LOW NO_x COMBUSTION SYSTEMS FOR MINIMIZING NO_x AND FLY ASH LOI:
Wall-Firing Petcoke and T-Firing Severe Slagging Coal

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Outline

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  - » Wall-Fired Low NO_x Combustion System
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  - » Post-Retrofit Results
- Owensboro Municipal Utilities Elmer Smith 2
  - » T-Fired Combustion System
  - » Scope of Work
  - » Post-Retrofit Results
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Challenges for Low NO_x Combustion Systems

- Lower furnace NO_x from combustion system reduces cost of post-combustion NO_x removal by SNCR or SCR
- Advanced low NO_x combustion system must not only minimize NO_x, but also CO and LOI
- Poor quality fuels place additional constraints on low NO_x combustion system:
  - » Petcoke: hard to ignite
  - » Colombian coal: hard to burn out
  - » High pyrite content coal: slagging and corrosion

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
3. Provide even coal distribution around the burner nozzle
4. Attain a stable, bright flame commencing in the throat.
5. Burn out CO and LOI with effective overfire air system: *no deep staging of the burners*

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

- Fuel: Hard to burn 20% petcoke/ 80% Colombian coal blend
- Requirements:
  - » NO_x guarantee: 0.30 lb/10^6 Btu *(Current limit is 0.5)*
  - » CO: <200 ppm
  - » LOI: <Baseline
- Combustion Modifications: 28 low NO_x fuel injectors*

  OFA system

  Windbox modifications

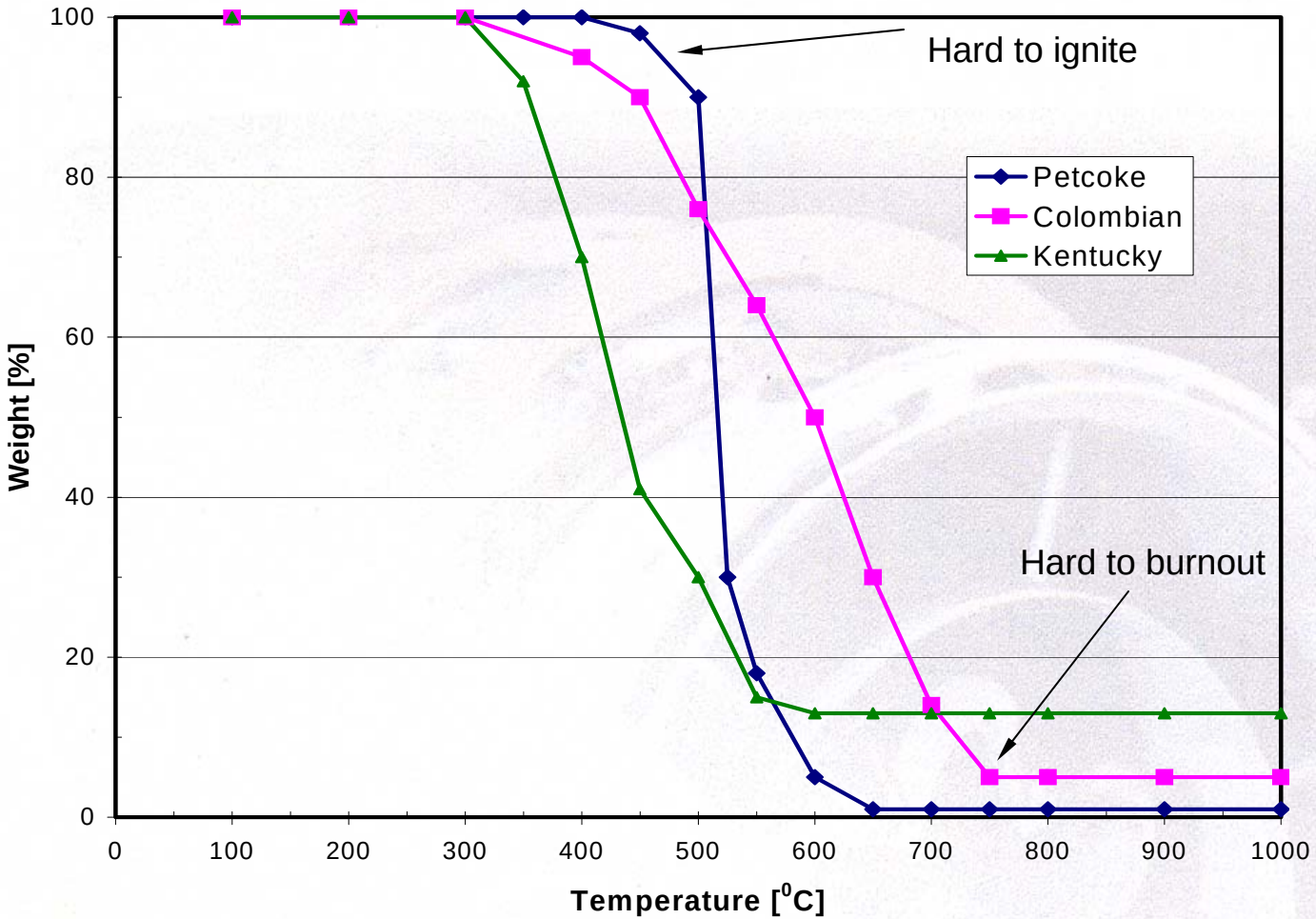
  ** Existing dual registers re-used with modifications*
- Installation Completed: Unit 2 – March 2004

  Unit 1 – March 2005

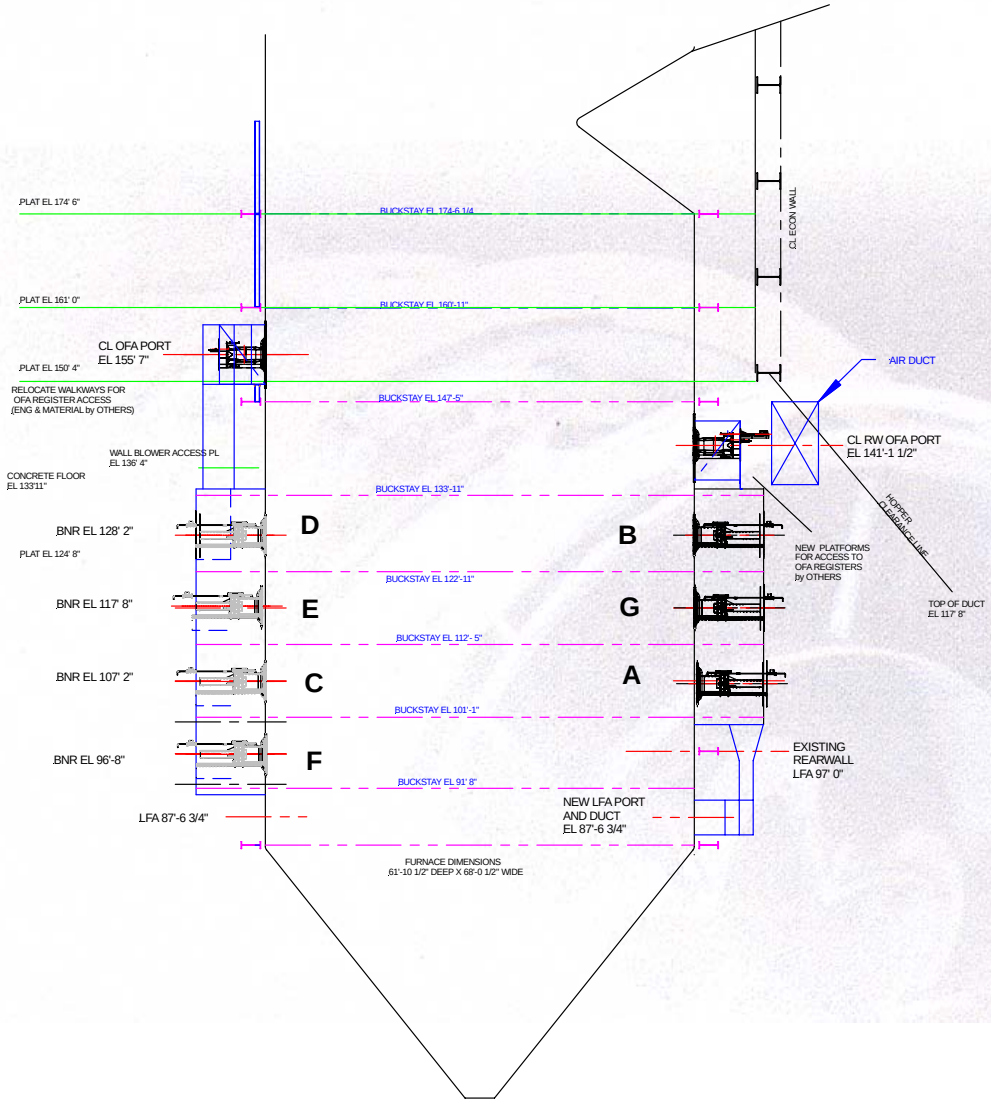
St. Johns Fuel Analyses

	Coke	Coal
Proximate Analysis (wt%, ar)		
Fixed Carbon	83.92	47.60
Volatile Matter	**8.50**	33.40
Ash	0.52	7.40
Moisture	7.06	11.60
Ultimate Analysis (wt%, ar)		
Carbon	82.22	66.54
Hydrogen	3.35	4.50
Oxygen	0.00	7.99
Nitrogen	**1.71**	**1.32**
Sulfur	5.14	0.65
HHV, Btu/lb	14,200	11,800
HGI	44	48

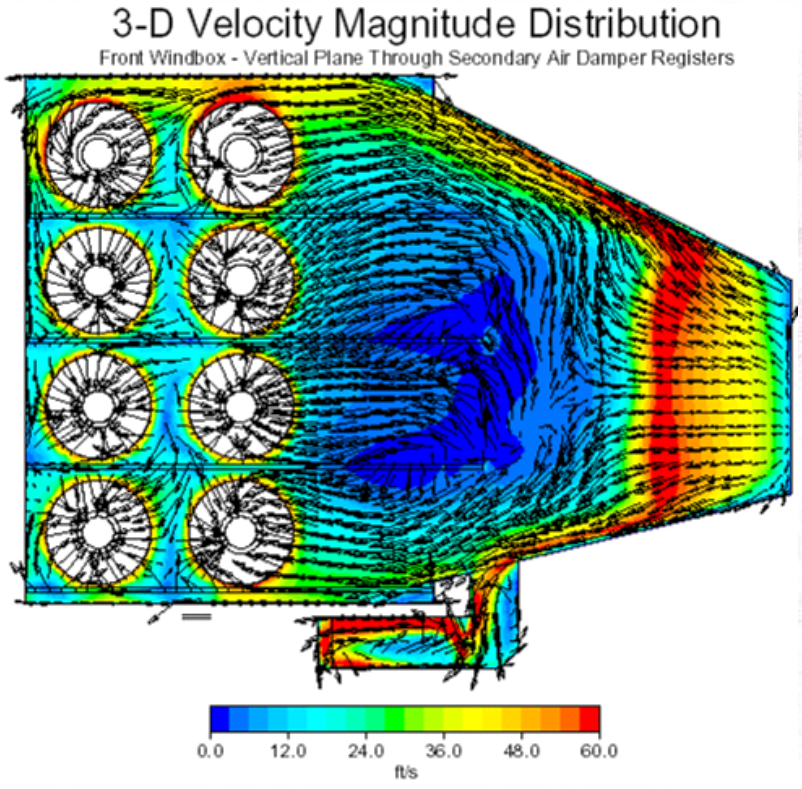
TGA Burning Profiles of Fuels



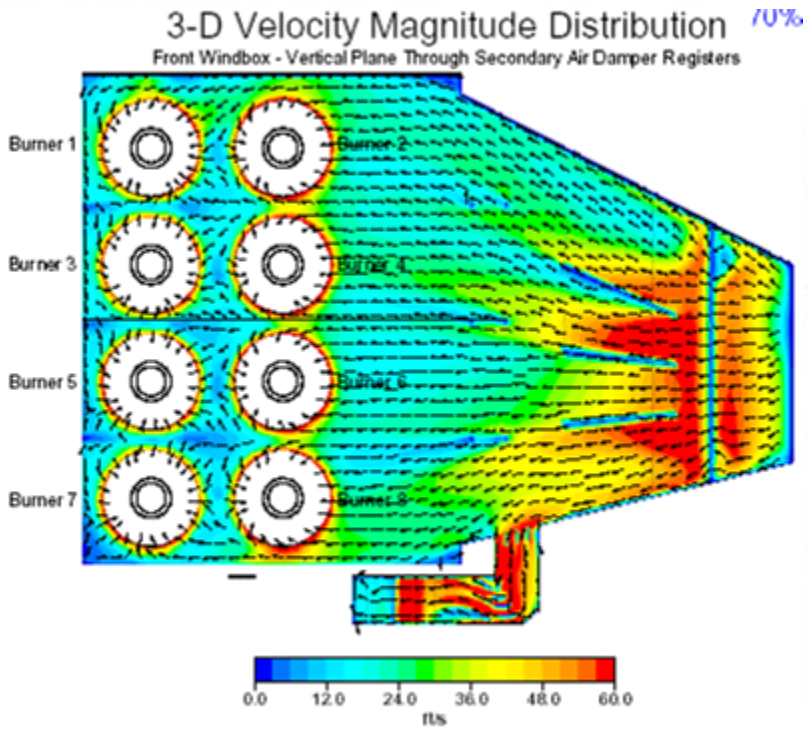
Layout of St. Johns Units 1 and 2



CFD Model of St. Johns Front Windbox



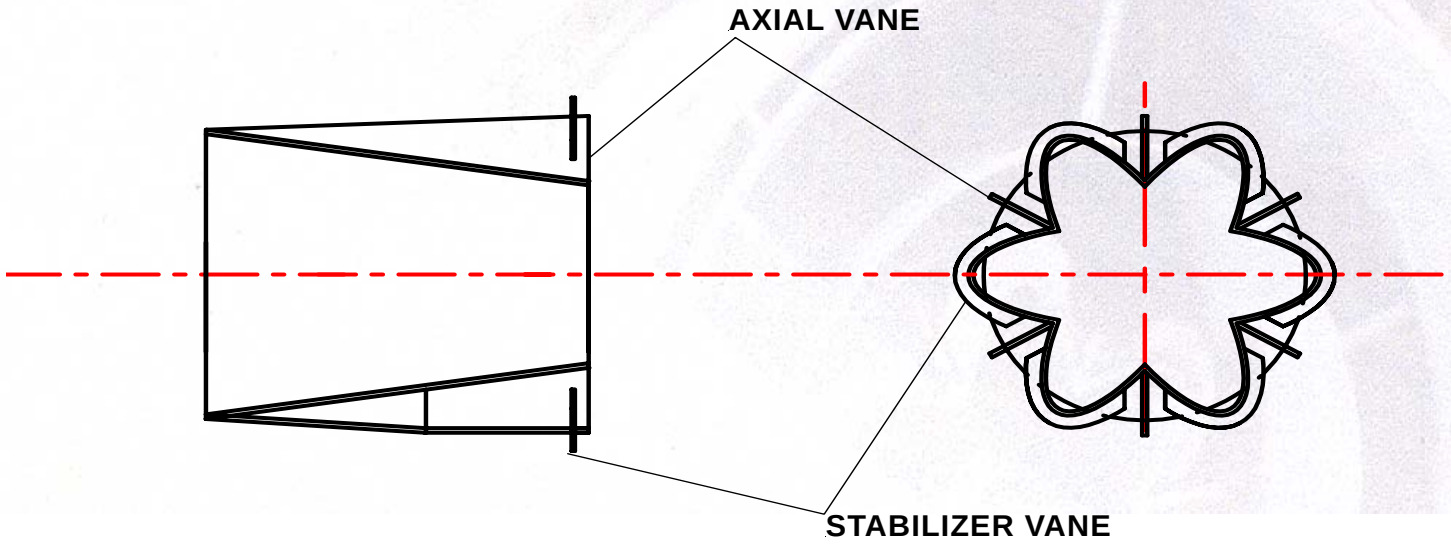
Baseline Air Velocity Distribution



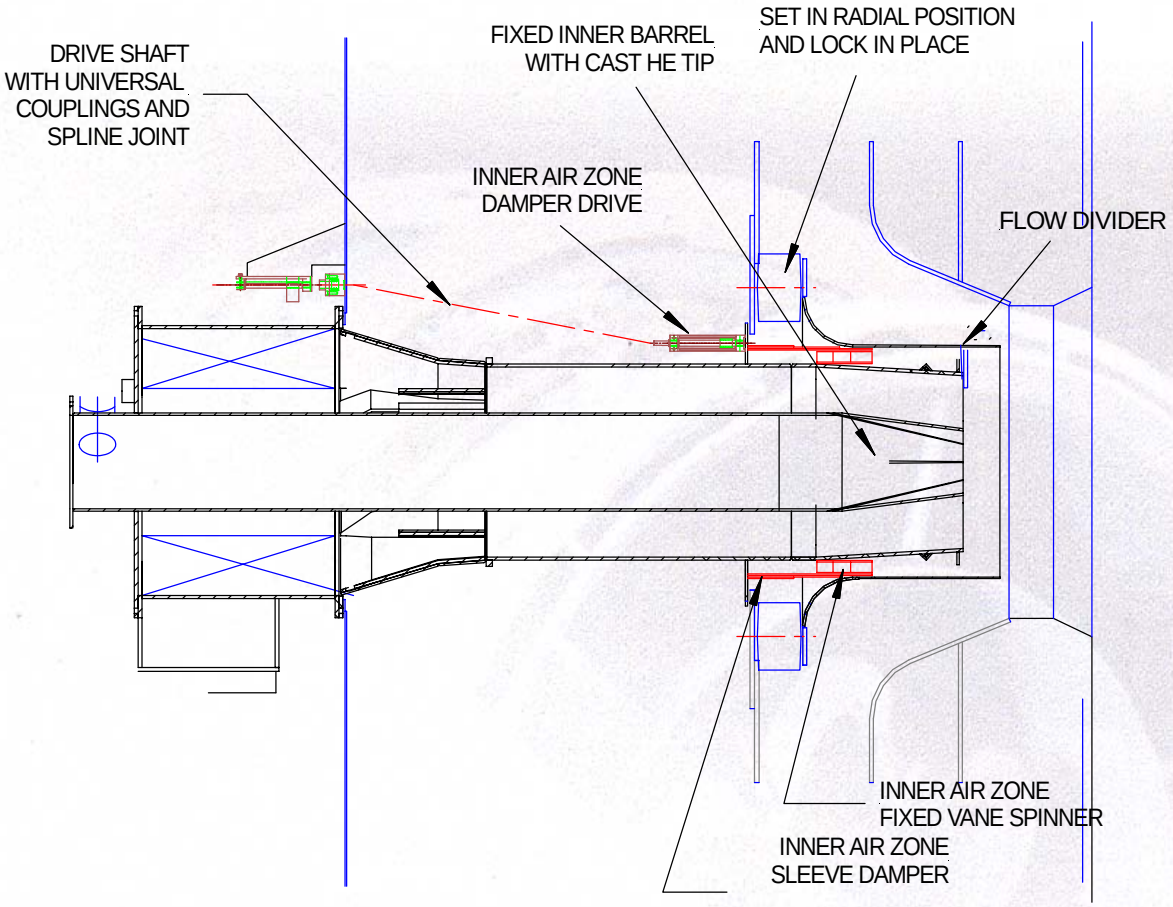
Air Velocity Distribution with Design Modifications

Opti-Flow™ Fuel Injector

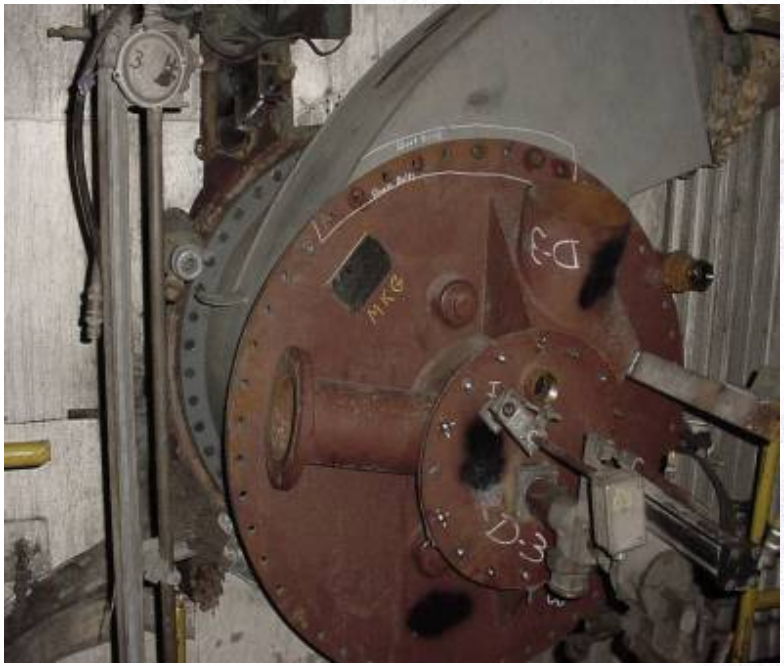
- Heart of the Opti-Flow™ low NO_x burner developed for wall-fired boilers
- 35% lower NO_x than the conventional LNB replaced by ABT and at least 60 to 70% below turbulent burner.
- Open nozzle, no erosion or coking

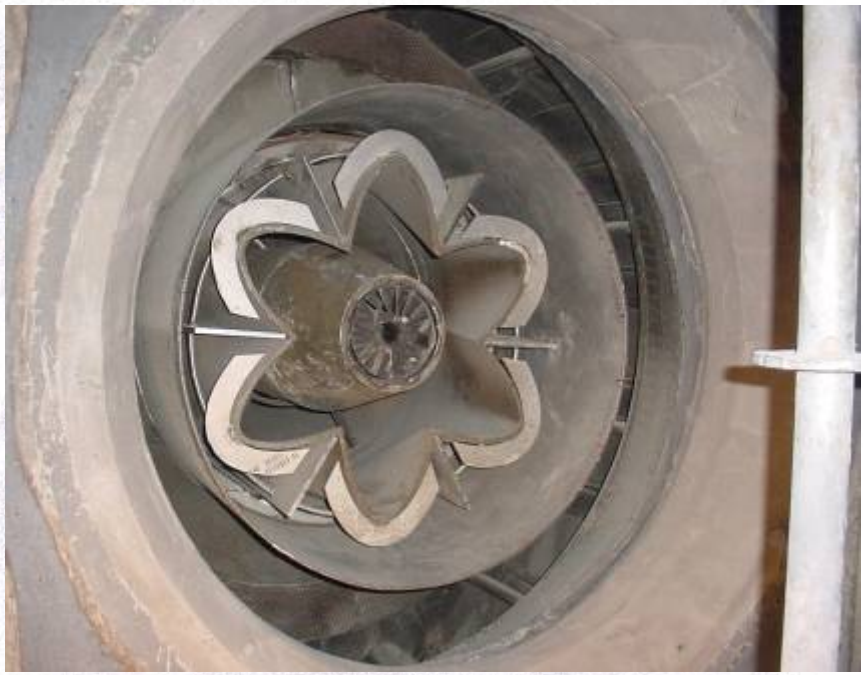


ABT Mark II Fuel Injector for St. Johns



St. Johns Unit 1 Burner





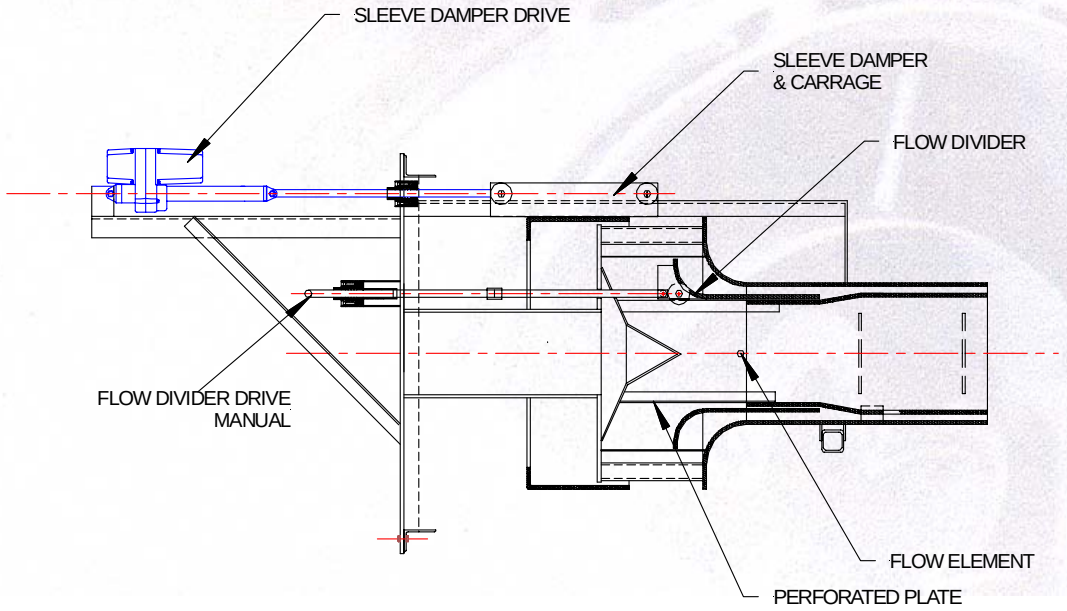
Comparison of ABT and OEM Fuel Injector Flames

ABT Fuel Injector: Unit 1 380 MW

OEM Fuel Injector: Unit 2 660 MW

Features of OPTI-FLOW™ Aerodynamic OFA Port

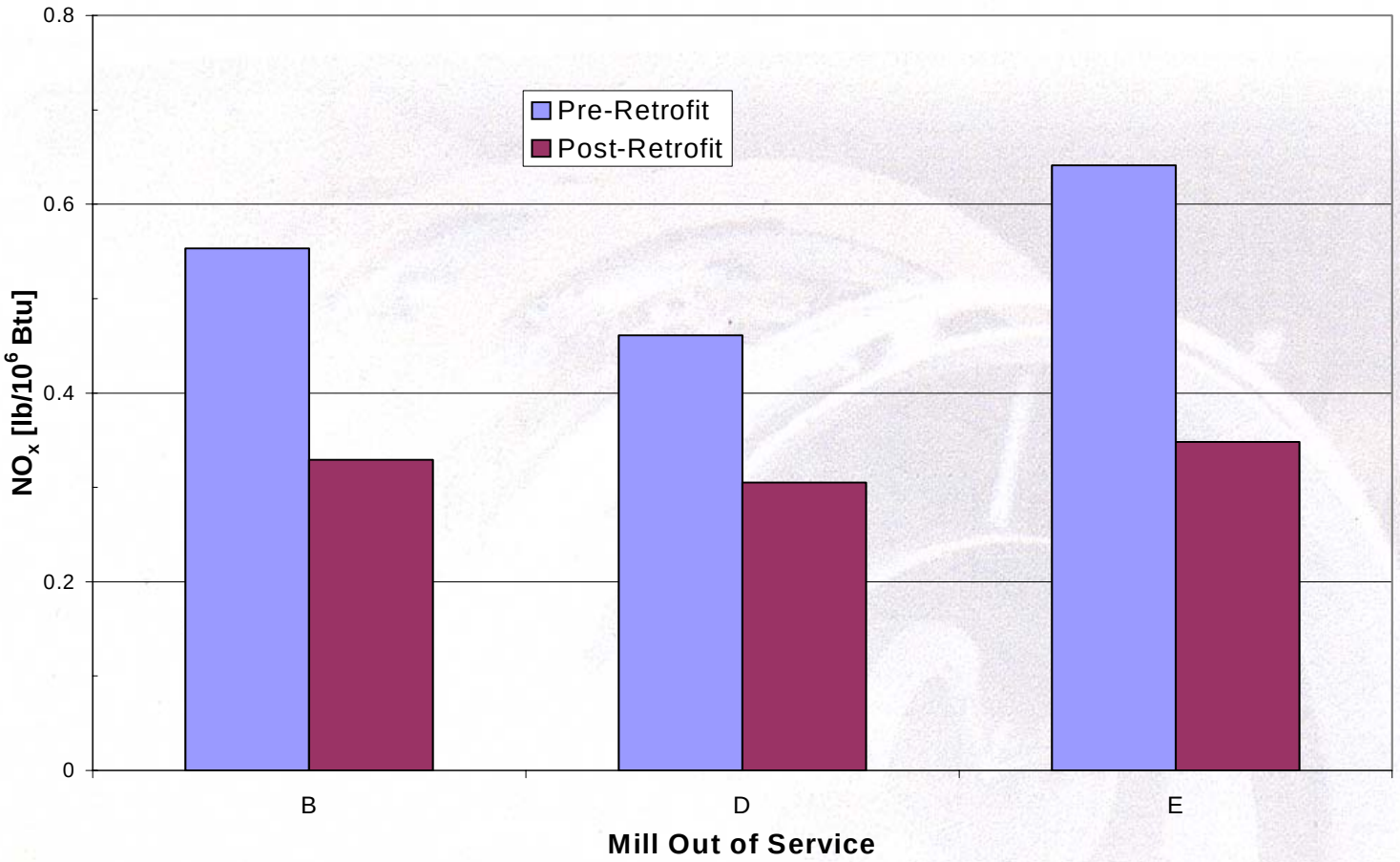
- Dual stage design
  - » One damper controls total flow
  - » One damper control inner/outer ratio
- No swirl vanes
- Deep penetration and excellent horizontal mixing



St. Johns Unit 2 Post-Retrofit Results Summary with Fuel Blend

- NO_x reduced from 0.46 to 0.3 lb/10^6 Btu with top mill out of service
- CO emissions reduced from >500 less than 100 ppm
- LOI reduced by 40%. LOI still relatively high ~20%.

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



St. Johns Unit 2 Firing Configuration:
Separate Fuel Firing

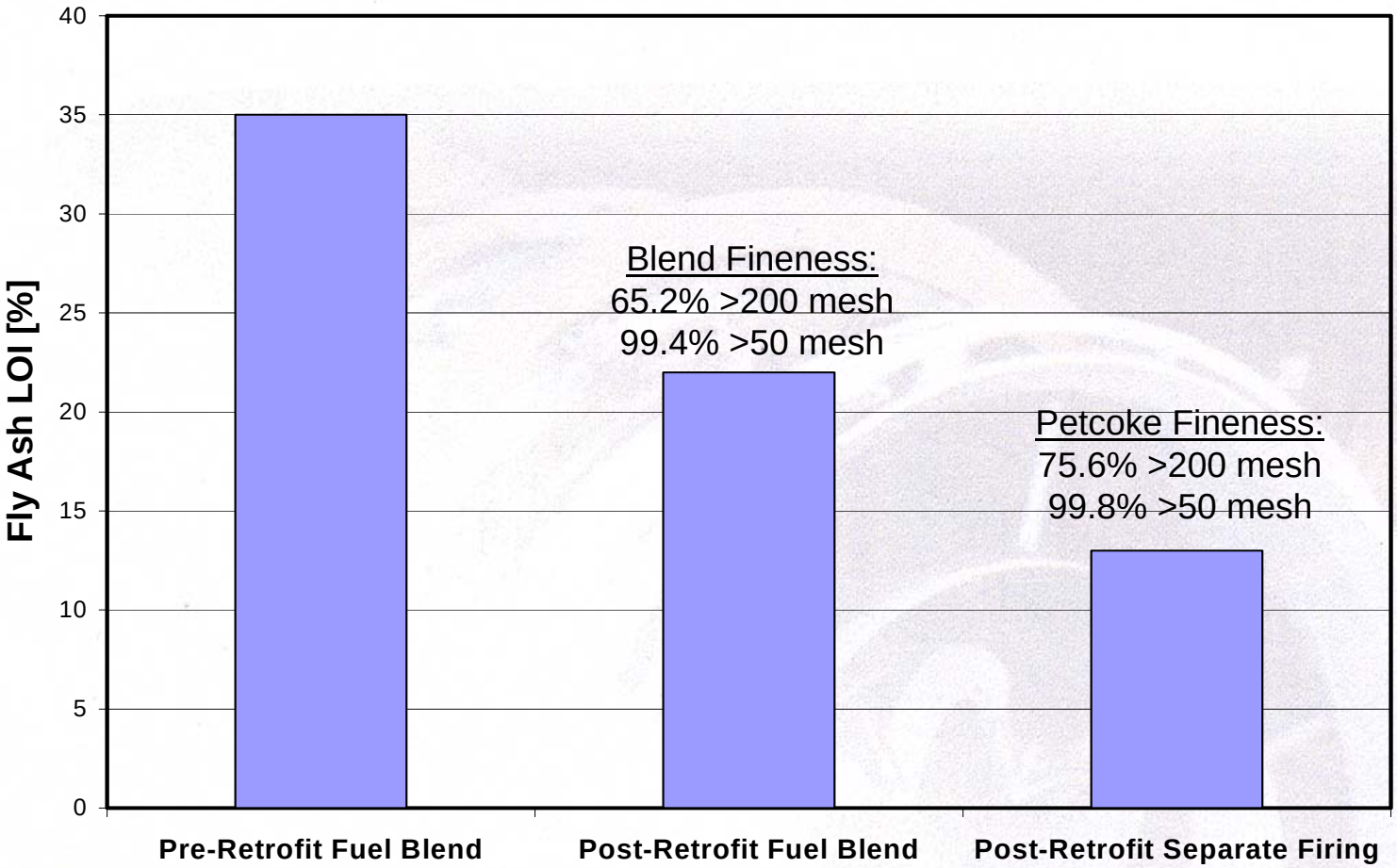
- 100% petcoke fired with C-row (second from bottom) burners on front wall
- Remaining burners firing 100% Colombian coal
- Fuel flow to mills adjusted to ~18% petcoke input on a weight basis

Petcoke and Colombian Coal Flames

100% Petcoke

100% Colombian Coal

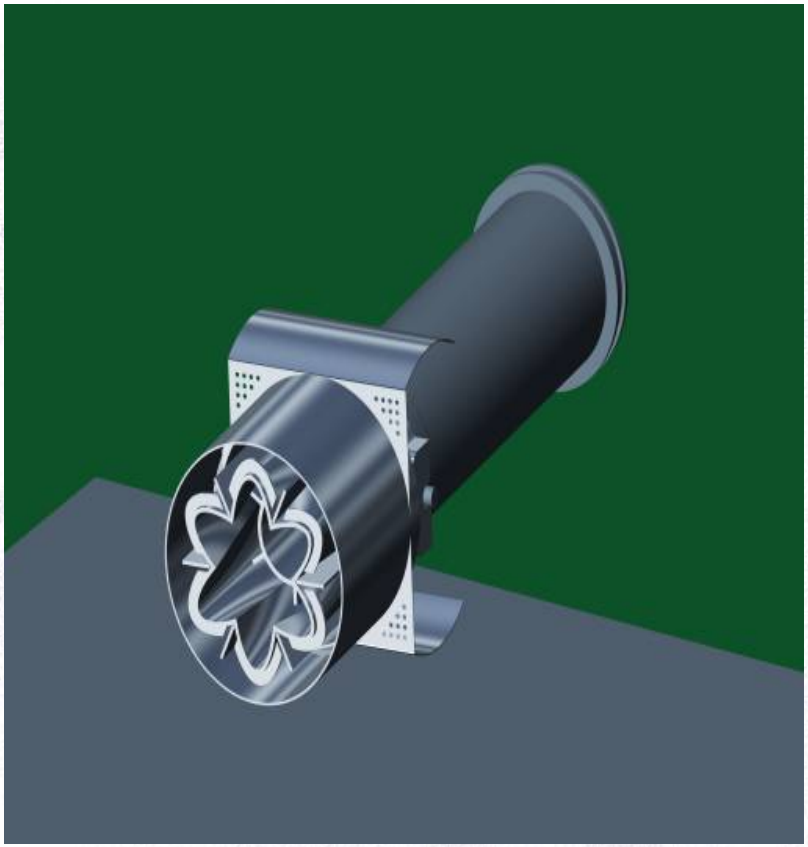
St. Johns Unit 2 LOI:
Fuel Blend vs Separate Firing



OMU Elmer Smith Unit 2: T-Fired

- Fuel: Severe slagging midwestern coal
- Boiler Information: 290 MW, Single furnace, Four burner levels, CCOFA
- Requirements:
  - » NO_x guarantee: 0.25 lb/10^6 Btu
  - » CO: <100 ppm
  - » LOI: <Baseline (~1%)
  - » Slagging: Reduced

Opti-Flow ™ T-Fired Fuel Injector

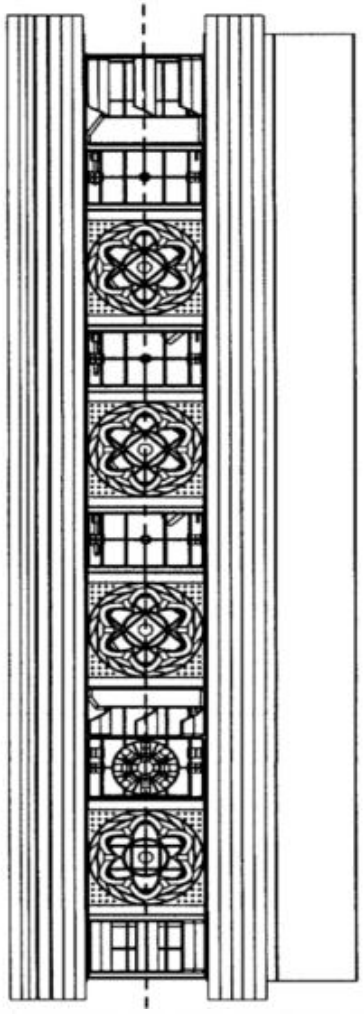


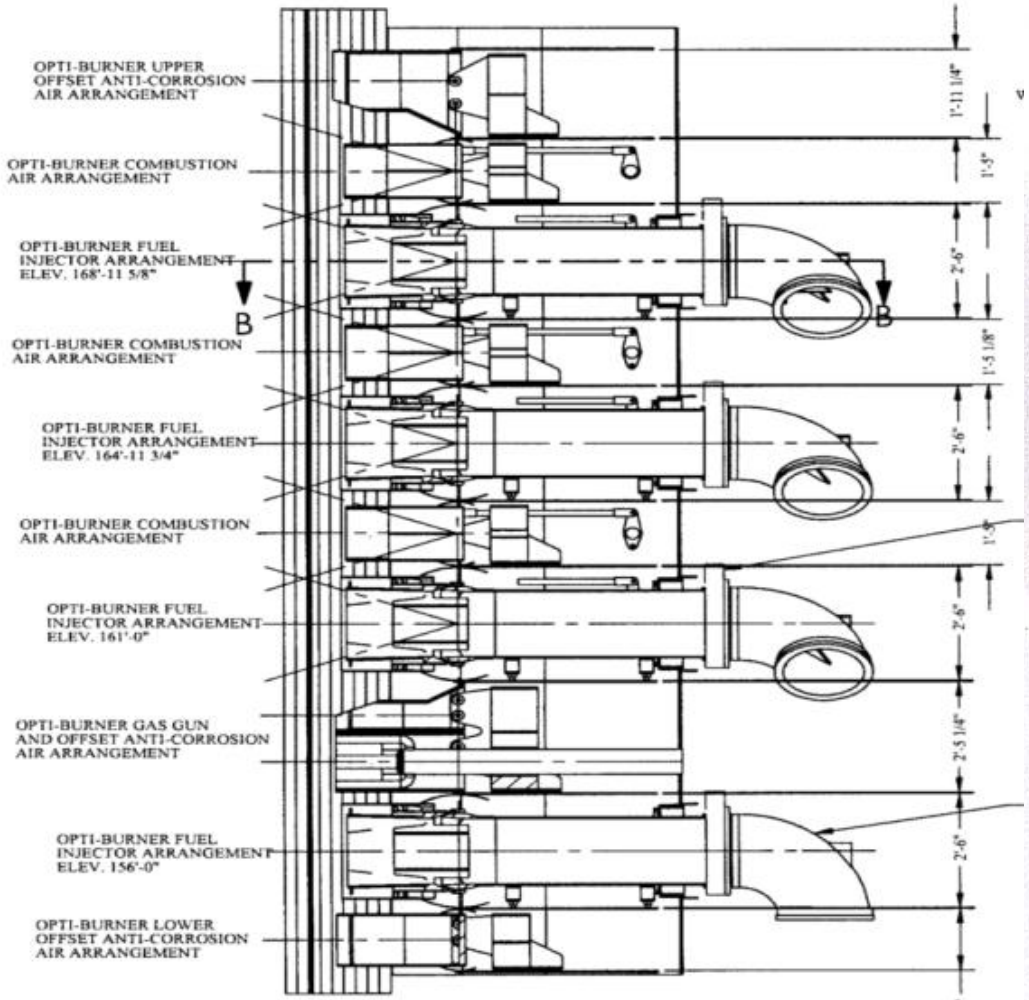
Scope of Work for OMU

- CFD modeling
  - » Fuel injector and combustion air
  - » OFA system
  - » Anti-corrosion and slagging system
- Low NO_x combustion equipment (April 2004)
  - » 16 new ABT Opti-Flow fuel injectors
  - » New combustion air buckets
  - » New one level SOFA system
  - » Anti-corrosion and slagging system

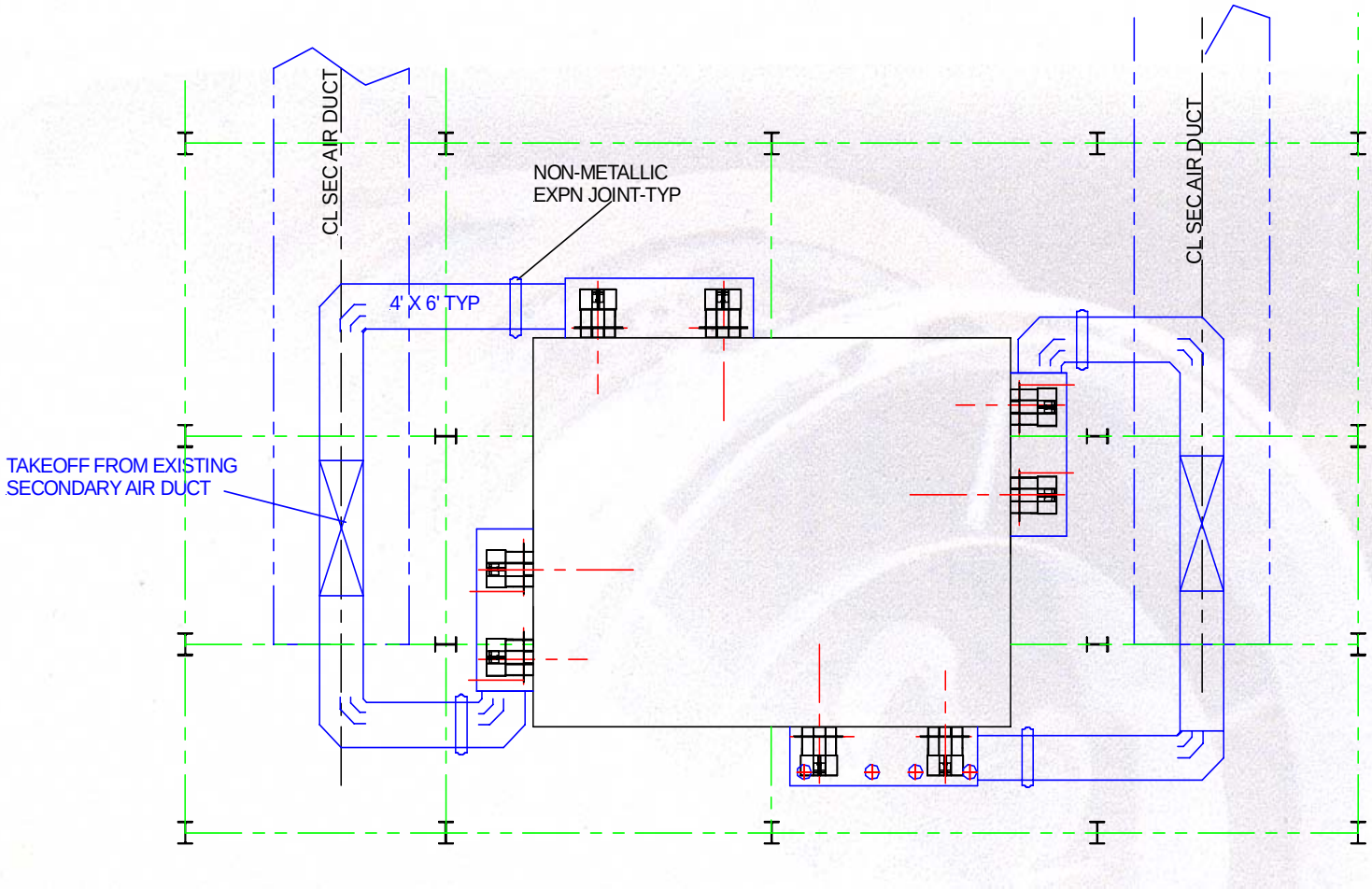
Opti-Flow Fuel Injector for OMU

OMU Burner Box Layout





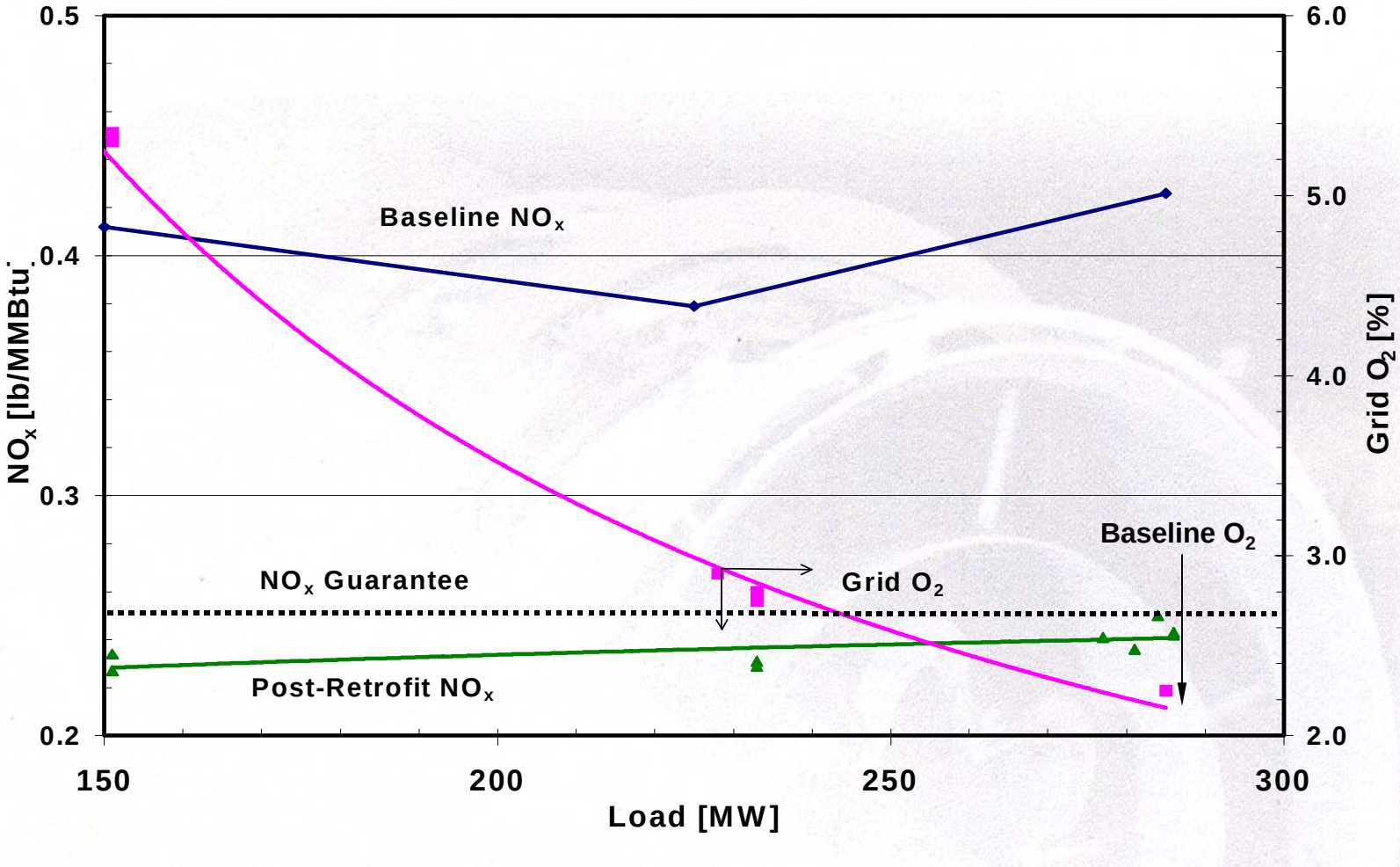
Plan View of SOFA Arrangement



OMU Post-Retrofit Results

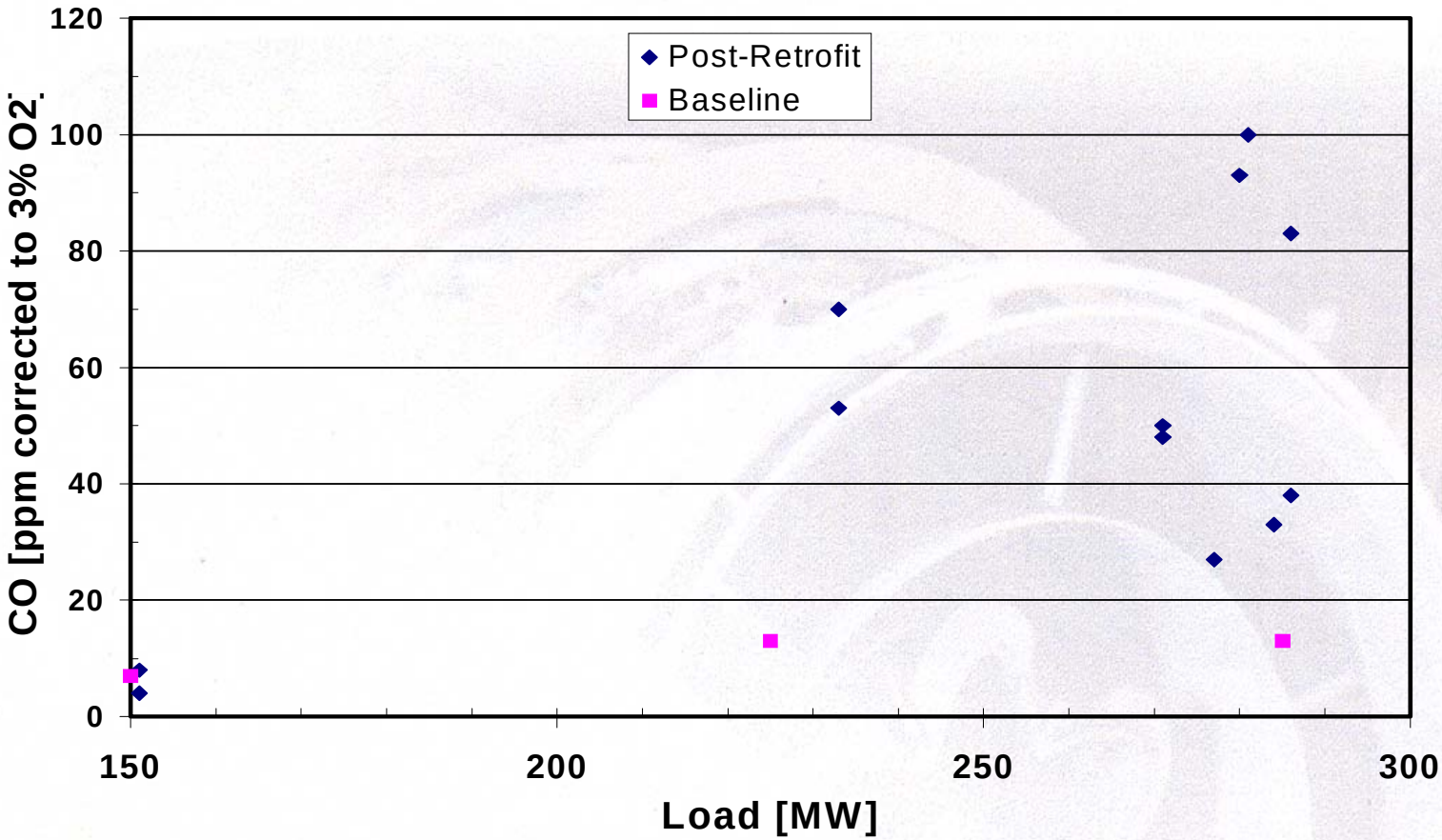
- All emissions guarantees easily met
- Severe slagging eliminated
- Fuel and secondary air flows balanced

NO_x Emissions vs Load:
Baseline and Post-Retrofit

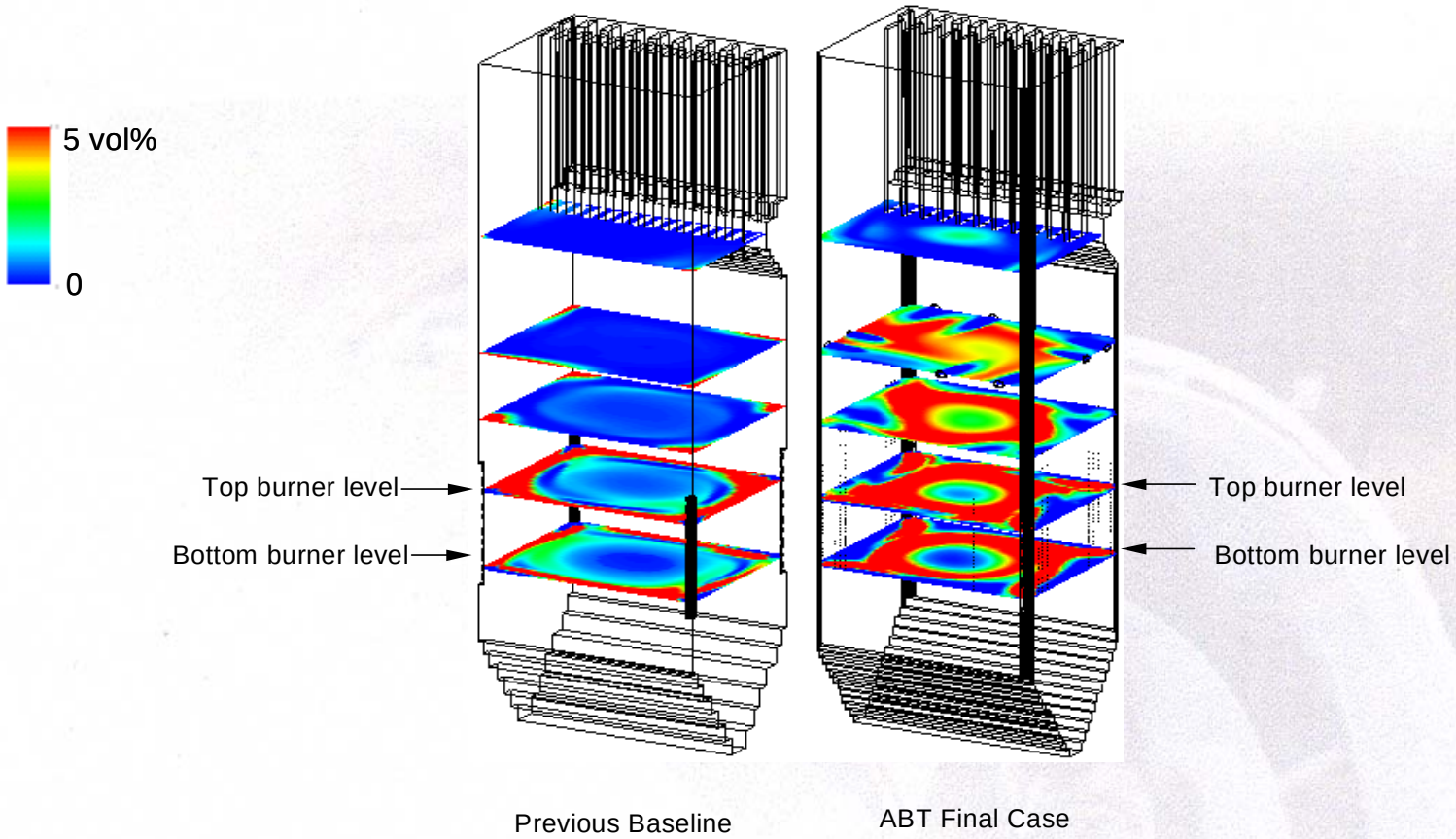


CO Emissions vs. Boiler Load

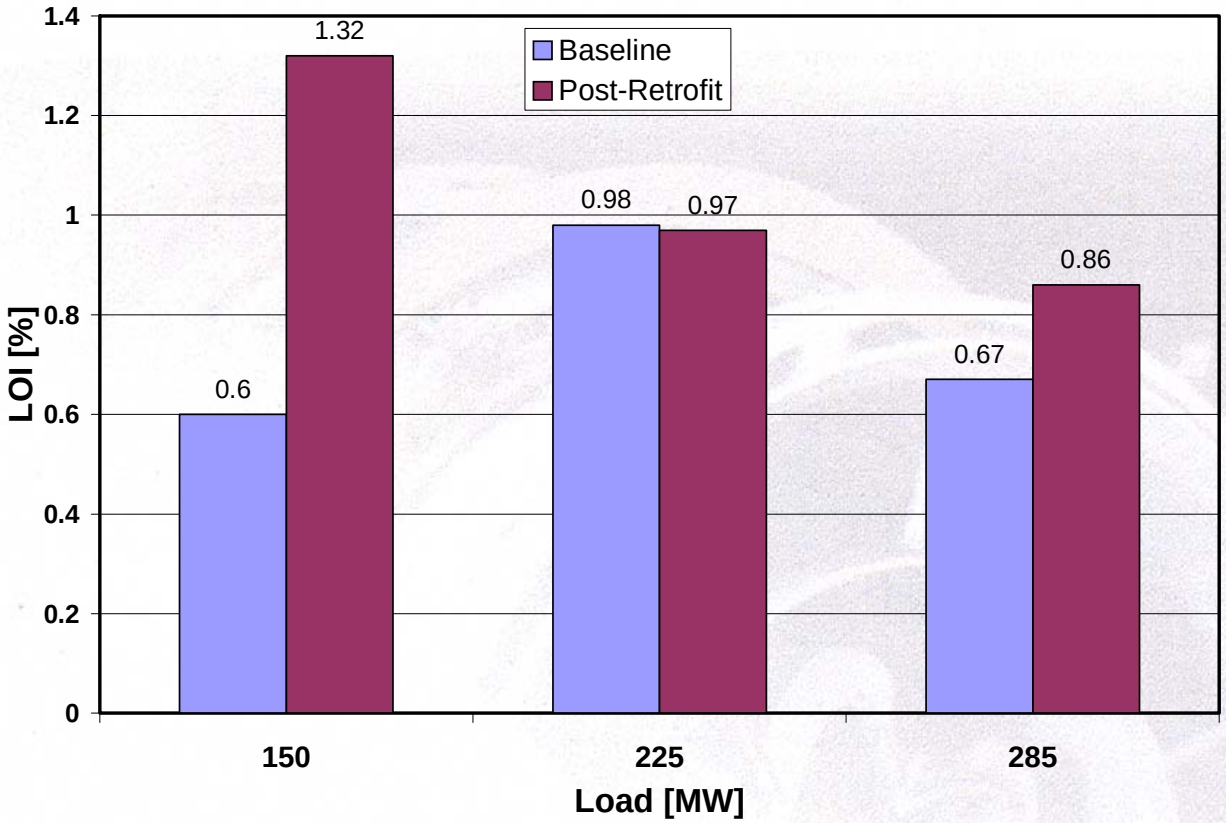
Baseline and Post-Retrofit



Furnace Model Results Showing CO



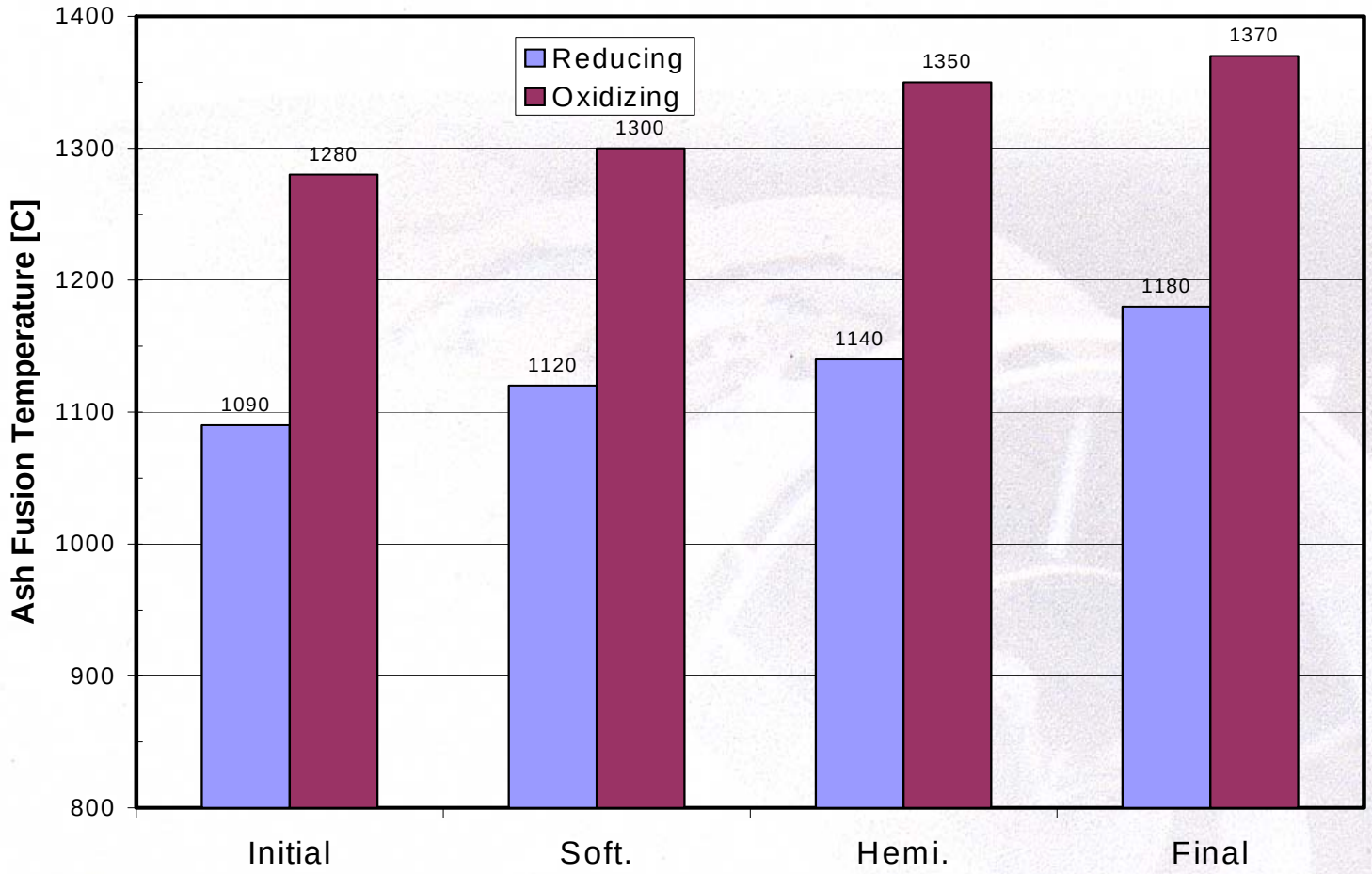
OMU Fly Ash Unburned Carbon



OMU Slagging Coal Analysis

Sulfur, wt%	4.4
Ash, wt%	21.3
SiO_2	40.6
Al_2O_3	17.2
Fe_2O_3	21.3
CaO	6.7
MgO	0.9
K_2O	1.9
Slagging Index	Severe

OMU Coal Ash Fusion Temperatures



Slagging at OMU

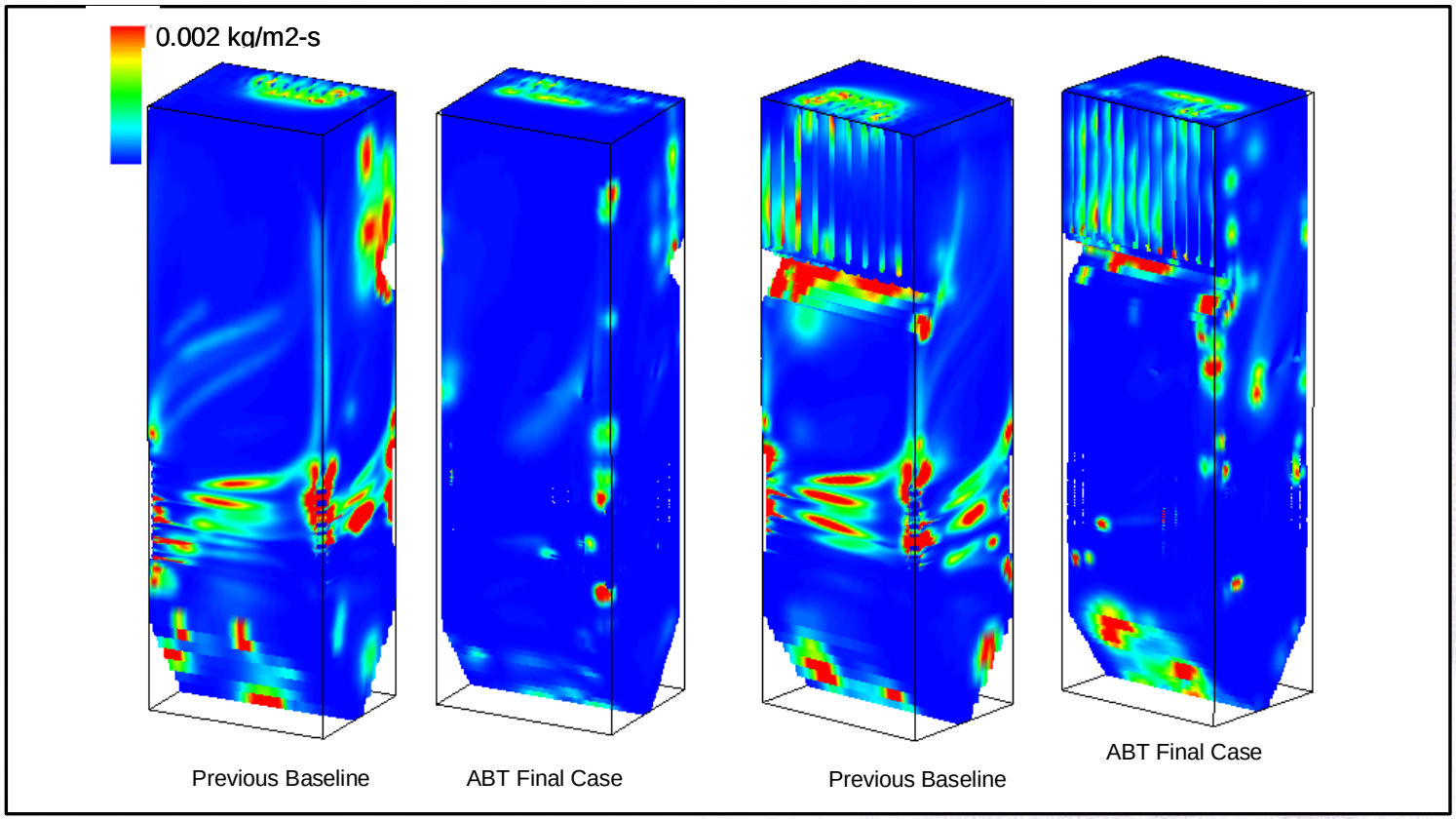
Pre-Retrofit:

- Severe slagging of furnace walls
- Burners unable to tilt due to slag build-up
- Dropping load required every shift to shed slag

Post-Retrofit:

- Furnace walls nearly completely clean
- Burners are capable of tilting
- No dropping of load required after months of operation

Furnace Model Ash Deposition Rate



Summary

- ABT has developed low NO_x combustion systems for both T-fired and wall-fired boilers to obtain minimum NO_x without an increase in CO or fly ash LOI
  - » Intense, very stable low NO_x flame
  - » Balanced coal flow to burners and around burner nozzle
  - » Effective OFA port with excellent penetration and mixing
- Combustion system with fuel flexibility:
  - » Wall-firing 100% petcoke with stable flames results in lower LOI than blending petcoke with coal
  - » T-firing severe slagging coal without problems; no increase in LOI even though excess air is reduced