

**REINHOLD ENVIRONMENTAL<sup>®</sup>**



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# Dry Scrubber Lessons Learned

TUESDAY JUNE 24<sup>TH</sup>, 2025

2025 REINHOLD/PCUG CONFERENCE

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# Overview



**Introduction**

**Common DFGD Lessons Learned**

**SDA Lessons Learned**

**CDS/NID Lessons Learned**

**Summary & Conclusion**

# Introduction

- 20 years in the air pollution control industry
  - ✓ 18 years with Alstom Power / GE Power (Vernova)
  - ✓ 2 years with Lhoist FGT group
  - ✓ Lead process engineer on a couple dozen DFGDs (NID & SDA)
  - ✓ Supported troubleshooting efforts at many others
- 9 years in water treatment at a small East TN utility prior to entering FGT world
- Worked remotely from East TN farm for 9 years
- Dry Scrubber User's Association board member since 2019



# Lessons Learned

- > What are “Lessons Learned”?
- > Definition according to Google:  
“The valuable insights and understanding gained from experiences, both positive and negative, that should be actively considered in future actions”
- > Why is it important to share?

Recent studies have shown that skilled workforce at plants has an average turnover rate of 5 years or less.

Many new employees have little or no prior experience with DFGD operations or maintenance



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# Common DFGD Lessons Learned

- Common meaning applicable to all DFGD technologies and not specifically one type
  - ✓ Since DFGD principles design philosophy are similar, regardless of technology, there are some shared lessons learned that are applicable for all technologies
  - ✓ Although, impacts could be more significant for one technology over another



# Temperature Considerations

- Many plants operate by measuring the dry bulb temperature
- “Spray down” is the difference between inlet and outlet dry bulb temperature.
  - For example, an inlet temp of 315°F and outlet of 165°F is a spray down of 150°F
  - $315 - 165 = 150$
- What is “Approach Temperature”?
  - ✓ In simple terms, it is the difference between the flue gas outlet temperature and the measured adiabatic saturation temperature
  - ✓ Since adiabatic saturation temperature is tricky to measure, so many folks often refer to dewpoint temperature
- Why does it matter?
  - ✓ Plants struggle with balancing lime consumption costs and maintenance costs associated with material accumulation and corrosion



Lime Consumption Costs



Corrosion Repairs

Approach to Saturation



Excessive Material Accumulation

# So... What Could Go Wrong?

## Vessel & Duct Corrosion



- Corrosion is often a result of operating with too cool of an outlet temperature
  - ✓ Most plants operate at an approach temperature of 30-50°F
  - ✓ Insufficient insulation can create cold spots which causes condensation to form and results in corrosion
  - ✓ The trick is to operate at a temperature cool enough to maximize  $\text{Ca}(\text{OH})_2$  reactivity and efficiency, while remaining above the risk of corrosion
- Other factors affect risk of corrosion
  - ✓ Materials of construction
  - ✓ Insulation thickness
  - ✓ Condition of insulation & lagging
- Corrosion Monitoring
  - ✓ Engineering or mechanical evaluation
  - ✓ Corrosion coupons

# Can We Measure Approach Temperature?

- Continuous Measurement Methods
  - ✓ In-duct dewpoint or moisture analyzers
  - ✓ Initial models had challenges, but reliability has improved over the past 10+ years
  - ✓ Can be used for temperature control loop (water supply) feedback or indication only for operator consideration for setpoints
  - ✓ Can be relatively expensive
- Intermittent Measurement Methods
  - ✓ Handheld moisture analyzers
  - ✓ Data is used for information purposes and setpoint determination
  - ✓ Relatively inexpensive, lightweight, and portable



Many past presentations are available with data and experiences of installing and implementing dewpoint measurement and approach temperature control

# Material Deposition & Drop-Out



- Often coincides with corrosion
  - ✓ Material deposition in ductwork, especially damp material
  - ✓ Can be a result of operating at too cool temperature or droplet size
  - ✓ Particles continue to dry and cool as they exit the scrubber
- “Wall falls” can also occur
  - ✓ Large accumulations of material on the sidewall of the reactor can break off. Referred to as wall shedding or wall falls.
  - ✓ Depending on material size, it can plug the bottom of the vessel completely
  - ✓ Other factors such as dispersion and droplet size also affect this

# Lime Consumption & Cost



- Lime OpEx vs. corrosion and deposition
  - ✓ Higher outlet temp – less risk of corrosion & deposition, but more  $\text{Ca}(\text{OH})_2$  consumption
  - ✓ Easier to forecast lime costs vs unknown maintenance outages
  - ✓ More  $\text{Ca}(\text{OH})_2$  reduces corrosion risk
- Reagent costs can be optimized
  - ✓ Implement byproduct recycle
  - ✓ Maintain consistent quality of  $\text{Ca}(\text{OH})_2$
  - ✓ Maintain consistent wt% solids and wt% moisture in the slurry Inconsistencies introduce oscillation into the process

# Water Quality

Don't forget about the water!



Hydration and slaking water vs. humidification water



Likely variations in water spec from each OEM



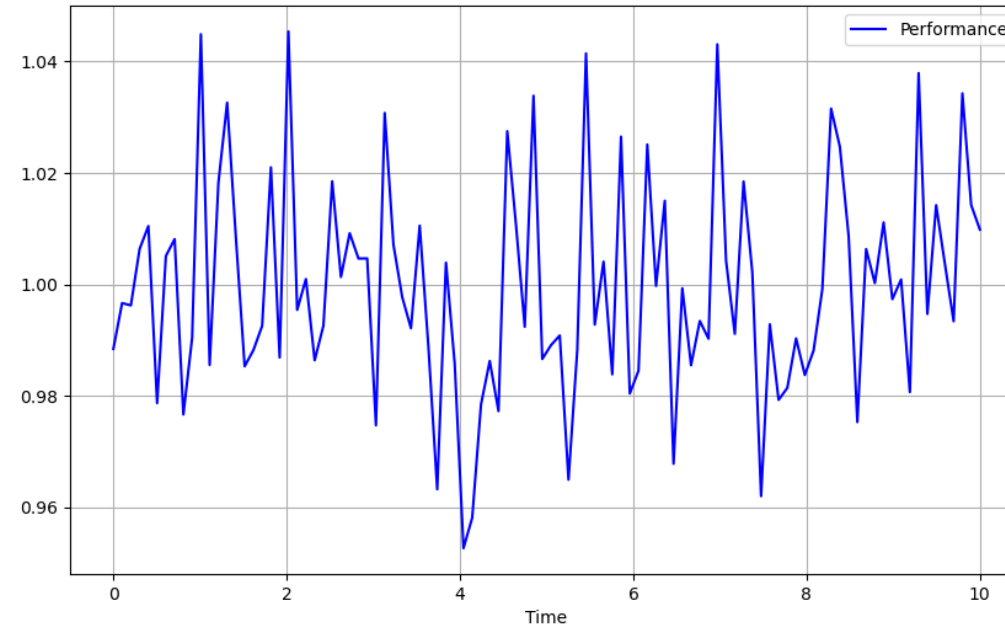
What is the water source? What are the chlorides, sulfates, etc.?

Are upgraded materials of construction required?  
Will it consume any available calcium?

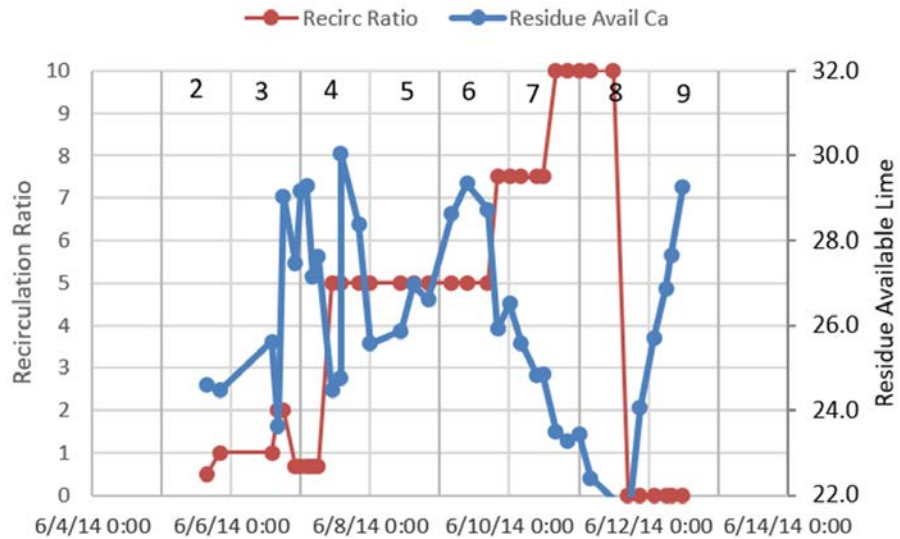
# Feed Composition

## Consistency is a good thing

- Lime only systems are less forgiving to optimize
  - ✓ Fewer “levers” to pull when trying to optimize process tuning compared to recycle systems
  - ✓ Maintaining consistent lime slurry or hydrated lime feed will make tuning and control more steady
  - ✓ Tend to be more susceptible to dropout due to less solids content in the slurry taking longer to dry
- Byproduct recirculation
  - ✓ Multiple design concepts and control schemes for blending recycle byproduct
  - ✓ Tuned during commissioning, but can change over time
  - ✓ Not all plants are the same



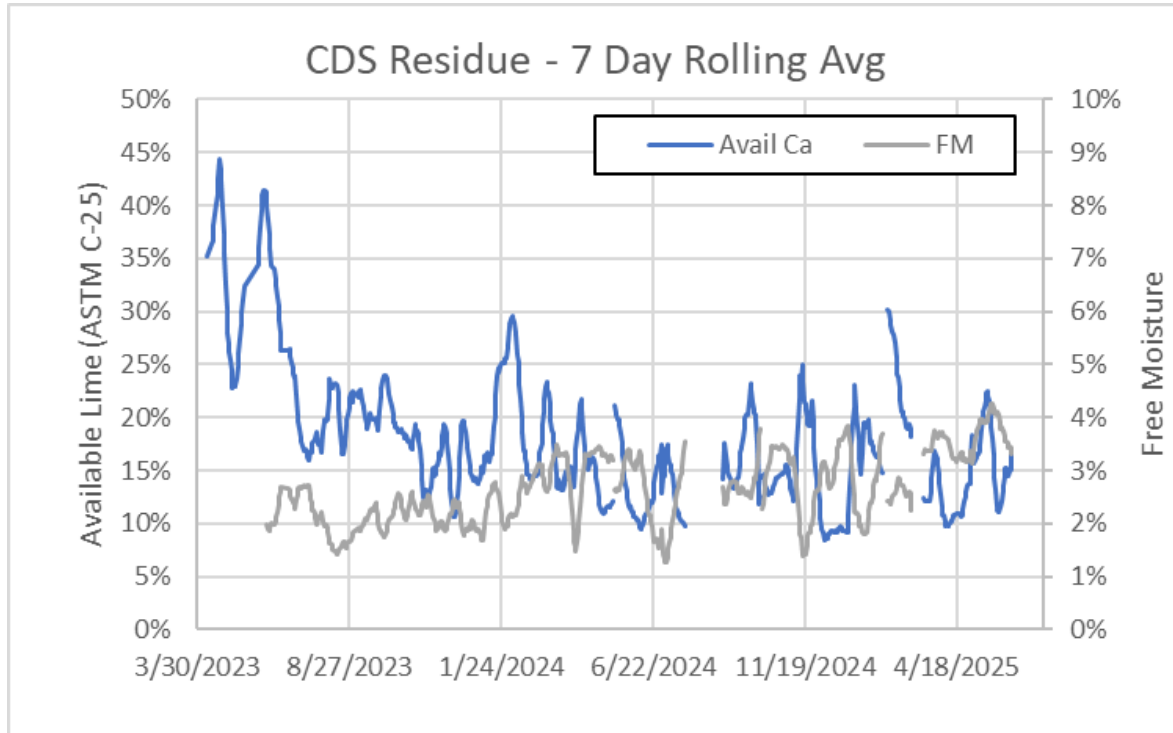
# Byproduct Analysis and Beneficial Reuse



- Byproduct sometimes referred to as Residue
- Routine sample analysis provide feedback on calcium utilization and process efficiency
- Sampling should be on a regular basis
  - ✓ During commissioning samples are taken to tune the system prior to testing, but conditions can change
  - ✓ Many plants rarely take samples after commissioning and performance testing
- Process optimization
  - ✓ Sample data and trends can optimize
- Circular economy
  - ✓ Localized reuse of residue/byproduct material
  - ✓ Historical analysis & trends are beneficial when talking to potential buyers/users

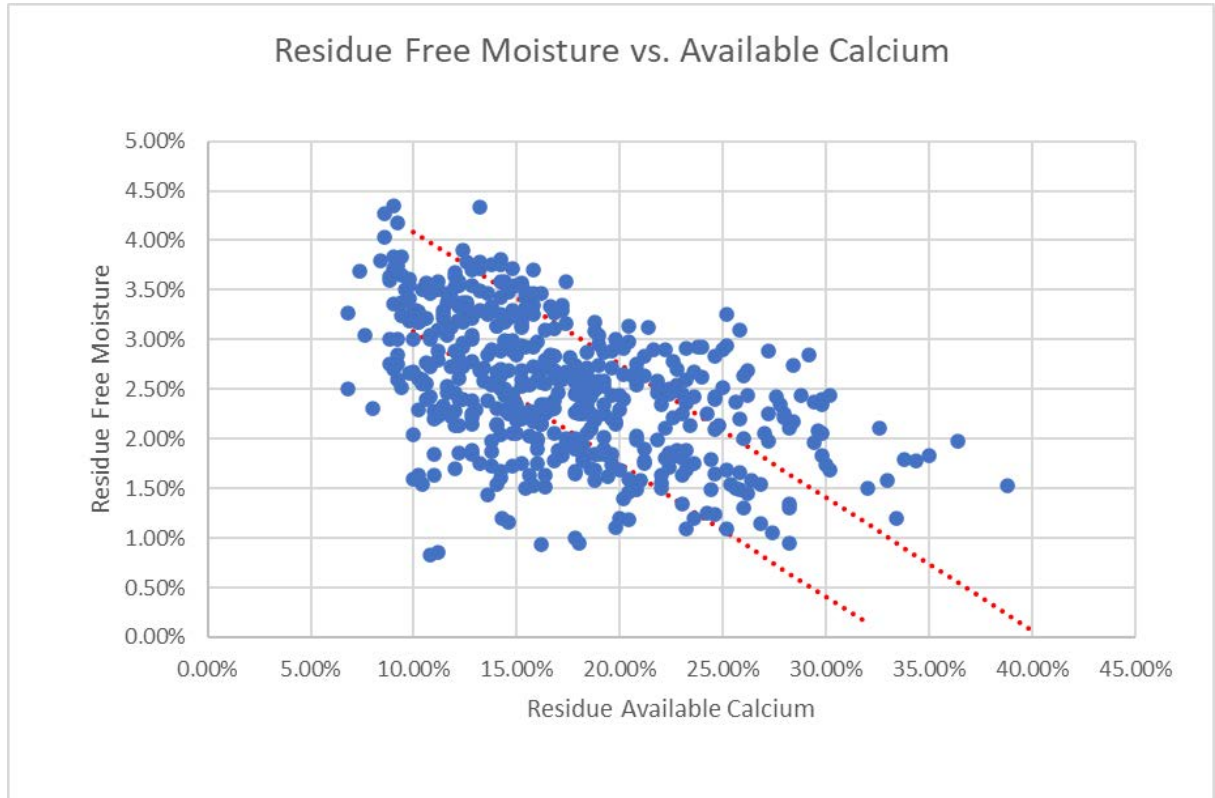


# Byproduct Analysis & Optimization



This CDS customer takes a byproduct/residue sample daily and analyzes it for available Ca (ASTM-C25) and free moisture.

Plot the results daily, note any observations, and try to remain within a range where the optimal free moisture to available calcium ratio is ideal



# Recycle Byproduct Density

## Factors Affecting Density

- Presence of flyash
- Recirculation rate

## Equipment Sizing & Design

- Lower density – could be volume limited
- Higher density – motor & materials challenges

## Control Variables

- Recycle feed logic depends on density
- Density can change over time
- ESP on/off operation

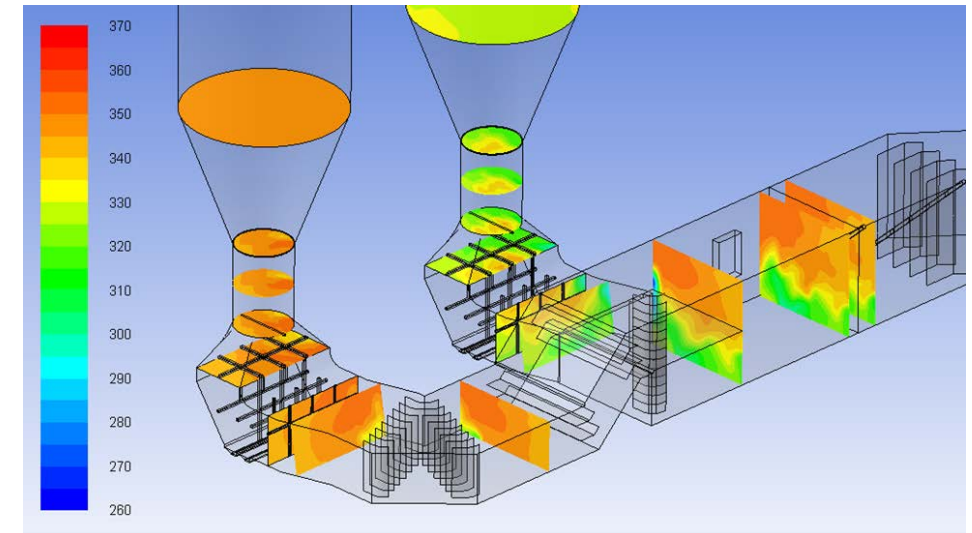
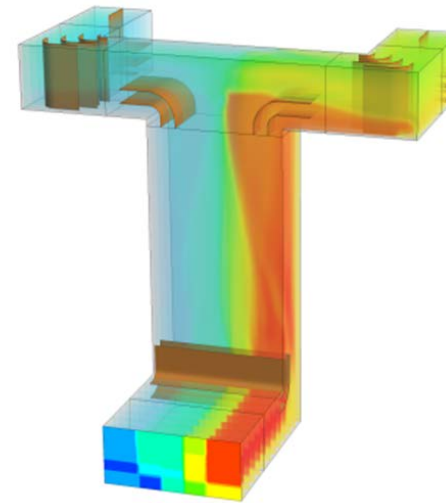
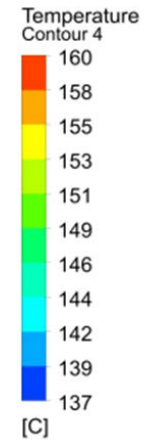
## Impacts

- Possible dropout on NID/CDS
- Higher velocity to minimize dropout
- Excessive recycle slurry density

# Distribution & Dispersion

## A reality of utility plants

- Temperature profile
  - ✓ More uniform distribution makes control easier with less complications
  - ✓ Most all utility plants have a significant APH temperature profile range
  - ✓ Temperature balancing controls?
- Acid gas distribution
  - ✓ Is part of the gas path seeing more acid gas than the rest?
- Byproduct recirculation
  - ✓ Multiple design concepts and control schemes for blending recycle byproduct
  - ✓ Setup during commissioning, but can change over time
  - ✓ Not all plants are the same



# Atomization, Droplets, & Nozzle Sizing



- Nozzle selection
  - Nozzle size
  - Nozzle shape or style
  - Spray coverage and droplet size
  - Abrasivity
- Insufficient atomization
  - Larger droplets -> longer drying time -> deposition or corrosion
- Maintenance of nozzles/atomizer wheels
  - Varies by plant (based on historical experience)
  - Flowrate
  - Load profile
  - Reagent makeup (lime only or recycle)
- Once a nozzle begins to plug or fail, performance decreases rapidly

# Atomizer & Nozzle Maintenance

## A lot to keep up with

- The more you have, the more important tracking maintenance becomes
  - ✓ Run time, next routine maintenance, and upcoming major maintenance
  - ✓ Some plants use a large white board to track this where it is visible to everyone
  - ✓ Frequency will most likely vary from what the OEM originally suggested
- Cleaning procedure
  - ✓ OEM procedures are typically sufficient
  - ✓ Often modified based on staffing and observed experiences
  - ✓ Citric acid solution soak reduces the duration of the physical cleaning process
  - ✓ Some plants have shifted to more concentrated commercial cleaners
  - ✓ Pros & cons of each



# Atomizer & Nozzle Maintenance



# Fabric Filter Considerations

Let's quickly touch on bags and cages



Filter bag material:

PPS, P84, Fiberglass, Membrane, etc.



Coated or uncoated cages

What coating to use?



Cage plate and wire thickness

Variations in the plate thickness can occur

# System & Equipment Layup

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Short term or long term outage?

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Recycle material can be a challenge, especially slurry

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Do you empty your slurry tanks? Difference between lime slurry and recycle slurry

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How long to keep dry material in troughs or hoppers?

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What do you do with the slurry or dry material?

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Any way to reuse it for a restart? Possibly bag precoat or fluid trough first fill

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# Factors Affecting Lime Slurry Quality



QUICKLIME  
QUALITY



WATER QUALITY



WATER  
TEMPERATURE



SLAKING  
TEMPERATURE

# Grit Screens



## Types

Vibrating  
Basket  
Auto/Manual



## Purpose

Avoid Nozzle  
Plugging  
Remove Grit



## Sizing

Last screen should  
be the smallest



## Quantity

Redundancy  
Single / Double

# Slurry Piping

## Materials of construction

- Carbon Steel, FRP, Stainless, etc.
- Pipe thickness (Sch 40 vs Sch 80)

## Routing

- No “deadlegs”, use feed loops
- Minimize low points, drain at each one
- Syphon break / vent line

## Feed Pressure

- Head tank
- PCV

## Valve Type

- Balance simplicity, cost, and maintainability

## What about flushing philosophy?

- Drain to sump only
- Fill & drain
- Full system flush

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# Nozzle Placement & Orientation



Insertion  
Depth

Rotation

Spray  
Angle



Insertion depth and rotation can be controlled by including engineering controls that ensure consistency

# Recycle Rotary Feeder Challenges

## Extremely Large Volumes

- NID RRFs feed up to 1,000,000 lb/hr

## Ventilation

- Sufficient ventilation required

## Turndown

- How much turndown is necessary

## Additional Features

- Cooling fan recommended for turndown >10:1
- Is a brake required for maintenance outages?
- Direct drive vs. worm drive...



# Hopper & Trough Inventory Management

## Normal Operation vs Startup



- Level Control Philosophy
  - ✓ Timer basis
  - ✓ Level switch basis
  - ✓ Hybrid system
  - ✓ What type of instrumentation
- Shutdown & Startup
  - ✓ Material selection for refill
    - ✓ Hydrated lime
    - ✓ Byproduct material
  - ✓ Level
    - ✓ Account for material loss to recover the bed
    - ✓ Bag filter cake requirements
    - ✓ Sufficient material to achieve both while not tripping low level alarm



# Conclusion

- Summary
  - ✓ 40+ years of lessons learned from DFGD installations
  - ✓ Large amount of industry knowledge has retired in the past 10 years
  - ✓ Lessons learned should be routinely shared as plant turnover is typical
  - ✓ This addressed high-level topics
    - A typical training session lasts anywhere from 4-8 hours for a single technology
  - ✓ As DFGD installations grow into industrial markets, there is a growing number of operators and maintenance personnel with no prior experience

# THANK YOU!



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