REINHOLD ENVIRONMENTAL Ltd.

2019 NOx-Combustion-CCR Round Table Presentation

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Cost Effective DSI System Advancements for Future Plant Performance

2019 NOx RT

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Mark Thomas & Associates Consulting, LLC

Background & Perspective

- 29 Years of Utility Power Plant Experience
  - Cincinnati Gas & Electric
  - Cinergy
  - Duke Energy thru 2010
  - Mark Thomas & Associates Consulting since 2011
- 20 Years of SO3 Mitigation Experience
- Testing, System Design & Construction, O&M
- Used and/or Tested 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

Future Plant Performance Objectives

- DSI System Performance Improvements
  - Minimize Sorbent Utilization
  - Maximize Target Pollutant Capture
    - SO3, SO2, HCl, Hg
  - Reliability/ Consistent Operation
  - Minimize Maintenance
  - Maximize Flexibility

Future Plant Performance Objectives

Balance Of Plant Effects

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

Future Plant Performance Objectives

Minimize 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
  -

Future Plant Performance Objectives

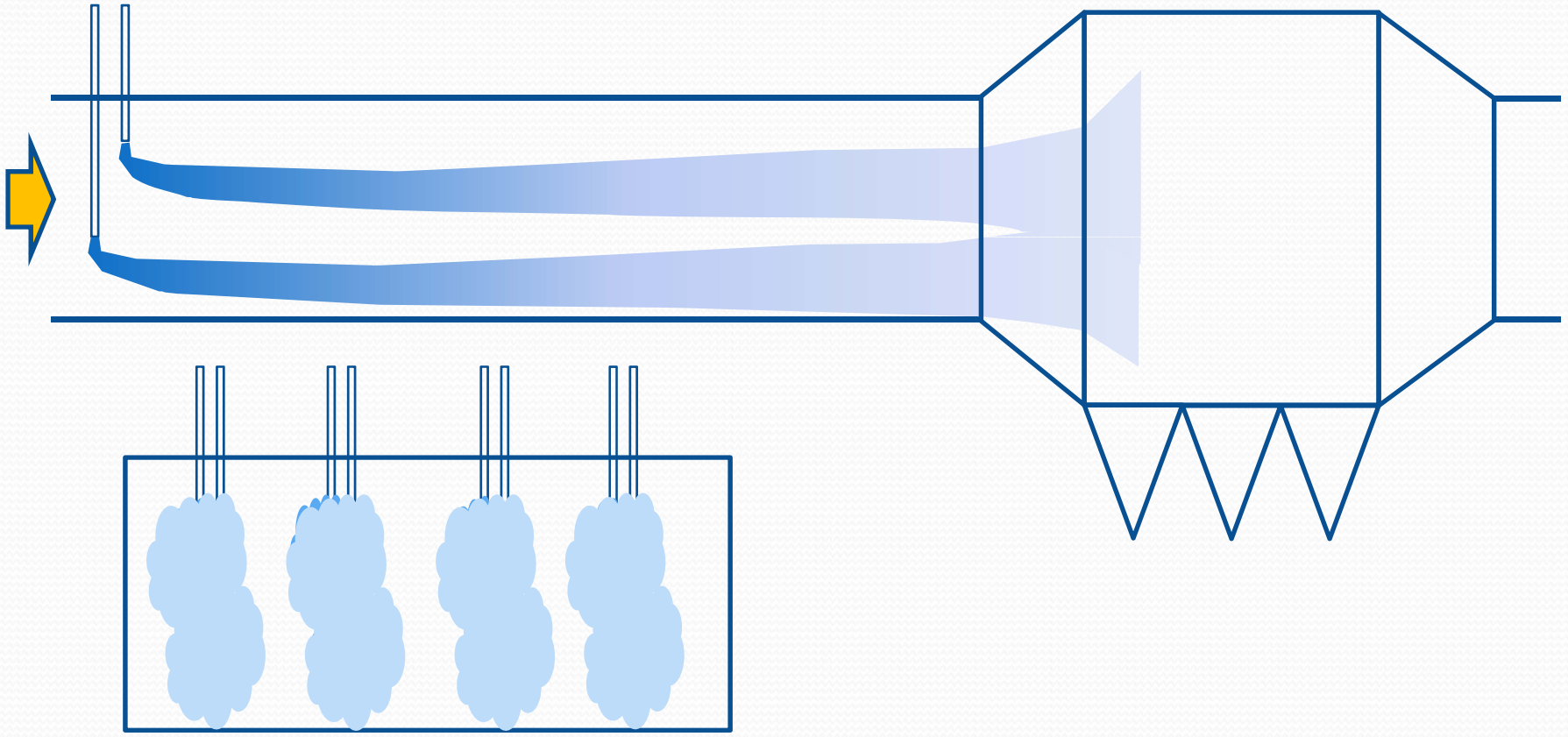
- Performance, Maintenance & BOP Objectives Interrelated
  - Ex: Plugged & Corroded lances Impact Dispersion and overload ESP zones
- Flexibility becoming more important
  - Drives, contributes to need for cost effective advances
- Ability to make changes online can be beneficial

General DSI Advancements Focus

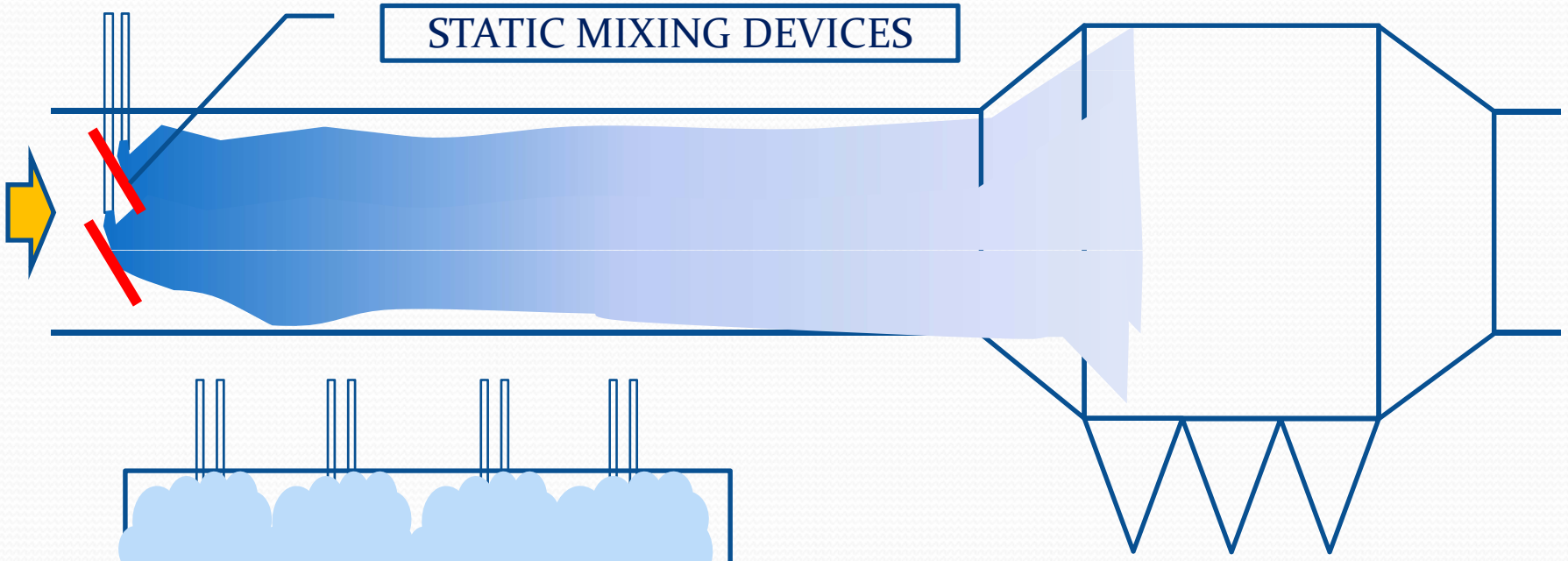
- Improved Dispersion & Mixing
- Improved Reliability
- Added Injection Locations for Co-Benefits

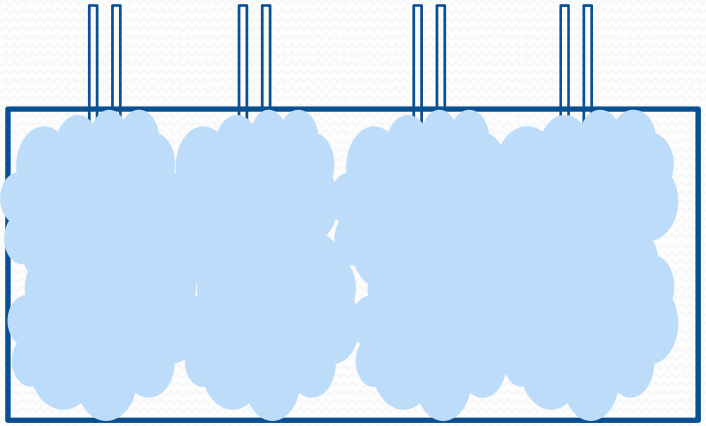
This presentation will focus on options that work and are cost effective.

Dispersion & Mixing – Older & Current Systems



Dispersion & Mixing - Improved Systems





Better Dispersion & Mixing by:
Static Mixing or Additional Lances

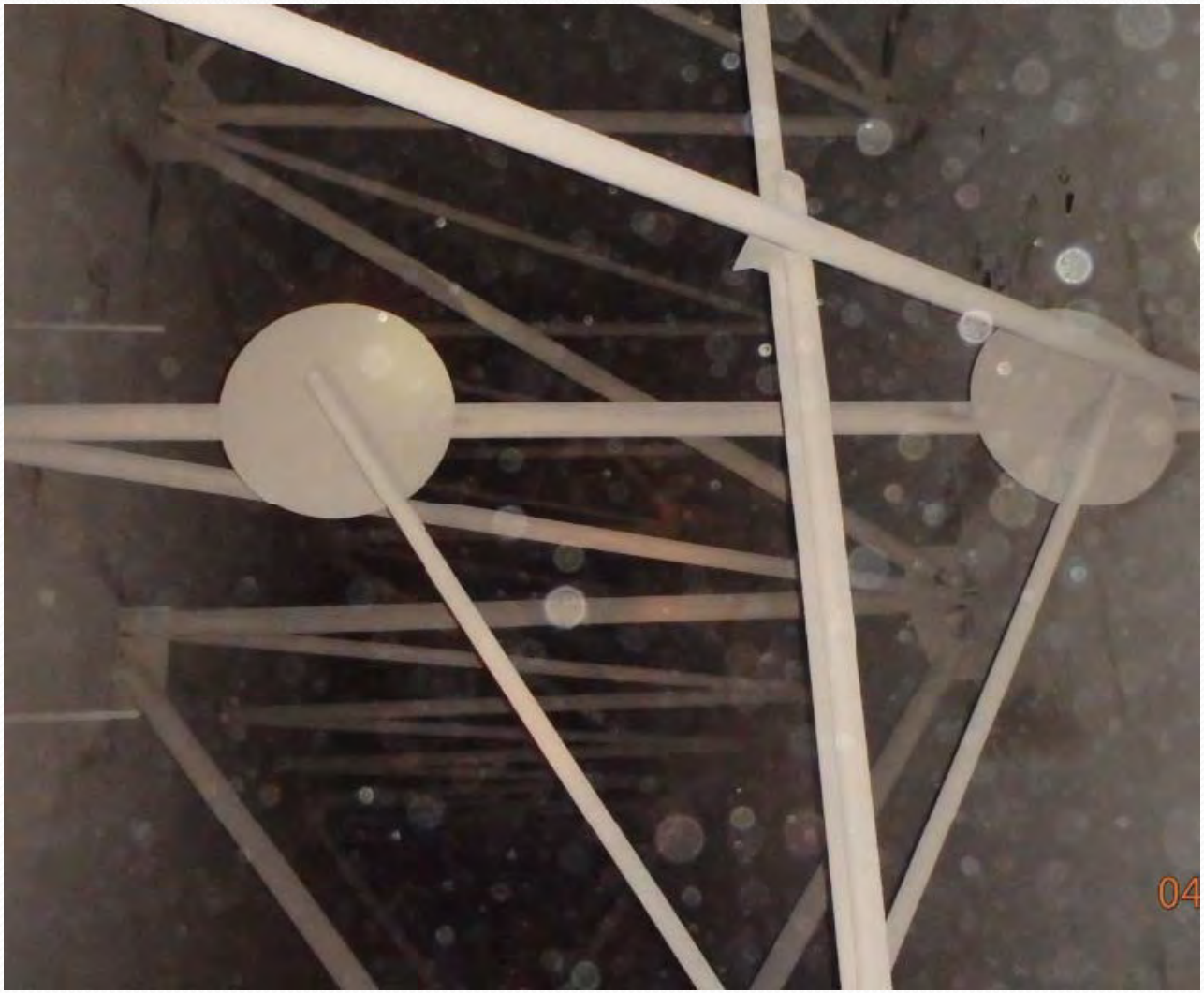
Cost Effective Advancements in Dispersion and Mixing

- Focus is on advanced lance designs
  - Lances tend to be less costly
  - Lances are relatively easy to install
  - Many Lance systems are drastically more reliable than past systems
- Background to show how lances progressed
- Some 'new' ideas have evolved from past efforts to achieve good dispersion

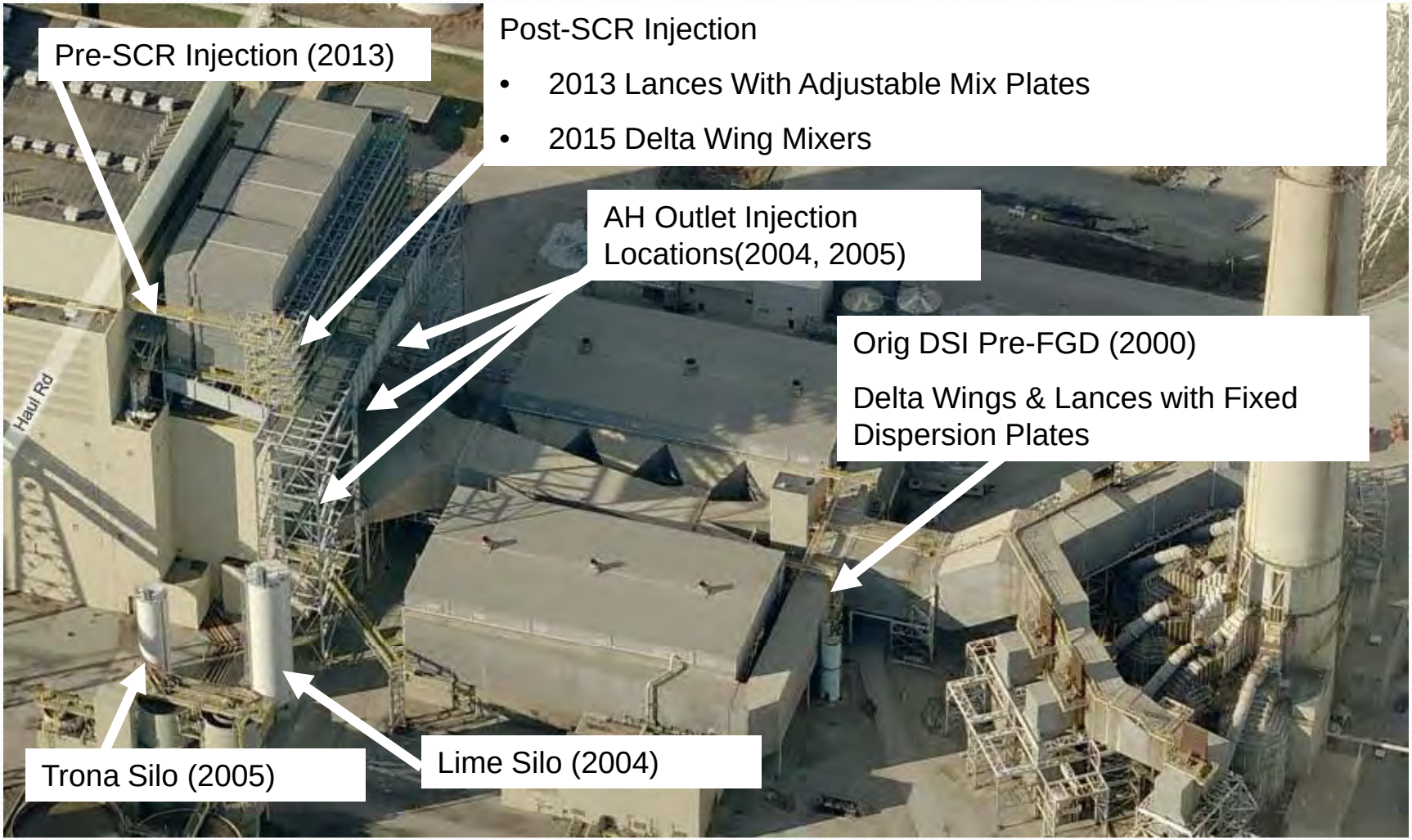
Lance Design Development

- Current Advanced Lance design started in 2000
- Designed for a temporary lime injection system
- Clearly understood then that good mixing and dispersion was critical for good performance
  - Installed Delta Wing Mixers
  - Installed fixed lances with 30” Dia Mixing plates to supplement areas missed by delta wings.

Initial Lances with Integral Mix Plates 2000 Thru 2003

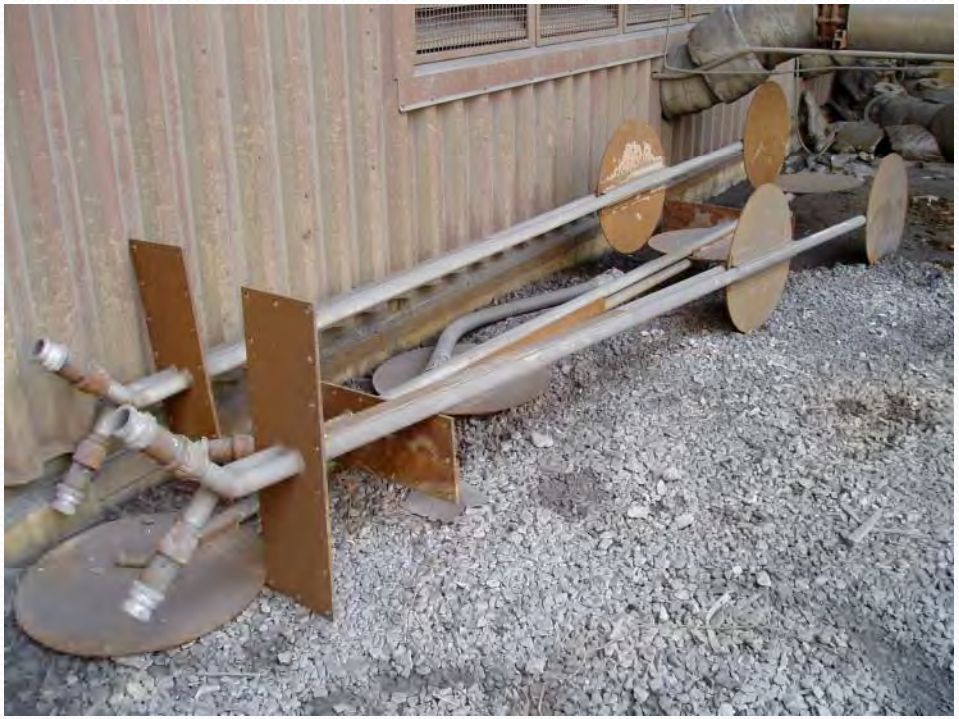


Zimmer DSI Systems History



Additional Early Generation Advanced Lances

2004 Trona & Lime Lances



2005 Trona Lances

2009 1st Design Using Shroud/ Guide Tube with Easily Removable Lance

Additional Early Generation Advanced Lances

2010 Trona & Lime Lances, Shrouded with Removable Lance Tube

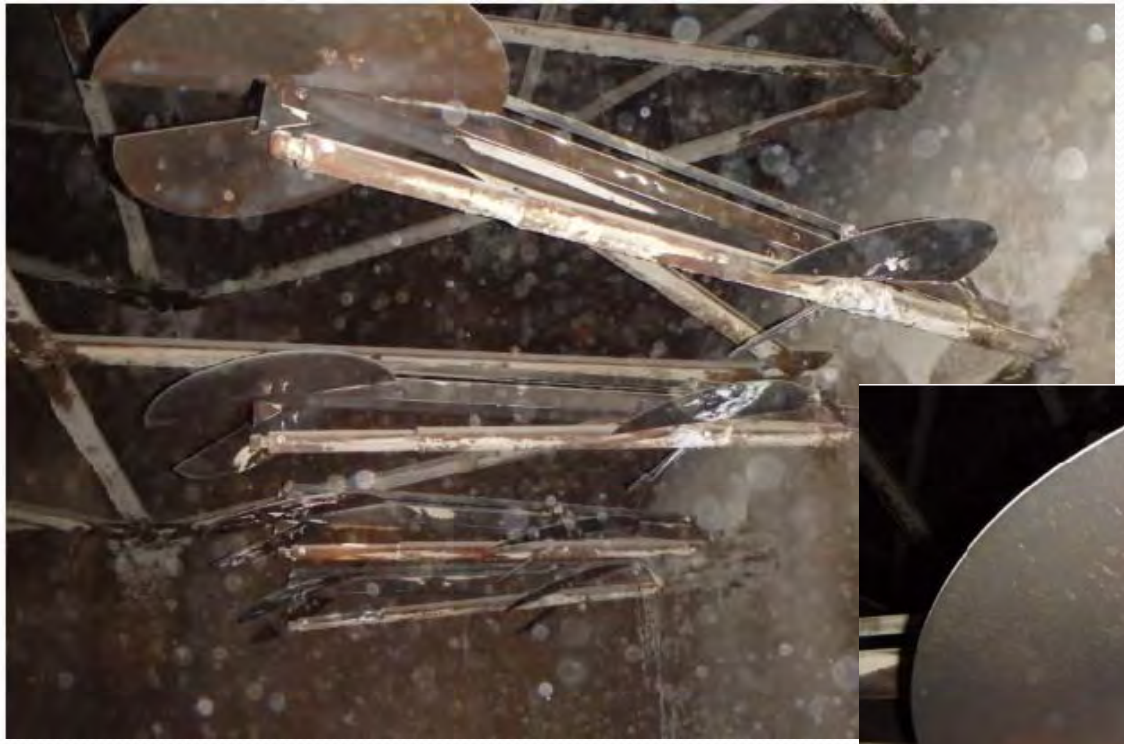
Typical Industry Standard Lance Design

2007 Lime Lances

2012 Trona Lances

Continued Development of Advanced Lances

2013 Lime Lances with Independent Adjustable Plates



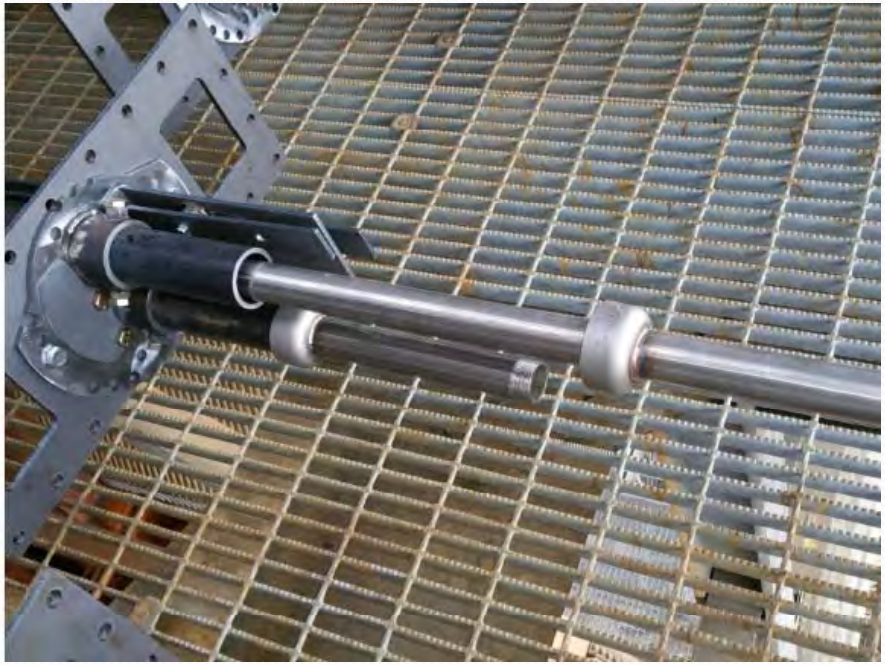
Continued Development of Advanced Lances

2016 Lime Lances

2017 Lime Lances

Continued Development of Advanced Lances

2018 Lime Lances – Adjustable Mix Plates & View Ports



Note: Lance removal requires no tools

Benefits from Advanced Lance Designs

- Effective at Very Reasonable Fabrication Cost
- Easy to 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

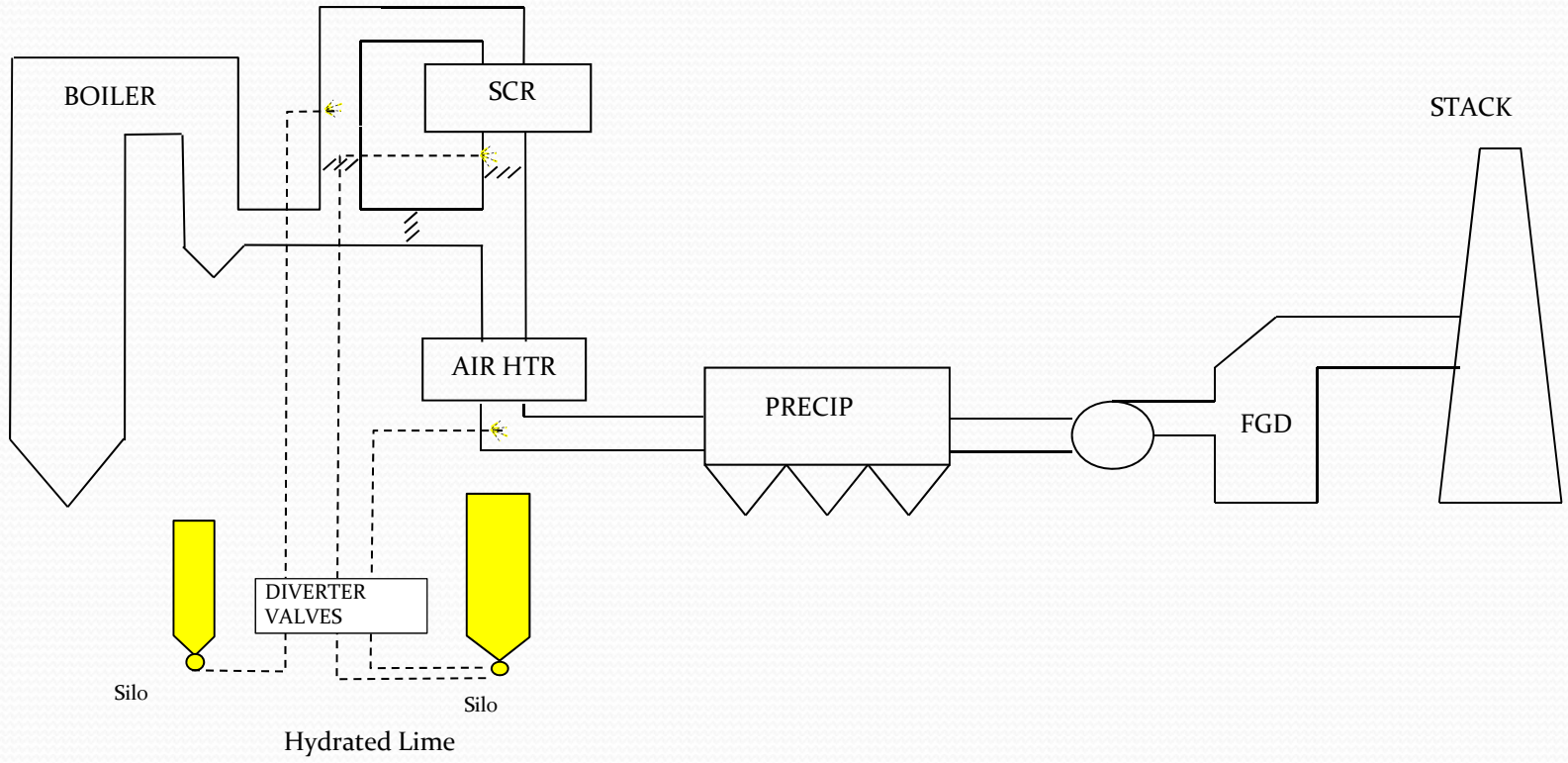
Benefits from Advanced Lance Designs

- 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

Typical Industry Lance Mounting Arrangements

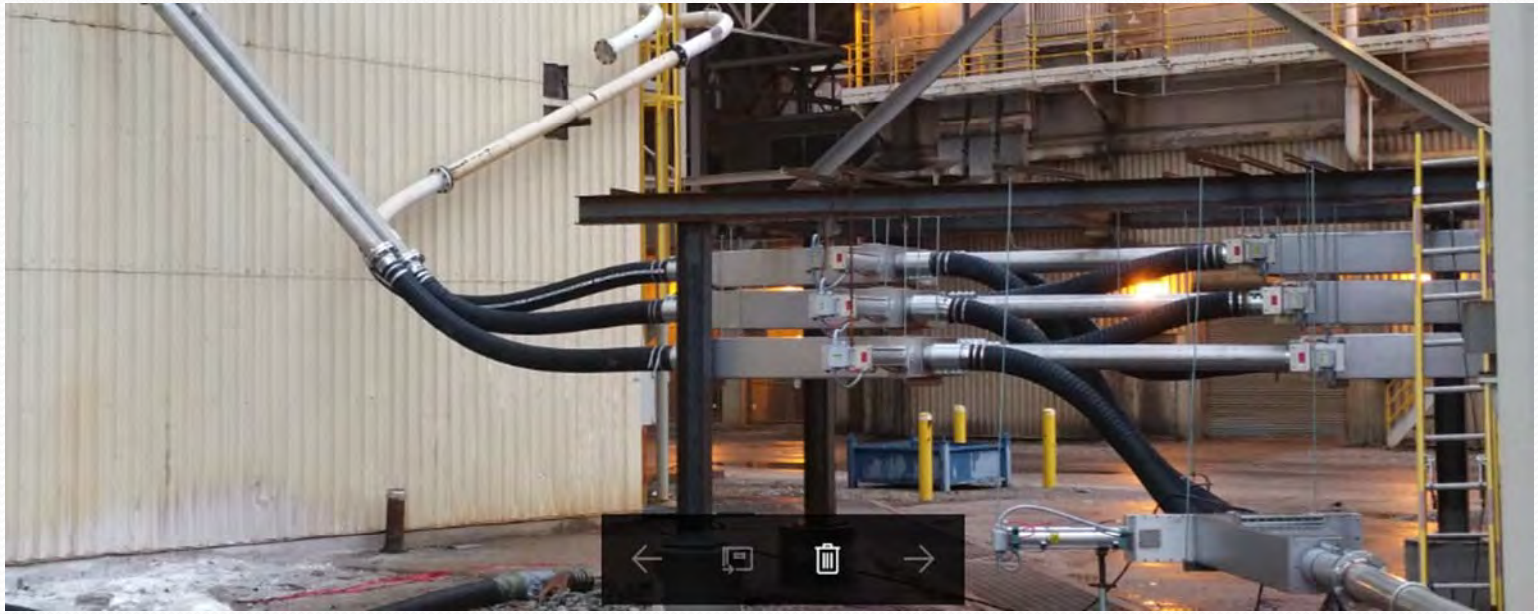
Additional DSI System Advancements

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



Additional DSI System Advancements

- 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



Additional DSI System Advancements

- 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

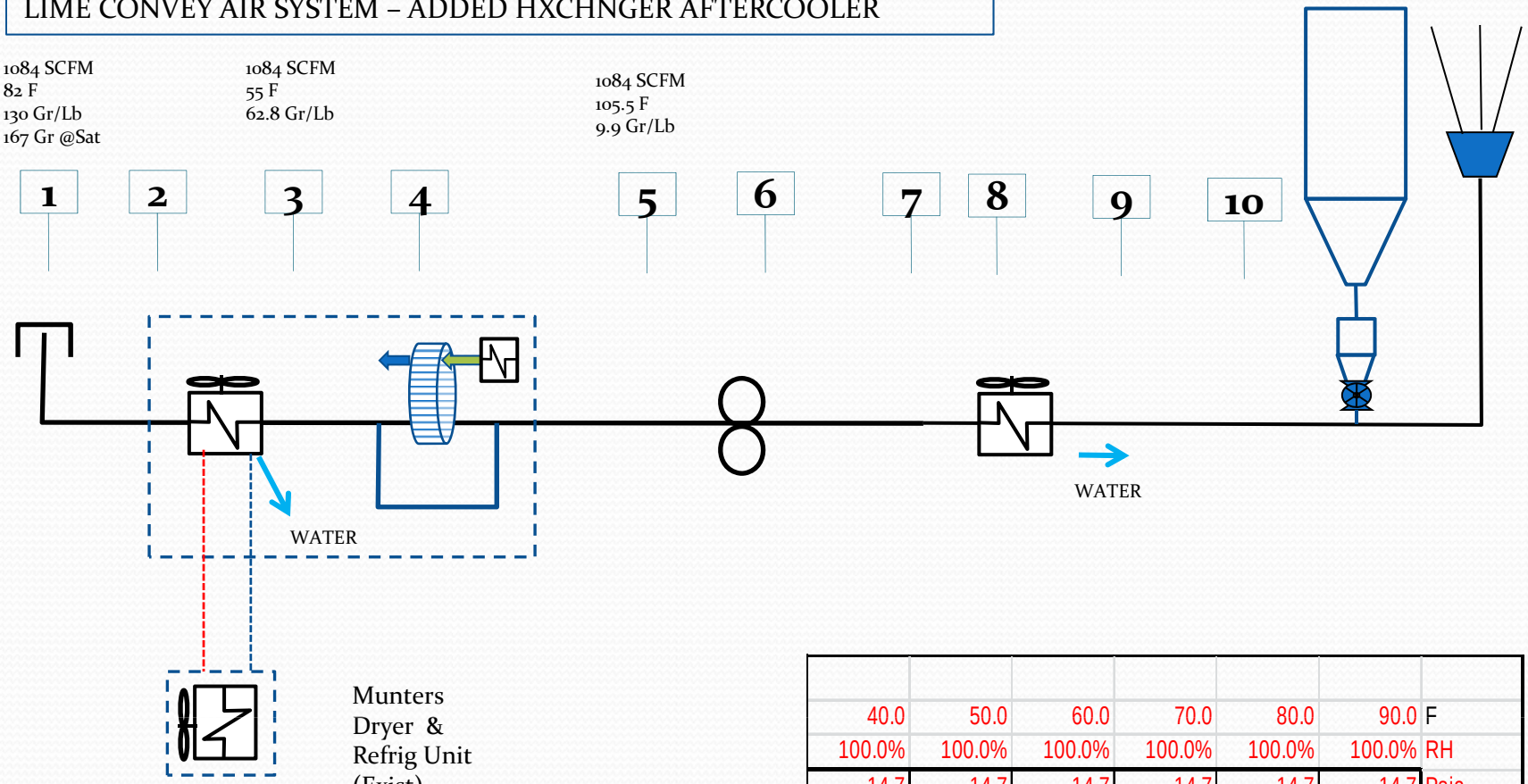
AIR QUALITY IMPROVEMENTS ALSO IMPORTNT

LIME CONVEY AIR SYSTEM – ADDED HXCHNGER AFTERCOOLER

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

1084 SCFM
55 F
62.8 Gr/Lb

1084 SCFM
105.5 F
9.9 Gr/Lb



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

Advancements Continue

- Thorough assessments important
- Know your current and possible future objectives
- Integrated/ Holistic Approach Critical
- DSI Experience is growing rapidly
- Past experience critical but past conclusions can be misleading

QUESTIONS?