REDUCING NO_X AND LOI AT THE ST. JOHNS RIVER POWER PARK

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Outline

- Introduction
- Description of ABT Opti-Flow™ Fuel Injector
- CFD Modeling
- Post-Retrofit Results
- Summary

St. Johns 1 and 2: 670 MW Opposed-Fired

- Fuel: Hard to burn 20% petcoke/ 80% Colombian coal blend
- Requirements:
  - » NO_x guarantee: 0.40 lb/10^6 Btu *(Current limit is 0.5)*
  - » CO: <200 ppm
  - » LOI: <Baseline
  - » Flame stability: Improved turndown
- Combustion Modifications: Unit 2 – 8 Mark I low NO_x fuel injectors*

  Unit 1 – 28 Mark II low NO_x fuel injectors*

  * *Existing dual registers re-used with modifications*

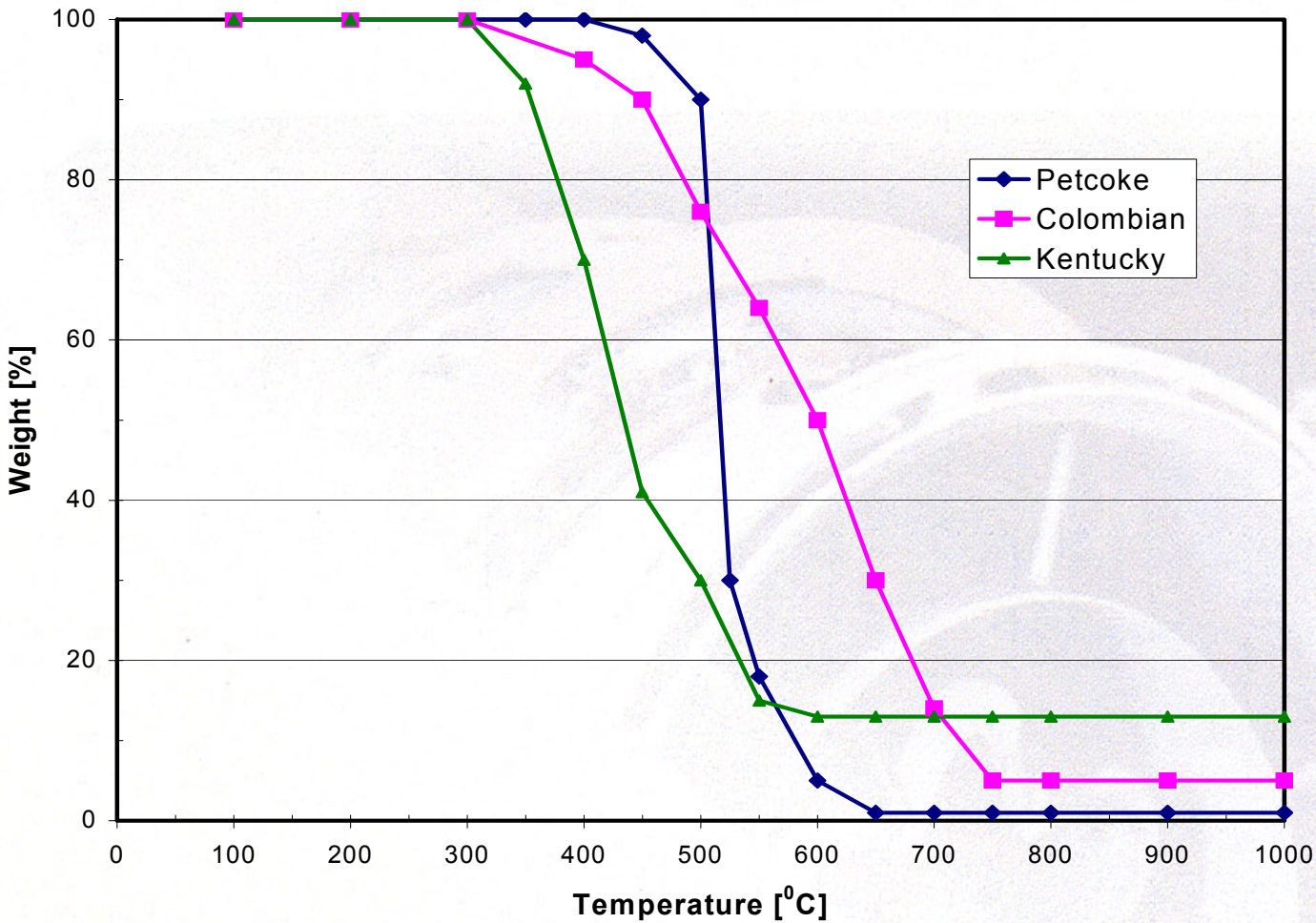
  Windbox/SA duct modifications
- Installation Completed: Unit 2 – March 2002

  Unit 1 – March 2003

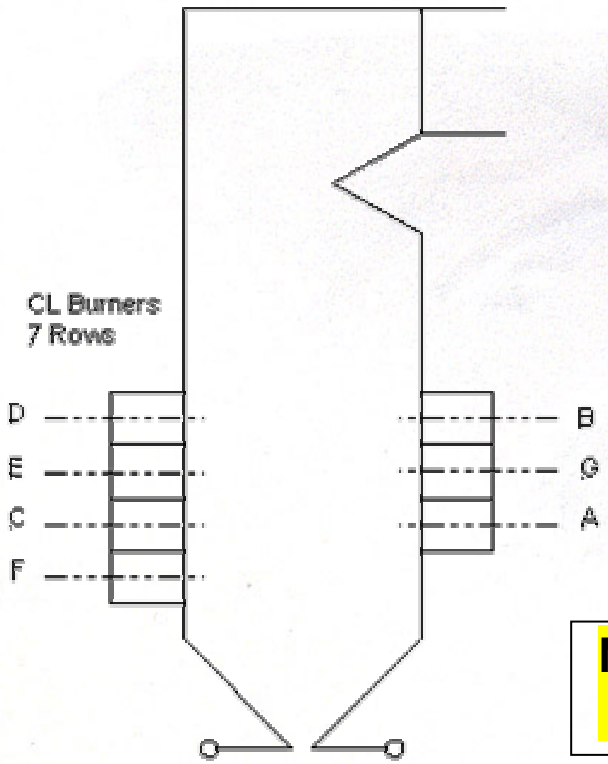
Fuel Blend Analyses

	Coke	Coal	20/80 Blend	
Proximate Analysis (wt%, ar)				
Fixed Carbon	83.92	47.60	**54.87**	
Volatile Matter	8.50	33.40	**28.42**	*1.93 FC/VM*
Ash	0.52	7.40	6.02	
Moisture	7.06	11.60	10.69	
Ultimate Analysis (wt%, ar)				
Carbon	82.22	66.54	69.67	
Hydrogen	3.35	4.50	4.28	
Oxygen	0.00	7.99	6.40	
Nitrogen	1.71	1.32	**1.40**	*1.14 lb/10^6*
Sulfur	5.14	0.65	1.54	
HHV, Btu/lb	14,200	11,800	12,280	

TGA Burning Profiles of Fuels



St Johns Firing Configuration



- 28 OEM Dual Register Low NO_x Burners
- 7 Vertical Mills
- 22” O.D. Coal Pipes

Normal operation with D-Mill out of service and SA registers open for simulated OFA

St. Johns Pre-Retrofit Conditions:

Normal Operation with D-Mill Out of Service

	Unit 1	Unit 2
NO_x, lb/10^6 Btu	0.46	0.46
CO, ppm	250 - 300	>500
LOI, %	25 – 30	30 – 40

- SA maldistribution: Very high air flow to D-Mill row
- Turndown: Limited to 30% with one mill out of service
- Sidewall corrosion: Localized reducing conditions
- Slagging: Upper furnace slag falls damaged hopper

Conditions for Minimum NO_x/CO/LOI

1. Minimize burner-to-burner stoichiometry imbalance by:
   - » Minimizing imbalances between coal pipes
   - » Equalizing secondary air distribution to burners
2. Maintain good coal fineness for the specific fuel blend
3. Prevent coal roping leaving the burner nozzle
4. Burner must attain a stable, bright flame commencing in the throat.

OPTI-FLOW™ FUEL INJECTOR

NO_x Control Conditions at St. Johns

1. Burner Stoichiometry Control:
   - » Coal pipes not balanced
     (Evaluate results and balance coal pipes if needed)
   - » Secondary air balance via windbox/SA duct modifications
2. Guarantees based on as-found coal fineness
3. Fuel injector coal ropes eliminated with ABT de-spin assembly in scroll
4. Opti-Flow™ fuel injector develops stable flame in all burner throats

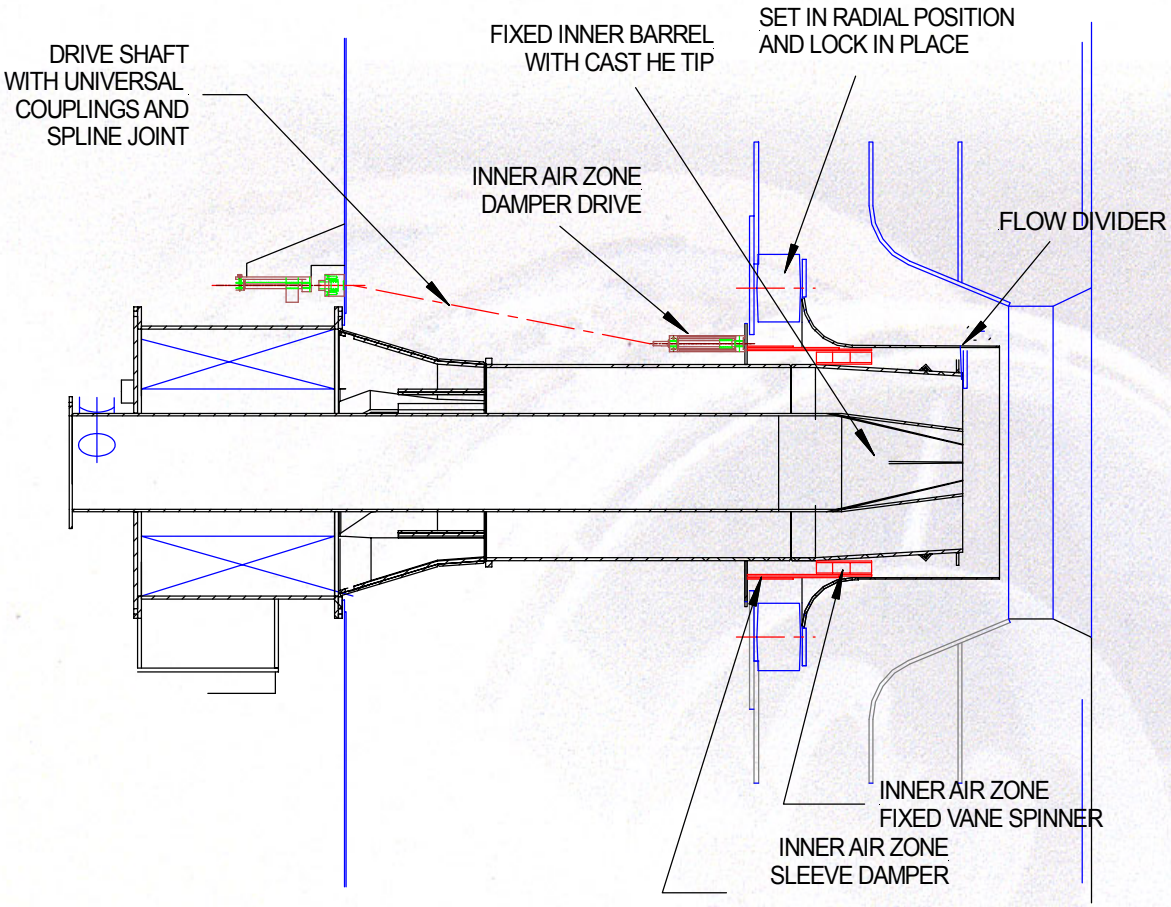
Combustion System Scope of Supply

- Low NO_x Fuel Injectors
  - » Unit 2: 8 Mark I fuel injectors (front bottom row/rear top row)
  - » Unit 1: 28 Mark II fuel injectors (complete retrofit)
- Windbox Modifications (Units 1 and 2)
  - » Secondary air duct turning vanes
  - » Windbox perforated plates and splitter vanes
- Anti-Corrosion Ports (Unit 1)
- System Models
  - » SA duct/burner windbox (subcontracted to Airflow Sciences)
  - » Furnace (subcontracted to ASC)

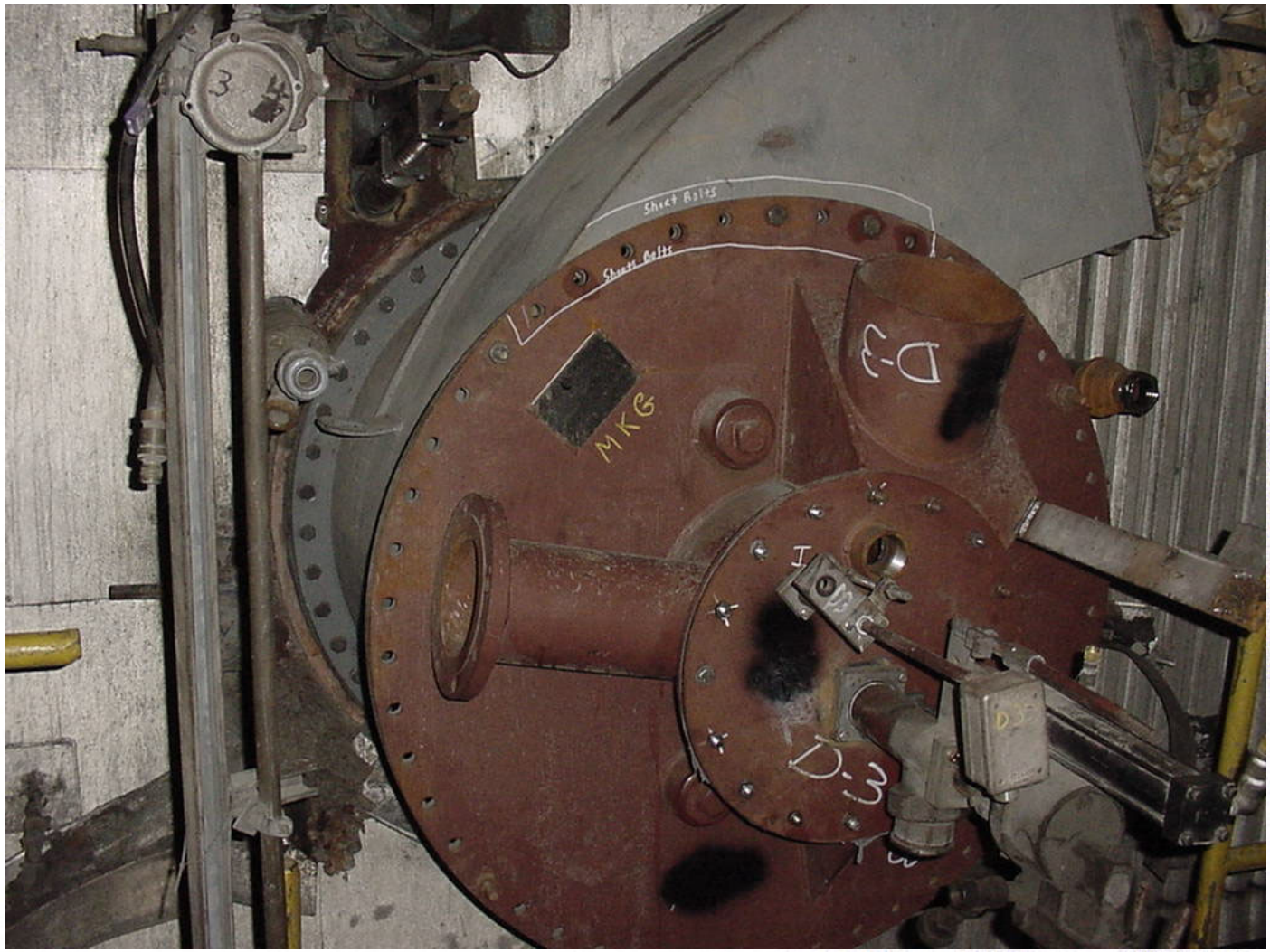
Low NO_x Fuel Injector Scope of Supply

- "Plug-in" assembly with ***existing register used***
- New secondary air flow dividers
- Existing coal feed scrolls modified to include ABT's de-spin assembly
- New inner secondary air zone damper for Mark II fuel injector (Unit 1)
- Fixed vane swirler for the inner air zone of Mark II fuel injector
- Fixed inner barrel with cast tip for Mark II fuel injector

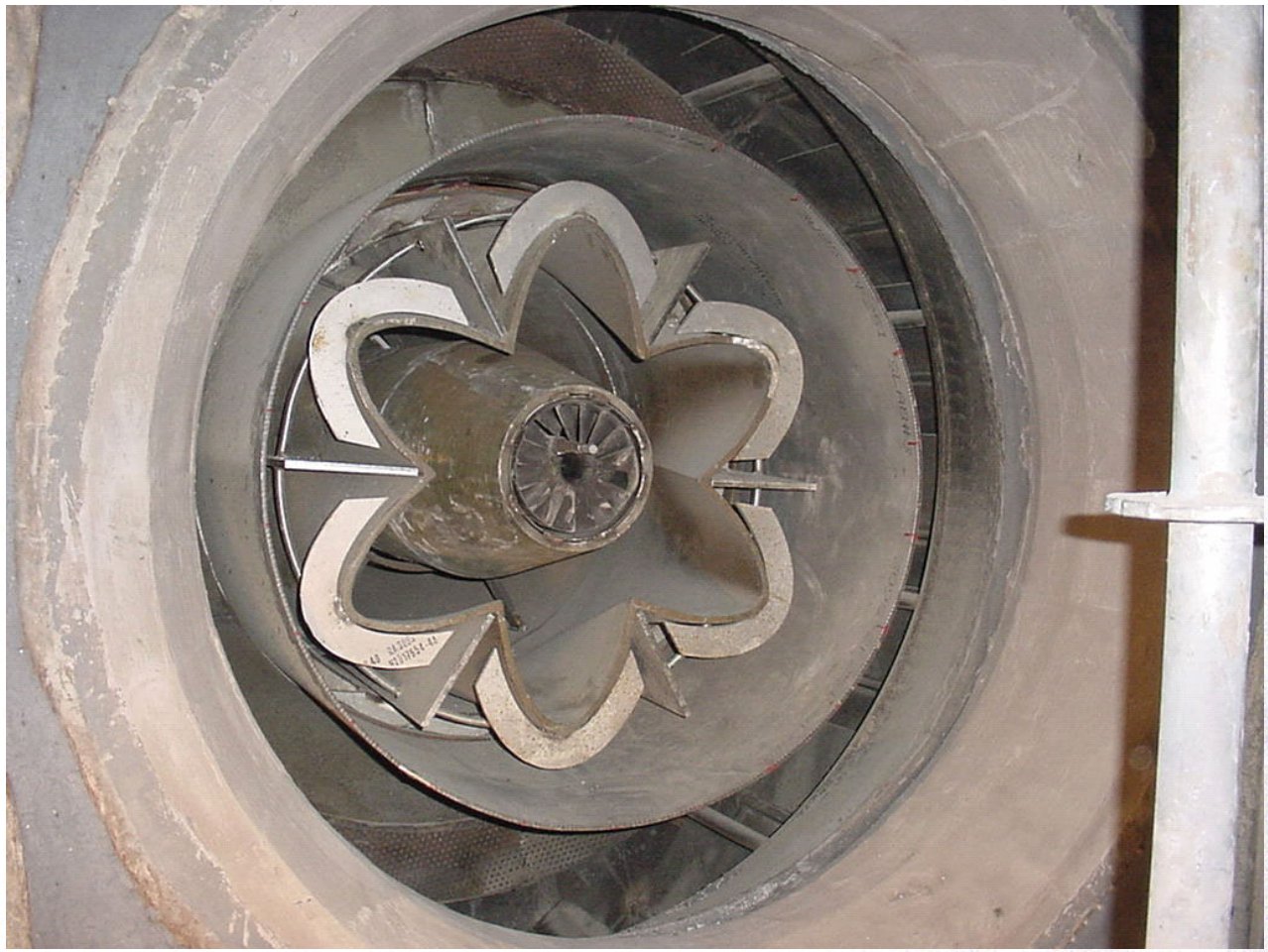
ABT Mark II Fuel Injector for St. Johns



St. Johns Unit 1 Burner Front



St. Johns 1 Fuel Injector Tip



ABT's Anti-Corrosion Ports (ACP)

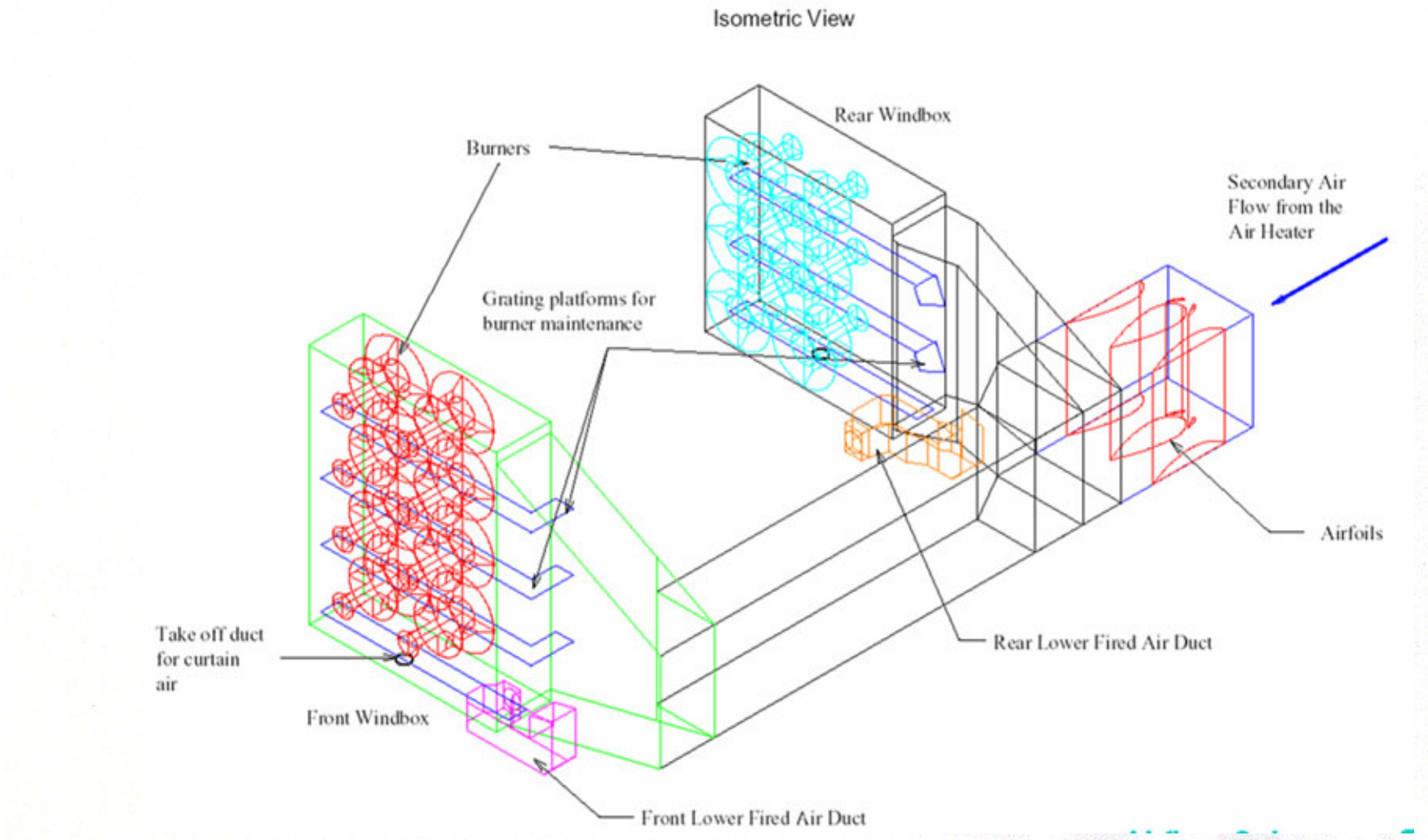
- Circular ports with baffles placed at top burner elevations next to sidewalls within existing windboxes.
- Ports provide a blanket of oxygen along the sidewalls to minimize corrosion from high sulfur fuels.
- Air flow to ACP's controlled by individual sleeve dampers

CFD MODELING RESULTS

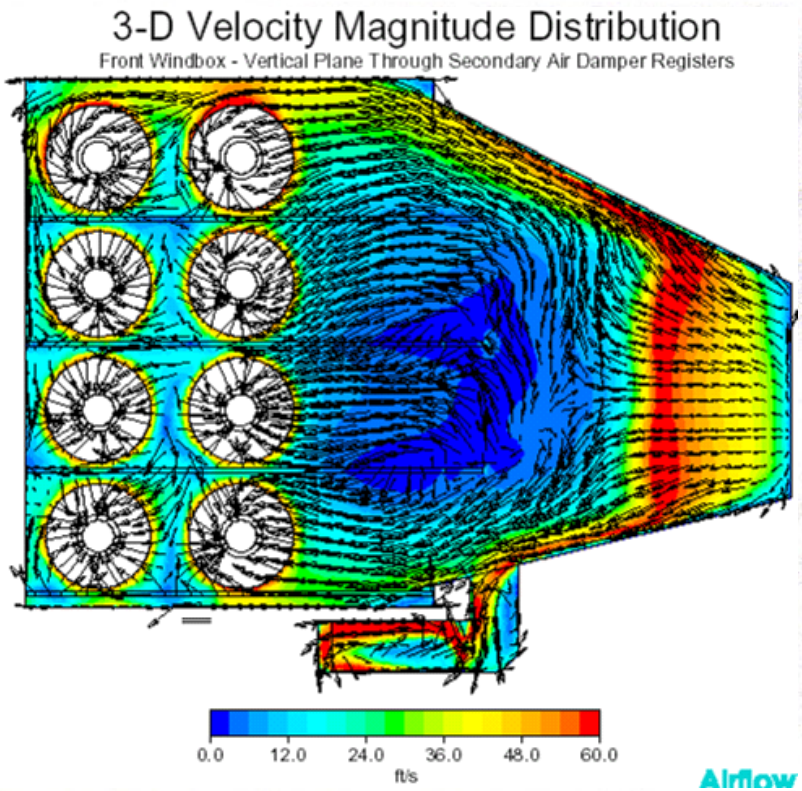
Modeling Scope

- Burner Secondary Air Flow: Correct maldistribution
  - Secondary air ducts
  - Front and rear windboxes
- Furnace Model: ACP location and LFA modifications
  - CO distribution
  - O_2 distribution
  - H_2S distribution
  - Temperature

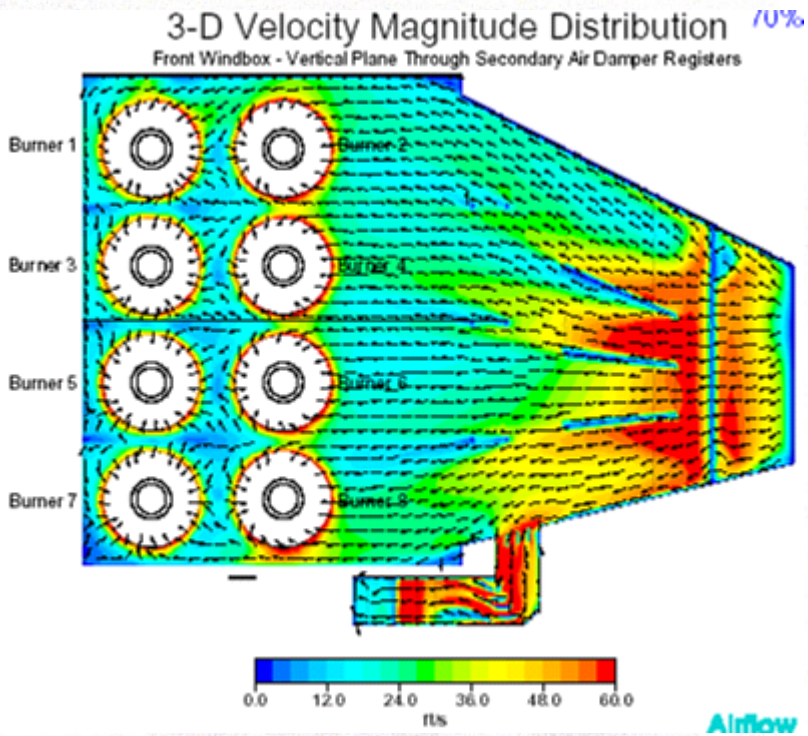
St. Johns Existing Windboxes Schematic



CFD Model of St. Johns Front Windbox

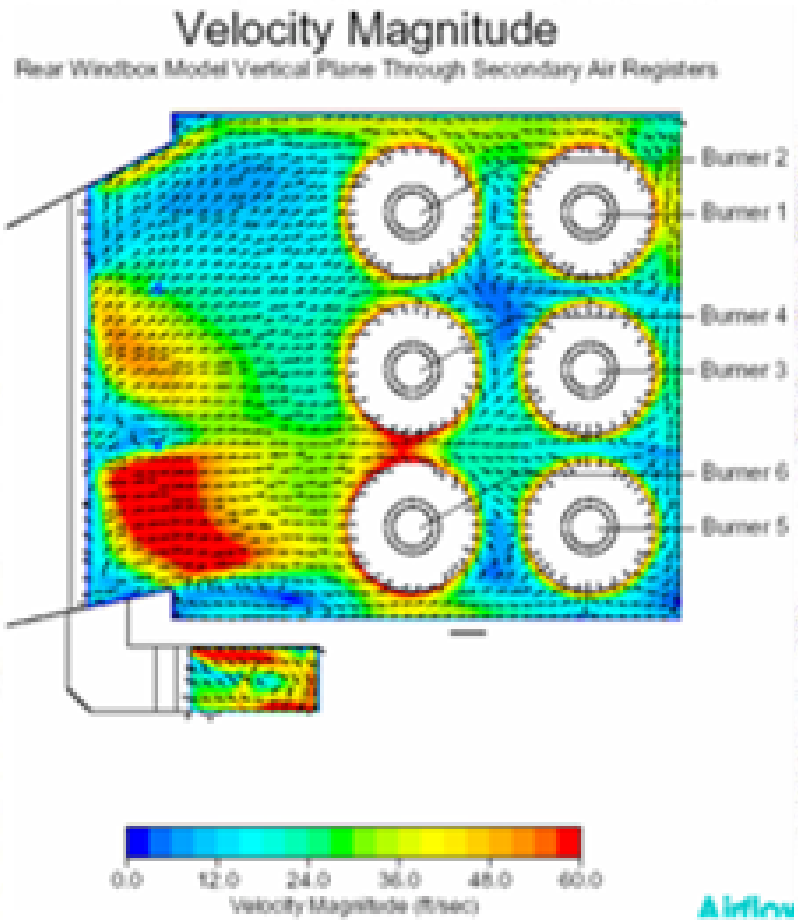


Baseline Air Velocity Distribution

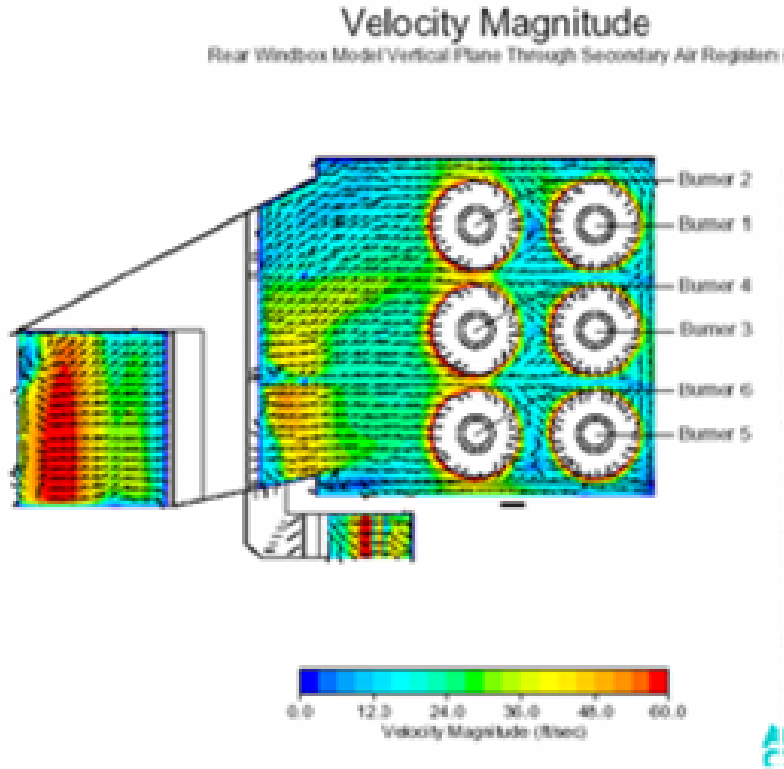


Air Velocity Distribution with Design Modifications

CFD Model of St. Johns Rear Windbox

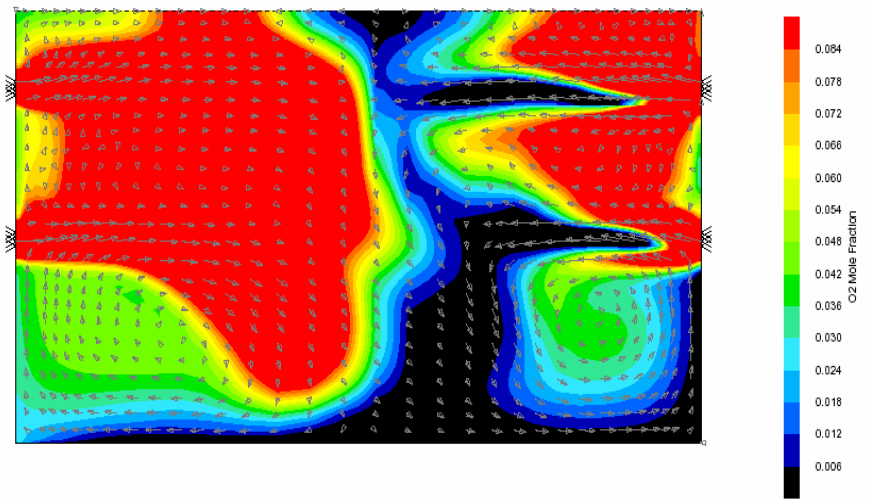


Baseline Air Velocity Distribution

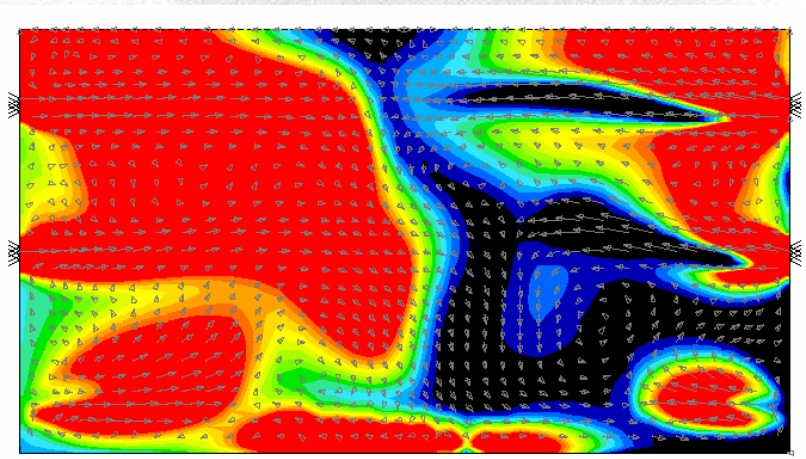


Air Velocity Distribution with Design Modifications

Furnace Model of Sidewall in Corrosion Region: O_2 Concentration



Sidewall without ABT Anti-Corrosion System



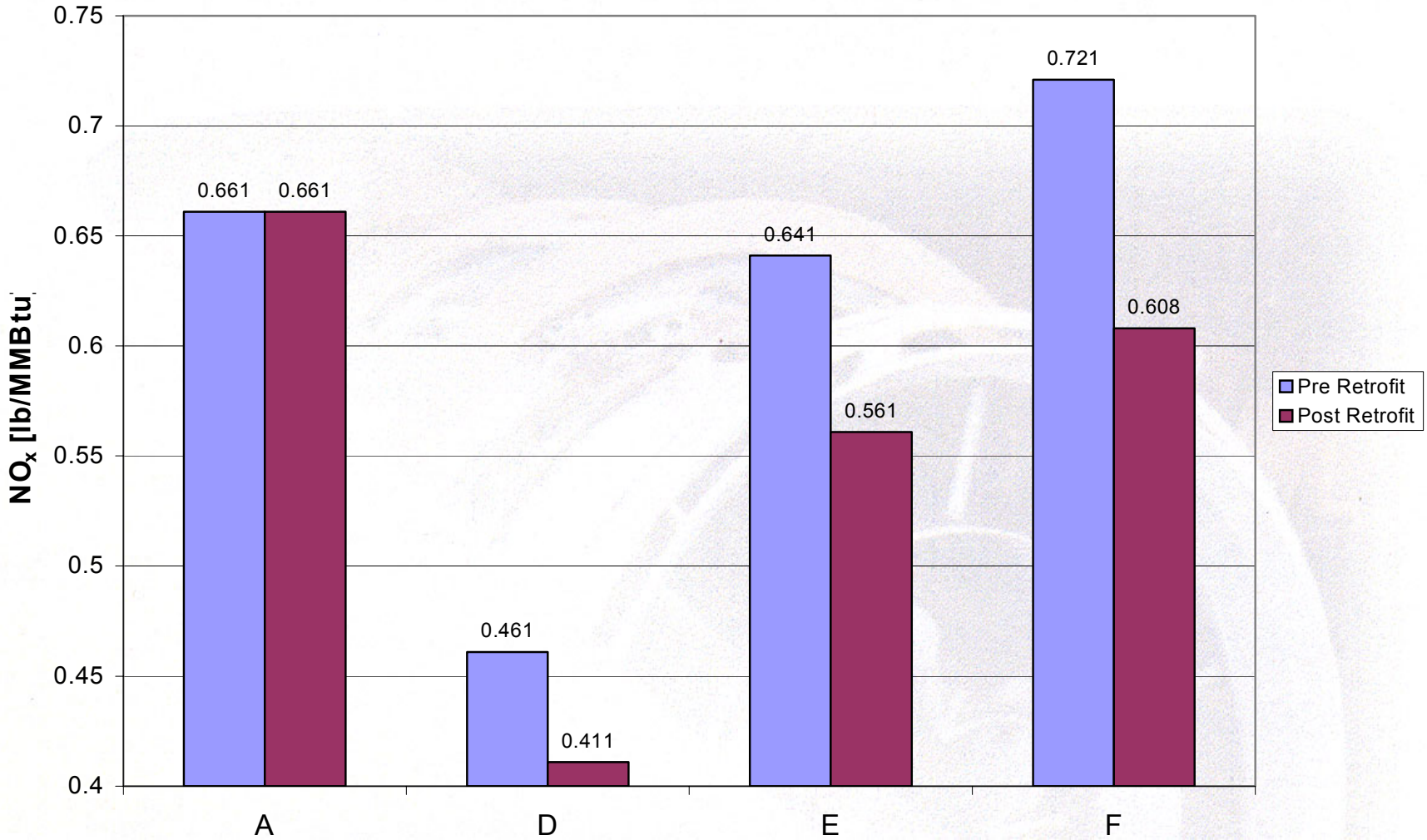
Sidewall with ABT Anti-Corrosion System

POST-RETROFIT RESULTS

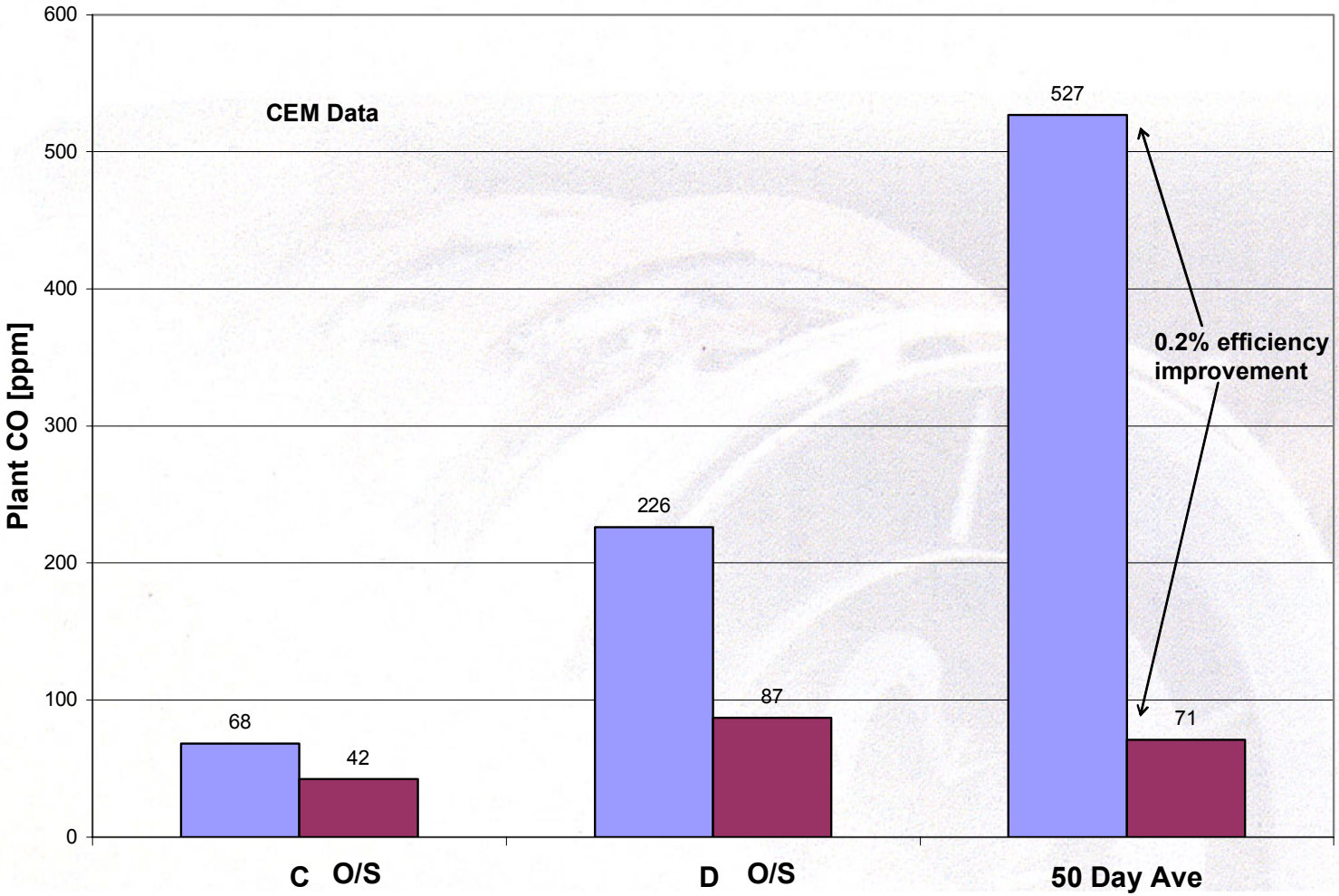
St. Johns Unit 2 Results Summary

- Moderate NO_x reduction of approximately 10% for normal operation with only two rows of new ABT fuel injectors
- Significant reduction in CO emissions to less than 100 ppm.
- Reduction in fly ash LOI of approximately 50%
- Improved SA flow distribution allows lower excess air operation (2.5 vs. 3.0%)
- Efficiency improvement of approximately 1% results in annual fuel savings of $600,000

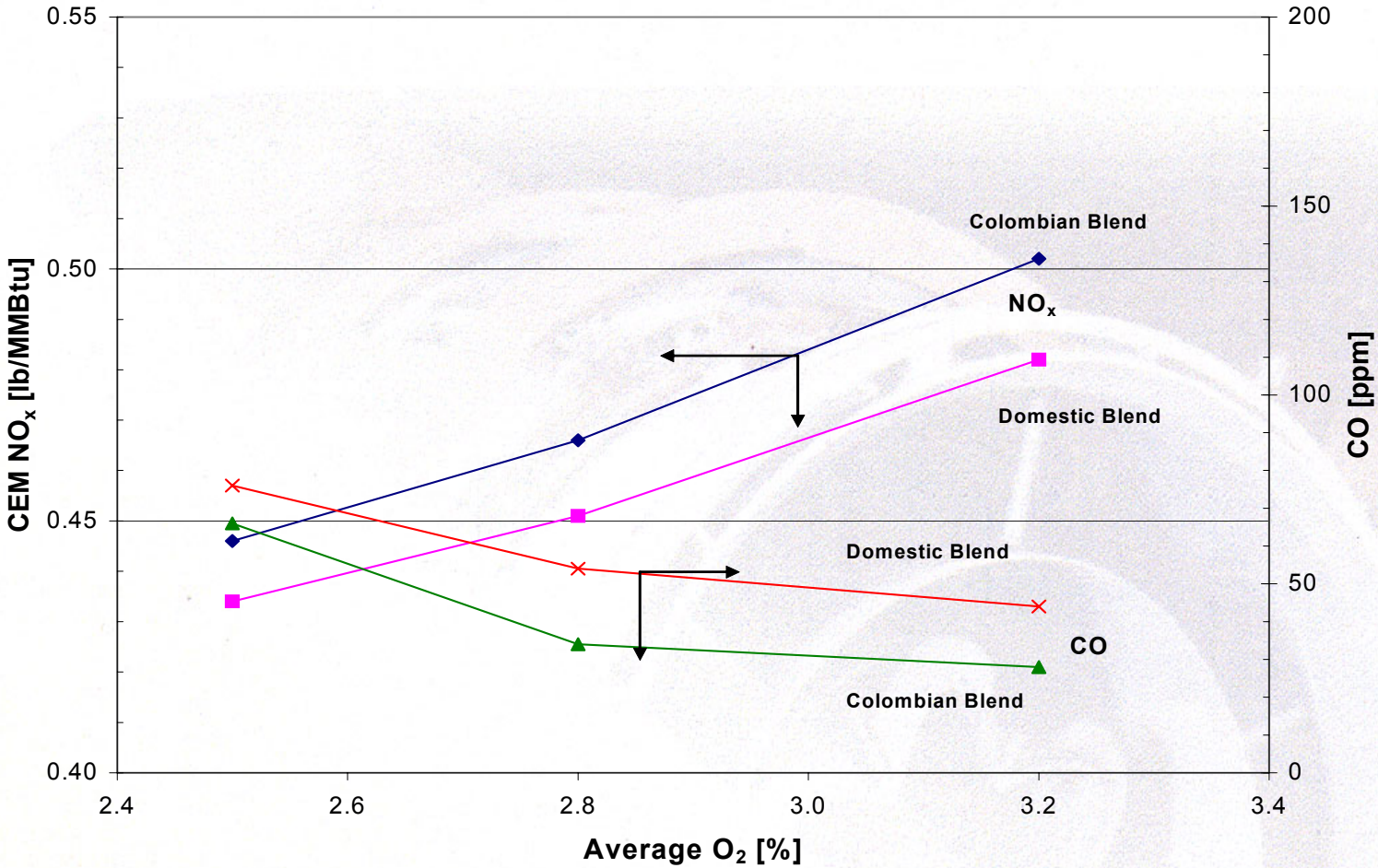
St. Johns Unit 2 NO_x Emissions:
Post vs. Pre-Retrofit



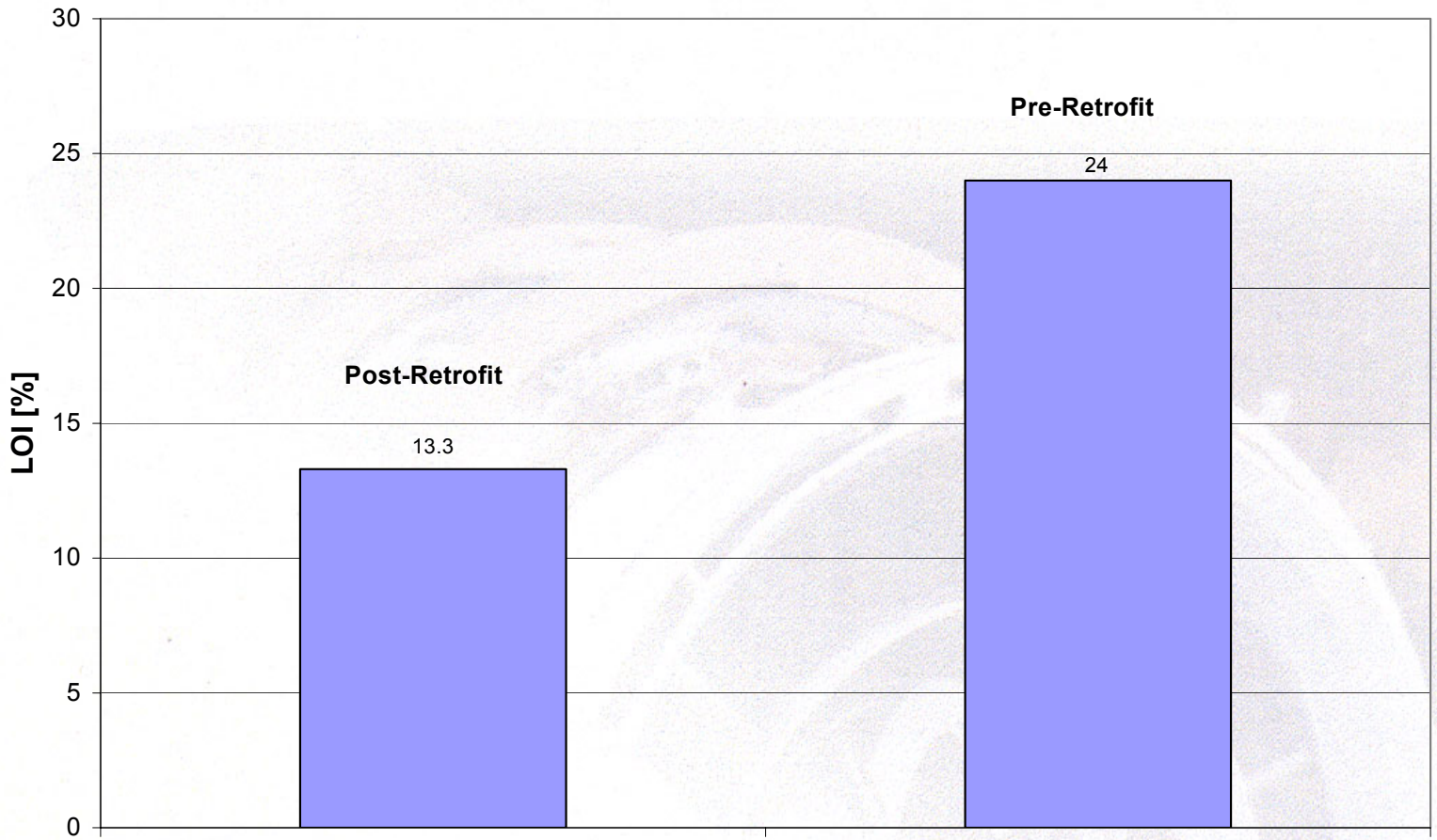
St. Johns Unit 2 CO Emissions:
Post vs. Pre-Retrofit



St. Johns Unit 2 NO_x and CO:
Post-Retrofit Colombian vs. Domestic Blend



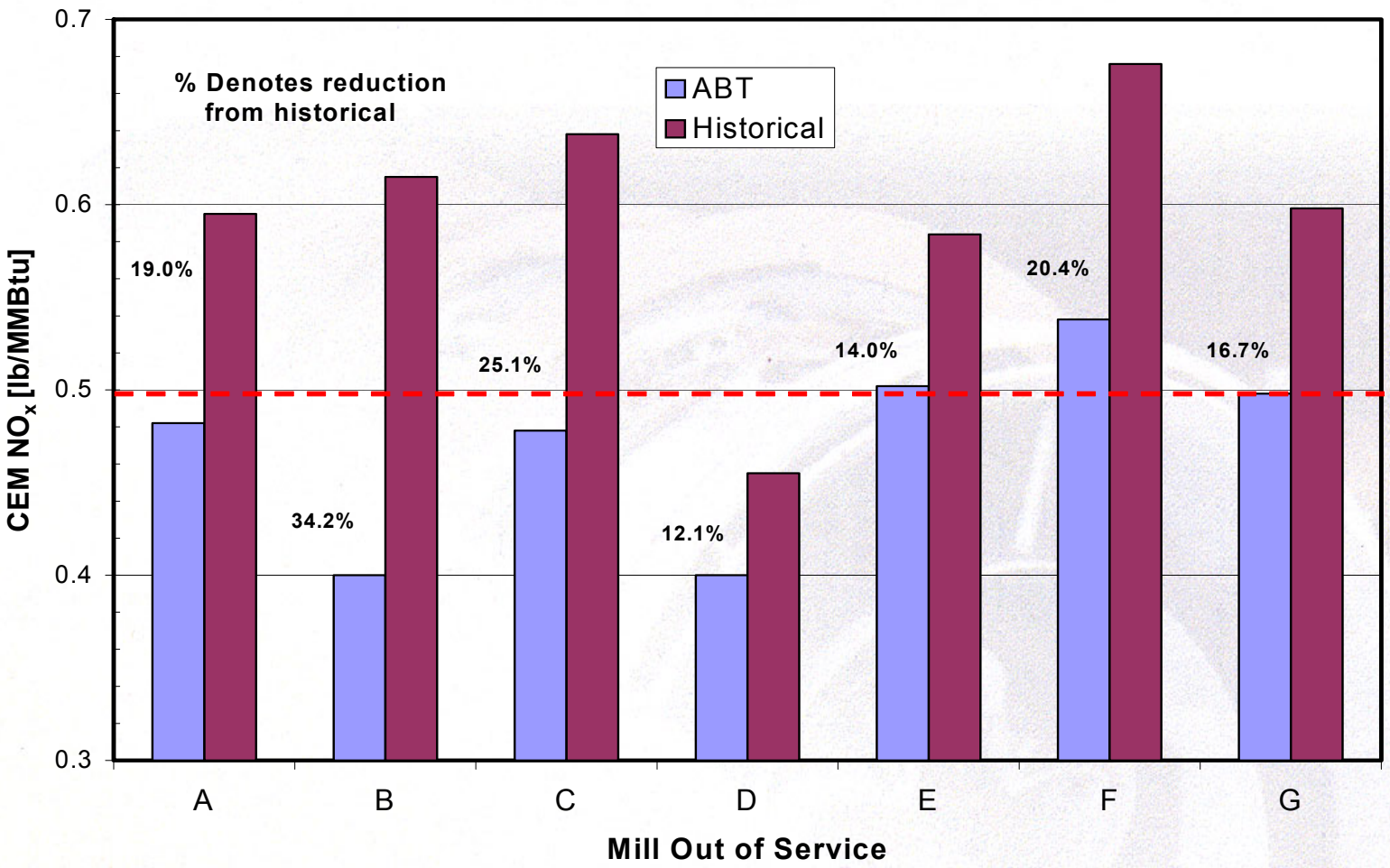
St. Johns Unit 2 Fly Ash LOI:
Post vs. Pre-Retrofit with D-Mill Out of Service



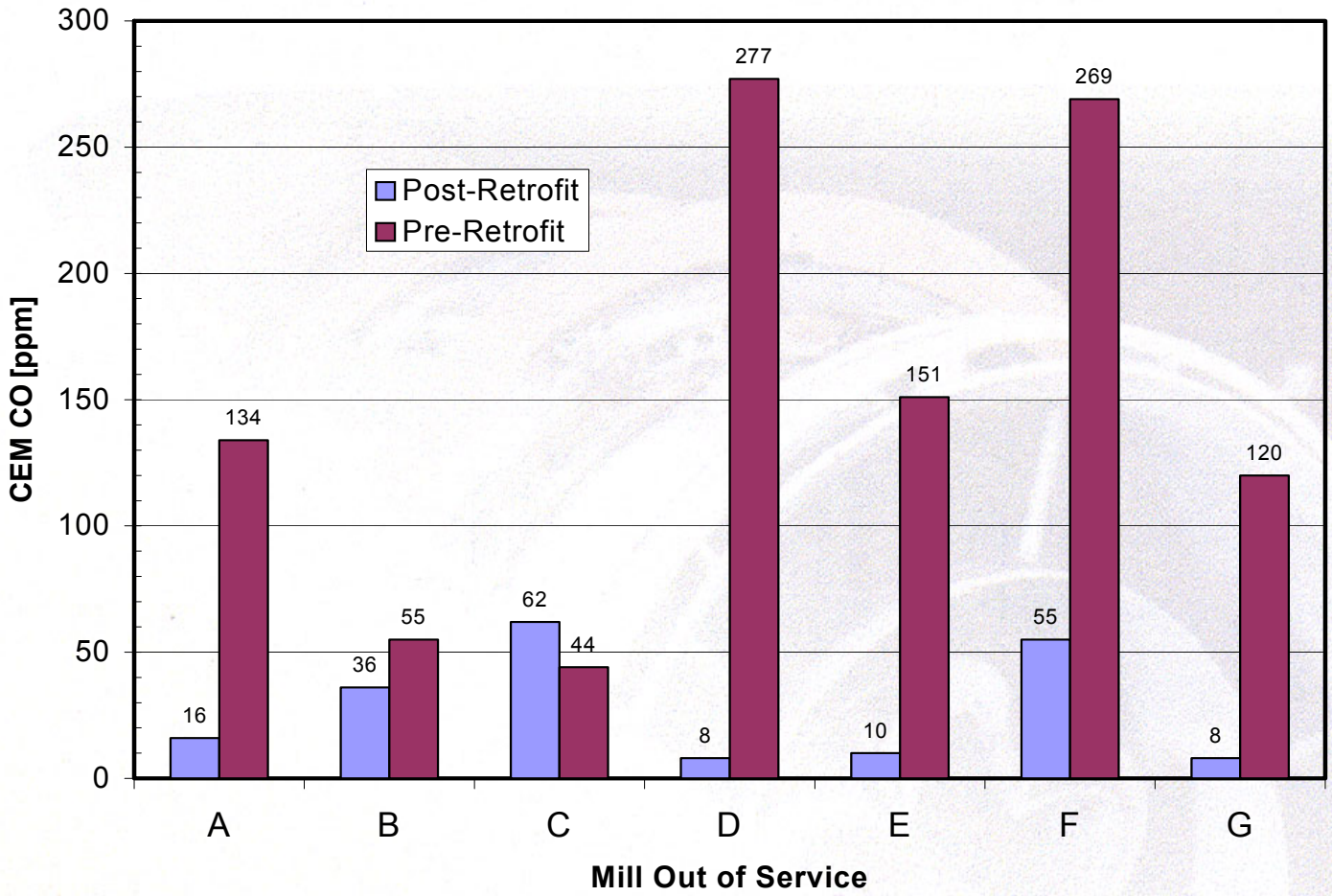
St. Johns Unit 1 Results Summary

- Average NO_x reduction > 20% achieved for all mill configurations. Guarantee of 0.4 lb/10^6 Btu met.
- Significant reduction in CO emissions to less than 10 ppm for normal operation with D-Mill out of service
- Fly ash LOI reduced from 30 to 40% range to 15 to 20% range. Lower reduction achieved compared to Unit 2 due to poor mill performance
- Improved flame stability and burner turndown

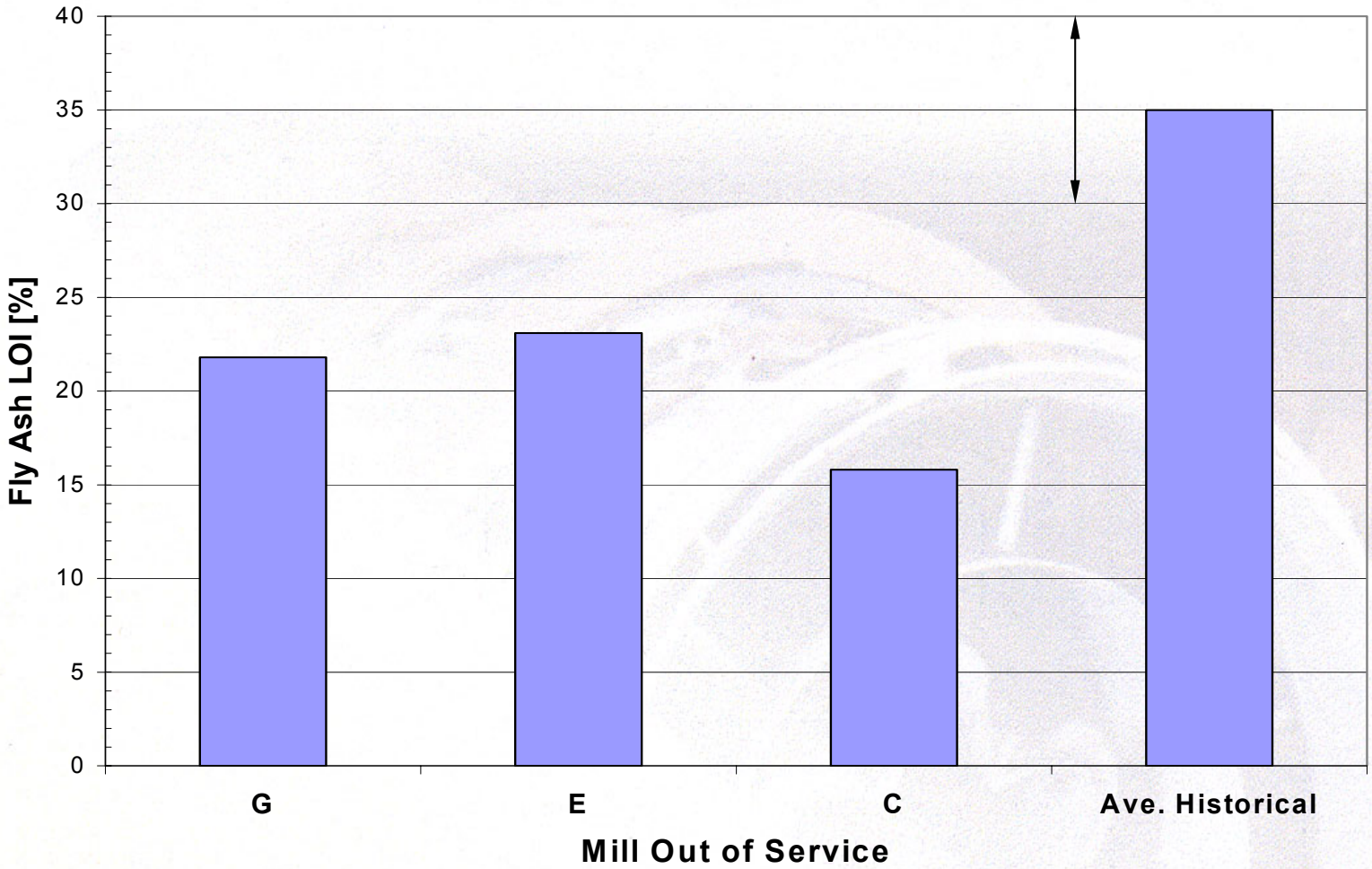
St. Johns Unit 1 NO_x Emissions:
Post vs. Pre-Retrofit



St. Johns Unit 1 CO Emissions:
Post vs. Pre-Retrofit



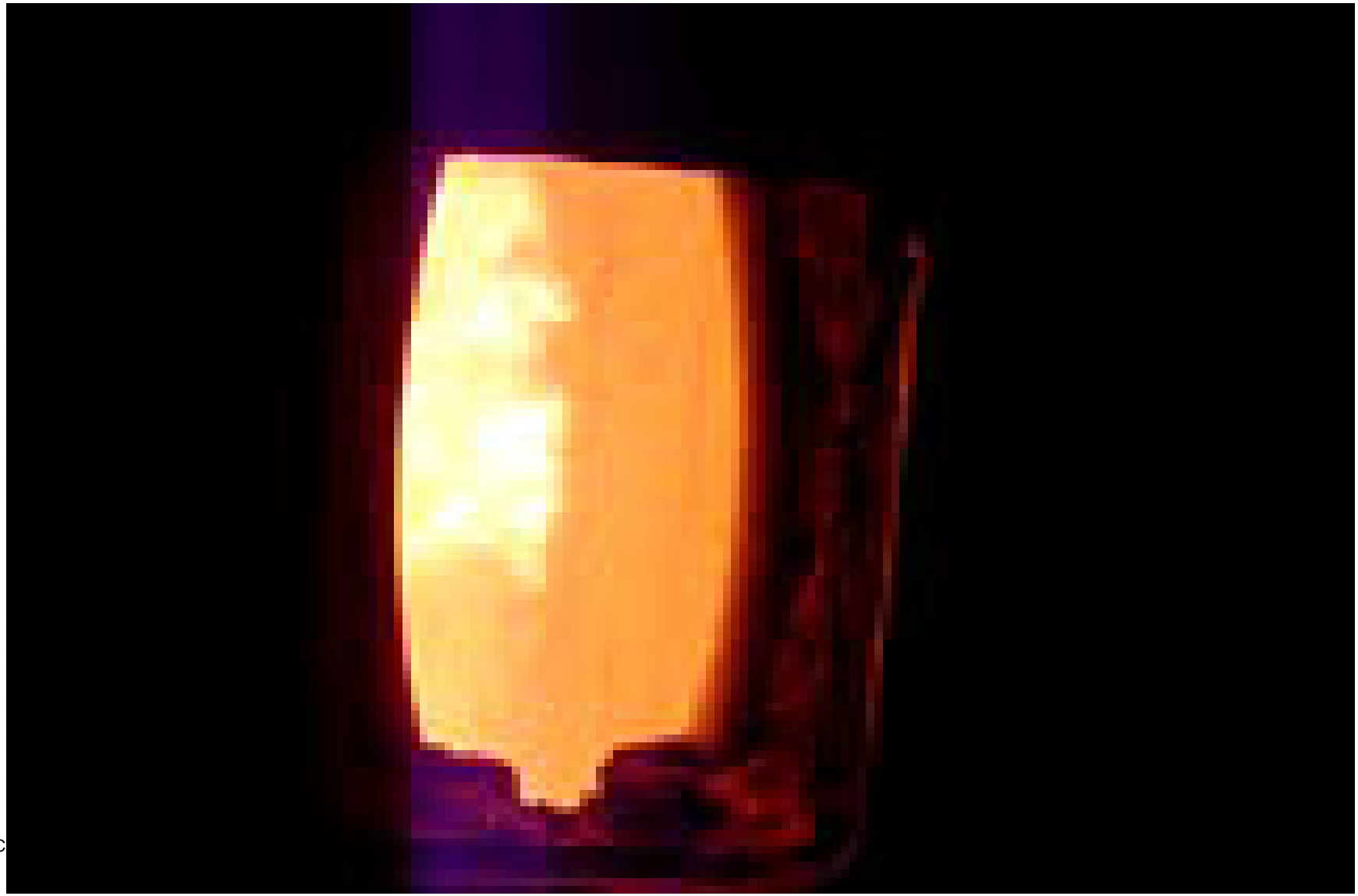
St. Johns Unit 1 Fly Ash LOI:
Post vs. Pre-Retrofit



St. Johns Unit 1 Burner Turndown

- Only 30% turndown to 475 MW could be achieved with the existing OEM burners and one mill out of service
- Turndown to 380 MW has been achieved with the ABT fuel injectors with only one mill out of service
- Improved turndown requires fewer mills taken out of service when dropping load – reducing oil consumption if these mills had to be put back online for unit ramp up.

ABT Opti-Flow™ Fuel Injector: Unit 1 380 MW



OEM Fuel Injector: Unit 2 660 MW

Summary

- For St. Johns Unit 1, a complete retrofit of ABT's fuel injectors has achieved the NO_x guarantee of 0.40 lb/10^6 Btu ***while reducing CO and LOI***. Almost all mill configurations can now be used to achieve the NO_x limit of 0.5 lb/10^6 instead of D-Mill only out of service.
- St. Johns Unit 2 has been partially retrofitted with ABT fuel injectors. In the Spring of 2004 a complete fuel injector retrofit and OFA system will be installed.
- CO emissions have been reduced to less than 100 ppm for both units.

Summary (cont'd)

- LOI has been reduced by 50% for Unit 2 and 35% for Unit 1
- For Unit 1, improved flame stability has resulted in better turndown with a complete retrofit of ABT fuel injectors
- For Unit 1 furnace ACP's have been effective in greatly reducing sidewall CO concentrations as shown by gas measurements (<500 ppm).
- ABT has been the first to demonstrate co-firing petroleum coke in an advanced low NO_x burner to minimize NO_x, CO and LOI and attain a 2:1 turndown.