REINHOLD ENVIRONMENTAL ®

2026 Reinhold/PCUG Round Table Presentation

Hosted by TVA, Southern Company and Vistra

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From Why to How: A Hydrated Lime DSI Primer

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Workshop 25 - Reinhold Conference Round Table

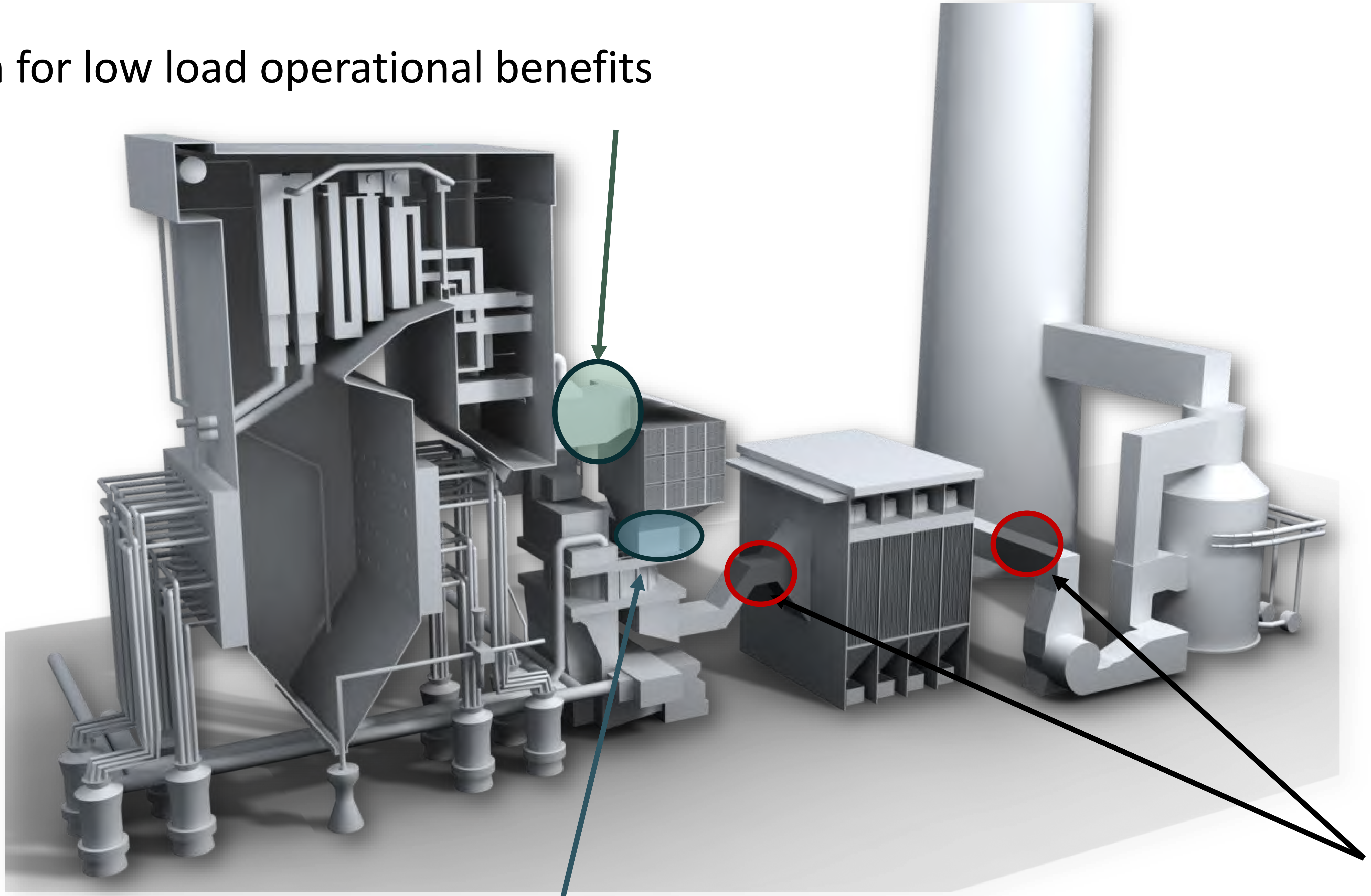
June 23, 2026

MLC™

AN HBM COMPANY

Dry Sorbent Injection Using Hydrated Lime

Pre-SCR injection for low load operational benefits

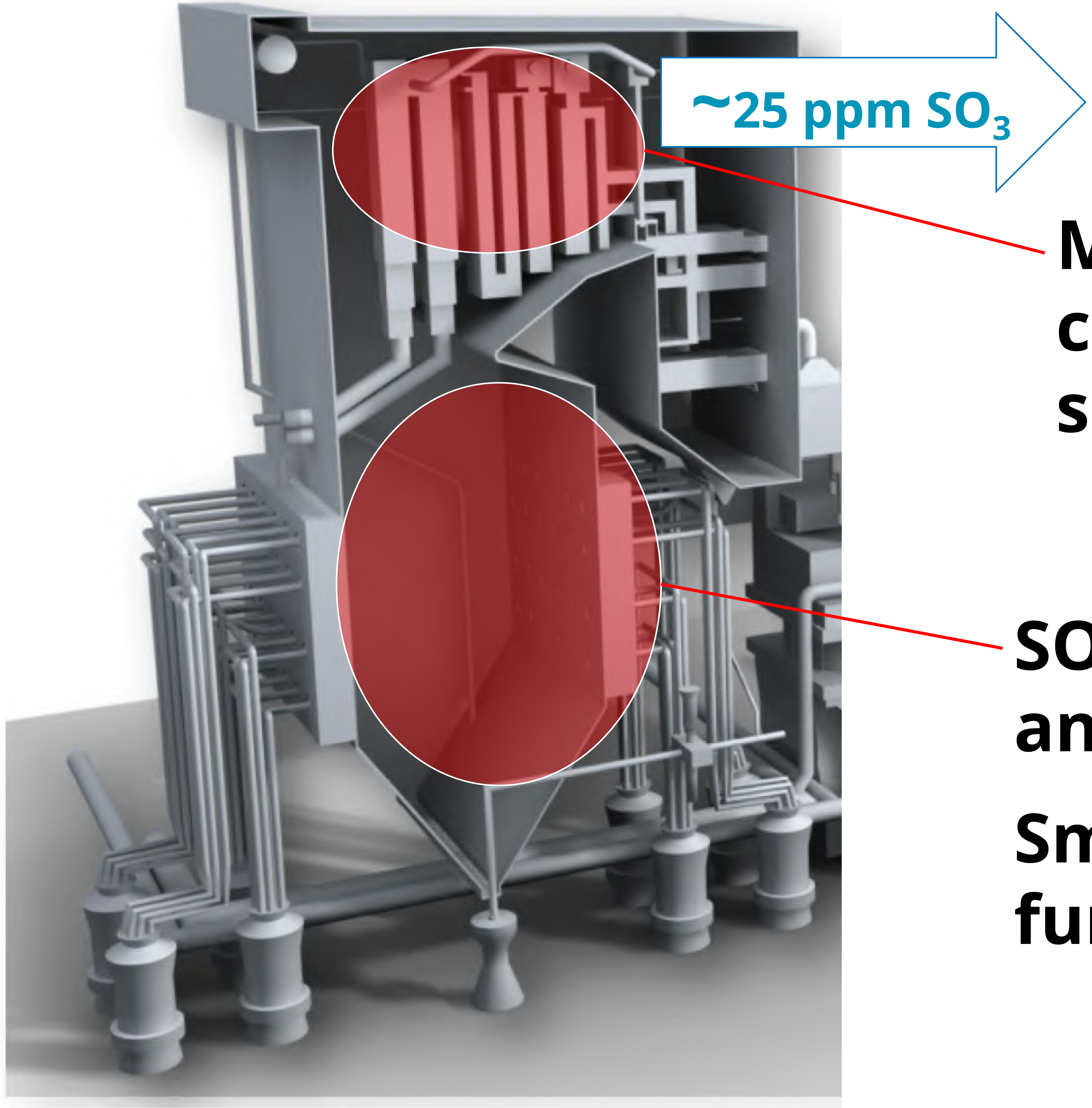


Post-APH injection to meet regulatory requirements

Pre-Air Preheater (APH) injection for APH cleanliness and other operational benefits

Why are we using Hydrated Lime?

SO_3 Generation in the Furnace



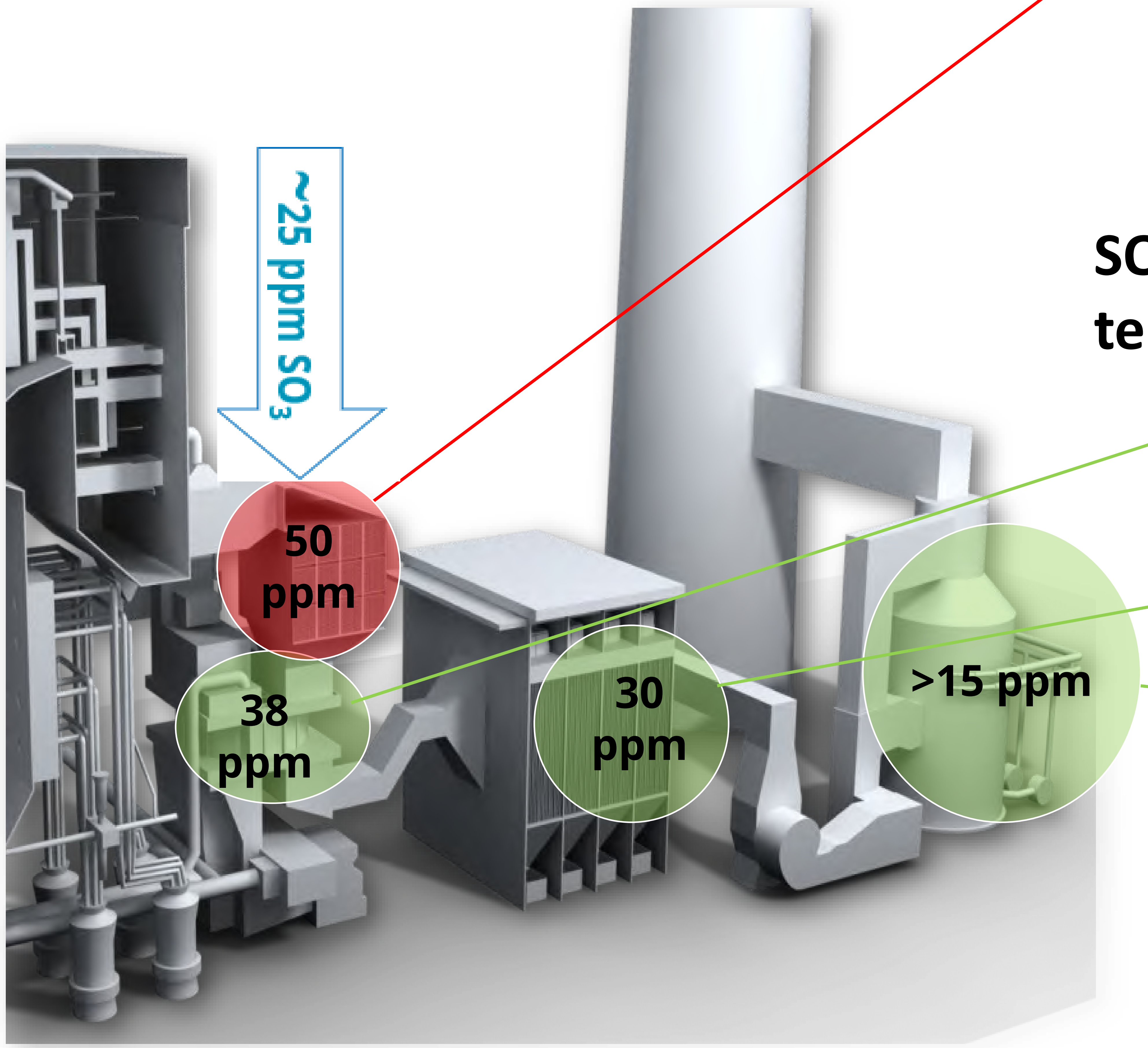
Most Furnace SO_2:SO_3 conversion happens in the convective zone in the presence of iron, oxygen and suitable temperature

SO_2 is formed during coal combustion at the burner and in the fire ball.

Small amount of SO_3 generated; excess O_2 in the furnace is typically low

Rule of Thumb is that 1% of the Furnace SO_2 converts to SO_3

SO_3 Fate Downstream of the Furnace



SCR increases SO_3

- **Catalyst (type/layers/activity), ammonia, and temperature are major influencers**

SO_3 converts to H_2SO_4 downstream of SCR depending on temperature and moisture in flue gas

Lose 20-25% of SO_3 across the Air Preheater

Can lose 10-25% H_2SO_4 in ESP/BH

Can lose 10-50% H_2SO_4 in Wet FGD

Loss of SO_3/H_2SO_4

- **Deposition on flue internals (corrosion) and ash**
- **Reaction with ammonia to form ammonium bisulfate**

How Much Sulfuric Acid Mist Needs Mitigated?

- Eliminate visual blue plume (~5-8 ppm SO_3 at the stack)
- Eliminate the SO_3 created from installation of SCR
- Limit applied by a regulatory authority
  - Stack testing on a frequency
  - Stack emissions tracked by a Continuous Emissions Monitor

Modern Era of Dry Sorbent Injection for Sulfuric Acid Mist Control

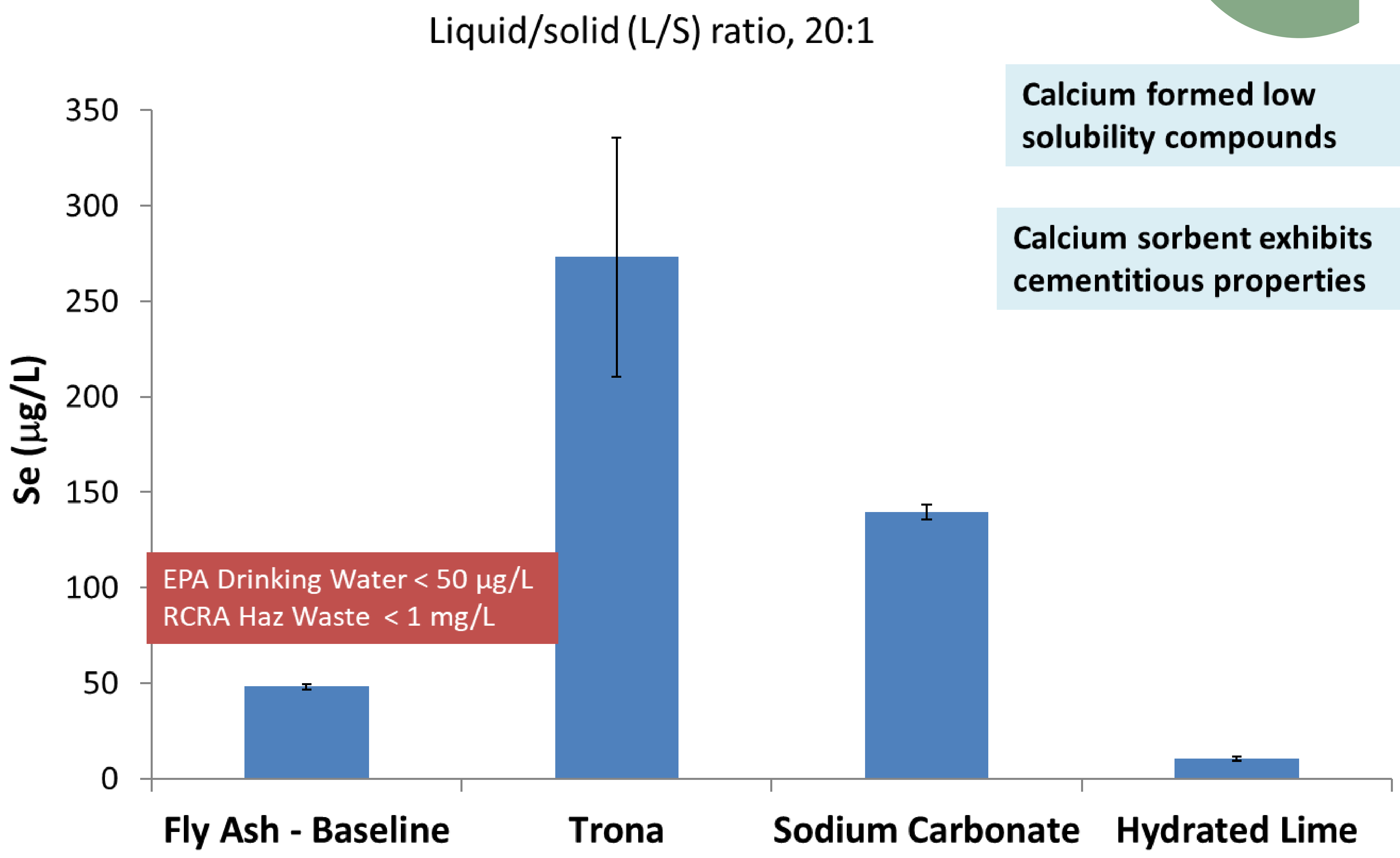
- Problem created from solving two problems
  - SCRs (NO_x) + Wet Scrubbers (SO_2) + High Sulfur Coal = Stack Sulfuric Acid Mist
  - Blue plume touchdown on local communities

- Required rapid resolution – neutralize with base
  - Trona
  - Sodium Bisulfate Solution (SBS)
  - Hydrated Lime

- Utilities initially successful with sodium-based sorbents

How Did Hydrated Lime Flip the Field

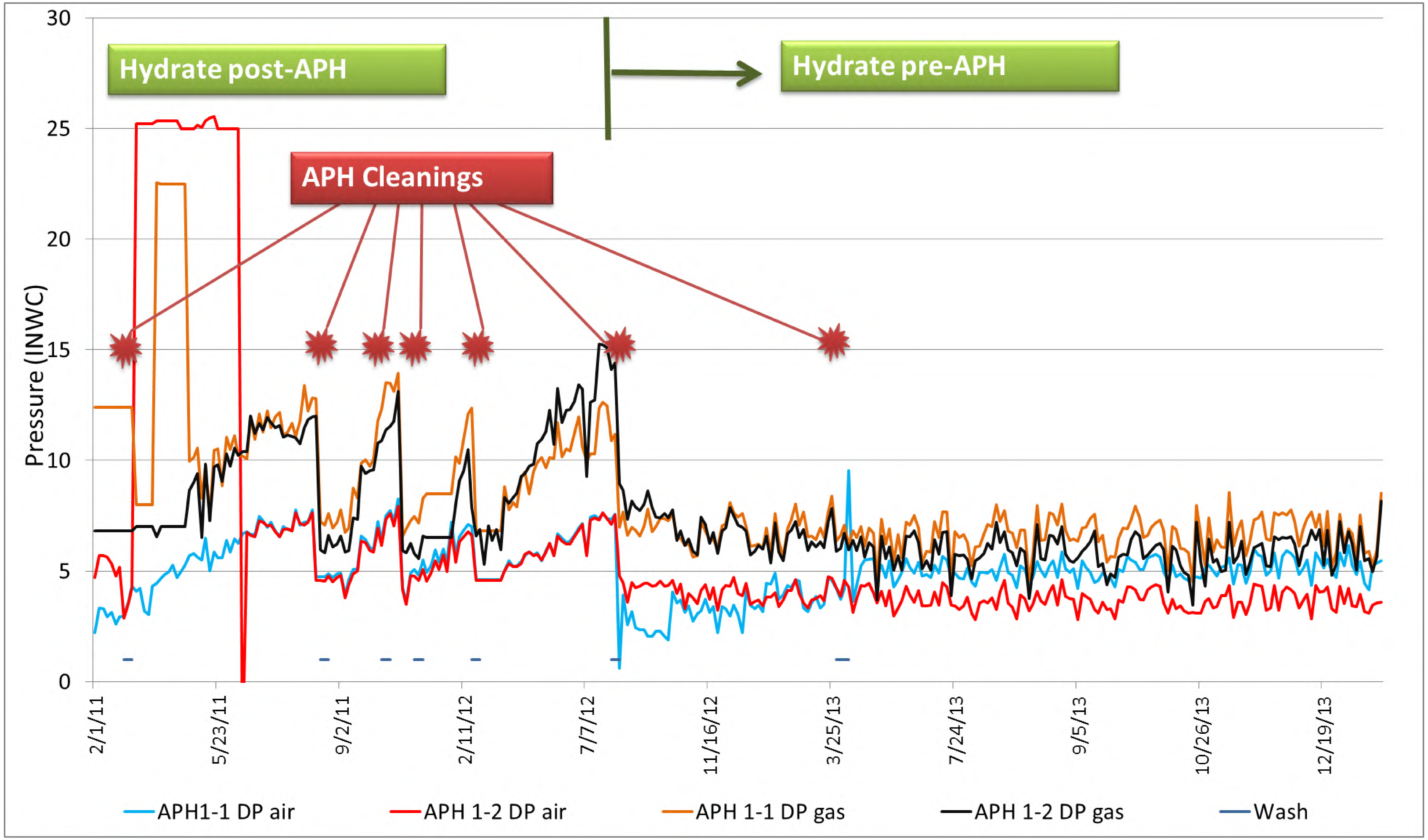
- Improved performance
  - Better entry-level products
  - Enhanced hydrates
- Fewer or less stringent ancillary issues
  - No problematic byproducts in ducts
  - Sellable ash
  - <u>Relatively</u> fewer conveying issues
- Advantages over sodium sorbents
  - Multiple hydrated lime sources in regions where SO_3 emissions are an issue
  - Operational benefits benefit beyond pollution control
    - Pre-APH injection



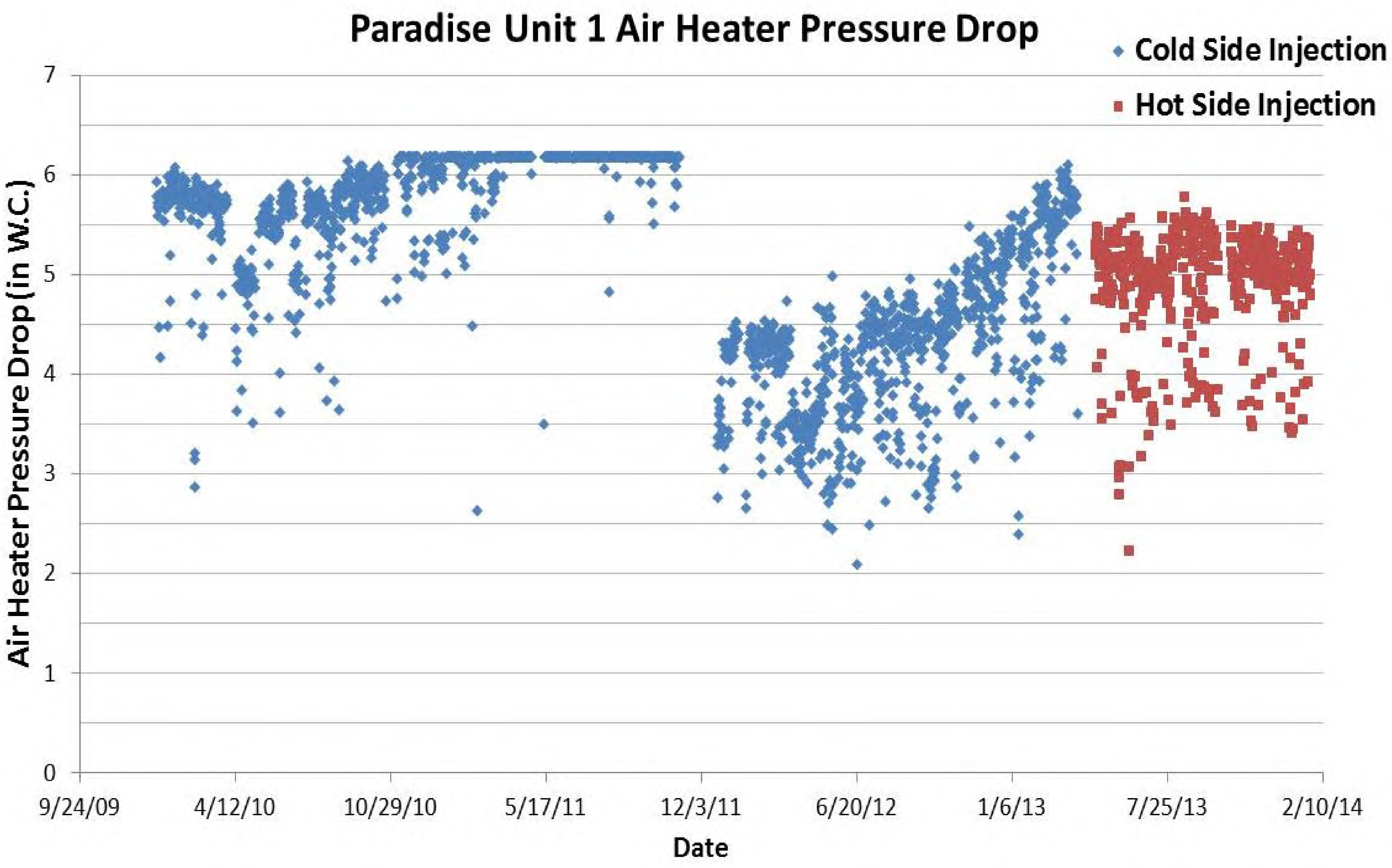
Calcium formed low solubility compounds

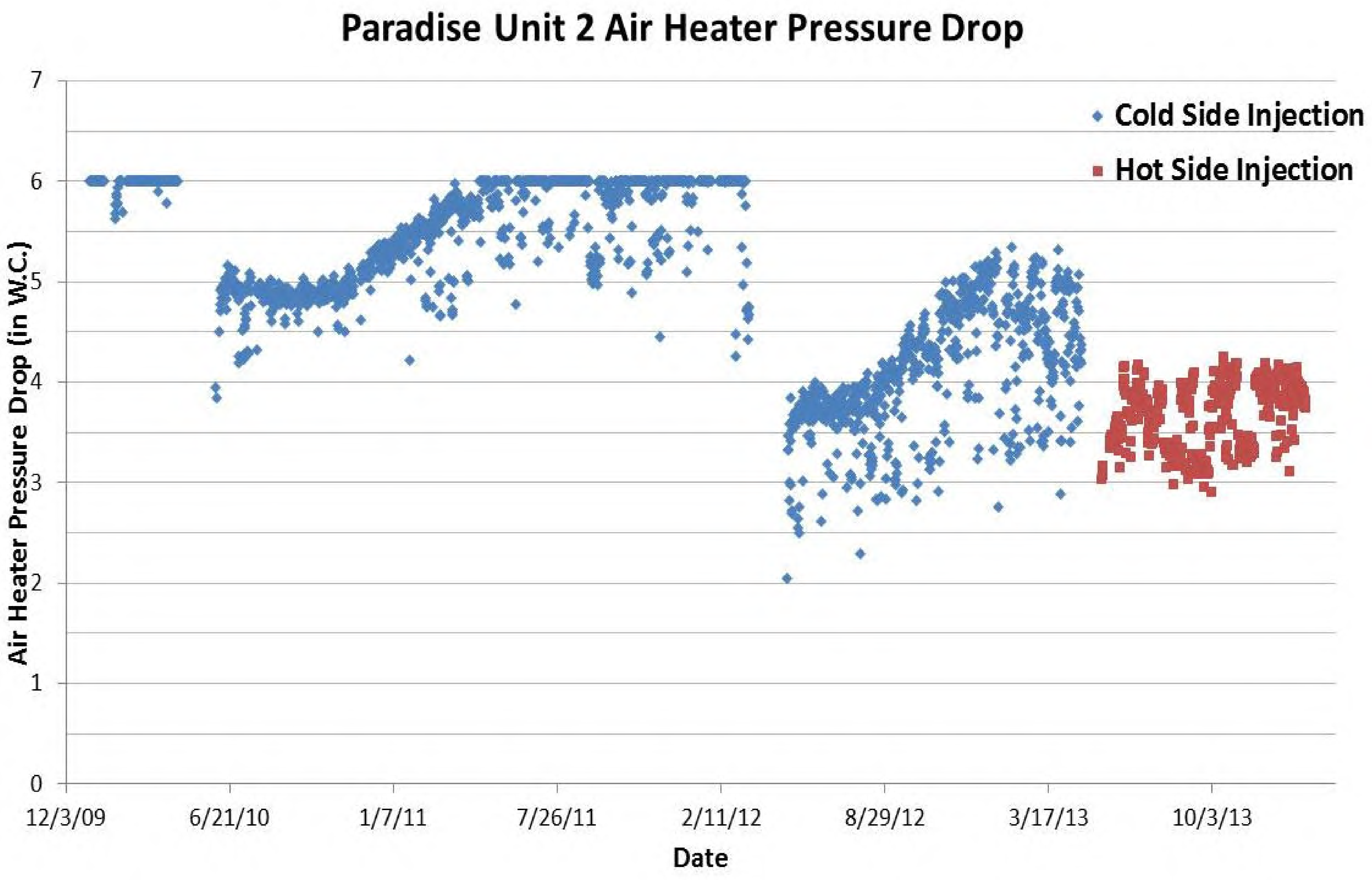
Calcium sorbent exhibits cementitious properties

Hydrated Lime Pre-APH – Effects on APH Dp



Pre-APH Hydrate Benefits at TVA Paradise





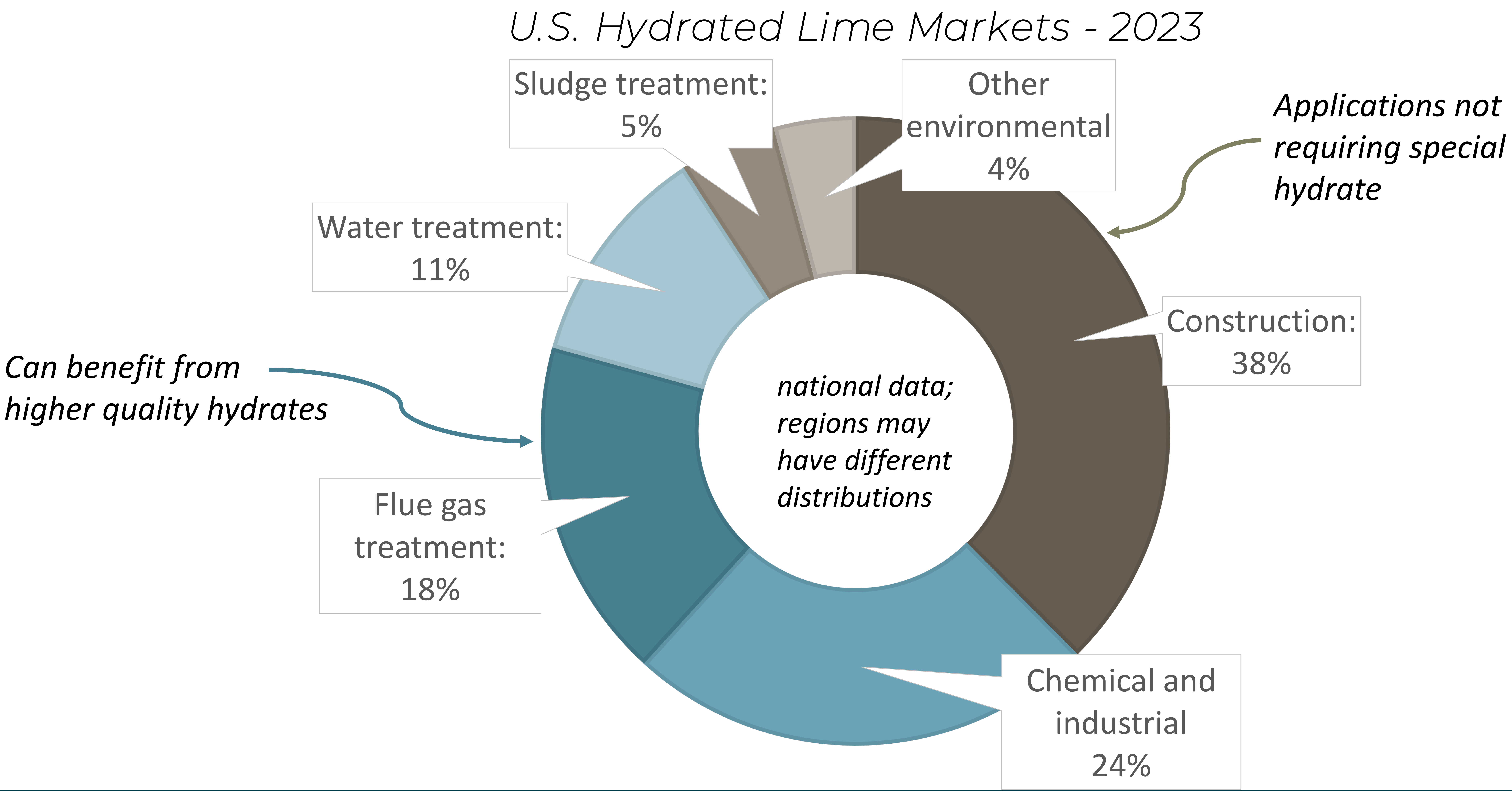
Jan 2011 – Mar 2013: over **570,000 MWh** lost due air heater fouling from both units.

Began hot side injection Apr 2013, **0 MWh** were lost due air heater fouling (Feb 2014 report)

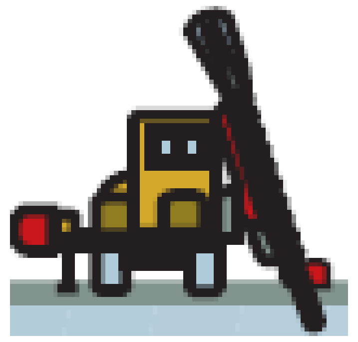
Pre–SCR Injection of Hydrate

- Reduce the Minimum Operating Temperature
  - Interaction of SO_3 deposition onto SCR catalyst sets minimum load
  - Neutralize SO_3 -> Reduced dew point
  - Hydrate or calcium sulfate should not chemically degrade catalyst
- Lower MOT = Reduced Minimum Load
  - Fuel cost savings while awaiting load ramp
  - Reduce CO_2 emissions
- Typically need second hydrate injection point to capture SO_3 generated in SCR

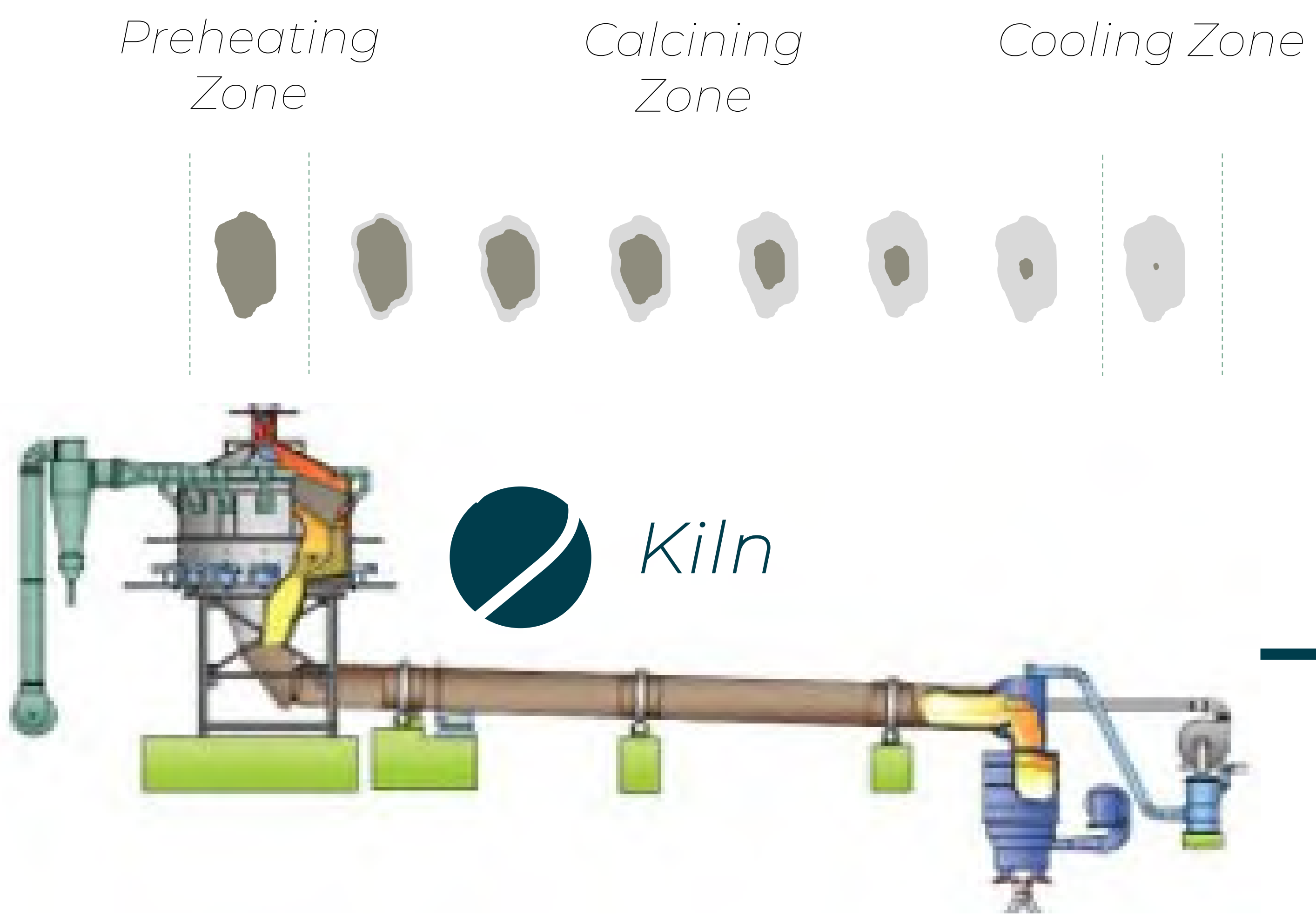
USGS – Survey of Hydrated Lime Production in US



Quicklime Production (Calcium Oxide)



Drilling & Blasting Limestone (Calcium Carbonate)



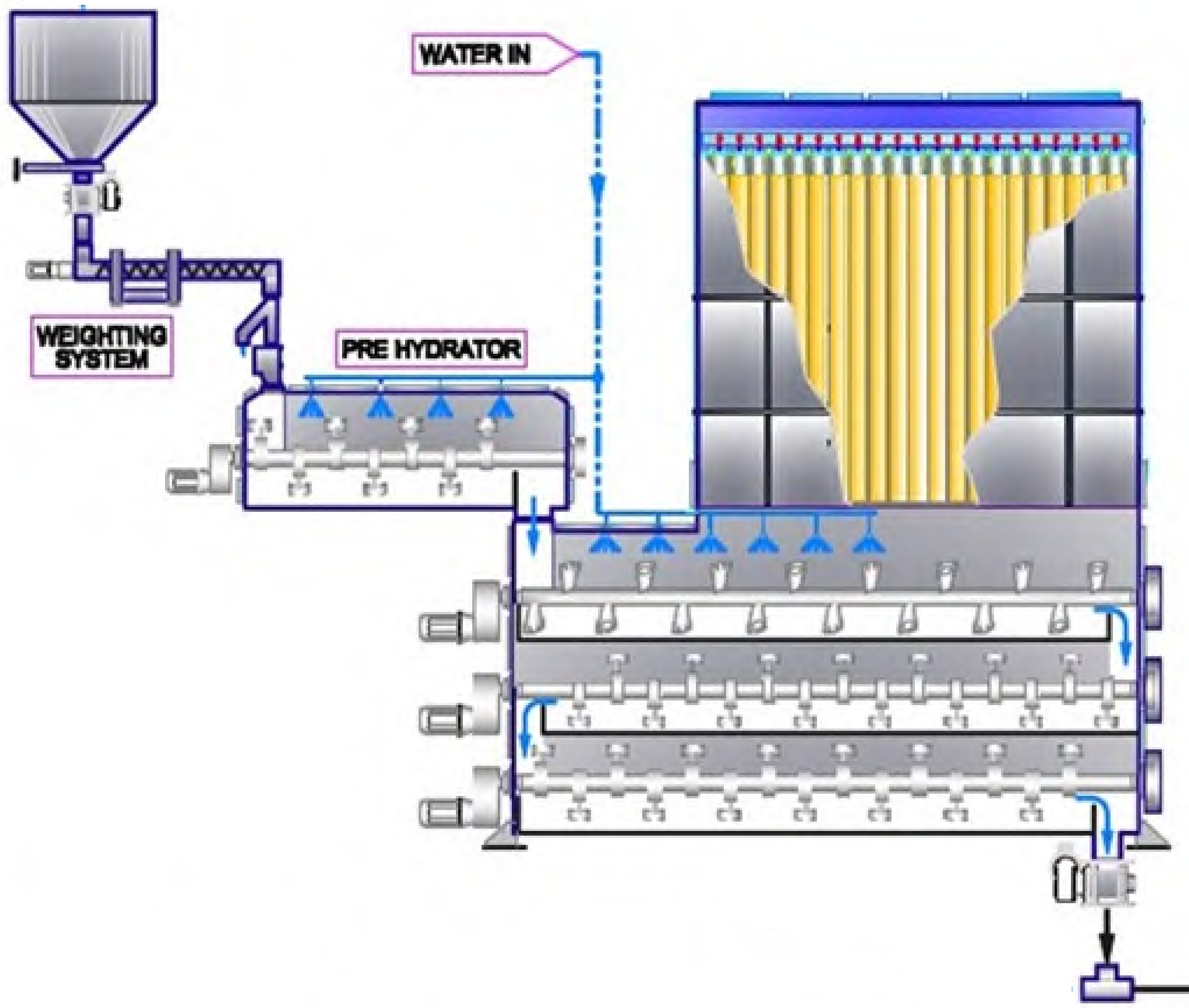
Kiln

Quicklime (Calcium Oxide)

Hydrate Production(Calcium Hydroxide)

Quicklime
(Calcium Oxide)

Hydration*



Refinement

Hydrated Lime
(Calcium Hydroxide)

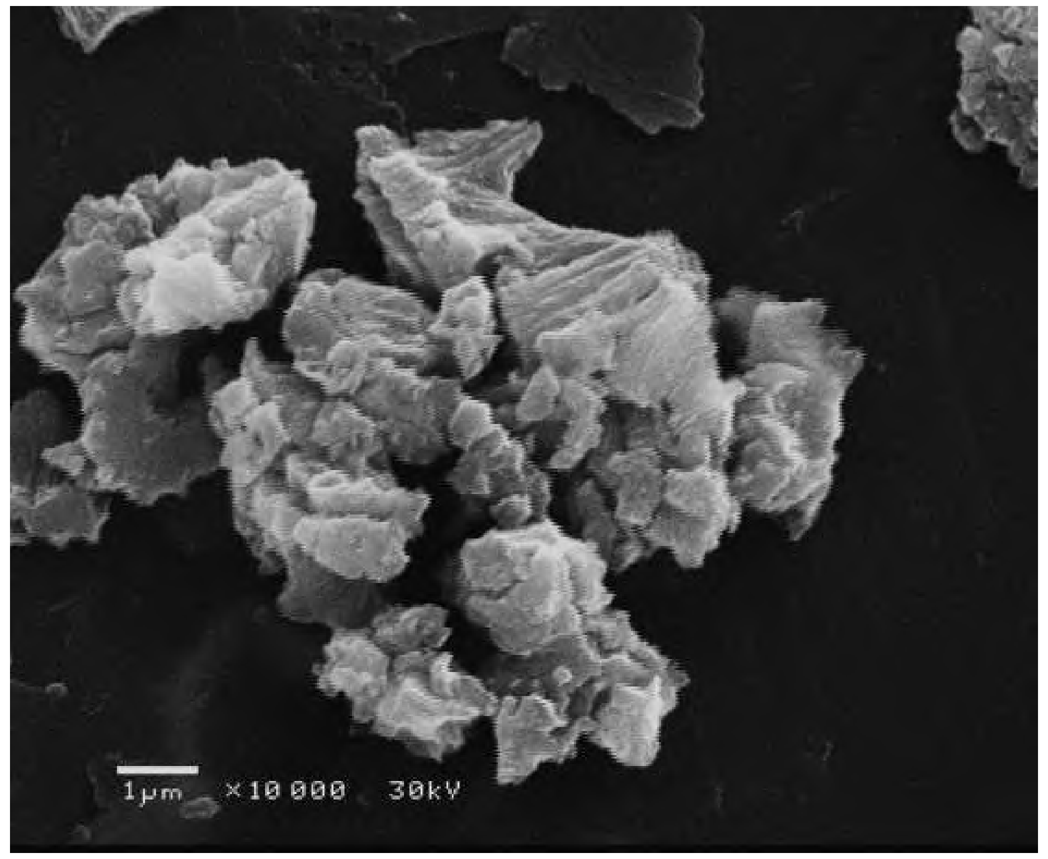
* Image source: modified from Sic-lime.com.

What Makes a Hydrated Lime "Enhanced"

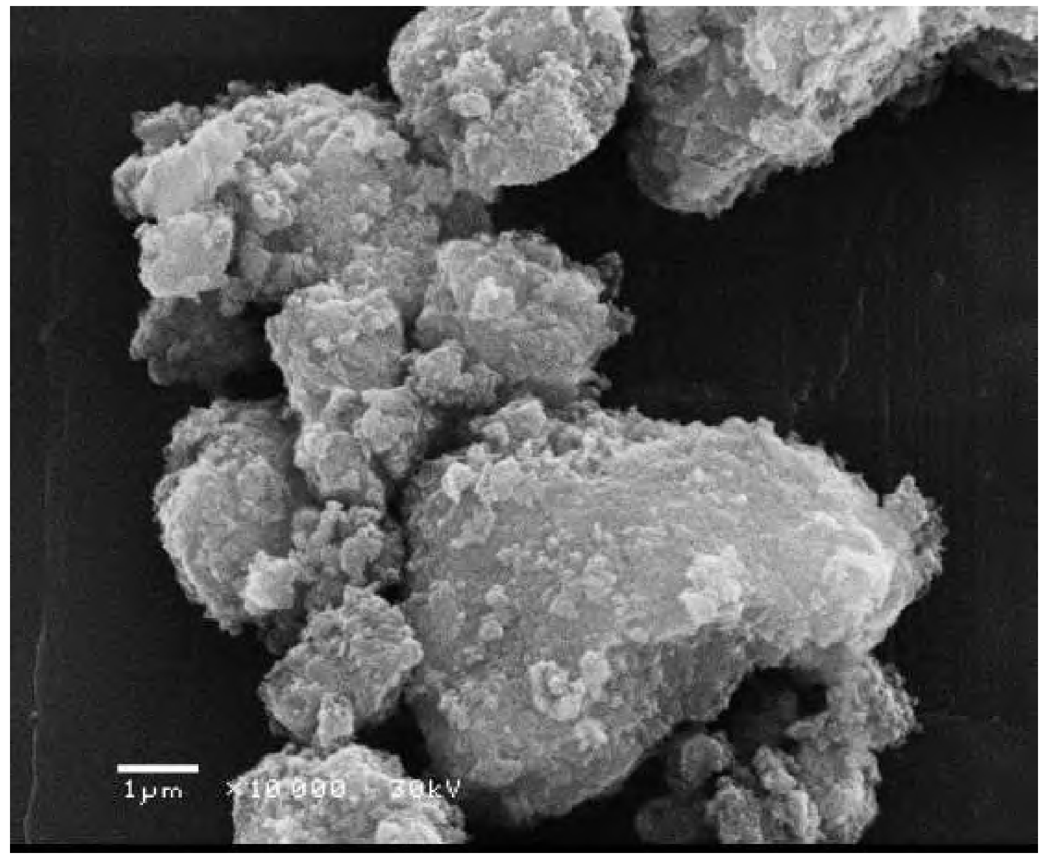
Lime supplier has **modified the manufacturing process** to **consistently** produce a hydrated lime that has **more active sites for neutralization of acids**

Think in terms of "effective surface area"
J.A.H. Oates, "Lime and Limestone"

1. The specific surface area (BET)
2. Total volume and size of pores
3. Particle size
4. Degree of agglomeration



Enhanced hydrate



Standard hydrate

Enhanced hydrates are patented/proprietary technology

Comparing suppliers solely on specifications is not simple

Proof of performance comes in plant evaluations

Benefits of Enhanced Hydrated Lime

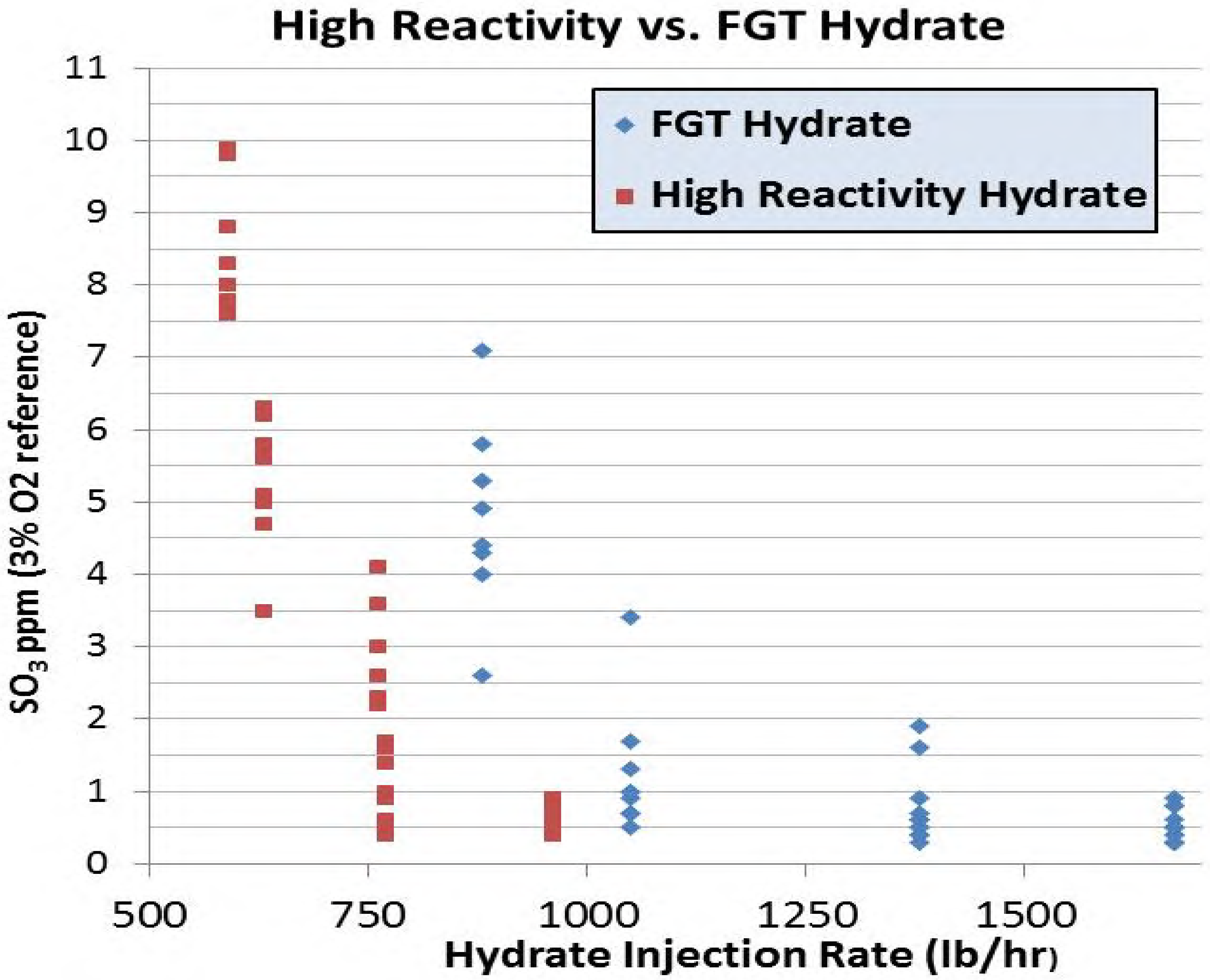
- Reduced emissions of SO_2 , SO_3, and HCl
  - Lower annual delivered hydrate costs while maintaining existing emission levels
- Flexibility:
  - Higher sulfur or chloride fuel
  - SCR operations to maximize NO_x reduction
  - Ability to control emissions with more challenging flue gas
- Reduce truck traffic and potential safety exposures during product deliveries
- Less ash
- Increase # days of sorbent storage

FGT vs. High Reactivity Hydrate

- Both hydrates reduced SO_3 by **94%-98%** across the APH

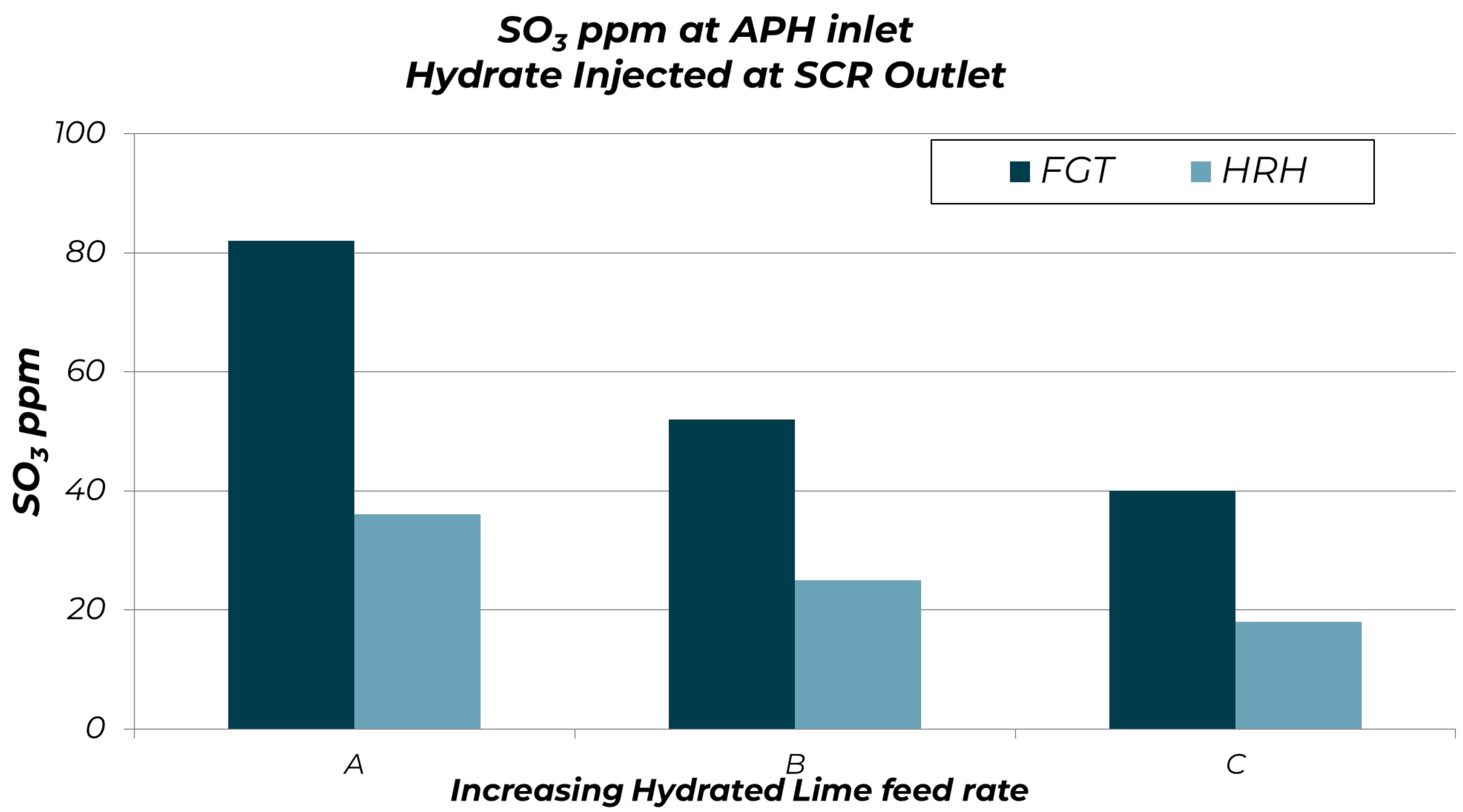
  - FGT = 1,000-1,100 lb/hr
  - **HRH = 750-800 lb/hr**

- Acid dew-point reduction from 300°F to ~275°F



HRH Works Better in a Tight Reaction Window

Utility desired high SO_3 capture at Air Preheater inlet so they evaluated HRH versus their existing hydrate, FGT (Flue Gas Treatment)

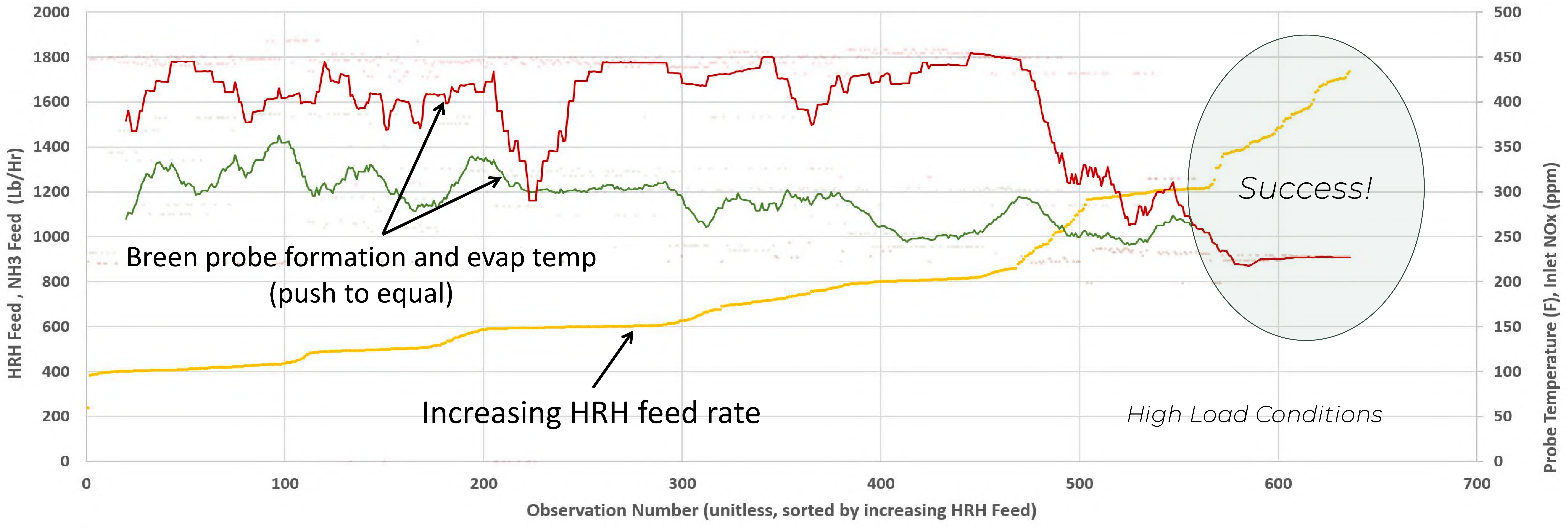


HRH reduced SO_3 significantly compared to FGT hydrate

Customer had confidence the high reactivity sorbent would better prevent APH buildup

Understand the in-flight capture of your hydrated lime

HRH Feed Rate + Condensable Formation Temperature Relationship



- HRH pre-SCR injection rate equivalent to trona post APH.
- APH diff pressure stabilized / ID Fan power consumption reduced / Soot blowing frequency minimized / Steam coil usage cut in half
- Marketable fly ash

DSI Conveying System Components

Feed Bin

Convey Air

Feeder

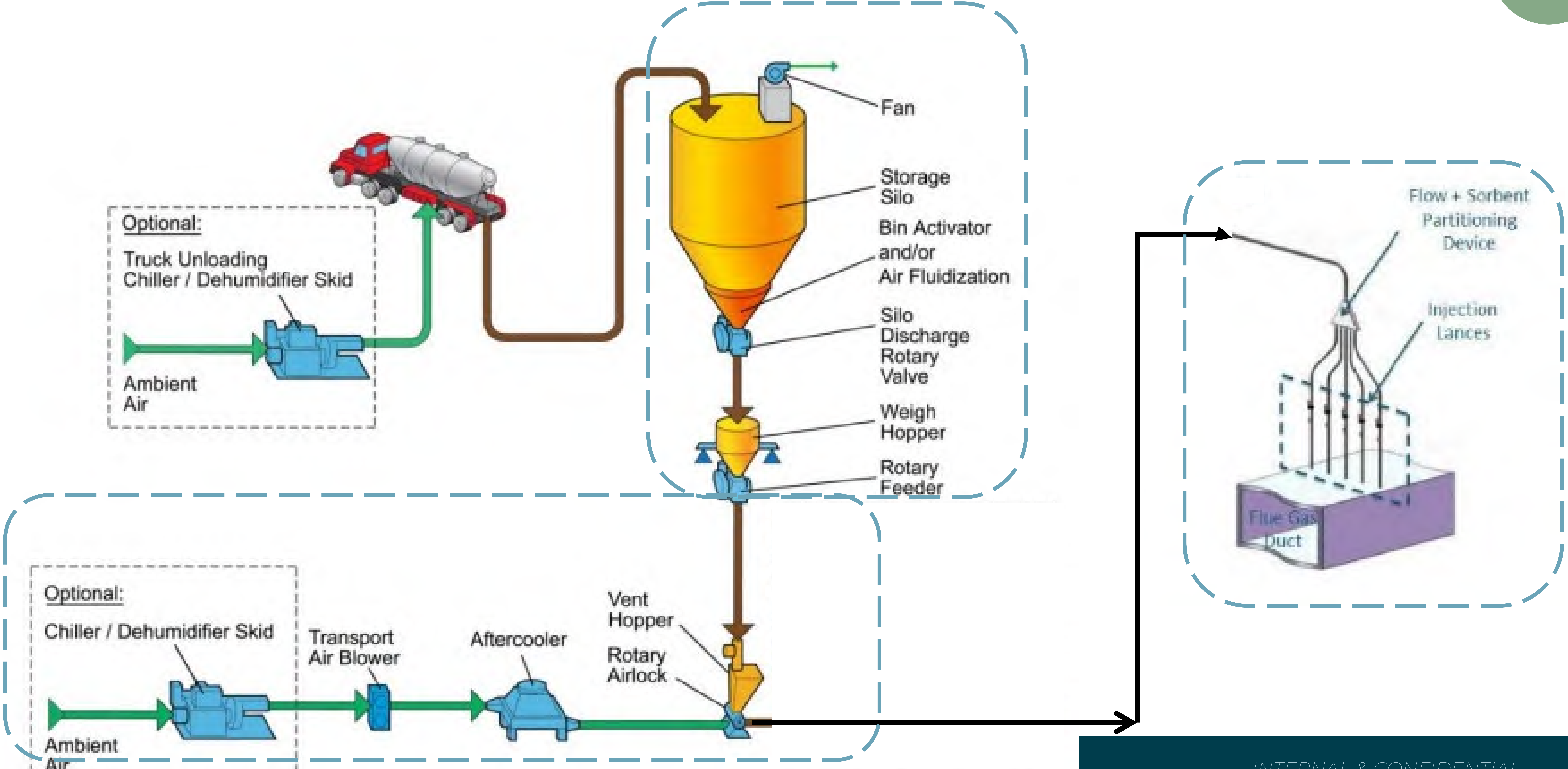
Convey Pipe

Splitter

Injection

Also used: dehumidifier, chiller/air-air heat exchanger, in-duct mixing devices, high dispersion lance tips

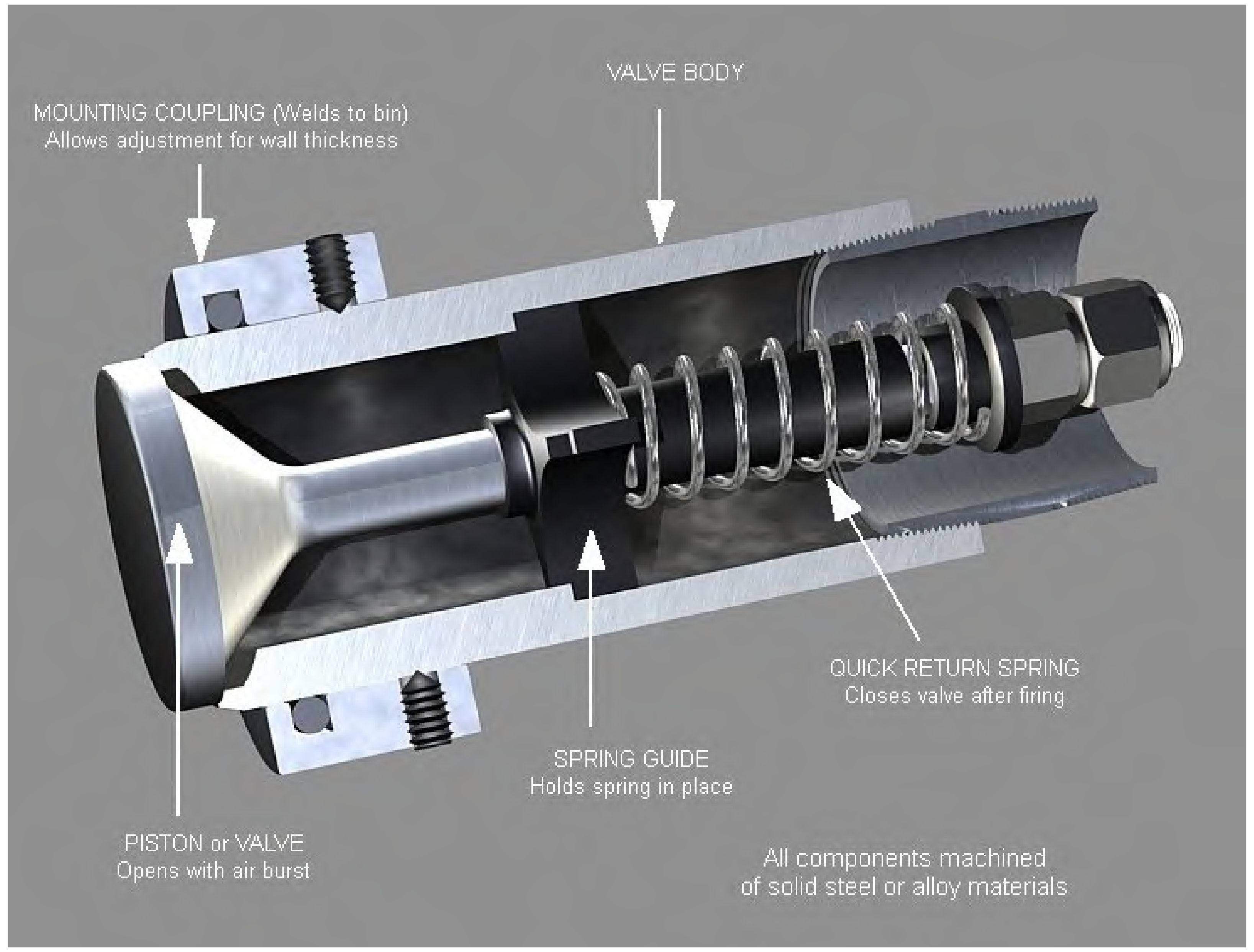
DSI System

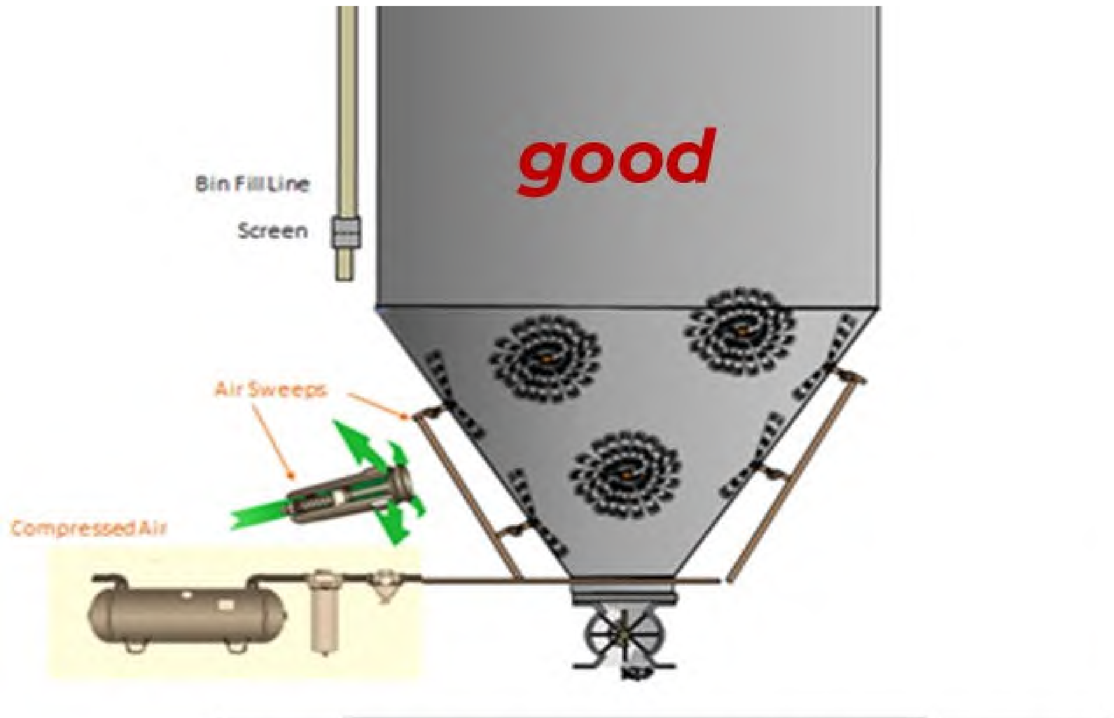


Dry Sorbent Injection for Acid Gas Control, ICAC, July 2016

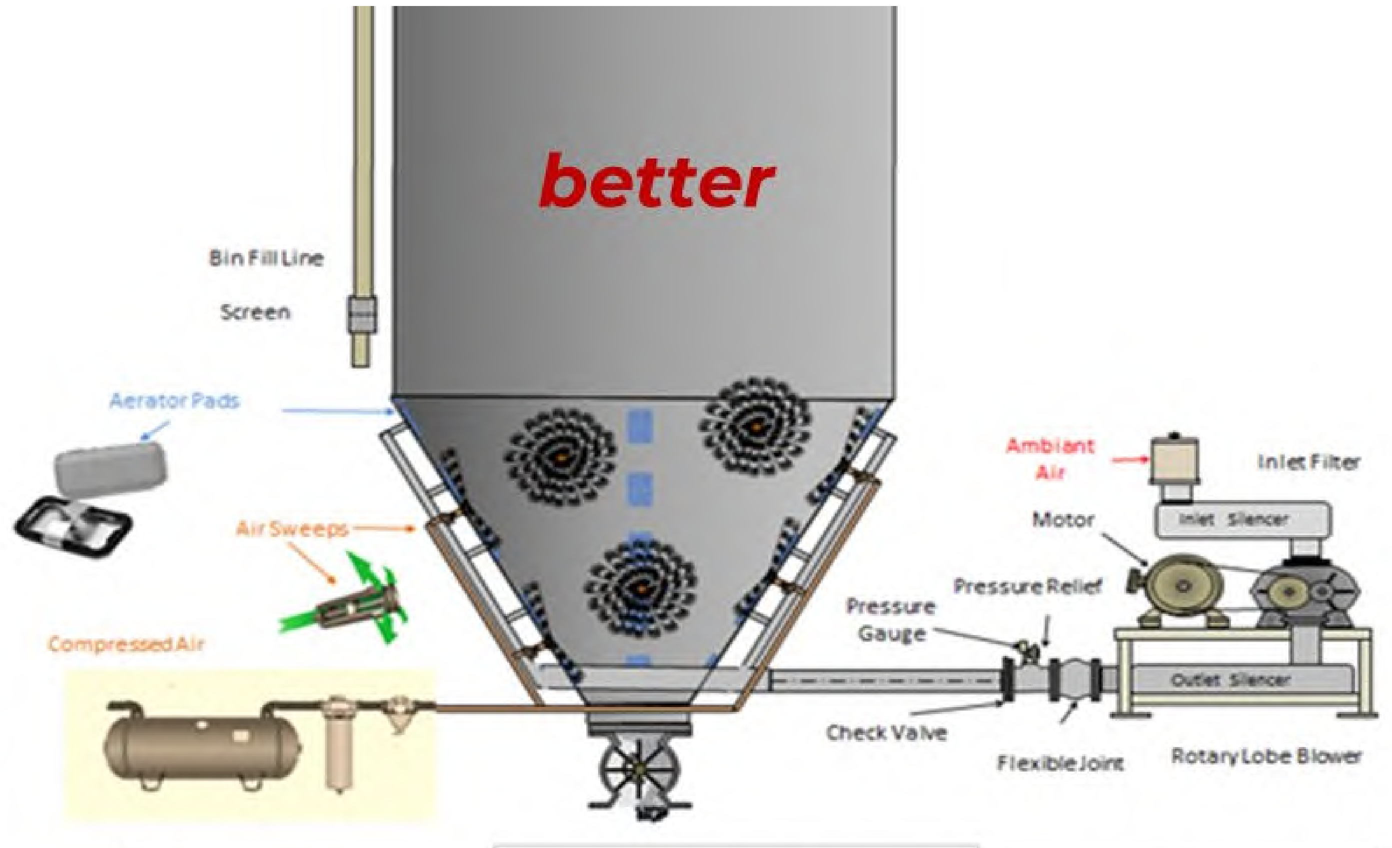
Storage Silos

- Silo size to hold at least two truckloads (loose bulk density 20-25 lb/ft^3)
- Level transmitter –
  - Radar or guided radar level detector
  - Capacitance detector for High/Low levels
- Dust collector – bag, not cartridge
- 60° Cone
- Fluidization
  - Air Sweeps + Air Pads > Air Sweeps >> Air Pads >> Live Bottom bins





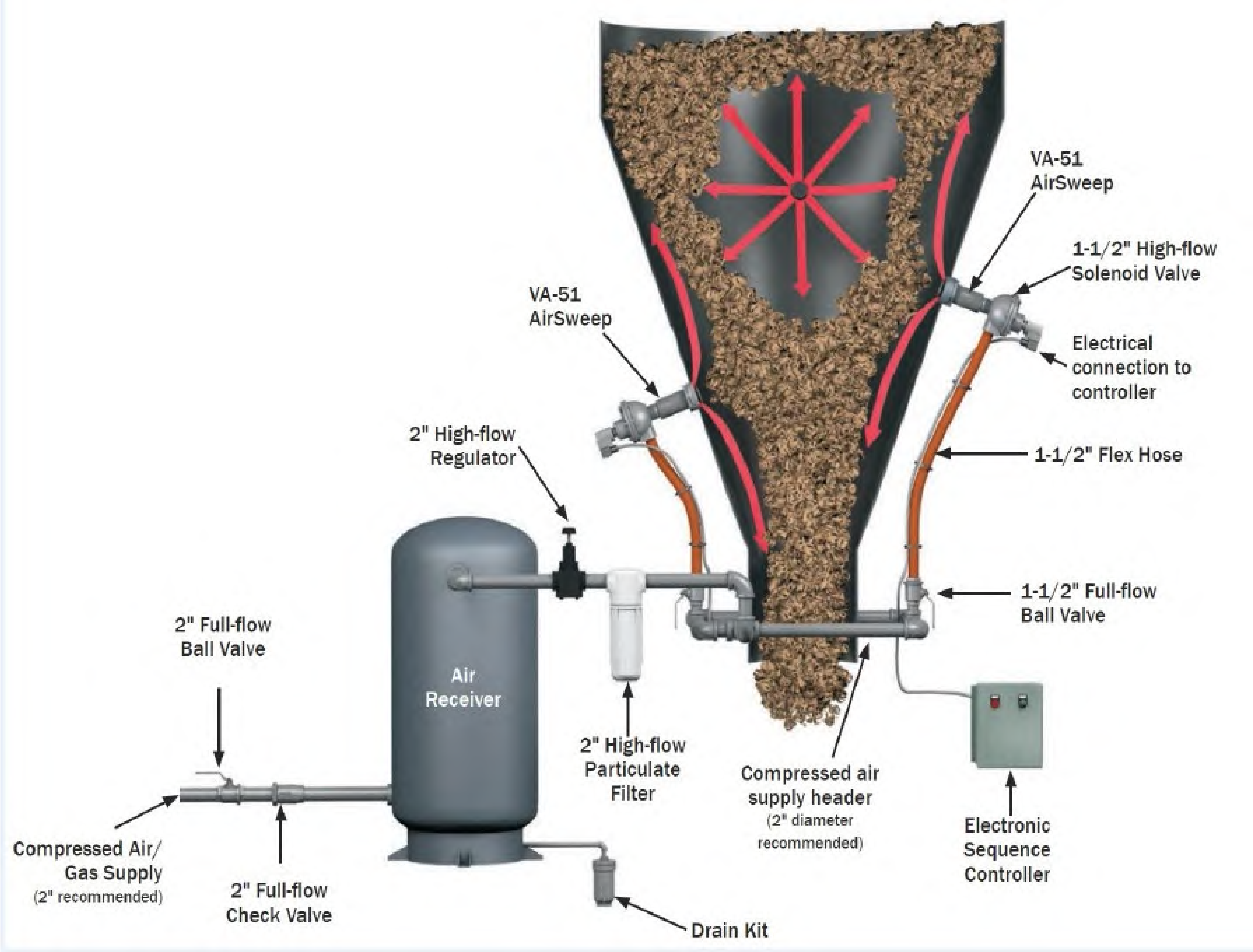
Storage Silo + Air Sweeps

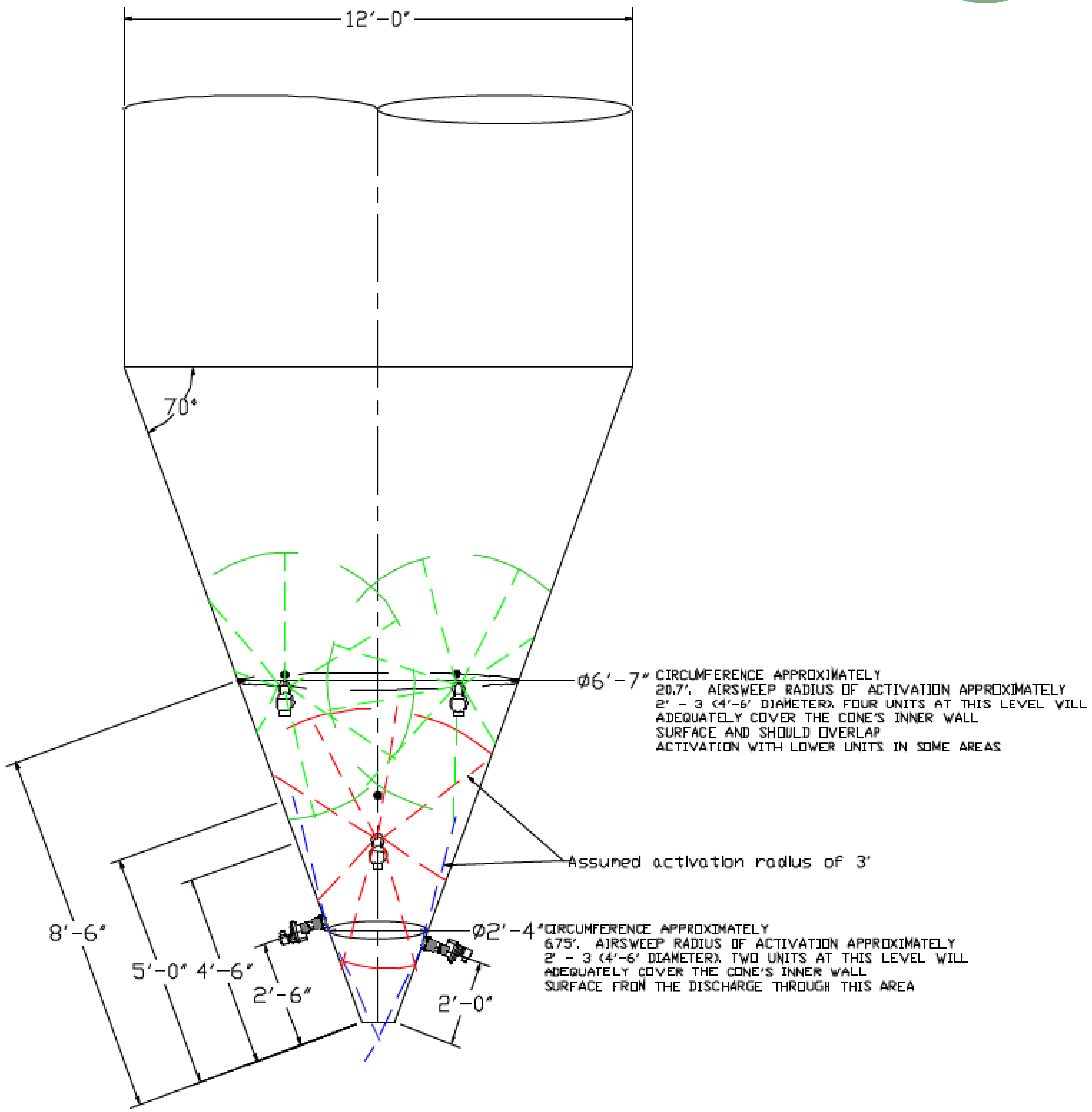


Storage Silo + Air Sweeps + Air Pads

Fluidization Key – Break Bridged Material

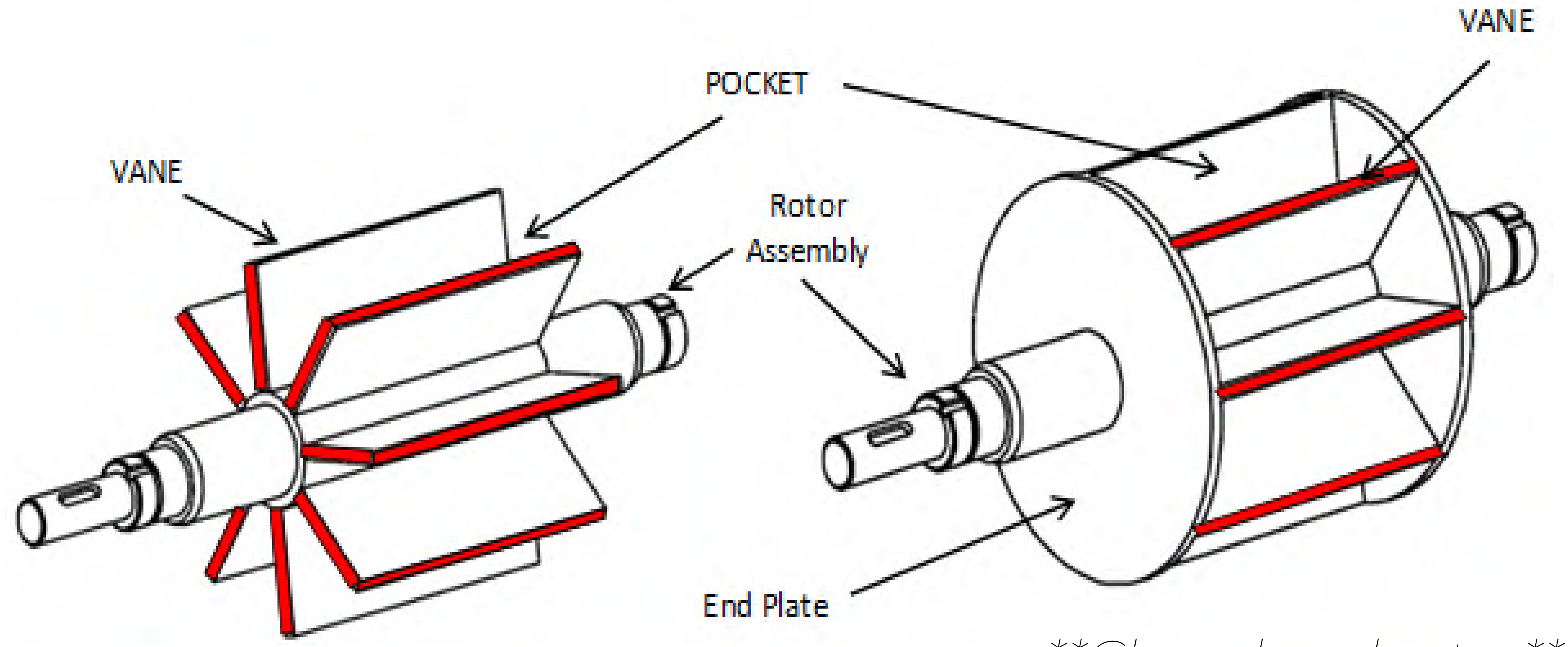
Mass, not funnel flow



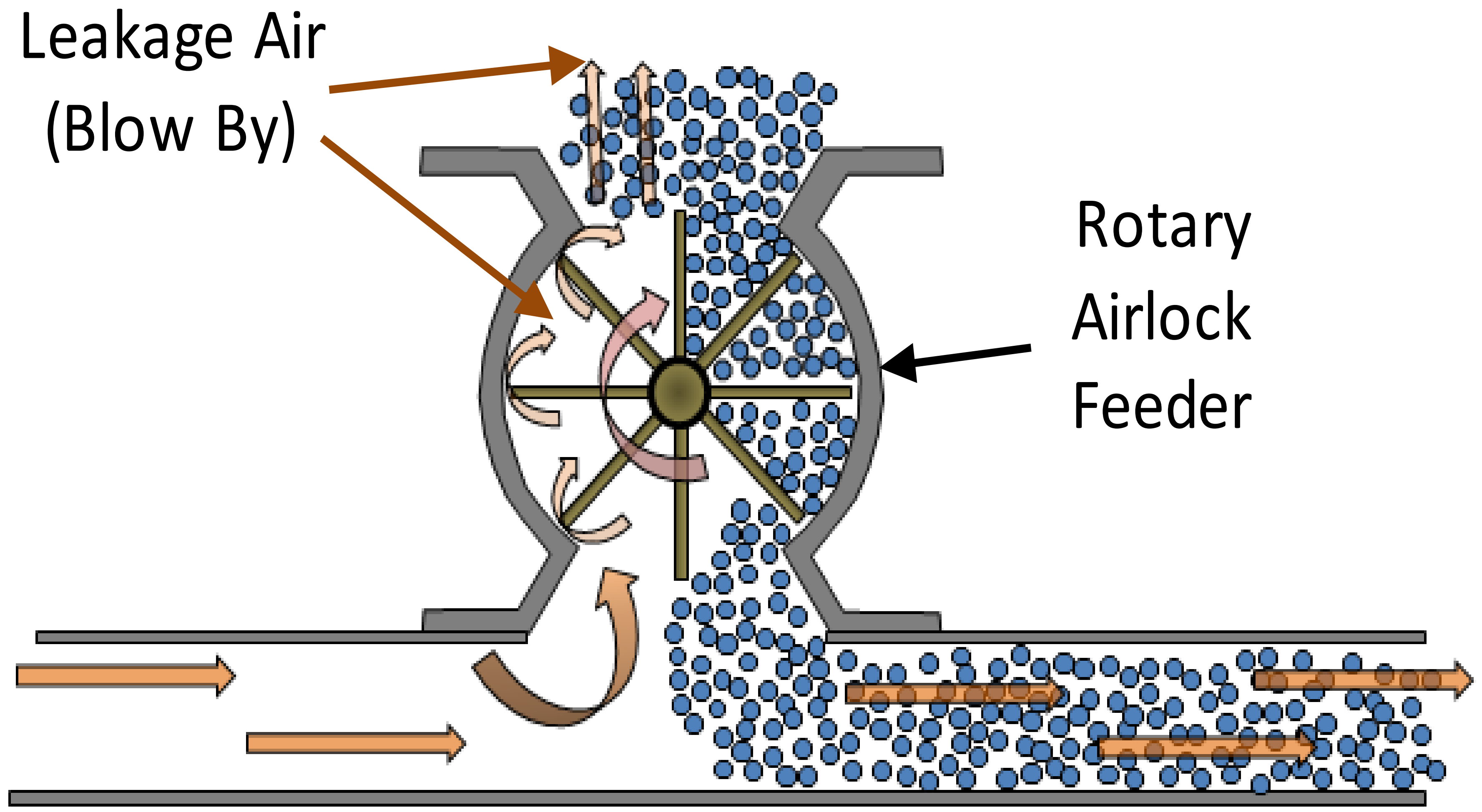


Rotary Feeders

- Closed end rotors
- Consider shallow pocket valves to avoid slug flow
- Rotary Air Locks are wear items!
  - Abrasive and/or erosive effects
  - Reduction in conveying air velocity
  - Deposits in conveying line
  - Increase/Spikes in conveying air pressure
- Potential flooding with Screw Feeders
  - Rotary at inlet plus maintenance gate

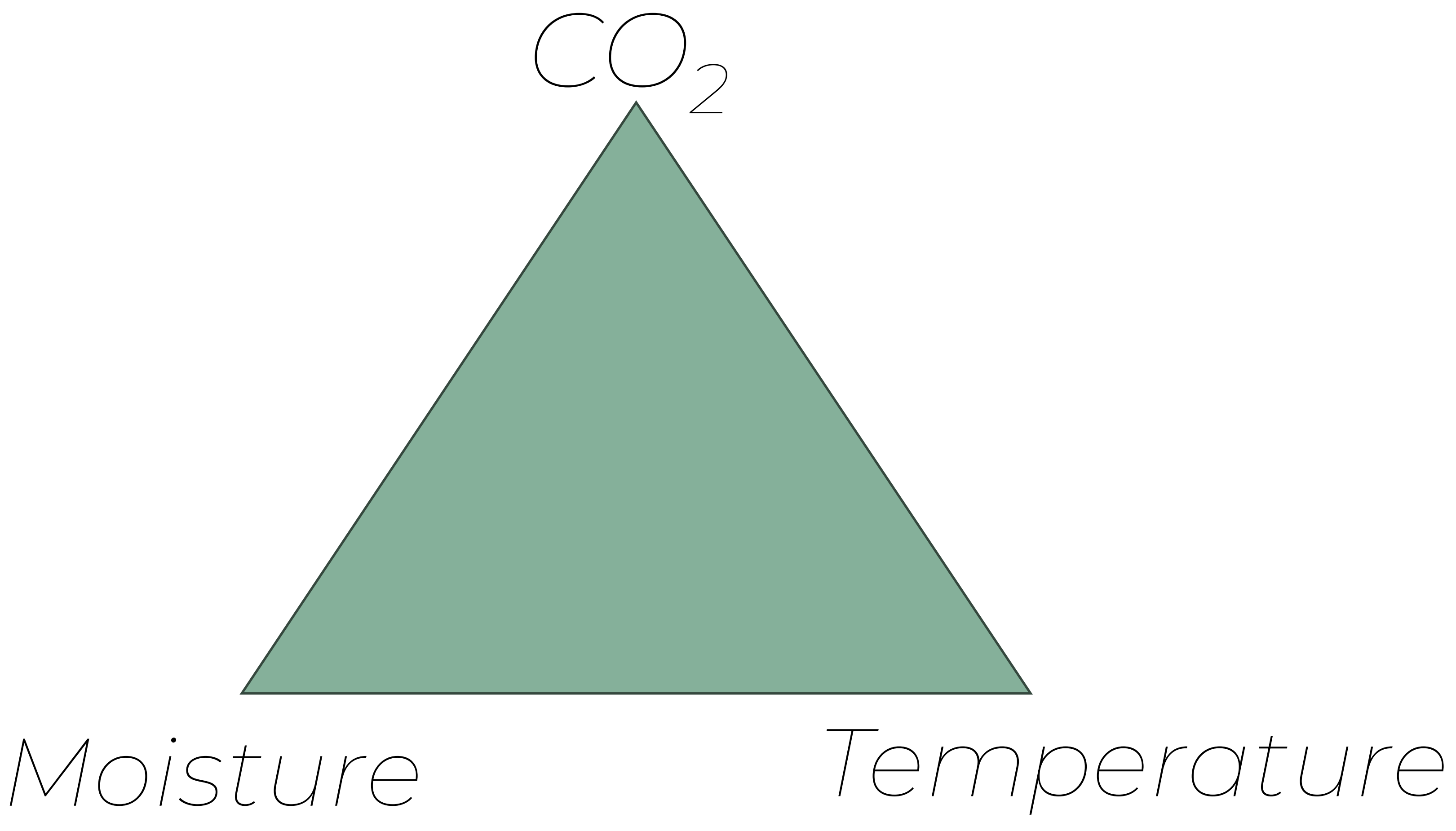


Closed end rotor



Conveying Issues – Deposit in Piping

- Hard Scale (calcium carbonate)
  - Short term formation – convey air effects
    - Quality
    - Quantity
  - Long term formation
    - Minimize physical ‘hot spots’
      - Unions and elbows
- Soft scale (hydrated lime powder)
  - Saltation velocity ~2,400 ft/min
  - Target 3,300-4,000 ft/min to keep hydrate suspended



Scale formation is observed generally in Dry Sorbent Injection systems and usually not an issue in Circulating Dry Scrubbers

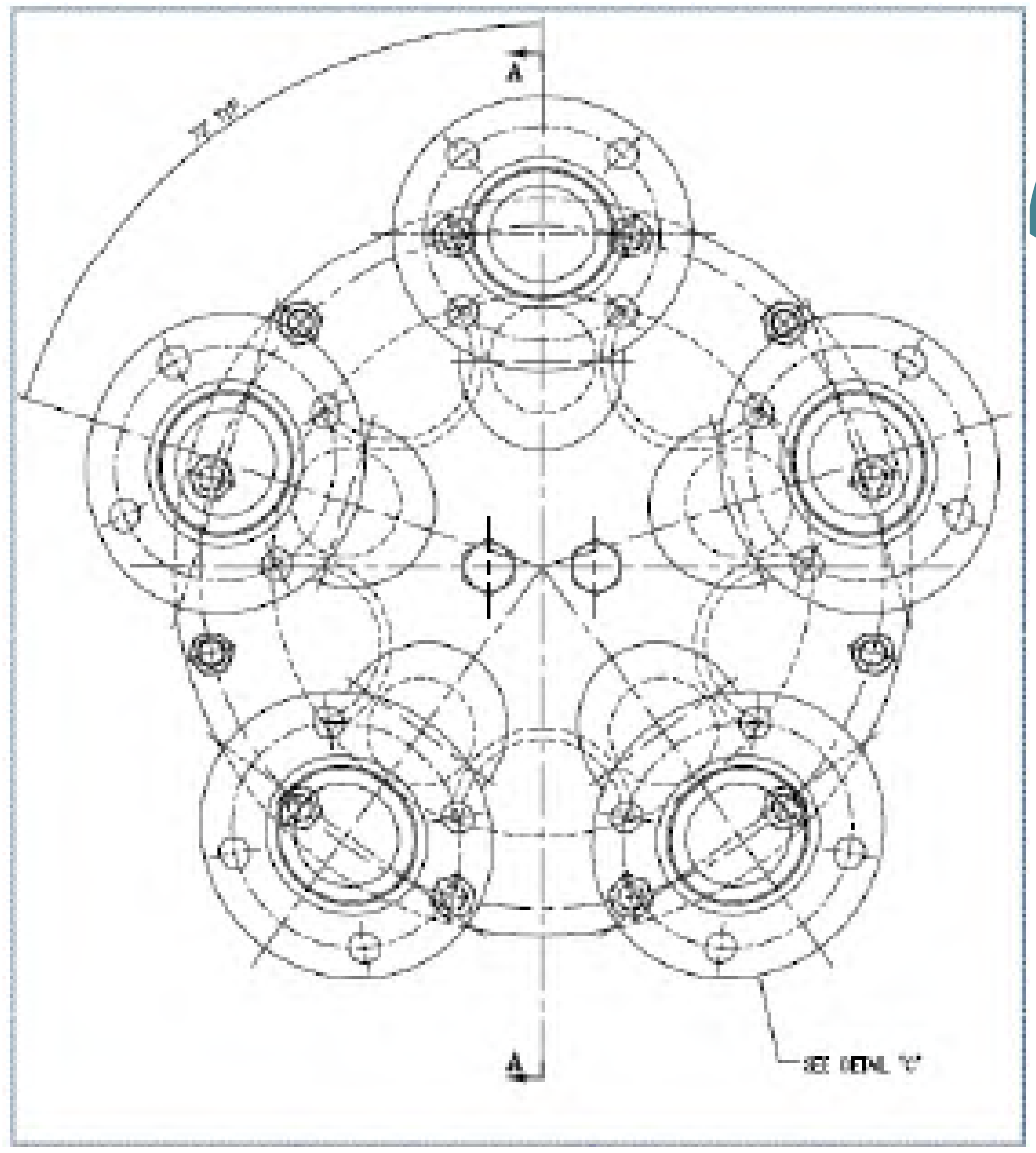
Conveying Conditions at Hydrate Feed Point

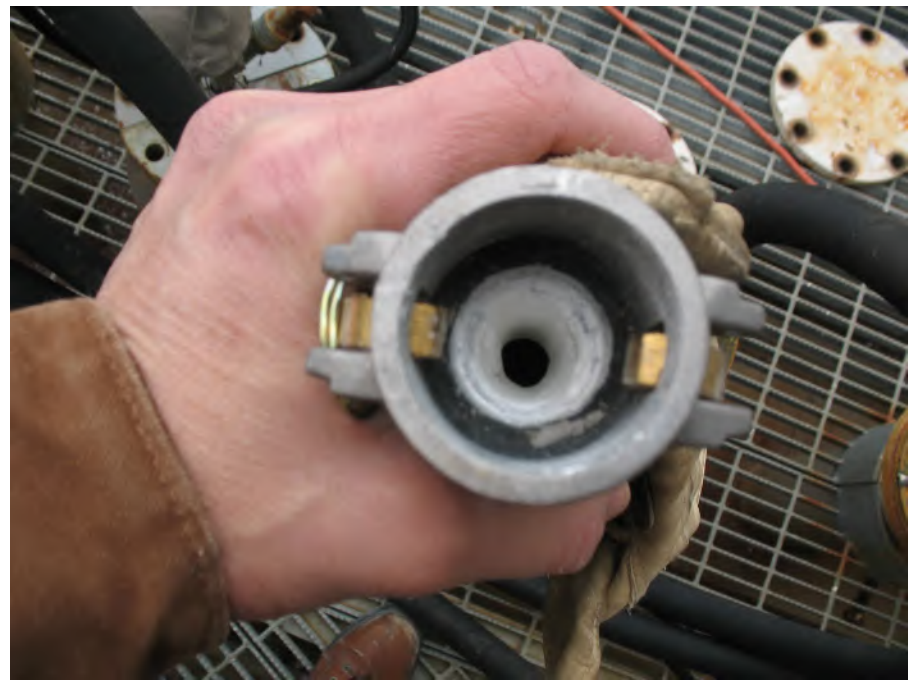
- Limit moisture and extreme temperature in conveying air
- Convey air quantity
  - Above the pickup velocity (2,400 ft/min)
  - Below an amount that leads to scale buildup
  - Example on system with 4” ID pipe and operating at 5 psi

Hydrate lb/hr	Blower SCFM	Pickup velocity	Hyd:Air	Comment
1500	300	2567 ft/min	1.03	Low P/u velocity
1500	400	3422 ft/min	0.77	Good operating conditions
400	400	3422 ft/min	0.21	Low Hyd:Air Prone to scale buildup unless convey air is conditioned
800	350	2994 ft/min	0.47	Better than above but borderline

Splitters

- Most successful DSI systems use a conical splitter
- Preference is upward split but descending splits can work
  - Horizontal is not recommended
  - Avoid elbows prior to a splitter
- Goal: equivalent flow to each leg
  - Equal lengths from splitter to lance
  - Resistive flow if equal lengths is not possible
- Consider troubleshooting and maintenance
  - Shut down a leg vs whole splitter
  - Avoid neckdowns in camlock fittings





Post-splitter air flow

- Stay above saltation velocity between splitter and lances
- If below saltation, dry powder plugs form
  - No injection at that lance until plug is cleared

6 lances, 3 options on diameter

Velocity, ft/min	Comment
< 2400	Expect dry powder plugs
2400 – 3300	suboptimal
>3300	Good
>5000	Excess air; potential scale formation

Velocities In Line (Std Wall Sch 40)

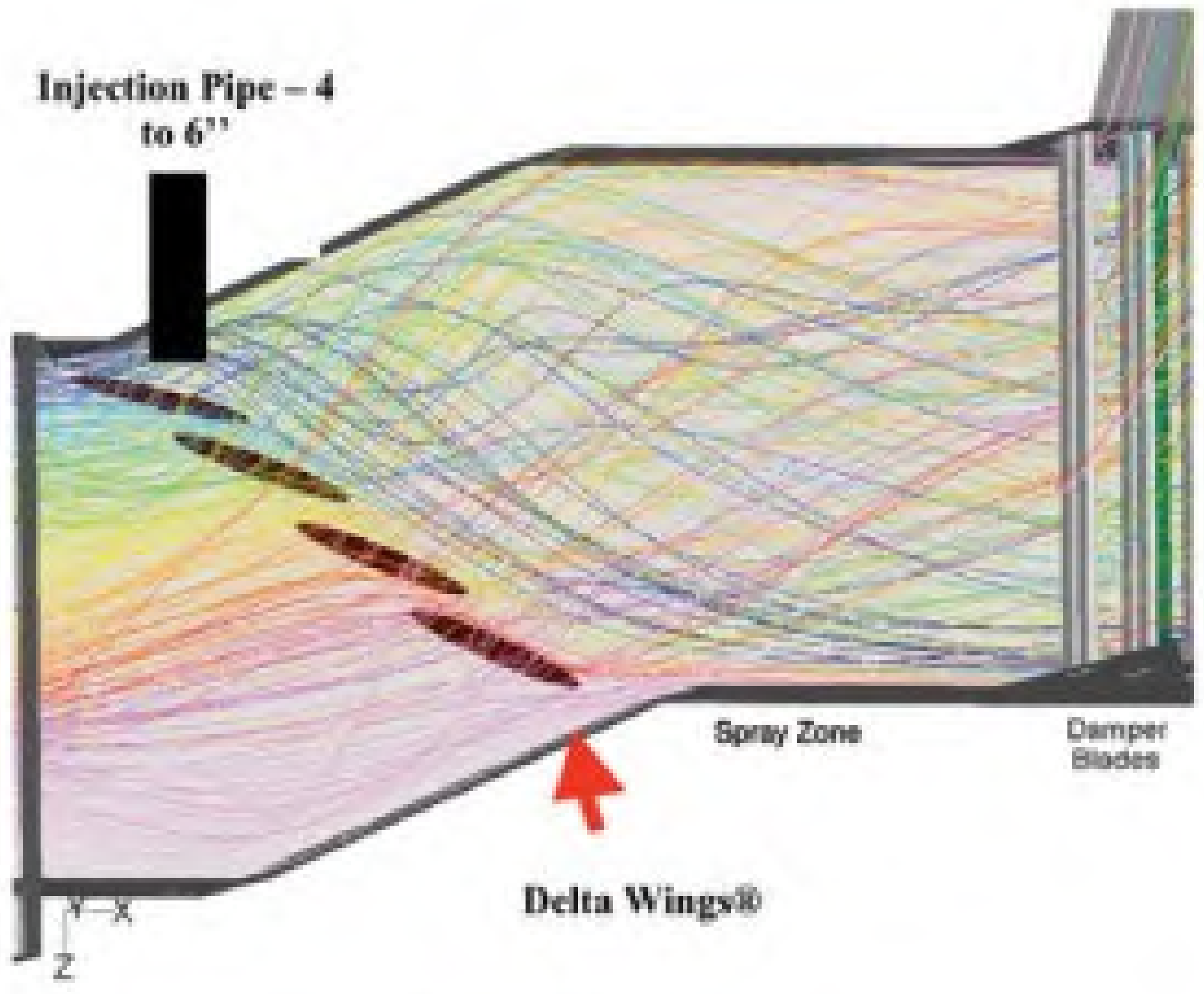
Pipe Size	**1.25**	**1.5**	**2.0**
Pipe Dia. (I.D.)	1.380	1.610	2.067
Sq Ft	**0.0104**	**0.0141**	**0.0233**
# of Lines	6	6	6
Total Sq Ft	**0.0623**	**0.0848**	**0.1397**
150	2,408	1,769	1,073
170	2,729	2,005	1,216
190	3,050	2,241	1,360
210	3,371	2,477	1,503
230	3,692	2,713	1,646
250	4,014	2,949	1,789
270	4,335	3,185	1,932
290	4,656	3,420	2,075
310	4,977	3,656	2,218
330	5,298	3,892	2,361
350	5,619	4,128	2,505
370	5,940	4,364	2,648
390	6,261	4,600	2,791
410	6,582	4,836	2,934
430	6,903	5,072	3,077
450	7,224	5,308	3,220
Blower Output SCFM	**Feet Per Minute Velocities**		

Injection Lances

- Early lances attempted to induce distribution
- Straight pipe less prone to Pluggage
  - No smaller than 1.25” diameter!
- Philosophies
  - “Just don’t plug”: pipe or shrouded lance
  - Improve coverage
    - Engineered fins on lance
    - Duct mounted engineered plates
    - Add more lances

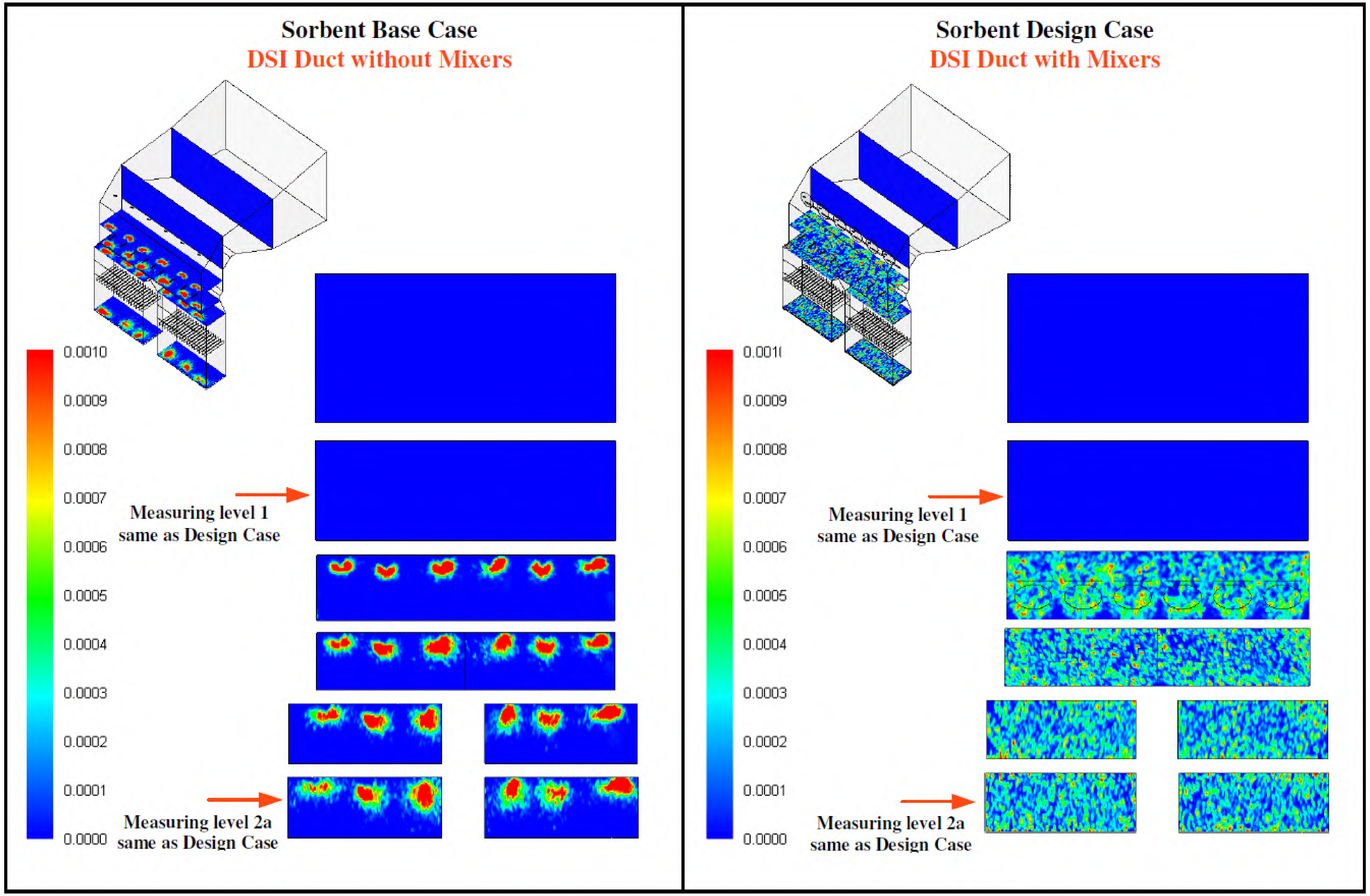
The good old days

UCC Cobra Lance



Babcock Power Delta Wings

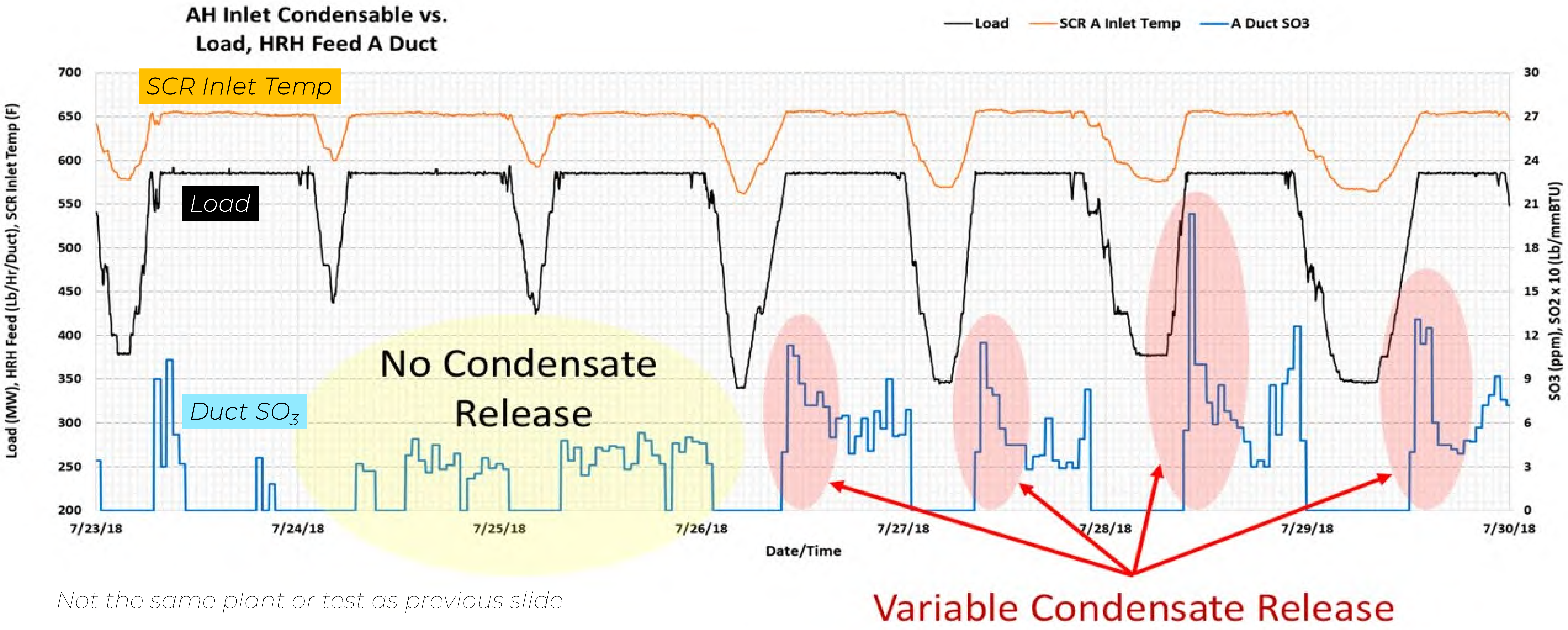
Straight Pipe vs. Induced Distribution



Provided by Babcock Power

Potential Pitfalls

Flue Gas Characteristics During Testing

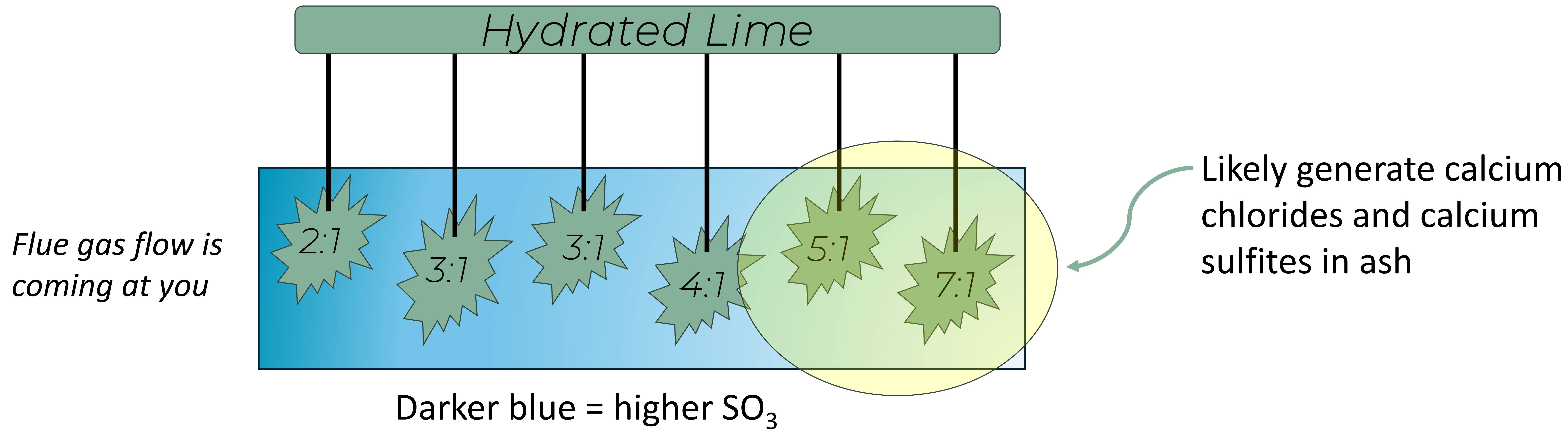


Not the same plant or test as previous slide

Load ramp can cause condensable acid burn-off

Make sure to account for this when stack testing

The Problem with Stratification



- Local NSR is different across the duct (Hydrate:SO_3)
- Locally high levels of hydrate will react with any acid present to form the calcium salt (HCl, SO_2, and CO_2)
- Stratification typically more problematic at post-APH injection locations

Other tips

- Begin stack test with a full silo
- Evaluate high hydrate feed rate early for a quick litmus test
- Seasoning – it can be a thing
- Leave blowers running even if you shut down hydrate feed

Thank you

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MLC
Booth 21