Operating Air Quality Control Equipment after a Gas Conversion

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10:15 – 11:15

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Dual Fuel Operation

- What is dual fuel operation?
  - Firing coal and natural gas, separately and as a blend
- Why dual fuel operation?
  - Impact of fuel price and cost of generation
  - Increases fuel flexibility
  - Creates market opportunities
- Considerations of dual fuel operation
  - Natural gas supply
  - Boiler efficiency
  - Safe and reliable operation of backend equipment

Let's Focus on Back End Equipment

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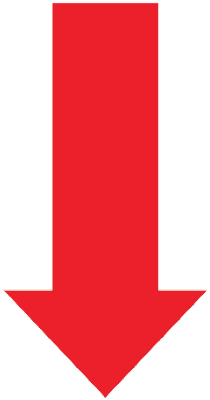
Impact of Offsetting Coal with Natural Gas



- Flue Gas Parameters that Decrease
  - NO_x, Hg, SO_2, SO_3, PM Concentrations
  - Flow rate (typically a small reduction)

- Flue Gas Parameters that Increase
  - Moisture Content
  - Adiabatic Saturation Temperature

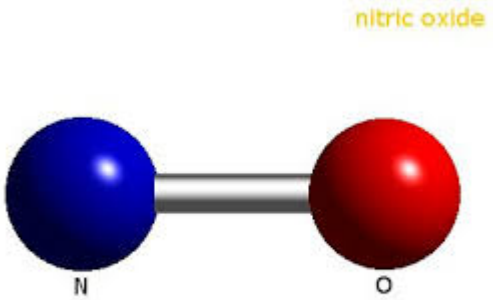
Backend Equipment Considerations

- What are the impacts of these changes on the system…
  - ✓ Design
    - e.g., personnel safety, thermal expansion, materials of construction,.
  - ✓ Control
    - e.g., operating temperature, alarm settings, etc.
  - ✓ Operation
    - e.g., turndown, transition between coal and natural gas, etc.

All of these items combine to affect AQCS: SCR, DSI/PAC, PM Device, FGD, WWT

Impacts from Firing NG – NO_X

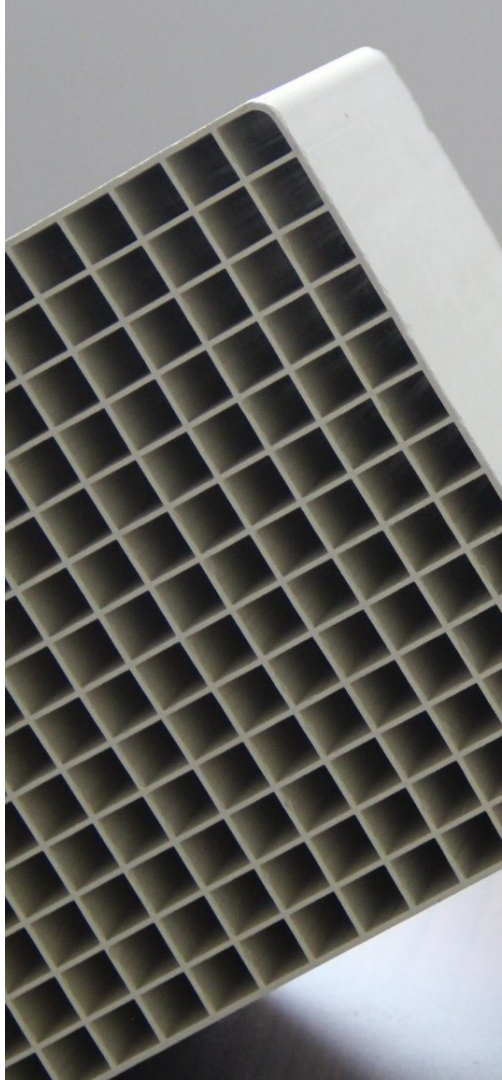
- NO_x is generated by the oxidation of atmospheric nitrogen during combustion
  - Nitrogen is typically considered inert
  - Occurs due to high flame temperatures in the boiler



- Generation of NO_X is reduced during NG firing:
  - Reduced flame temperatures due to increased flue gas moisture
  - Reduced excess air (and therefore nitrogen) in combustion gas

Impacts from Firing NG – NO_x Control

- Lower NO_x levels = reduced NH_3 injection rate
  - NH_3 turndown can be ≥ 10x design
  - Requires feed system modifications
- Impact on SCR Minimum Operating Temperature (MOT)
  - Work with *catalyst* vendor to determine impact of dual fuel operation (NOx and SO_3 levels) on MOT
  - Maintain SCR inlet temperature above MOT based on fuel blend
- Boiler Primary Air Fan
  - PA fan operation may not be required when firing 100% natural gas



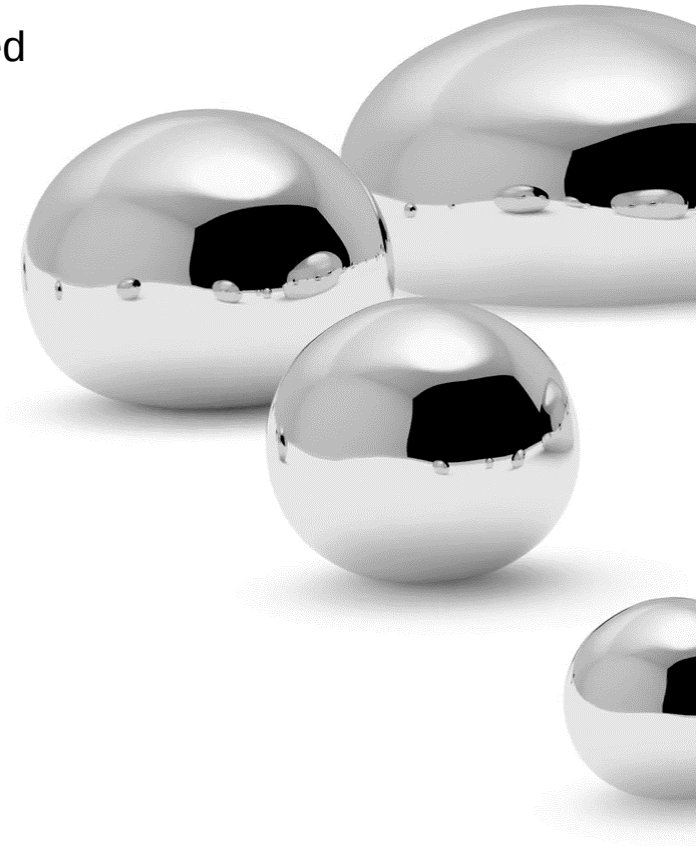
Impacts from Firing NG – SO_3 Control

- Flue gas SO_3 is generated during combustion and across the SCR
- Flue gas SO_3 concentration will reduce due to lower sulfur content of the fuel blend
- However flue gas moisture will increase, affects dew point
- SO_3 Control
  - Lower SO_3 = additional turndown needed
  - Less fly ash & sorbent injection = longer duration between cleaning cycles
- If you have a fabric filter, there's a need to retain "cake" thickness for SO_3 removal

Impacts from Firing NG – Hg Control

- Hg Control
  - Lower Hg, SO_3 & Temp = additional turndown needed in DSI or PAC
  - Less fly ash = less native removal
  - Lower halogens in flue gas = lower Hg oxidation across SCR
  - Dilute WFGD Absorber Slurry = Hg re-emissions during transitions

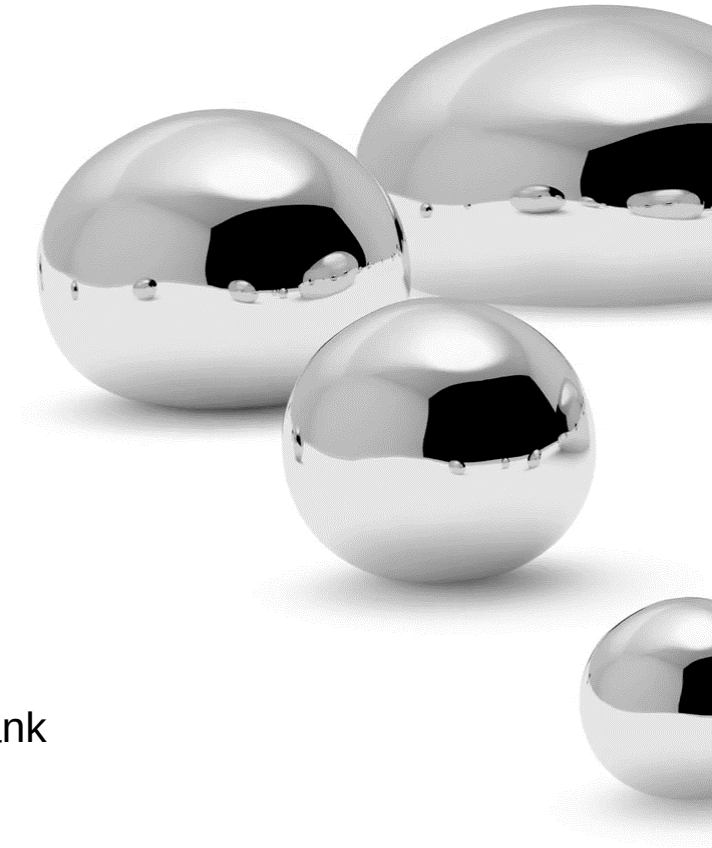
- If you have a fabric filter, there's a need to retain "cake" thickness for SO_3 & Hg removal



Impacts from Firing NG – Hg Control

Hg Re-Emissions during transitions:

- Switching from coal-only to co-firing and then gas-only:
  - Should maintain ORP in range of 100-250mV
  - Should maintain chlorides in absorber slurry
  - Must find ideal range of fines in slurry
  - Could use re-emission additive
- Switching from gas-only to co-firing
  - Similar to starting unit up with only limestone and service water
  - May introduce slurry from another unit or storage tank to maintain sufficient fines



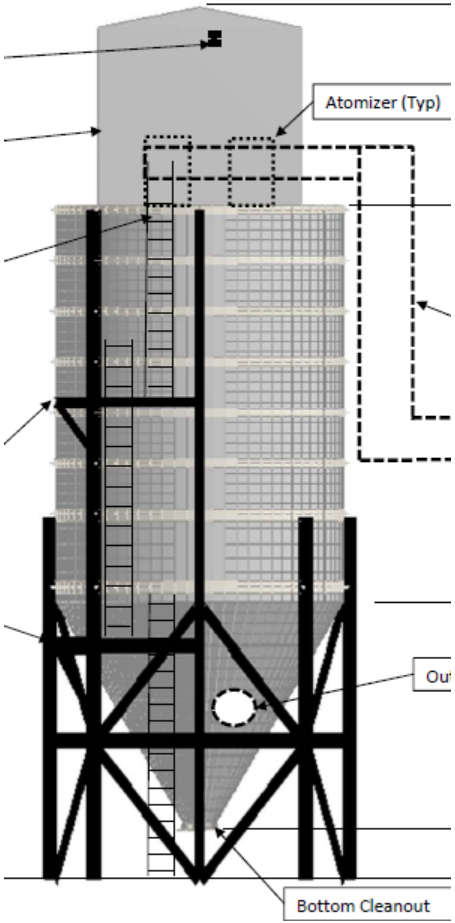
Impacts from Firing NG – PM Control

- PM loading decreases as the percentage of NG fired increases
- Ash resistivity changes with flue gas SO_3, moisture & temperature
- Impact of sorbents for SO_3 / Hg control on PM loading & ratio of ash to sorbent
- Operation of the PM Control device needs to be adjusted based on changing conditions
  - For ESPs – # of fields in service
  - ESP Gas Conditioning System Turndown
  - For FFs – consideration must be given to dP, cake thickness and minimum approach temperature (avoid condensation)

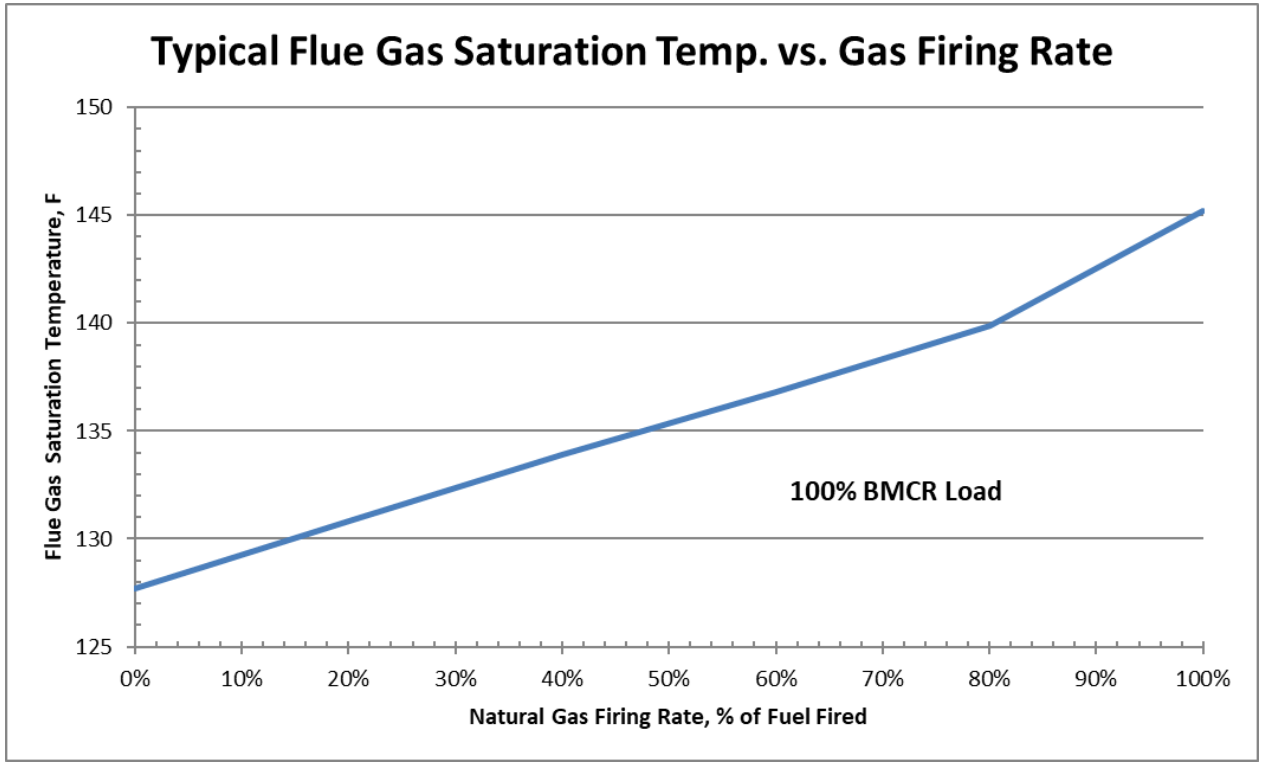
Impacts from Firing NG – SO_2 Control

Spray Dryer Absorbers (SDA) and Circulating Dry Scrubbers (CDS)

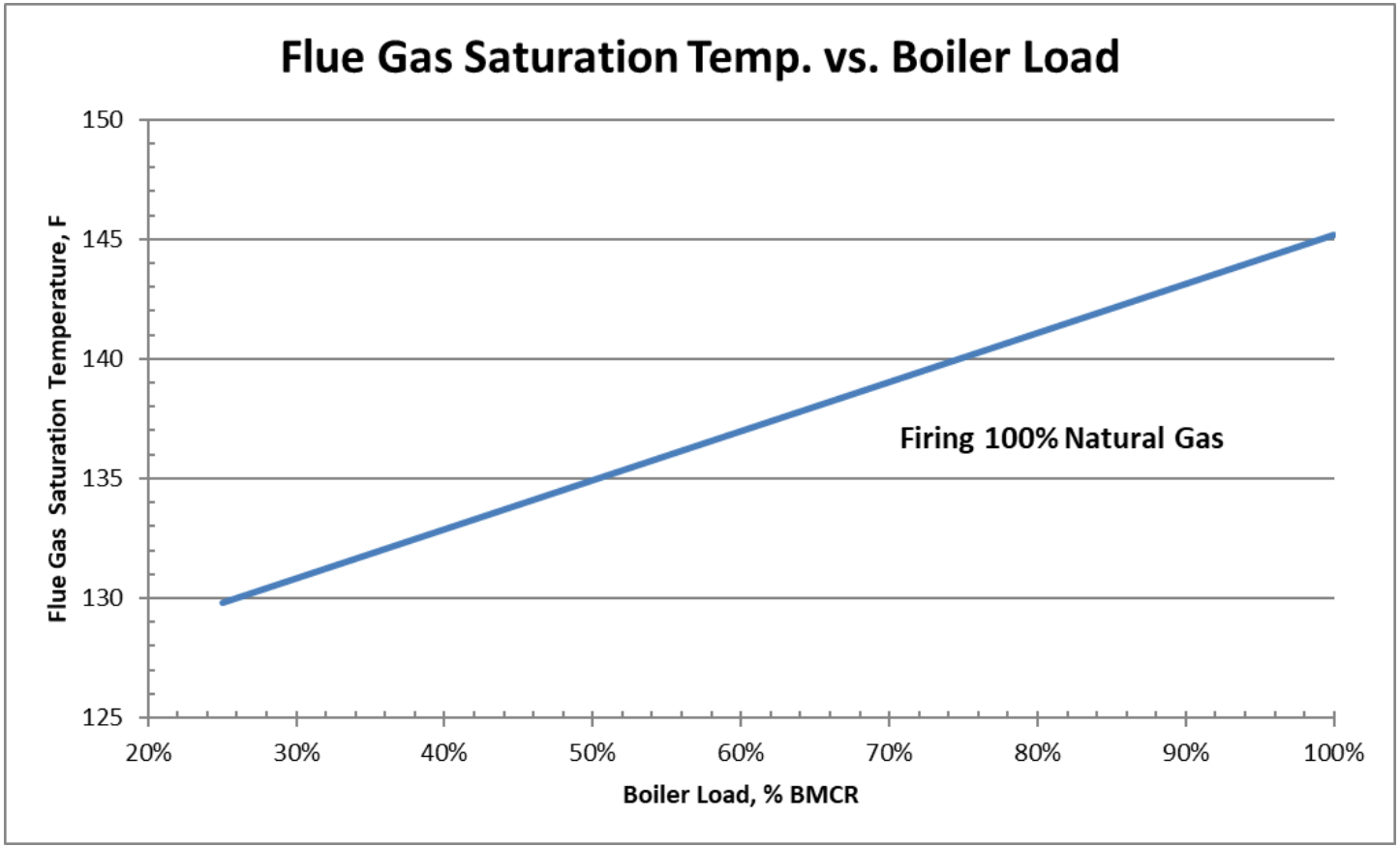
- Impact of increasing moisture content
  - Higher saturation temperature
    - Requires adjustment to SDA / CDS operating temperature to maintain required approach-to-saturation temperature
  - Reduces amount of water evaporated
- Requires operational and possibly design modifications for effective turndown
- At 100% natural gas, may be able to discontinue operation



Adiabatic Temperature vs. Fuel Mix



Adiabatic Temperature vs. Load



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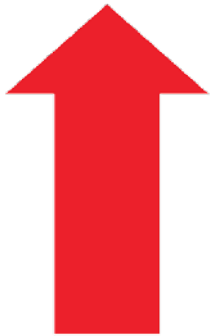
Impacts from Firing NG – SO_2 Control (Wet FGD)

- Parameters that Decrease
  - Reagent demand (e.g., limestone)
  - Oxidation air demand
  - TSS concentration and particle size

- Parameters that Increase
  - Saturated Gas & FGD Liquor Temperatures
  - pH
  - Concentration of trace metals, carbonate, TDS and chlorides



Impacts from Firing NG – SO_2 Control

Wet FGD

- Saturation Temperature
  - ≤ 140°F: analysis required to determine change
  - > 140°F: materials of construction & thermal expansion (pipe, mist eliminator, pH/r loop)
- 100% natural gas
  - Can turn down / off, but …
    - ✓ Operate recycle pumps
    - ✓ Equilibria shift, limestone precipitate
    - ✓ Gypsum may become unsaleable
    - ✓ Residence / response time

Impacts from Firing NG – SO_2 Control

Wet FGD – Recycle Pumps

- During co-firing:
  - Lower percent SO_2 removal allows reduction in number of pumps running

- During 100% natural gas firing
  - At least two pumps should be run to ensure the flue gas is adequately cooled should one fail
  - The pumps delivering fluid to the lowest levels should be run to save the most power

$$\frac{P_1}{P_2} = \left(\frac{H_1}{H_2}\right)^{1.5}$$

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Impacts from Firing NG – SO_2 Control

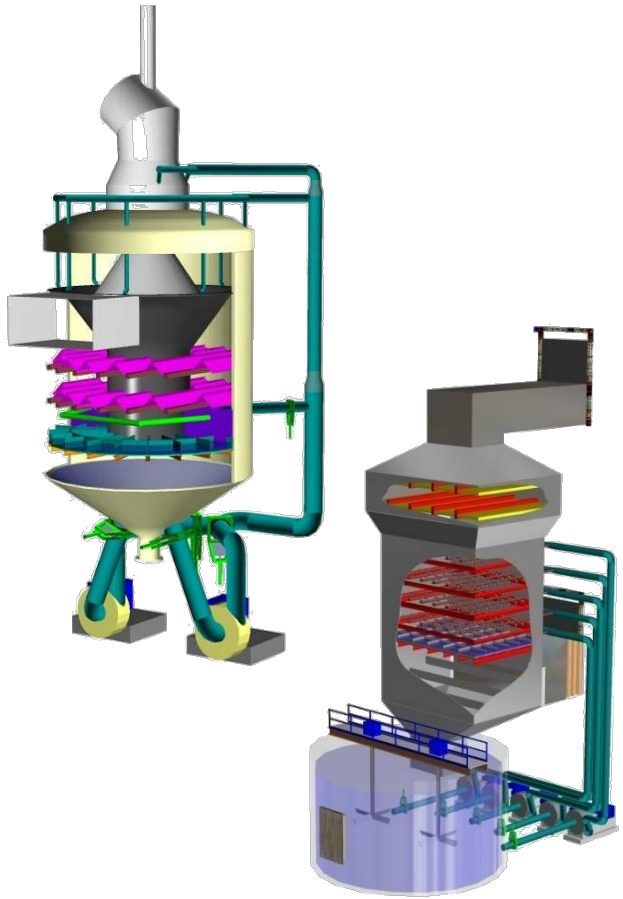
Wet FGD

- Water Balance
  - Increased moisture content in flue gas will reduce evaporation rate in the absorber
  - Evaporation rate may decrease such that ME wash water must be reduced
  - ME fouling could be an issue in the case of prolonged low-load operation

Impacts from Firing NG – SO_2 Control

Wet FGD -Is a purge stream necessary?

- Pros:
  - Prevents accumulation of dissolved solids
  - Prevents calcium carbonate scaling
  - Provides a feed to biological WWT
- Cons:
  - Necessitates new control loop(s)
  - Exposes downstream equipment to increased slurry temperatures
  - May increase Hg re-emissions from absorber
  - Purge stream must be treated to permitted limits



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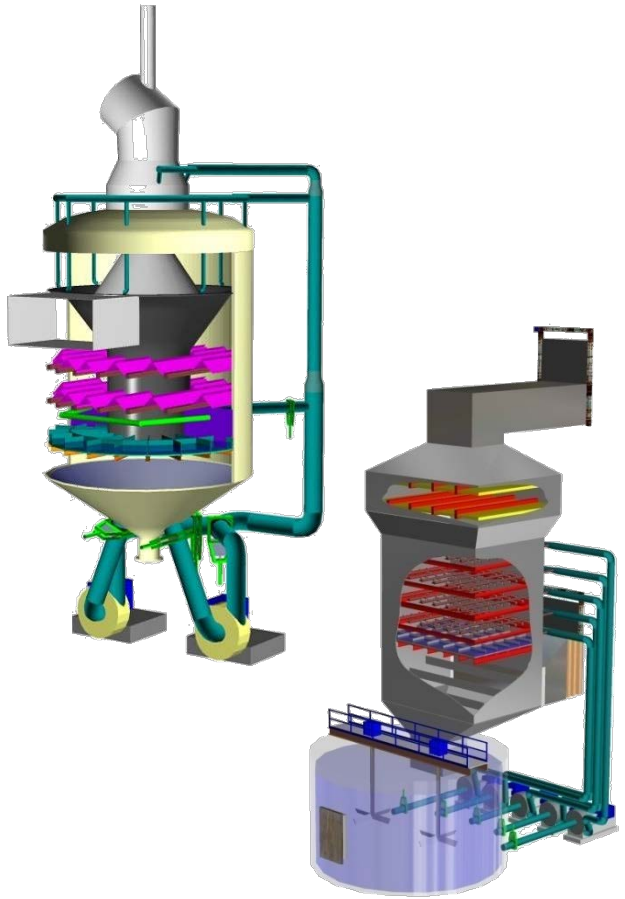
Impacts from Firing NG – SO_2 Control

Wet FGD – Purge Stream

- Considerations for gas-only operation w/out a purge stream:
  - Recirculate existing slurry for an extended period
  - Reduce pH (near end of the coal burn period), could cause corrosion issues
  - Drain the reaction tank and operate with only water



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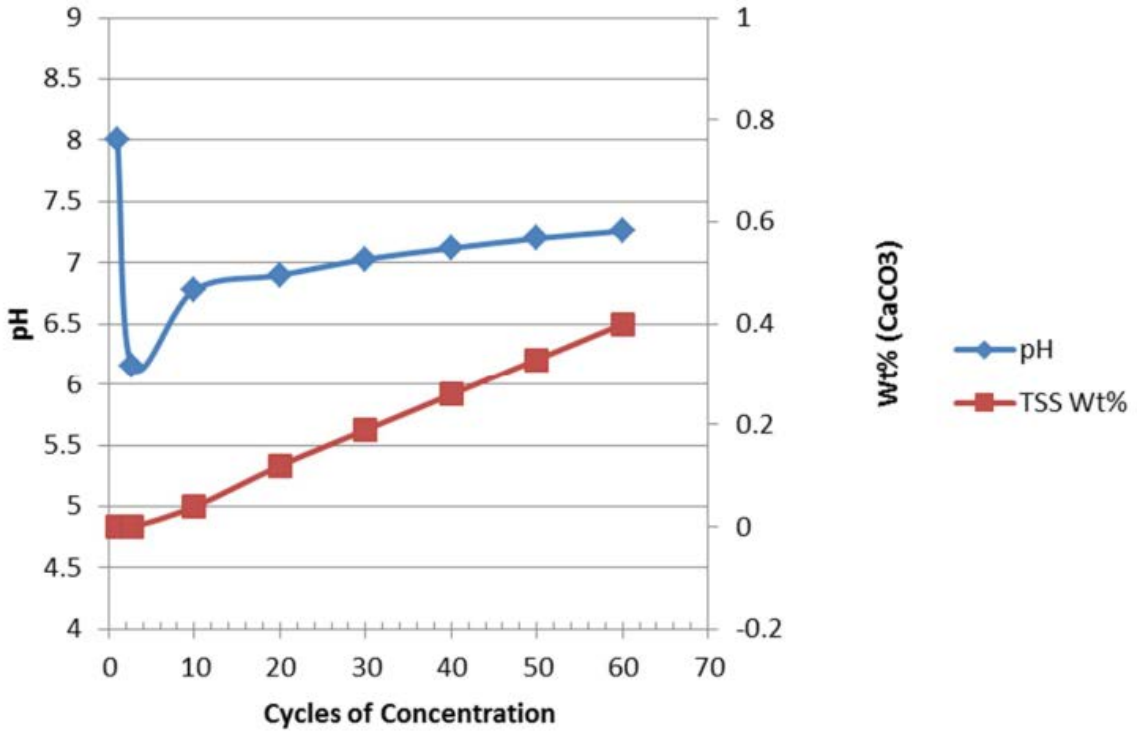
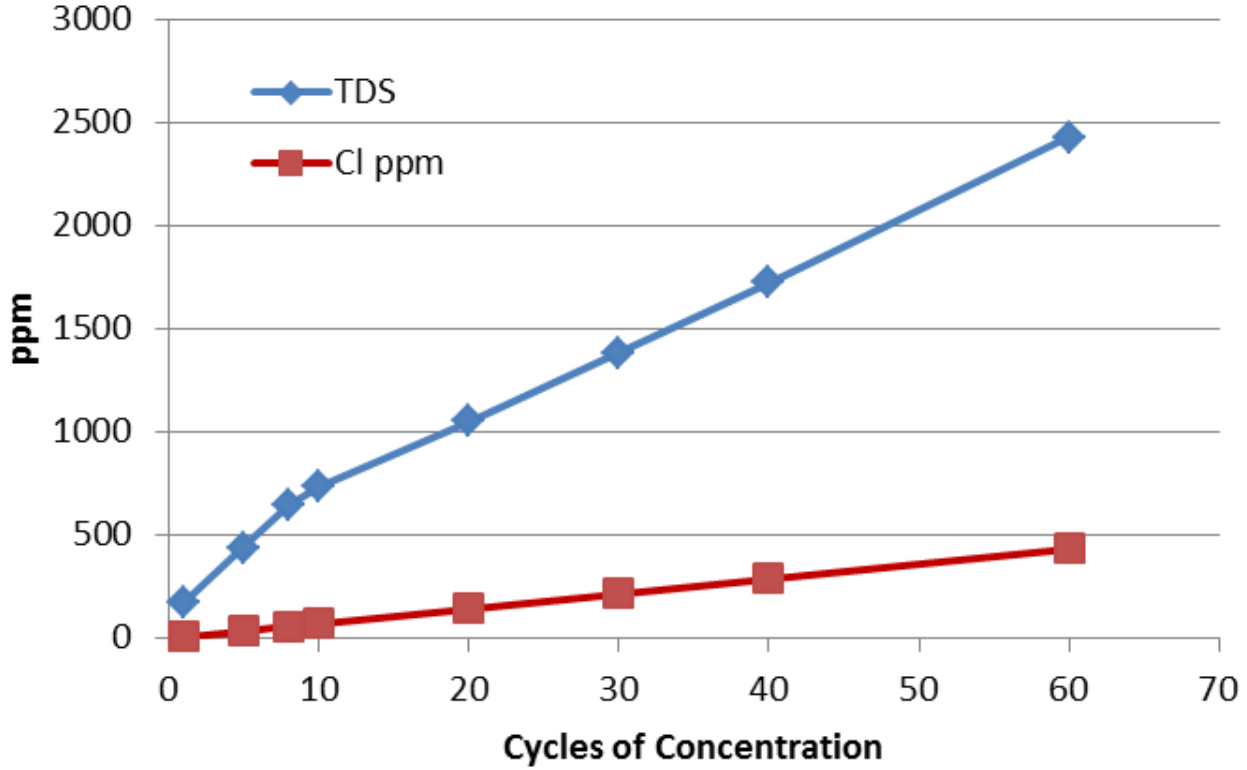
100% Gas Impact on pH & Carbonates in Wet FGD Liquor



100% Gas Impact on TDS & Chlorides in Wet FGD Liquor



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Impacts from Firing NG – SO_2 Control

Wet FGD - Gypsum

- 50% NG: Gypsum quality should be maintained
  - Gypsum production rate will be reduced
- Gas-only will
  - Extend solids residence time in the absorber
  - Crystal structure should be monitored via PSD/microscope/settling tests
    - May need to be harvested from another absorber
  - Belt filters need not be operated during extended periods of 100% NG
  - Dewatering (HC not effective @ low TSS)

Impacts from Firing NG – wFGD Component Temperature Limitations

Wet FGD/Dewatering

- Increased flue gas adiabatic saturation temperatures increase absorber slurry temperatures
- FGD and downstream gypsum production and wastewater treatment components should be evaluated
- Particular attention should be given to HDPE piping and other components with plastic construction
    - Instrument isolation valves can sometimes be plastic

Impacts from Firing NG – wFGD Component Temperature Limitations

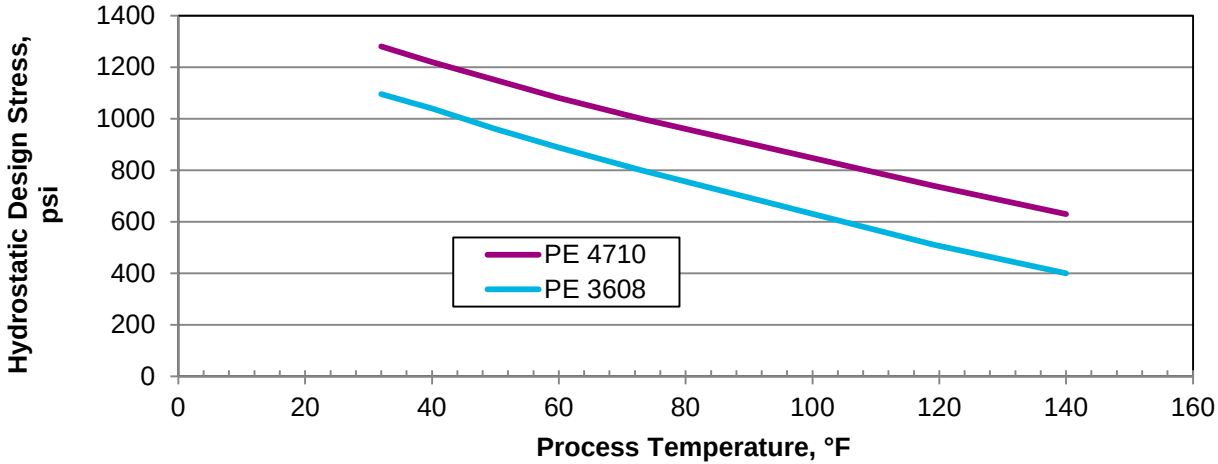
Wet FGD/Dewatering Equipment

- Lowest recommended maximum temperature (for one site)
  - Gypsum belt filter - 140°F
  - Hydrocyclone - 140°F
- Check mist eliminator material of construction
- There are mitigation strategies available to preclude equipment replacement
- All other equipment was found to be acceptable up to ≥150 °F (for one site)

Impacts from Firing NG – wFGD Component Temperature Limitations

HDPE Piping

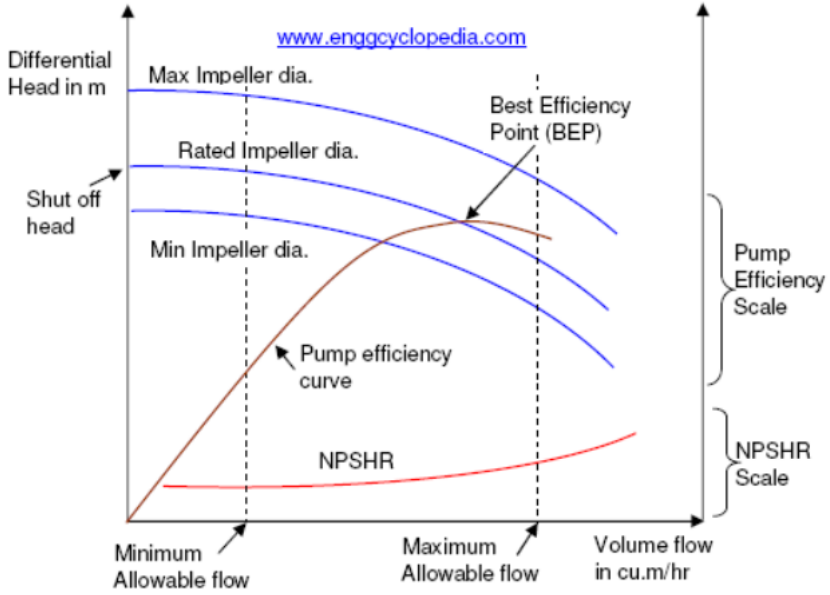
- Increased absorber slurry temperatures reduce HDPE pressure ratings
- Use of 3608/4710 HDPE not recommended for pressure service above 140°F



Impacts from Firing NG – wFGD Component Temperature Limitations

HDPE Piping

- Need to make a decision about what lines will see increased temperatures
- Piping downstream of some pumps may need to be replaced
- Piping should be analyzed at:
  - Pump dead head or shut off head
  - Maximum feed tank level
  - Maximum fluid specific gravity
- Increased impeller diameter or pump speed can be considered but may be prohibitive



Impacts from Firing NG – wFGD Component Temperature Limitations

HDPE Piping

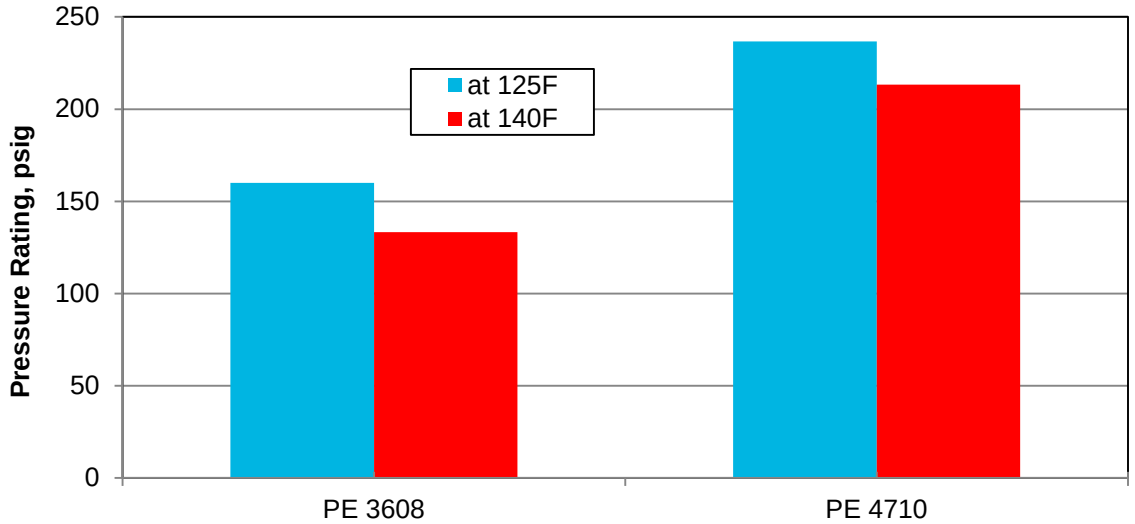
$$PR = \frac{2\,HDS\,f_E\,f_T}{(DR-1)}$$

PR – Pressure Rating, psig

f_E – Environmental Factor (for hydrocarbon service)

f_T – Temperature Factor

DR – Dimension Ratio



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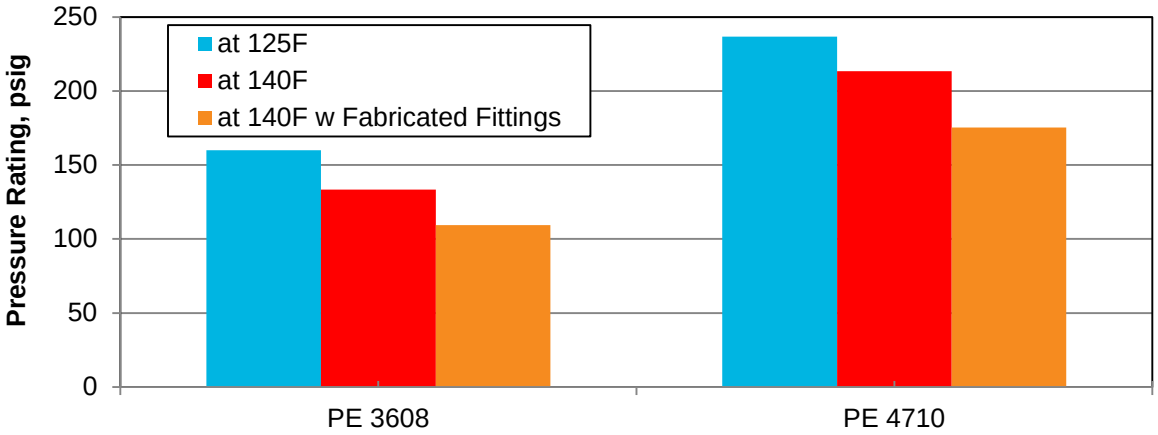
Impacts from Firing NG – wFGD Componen‡ Temperature Limitations

HDPE Piping

- Fabricated fittings will further reduce pressure ratings due to modified geometry
- Typically, thicker fittings will be used to avoid this pressure de-rate but this is not possible with DR-7.3



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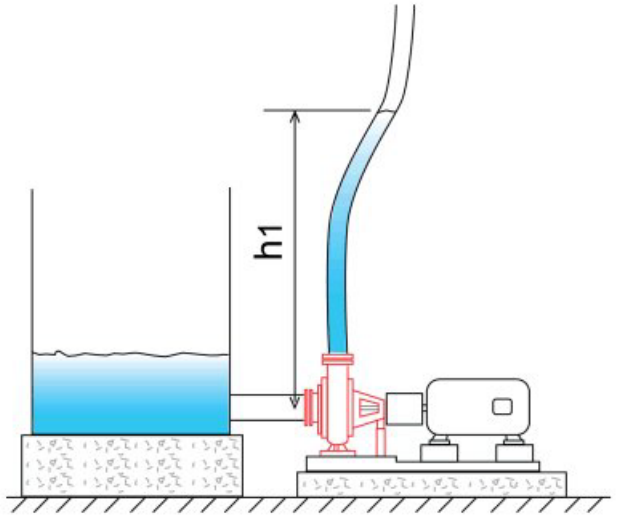
Impacts from Firing NG – wFGD Component Temperature Limitations

HDPE Piping

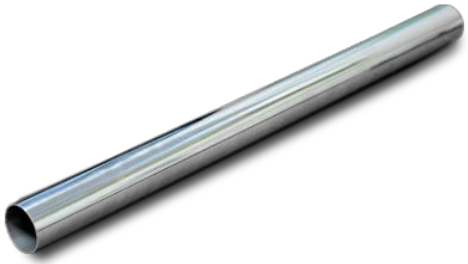
- With smaller bore DR-7.3 piping, a re-rate may be possible based on lack of fabricated fittings in existing lines
- Additionally, existing piping may remain in service if the elevation rises such that pressure rating is acceptable
    - Important for hydrocyclone feed piping and other lines with significant elevation changes



Impacts from Firing NG – wFGD Component Temperature Limitations

Other Piping

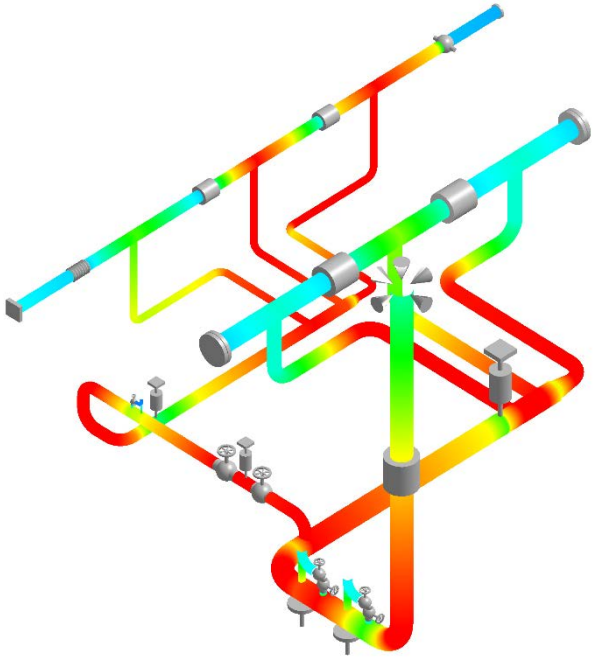
- Likely no issues with FRP
  - FRP maximum temperature often ≥180°F
  - Some mechanical degradation may occur above 150°F
- Metallic piping pressure rating likely too high to
  - Most CS and SS show no mechanical degradation until ≥300°F
- Coal-firing temperature likely already too high for PVC



Impacts from Firing NG – wFGD Component Temperature Limitations

Pipe Stress Analysis

- Issues may arise from additional vertical/horizontal thermal growth of piping or the absorber
- HDPE likely to not have pipe stress issues due to stress relaxation properties
- Original design temperatures/pipe stress analyses should be checked and compared to new temperature
- Ductwork/Piping expansion joint travel should also be confirmed



Impacts from Firing NG – wFGD Component Temperature Limitations

Case Study – What components need to be replaced?

- Began by analyzing the process
  - Determined that relevant scope extended to belt filters
  - Wash water would mitigate temperature increase due to NG firing
- Reached out to vendors for maximum recommended equipment/valve temperatures – often difficult to find if vendor has been purchased!
- Estimated line design pressures and compared to pipe thickness / pressure allowable by code
- For HDPE, back-calculated maximum recommended pressure based on line pressure
- Site visit performed by AECOM mechanical engineer

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Impacts from Firing NG – wFGD Component Temperature Limitations

Case Study – What components need to be replaced?

- No equipment was found as needing to be replaced
- Needed to be replaced:
  - A couple instrument isolation valves were found to be inadequate
  - HDPE piping downstream of the primary and secondary hydrocyclone pumps
- Strategies were available to mitigate replacement
- Replacement was chosen so recommendations were made on the elevation to which the pipe must be replaced
- Pipe only needed to be replaced up to 12’ above grade

Summary
For Dual Fuel Operation

- Every AQCS unit operation is impacted – competing effects of firing NG
- Plant Changes
  - Consider materials of construction
  - Add turndown capability
  - Add controls to maintain temperature within design limits or make modifications
  - Dewatering/Wastewater Treatment System performance may be affected
- Operational Changes
  - Add/Enhance process control for extended operating range
- *Every plant is unique* and requires an individual assessment to determine specific impacts and associated solutions

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