REINHOLD ENVIRONMENTAL ®

2023 Reinhold/PCUG Round Table Presentation

Cohosted by Duke Energy and Vistra in The Westin Hotel, Cincinnati, OH on June 26-27, 2023

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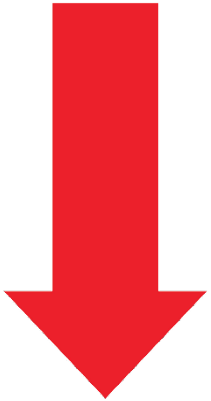
Operating Backend Equipment after a Gas Conversion

~~*Max Bernau, PE*~~
Sterling Gray, PE
AECOM

2023 Reinhold/PCUG Conference, Cincinnati OH
9:15 am
June 27, 2023

Impact of Replacing Coal with Natural Gas



- Flue Gas Parameters that Decrease or Go to Zero
  - NO_x, Hg, SO_2, SO_3, PM Concentrations
  - Flow rate (a small reduction, 3-5%)

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

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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

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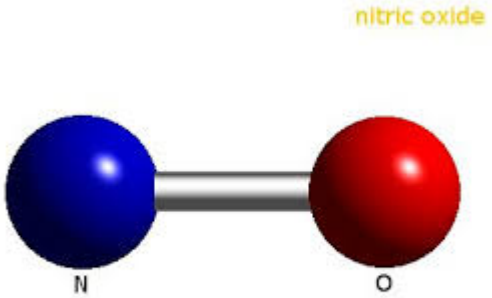
Impacts from Firing NG – NO_X

- NO_x is generated by the oxidation of atmospheric and fuel nitrogen
  - 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
  - Reduced nitrogen in the fuel

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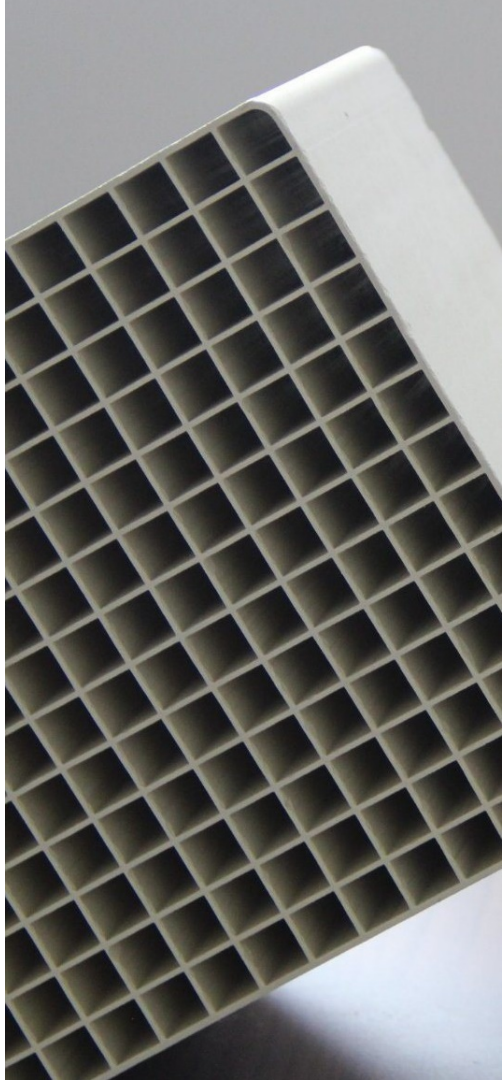
Impacts from Firing NG – NO_x Control

- Impact on SCR Minimum Operating Temperature (MOT) at low load
  - Reduction or lack of SO_3 will ease MOT constraint
  - Allows reduced economizer bypass improving heat recovery
  - Work with *catalyst* vendor to determine impact of dual fuel operation (NOx and SO_3 levels) on MOT



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Impacts from Firing NG – NH_3 Rate

- NH_3 injection rate will need to be reduced due to:
  - Increased boiler turndown
  - Reduced inlet NO_X
- NH_3 turndown can be ≥ 10x design
- Requires feed system modifications
  - Anhydrous ammonia control valve may need to be replaced
  - Valve is typically small so should not be a large cost impact
  - May also need to look at ammonia flow measurement depending on technology used

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Impacts from Firing NG – PM Control

- PM control device can be bypassed or shut off
- May bypass baghouse or run through and de-energize ESP
- If bypass duct does not exist, contact vendor about removing bags
- May need to consider reduced system dP at low loads

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Impacts from Firing NG – ID Fans

ID Fans

- Likely impact will be minimal at full load assuming particulate and FGD equipment are still in line/operated
- ID fans may become limiting factor for boiler turndown unless capacity control is included
- Boiler turndown to 25% will likely be in very low efficiency regime for centrifugal fans
- Axial fans may have better efficiency

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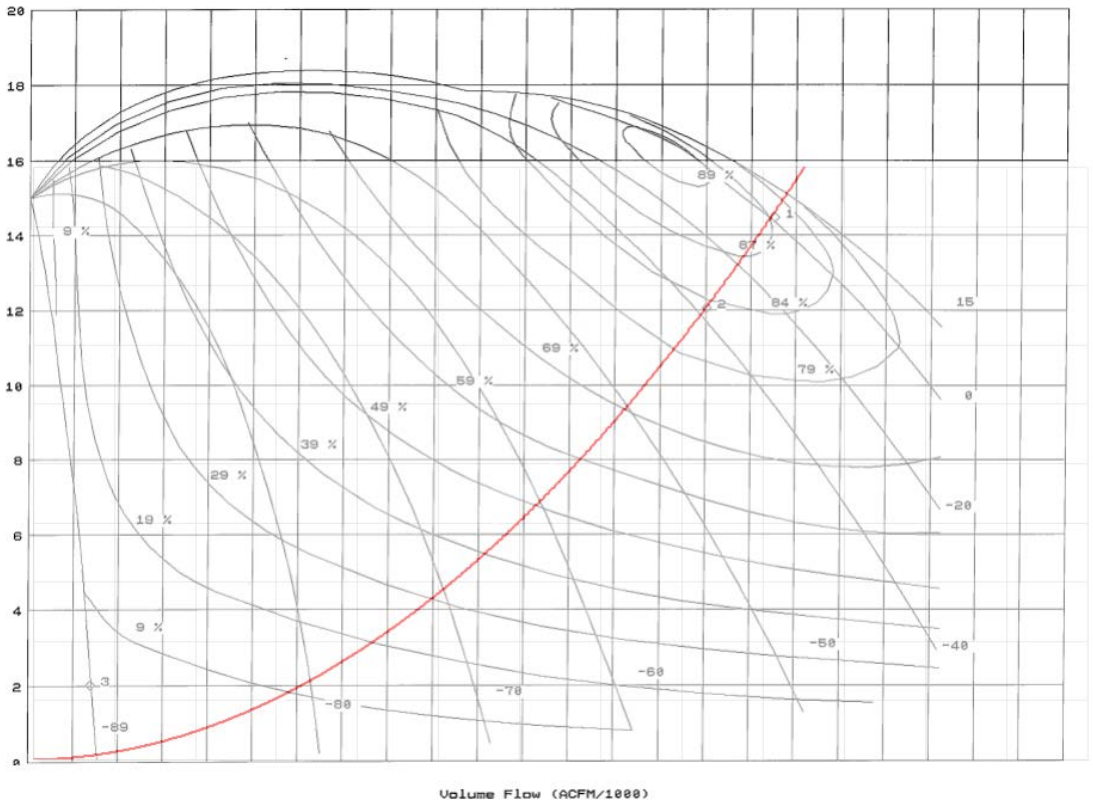
Centrifugal Fan Curve Comparison – with scrubber in-line



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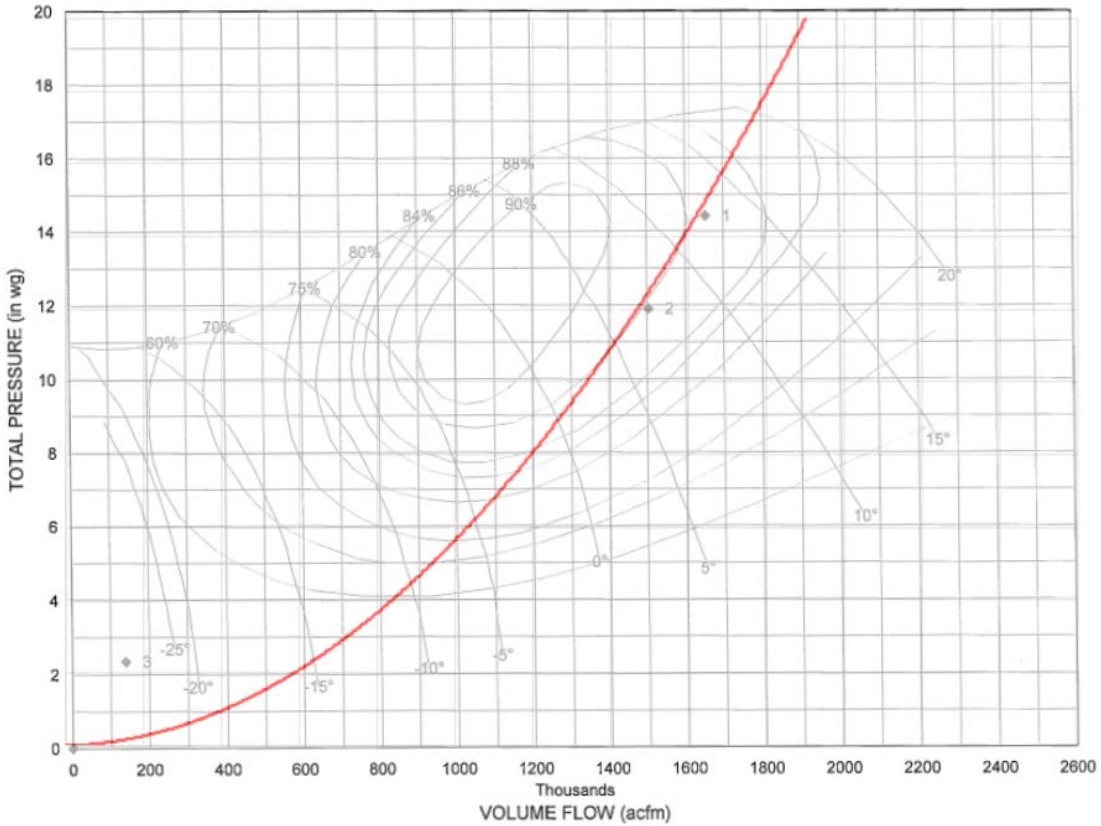
Axial Fan Curve Comparison – with scrubber in-line



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Impacts from Firing NG – ID Fans

ID Fans

- If FGD equipment will be bypassed, system dP may need to added back in to avoid fan modifications
- Methods include closing dampers or fan inlet vanes
- Cost-Benefit analysis required
  - Adding flow restrictions or closing existing dampers
  - Modifying ID fans (speed, wheel diameter)
  - Variable Frequency Drive (VFD)

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Impacts from Firing NG – SO_2 Control

Wet FGD Can turn down, but …

- ✓ Should operate recycle pumps
- ✓ FGD will act as cooling tower
- ✓ Gypsum will not be created

- During 100% natural gas firing
  - At least two pumps should be run to ensure the flue gas is adequately cooled should an air preheater failure occur
  - The pumps delivering fluid to the lowest levels should be run to save the most power
  - Operating FGD will help ID fan operate closer to design point

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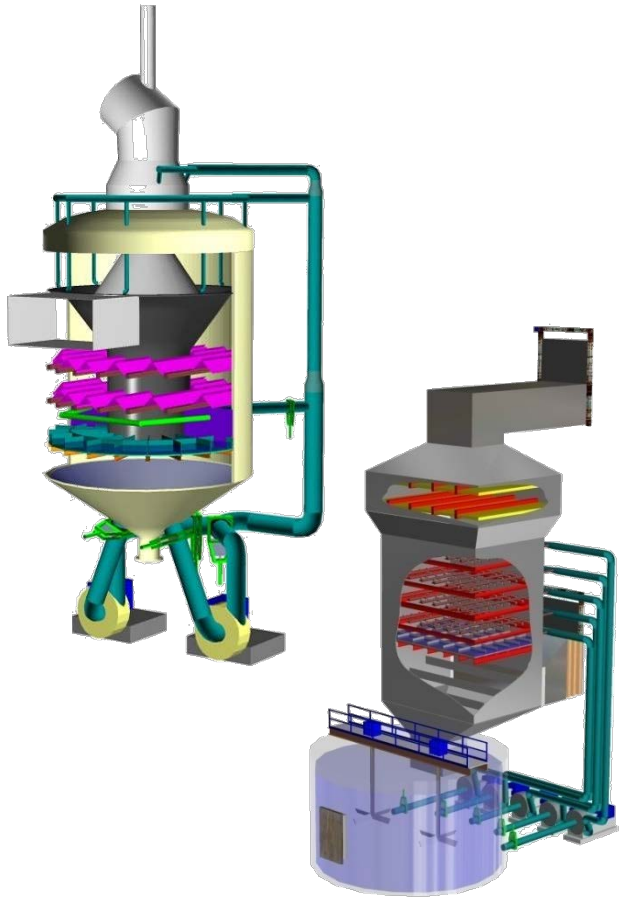
Impacts from Firing NG – SO_2 Control

Wet FGD -Is a purge stream necessary?

- Possibly not for chloride-corrosion concern
- Will need to look at calcium carbonate scaling
- Impacts
  - Necessitates new control loop(s)
  - Exposes downstream equipment to increased slurry temperatures
  - Purge stream must be treated to permitted limits



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Impacts from Firing NG – Reduced PM Permit Level

Reduced permit levels for PM may drive need for purge stream

- TDS and TSS in mist eliminator carryover count towards PM emissions
- Analysis at an existing plant indicated that mist eliminator carryover constituted up to 10-50% of PM emissions during coal firing
- Reducing TDS and TSS via a purge stream will reduce emissions

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Impacts from Firing NG

Wet FGD

- Water Balance and Mist Eliminators
  - 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

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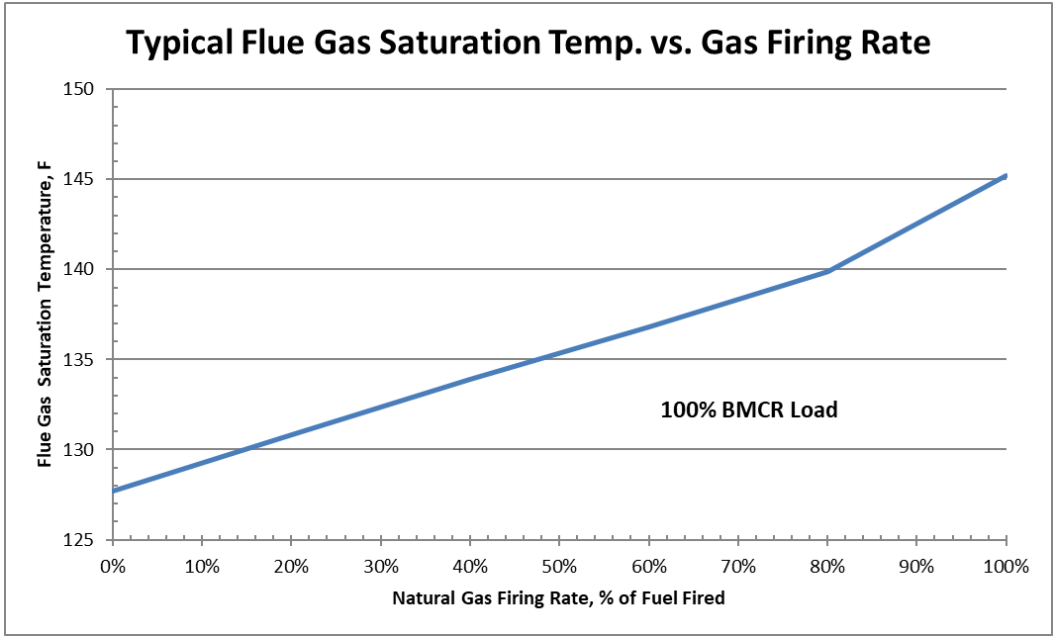
Impacts from Firing NG - Scrubber

Wet FGD

- Saturation Temperature
  - ≤ 140°F: analysis required to determine change
  - > 140- 150°F: materials of construction & thermal expansion (pipe, mist eliminator, pH/r loop) likely to be impacted



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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)

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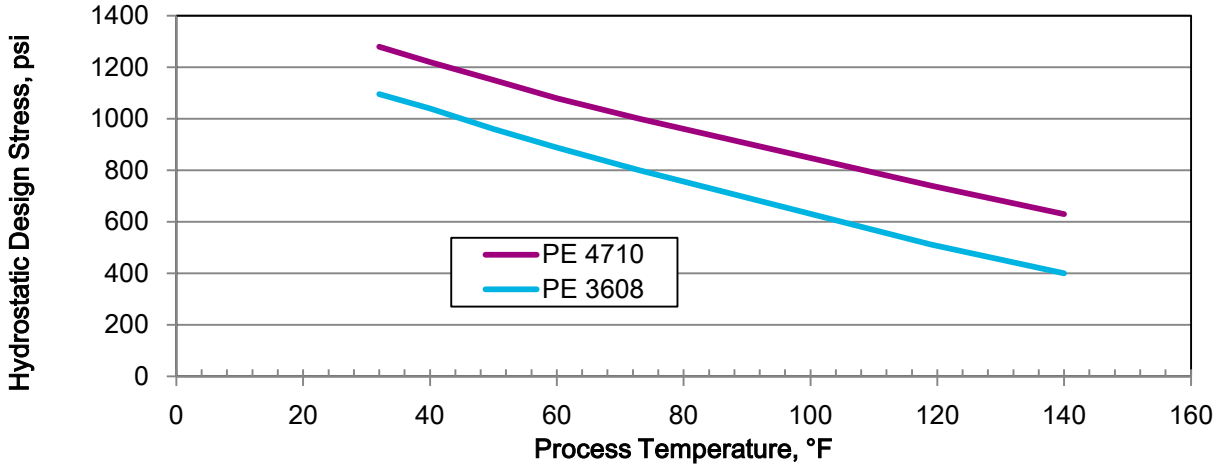
Impacts from Firing NG – WFGD Component Temperature Limitations

HDPE Piping

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



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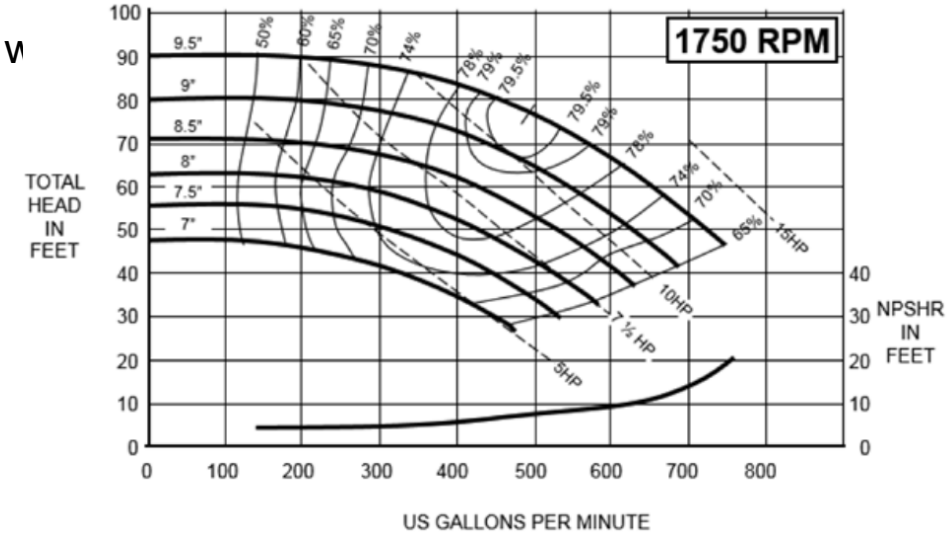
Impacts from Firing NG – WFGD Component Temperature Limitations

HDPE Piping

- Need to make a decision about what lines w 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
- Impeller diameter or pump speed changes can be considered but may be prohibitive



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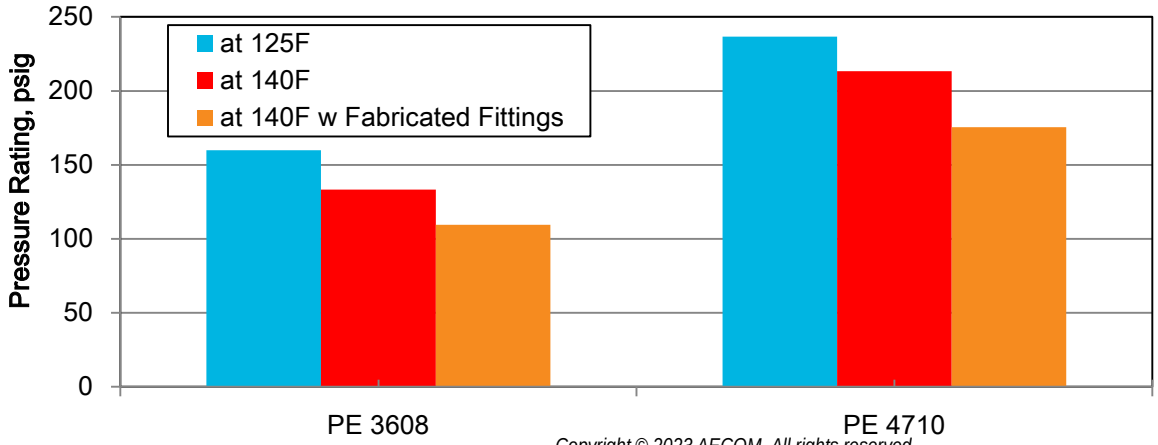
Impacts from Firing NG – WFGD Component Temperature Limitations

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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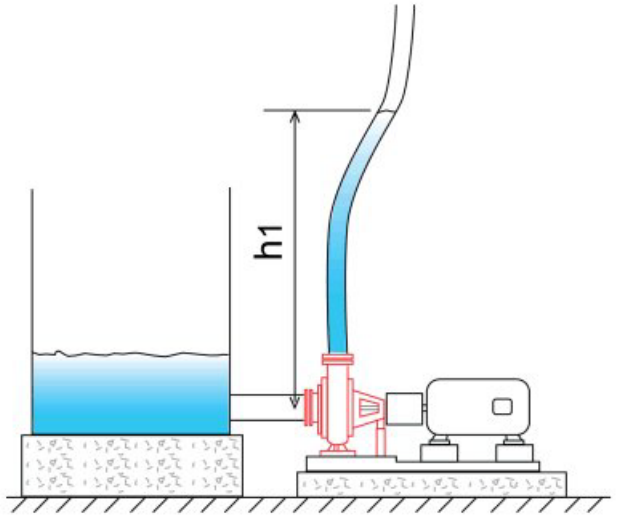
Impacts from Firing NG – WFGD Component Temperature Limitations

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



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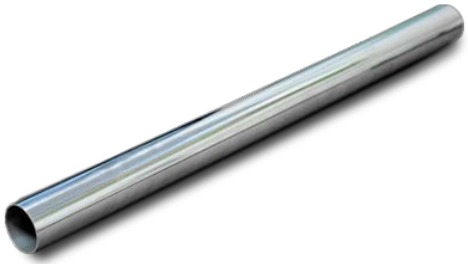
Impacts from Firing NG – WFGD Component Temperature Limitations

Other Piping

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



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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:
  - HDPE piping downstream of the primary and secondary hydrocyclone pumps up to 12’ above grade

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Impacts from Firing NG – Stack Liner Limitations

FRP stack liners may require operation of FGD

- Operating without WFGD may cause FRP blistering
- One vendor cited maximum operating temperature of 300°F
  - Maximum excursion of 400°F for two hours
- Air preheater failure would seriously damage FRP stack liner if the scrubber were bypassed or not operated
- Some plants include emergency quench at scrubber inlet to protect against air preheater failure

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Summary

For Conversion to 100% Natural Gas Operation

- Every AQCS unit operation is impacted
  - Fans may limit turndown capability
  - Scrubber probably still needs to be operated
  - Water balance requirements will change
  - Consider materials of construction

Every plant is unique and requires an individual assessment to determine specific impacts and associated solutions

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