REINHOLD ENVIRONMENTAL Ltd.

# 2018 APC & Wastewater Round Table & Expo Presentation

July 23 & 24, 2018 in Lexington, KY / Hosted by East Kentucky Power Coop

*2018 Reinhold Environmental Conference – Lexington, KY*
*Workshop 15*

# Value Added Tools for Continuous Improvement to DSI Systems

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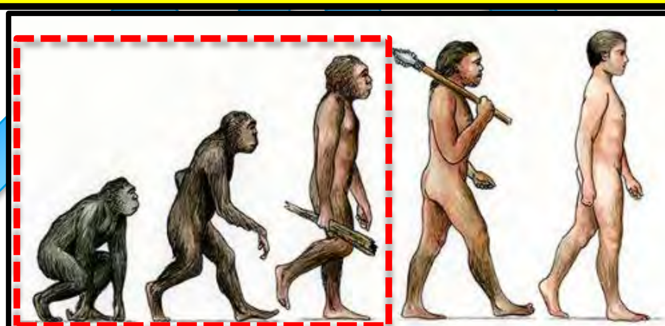
# Introduction

## DSI Technology Past



DSI Technology Evolution

Early on $SO_2$ w/ Sodium


Growth for $SO_2$ w/ Sodium

$SO_3$ w/ Hydrated Lime & Tr
("Blow and Go")

System Reliability Issues

HCl Control w/ Sodium

HCl Control w/ Hydrated Lime

mercury & air toxics standards

BOILER MACT

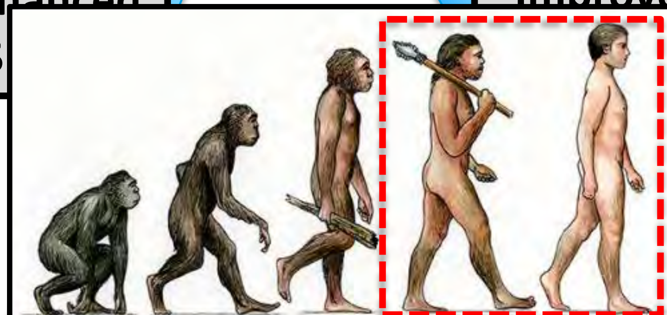
DRY HYDRATE USERS GROUP

# Introduction

**DSI Technology Present**

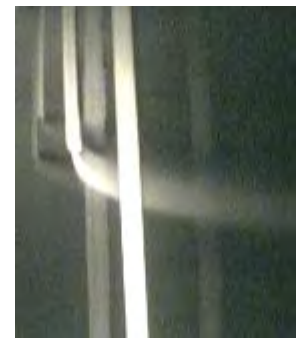
**$SO_3$ & HCl Optimization w/ Enhanced Hydrates (i.e. Sorbacal® S**


**40+ $m^2$/gram**
**0.20+ $cm^3$/gram**



DSI Technology Evolution

**Improved Mixing Technologies**



**$SO_2$ w/ Enhanced Hydrates (i.e. Sorbacal® SPS)**

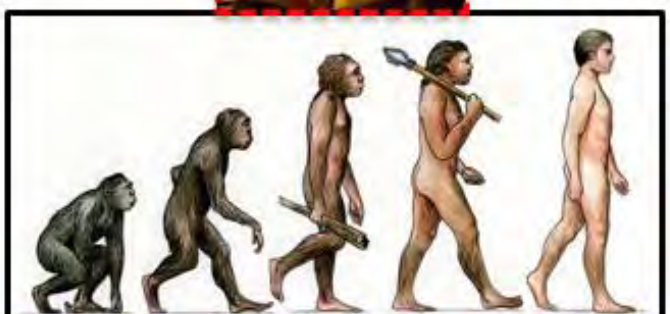

**40+ $m^2$/gram**
**0.20+ $cm^3$/gram**
**Activation**

**$SO_3$ Optimization w/ Injection Upstream**

# Introduction

**DSI Technology Future**

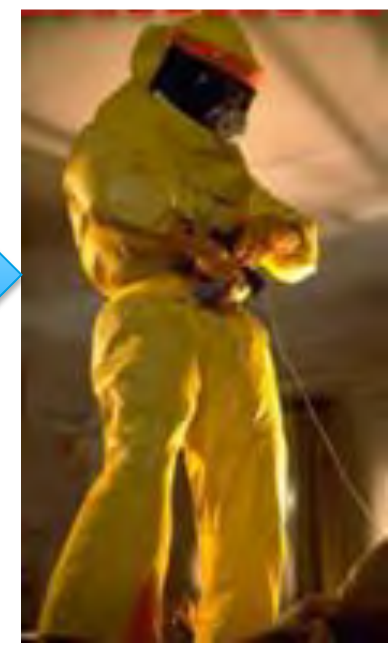
- Heavy Metals Removal (i.e. Se)
- Additional $SO_2$ Controls w/ NAAQS
- HCl Control for ELG
- Further $SO_3$ Optimization w/ Injection Upstream
- Holistic Cost Optimization
- Further Improvement in DSI System Reliability



DSI Technology Evolution

## How Did We Get Here?

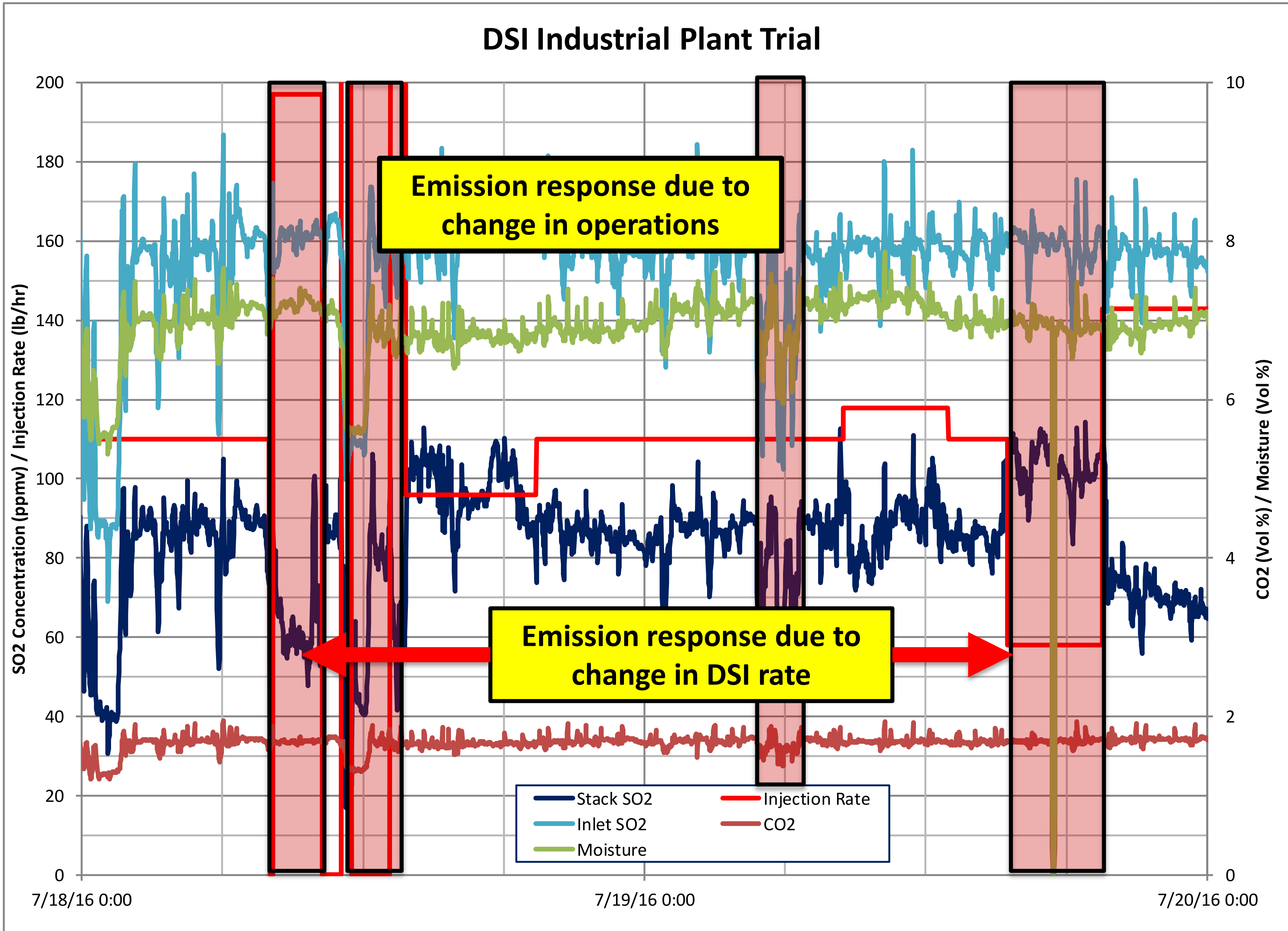
## How will We Get Where We Need to Go?



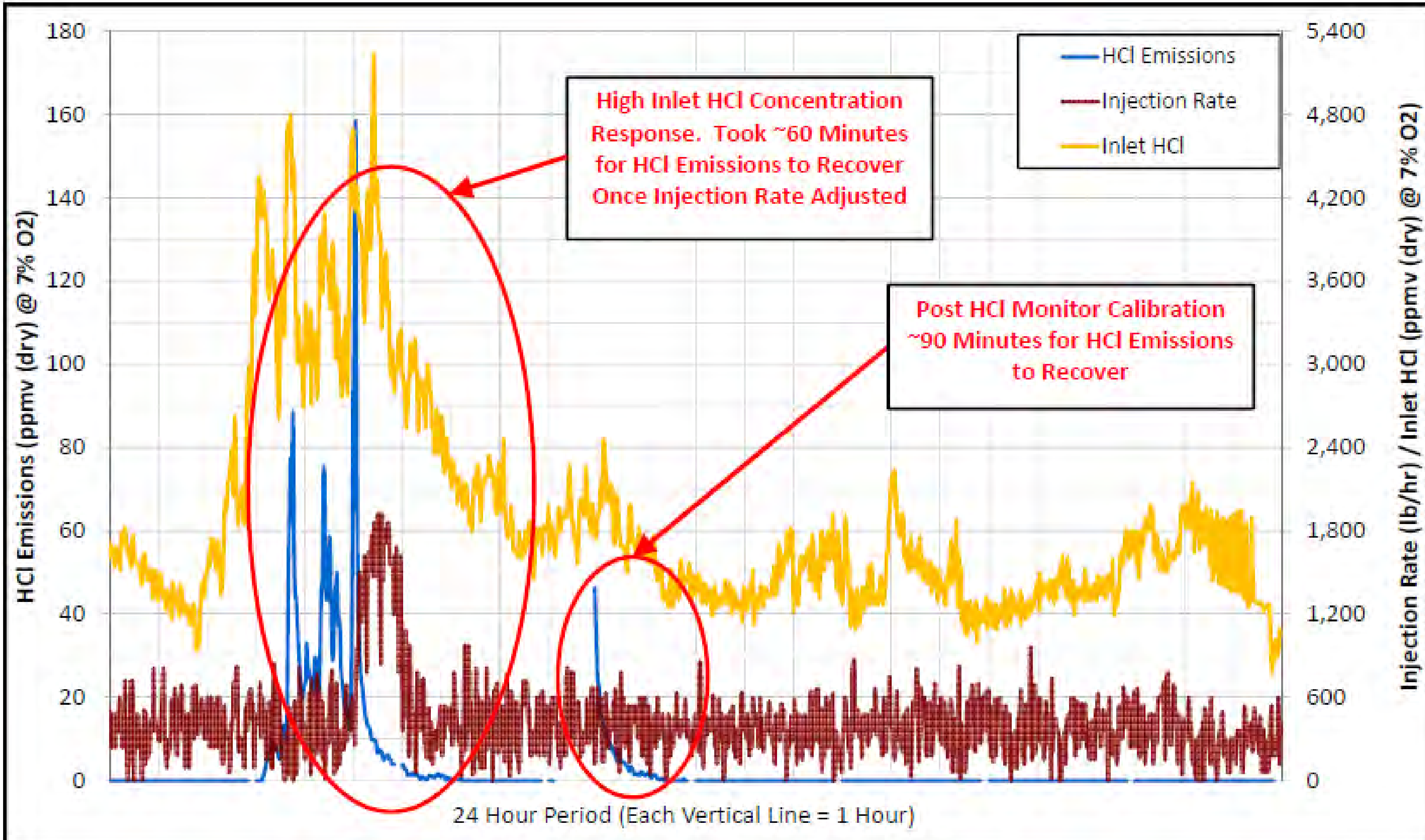
# Use of Continuous Emissions Monitors

- Simultaneous CEMS/analyzers upstream of injection location and at stack or ESP/FF can collect valuable data
  - ➢ HCl monitors (i.e. MKS FTIR)
  - ➢ Testo
- FTIRs provide additional value with multi-constituent measurements for DSI;
  - ➢ Acid gas: $SO_2$ and HCl
  - ➢ Operational parameters: $CO_2$ and $H_2O$


# Use of Continuous Emissions Monitors



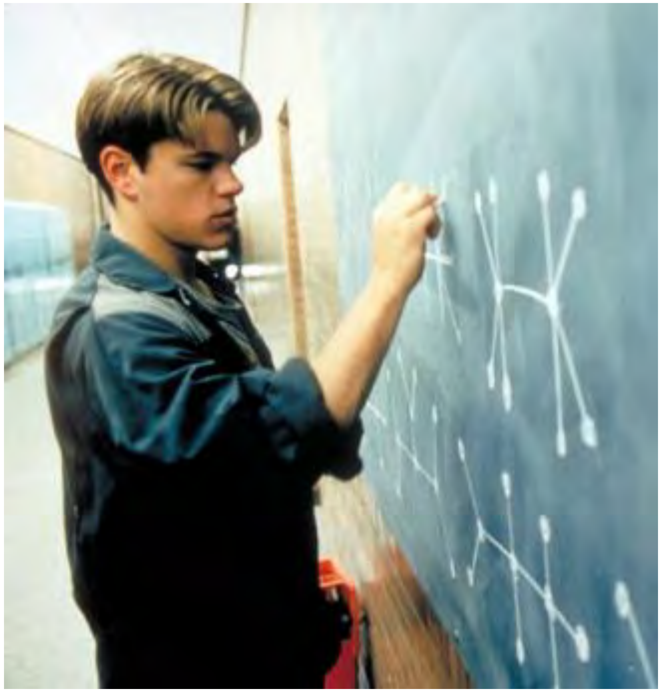
# Use of Continuous Emissions Monitors




**Inlet HCl monitor can provide early indication when uncontrolled HCl emissions changed to enable faster dosage response**

# Ability to Properly Interpret/Analyze Data

- Increase probability of passing compliance testing
- Develop historical trends to check against current operation
- Compare different sorbents
- Compare different mixing technologies
- Quantify performance delta at variable boiler loads
- Identify inefficiencies and/or potential for optimization
    - Optimize injection grid design
    - Best performing injection location
- Identify issues with data (i.e. emission measurements, readings, etc.)



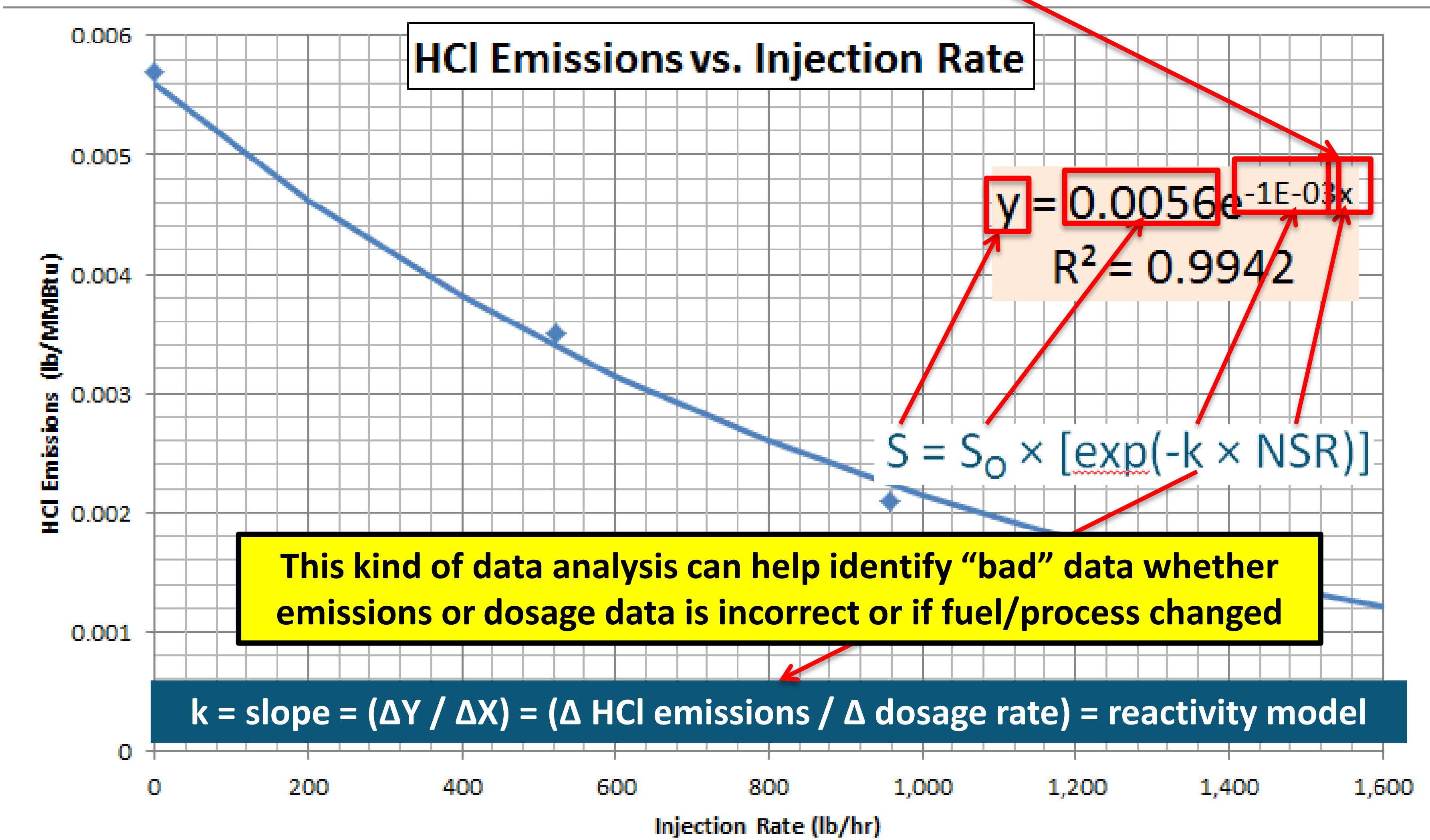
# Ability to Properly Interpret/Analyze Data

1) $S = S_O \times [\exp(-k \times NSR)]$
2) $S / S_O = \exp(-k \times NSR)$
3) $(S / S_O) - (S_O / S_O) = \exp(-k \times NSR) - (S_O / S_O)$
4) $[(S - S_O) / S_O] = [\exp(-k \times NSR)] - 1$
5) $[(S_O - S) / S_O] = x = 1 - [\exp(-k \times NSR)]$

$S_O$ = Initial concentration
S = Final concentration
NSR = Normalized stoichiometric ratio
k = Rate constant
x = Removal efficiency

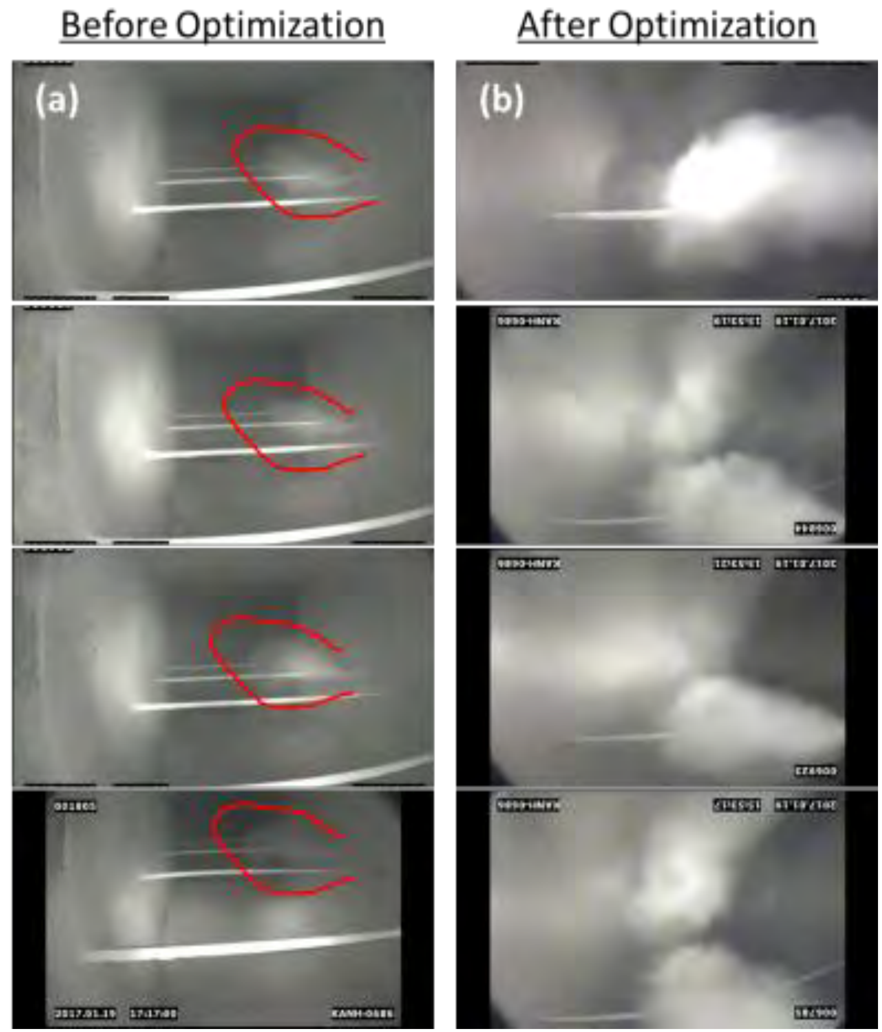
# Ability to Properly Interpret/Analyze Data

- "x" can be NSR, Mass Ratio, lb/hr, etc.



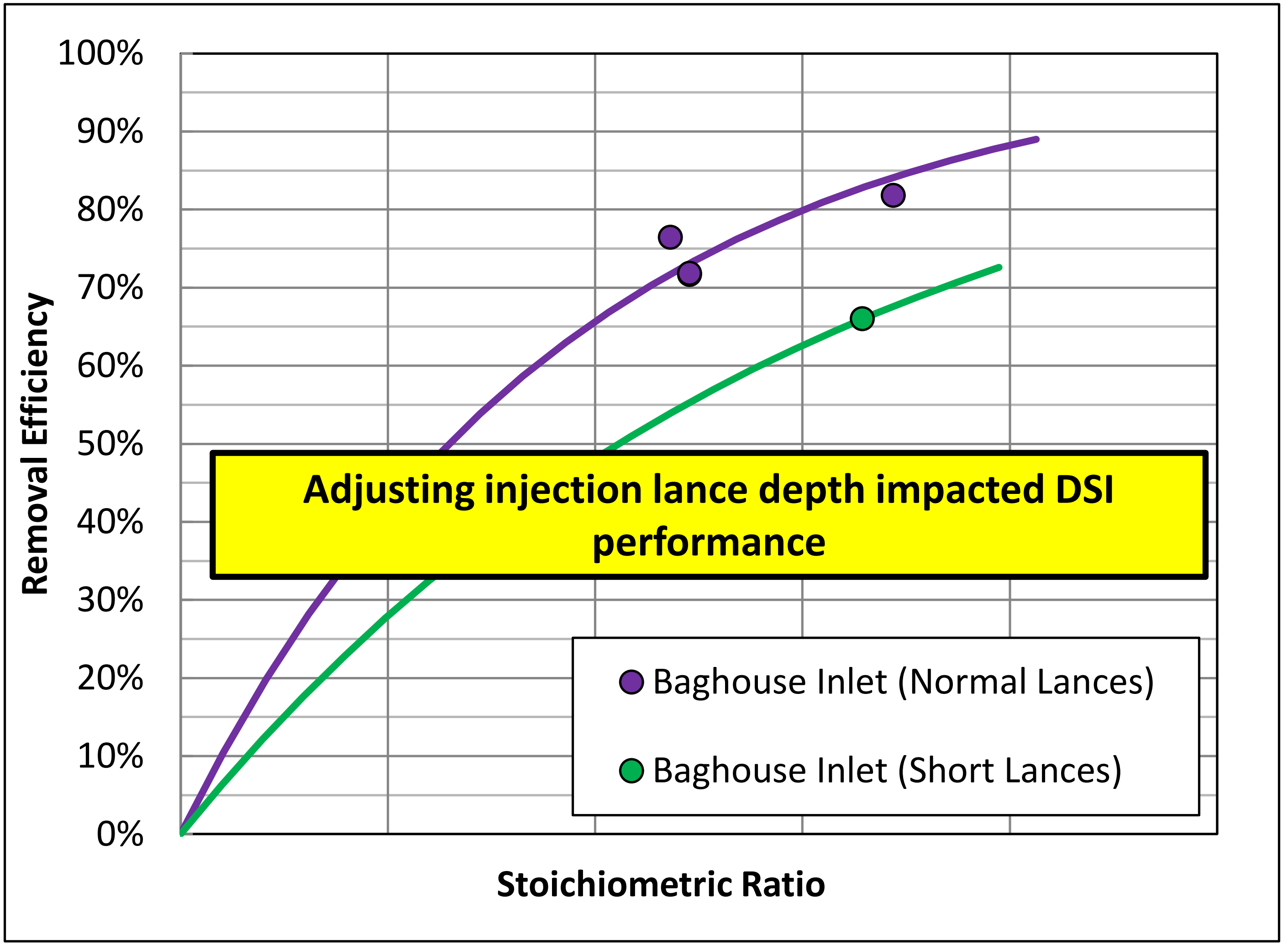
# Evaluation of Sorbent Distribution & Optimization

- In-duct camera
  - ➢ Visually observe sorbent distribution in gas stream
- Data analysis
  - ➢ Identify distribution inefficiencies
  - ➢ Quantify benefits of improved mixing technologies
- Engineered injection grid for improved sorbent dispersion
  - ➢ ↓ dosage rates, ↓ sorbent costs

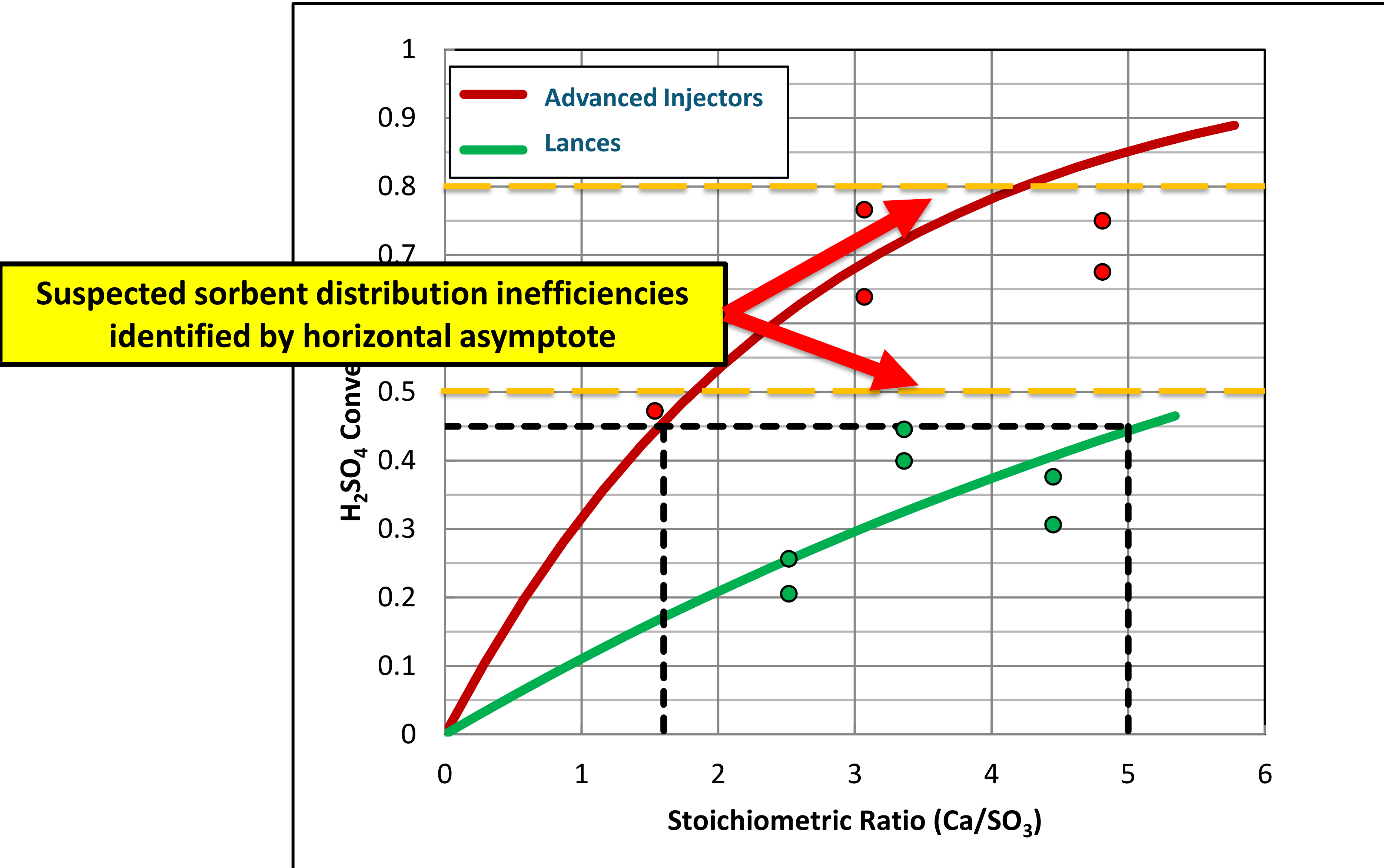


# Evaluation of Sorbent Distribution & Optimization

**Using proper data analysis enables end user to quantify impacts by making DSI operational change**

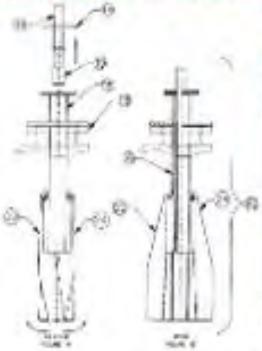


# Evaluation of Sorbent Distribution & Optimization



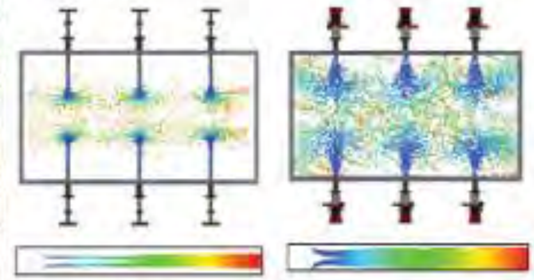
# Evaluation of Sorbent Distribution & Optimization

## Distribution Plate Technology

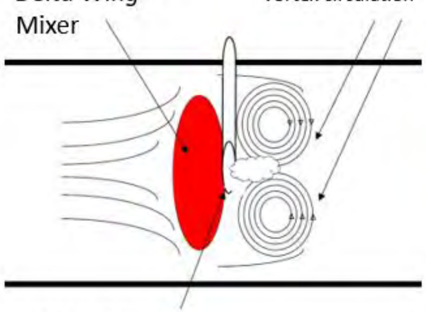


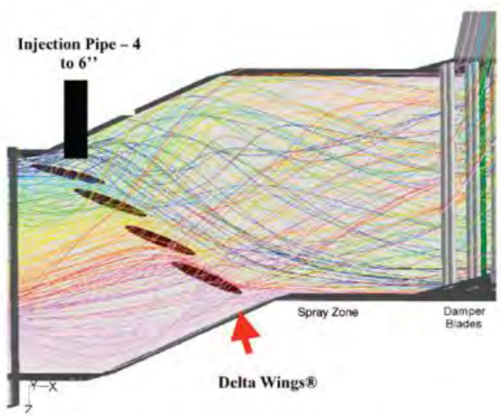
Courtesy of UCC © 2017 United Conveyor Corporation - UCC

## Boosted Air, Lance-less Injector




Courtesy of Nol-Tec Systems ©2017 Nol-Tec



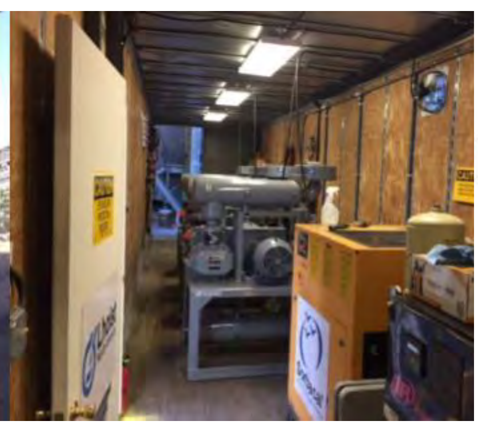

Courtesy of BPEI © 2017 Babcock Power Environmental

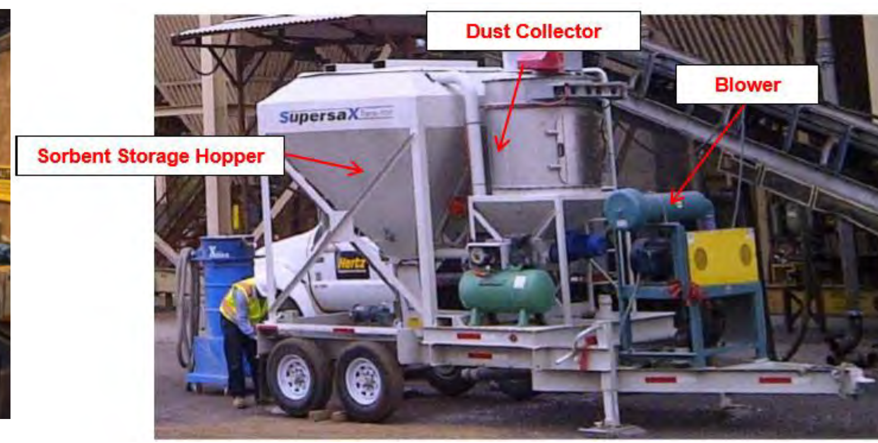
## In-Duct Static Mixer Technology

**These technologies are improving DSI acid gas removal efficacy while reducing operating costs**

# Modern Day Use of Temporary DSI Skid

- Full scale DSI testing using temporary DSI skids was frequent leading up to MATS and IB MACT (HCl, $SO_3/H_2SO_4$, Hg)
- DSI vendors and testing companies then began to sell off DSI test skids
- Expectation that full scale testing will not be needed





# Modern Day Use of Temporary DSI Skid

- Yet still a need for DSI test skids in today's market
  - Testing new sorbents (i.e. enhanced hydrated limes)
  - Testing new injection locations (i.e. injection further upstream)
  - Back-up operations until permanent DSI system ready
- End users more focused to reduce costs today which is catalyst for testing to optimize DSI performance and reduce holistic costs
- EGUs continue to look at reducing $SO_3/H_2SO_4$ further upstream to take advantage of potential cost savings

# Modern Day Use of Temporary DSI Skid

## $SO_3$ Case Study – Operational Benefits

- Large EGU had existing permanent DSI system injecting trona for $H_2SO_4$ / visible blue plume control
- Full scale DSI trial performed with temporary DSI skid injecting Sorbacal® SPS
- Objective: Achieve 15-20 ppmv $H_2SO_4$ at AHI for reduced AH fouling, eliminate quench air, heat rate benefits
- Evaluate improved mixing technology benefits
  - Improved mixing technology ↓ sorbent consumption by 68% vs. standard lances

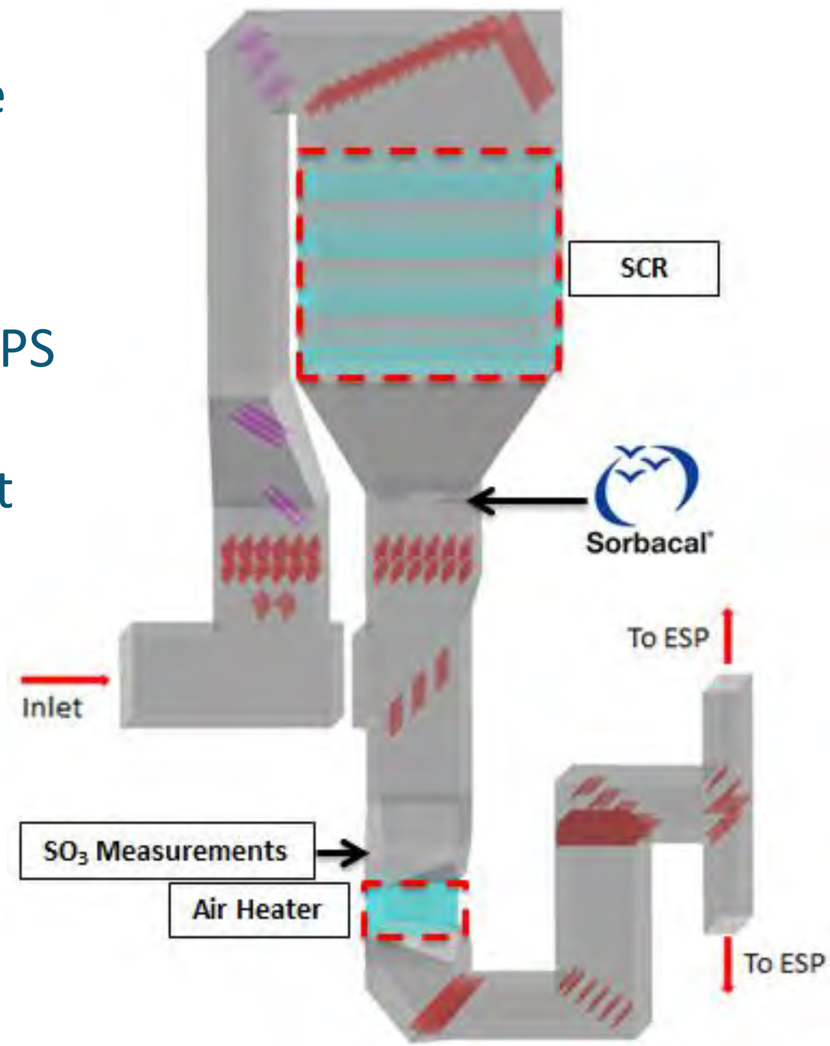
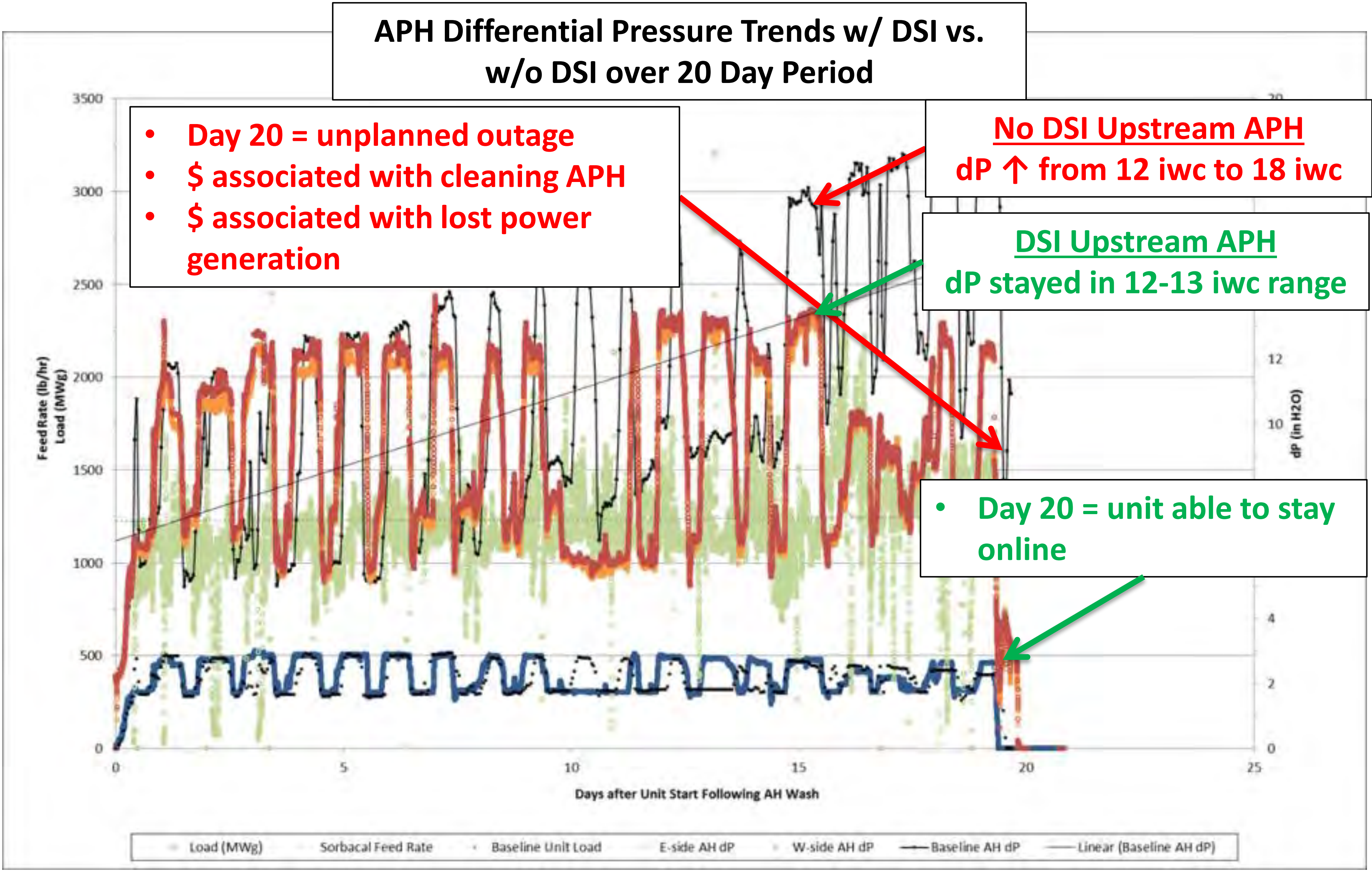


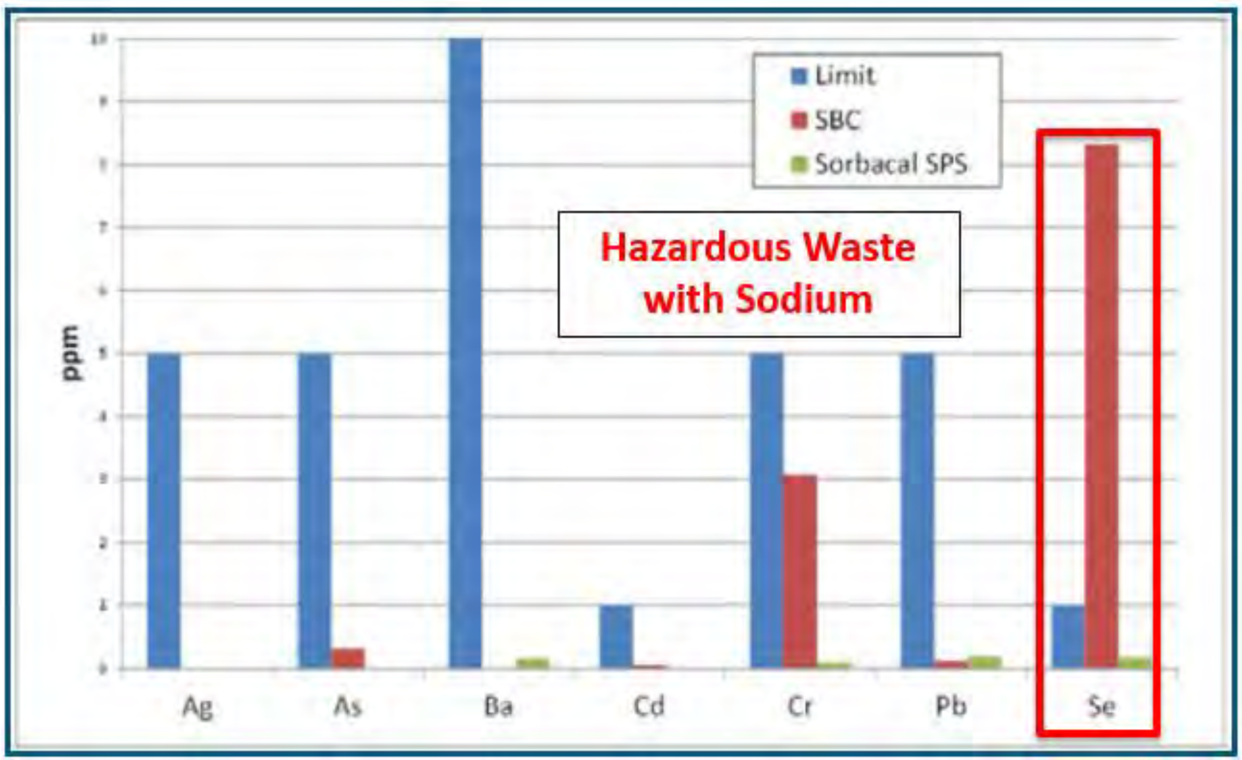

Figure Provided by Nol-Tec Systems

# Modern Day Use of Temporary DSI Skid



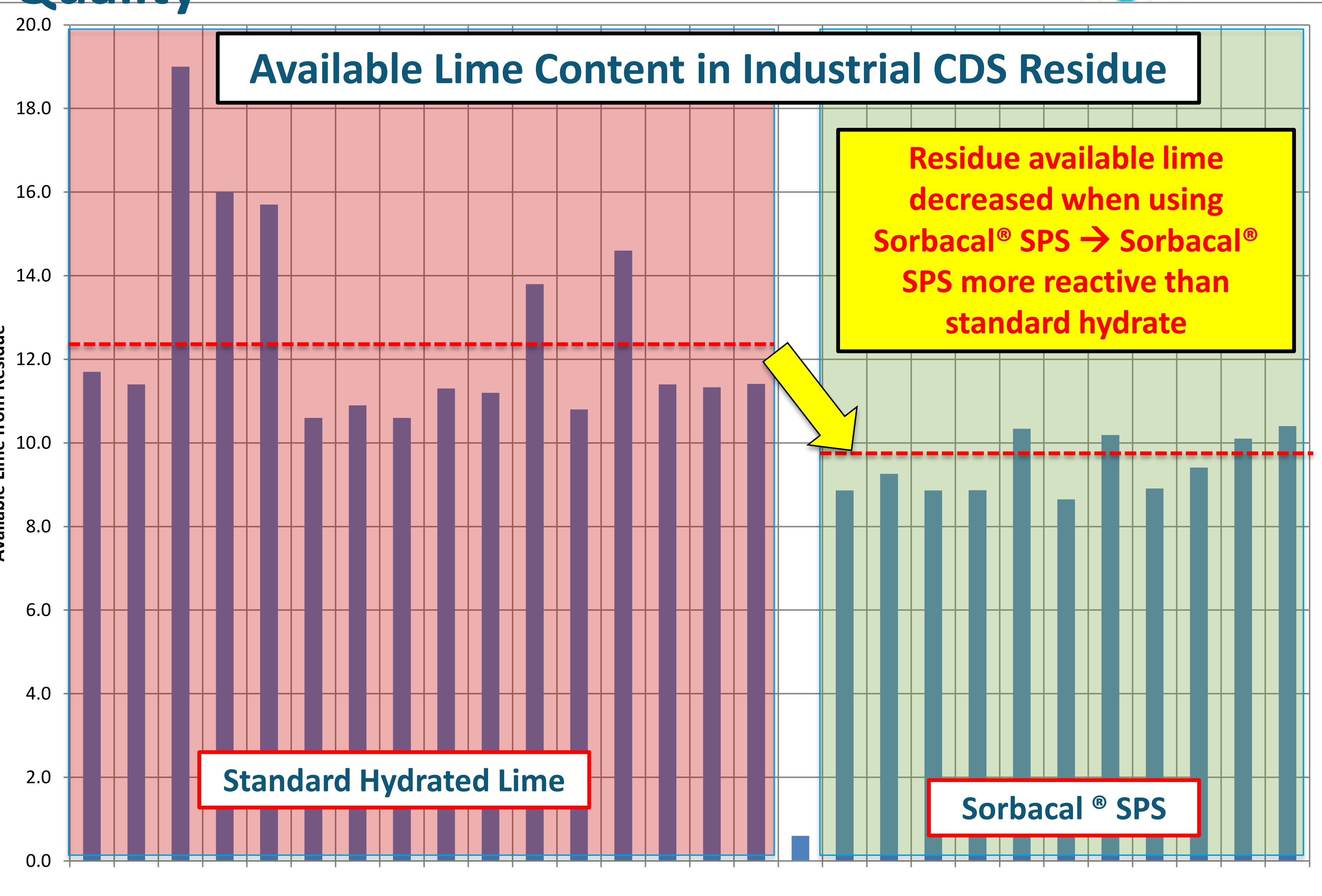
# Evaluation of Fly Ash Impacts & Sorbent Quality

- Value in characterization of fly ash to assess impacts associated with installing/optimizing DSI
- Fly ash analysis can be used to evaluate acid gas removal efficacy and assess disposal costs



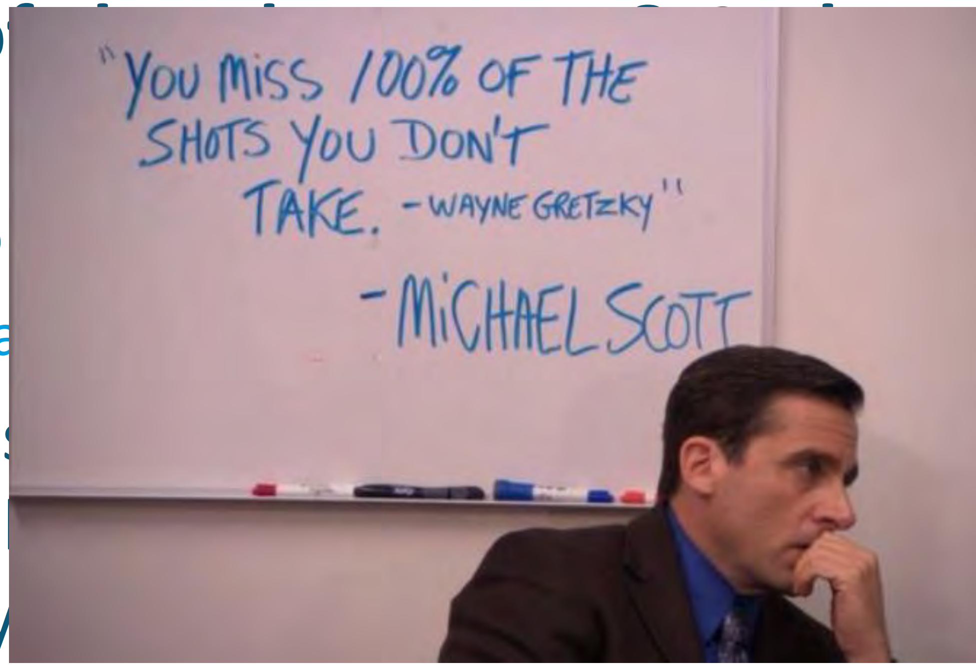

**Leachability testing done in LNA laboratory to assess relative disposal impacts between various sorbents**

# Evaluation of Fly Ash Impacts & Sorbent Quality



# Evaluation o… Quality

- Access to … ent quality
  - ➢ Surface a…
- Strategic … may be useful to … impacted by the DSI sy…




- Most DSI systems not set up for easy sample collection

# Line Scaling / System Reliability

- While issue has been addressed and improved over the years, still a common issue for DSI system operation
  - Plugging/scaling of elbows, splitters, injection lances
- Ample instrumentation on conveying air
  - Blower discharge pressure, after-cooler discharge temperature
  - Dew point monitor not common → % relative humidity
  - How do you know when/if dehumidifier working properly?
- Blower w/ VFD to control line velocity
  - Modulate with changes in dosage rates?
- Maintenance logs and data trends
  - Recording when/where plugging and scaling occurs?
  - Observations about conditions when plugging and scaling occurred?

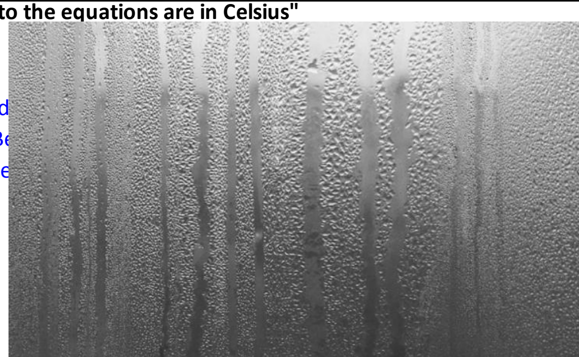
# Line Scaling / System Reliability

Values are calculated using the August-Roche-Magnus approximation

| | Conveying Air Temperature ("T") | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conveying Air Dew Point ("TD") (°F) | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 |
| -70 | 0.2% | 0.2% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| -60 | 0.5% | 0.3% | 0.2% | 0.2% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| -50 | 0.9% | 0.6% | 0.4% | 0.3% | 0.2% | 0.2% | 0.1% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% |
| -40 | 1.5% | 1.1% | 0.8% | 0.5% | 0.4% | 0.3% | 0.2% | 0.2% | 0.1% | 0.1% | 0.1% | 0.1% |
| -30 | 2.7% | 1.9% | 1.3% | 1.0% | 0.7% | 0.5% | 0.4% | 0.3% | 0.2% | 0.2% | 0.1% | 0.1% |
| -20 | 4.6% | 3.2% | 2.3% | 1.6% | 1.2% | 0.9% | 0.6% | 0.5% | 0.4% | 0.3% | 0.2% | 0.2% |
| -10 | 7.7% | 5.3% | 3.8% | 2.7% | 2.0% | 1.4% | 1.1% | 0.8% | 0.6% | 0.5% | 0.4% | 0.3% |
| 0 | 12.4% | 8.6% | 6.1% | 4.4% | 3.2% | 2.3% | 1.7% | 1.3% | 1.0% | 0.8% | 0.6% | 0.5% |
| 10 | 19.6% | 13.6% | 9.6% | 6.9% | 5.0% | 3.7% | 2.7% | 2.1% | 1.6% | 1.2% | 0.9% | 0.7% |
| 20 | 30.3% | 21.1% | 14.9% | 10.6% | 7.7% | 5.7% | 4.2% | 3.2% | 2.4% | 1.9% | 1.4% | 1.1% |
| 30 | 46.0% | 31.9% | 22.5% | 16.1% | 11.7% | 8.6% | 6.4% | 4.8% | 3.7% | 2.8% | 2.2% | 1.7% |
| 40 | 68.4% | 47.5% | 33.6% | 24.0% | 17.4% | 12.8% | 9.5% | 7.2% | 5.5% | 4.2% | 3.2% | 2.5% |
| 50 | 100.0% | 69.5% | 49.1% | 35.1% | 25.5% | 18.7% | 13.9% | 10.5% | 8.0% | 6.1% | 4.7% | 3.7% |
| 60 | [redacted] | 100.0% | 70.6% | 50.5% | 36.7% | 27.0% | 20.1% | 15.1% | 11.5% | 8.8% | 6.8% | 5.3% |

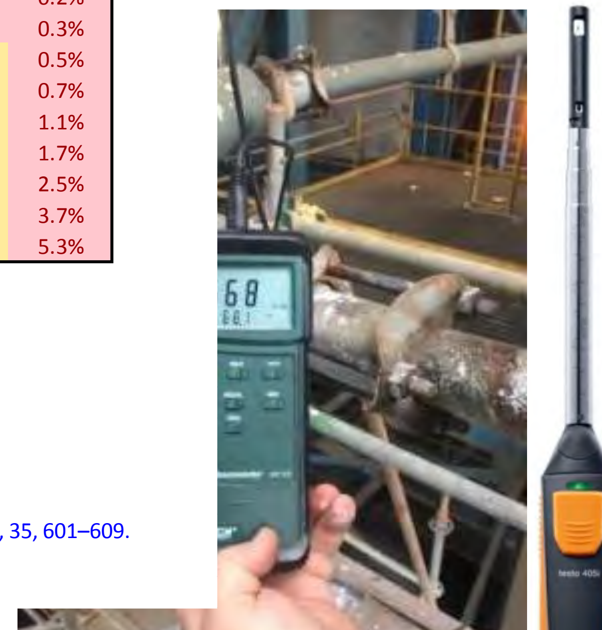
**Ample instrumentation enables you to calculate % relative humidity**

RH: =100*(EXP((17.625*
TD: =243.04*(LN(RH/100
T: =243.04*(((17.625*TD
**"--> T and TD inputs/outputs to the equations are in Celsius"**



References:


Alduchov, O. A., and R. E. Eskrid … n vapor pressure. J. Appl. Meteor., 35, 601–609.
August, E. F., 1828: Ueber die Be … hem., 13, 122–137.
Magnus, G., 1844: Versuche übe … 25–247.

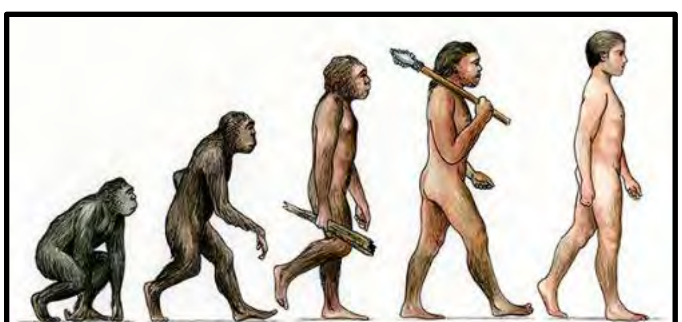



**Instrumentation for measuring conveying air velocity**

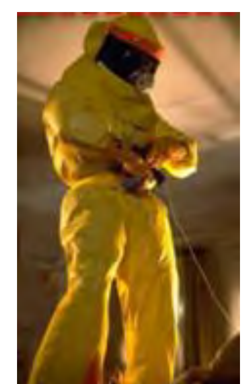
**ADA-ES Trademark "Keep it cool, keep it dry, keep it slow"**

# Summary

- "Modern" day DSI system around for > decade and installed in hundreds of EGU and industrial facilities
- Initial DSI systems were installed for reducing a visible blue plume ($SO_3$ / $H_2SO_4$) at EGU sites
- Federal regulations (i.e. MATS, IB MACT, NAAQS, etc.) have been instrumental in growing DSI applications for additional acid gas removal (HCl, $SO_3$ / $H_2SO_4$, $SO_2$)
- Many useful tools are available to continue the DSI evolution to improve efficacy/reliability and reduce costs

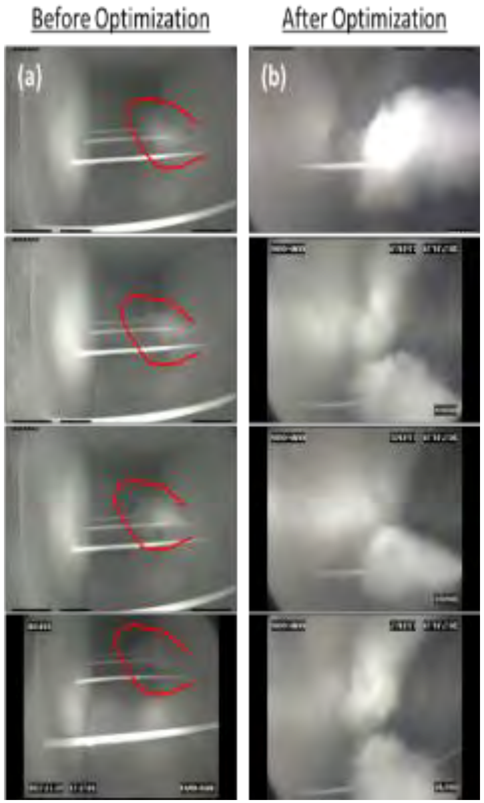


**DSI Technology Evolution**

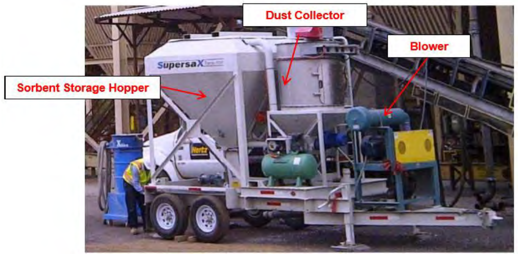


# Conclusions

- Lhoist has invested in many of these tools and developed expertise to be a ***DSI solution provider*** to the industry
  - ➢ FTIRs and Testos
  - ➢ Expertise to perform thorough DSI data analysis and interpretation
  - ➢ In-duct camera and DSI test skids
  - ➢ Laboratory with instruments for fly ash and sorbent analysis
  - ➢ Expertise in DSI system process design to understand how to address reliability issues






# Thank you for your time!

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