REINHOLD ENVIRONMENTAL ®

2024 Reinhold/PCUG Round Table Presentation

Hosted by LG&E/KU and Co-hosted by Southern Co. and TVA

in The Marriott Resort Lexington Griffin Gate Hotel, Lexington, KY on June 24-25, 2024

Evaluating DSI Upgrades for Cost Effective Plant Improvements

2024 NOx RT

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Mark Thomas & Associates Consulting, LLC

Background & Perspective

- 35 Years of Utility Power Plant Experience
  - Cincinnati Gas & Electric > Cinergy > Duke Energy
  - Mark Thomas & Associates Consulting since 2011
- 25 Years of SO3 Mitigation Experience
- 19 Years of SCR & Catalyst Experience
- DSI System Design, Testing & Performance Evaluations, O&M
- Used Most Available Reagents
  - Calcium (Hydrated Lime, Limestone, Cao)
  - Sodium (Trona, Sodium Bicarbonate, SBS) (Wet & Dry)
  - Magnesium (Mag Hydroxide (Wet & Dry), Magnesium Sulfate (Wet)
- Various Injection Processes & Locations
  - Wet & Dry
  - Furnace to FGD Inlet
  - Coal Additives
- Work with but Independent from any Sorbent or DSI System Provider

Current DSI Systems Application

- DSI has become more widespread in the last 20 years.
  - Power Stations & Industrial Facilities
    - Used for Acid Gas Mitigation
      - SO_3/H_2SO_4
      - SO_2
      - HCl
  - Some DSI systems are approaching 20 yrs old
  - Principles apply to Activated Carbon Systems

Reasons to Consider DSI Upgrades

- Chronic O&M issues due to poor design
- Inadequate performance / inefficient
- Need to change sorbents
- Considering modified injection location for operational benefits
- Considering modified injection scheme / location for BOP benefits
- Combinations of above factors

DSI System Performance Objectives

- Minimize Sorbent Utilization
- Maximize Target Pollutant Capture
  - SO3, SO2, HCl, Hg
- Maximize Reliability & Consistent Operation
- Minimize Maintenance
- Maximize Flexibility for BOP Co-Benefits

Potential Balance Of Plant Improvements

- Maximize BOP Co-Benefits
  - SCR Min Load Operation
  - APH
    - Reduce APH Pluggage
    - Reduce APH Corrosion
    - Heat Rate Improvements
  - MATS / Hg Control
  - FFDC
    - Bag Protection
  - ESP
    - Improve Capture

Evaluating Potential DSI Upgrades

- Economic Factors
  - Cost of upgrades
    - Scope dependent
  - Operating & Maintenance cost / benefit evaluation
    - Sorbent Cost Savings
      - Improved performance
      - Changed sorbent
    - Reduced Maintenance Costs
    - BOP Impacts
      - Ash Sales Impact, etc
    - Impact on station dispatch
  - Consider Expected life of station

Evaluating Potential DSI Upgrades

- Qualitative Evaluation
  - Need for Flexibility
  - Need for Redundancy
  - Simplification
    - Helps Operations & Maintenance Personel
    - Easier to troubleshoot problems
    - Easier for new equipment owners to understand

Evaluating Potential DSI Upgrades

Consider Potential BOP Impacts

- SCR Catalyst Impacts
- APH Pluggage Potential
- Fly Ash Impacts
  - Na, Ca, Cl, C/LOI
  - Sorbent Layout in duct
- ESP
  - Ash resistivity
  - Perf Plate Pluggage (Trona)
  - Uneven Sorbent Loading
- FFDC
  - Uneven Sorbent loading, unprotected areas

Evaluating Potential DSI Upgrades

Need Cost Effective New & Retrofit Solutions

- Cost Savings Always Desirable
- Can use cost savings to add redundancy / flexibility
- Can use cost savings to improve other plant systems
- Some plants have nearer term closure dates

Evaluating Potential DSI Upgrades

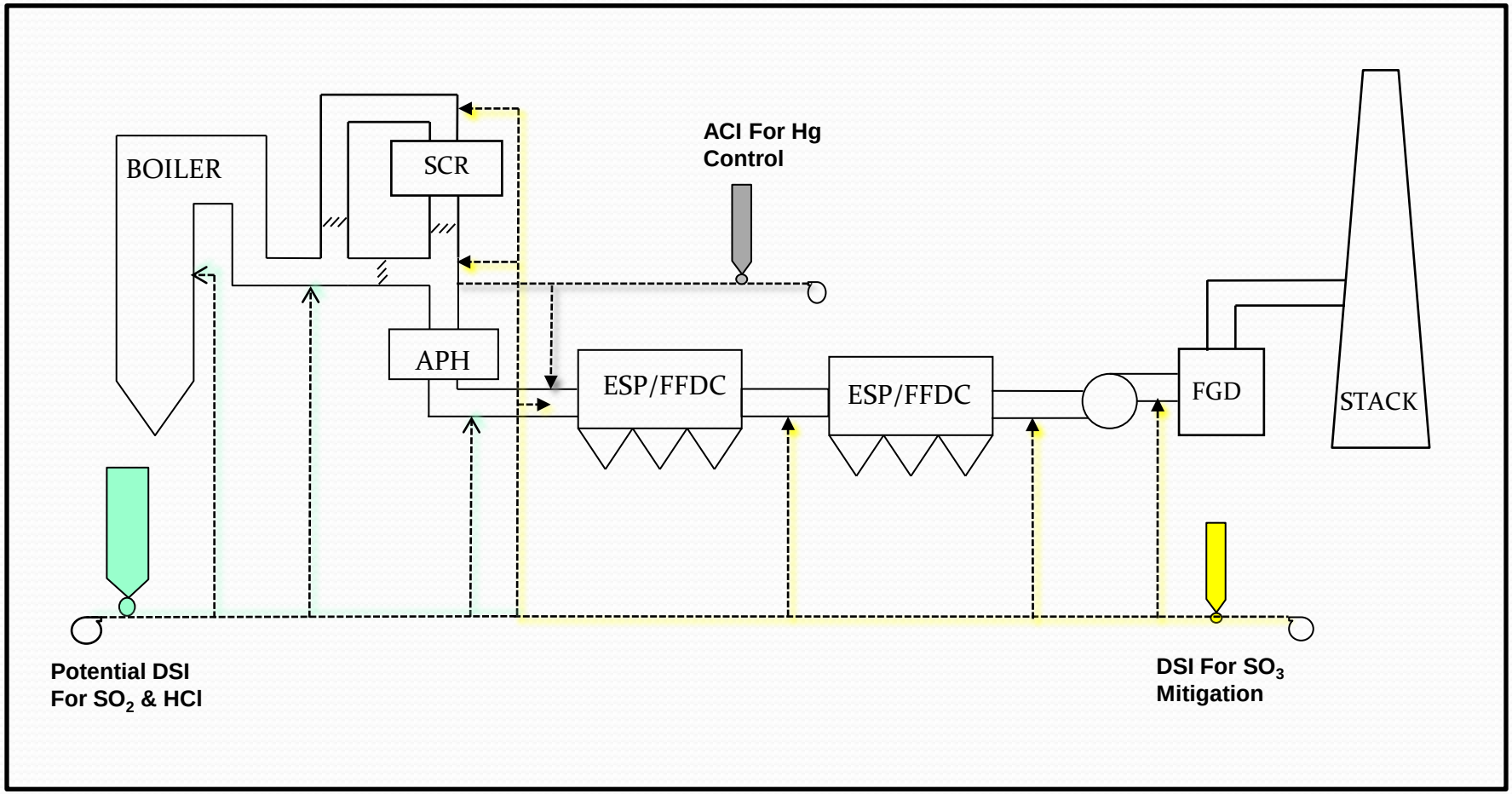
How to achieve reliable upgrades while saving costs?

- Determine what part(s) of the system need to be retrofitted
  - Requires a clear understanding of current problems
    - Examples
      - Is Pluggage an air quality problem or a system design problem?
      - Is poor performance due to the injection location or poor dispersion.
  - Requires a clear understanding of desired objectives and expected results
    - May require some testing to quantify or prove concept

Evaluating Potential DSI Upgrades

- How to achieve reliable upgrades while saving costs?
  - Determine if existing Equipment be re-used or repurposed?
    - Silo / Storage
    - Feed system
    - Convey Air system
    - Sorbent convey & splitting
    - Injection lances (or lanceless injectors)
    - Dispersion & mixing
    - Injection location

POTENTIAL DSI & ACI INJECTION LOCATIONS



Examples of Cost Effective DSI Retrofits

- Improved Feed System
- Distribution & Splitting for Added Injection Locations
- Improved Dispersion & Mixing
- Convey & Unloading Air Quality

This presentation will focus on options that work and are cost effective.

DSI FEED SYSTEMS – STANDARD DESIGN

DSI FEED SYSTEMS - SIMPLIFIED

- Single Feeder
- Vent to Top of Silo – No Cartridge Filters
- No Aeration in Weigh Bin

DSI FEED SYSTEM IMPROVEMENTS

- Longer Fill Cycles
- Smoother LIW Signal
  - No Interference from Bag cleaning and blinding
  - Vent line maintains constant pressure
- Reduced Maintenance on Rotary Airlocks
- Self Clearing vent line
- Hose Connections for ease of cleaning and inspections

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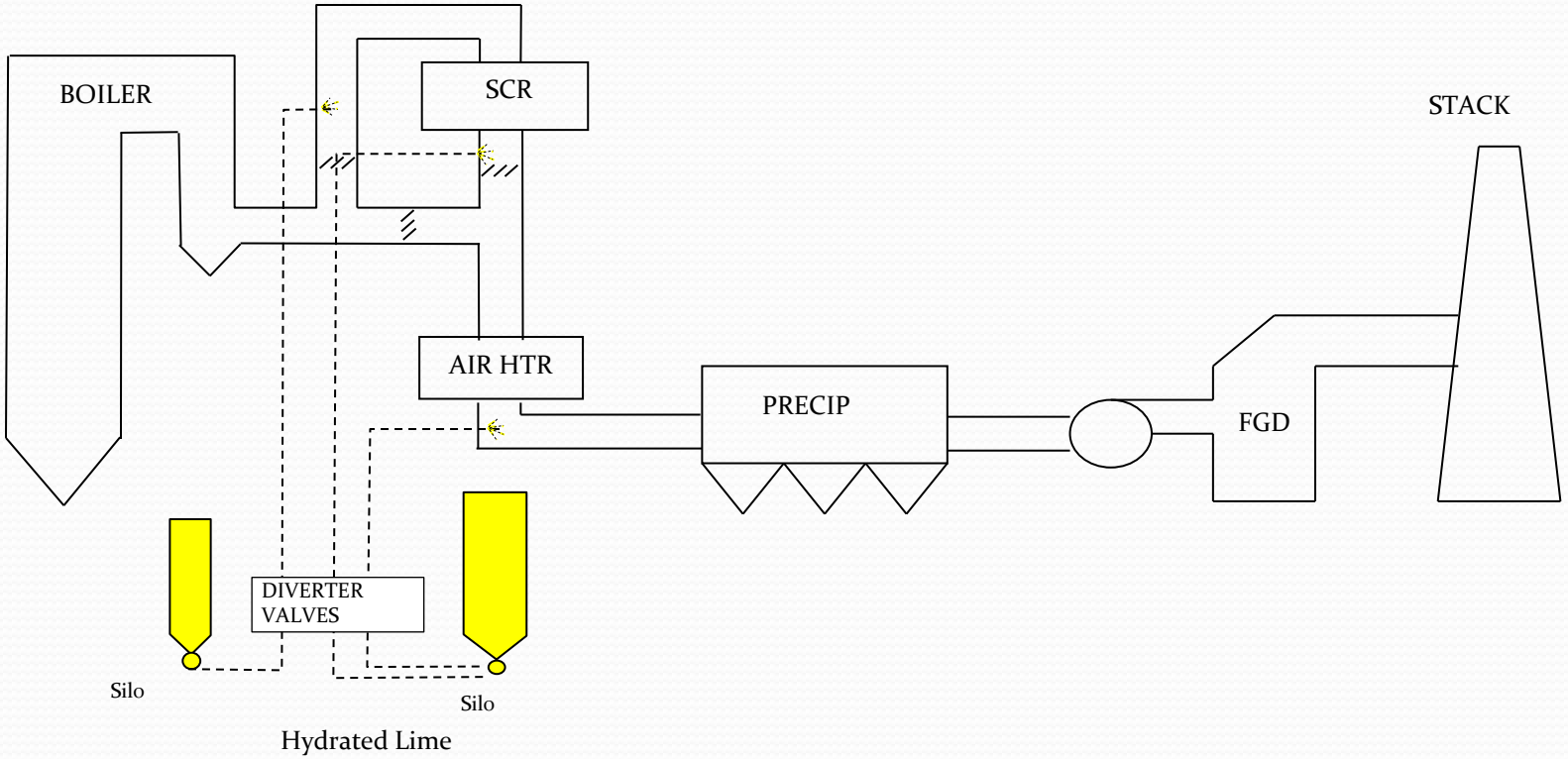
DSI CONVEY & SPLITTER SYSTEMS

- Multi Point Injection
  - Drives the need for cost effective but high performing lances and feed systems



DSI System Convey System Retrofits

- Use of Diverter Valves to feed alternate Injection Sites
  - Can be swap quickly to alternate injection grid location
  - Can be used to achieve redundancy for more critical application

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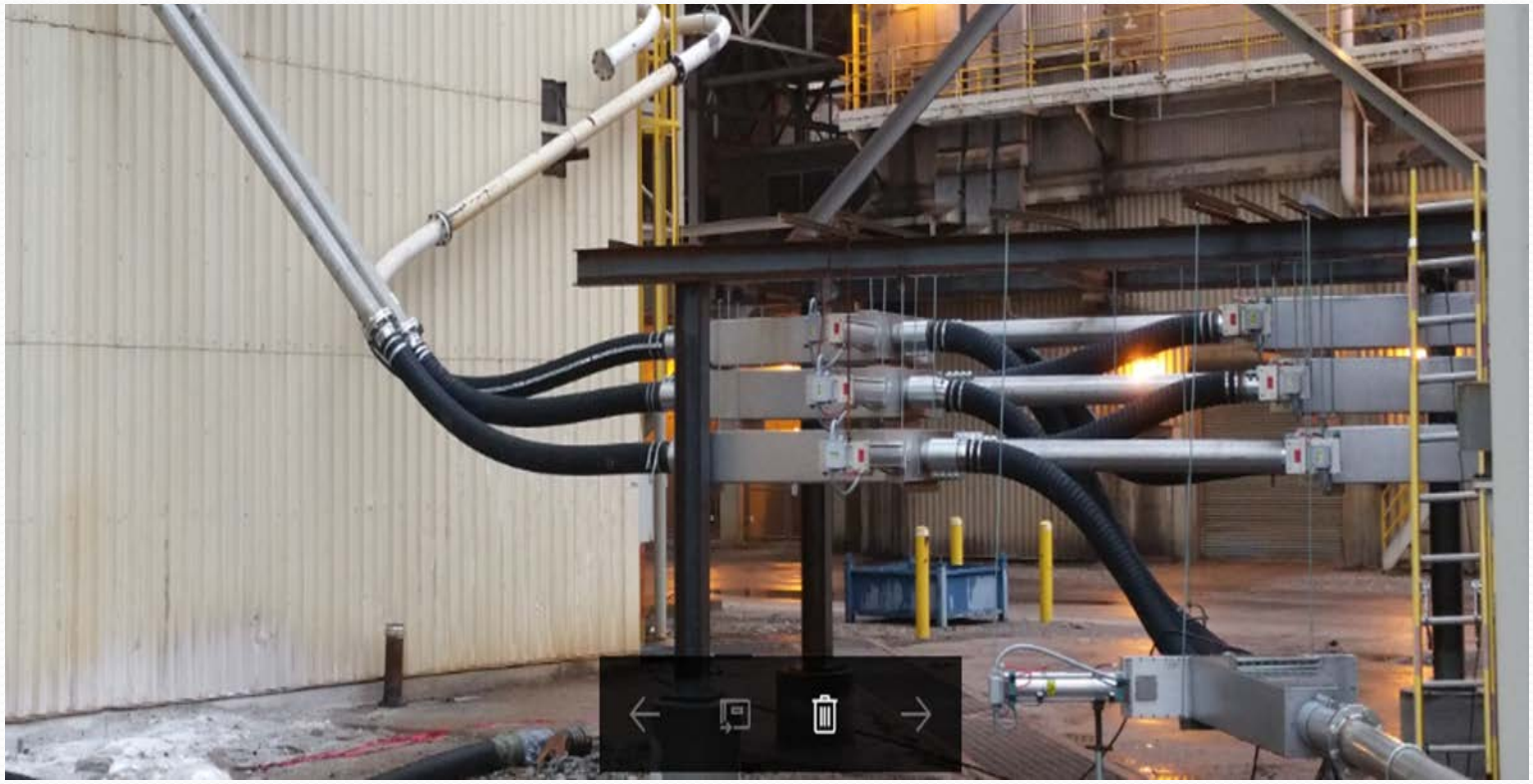


SPLITTER DESIGN WITH INTEGRAL SIGHT GLASSES

- Cost Effective
- Provides ability to easily see relative flows to each lance
- Splitter body less prone to surface rust & product clinging
- Easy to clean and replace sight glaass

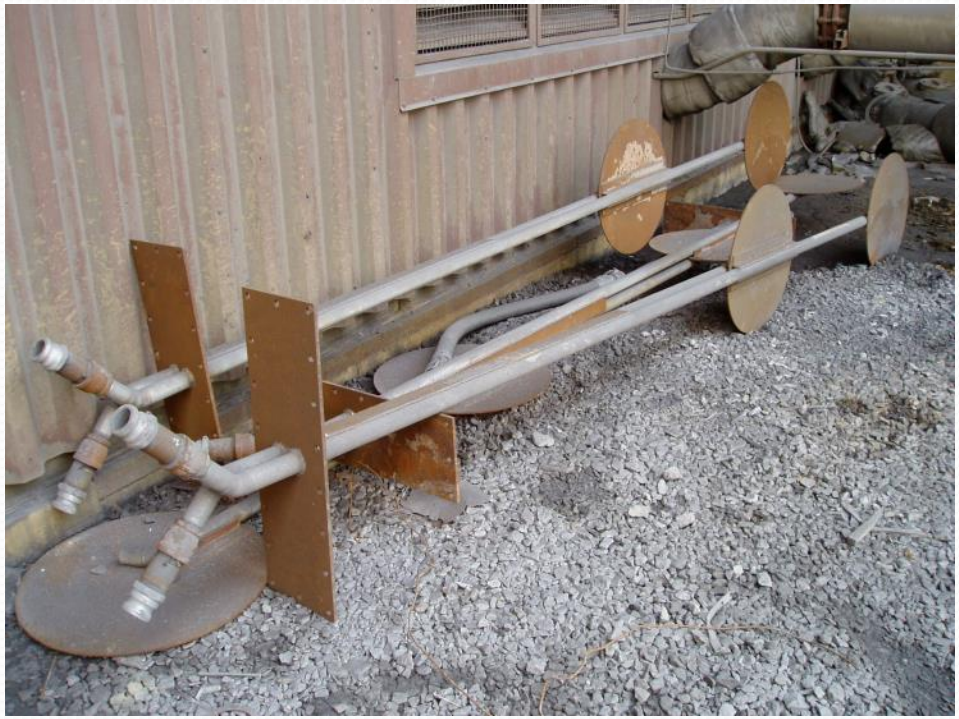
Typical Industry Standard Lance Design

2007 Lime Lances

2012 Trona Lances

Additional Early Generation Advanced Lances

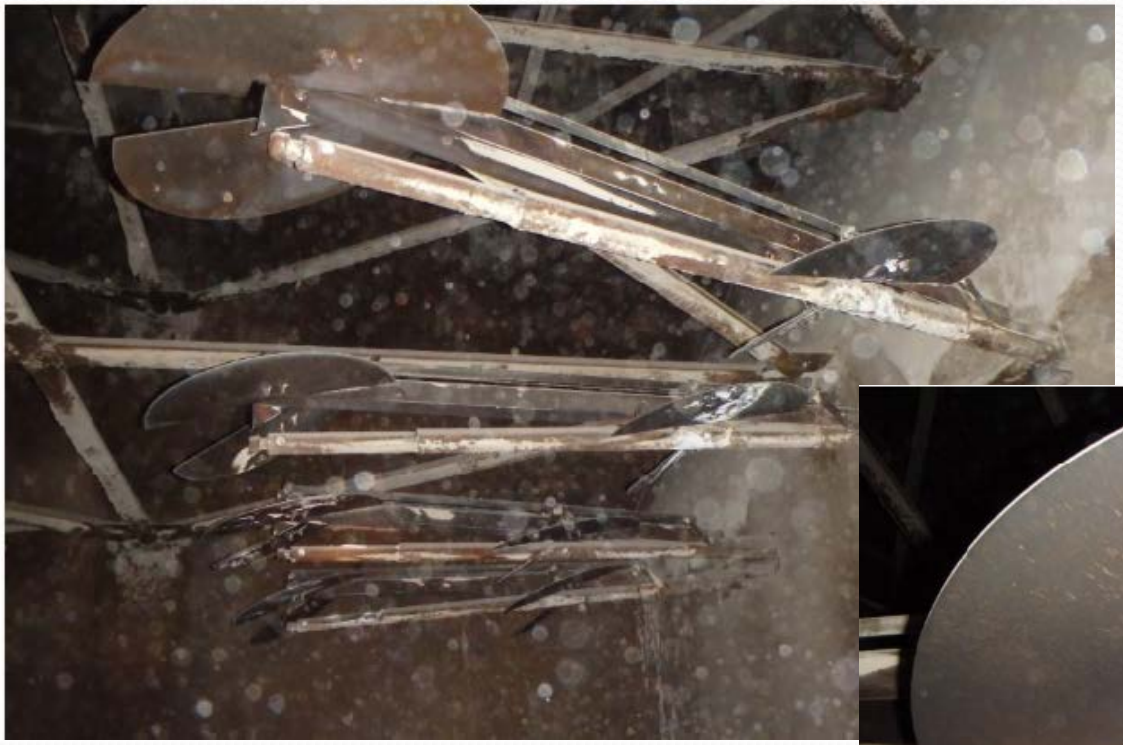
2004 Trona & Lime Lances



2005 Trona Lances

Continued Development of Advanced Lances

2013 Lime Lances with Independent Adjustable Plates



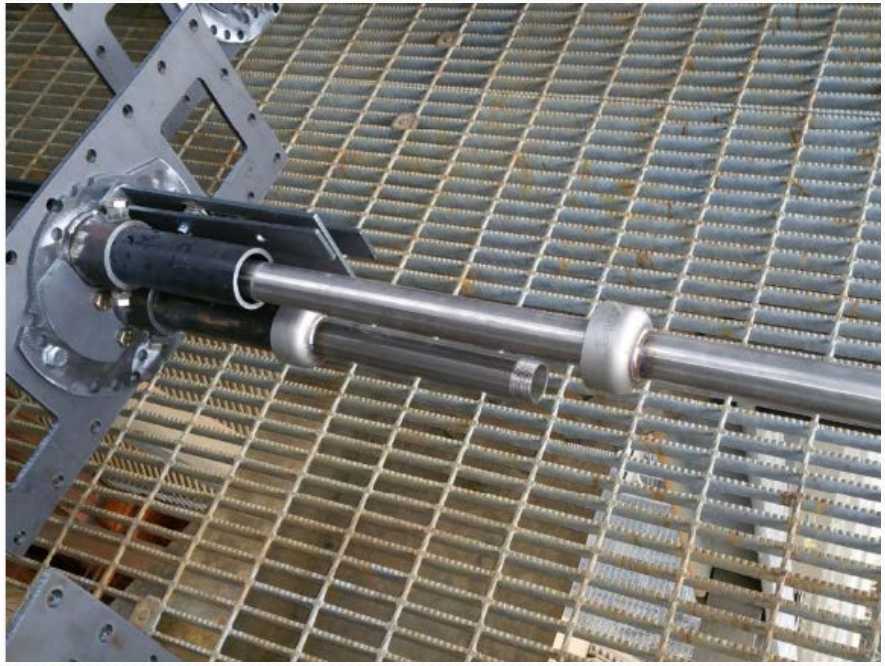
Continued Development of Advanced Lances

2016 Lances

2017 Lances

Continued Development of Advanced Lances

2018 DSI Lances – Adjustable Mix Plates & View Ports



Note: Lance removal requires no tools

Continued Development of Advanced Lances

2020 – Current Lances – Adjustable Mix Plates & View Ports

Note: Lance removal requires no tools

Benefits from Advanced Lance Designs

- Significantly Improved Dispersion
  - Currently up to 42 " Diameter Mixing Plates
- Effective at Very Reasonable Fabrication Cost
- Easy go install thru rectangular ports
  - Existing ports can be used but require internal mixer attachment
- Can eliminate the need for internal scaffolding for installation or maintenance or modifications.
- Designed to be easily modified for future improvements
- Can install multiple lances in same port at different elevations
- Can be installed in any orientation

Benefits from Advanced Lance Designs

- Designs can be customized for specific applications
  - Plate Tilt & (Rotation) Adjustable from duct exterior or interior
    - Can evaluate performance realtime
    - Can evaluate pressure drop
    - Can adjust to minimize erosion patterns on lances or on erosion induced by mixing plates
- Maintenance for lance checks drastically simplified.
  - Lance tube removal requires no tools
  - Can be removed and replaced in a few minutes
  - Lance tube protected from corrosion and excessive heat

Convey Air Upgrades - Dehumidifiers

AIR QUALITY IMPROVEMENTS USING DEHUMIDIFICATION SYSTEM

1084 SCFM
82 F
130 Gr/Lb
167 Gr @Sat

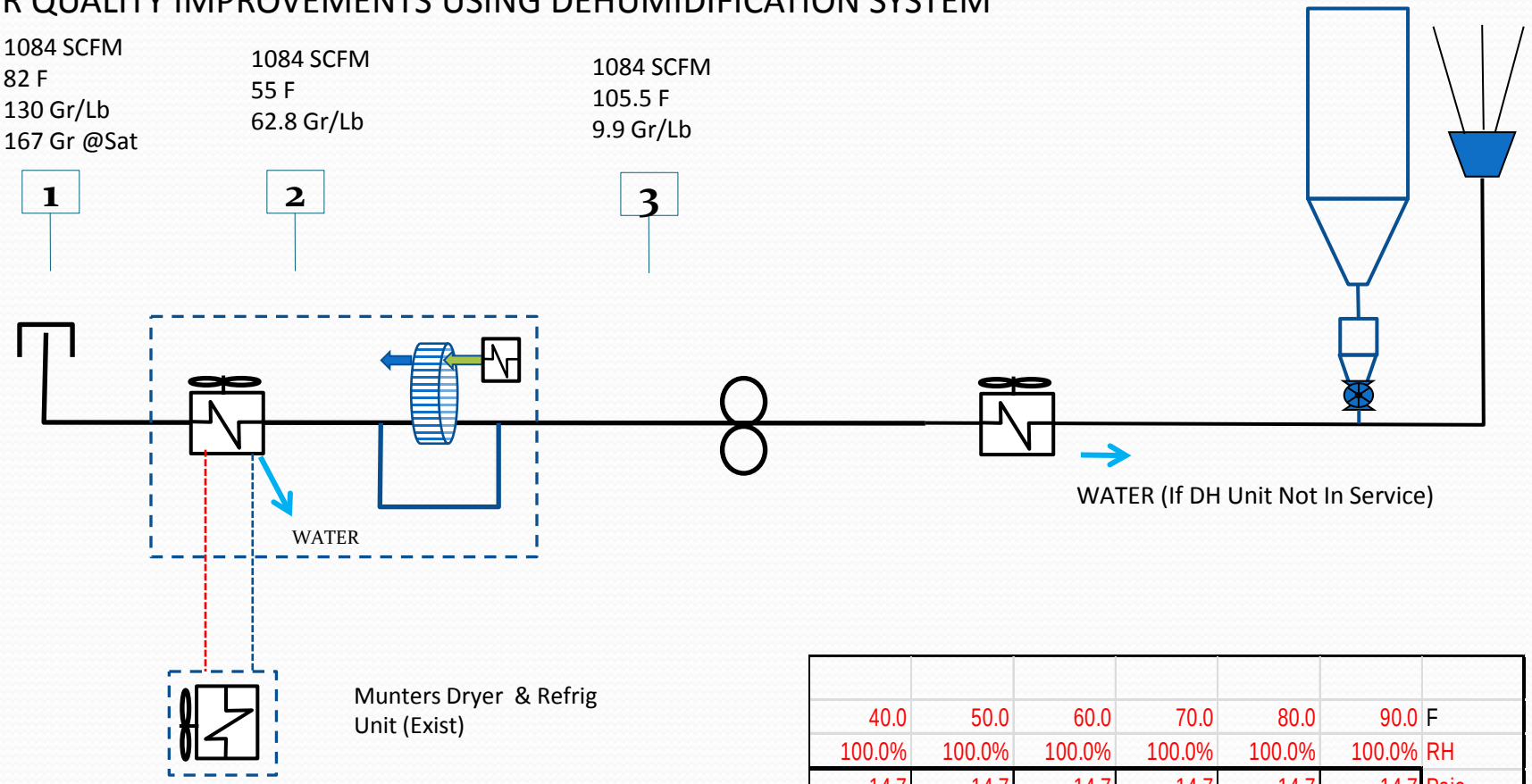
1

1084 SCFM
55 F
62.8 Gr/Lb

2

1084 SCFM
105.5 F
9.9 Gr/Lb

3



Munters Dryer & Refrig Unit (Exist)

40.0	50.0	60.0	70.0	80.0	90.0	F
100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	RH
14.7	14.7	14.7	14.7	14.7	14.7	Psia
36	53	77	110	156	217	Gr/Lb
23.7	23.7	23.7	23.7	23.7	23.7	Psia
22	33	48	68	95	132	Gr/Lb

Evaluating Potential DSI Upgrades - Summary

- Thorough assessments important
- Know your current and possible future objectives
- Consider re-use of existing equipment
- Integrated approach critical
- Help available from industry experts

QUESTIONS?