Lhoist North America
Lhoist Group

Energy, Utility & Environment Conference

San Diego, CA

February 18, 2015

SO_2 Control Using Dry Sorbent Injection Technology with Hydrated Lime

Author: Gerald Hunt
Co-Author: Jim Dickerman

Agenda

Lhoist North America
Lhoist Group

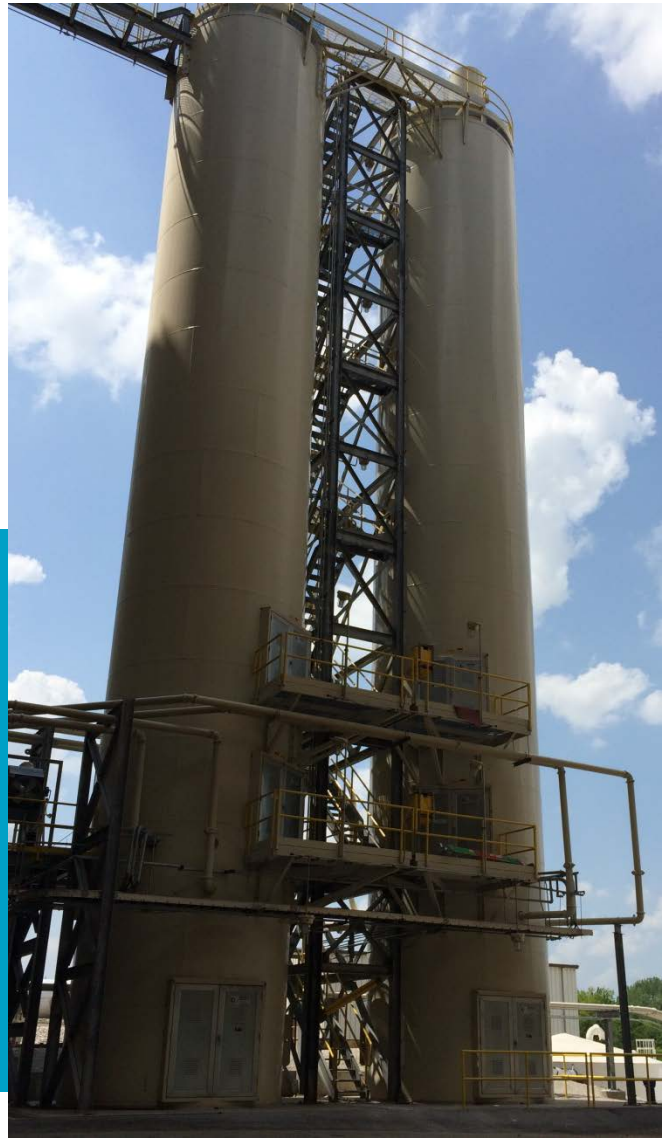
- Why Dry Sorbent Injection (DSI)?
- Hydrated Lime Sorbents
- DSI Case Studies
- Conclusions
- Summary

Lhoist North America
Lhoist Group

Why Dry Sorbent Injection (DSI)?

Why Dry Sorbent Injection (DSI)?

Lhoist North America
Lhoist Group



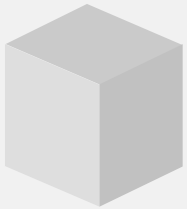
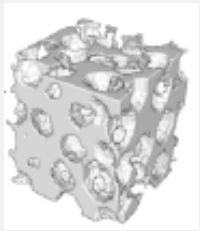
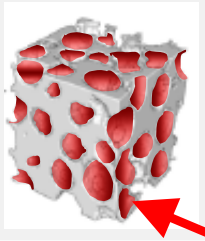
- Equipment is low installed capital cost
- System relatively easy to retrofit to most plants
- Small equipment footprint
- Mechanically simple system
- ~1 year schedule
  - ✓ award to installation
- Low consumable requirement
  - ✓ air, power

Lhoist North America
Lhoist Group

Hydrated Lime Sorbents

Range of Products

Lhoist North America
Lhoist Group

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

Lhoist North America
Lhoist Group

DSI Case Studies

DSI Case Studies #1a and #1b

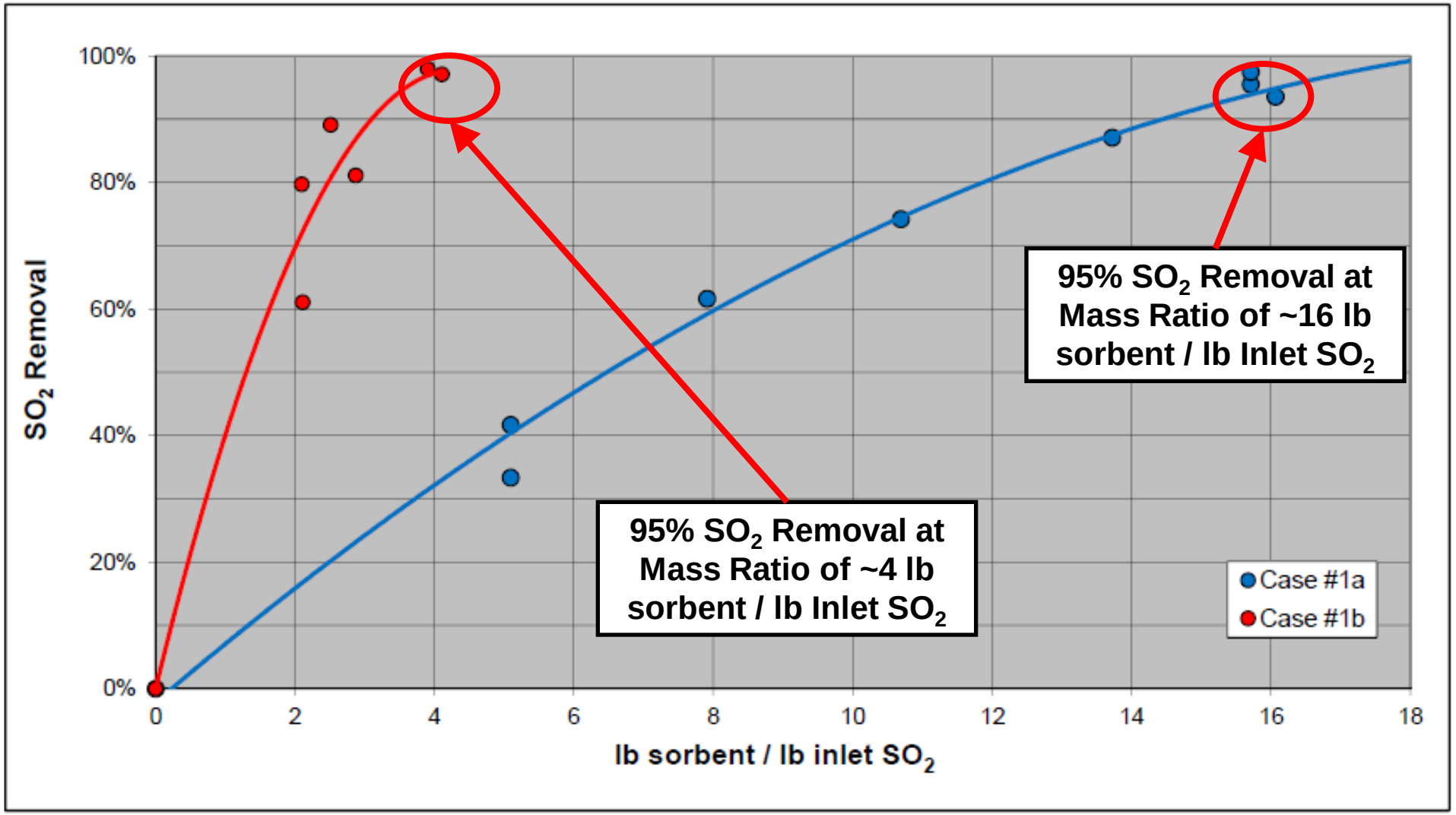
Lhoist North America
Lhoist Group

- Application → Industrial Manufacturing Process
- Goal → 95+% SO_2 Removal Efficiency
- Why → Meet Future SO_2 Permit Limit
- Process → SDA → Multi-Clone → DSI → FF
- Flue gas temperature at DSI location 300-350°F
- DSI → One (1) Injection Lance @ Fabric Filter Inlet
- Sorbent → Sorbacal® SPS

Case	Flue Gas Volume	Moisture Content	Baseline SO_2 Conc.
	ACFM	**Vol. %**	**ppmv**
1a	10,000	~14	100
1b	55,000	~36	300

DSI Case Studies #1a and #1b

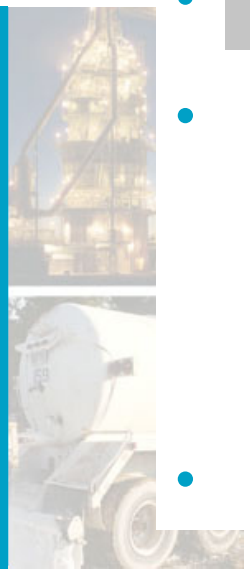
Lhoist North America
Lhoist Group



DSI Case Study #2

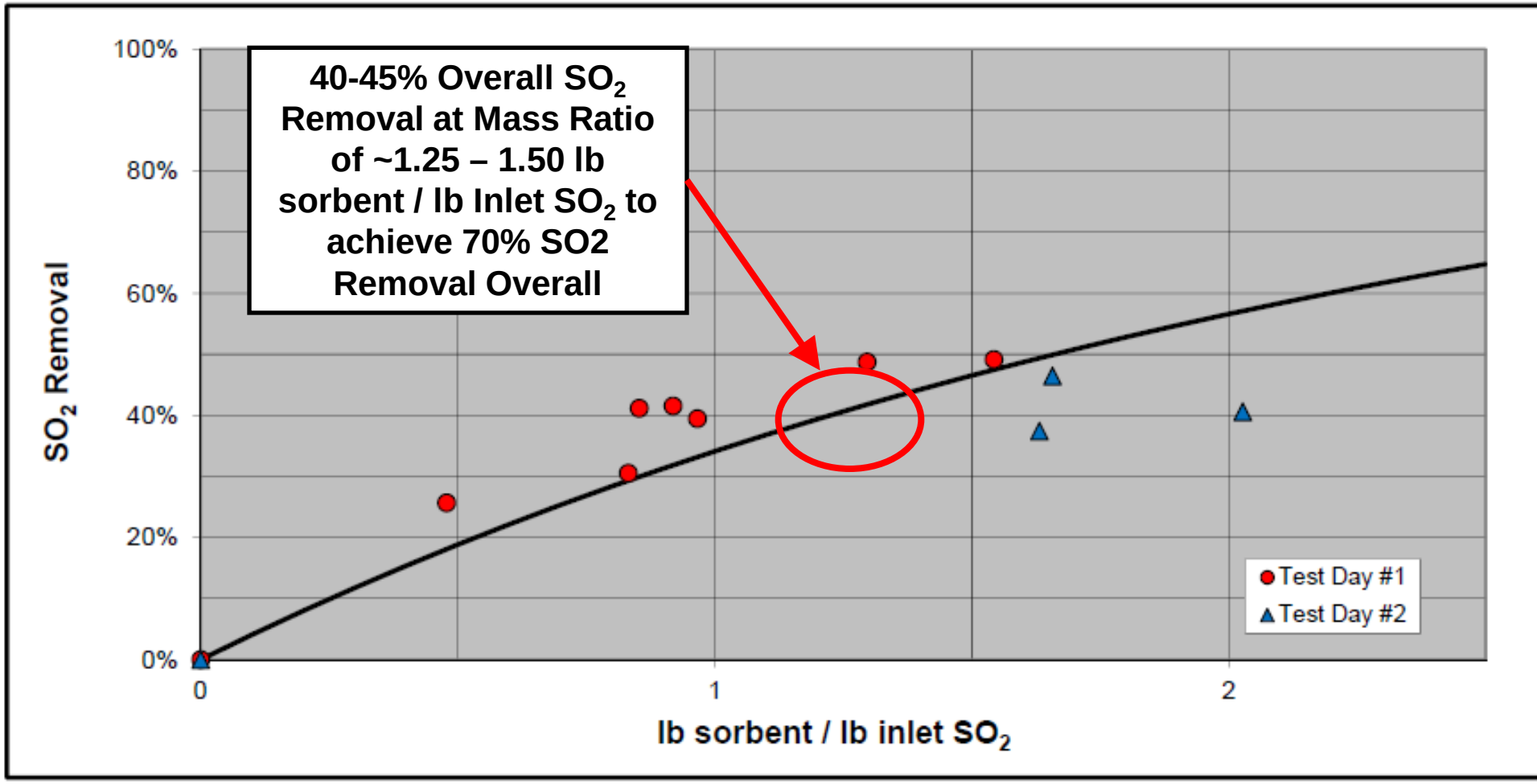
Lhoist North America
Lhoist Group

- Application → 500 MW Electric Generating Utility (EGU)
- Goal → Increase Overall SO_2 Reduction to ~70% (40-45% Incremental SO_2 Removal with DSI)
- Why → Meet Future SO_2 Limit
- Low Sulfur Coal → Boiler → Air Heater → DSI → SDA → FF
- Process Conditions
  - ✓ Flue gas moisture ~20% relative humidity at stack
  - ✓ Baseline concentration ~225-250 ppmv SO_2
  - ✓ Flue gas temperature at DSI location 275-300°F
- DSI → Five (5) Injection Ports @ DSI Location
- Sorbent → Sorbacal® SPS



DSI Case Study #2

Lhoist North America
Lhoist Group



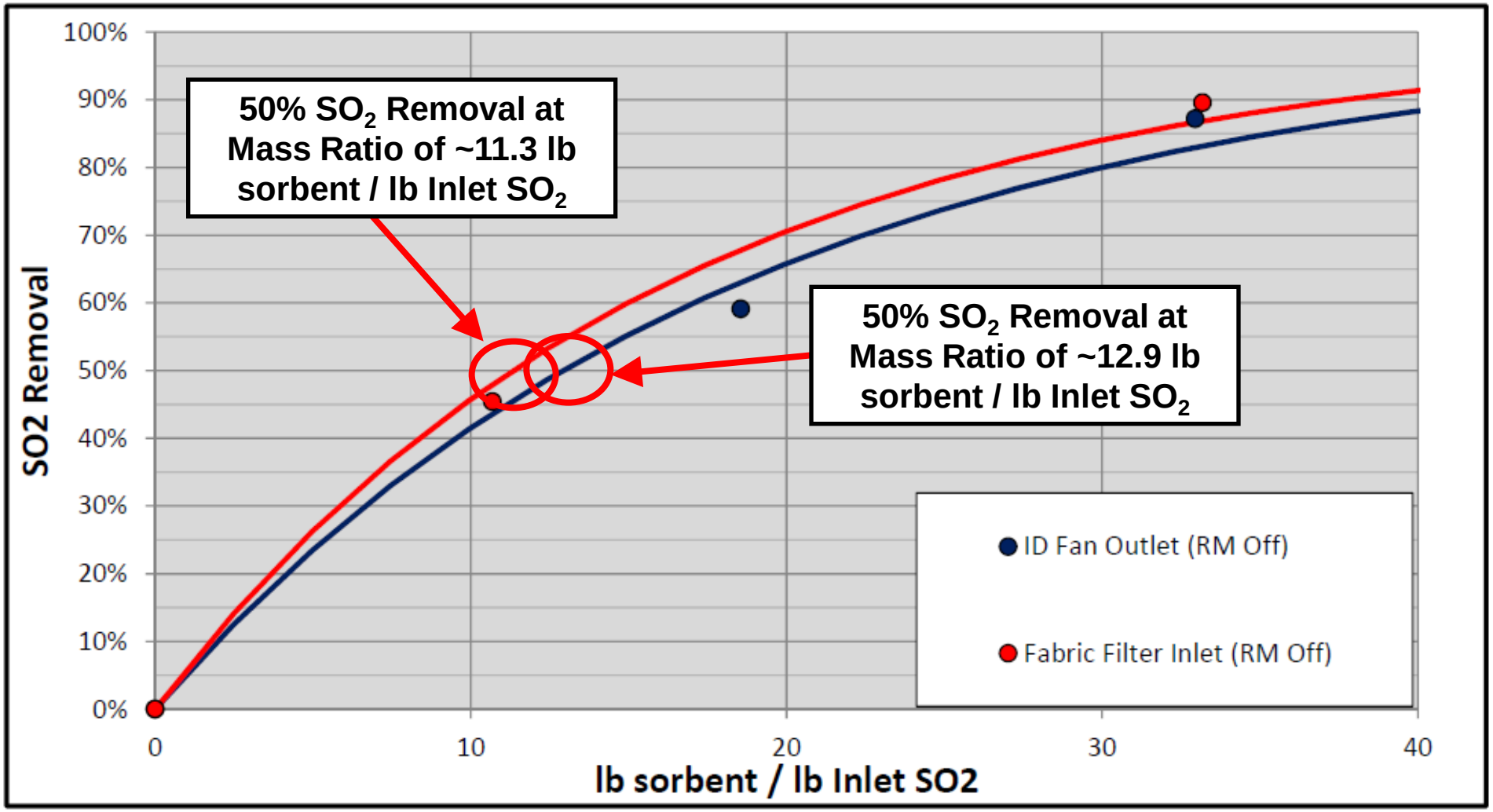
DSI Case Study #3

Lhoist North America
Lhoist Group

- Application → 985,000 ACFM Cement Plant
- Goal → At Least 50% SO_2 Removal Efficiency
- Why → Comply with Future Permit SO_2 Limit
- Raw Feed & Fuel → Kiln → Pre-Heater → ID Fans → Raw Mill → Fabric Filter
- Process Conditions
  - ✓ Flue gas moisture unknown
  - ✓ Baseline concentration 15 ppmv SO_2 with Raw Mill on / 35 ppmv SO_2 with Raw Mill off
  - ✓ Flue gas temperature at DSI location
    - ID Fan Inlet 575-675°F / Fabric Filter Inlet 370-470°F
- DSI → Four (4) Injection Lances per Duct @ DSI Location
- Sorbent → Sorbacal® SPS

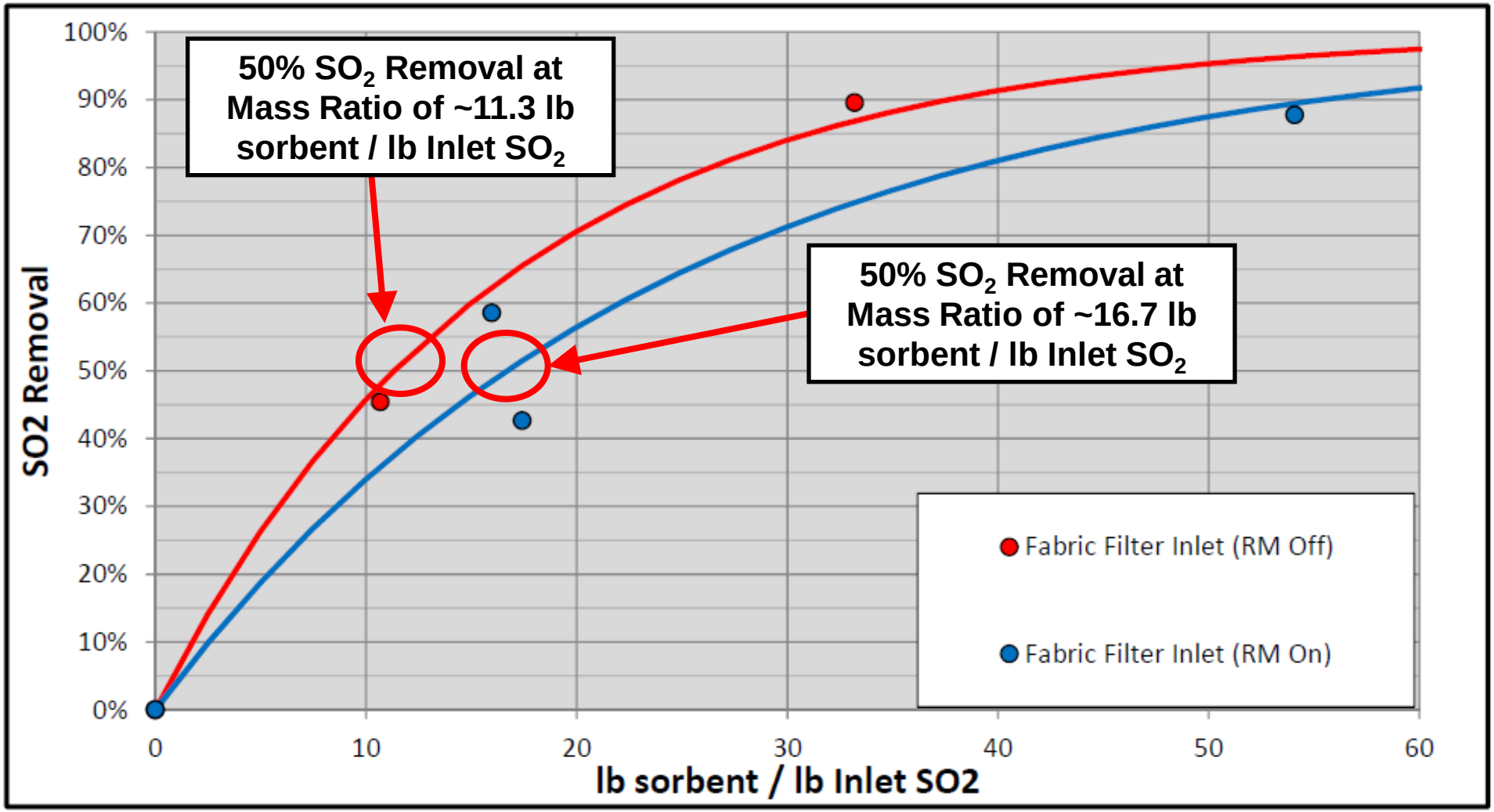
DSI Case Study #3

Lhoist North America
Lhoist Group



DSI Case Study #3

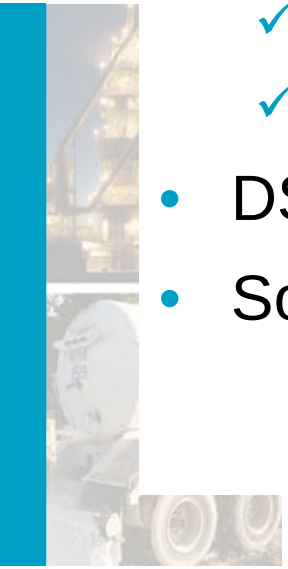
Lhoist North America
Lhoist Group



DSI Case Study #4

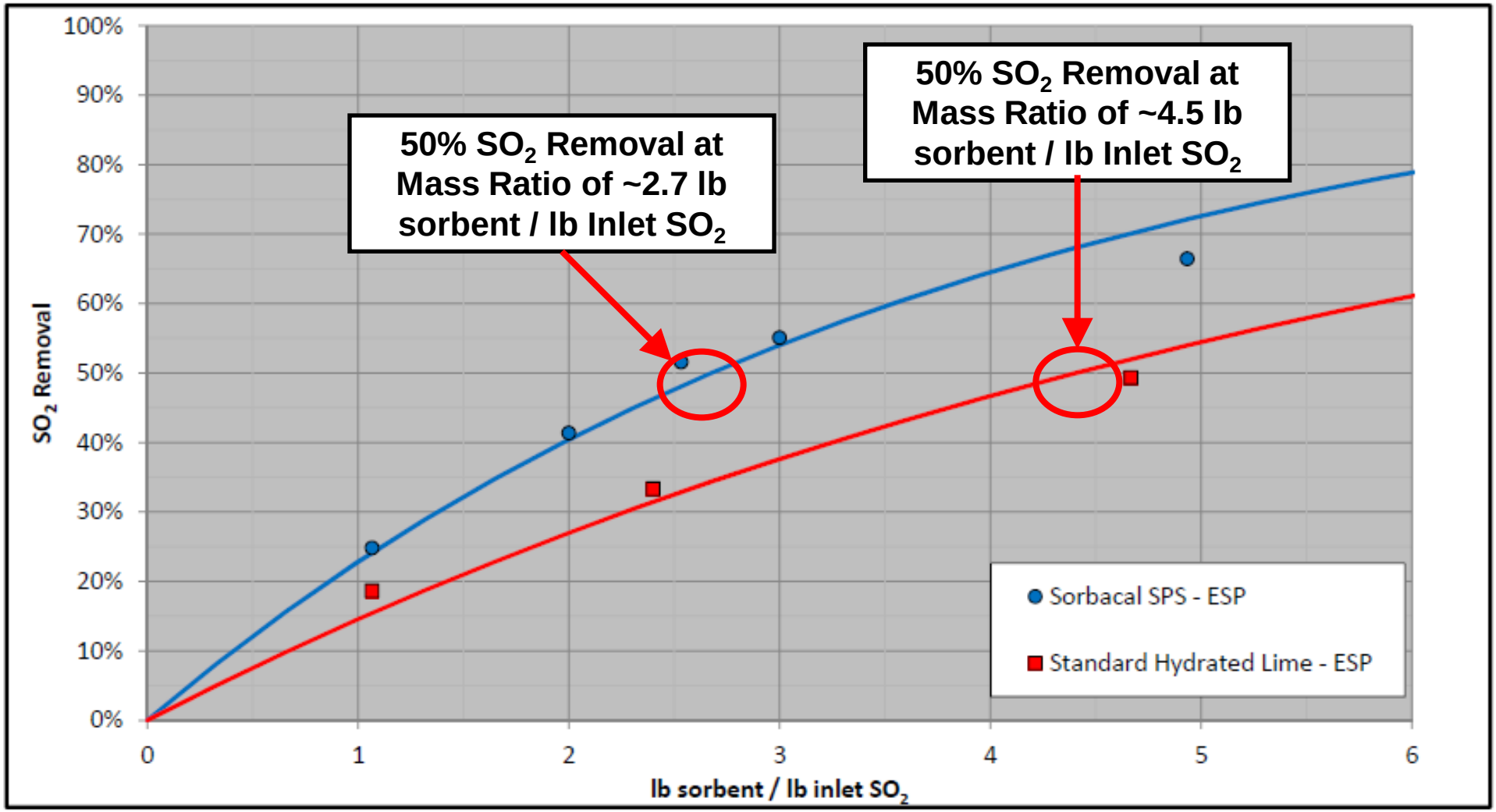
Lhoist North America
Lhoist Group

- Application → 580 SCFM Pilot Plant
- Goal → Compare Relative SO_2 Removal Efficiency
- PRB Coal → Boiler → DSI → Heat Exchanger → ESP
- Process Conditions
  - ✓ Flue gas moisture ~9% by Volume
  - ✓ Baseline concentration ~150 ppmv SO_2
  - ✓ Flue gas temperature at DSI location ~700-750°F
- DSI → One (1) Injection Lance @ DSI Location
- Sorbents → Standard Hydrated Lime & Sorbacal® SPS



DSI Case Study #4

Lhoist North America
Lhoist Group



Conclusions / Discussion

Conclusions

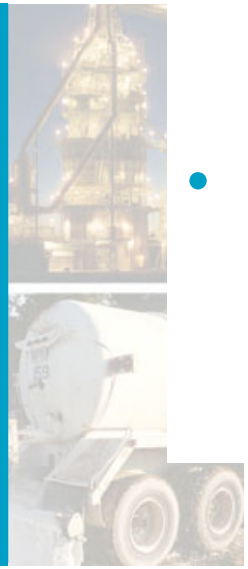
Lhoist North America
Lhoist Group

- All cases were successful in achieving target SO_2 removal efficiency using DSI technology with hydrated lime sorbent
- Cases 1a and 1b
  - ✓ DSI using Sorbacal® SPS able to achieve high SO_2 removal efficiencies (> 95%)
  - ✓ Flue gas moisture content appears to be primary factor driving better performance in Case 1b
- Case 2
  - ✓ DSI using Sorbacal® SPS effective solution for SO_2 trim application even on large scale

Conclusions

Lhoist North America
Lhoist Group

- Case 3
  - ✓ DSI using Sorbacal® SPS able to achieve target SO_2 removal at various injection locations under varying conditions
  - ✓ Demonstrated high SO_2 removal (85-90%) at three (3) injection locations
  - ✓ Illustrates why each site must be evaluated on case by case basis
- Case 4
  - ✓ DSI using Sorbacal® SPS was ~40% more efficient than standard hydrated lime for SO_2 control at 700-750°F injection temperature based on PRB coal



Summary

Summary

Lhoist North America
Lhoist Group

- DSI technology using hydrated lime sorbents viable SO_2 compliance solution
- Flue gas moisture important for performance
- Sorbent properties also important
  - ✓ standard hydrated lime vs. enhanced hydrated limes
- Path Forward:
  - ✓ Additional SO_2 trials to understand how different parameters impact performance
  - ✓ Improve flue gas to sorbent mixing
  - ✓ Improve understanding of impacts of competitive reactions, flue gas temperature, flue gas moisture, sorbents, etc. on SO_2 removal
  - ✓ High temperature applications (furnace injection)

Summary

Thank you!!

If you have any questions feel free to contact,

Gerald Hunt
Lhoist North America
Flue Gas Treatment (FGT) Specialist
(412) 979-6337
gerald.hunt@lhoist.com