

REINHOLD ENVIRONMENTAL®



2025 Reinhold/PCUG Round Table Presentation

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on June 23-24, 2025

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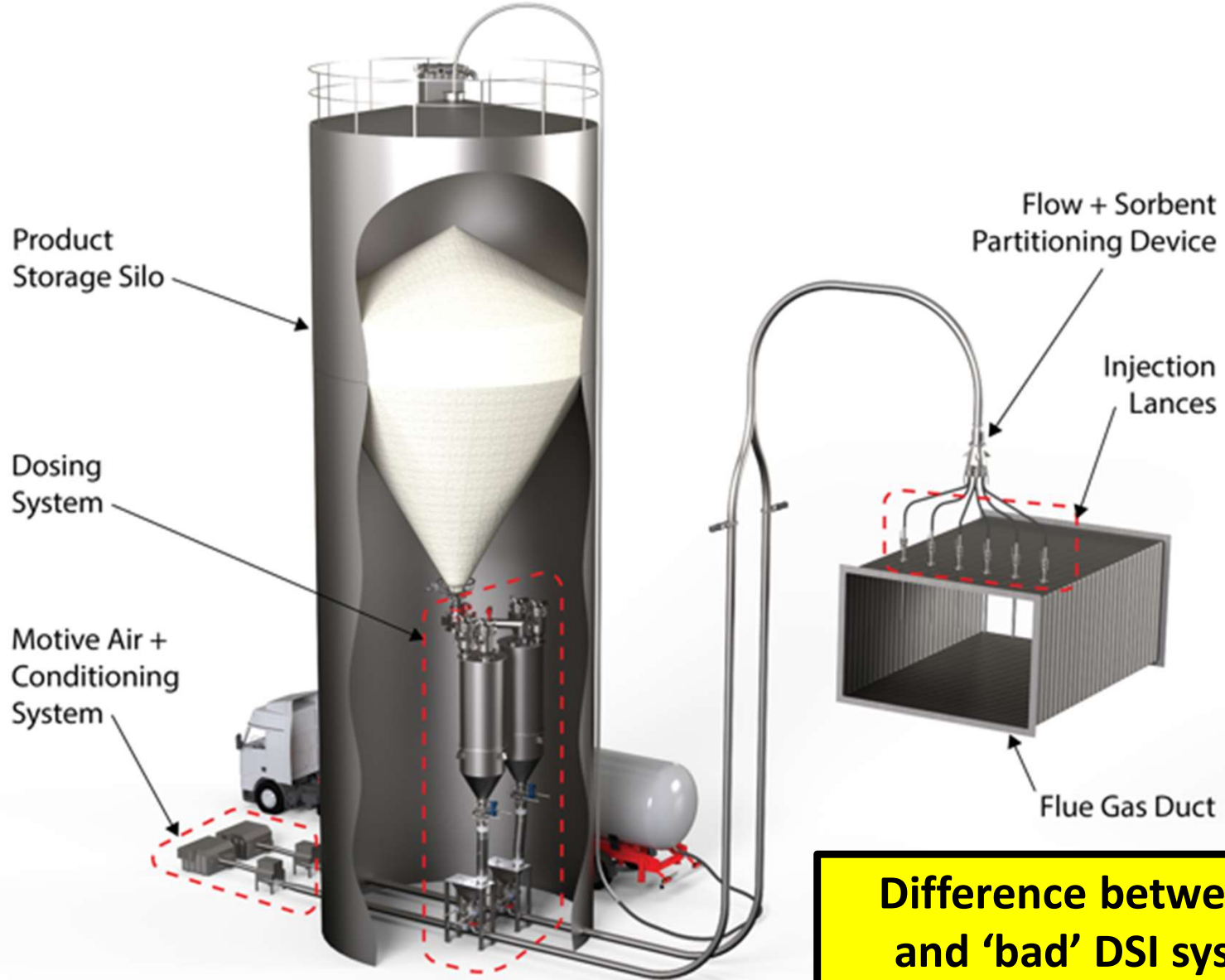
Dry Sorbent Injection: System Operations and Maintenance Best Practices

JUNE 23, 2025

Ian Saratovsky PhD
Gerald Hunt

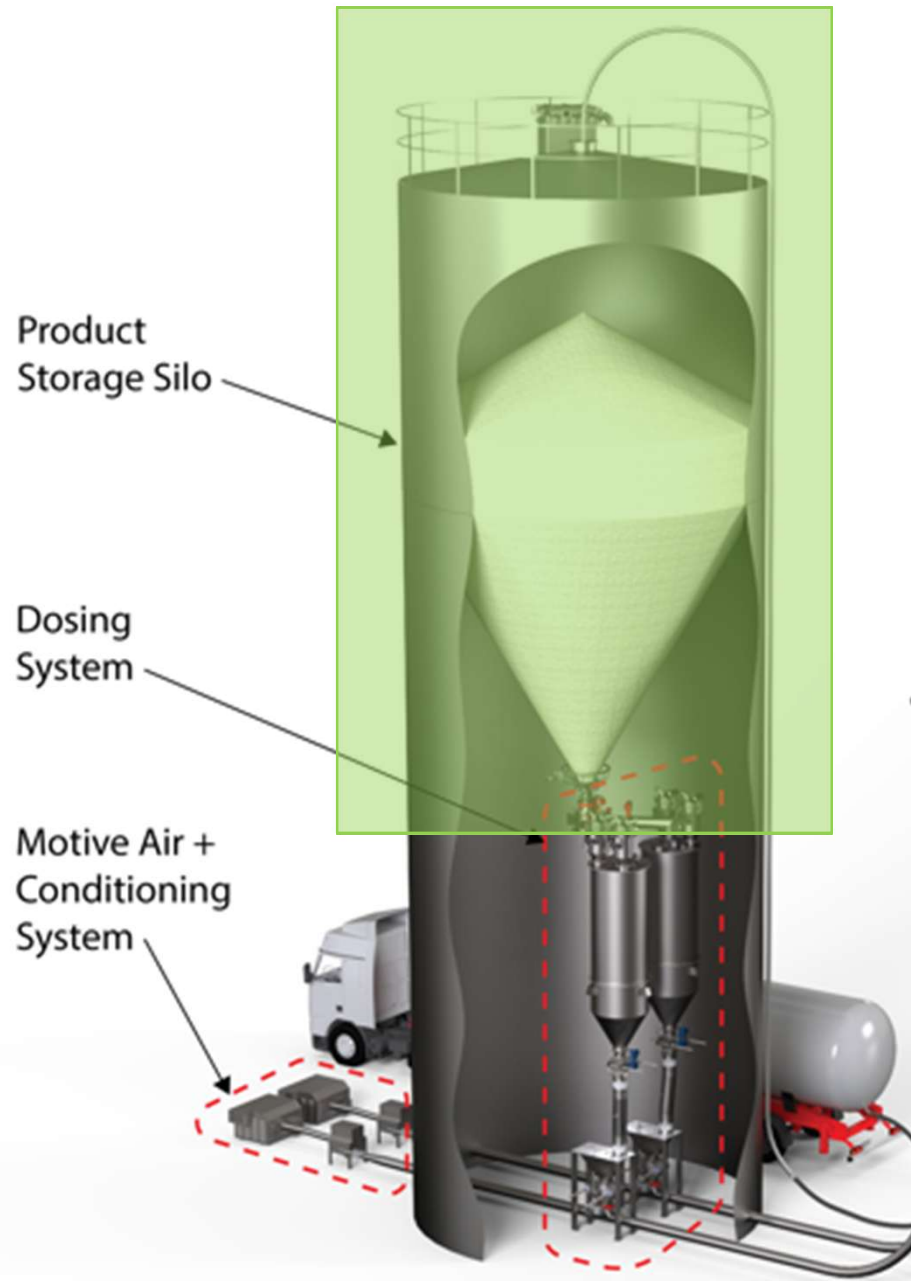


Fundamental DSI System Design



Difference between 'good' DSI system and 'bad' DSI system is in the details

Storage Silo

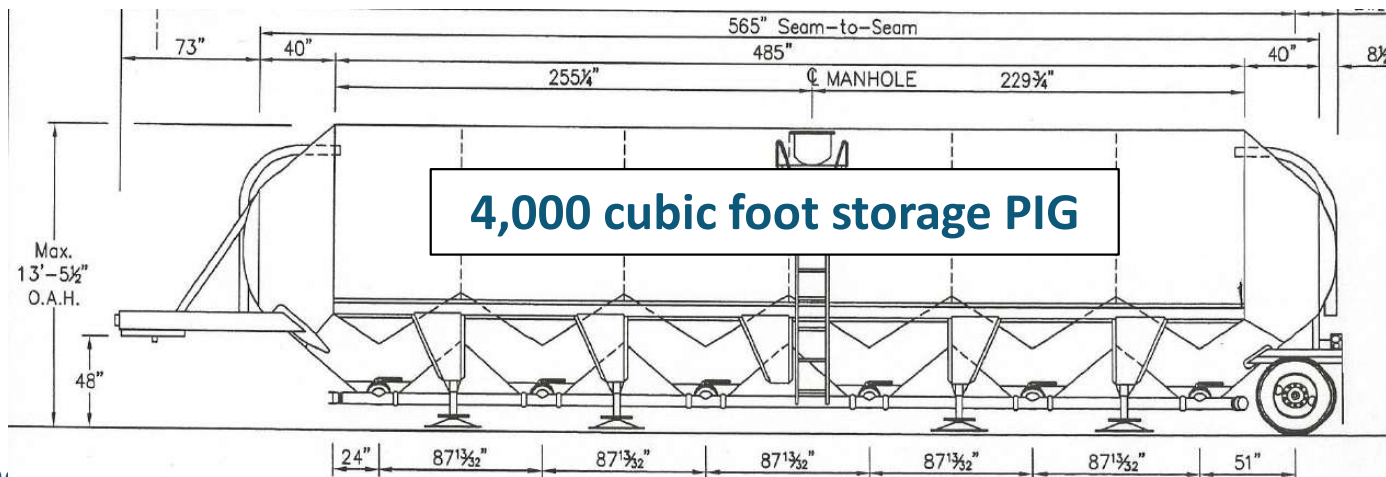
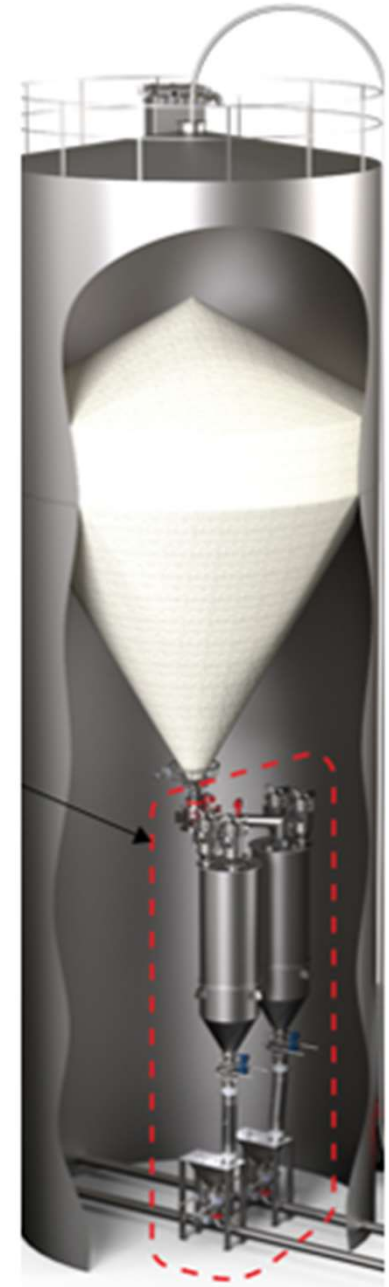


- Critical aspect of supply chain (running out of sorbent is NOT an option)
- Impacts end user day-to-day from ordering to tracking down trucks to unloading process
- Impacts end user activities and DSI system operations if 'tramp' material unloaded
- Impacts end user from environmental and clean-up perspective if dusting event occurs

Storage Silo

Insufficient Silo Storage Capacity

- **Challenges**: Running out of sorbent, not being able to fully unload a truck, over-filling silo causing dusting.
- *Initial Design Solution*
 - ✓ End user determines proper silo size
 - ✓ Consult with OEMs, sorbent suppliers, other end users
- *Retrofit Solution*
 - ✓ Rent a storage PIG with onboard blower
 - ✓ No capital required



Storage Silo

No Protection from 'Tramp' Material

- **Challenges**: Lack of screener box provides risk of unloading a problem into your system (unwanted material to pass tight clearances in feed train).
- *Retrofit Solution*
 - ✓ Multiple options with cam-lock connections to purchase for < \$500
 - ✓ See links below



<https://bulktankinc.com/product/pneumatic-conveying-filter-screen/>

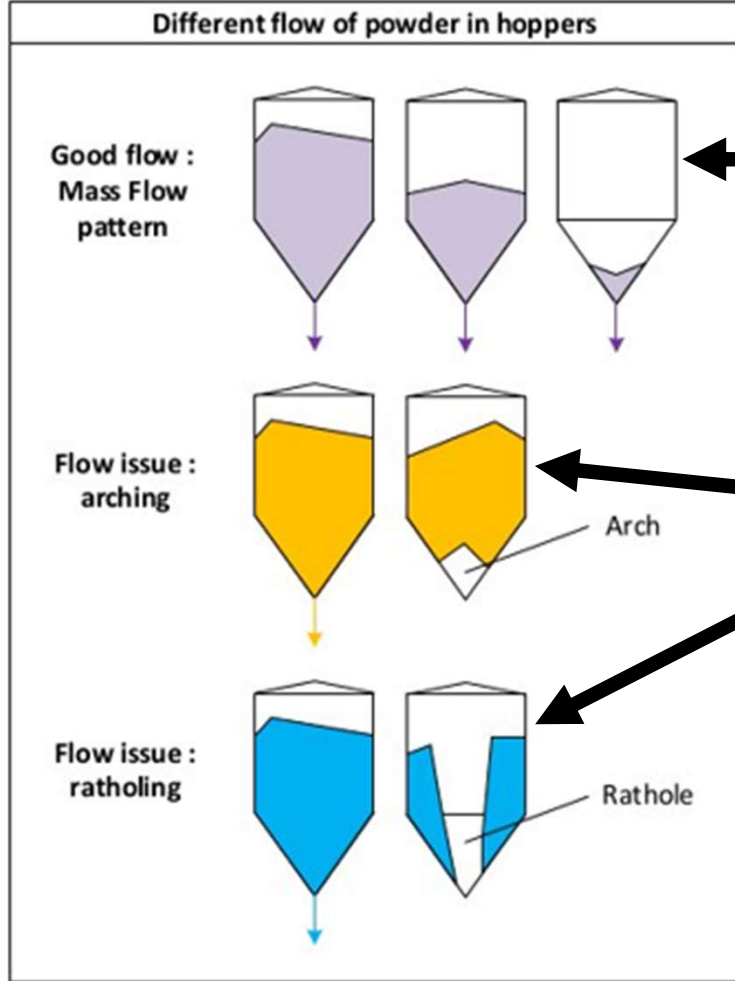
<https://www.olstaco.com/db1000-sfi/?srsltid=AfmBOopXlhzNvsWcPb3tcAqULo09UuaarBN65ldW1I7epB35WLwD7gRQ>

Storage Silo



Unreliable Silo Inventory Measurement

- Challenges:** Sorbent flow characteristics are variable and typically only a single means to directly measure silo inventory.



How often do you operate like this...

Or like this...or don't know?



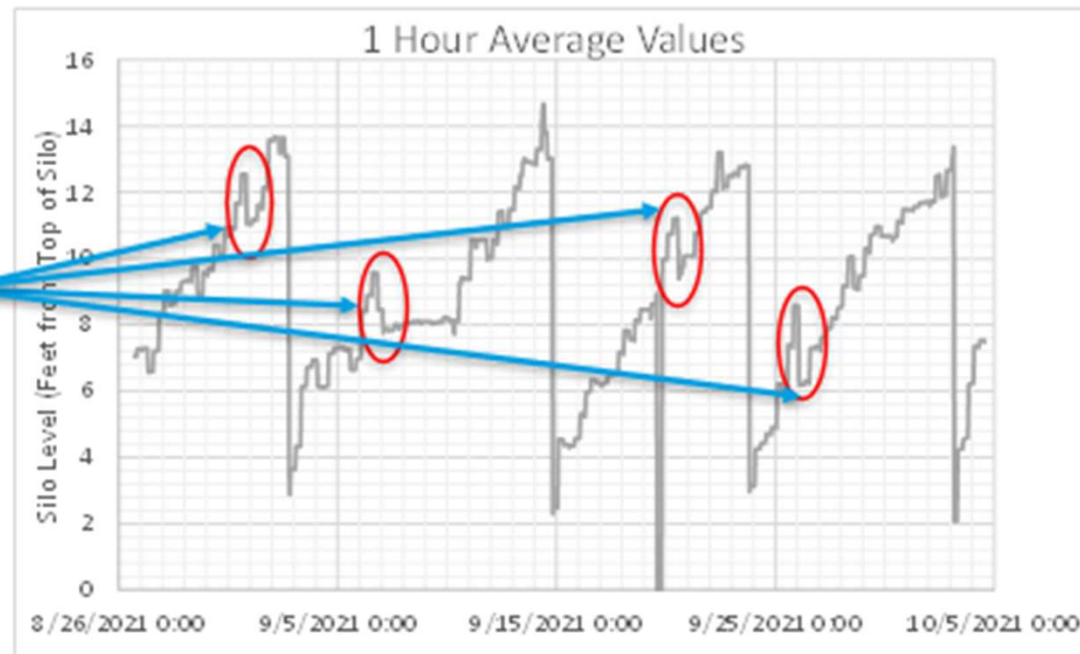
Storage Silo

Unreliable Silo Inventory Measurement

- *Initial Design Solution*
 - ✓ Incorporate silo load cells
 - ✓ Redundant level transmitters
- *Retrofit Solution*
 - ✓ Use Loss-in-Weight (LIW) data to create inventory calculator
 - ✓ Add level transmitter(s) aimed different location



How can end user rely on silo level % alone to track inventory?



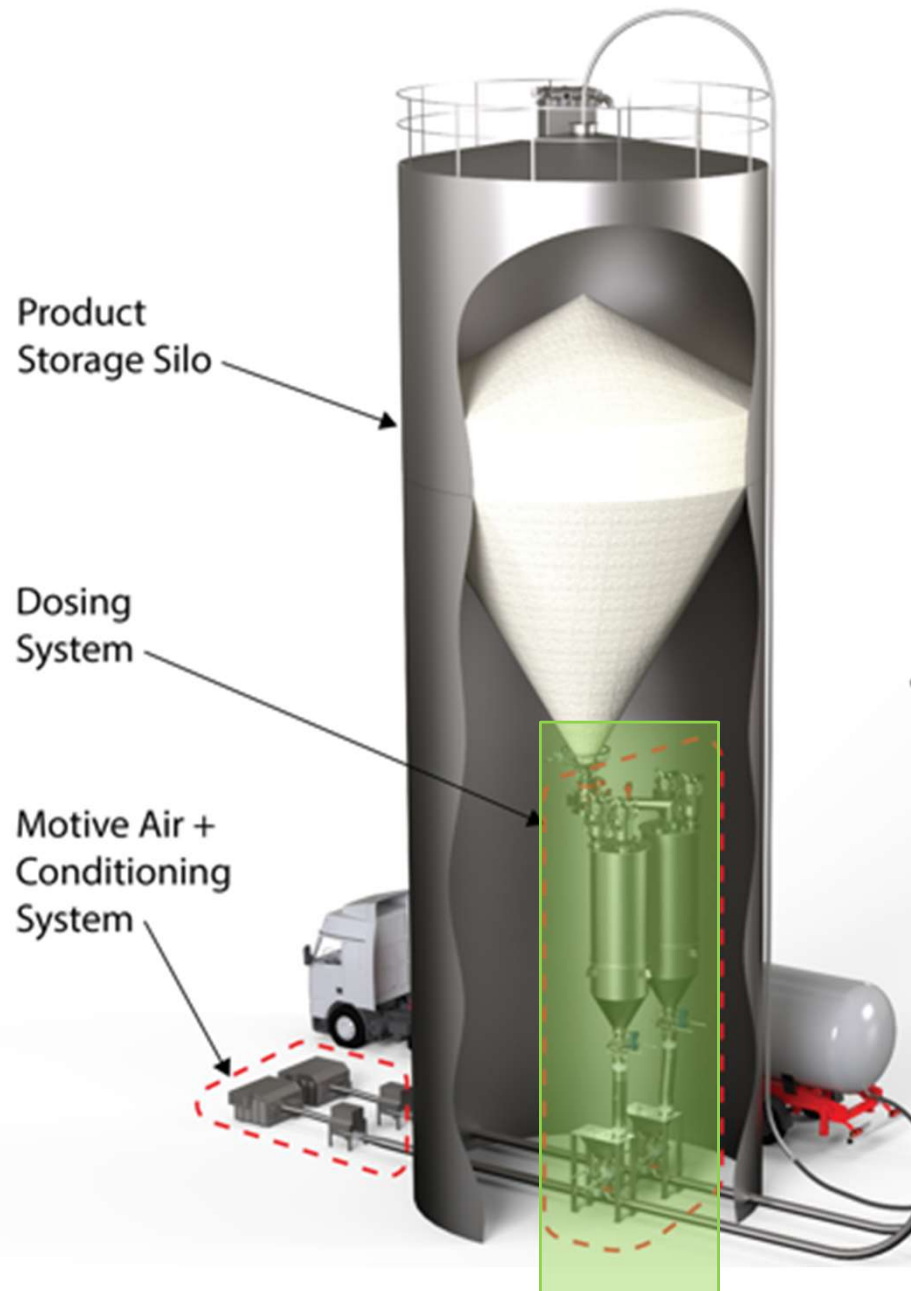
Storage Silo

Dusting Issues during Silo Filling

- **Challenges**: Sorbent dusting (due to over-filling silo, under-sized bin vent, malfunctioning high-level indicator) during unloading makes messes and may require environmental reporting.
- *Initial Design Solution*
 - ✓ Ample silo sizing
 - ✓ Appropriate bin vent sizing (sorbent suppliers can provide truck blower flow rates)
 - ✓ Include audible high-level alarm
- *Retrofit Solution*
 - ✓ Routine preventative maintenance on high-level indicators to verify working



Feed Train

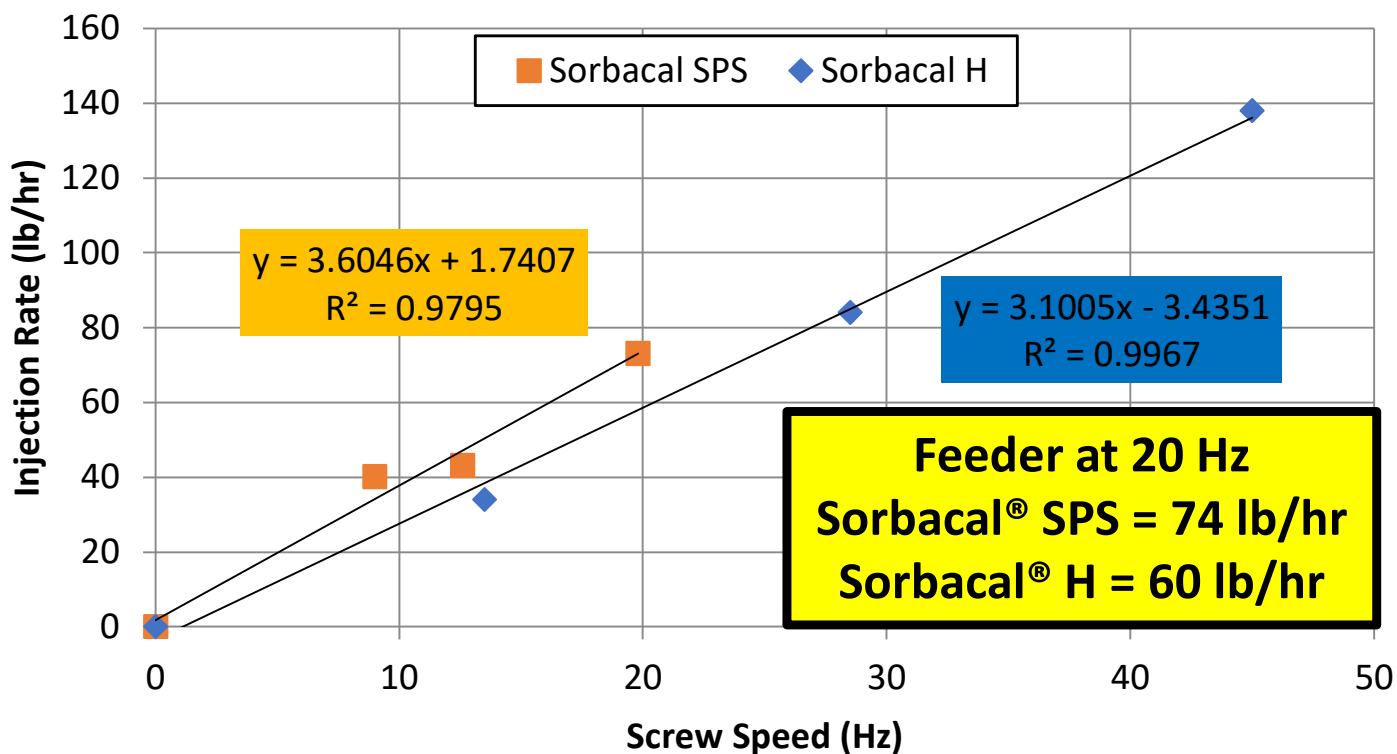


- Poor/no sorbent feed can result in emission violations / failed stack tests
- Issues associated with rotary airlock (RAL) can cause sorbent feed issues requiring in end user maintenance response
- Tracking and assessing sorbent feed characteristics can help identify issues requiring end user attention

Feed Train

LIW vs. Volumetric Design

- Challenges:** Sorbent flow characteristics are variable and even different hydrated lime sorbents will flow different despite being chemically the same...cannot consistently quantify dosage rates if not directly measured.



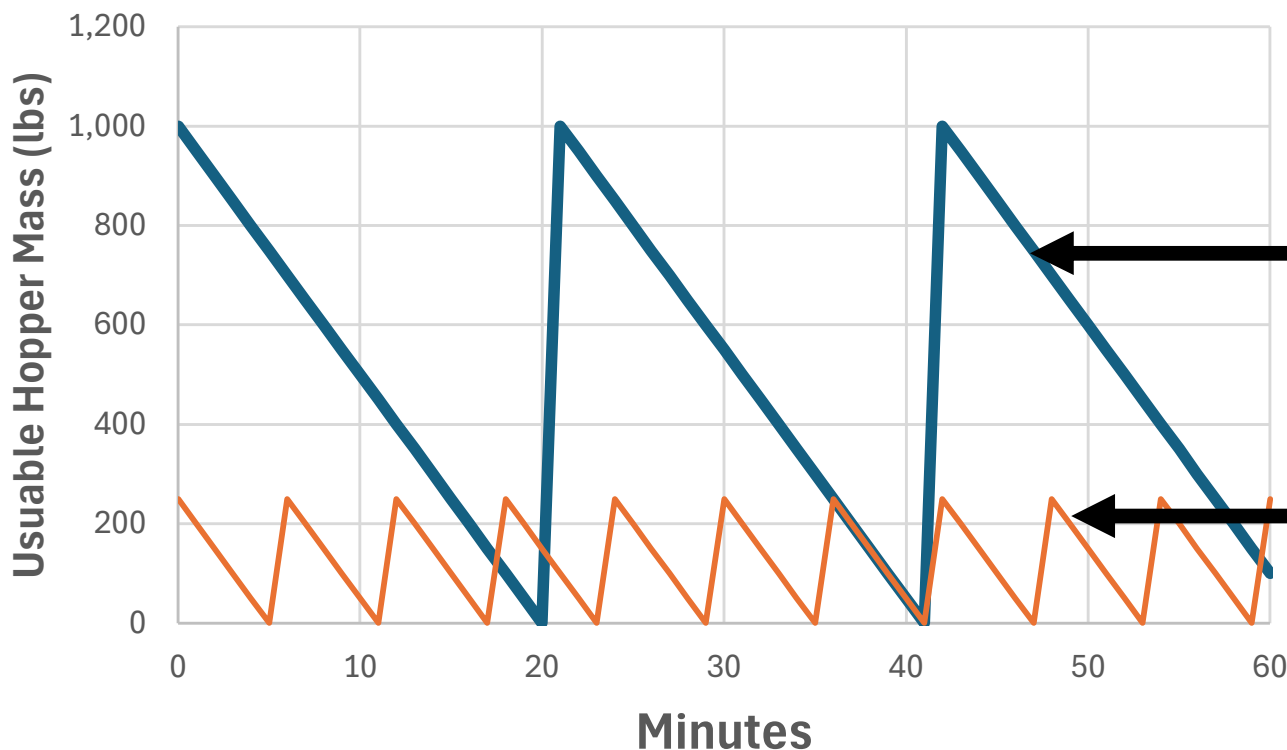
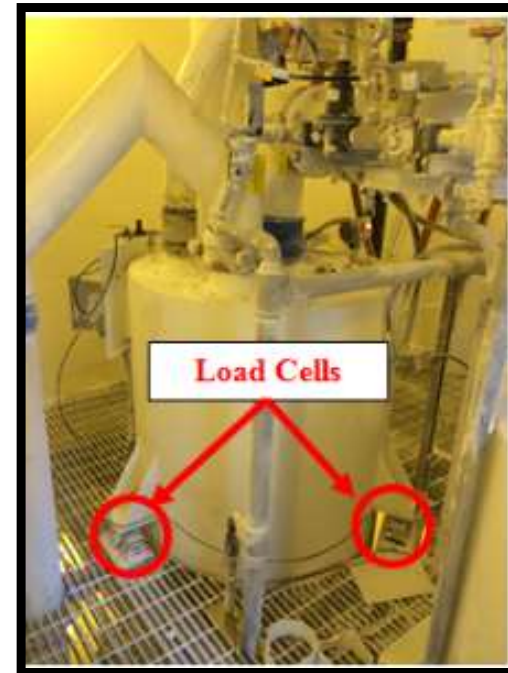
DSI feed rate was 20+% greater with Sorbocal[®] SPS than Sorbocal[®] H

D₅₀ Particle Size
 Sorbocal[®] SPS = 12 μm
 Sorbocal[®] H = 5 μm

Feed Train

LIW vs. Volumetric Design

- *Initial Design Solution*
 - ✓ Include LIW measurements via load cells
 - ✓ Ample weigh hopper sizing
- *Retrofit Solution*
 - ✓ “Bucket” test
 - ✓ Load cells or scale (if ample clearance available)



**1,000 lb Usable Hopper =
Two (2) fill cycles at 3,000
lb/hr**

**250 lb Usable Hopper = Ten
(10) fill cycles at 3,000 lb/hr**

Feed Train

Rotary Airlocks (RAL) = Wear Part

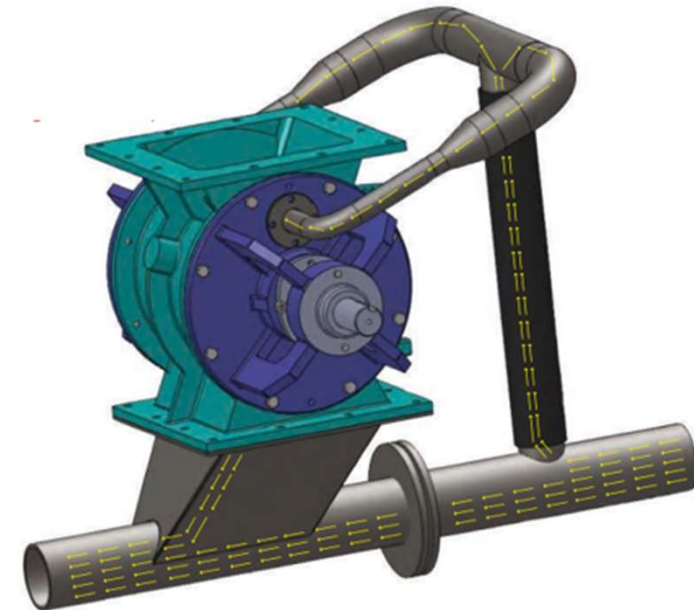
- **Challenges**: RALs are critical part of DSI feed train used to control sorbent feed as well as provide 'barrier' from conveying air.
- *Initial Design Solution*
 - ✓ RAL materials of construction (MOC)
 - ✓ RAL design (non-commodity designs)
- *Retrofit Solution*
 - ✓ Rebuild RAL
 - ✓ Buy new RAL

Internal Component Coatings = Heavy Chrome, Diamond Chrome, Ceramic, Chrome Carbide

Design = Shaft Packing, Clean Air Injection



<https://carolinaconveying.com/standard-duty-rotary-airlock-valves/>



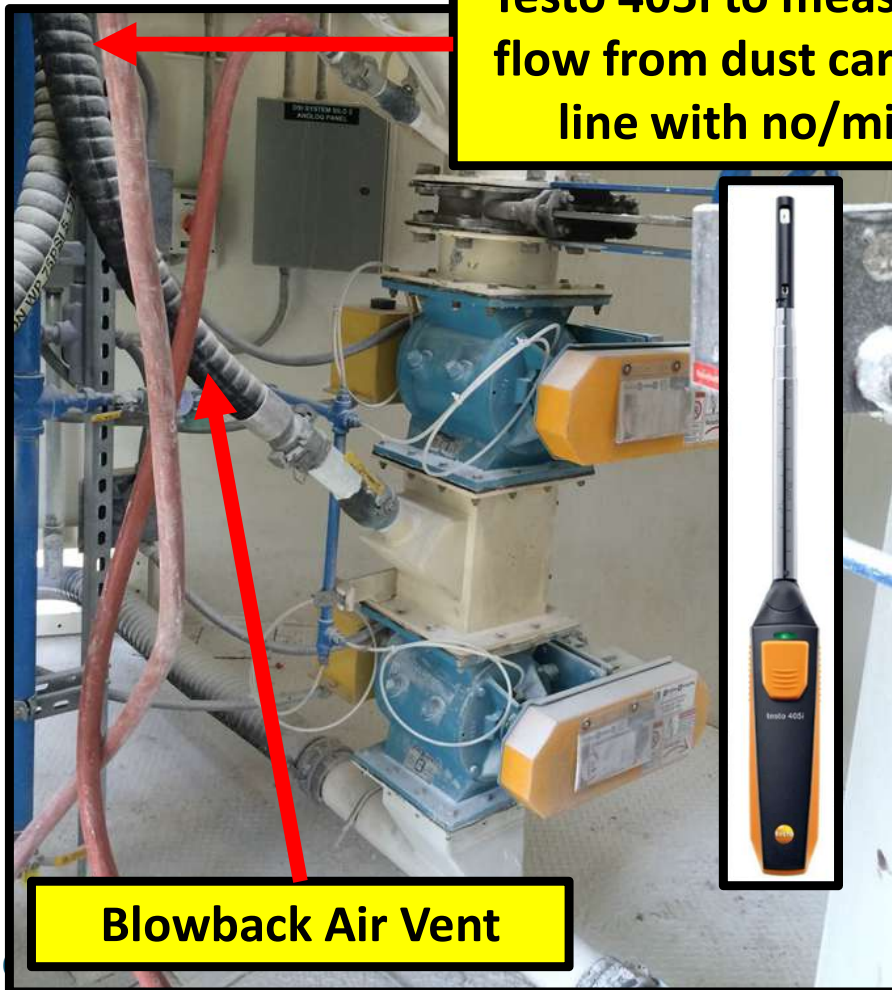
meyerindustrial.com/products/w-e-a-r-valve/

Feed Train

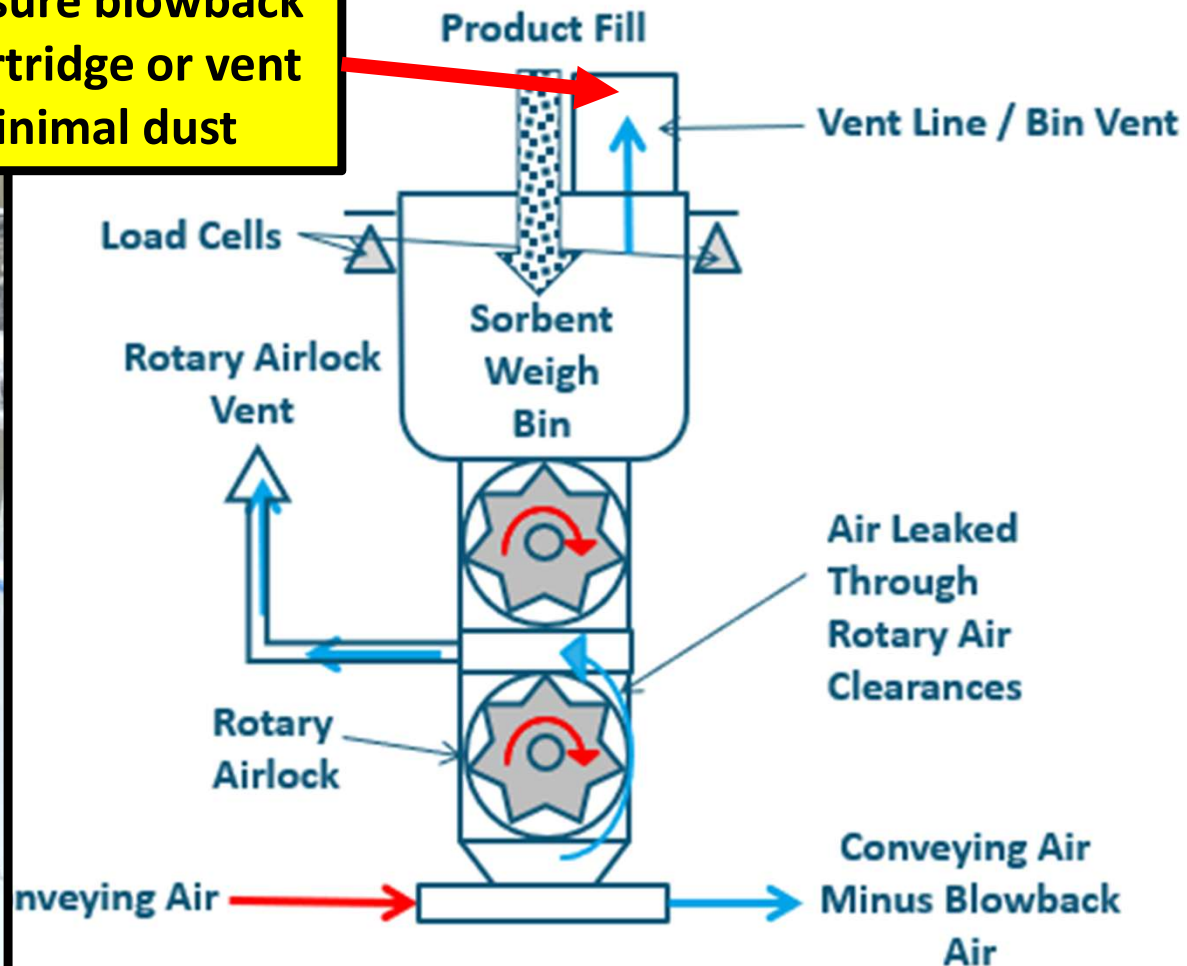
Conveying Air Blowback and Venting

- Challenges:** Conveying air will take path of least resistance; therefore, blower discharge pressure, RAL condition and venting design can impact feed train operation and maintenance activities.

Testo 405i to measure blowback flow from dust cartridge or vent line with no/minimal dust



Blowback Air Vent

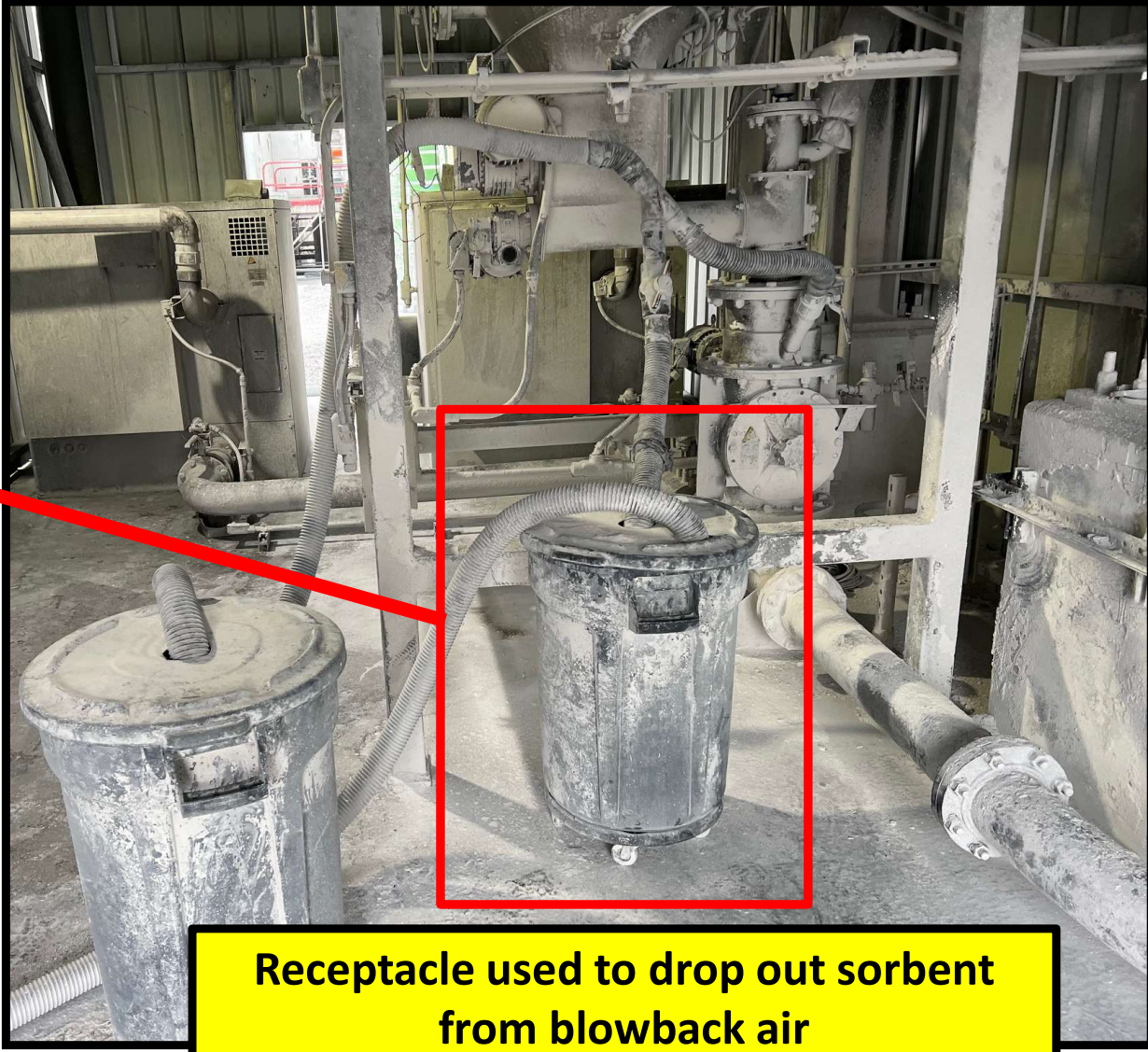


Feed Train



Conveying Air Blowback and Venting

Blowback Observations due to RAL Condition/Design and Conveying Air Operation (Single Speed Blower)



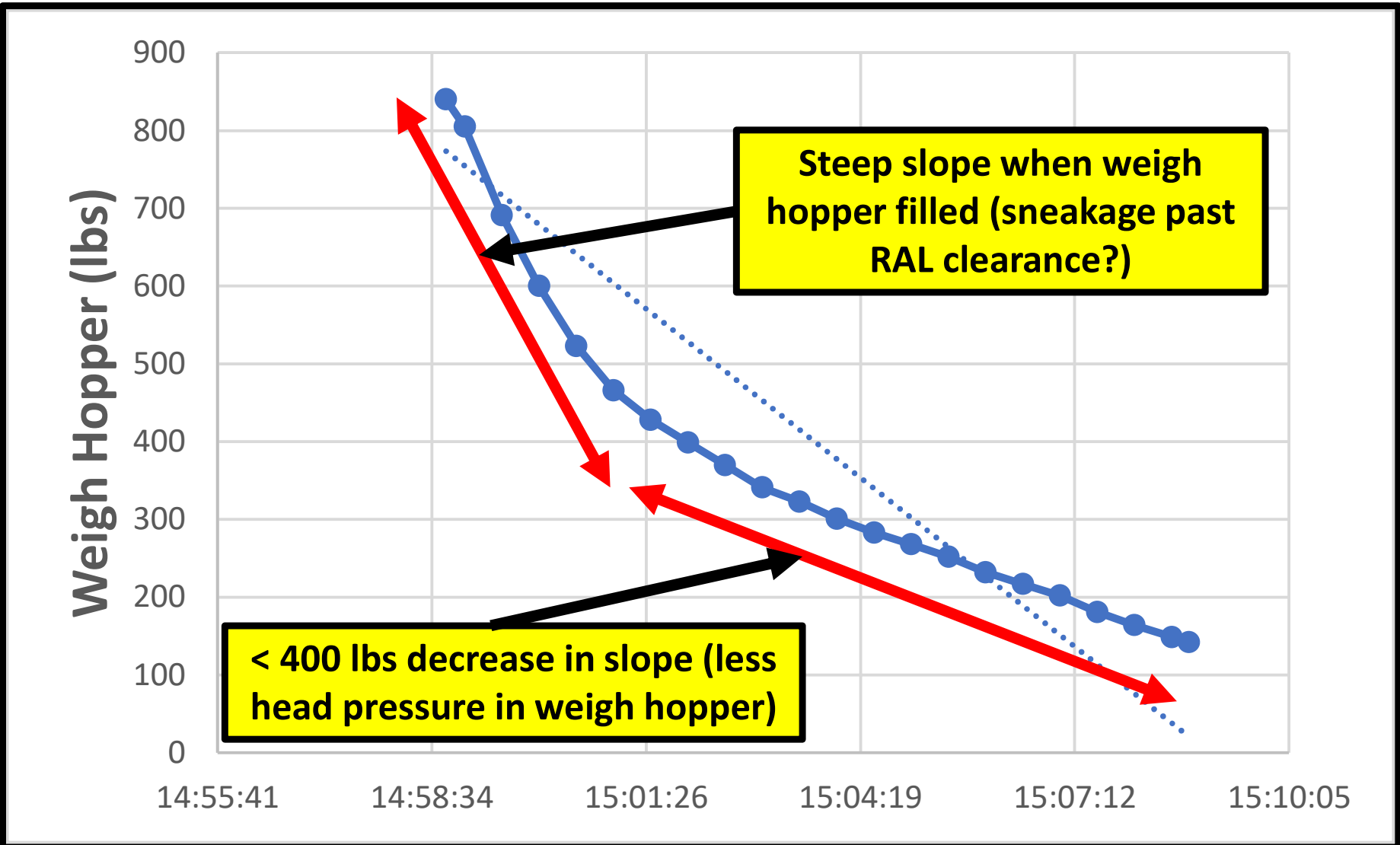
Receptacle used to drop out sorbent from blowback air

Feed Train



Conveying Air Blowback and Venting

LIW Data Used to Identify Potential Issue with RAL and/or Conveying Air System (Curve from Injection System on Previous Slide)

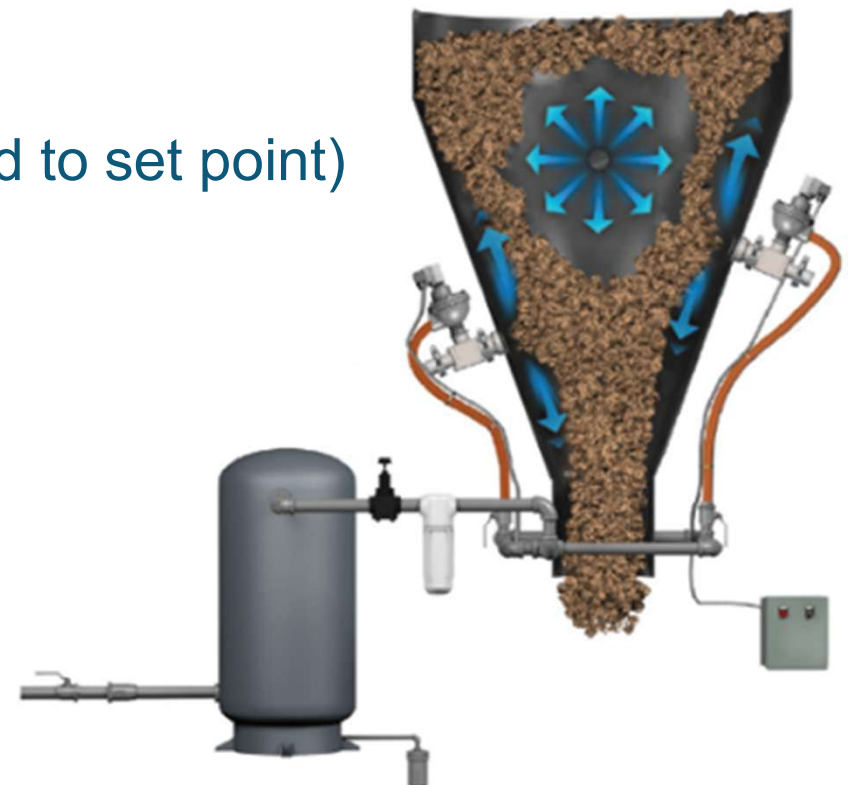


Feed Train



Weigh Hopper Fluidization and Sorbent Flow

- **Challenges:** Poor weigh hopper and/or fluidization design may impact DSI system feed and reduce system reliability.
- *Initial Design and/or Retrofit Solution*
 - ✓ Dry fluidizing air system
 - ✓ Fluidizer design (air sweep or similar) to address both bridging and rat-holing
 - ✓ Include LIW design to identify issue
 - ✓ DSI system feed control (modulate feed to set point)

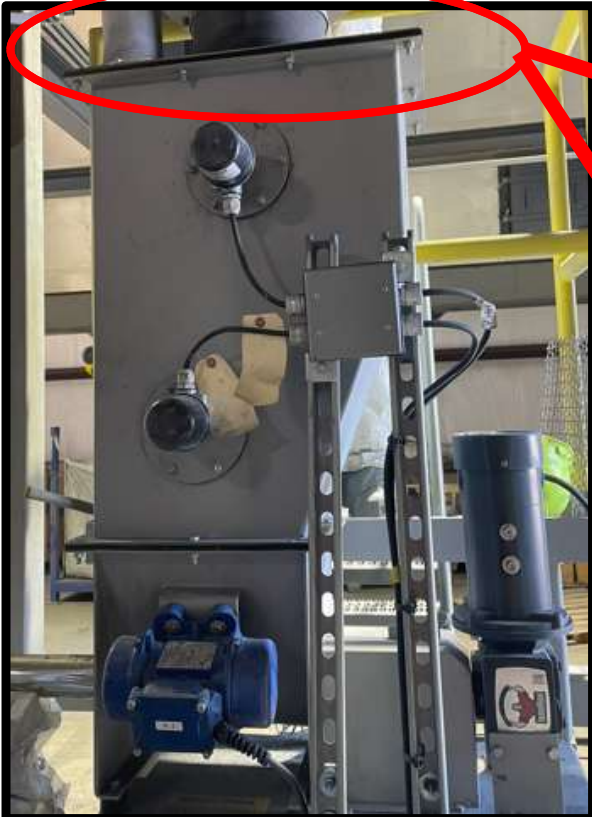


Feed Train



Weigh Hopper Fluidization and Sorbent Flow

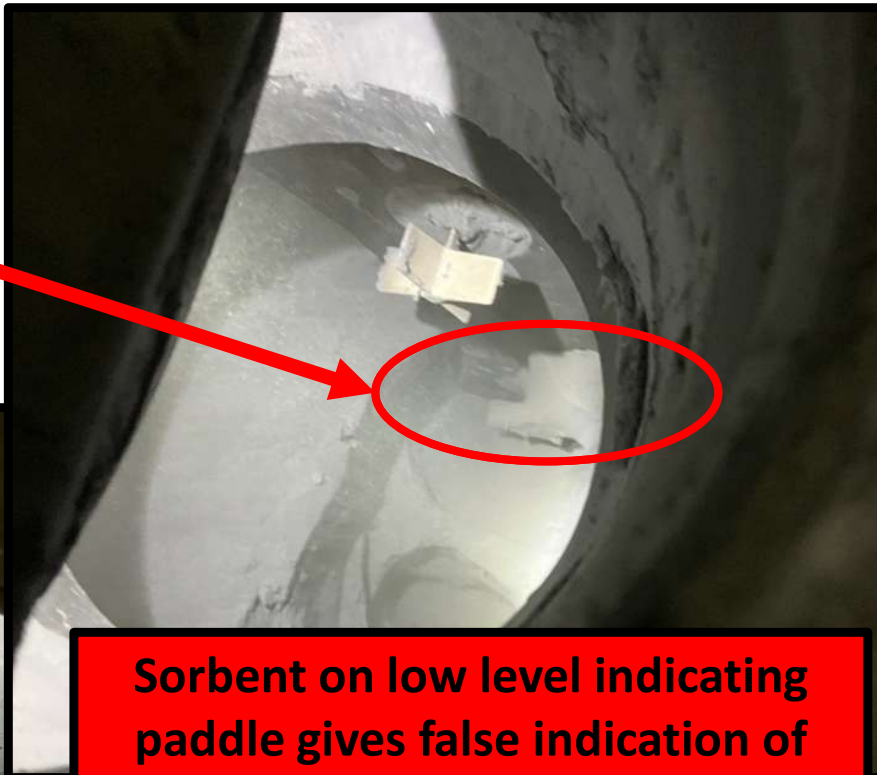
LIW Design would Identify this Issue OR Operating Fill Cycle on Mass Based Set Point Instead of Level Paddles (if LIW Design)



Hopper experiencing flow issues (Volumetric Design, No Fluidizing Air)



System operates consistently when level indicating paddles clean



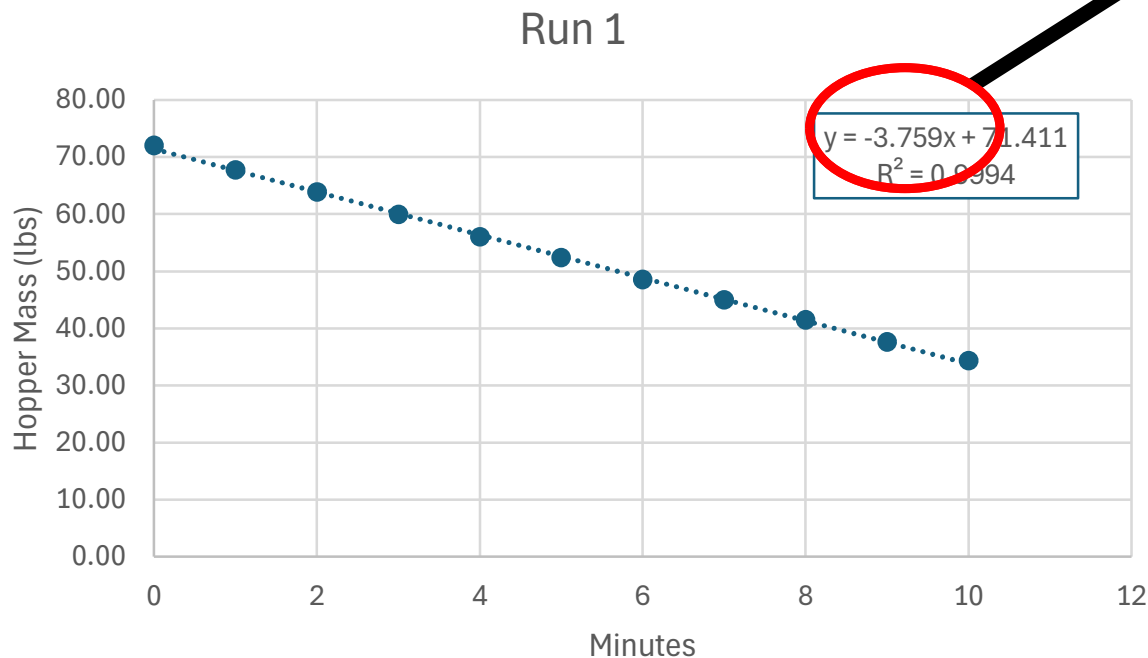
Sorbent on low level indicating paddle gives false indication of inventory so hopper does NOT fill

Feed Train

Manually Verifying Sorbent Feed Rate vs. Algorithm

- **Challenges:** Not performing a spot check on the LIW data may result in failing to identify operational issues with DSI system.
- *Initial Design and/or Retrofit Solution*
 - ✓ Means to perform “bucket test”
 - ✓ Time stamped weigh hopper mass
 - ✓ Compare to set point and OEM feed rate algorithm

Slope (Absolute Value)	lb/min	3.759
DSI Dosage Rate	lb/hr	226



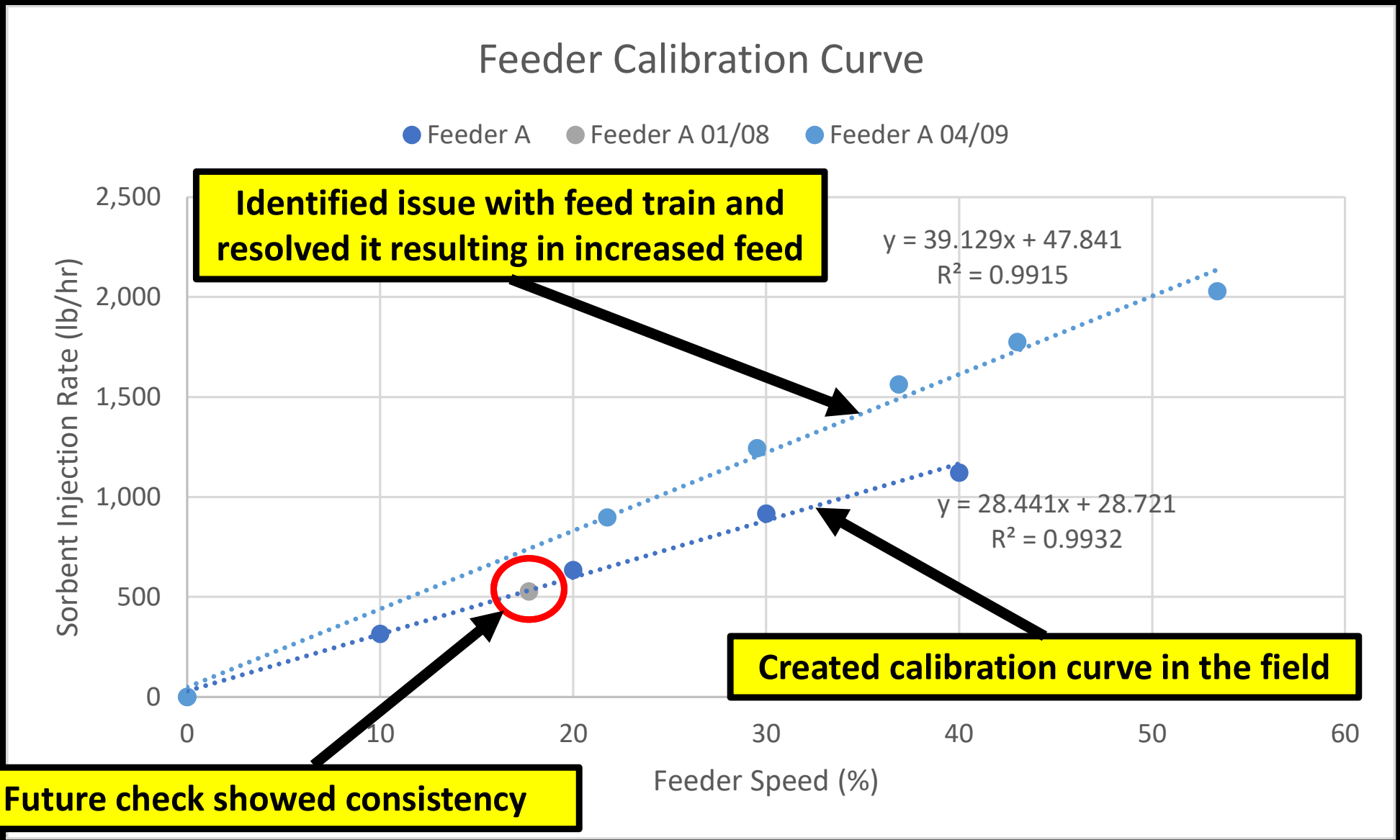
Mins	lbs	Delta	Spot (lb/hr)
0	72.00	-	-
1	67.69	4.31	258.6
2	63.86	3.83	229.8
3	59.94	3.92	235.2
4	56.05	3.89	233.4
5	52.36	3.69	221.4
6	48.57	3.79	227.4
7	44.95	3.62	217.2
8	41.45	3.50	210
9	37.59	3.86	231.6
10	34.32	3.27	196.2

Feed Train

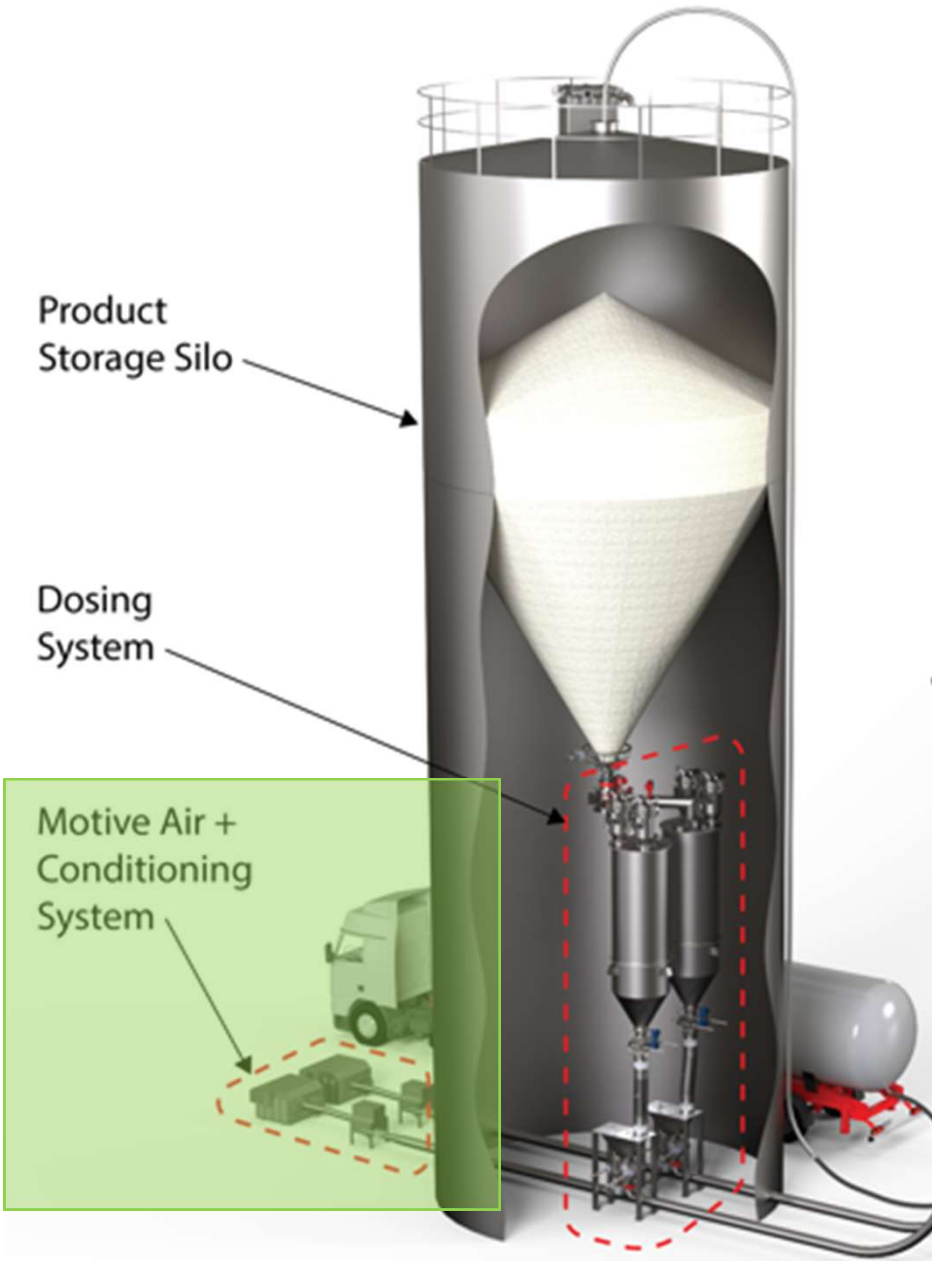


Manually Verifying Sorbent Feed Rate vs. Algorithm

Lack of LIW Data Increases Labor to Duplicate this Data



Conveying Air System



- **Pneumatic conveying of hydrated lime is a chemical process**
- Hydrated lime reacts with CO_2 to produce “hard” scale in conveying lines and conveying air RH directly impacts rate of carbonation
- Conveying air system design / operation can significantly impact DSI system reliability and frequency/duration of end user maintenance activities
- Can impact feed train operation and RAL wear

Conveying Air System

Single Speed Blower vs. Blowers with VFDs

- **Challenges:** Single speed blower must be oversized blower and lacks capability for convenient adjustments.
- *Initial Design Solution*
 - ✓ Design blower(s) to have VFD
- *Retrofit Solution*
 - ✓ Re-sheave blower motor
 - ✓ Testo 405i to directly measure velocity

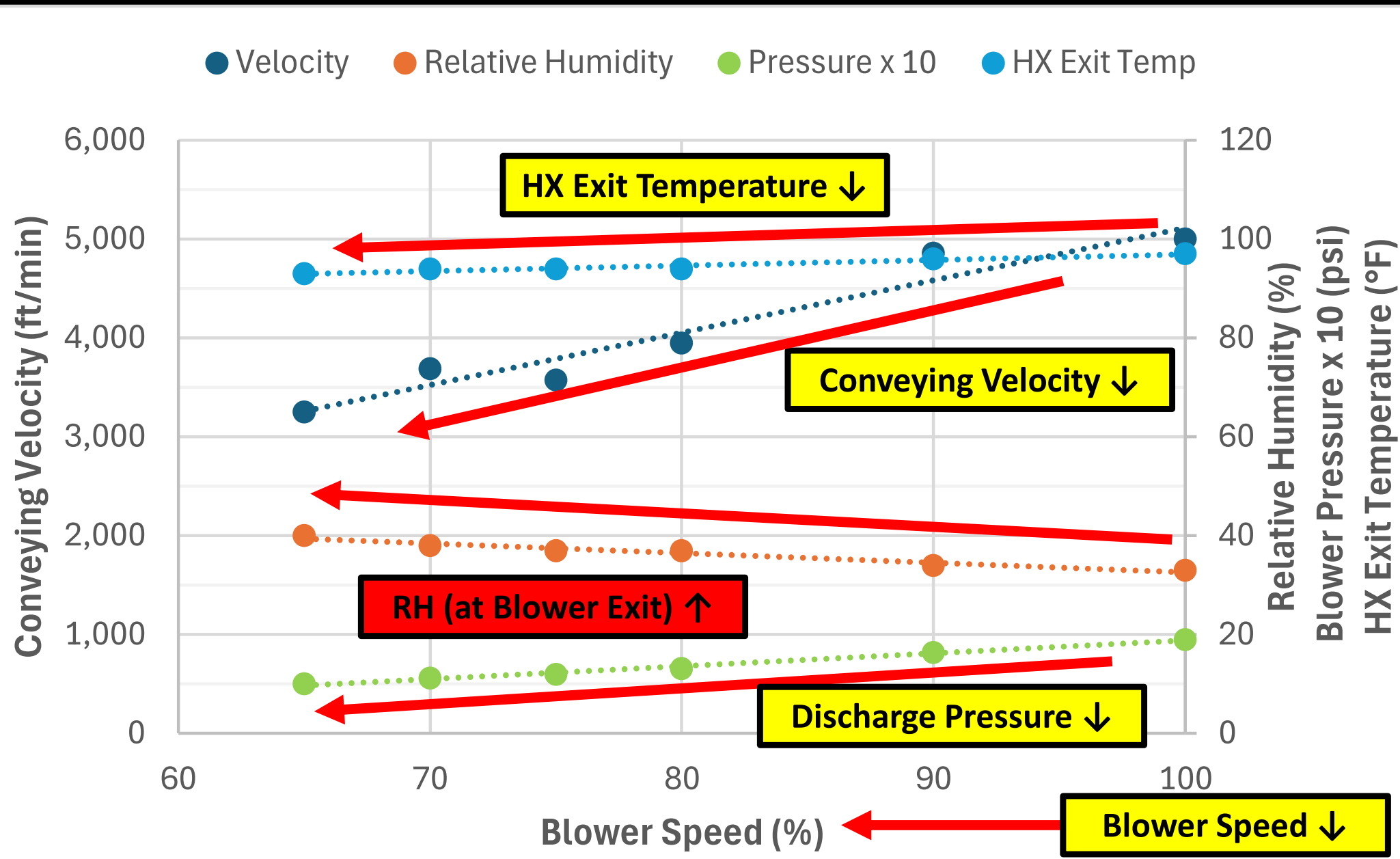


Motive Air +
Conditioning
System



Conveying Air System

Single Speed Blower vs. Blowers with VFDs



Conveying Air System



Measuring Impact of Velocity and Relative Humidity (RH)

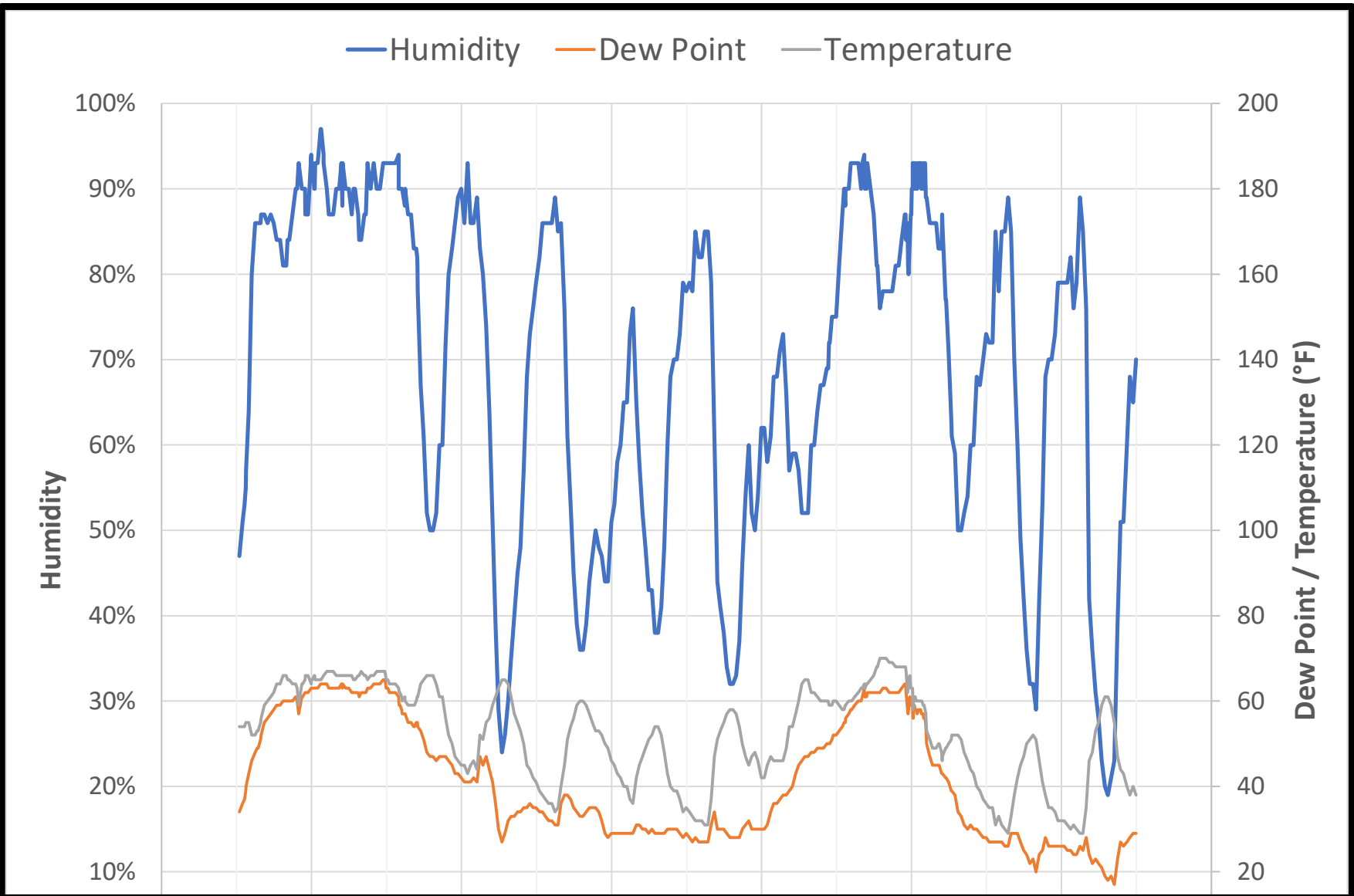
- **Challenges:** How does ambient conditions and each component of conveying air system impact RH.
- *Initial Design Solution*
 - ✓ Permanent RH transmitter
 - ✓ Logic to cycle conveying air system to minimize RH
- *Retrofit Solution*
 - ✓ Install taps in conveying line
 - ✓ Testo 405i and Testo 605i (~\$125 each on Amazon)



Conveying Air System



Ambient Condition Impact on DSI Operations



Central Alabama Site has Consistently > 50% RH even in December. Keep this in Consideration since Ambient AirSource of DSI System Conveying Air.

Conveying Air System



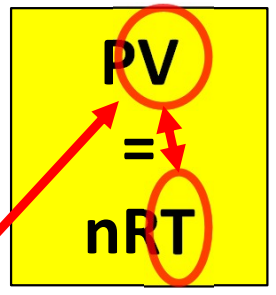
The Need for Blower Operational Flexibility

Condition 1 – Hard Scale

- DSI system commissioned with blower at 100%
- Elbows hard scale to point required maintenance in < 1 week
- Incrementally reduced blower speed while monitoring blower discharge pressure
- Ended running blower at 55%

Condition 2 – Soft Scale

- Experienced nearly instantaneous soft plugs
- Plant started to incrementally increase blower speed
- Ended running blower at 65% and plugging went away



Flow (ACFM) = Area x Velocity



Conveying Air System



The Need for Blower Operational Flexibility

Condition #1		
Volumetric Flow	290	ACFM
Piping Area (4" ID Pipe)	0.087	ft ₂
Conveying Velocity	3,323	ft/min
Temperature	90	°F
Temperature	32	°C
Temperature	305	K

Condition #2		
Temperature	20	°F
Temperature	-7	°C
Temperature	266	K
Volumetric Flow	253	ACFM
Piping Area (4" ID Pipe)	0.087	ft ₂
Conveying Velocity	2,900	ft/min

Blower VFD setting optimized for Condition #1

Blower VFD setting may be TOO LOW for Condition #2

$$V_2 = (T_2/T_1) \times V_1$$

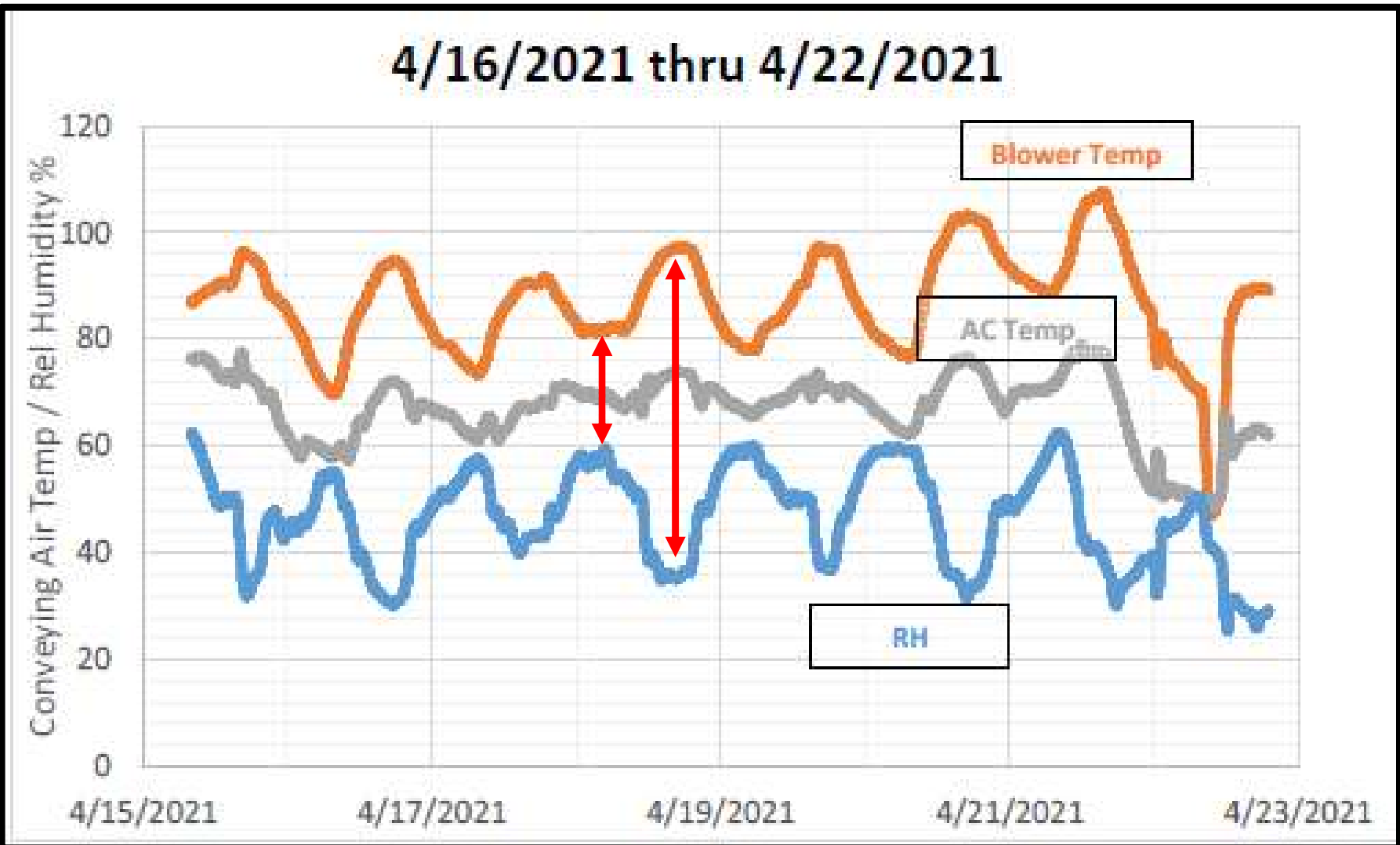
Air Will Expand and Contract with Temperature. Value in Checking Blower VFD Setting with Non-Trivial Temperature Changes.

Conveying Air System



Measuring Impact of Relative Humidity (RH)

- Challenges:** RH trends are not necessarily intuitive so having data to understand how changes in conveying air impact RH can help optimize DSI system reliability.

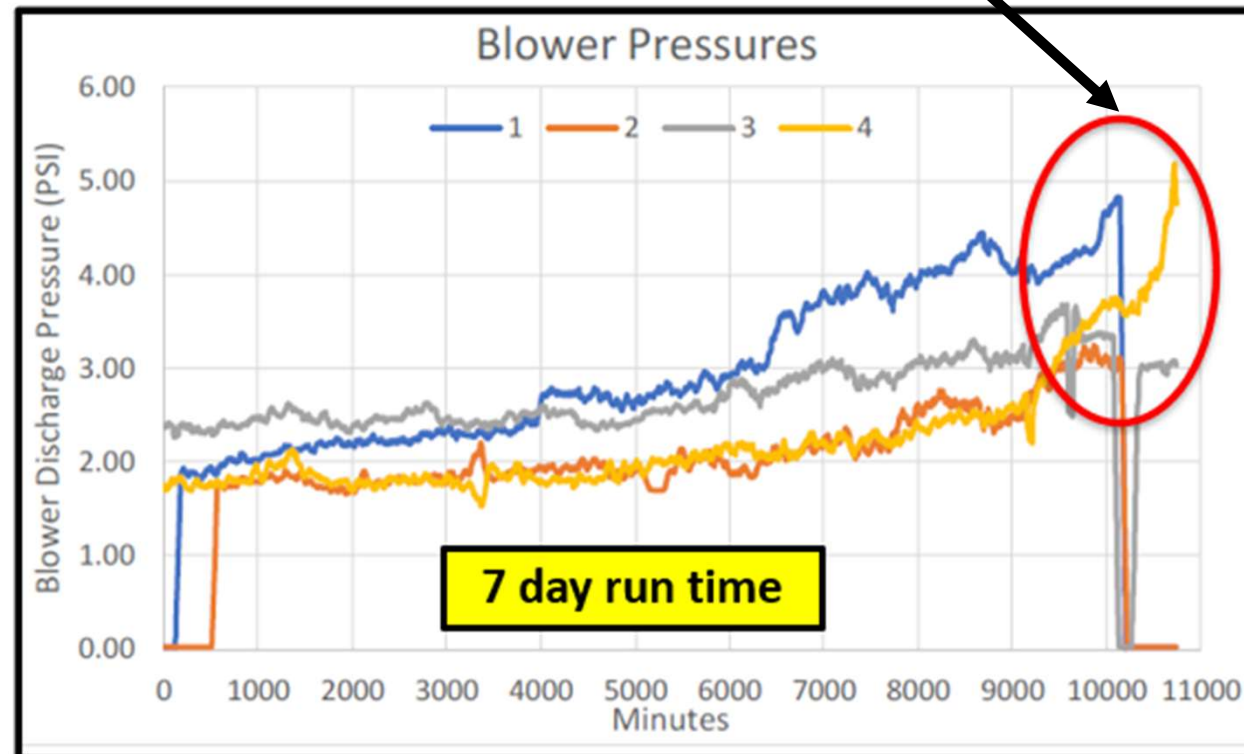


Conveying Air System

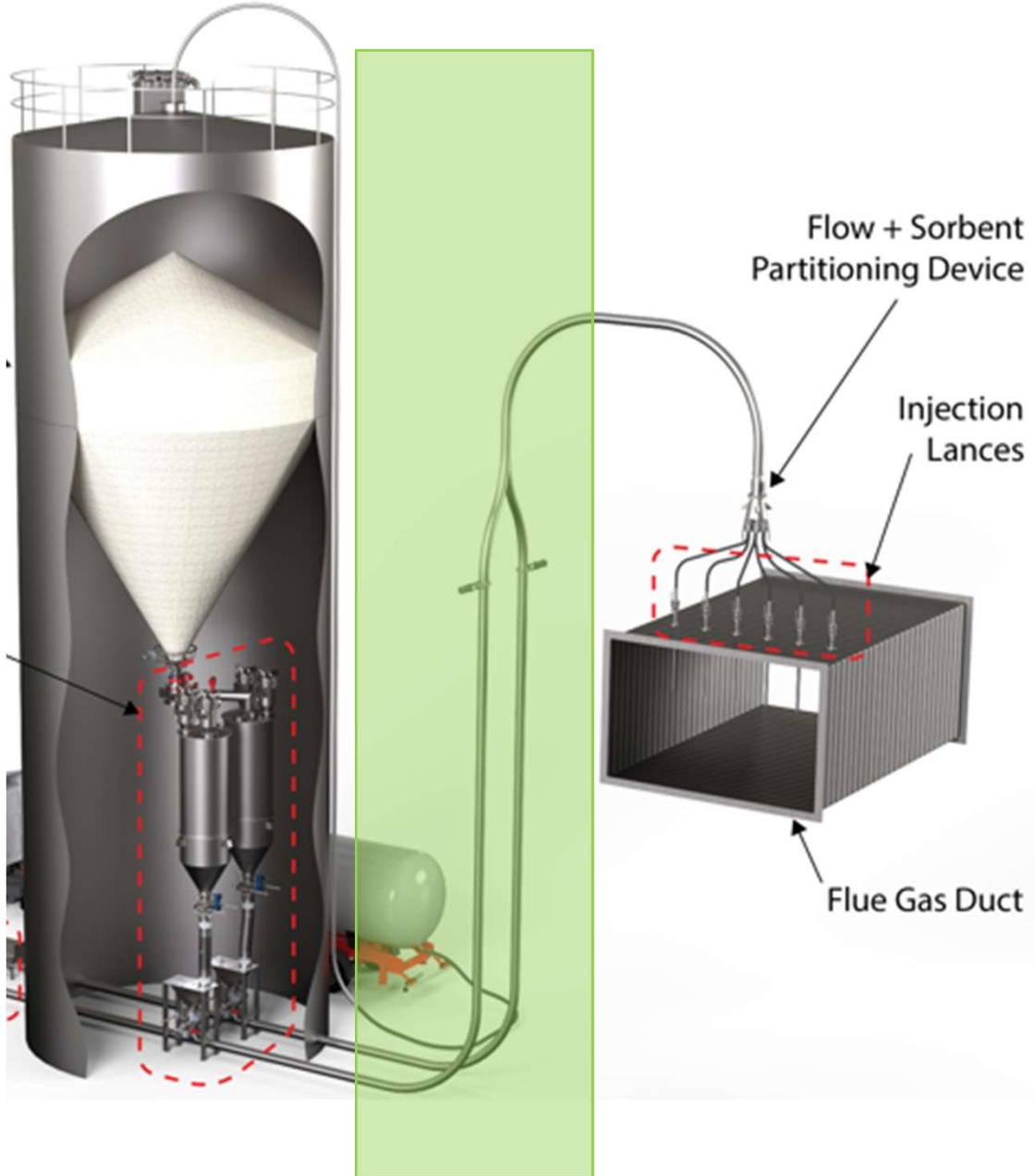
Blower Discharge Gauges vs. Transmitters

- **Challenges:** Blower discharge pressure provides meaningful diagnostic data that can help trigger proactive maintenance practices.
- *Initial Design Solution*
 - ✓ Install pressure transmitter with trends
- *Retrofit Solution*
 - ✓ Replace or supplement pressure gauge with pressure transmitter
 - ✓ Add blower discharge pressure trends (potential to incorporate set point to alarm maintenance)

Within 1 day scaling issues worsened to point that required maintenance activity



Transport Lines

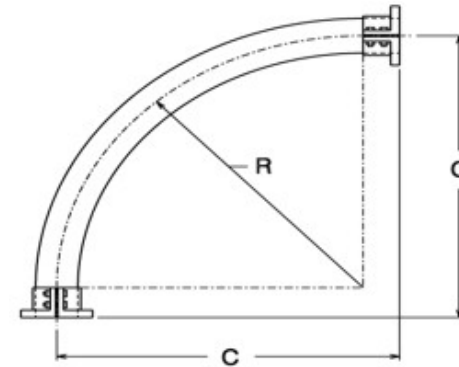


- Typically, where carbonate scaling occurs resulting in maintenance activities (elbows are common)
- Single point of failure if no redundant transport line

Transport Lines

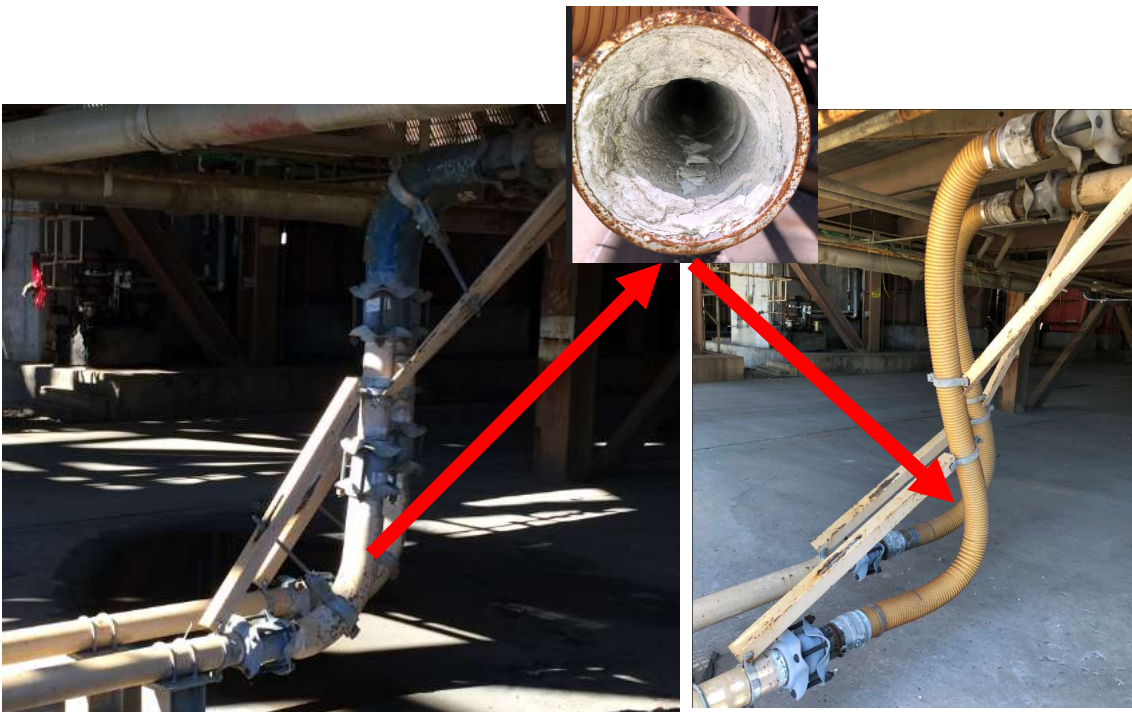
Elbows

- **Challenges:** Elbow design (bend radius, connection details) and materials of construction (metallic vs. hose) can impact carbonation formation.
- *Initial Design and/or Retrofit Solution*
 - ✓ Hose elbows
 - ✓ Pre-cut spare elbows



HOSE CAN BE USED TO FORM A 90° ELBOW WITH A R/D RATIO OF 8

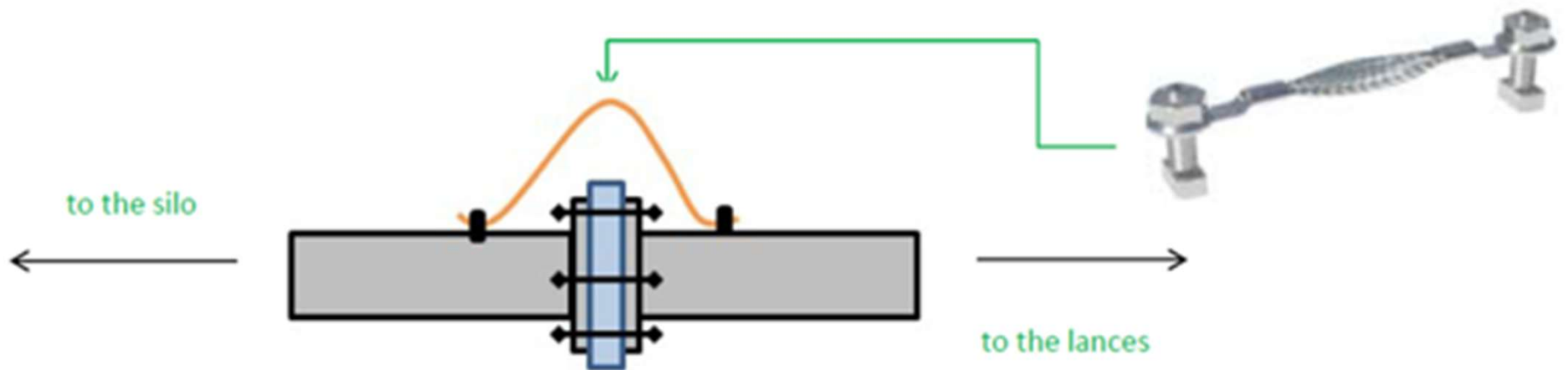
ID HOSE	R	C	L
3"	24"	28"	45"
4"	32"	36"	58"
5"	40"	44"	72"
6"	48"	53"	85"
8"	64"	70"	113"
10"	80"	87"	140"
12"	96"	104"	167"



Transport Lines

Grounding

- **Challenges:** Instances of static charge during pneumatic transport can contribute to carbonate scaling issues.
- *Initial Design and/or Retrofit Solution*
 - ✓ Low-cost grounding straps (McMaster-Carr)
 - ✓ Across each connection in transport line then ground to silo grounding system

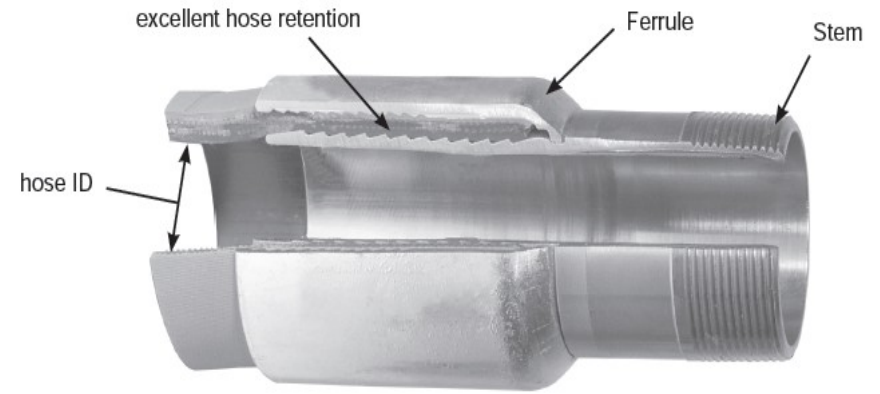


Saratovsky, I.; Analysis of Pipe Scale and Recommendations to Delay and Prevent $\text{Ca}(\text{OH})_2$ Deposition on Transfer Pipes, Private Paper, 2009

Transport Lines

Connection Type

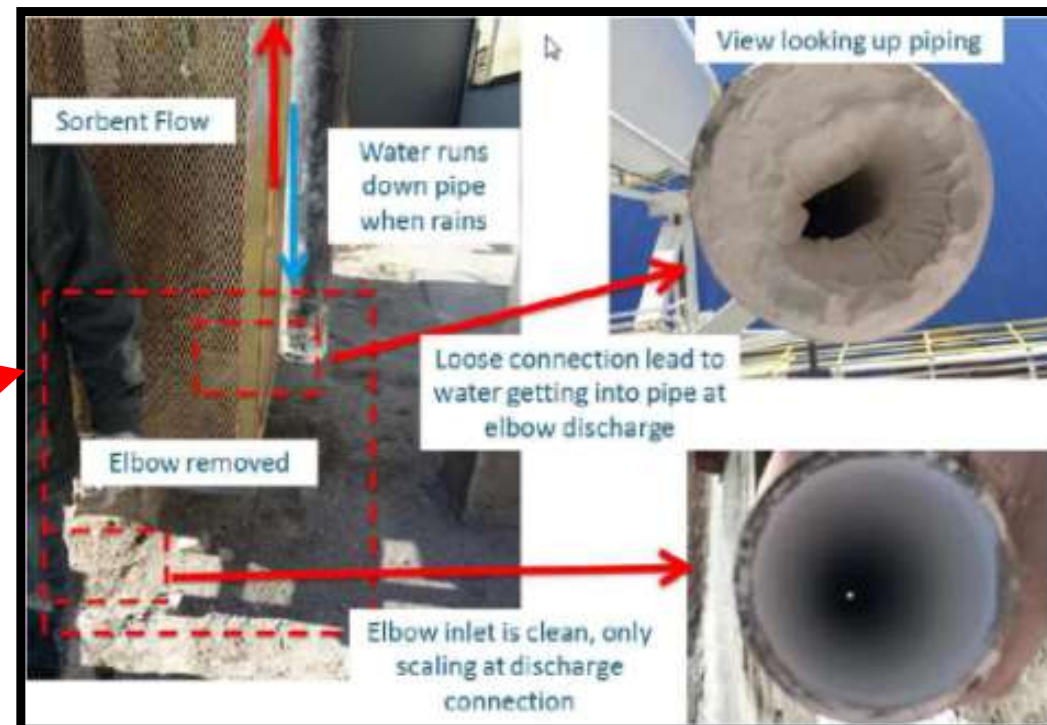
- **Challenges:** Proper connection of piping as well as connection type can impact frequency and location of carbonate scaling.
- *Initial Design and/or Solution*
 - ✓ Design and installation that properly seals connection
 - ✓ Sustains conveying line inner diameter at connection



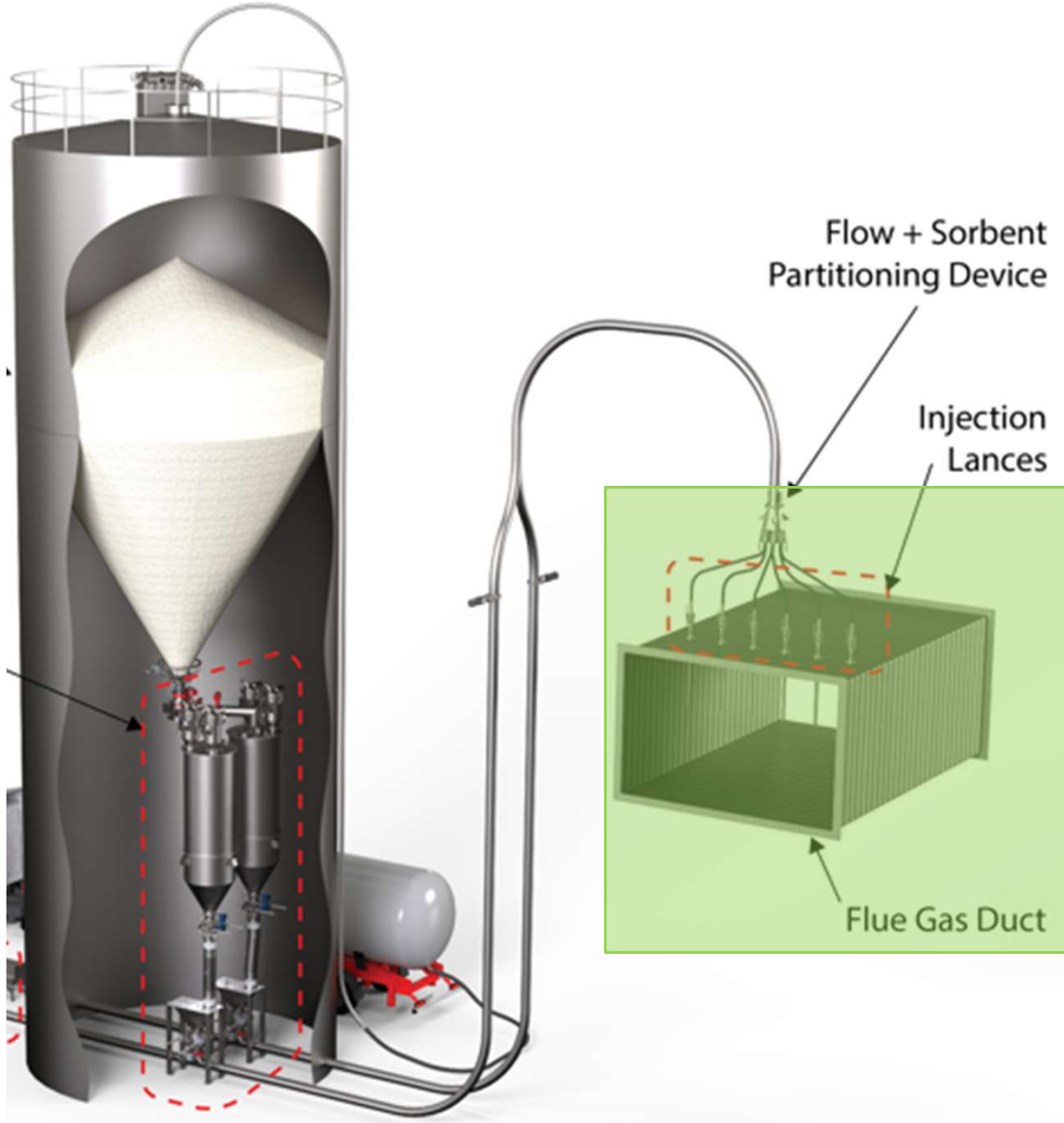
Cross-section of Holedall internally expanded assembly

<https://dixonvalve.com/en/products/internal-expansion-male-pipe-threaded-end-stem>

Poor piping installation allowed moisture contamination resulting in carbonation at connection



Injection Grid

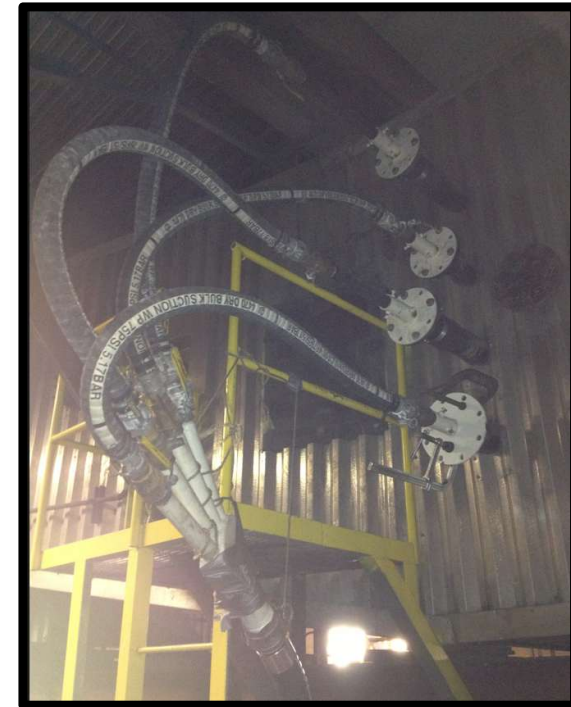


- Splitters and injection lances are also common points for carbonate scaling to occur
- Quality of injection grid design can directly impact DSI performance and associated operating cost

Injection Grid

Splitter System Design

- **Challenges:** Poorly engineered splitters and discharge lines can negatively impact DSI system reliability and sorbent dispersion.
- ***Retrofit Solution***
 - ✓ Replace discharge lines with appropriate hose design
 - ✓ Configure with proper bend radius
 - ✓ Equal discharge run/configuration



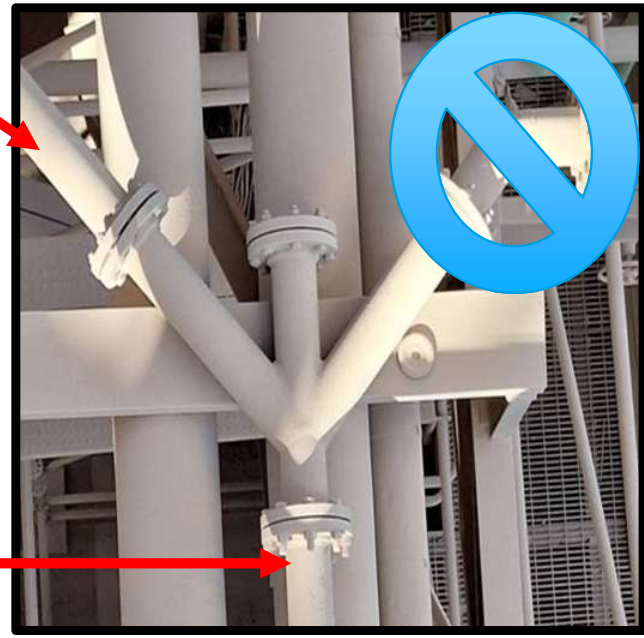
Injection Grid

Splitter System Design



Splitter Discharge			
Quantity of Lines	2	2	
Conveying Flow per Line	142.5	142.5	ft ³ /min (actual)
Pipe Inner Diameter (ID)	4	3	inches
Pipe Inner Diameter (ID)	0.33	0.25	feet
Pipe Radius	0.17	0.13	feet
Pipe Area	0.087	0.049	ft ²
Conveying Velocity	1,633	2,903	ft/min

May need to adjust blower VFD setting and use Testo 405i to check velocity in EACH discharge line

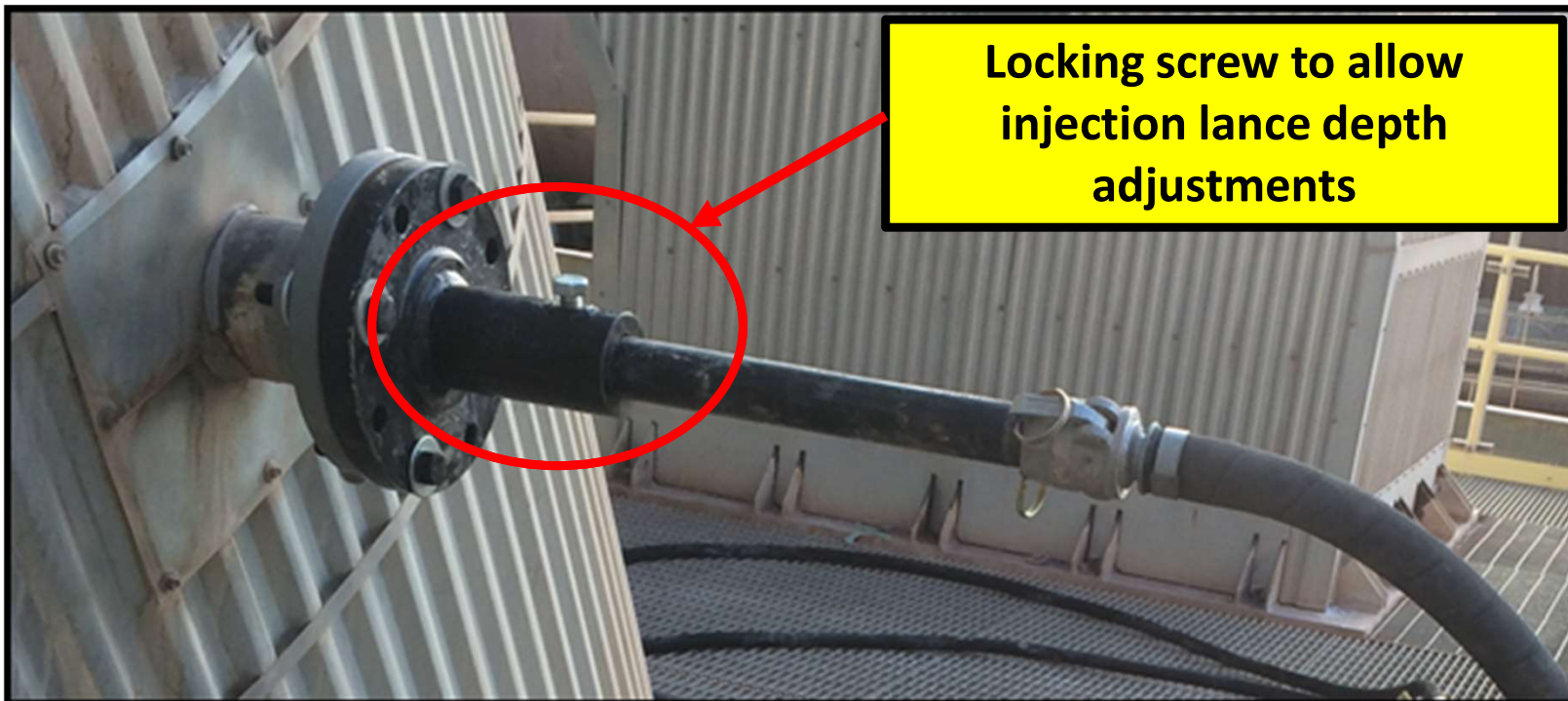


Splitter Inlet		
Quantity of Lines	1	
Conveying Flow per Line	285	ft ³ /min (actual)
Pipe Inner Diameter (ID)	4	inches
Pipe Inner Diameter (ID)	0.33	feet
Pipe Radius	0.17	feet
Pipe Area	0.087	ft ²
Conveying Velocity	3,266	ft/min

Injection Grid

Injection Lances

- **Challenges**: An optimal injection grid design may require flexibility to adjust in the field based on operating data.
- *Initial Design and/or Retrofit Solution*
 - ✓ Optimize test port quantity and placement to provide flexibility (hot tap ports for retrofits)
 - ✓ Flange connector with locking screw for adjustments



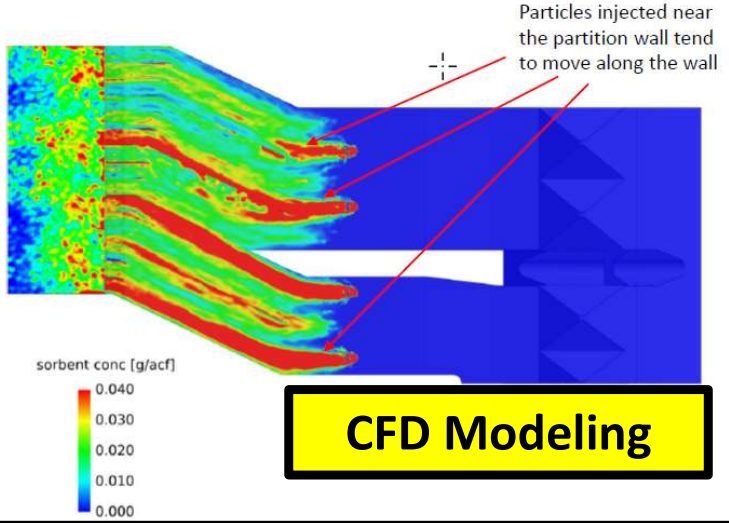
Injection Grid



Optimization Potential = Operating Cost Savings Potential

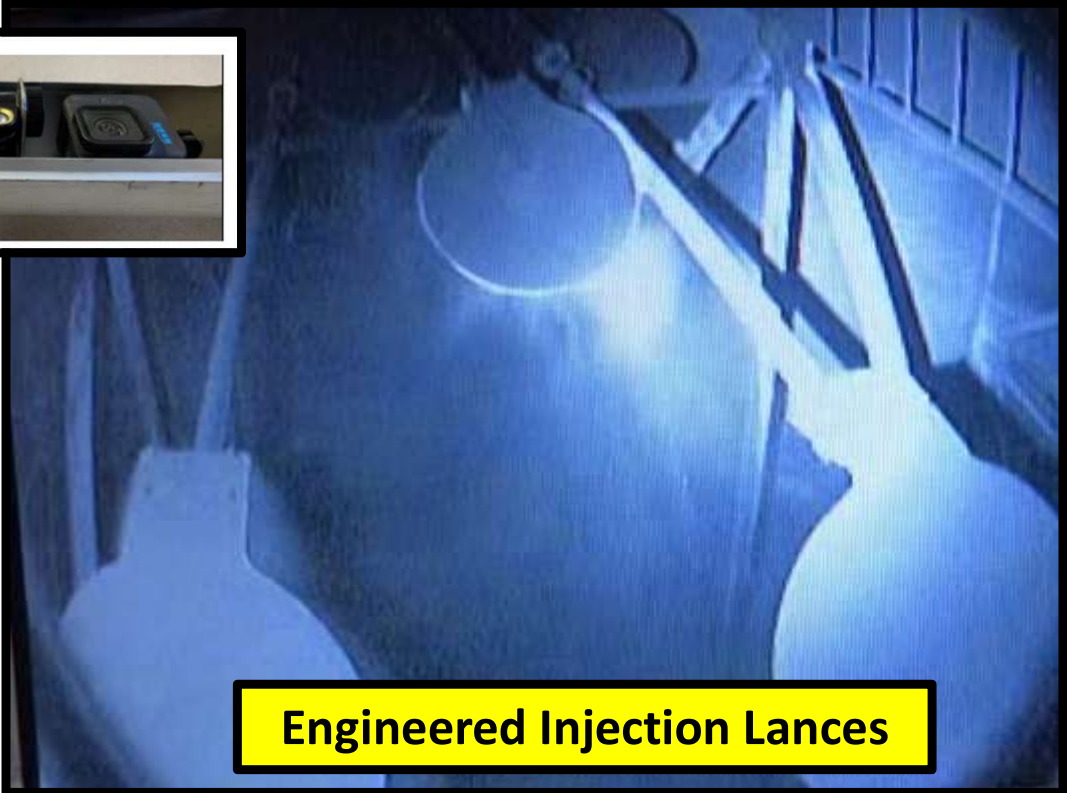


Static Mixers



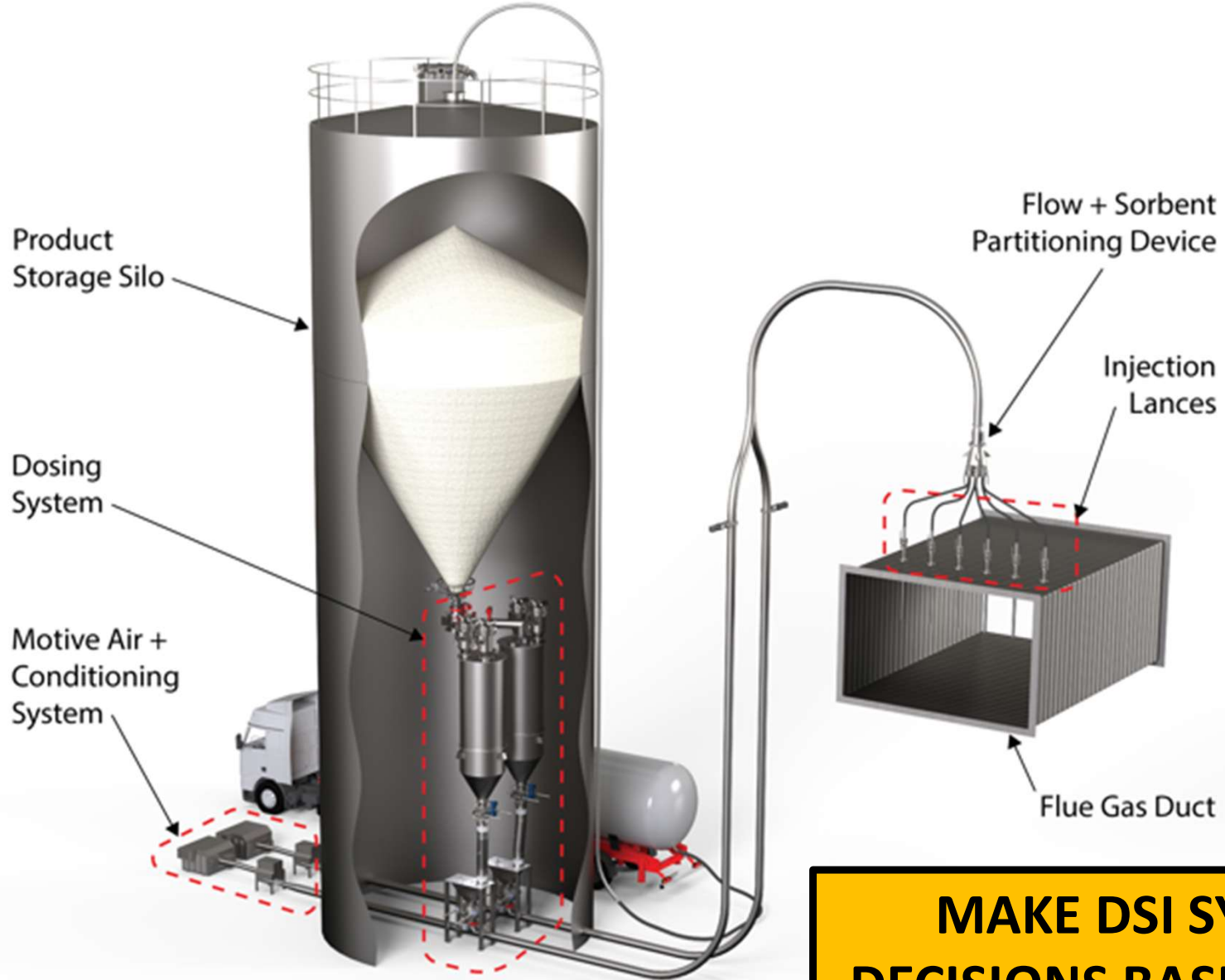
CFD Modeling

Assess dispersion with duct camera



Engineered Injection Lances

Fundamental DSI System Design



MAKE DSI SYSTEM DESIGN DECISIONS BASED ON VALUE NOT SOLEY DOLLARS

Thanks for your time...



Gerald Hunt
Senior Manager Flue Gas Treatment Applications
(412) 979-6337
Gerald.hunt@lhoist.com

Ian Saratovsky, PhD
Director, Environmental Solutions
(682) 774-2037
ian.saratovsky@lhoist.com

Visit our new website: www.sorbacal.us for information on Sorbacal[®] for DSI applications!

