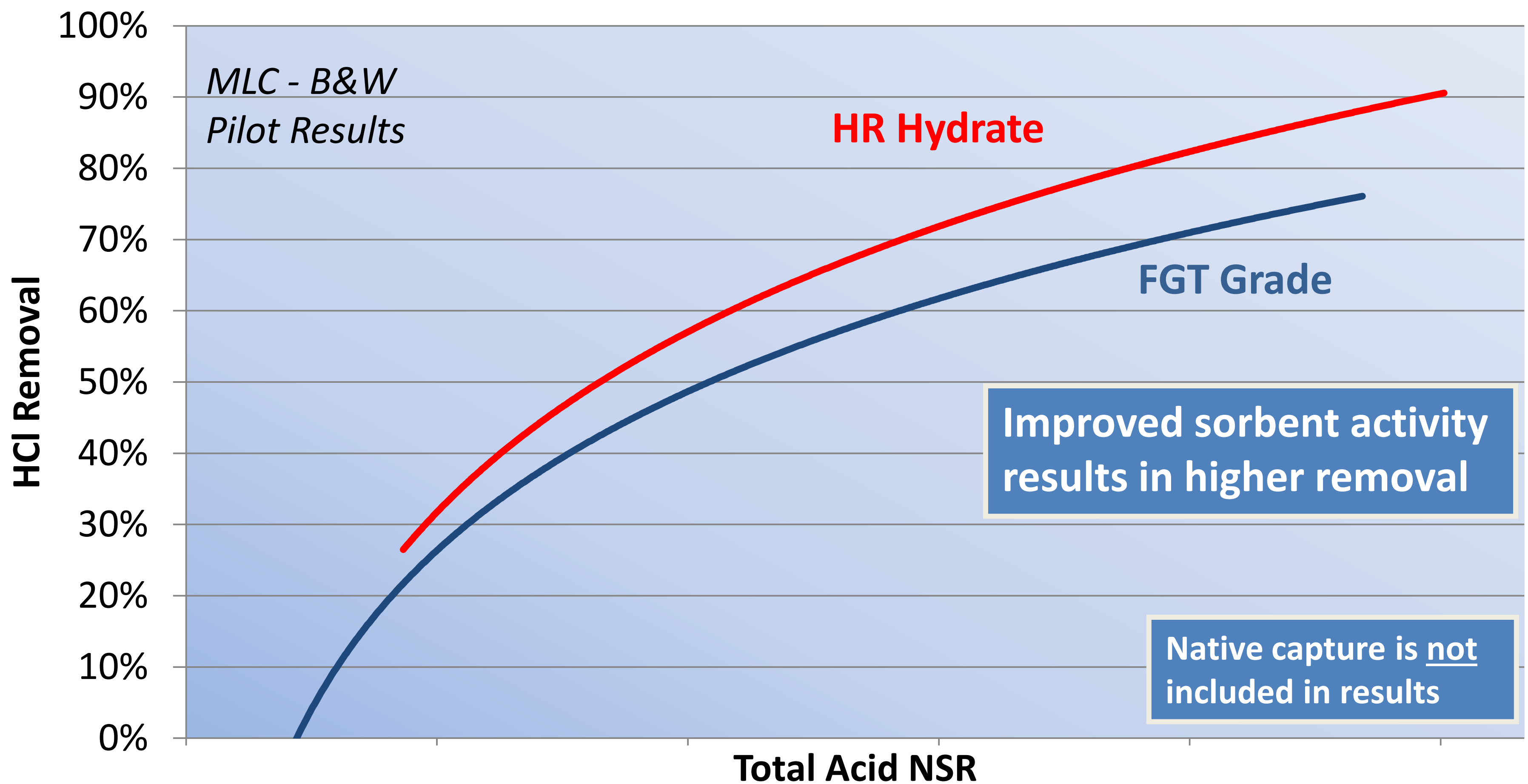
Pilot Scale Testing Hydrate for HCl – In-flight

Hydrate Comparison In-flight HCl removal (before baghouse)

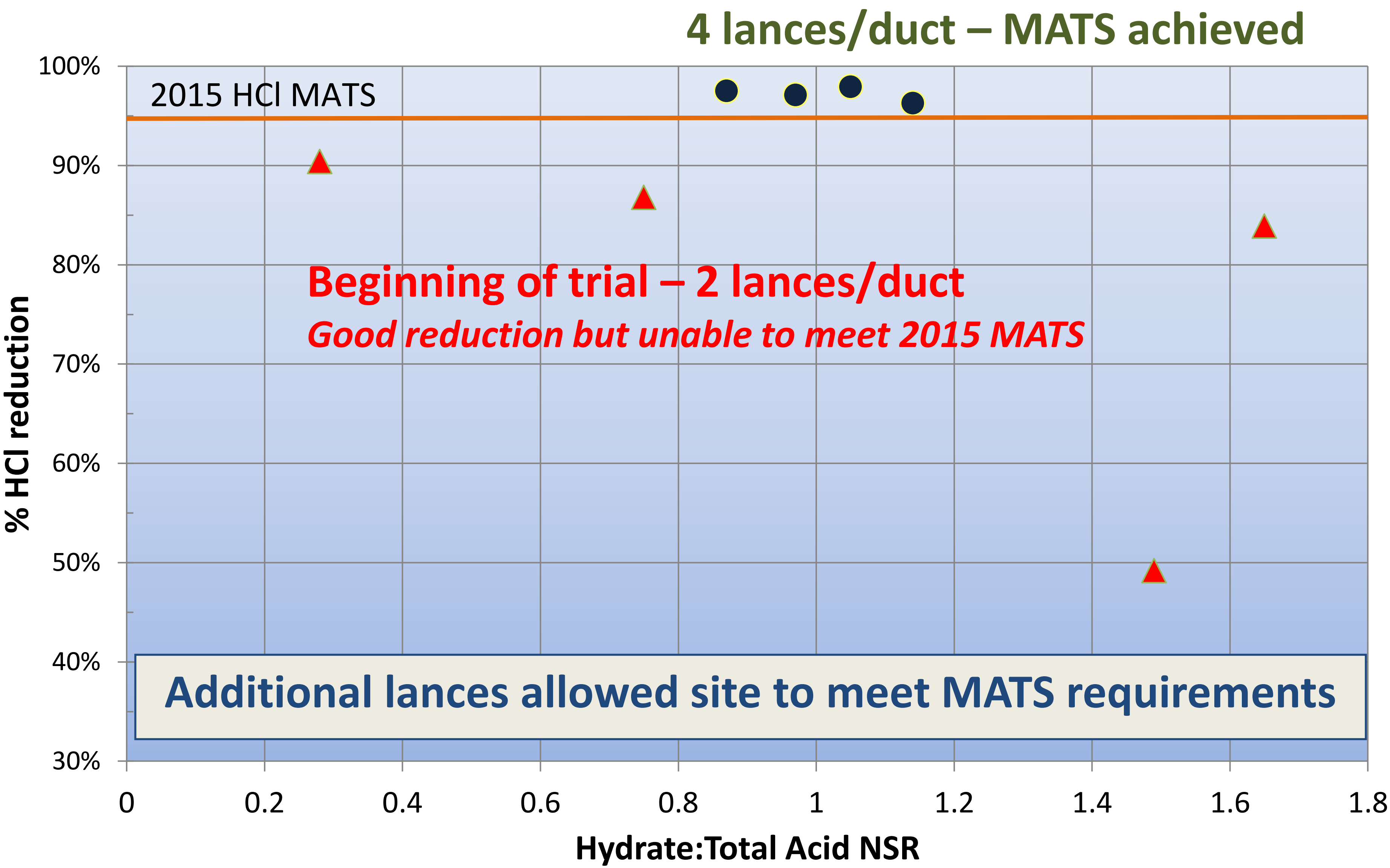


Pilot Scale Testing Hydrate for HCl – Baghouse Outlet

Overall (Baghouse outlet) HCl removal



Test Site 1 - Results of Improved Distribution



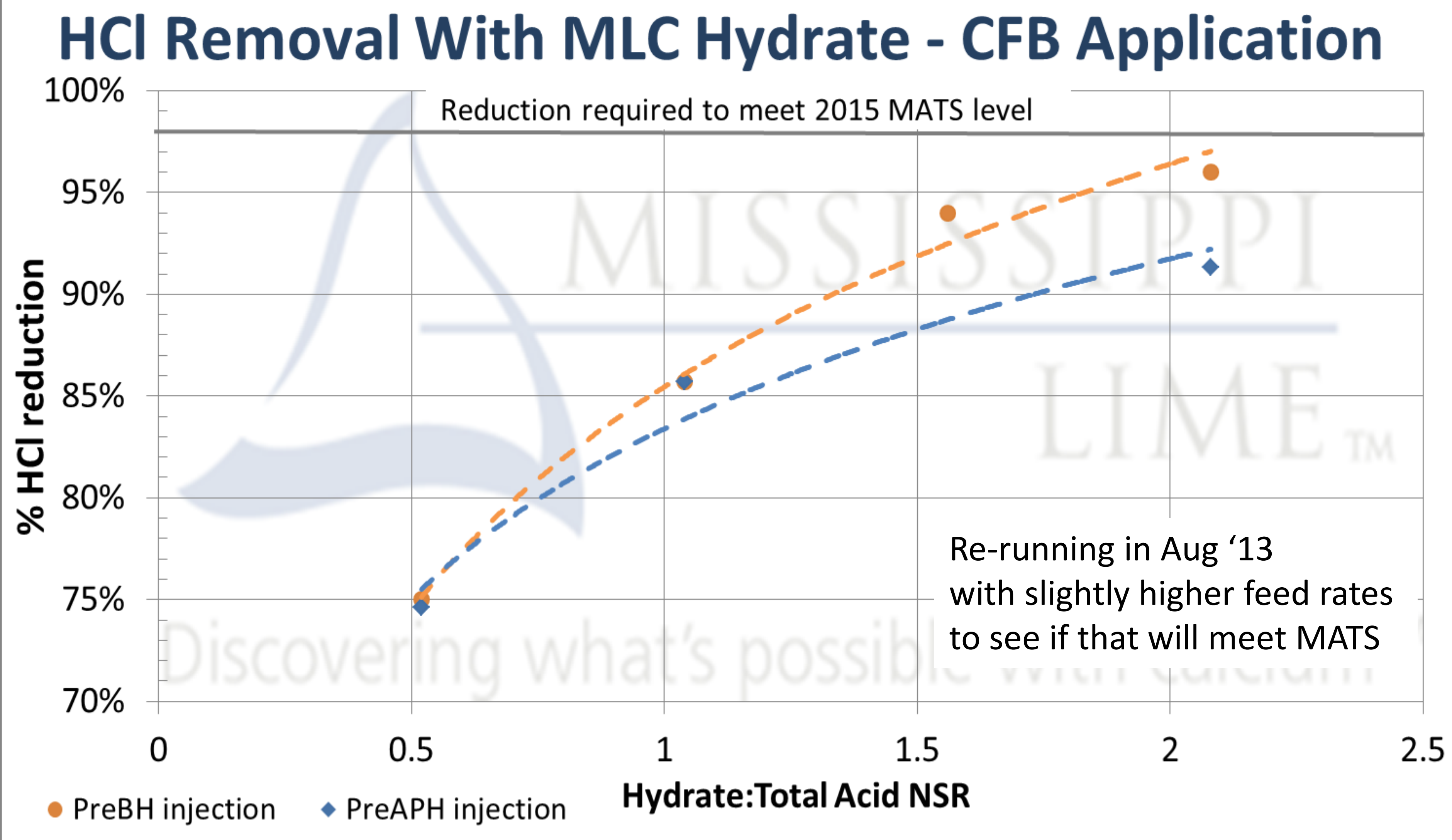
Test Site 2 – HCl Reduction for MATS

- Smaller (<200 MW) Unit with Baghouse
- Higher SO_2 (~500 ppm) and HCl (~90 ppm) levels
- MATS achieved with >99% HCl reduction
- Also some SO_2 reduction (40-50%)
  - Relatively high Hydrate: Total Acid ratio (>3.0)

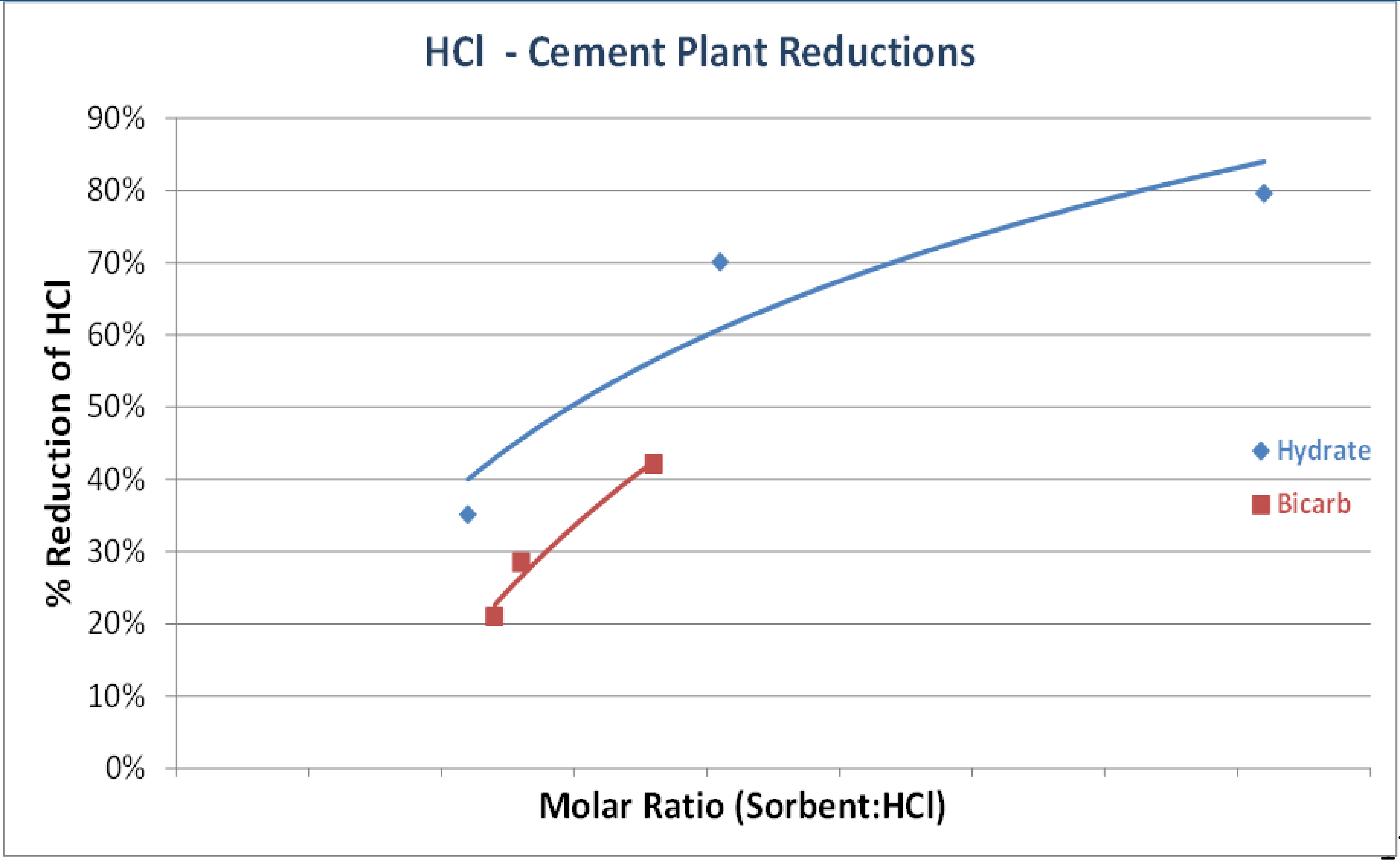
Test Site 3 – HCl and Hg Reduction for MATS

- Smaller (<200 MW) Unit with ESP
- Lower SO_2 (<400 ppm) and HCl (<10 ppm)
- MATS achieved for HCl
- Selenium emissions also reduced by ~80% when injecting hydrate
- Issues:
  – Opacity increase, but below limits
  – pH increase in wet ash pond

Test Site 4 – CFB for HCl



Test Site 5 – Cement Plant for HCl



Highlights of Full Scale Testing for HCl Control

HCl Removal

- MATS Limits met in 6 out of 7 trials in 2012
  - Baghouse
  - ESP
  - Marginal ESP
  - Industrial Waste Incinerator
  - One trial not meeting MATS (dosage? Repeating test in Aug '13)
    - 96% HCl reduction
- Very marginal ESP and short residence time
  - HCl reduction of ~90% at 0.7 NSR (hydrate:total acid)
  - High chloride coal

Benefits of Using Less Hydrate

- Lower annual freight costs
- Fewer trucks ordered per year
  - Fewer transactions
  - Less local and plant traffic
  - Safety incident potential is reduced
    - Less hookups and disconnects
  - CO_2 reduction from reduced truck shipments
- Less tons of ash to landfill
  - Freight, traffic, transactional, and CO_2 benefits here also
  - Lower $CaOH_2$ levels in fly ash

Summary

- Mississippi Lime is an industry leader in Hydrated Lime DSI
- Hydrated Lime FGT is proven for SO_3 and HCl
- High Reactivity Hydrate presents a solution to improved in-flight capture of SO_3 and HCl
- Mississippi Lime has testing equipment and R&D personnel focused on conveying optimization and next generation products

Questions

Pat Mongoven
Business Development Manager – FGT
pgmongoven@mississippilime.com

Curt Biehn
Manager, Marketing and Technical Services
crbiehn@mississippilime.com

Mark DeGenova
Chief Chemist
mgdegenova@mississippilime.com

Eric Van Rens
Vice President, Sales & Marketing
ecvanrens@mississippilime.com

Mississippi Lime Company
3870 S. Lindbergh Blvd.
Suite 200
St. Louis, MO 63127
www.mississippilime.com

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