REINHOLD ENVIRONMENTAL Ltd.

2019 REINHOLD Round Table Presentation

June 24 & 25, 2019, in Birmingham, Alabama / Hosted by Southern Company

Duke Energy Dual Fuel

Cliffside Natural Gas Firing Update





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Dual Fuel Cliffside Project Engineer
Cliffside Station System Owner

AGENDA

- ❑Goals of the Program
- ❑Projects Status
- ❑Program Overview – Unit Designs
- ❑Cliffside Installation
- ❑Cliffside Commissioning
- ❑Cliffside Lessons Learned
- ❑Cliffside Testing

Program Goals

Increase fleet flexibility to adapt to renewables

- Lowered Unit Minimum Load
- Increased Unit Ramp Rates

Reduce environmental footprint

- Reduced CO2
- Reduction in Fuel Oil usage and handling

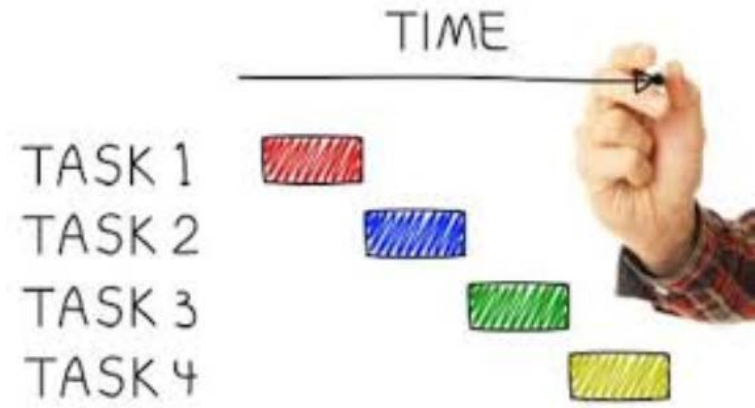
Deliver savings to our customers

- Option to utilize lowest cost fuel on a daily basis
- Drive competition

Projects Status

Cliffside

- Approved July 2016
- Feb 2018 - Engineering Complete
- Mar 2018 - Construction Start
- Unit 5 - Nov 2018 In Service Date
- Unit 6 - Dec 2018 In Service Date
- Unit 5 – Mar 2019 Performance Testing Complete
- Unit 6 – May 2019 Performance Testing Complete
- Firing Natural Gas or Coal based on Economics



Belews Creek

- Approved Aug 2017
- Oct 2017 – Engineering kick-off
- Nov 2018 – Engineering Complete
- June 2019 – Construction ~ 30%
- Unit 1 – Jan 2020 In Service Date
- Unit 2 - Jan 2021 In Service Date

Marshall

- Approved Dec 2017
- Feb 2017 – Engineering kick-off
- June 2019 – Engineering ~ 90% complete
- Units 3 & 4 – Fall 2020 In Service Date
- Units 1 & 2 – Year End 2021 In Service Date

Cliffside Unit 5

Unit Design

- Commercial in 1972
- 600 MWg
- Combustion Engineering Boiler
- 4 Corner T-Fired
- 24 coal burners
- 2400 psig (Sub-Critical)
- 1005 F SH / RH
- 100% MCR Heat Release 5910 r

- SOFA
- CCOFA
- LOFIR

Environmental Controls include

- Selective Catalytic Reduction (SCR)
- Electrostatic Precipitator
- Wet Flue Gas Desulfurization (WFGD)

Cliffside Unit 5

Gas System Design

- 40% Gas Capacity
- 2 Levels of Wafer Style Gas Burners
  - Located in Auxiliary Air Ports
- Each Burner Heat Release = 271 mm BTU/hr
- 1 Level of Wafer Style Ignitor for LOFIR level
  - Located in Auxiliary Air Port
- Each Ignitor Heat Release = 40 mmBTU/hr
- Goal is to operate with 2 Gas Levels and 4 Coal levels in service at Full load if doing 40%
- When U6 operating at full load – only 10% available

Gas Emissions Targets @ MCR (60/40 co-fire)

- NOx < Baseline
- CO < 0.08 lb/mmBTU
- 2170 mmBTU/hr Heat Input from Gas (40%)
- Baseline Excess Air (3% O3 wet)

[6/19/2019 9:20 AM] Rizzo, Mark J:
U6 Steam Flow - 5,952,000 lb/hr; EA - 17%, NOX - 0.25 lb/mmbtu; CO - 0.037 lb/mmbtu; VOC - 0.0023 lb/mmbtu

Cliffside Unit 6

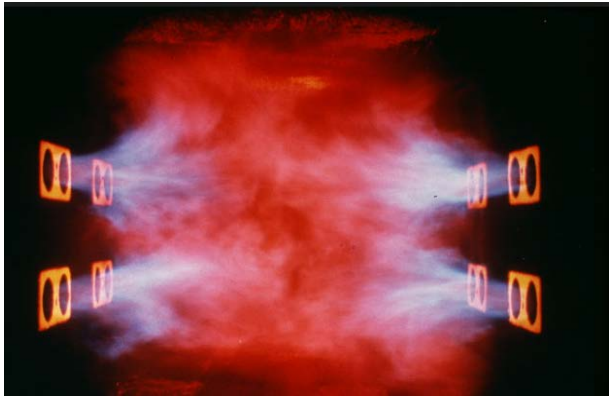
Unit Design

- Commerical in 2012
- 905 MWg
- Hitachi Boiler
- Opposed Wall Fired Spiral Furnace
- 30 coal burners / 3 Elevations per Wall
  - Full load on 25 burners
- 3700 psig (Super-Critical)
- 1055 F SH / 1075 F RH
- Each Burner Heat Release = 320 mmBTU/hr

- OFA
- Side Air Ports

Environmental Controls include

- Selective Catalytic Reduction (SCR)
- Spray Dryer Absorber (SDA)
- Fabric Filter
- Wet Flue Gas Desulfurization (WFGD)



Gas System Design

- 100% Gas Capacity
- 30 Gas Burners / 3 Elevations per Wall
  - 28 burners needed for full load
- Each Burner Heat Release = 263 mmBTU/hr

- Cane style gas burner located in Secondary Air Plenum of existing coal burners
- 1 Gas Flow Control Skid per burner level (Qty 6)

- Gas Targets:
  - NOx < 0.25 #/mmBTU,
  - CO < 0.037 #/mmBTU
  - VOC < 0.0023 #/mmBTU
  - Excess Air < 17%
  - MCR, 100% Natural Gas

Belews Creek Units 1 & 2

Unit Design

- 1170 MWg
- Opposed Wall Fired
- 80 coal burners / 4 Elevations per Wall
  - Full load on 72 burners
- 3500 psig (Super-Critical)
- 1005 F SH / RH
- 100% MCR Heat Release = 10,590 mmBTU/hr
- OFA

Gas System Design

- 50% Gas Capacity (~70% with ignitors)
- 32 Gas Burners / 2 Elevations per Wall
- Each Burner Heat Release = 171 mmBTU/hr
- Cane style gas burner located in Secondary Air Plenum
- 1 Gas Pressure Control Skid per burner level (Qty 4)
- Goal is to operate with 4 gas levels and 4 pulverizer burner sets in service at full load
- Replacing fuel oil ignitors with natural gas ignitors on remaining 48 burners = 50 mmBTU/hr

NOx Target < Baseline CO Target < 0.015 lb/mmBTU

Marshall Units 1 & 2

Unit Design

- 370 MWg
- 8 Corner T-Fired
- 40 coal burners
- 2400 psig (Sub-Critical)
- 1050 F SH / 1000 F RH
- 100% MCR Heat Release = 3885 mmBTU/hr

- SOFA
- CCOFA

Gas System Design

- 40% Gas Capacity
- 2 Levels of Wafer Style Gas Burners
  - Located in Auxiliary Air Ports
- Each Burner Heat Release = 90 mmBTU/hr
- 1 Gas Pressure Control Skid per unit
- 1 Level of Wafer Style Ignitor for LOFIR level
  - 18 mmBTU
  - Located in Auxiliary Air Port
- When Units 3 & 4 are utilizing maximum gas only 10% available for use on 1 & 2
- 40% capacity provides flexibility for times when 3 & 4 are at reduced load or possibly offline

NOx Target < Baseline CO Target < 0.015 lb/mmBTU

Marshall Units 3 & 4

Unit Design

- 700 MWg
- 8 Corner T-Fired
- 48 coal burners
- 3500 psig (Super-Critical)
- 1007 F SH / 1000 F RH
- 100% MCR Heat Release = 6930 mmBTU/hr

- SOFA
- CCOFA
- LOFIR

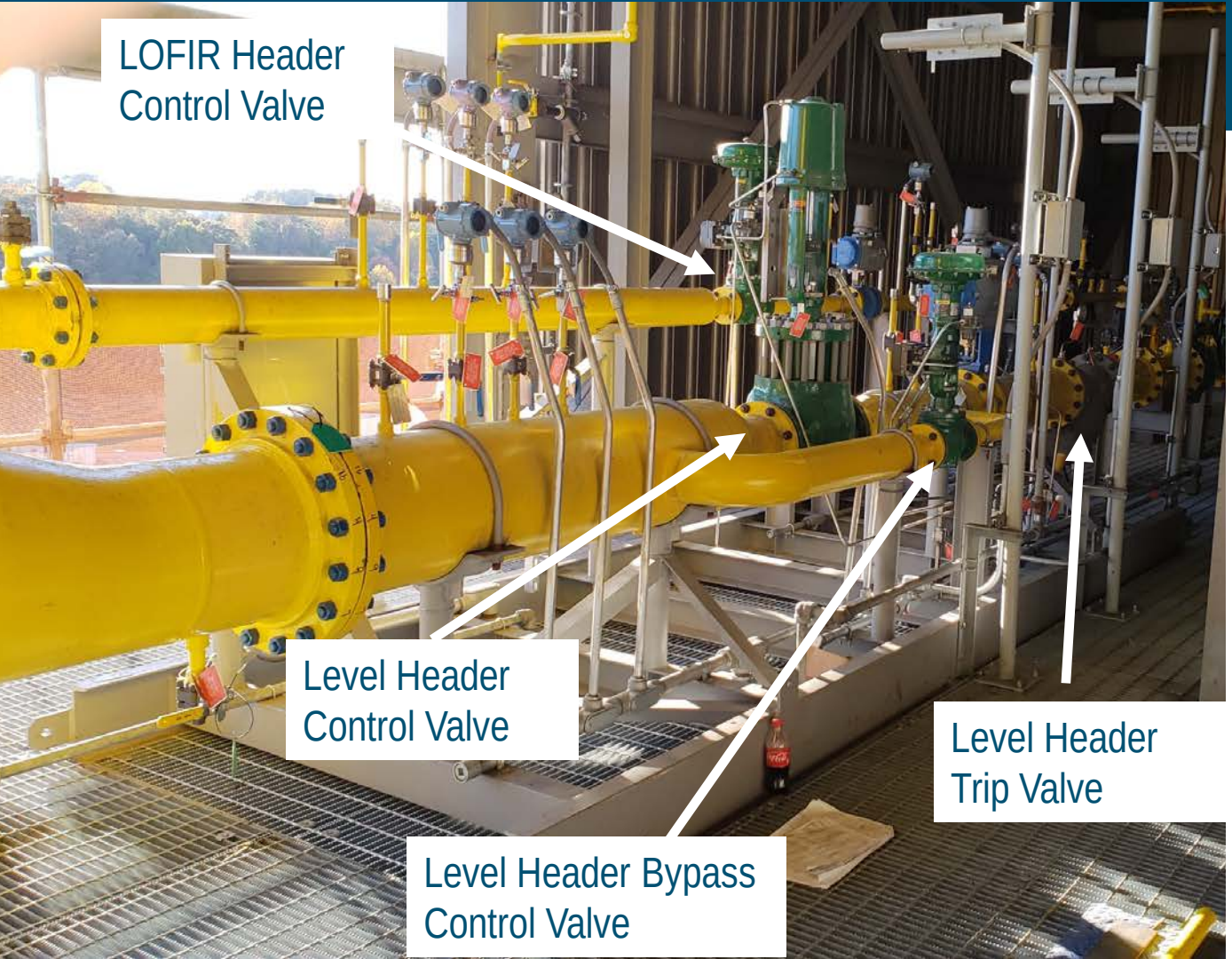
Gas System Design

- 50% Gas Capacity
- 2 Levels of Wafer Style Gas Burners
  - Located in Auxiliary Air Ports
- Each Burner Heat Release = 212 mmBTU/hr
- 1 Gas Pressure Control Skid per burner level (2)

- 1 Level of Wafer Style Ignitor for LOFIR level
  - 42 mmBTU/hr
  - Located in Auxiliary Air Port

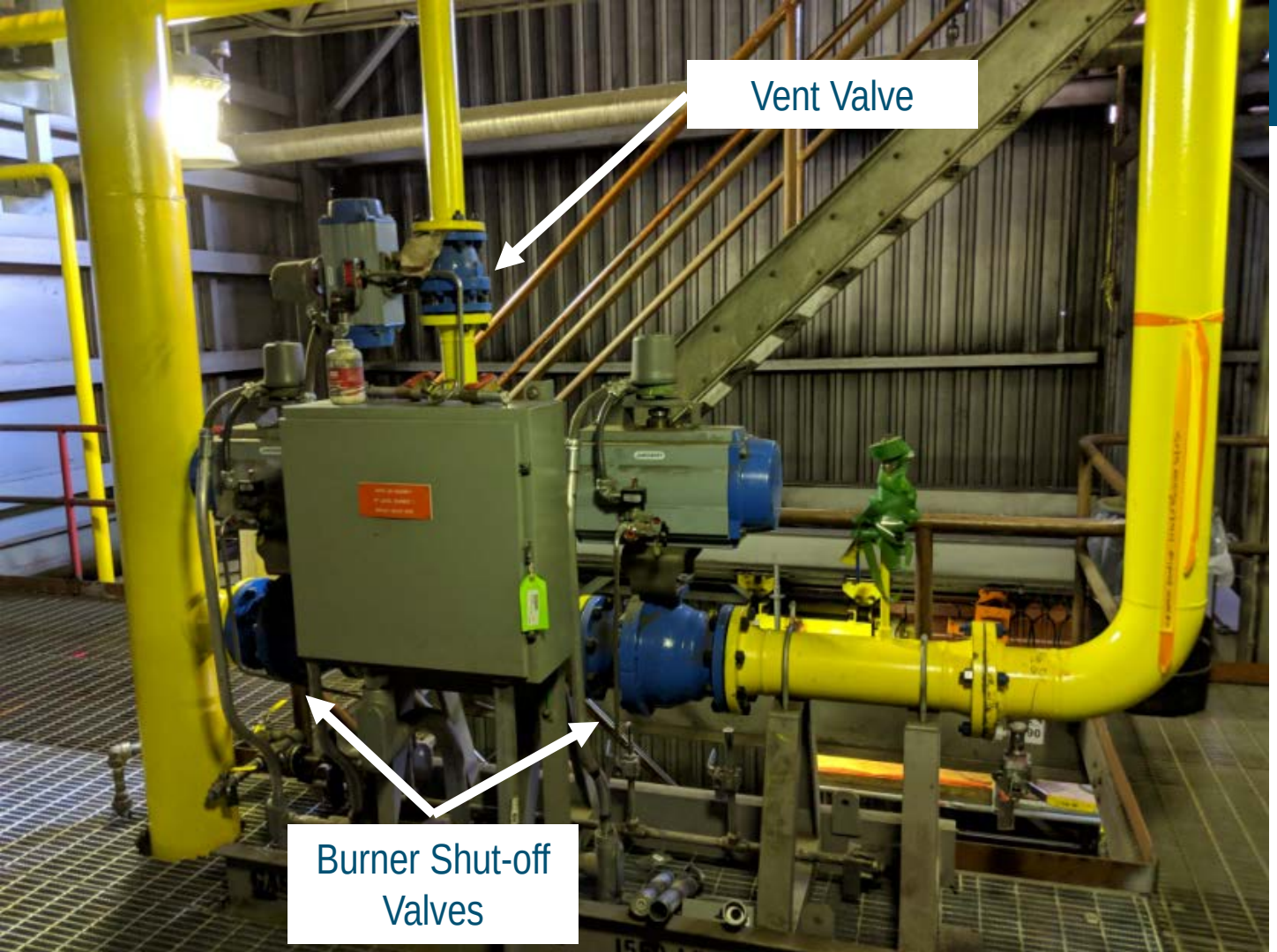
- Goal is to operate with 2 Gas Levels and 4 Coal levels in service at Full load

NOx Target < Baseline CO Target < 0.015 lb/mmBTU



Cliffside Unit 5

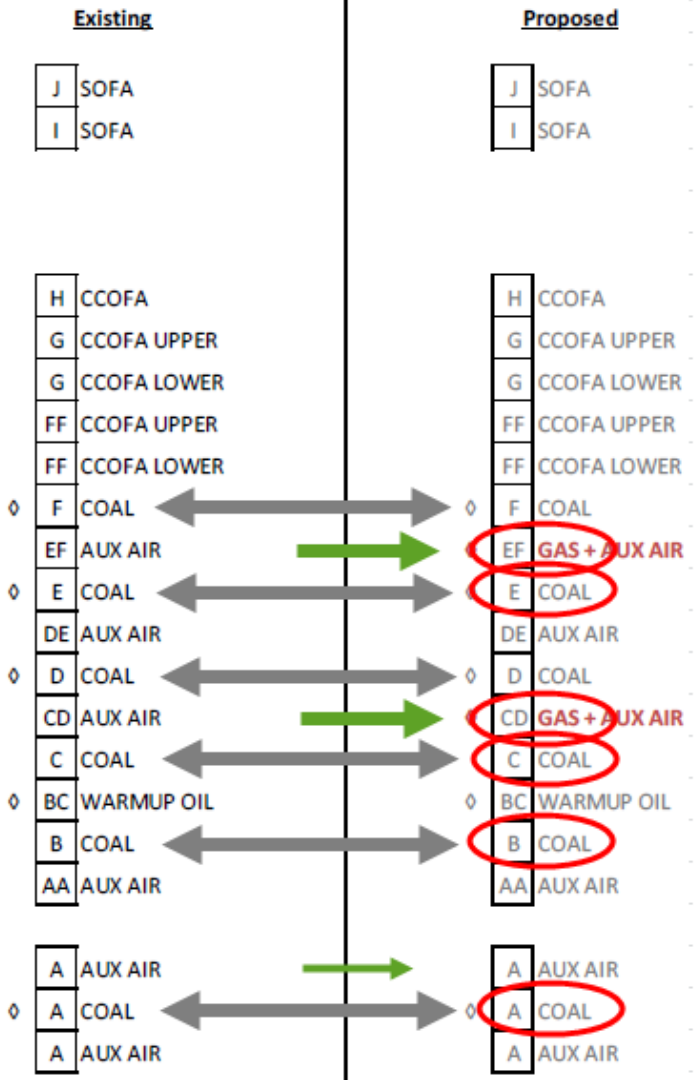
Fuel Control Skid



Cliffside Unit 5

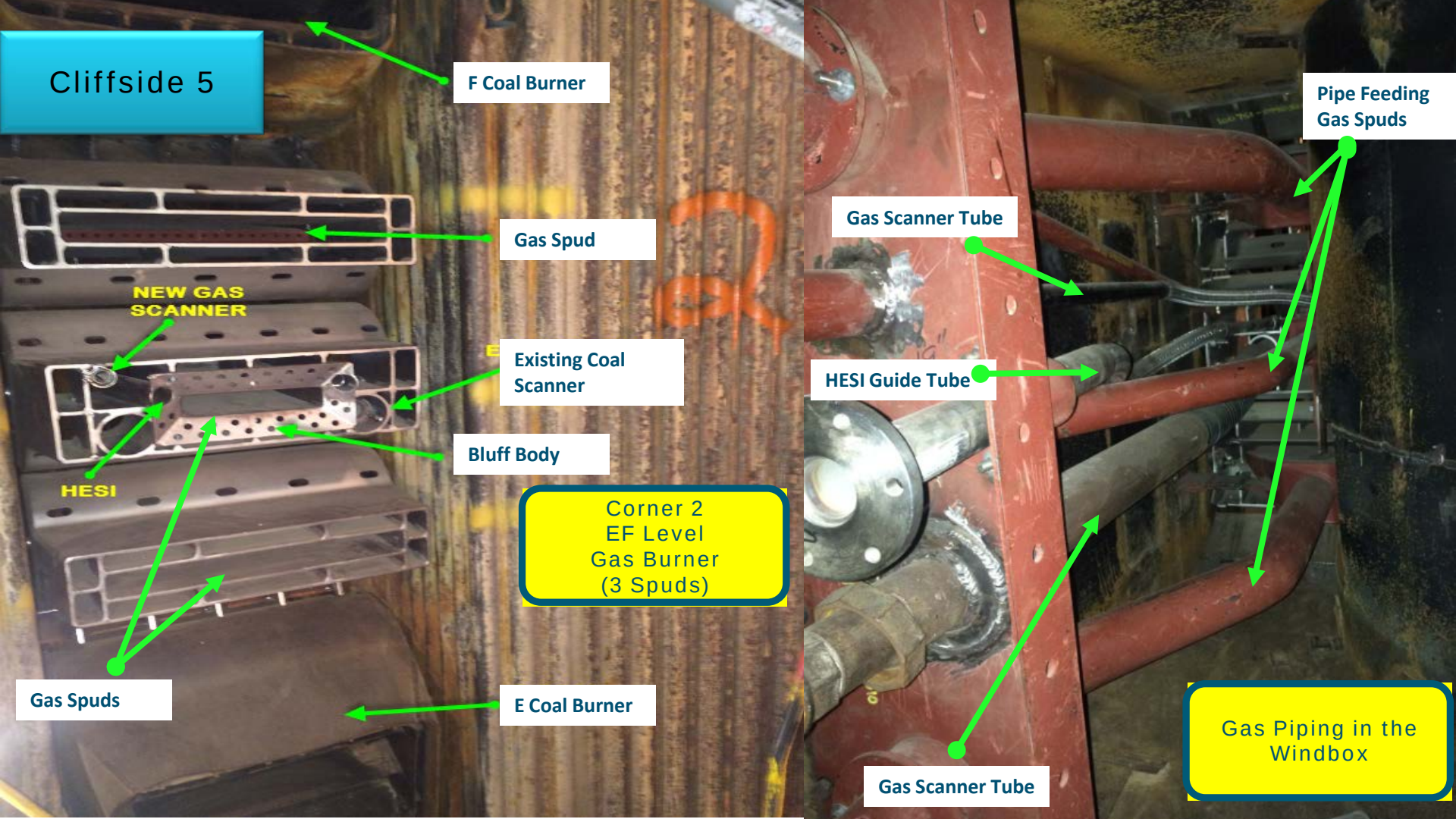
Burner Shut-off Skid

CS 5 Burner Elevations



- Gas Levels interspersed between Coal Levels
  - Based on modeling results to control temperatures and heat flux
  - Provides Gas ignition source for coal burners
  - Wafer Style gas ignitor for A Coal Burner

- Optimum Firing Arrangement
  - 2 Gas Levels In Service - CD and EF
  - 4 Coal Pulverizers In Service
    - A and B
    - Select 1 C or D
    - Select 1 E or F based on Temperature Control

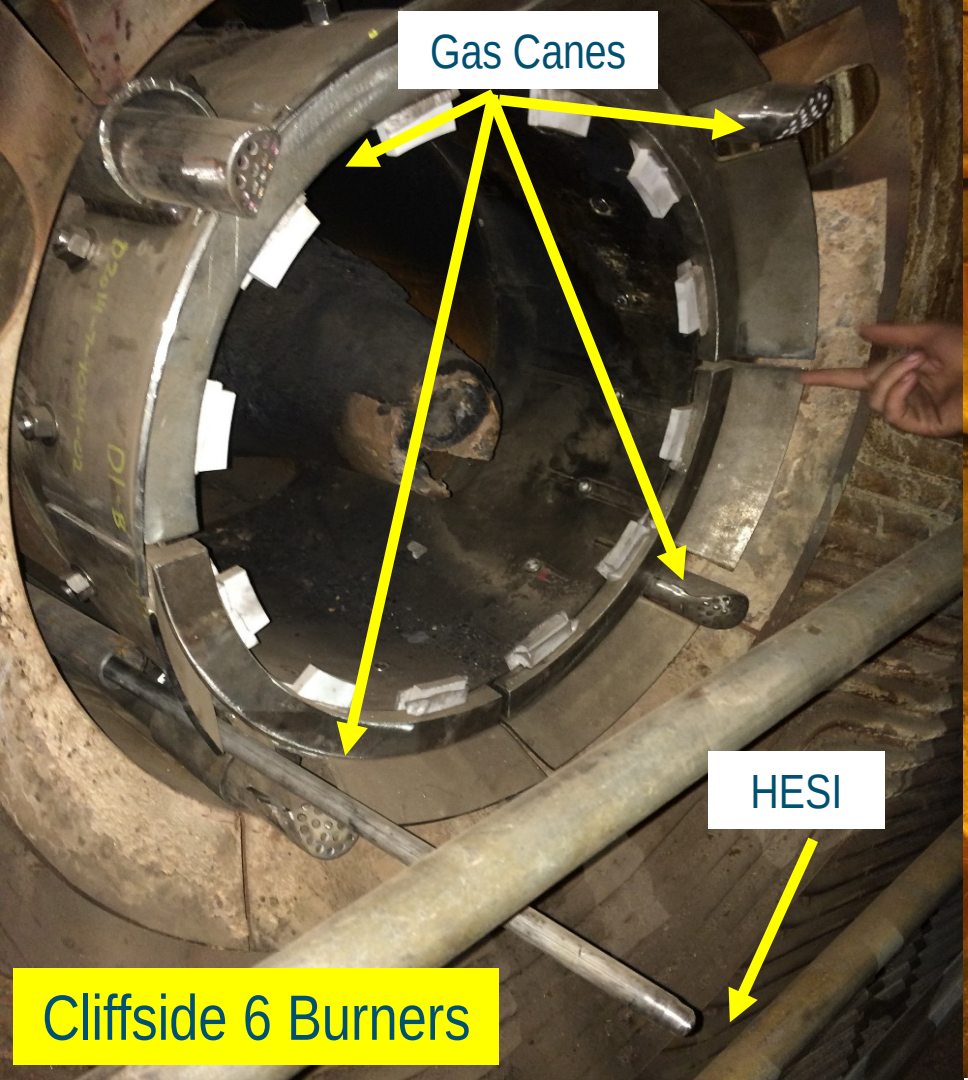

Cliffside 5
F Coal Burner
Gas Spud
NEW GAS SCANNER
Existing Coal Scanner
HESI
Bluff Body
Corner 2
EF Level
Gas Burner
(3 Spuds)
Gas Spuds
E Coal Burner
Pipe Feeding Gas Spuds
Gas Scanner Tube
HESI Guide Tube
Gas Scanner Tube
Gas Piping in the Windbox

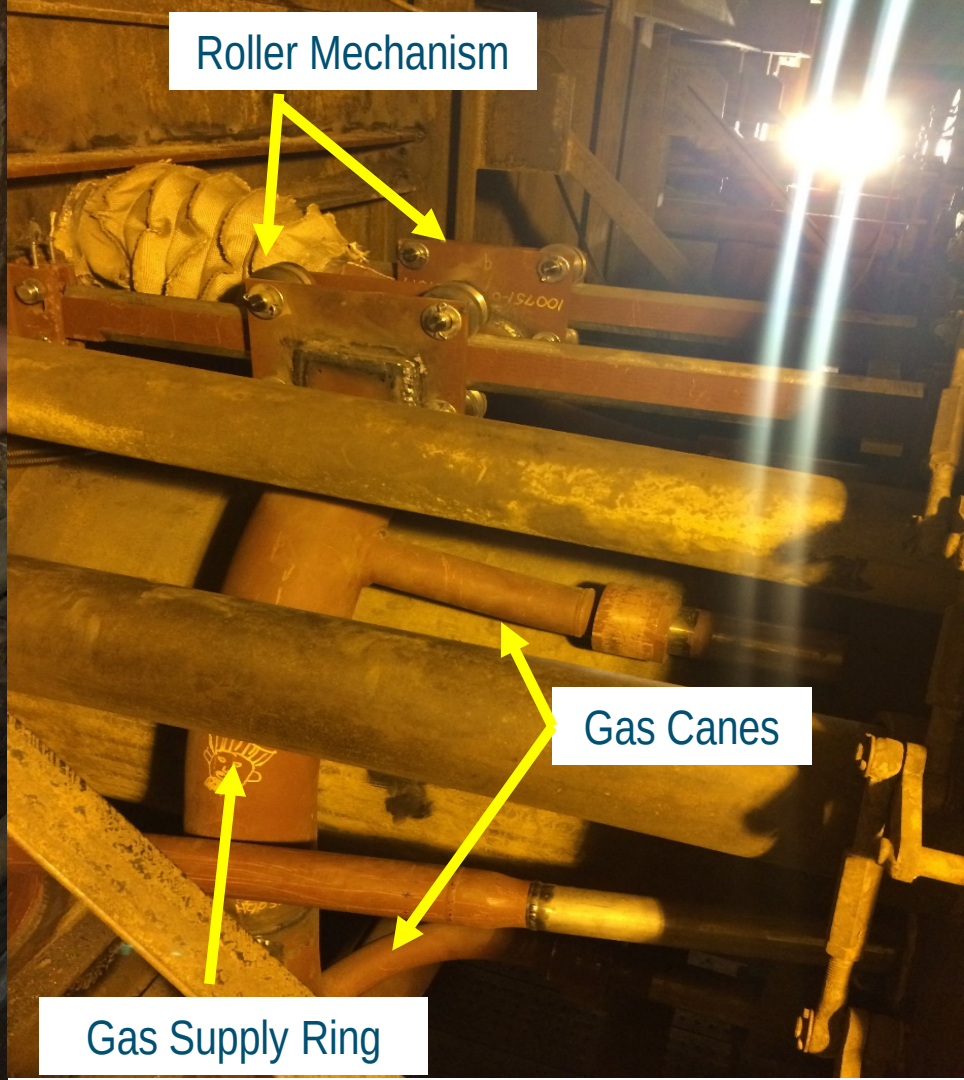
Cliffside Unit 6

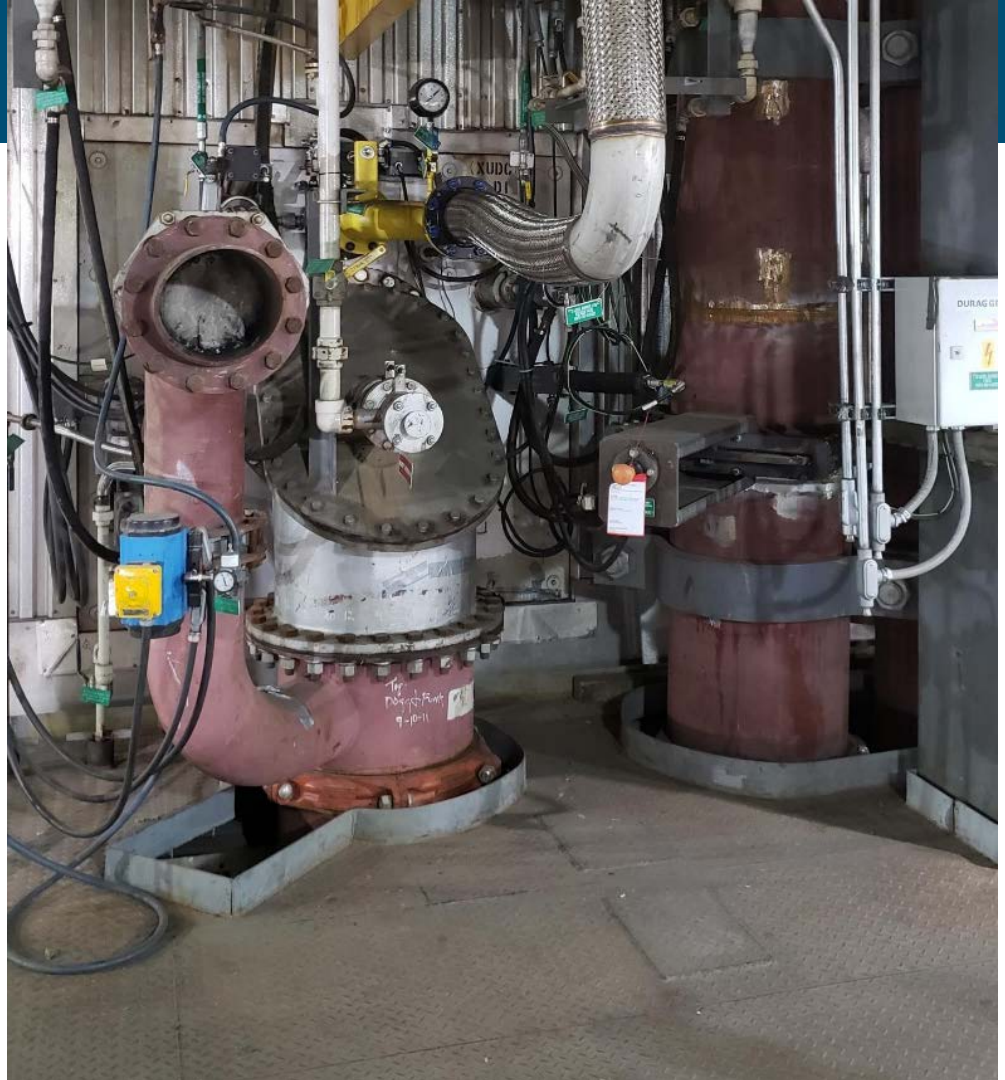
Fuel Control Skid

Cliffside Unit 6

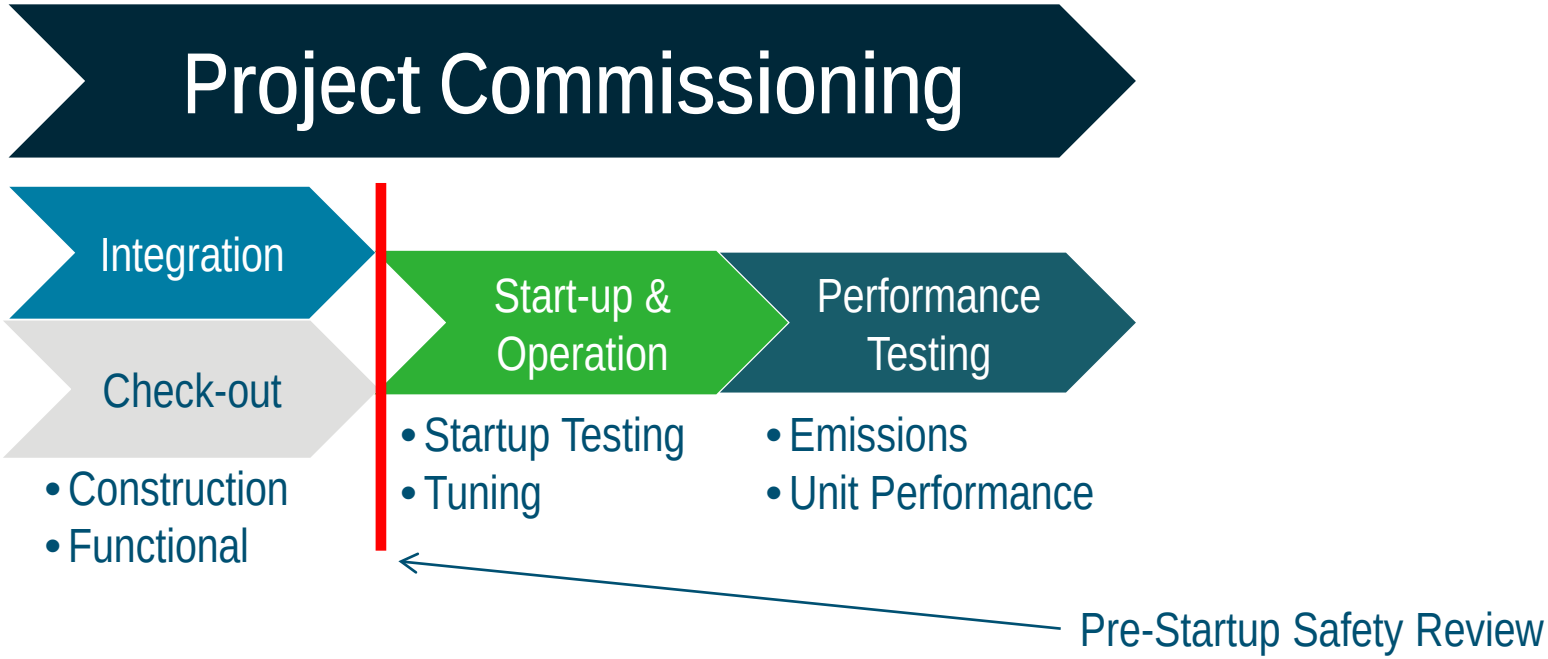
Burner Shut-off Skid


Gas Canes
HESI
Cliffside 6 Burners


Roller Mechanism
Gas Canes
Gas Supply Ring



Cliffside Commissioning Process



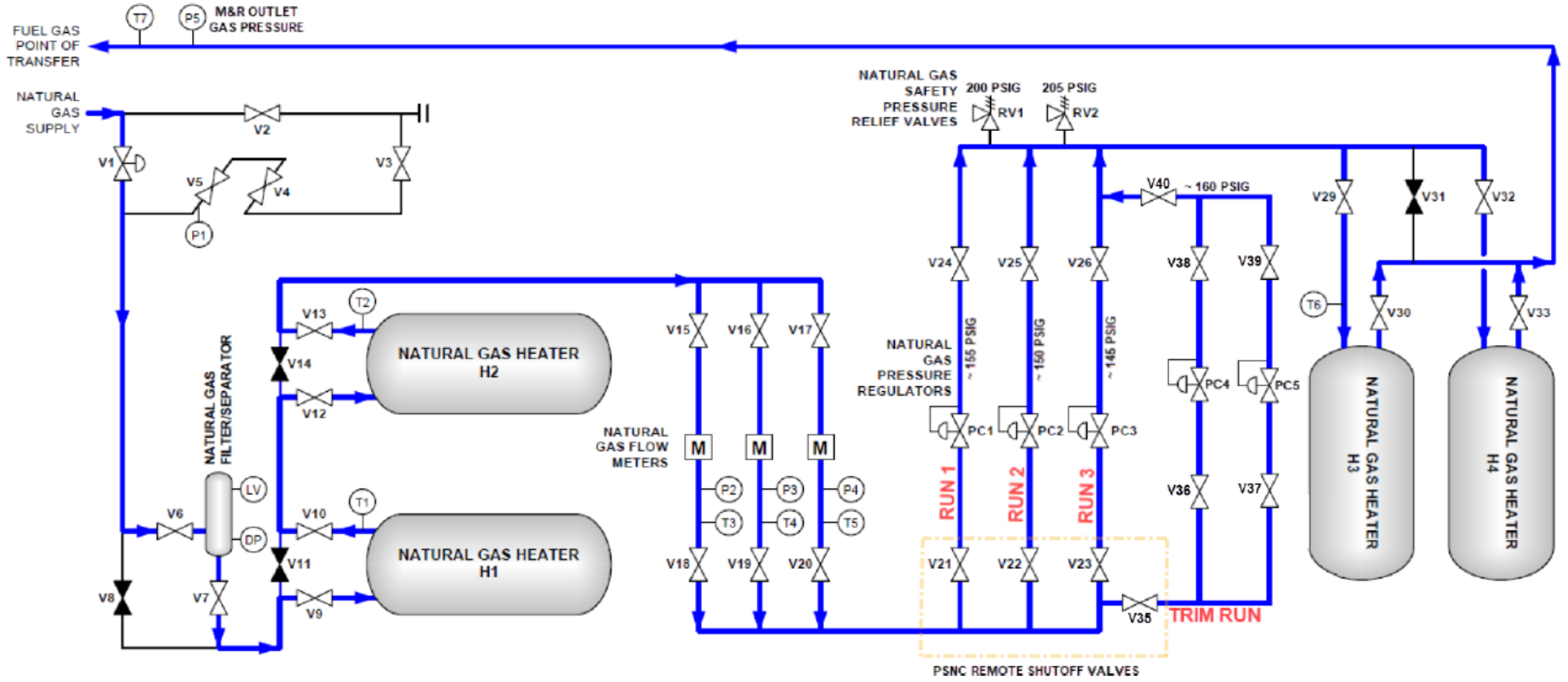
Integration: Getting the People and Processes ready to operate the equipment

Check-out: Getting the Equipment ready to be operated

Cliffside Commissioning Plan

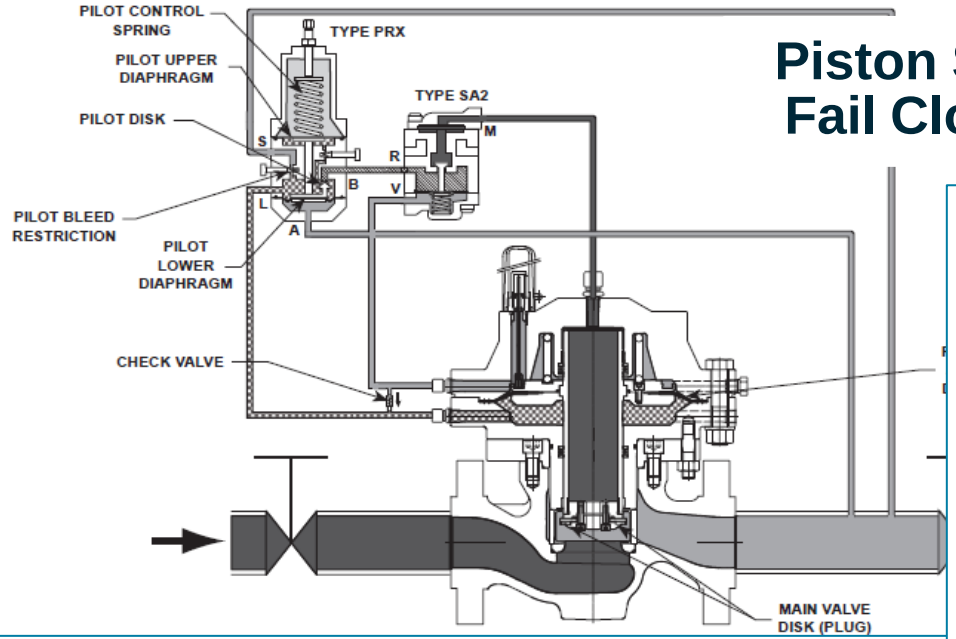
1. Gas Light Off Testing
   - Testing ignition of a single gas burner, flame scanner tuning. Group Start Testing
2. Initial Loading Plan
   - Build boiler pressure, gas valve tuning, Sync to grid on gas, load to max gas capacity with tuning
3. Gas Run Back Testing
4. Coal Start-up with Gas Ignition Testing
   - Typical unit start with coal but using gas for ignition not fuel oil
5. Co-firing Run Back Testing
6. Gas Minimum Load Testing
   - Testing of new unit minimum with tuning
7. Co-firing Ratio Testing
   - Testing with different coal to gas ratios, ramping and tuning.
8. Fuel Swap Testing
9. Natural Gas Firing at Maximum Natural Gas (40% for 5, 100% for Natural Gas)
10. Ramp Rate Testing

Cliffside Lessons Learned – M&R station Design

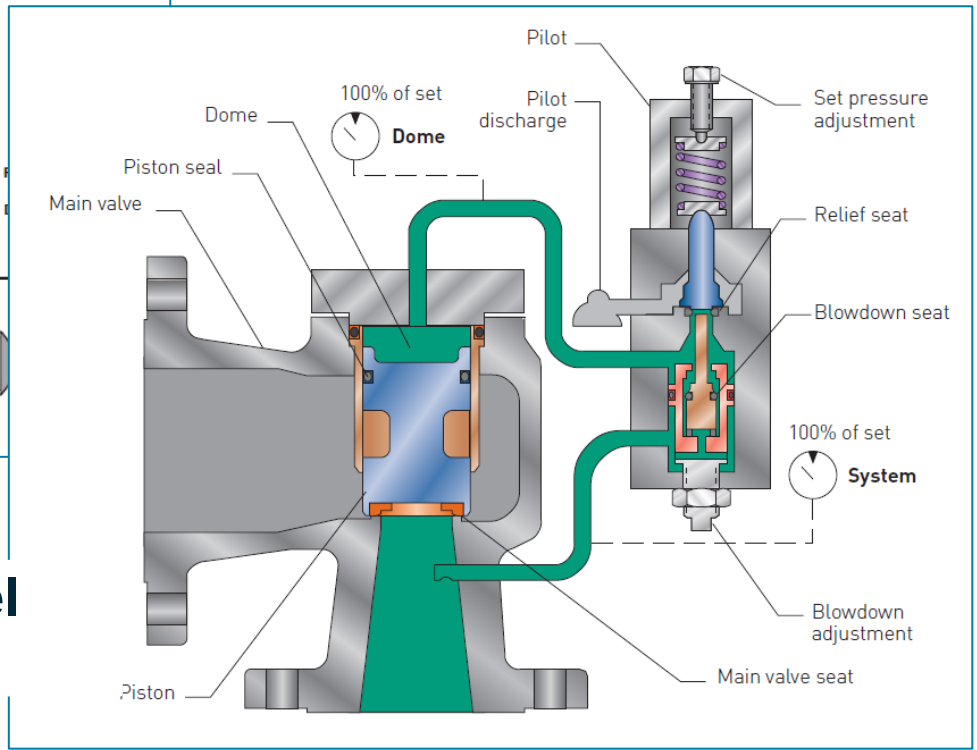


Cliffside Lessons Learned – M&R station Design

Piston Style Fail Closed



Stainless Steel Metal Seat

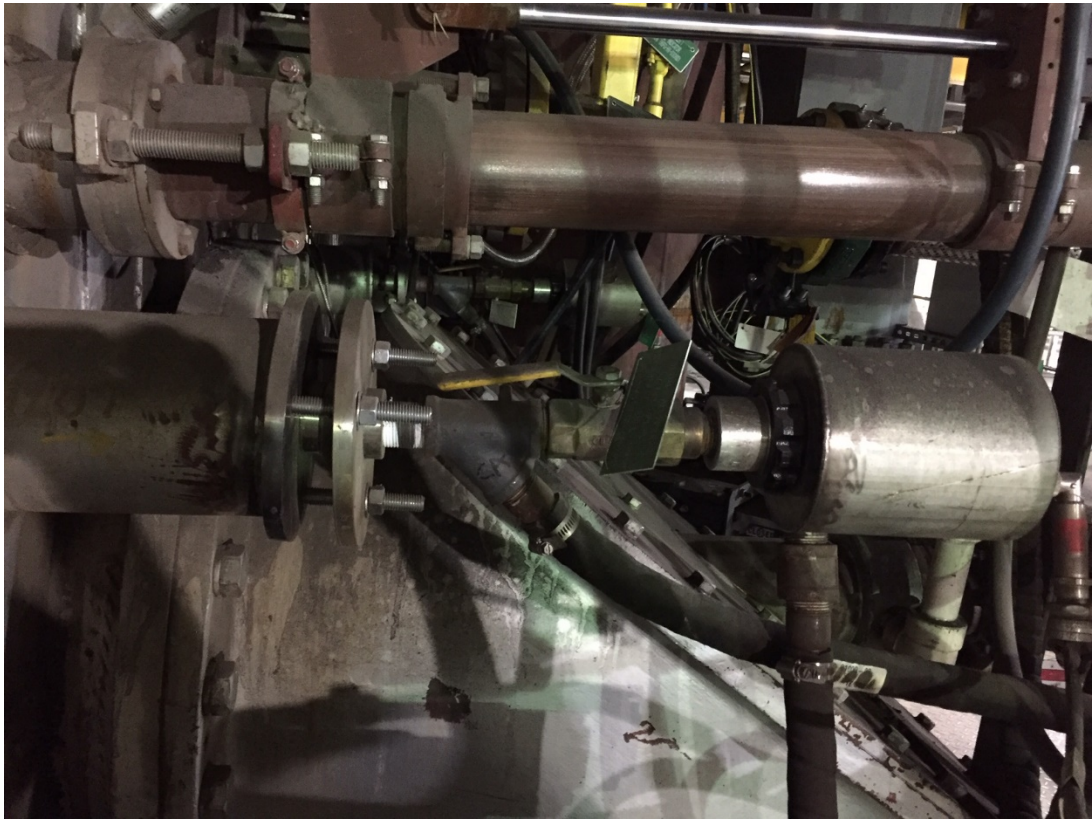


Cliffside Lessons Learned – Hot Burners leads to missing parts

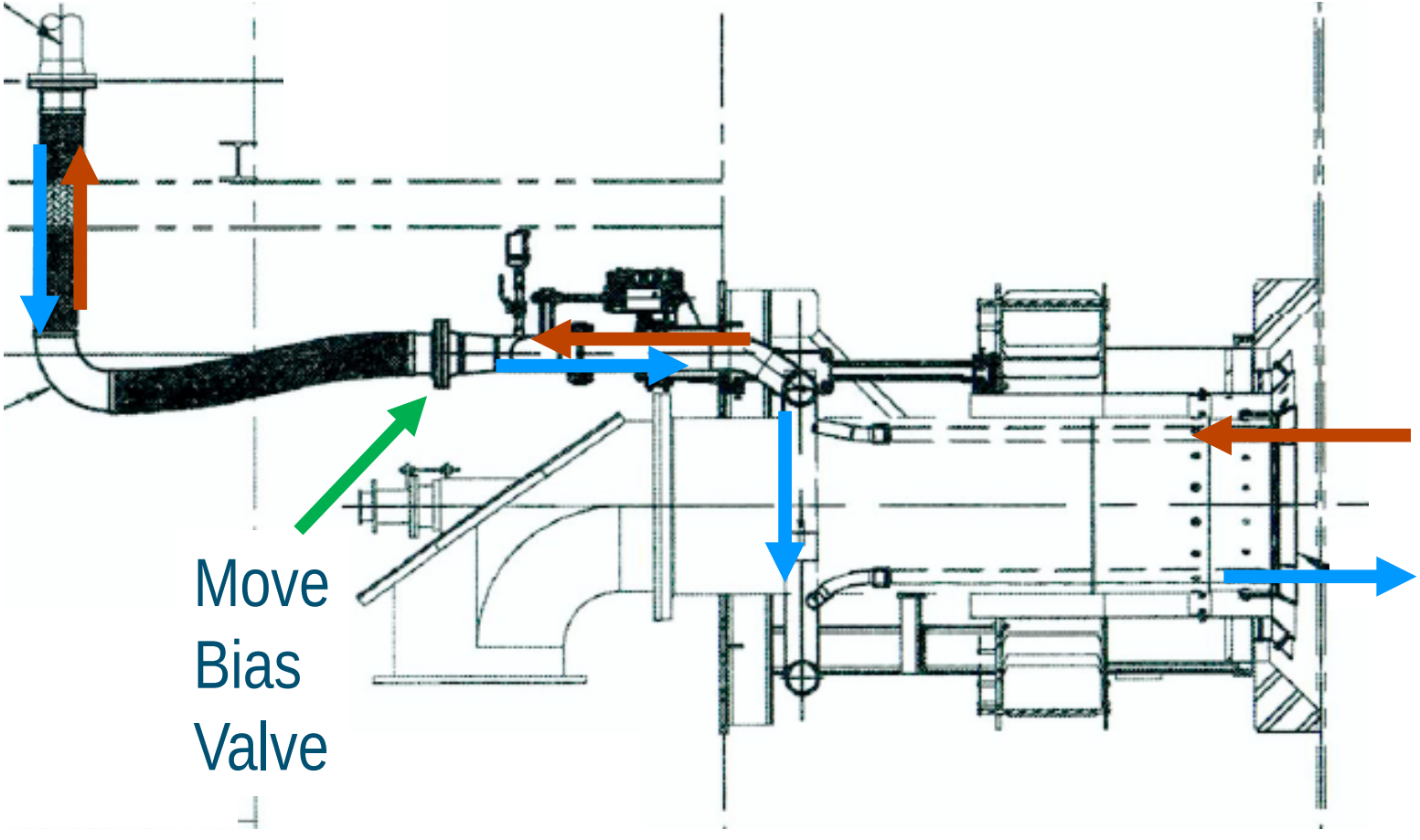
Burner thermocouples in alarm management
Higher gas pressures
Close tertiary air, more secondary air

Cliffside Lessons Learned – Flame scanner line-of-vision

Moved closer, reduce piping
Articulating head



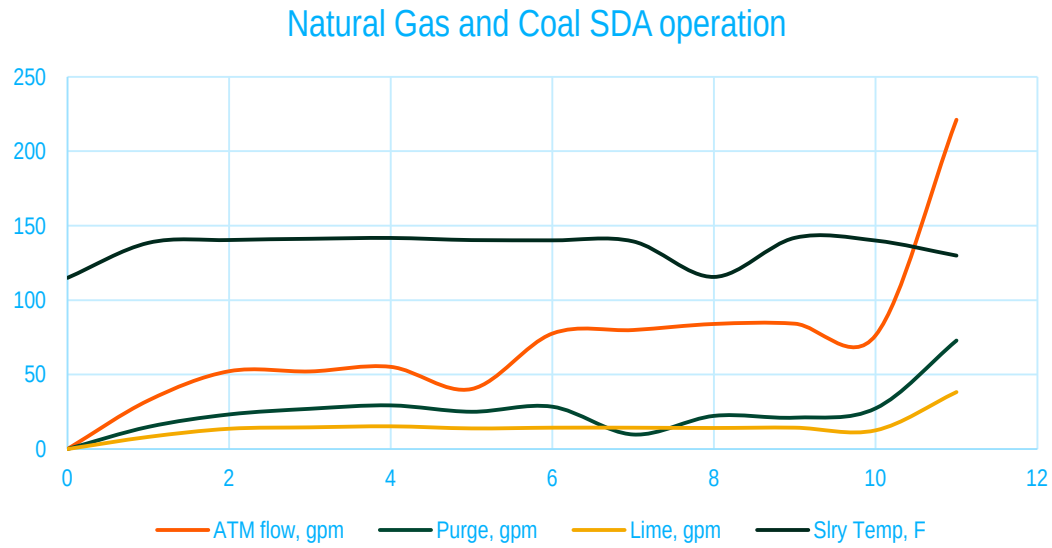
Cliffside Lessons Learned – Natural circulation leads to hose failures

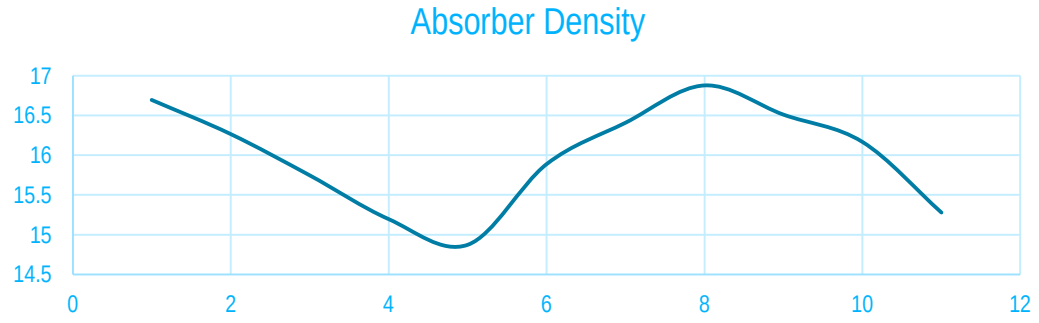


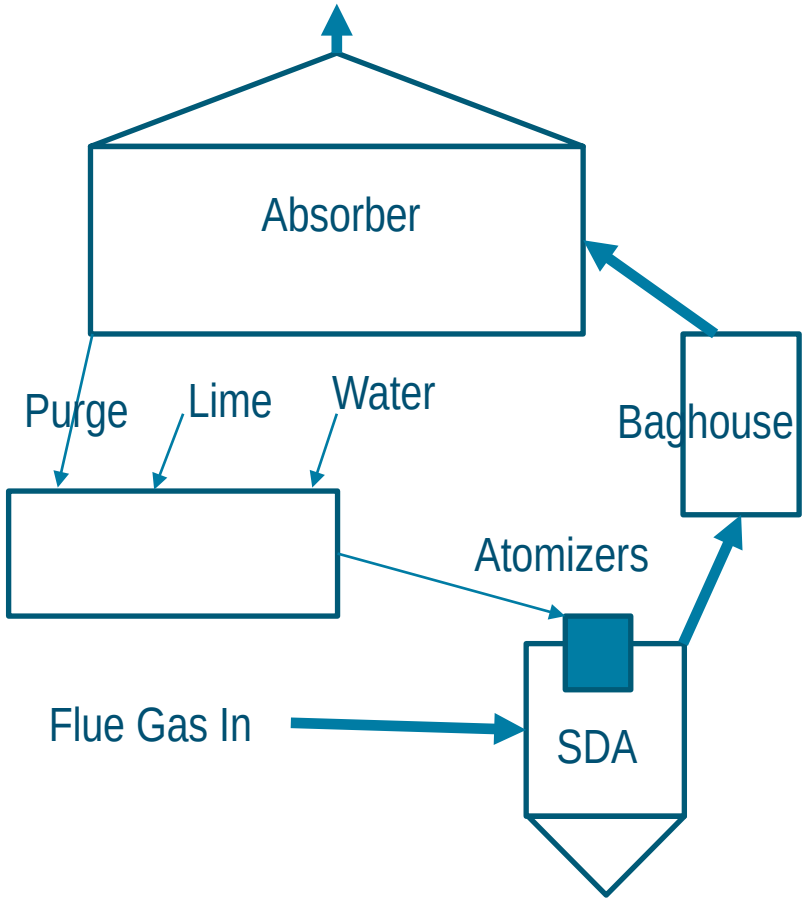
Cliffside Lessons Learned – Natural circulation leads to hose failures

Moved
Bias Valve

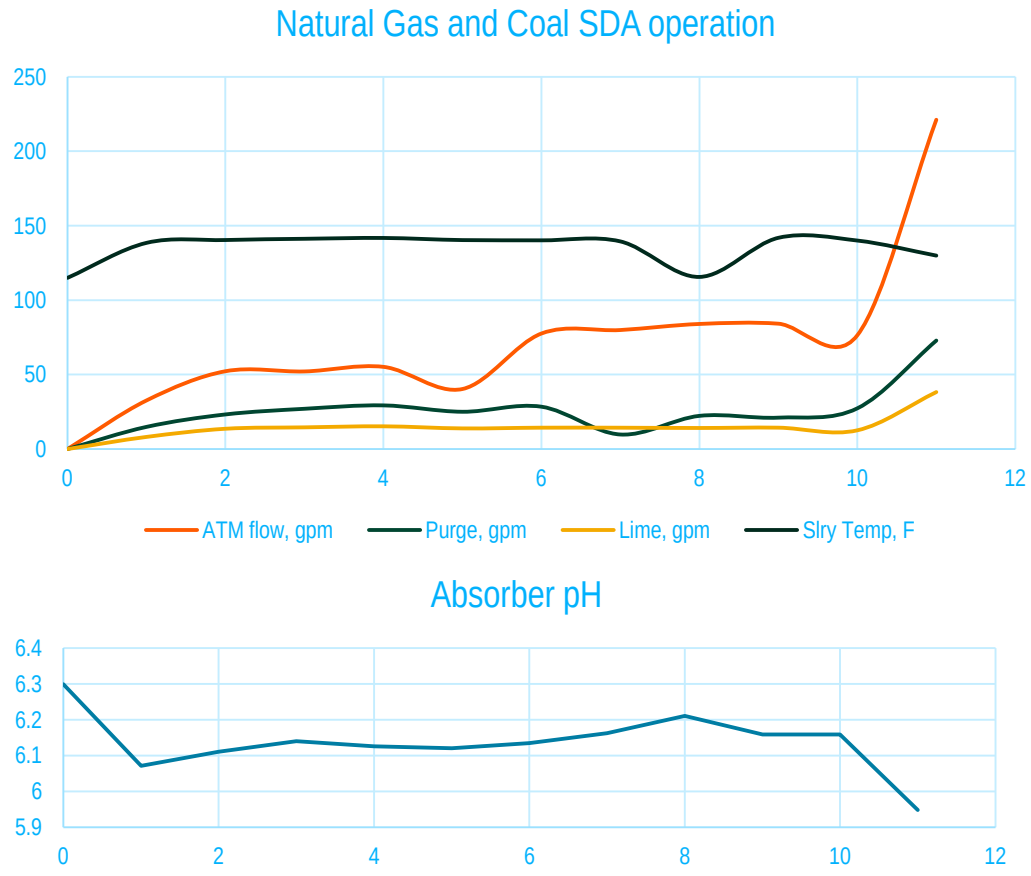
Cliffside Lessons Learned – FGD Temp and Solids

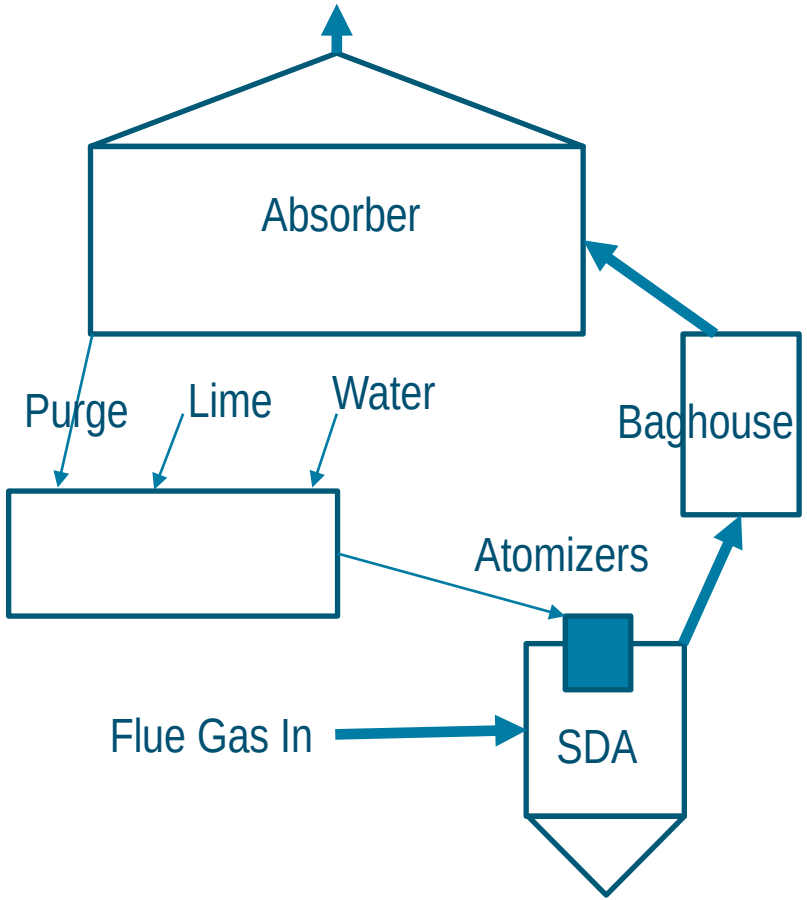






Cliffside Lessons Learned – FGD pH





Cliffside Lessons Learned

Purge Design and Validation NFPA 56

Procedure developed so that natural gas and air are not mixed in piping system.

- Natural Gas must be purged with Inert Gas (nitrogen) from piping systems for maintenance, then compressed air.
- Nitrogen and compressed air delivery piping must be designed
- Procedure must be validated

HESI Failures

- Upgrade HESI material

Cliffside 5 – Results

Burner design output achieved

Steam temperatures maintained

FGD operations impacted as expected

- Slurry temp increased with higher gas ratio

Improved unit startup for operations

- Emissions met targets (60% coal, 40% natural gas)
  - CO – 0.015 lb/mmbtu (target 0.08)
  - SCR Inlet NOx – 0.164 lb/mmbtu (target 0.25)

Min Load – 50 MWg reduction from Coal to Gas operation, Based on steam side issues – Turbine L0

Cliffside 6 – Results

Burner design output achieved

Met steaming requirements (Full Load)

Maintained design steam temperatures

Improved unit startup for operations

Less impact to some AQCS systems than expected

- SDA
- SCR

Maintain Heat-rate; lower boiler efficiency is offset with lower parasitic load. (PA fan, Pulverizers, 3 ARP)

Increase net generation as reduction in parasitic load

Emissions met targets @17% Excess Air

- CO – 0.03 lb/mmbtu (target 0.037)
- SCR inlet NOx – 0.109 lb/mmbtu (target 0.25)
- VOC @ air heater exit – 0.0019 lb/mmbtu (target 0.0023)
- Needed to achieve 78% lower furnace stoichiometry with no primary air.

Min Load – (350 to 250) 100 MWg reduction from Coal to Gas operation

- Unit Dry to Wet (steam side) transfer is the limiting factor

Ramp Rate

- Increase only limited by steam side, No hold points from min to max load for pulverizer light off.

Questions ??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