Babcock & Wilcox

a McDermott company

Ultra Low NO_x Combustion Solutions for Wall-Fired Boilers

NOx Formation

NOx is formed by three mechanisms:

- ***Thermal oxidation of atmospheric nitrogen -- "thermal NOx"***
- ***Oxidation of nitrogen contained in the fuel -- "fuel NOx"***
- ***Reaction of atmospheric nitrogen with hydrocarbon fragments -- "prompt NOx"***

Thermal NOx Formation

- ***Temperature dependent reaction described well by the Zeldovich mechanism***
- ***NOx formation dependent on:***
  - **Combustion process temperature**
  - **Available oxygen concentration**
- ***Easily understood***
- ***Represents all NOx emissions formed during natural gas combustion***

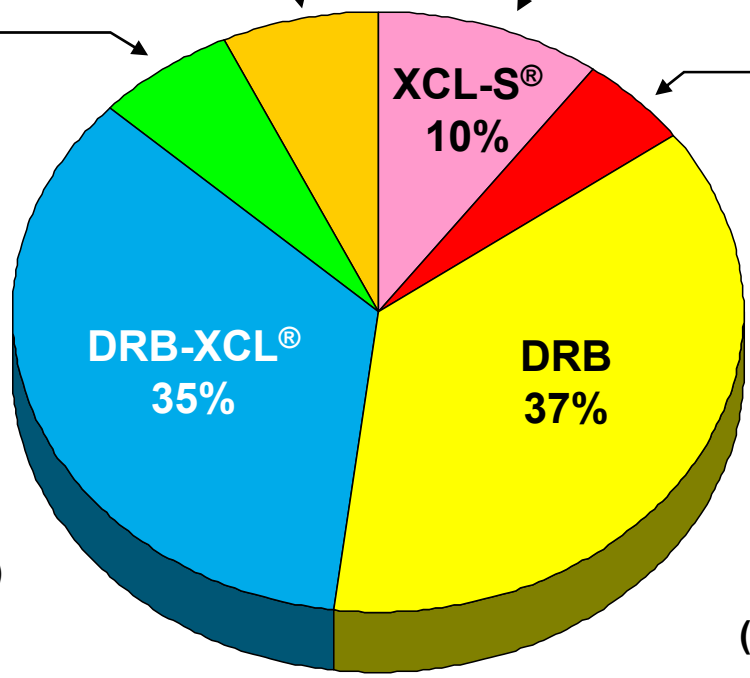
Fuel NOx Formation

- *Complex process*
- *Formed by the direct oxidation of nitrogen contained in the fuel*
- *Represents a significant portion of NOx formed in coal and residual oil combustion*
- *Sensitive to early combustion process stoichiometry but not effected by local temperature*

NOx Emissions Control

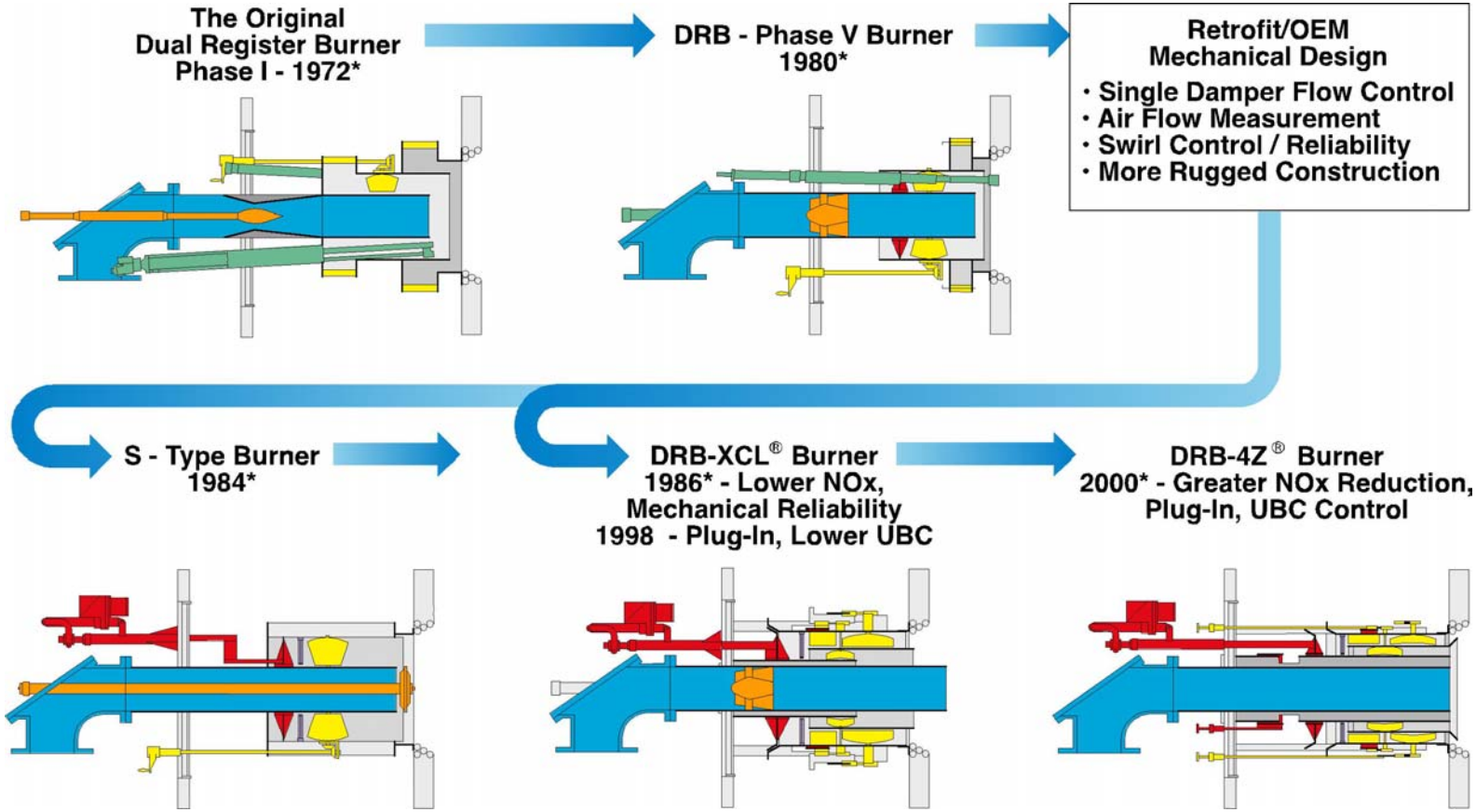
- **Combustion process modifications**
  - **Operation**
  - **OFA**
  - **Low NOx burners**
- **Post combustion techniques**
  - **Selective non-catalytic reduction (SNCR)**
  - **Selective catalytic reduction**

Low NO_X Combustion Equipment Experience
(All Fuels)



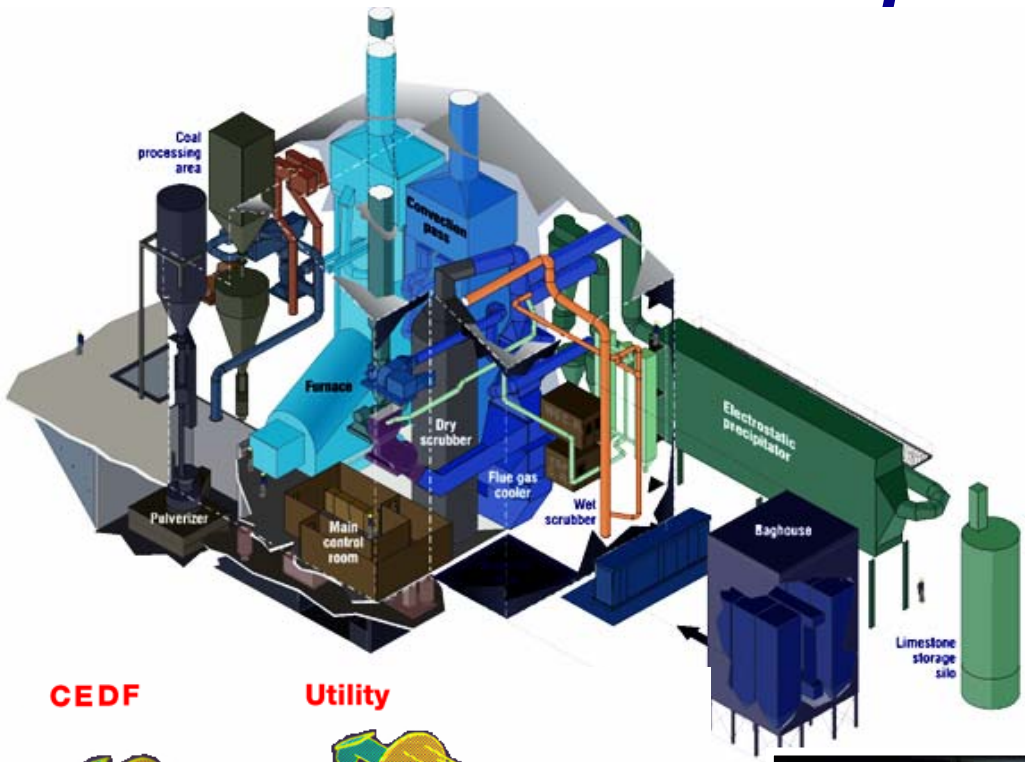
108,322 MW of Experience

30 Years of NO_x Reduction Leadership with Coal-Fired Burners



* First use in utility boiler

Clean Environment Development Facility

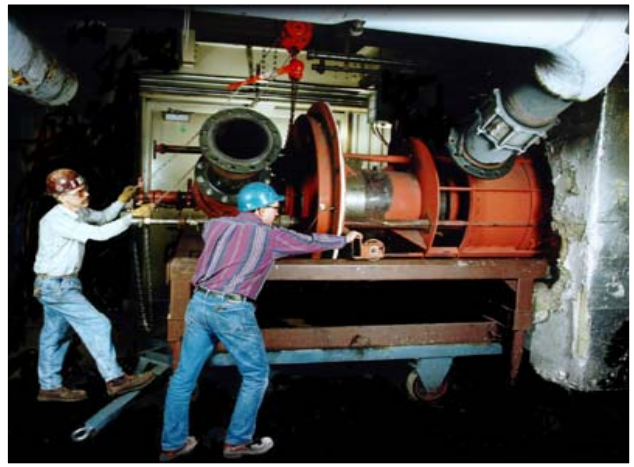


CEDF

Utility

MBtu/hr	100	170
MW_T	29.3	50
MW_e	9.8	17
Tons/hr coal (bit)*	4.0	7
Burner throat dia., inches	40	52

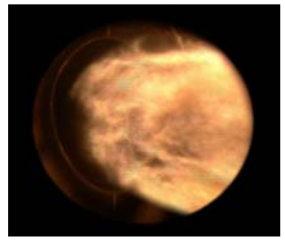
* 12,500 Btu/lb HHV



Combustion NO_X Control Innovation

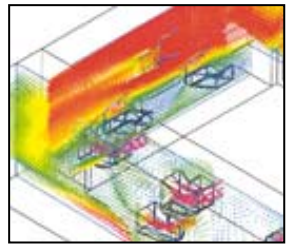
- **B&W pioneered Low NO_X combustion equipment (OFA patent 1962)**

- **Advanced combustion technology for wall- and tangential-fired units**



- **DRB-4Z™ ultra low NO_X burner available for bituminous and sub-bituminous coals**

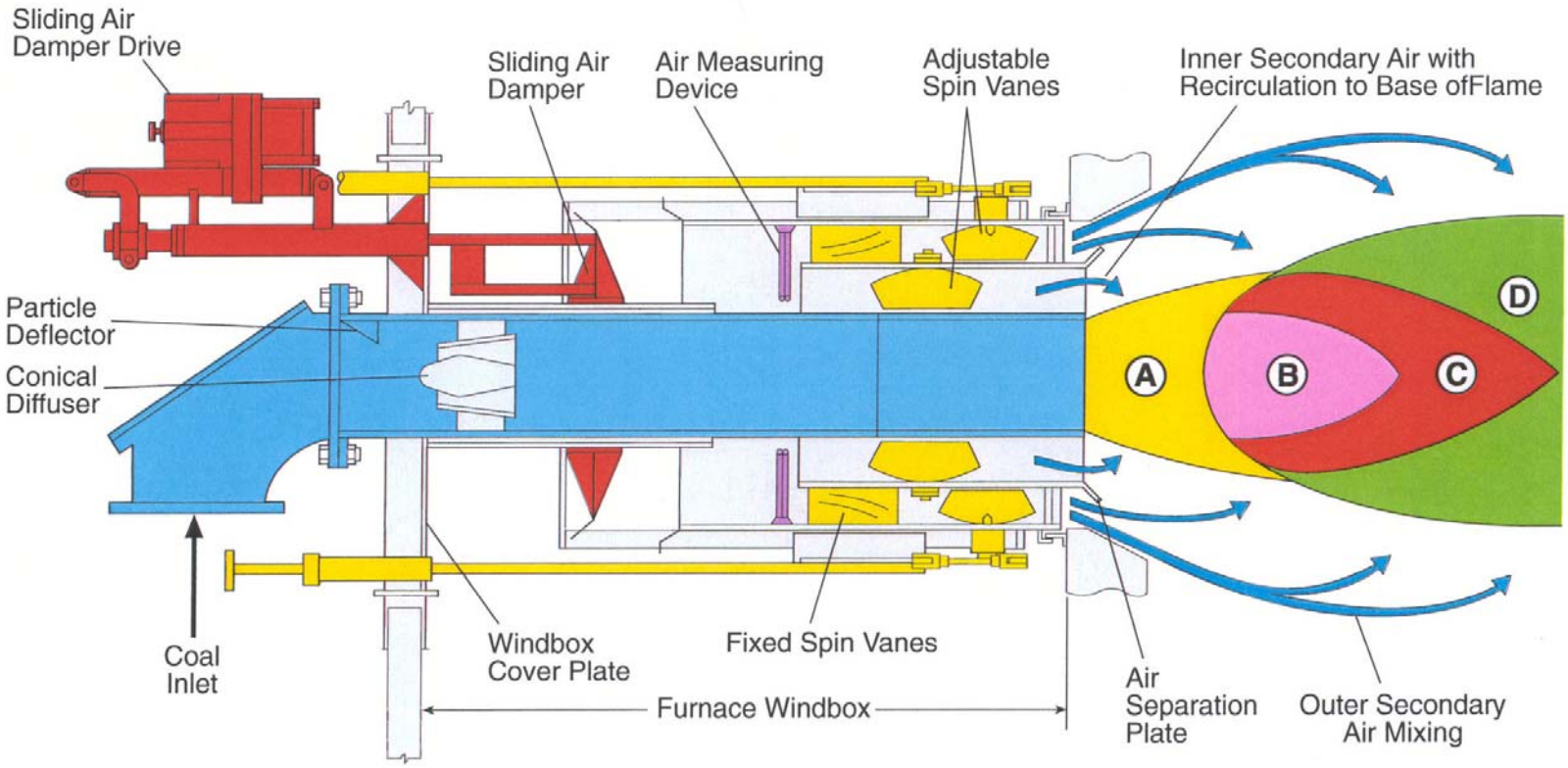
- **Advanced CFD-assisted design OFA system further reduces NO_X on wall- and tangential-fired units.**



- **Lower NO_X from the furnace leads to lower SCR costs**

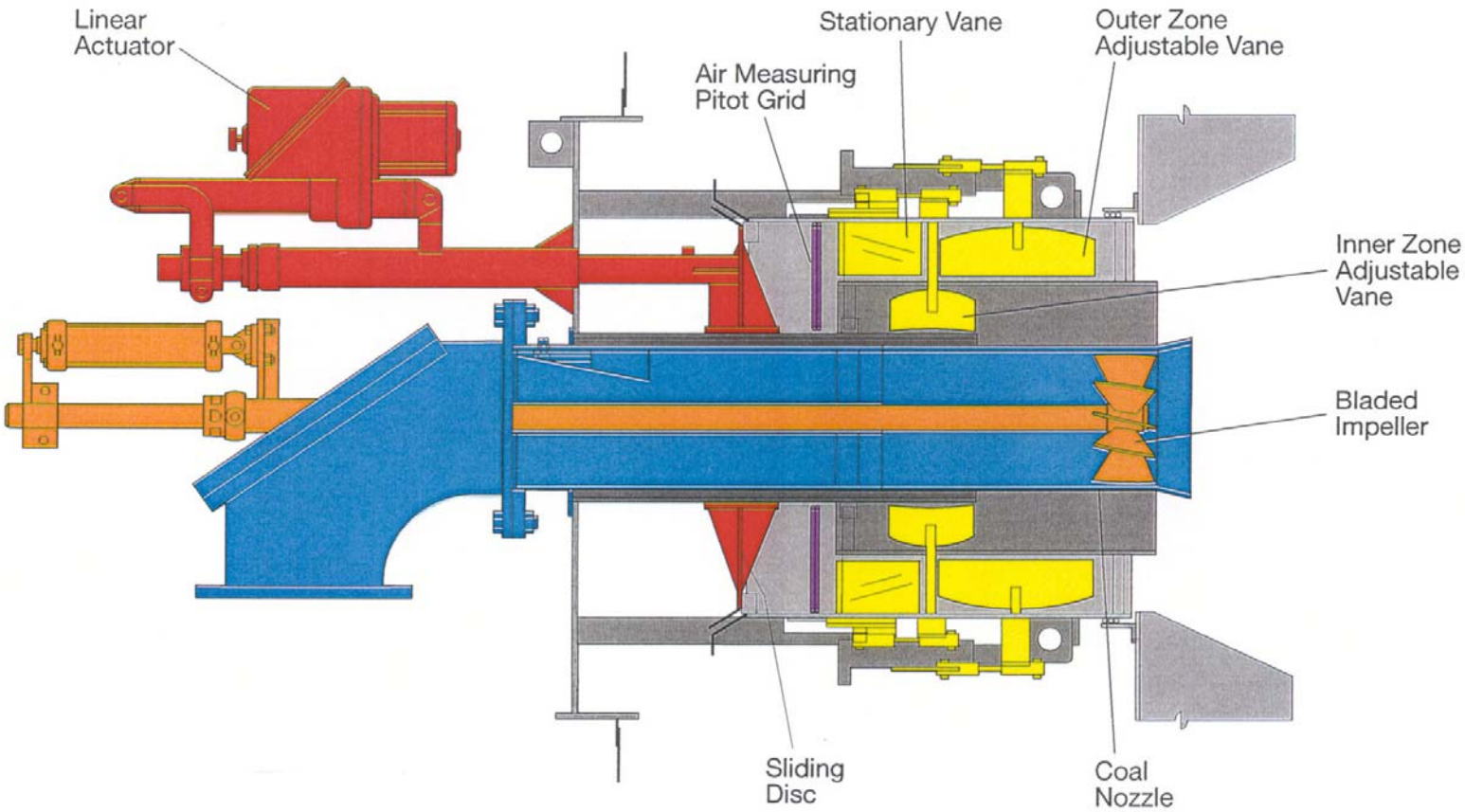
Low NO_x Combustion Zones

DRB-XCL® Burner (PC Fired)



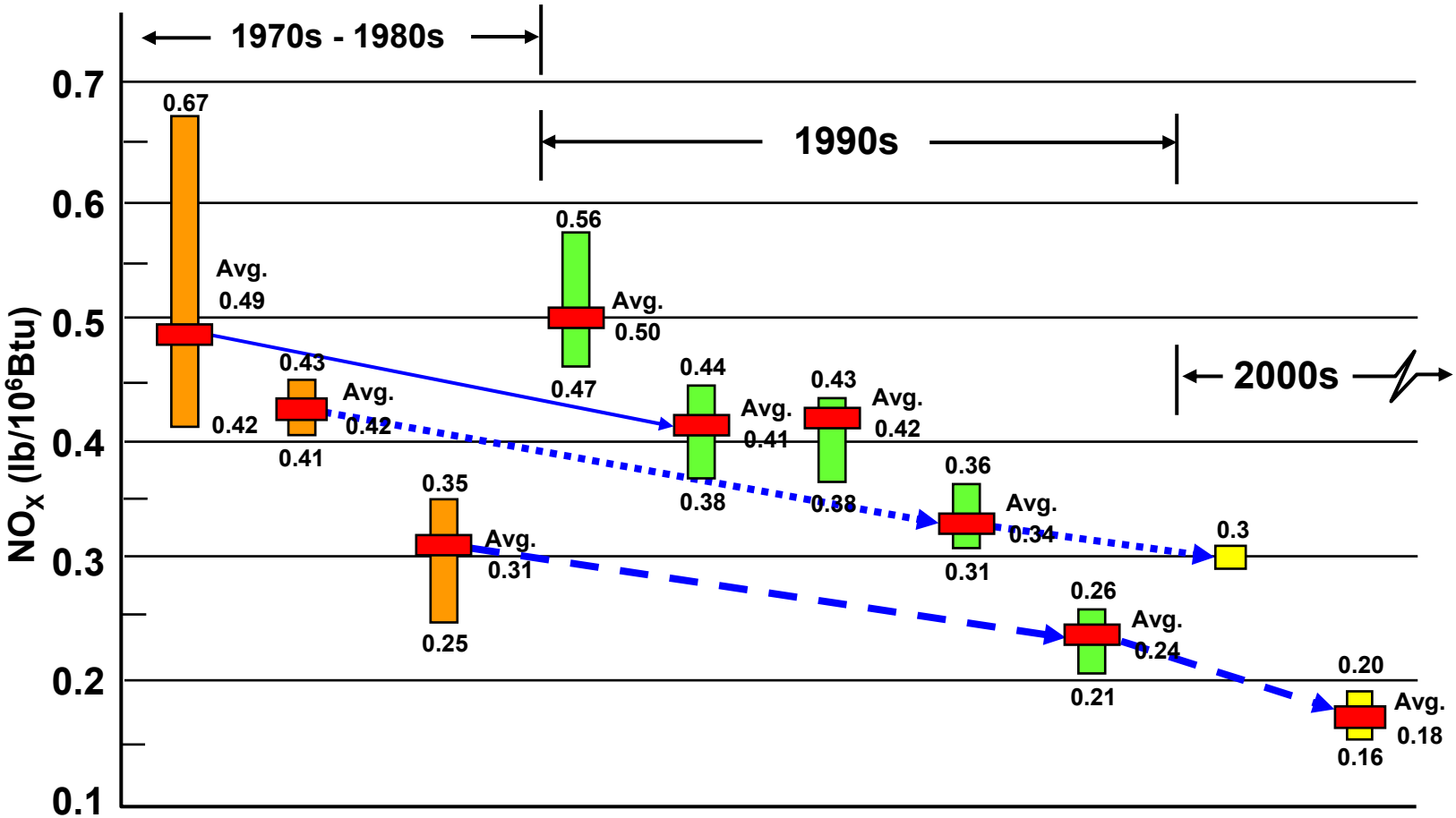
- (A) High temperature - fuel rich devolatilization zone
- (B) Production of reducing species zone
- (C) NOx decomposition zone
- (D) Char oxidizing zone

PC-Fired Plug-In Low NO_x DRB-XCL® Burner (Sectional Side View)



* Plug-in Application: No Furnace Wall Burner Throat Pressure Part Changes are Required with this B&W Burner Configuration.

B&W Low NO_X Burner Advancements



	Bit	Bit	Sub-Bit	Bit	Bit	Bit	Bit	Sub-Bit	Bit	Sub-Bit
	DRB	DRB + OFA	DRB	DRB-XCL	DRB-XCL	DRB-XCL + OFA	DRB-XCL + OFA	DRB-XCL + OFA	DRB-4Z + OFA	DRB-4Z + OFA
	9 Units (opposed)	2 Units (opposed)	14 Units (opposed)	5 Units (Single)	5 Units (Opposed)	5 Units (Single)	7 Units (Opposed)	5 Units (Opposed)	1 Units (opposed)	4 Units (opposed)
Avg. MW	713	480	564	155	335	169	556	550	480	564

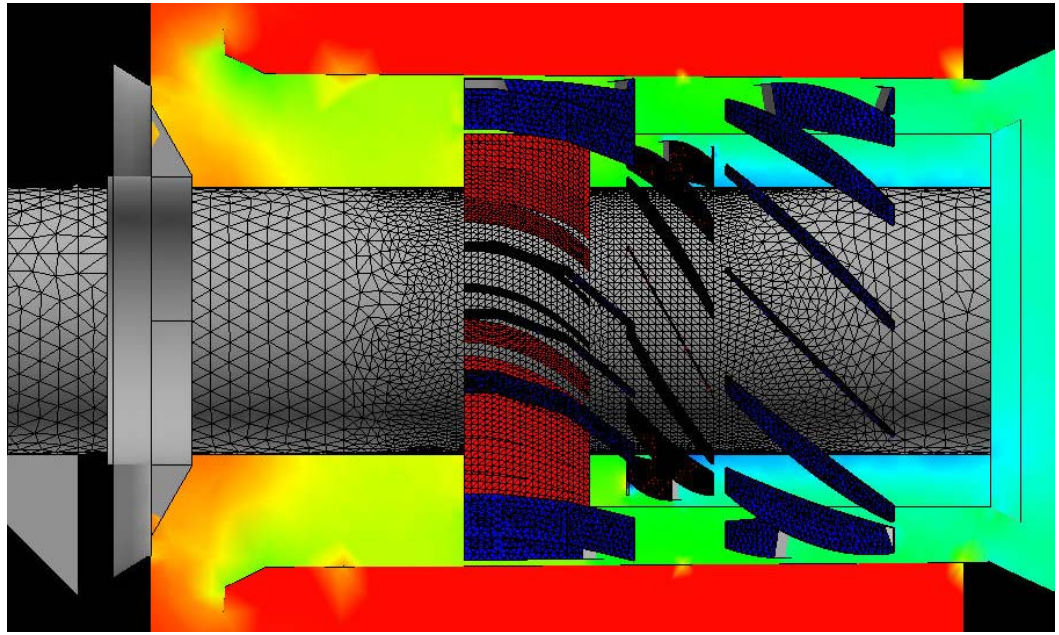
DRB-4Z and "Plug-in" DRB-4Z Burners

Problem:

- Design very low-NO_X burner without sacrificing carbon burn-out, pressure drop

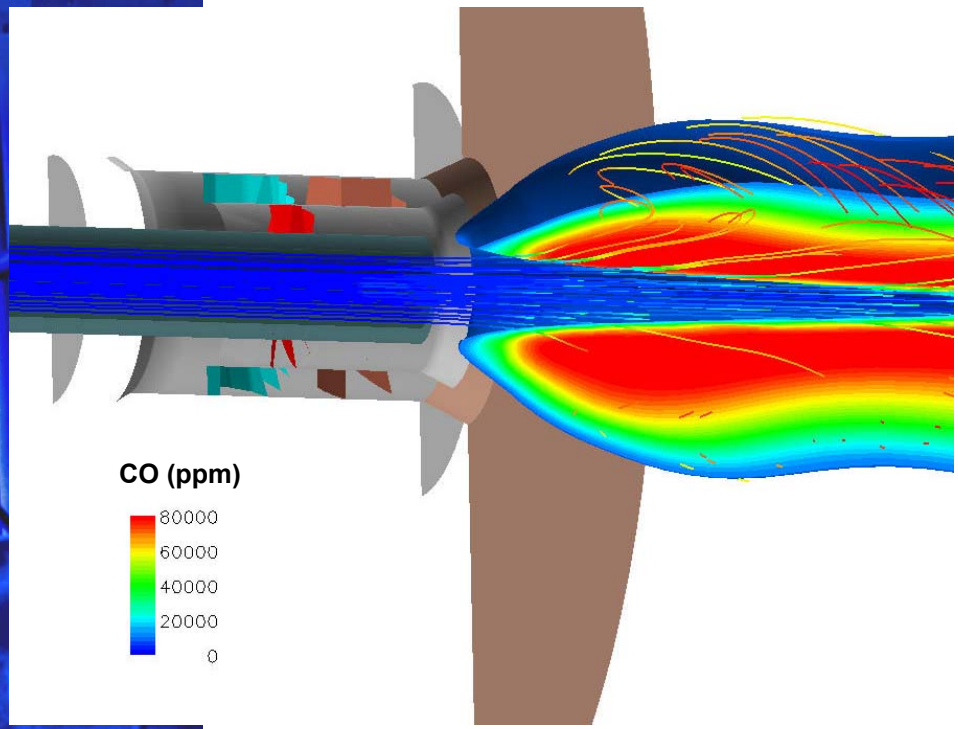
Why:

- Increasing need for low- NO_X combustion
- New product for B&W to stem competition

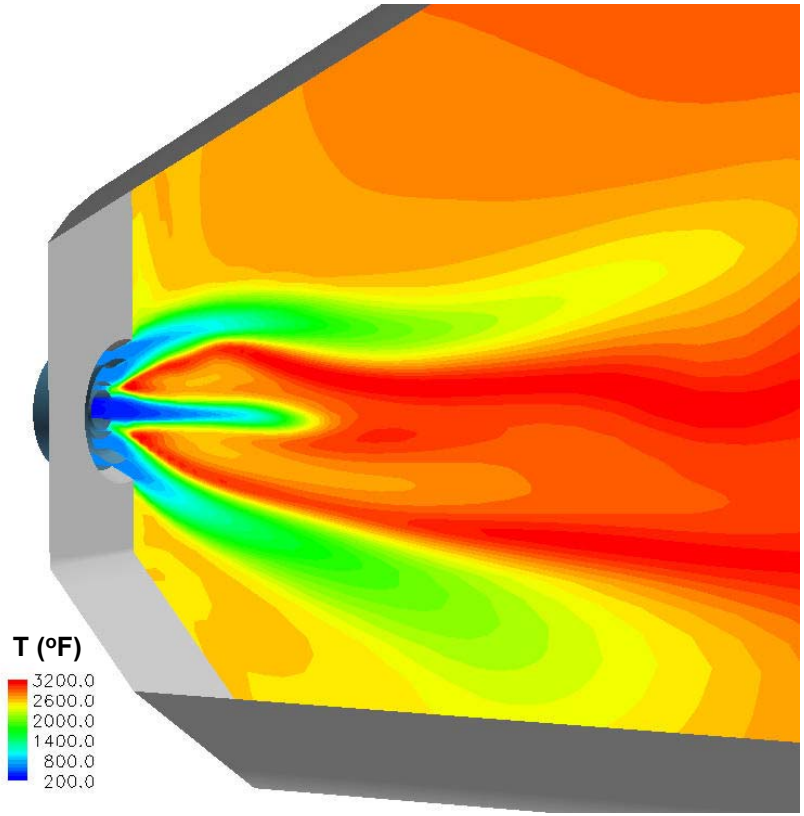


Static Pressure Distribution for plug-in DRB-4Z

DRB-4Z and "Plug-in" DRB-4Z Burners



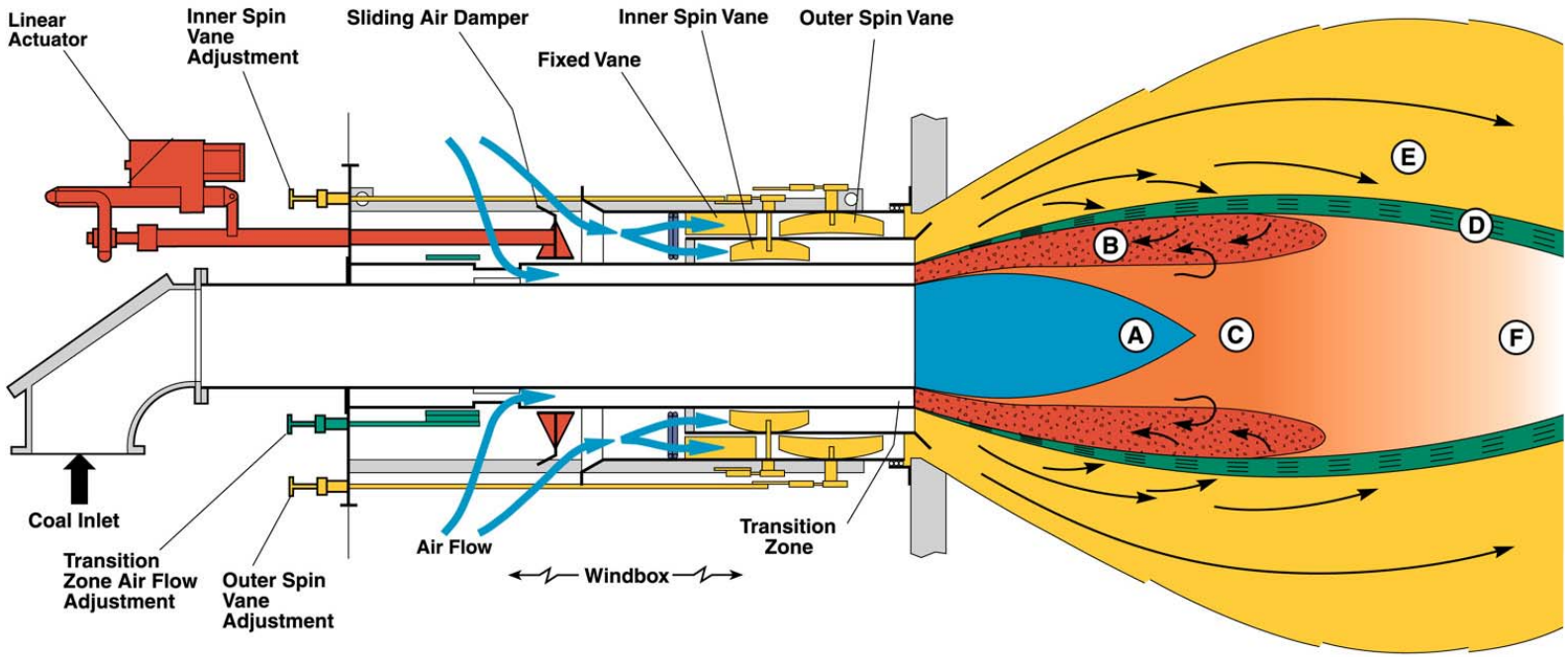
CO Concentrations Plotted with Particle Temperatures



Predicted Gas Temperature Distribution

Low NO_X DRB-4Z™ Burner Combustion Zones

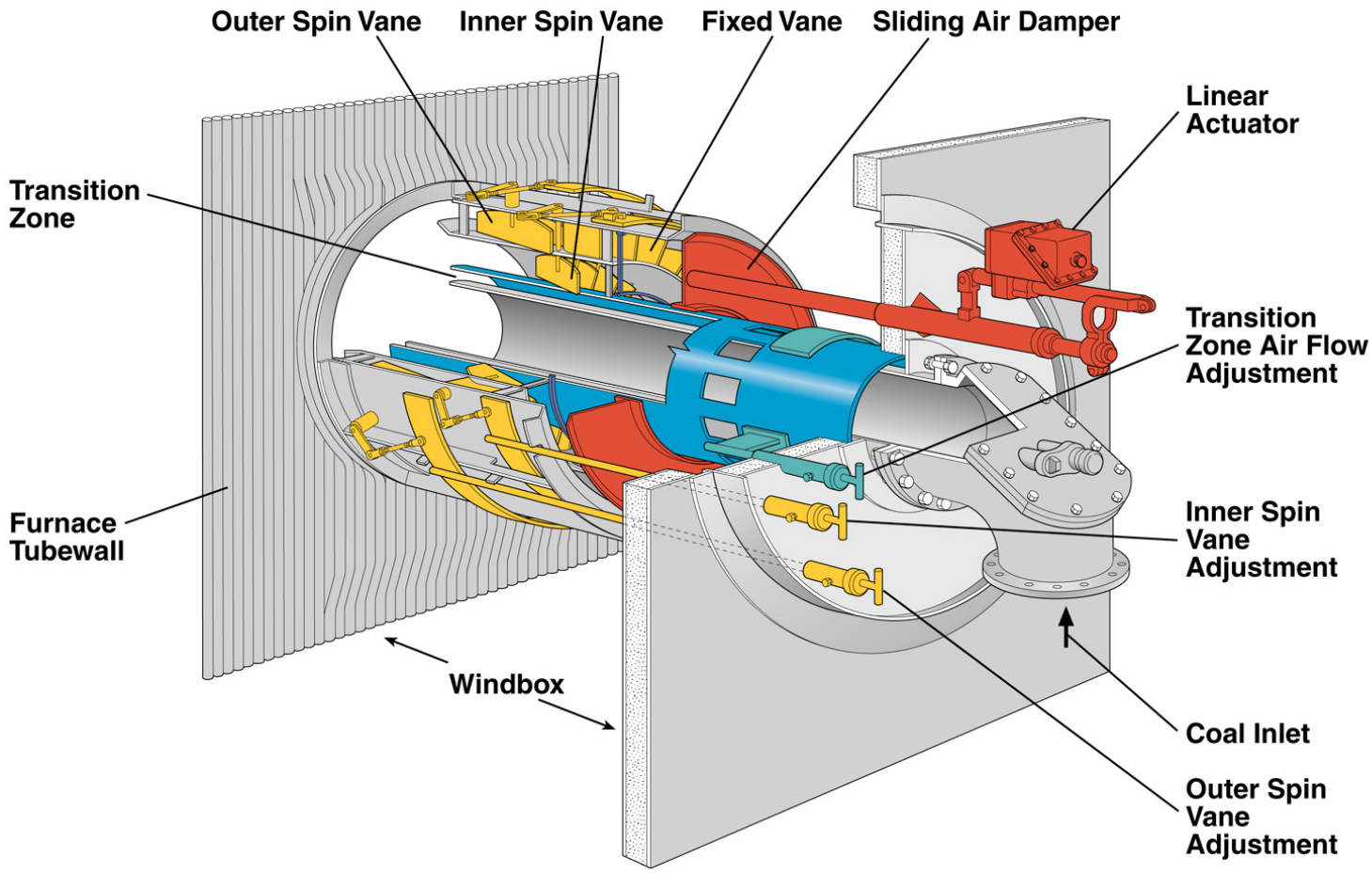
Maximum NO_x reduction at the burner



A. Oxygen lean devolitilization
B. Recirculation of products
C. NOx reduction zone
D. High temperature flame sheet
E. Controlled mixing of secondary combustion air
F. Burnout zone

Ultra Low NO_X DRB-4Z™ Coal-Fired Burner

Rugged construction • Simple design



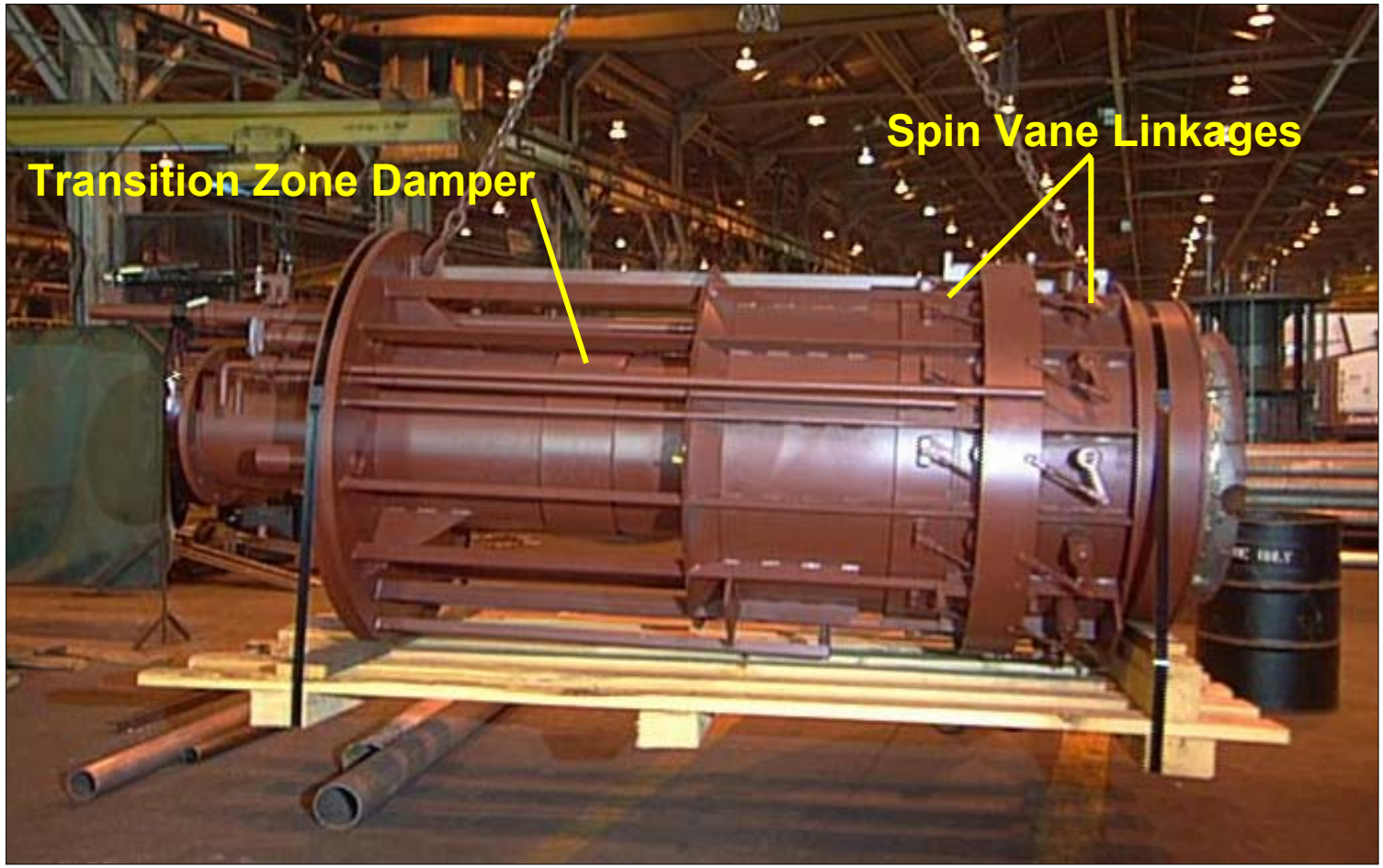
PC-Fired Low NO_X DRB-XCL® Burner

Successful Low NO_x Reduction Experience

DRB-4Z™ Low NO_X Coal-Fired Burner

Transition Zone Inlet Damper Shown)

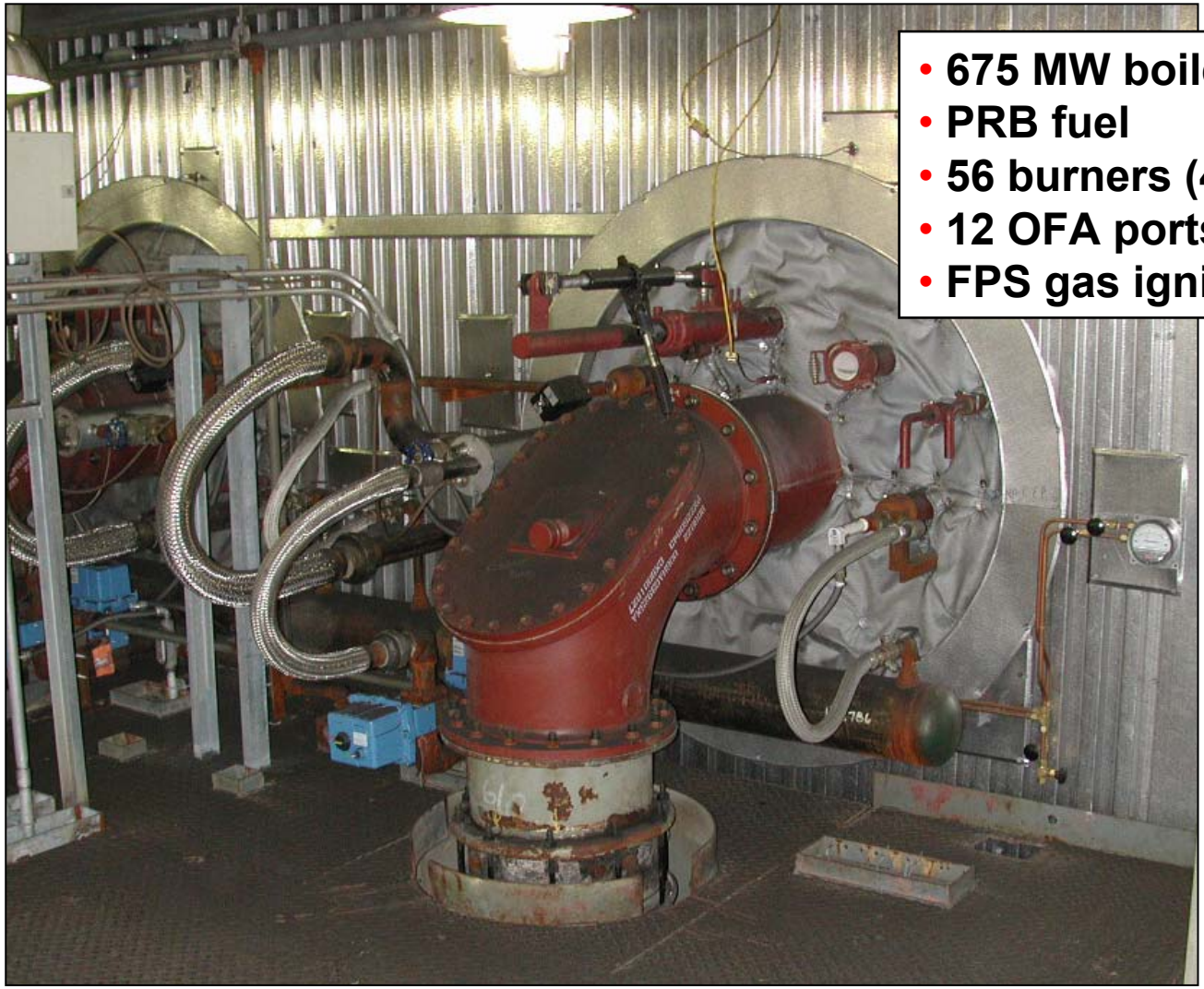
B&W Low NO_x Coal-Fired DRB-4Z™ Burner



DRB-4Z Low NO_X Coal-Fired Burner in Fabrication

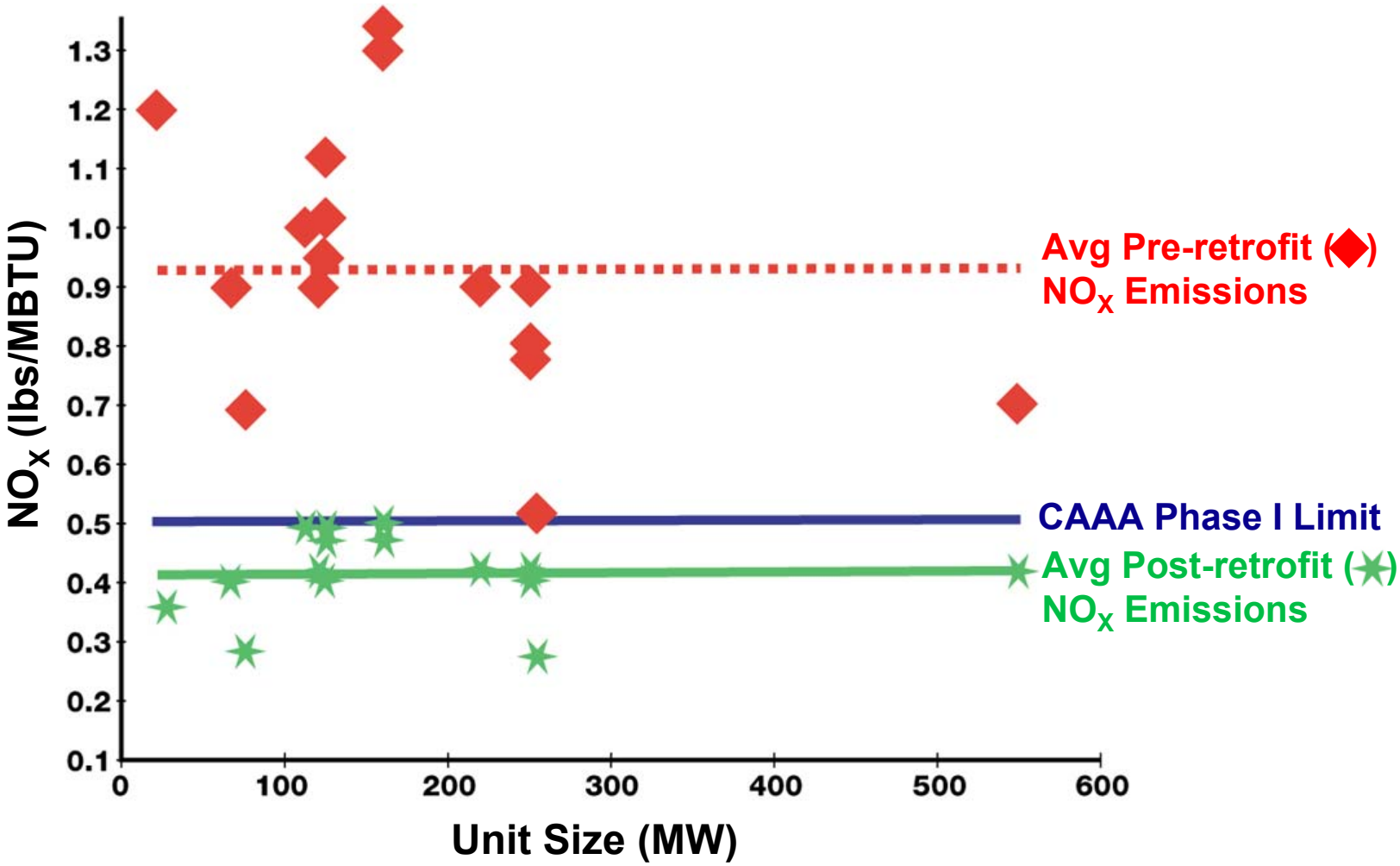
Parts exposed to radiant furnace heat are constructed of high temperature alloy material (bottom of photo)

DRB-4Z™ Coal-Fired Burner
Reliant Energy, WA Parish Unit 6

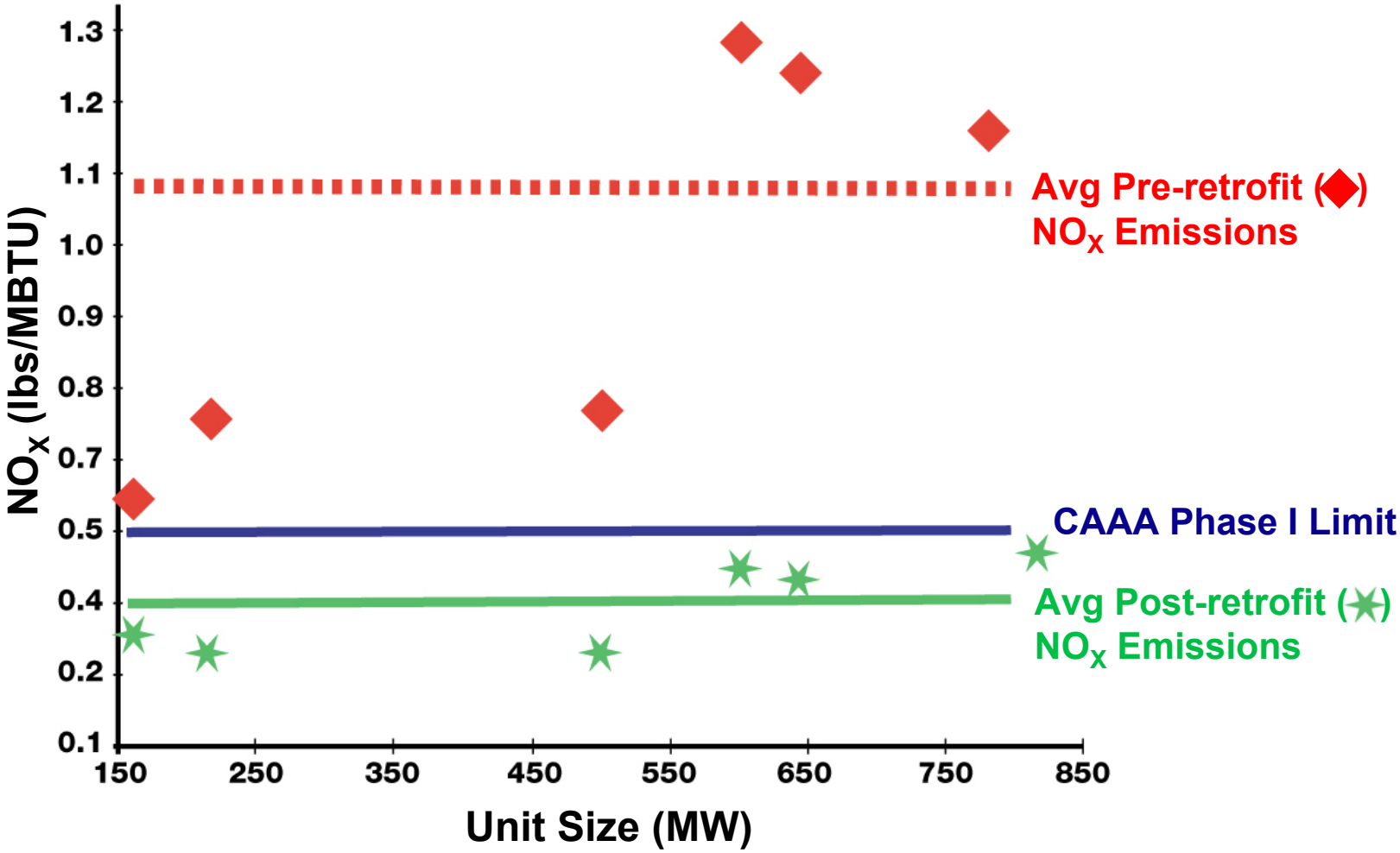


- 675 MW boiler
- PRB fuel
- 56 burners (40 pc/gas)
- 12 OFA ports & panels
- FPS gas ignitors

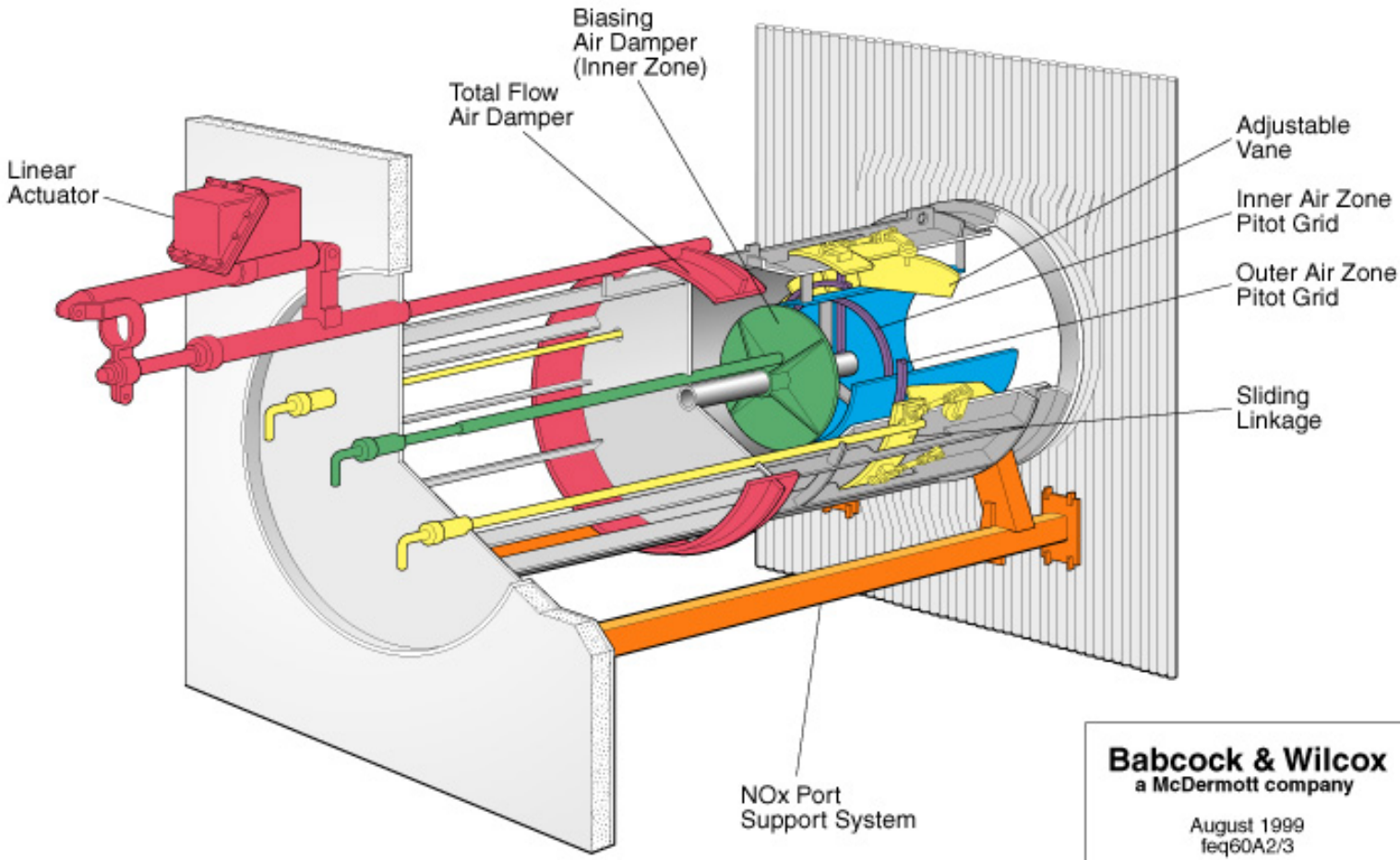
Independent NO_X Evaluation of B&W's DRB-XCL® Burners by EnTEC for EPRI - October 1996



Independent NO_X Evaluation of B&W's DRB-XCL® Burners + OFA Ports by EnTEC for EPRI - October 1996



Dual Air Zone NO_x Port
with Total Air Flow Control



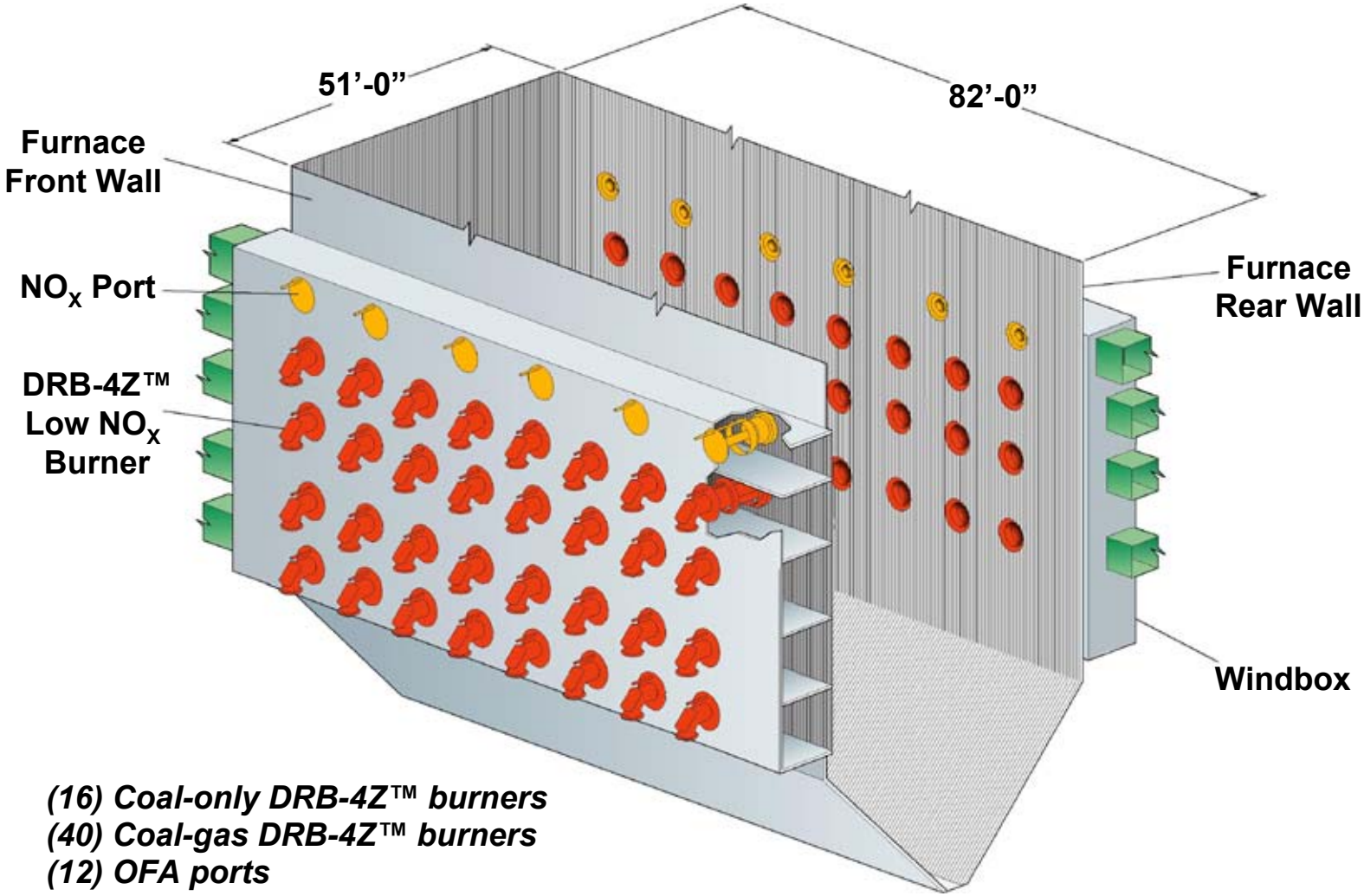
Babcock & Wilcox
a McDermott company

August 1999
feq60A2/3

FEQ60A2/3 COL.FH8

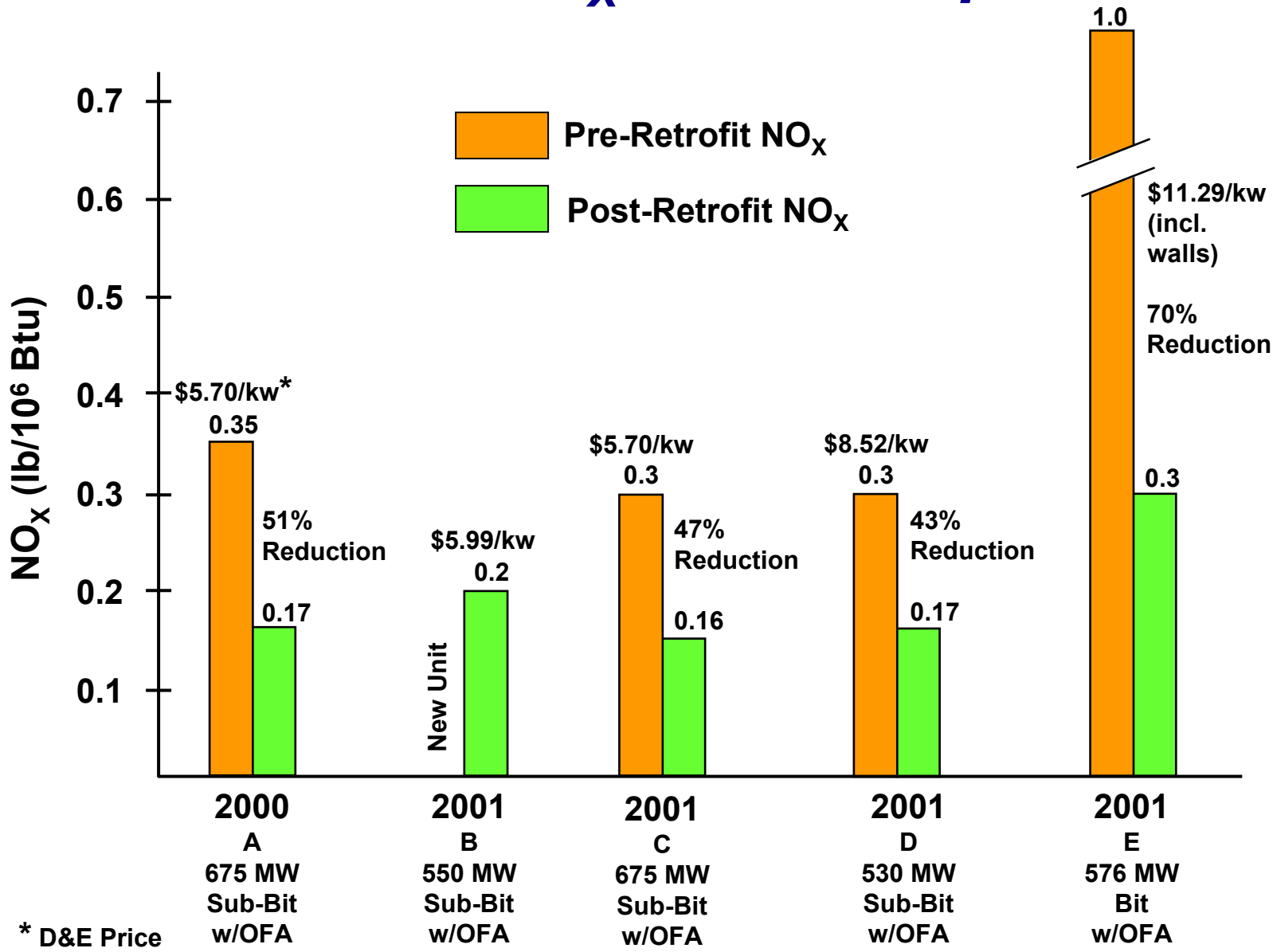
Dual Air Zone OFA (NO_X) Port with Total Air Flow Control - W.A. Parish Unit 6

W.A. Parish Unit 6 - Retrofit Burner and OFA Port Arrangement



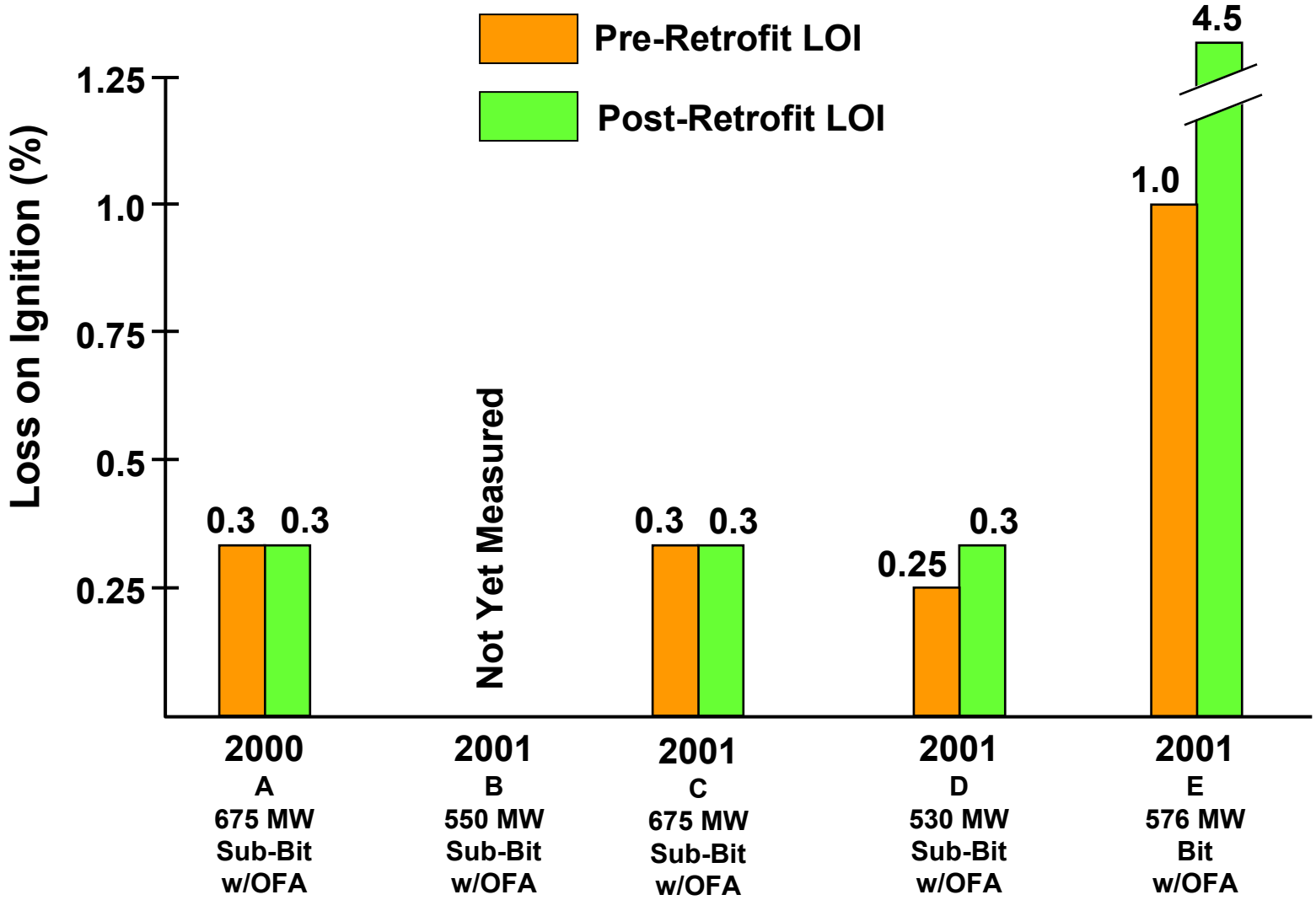
(16) Coal-only DRB-4Z™ burners
(40) Coal-gas DRB-4Z™ burners
(12) OFA ports
690 MW boiler unit

DRB-4Z™ Low NO_X Burner Experience



* D&E Price

DRB-4Z™ Burner LOI Results



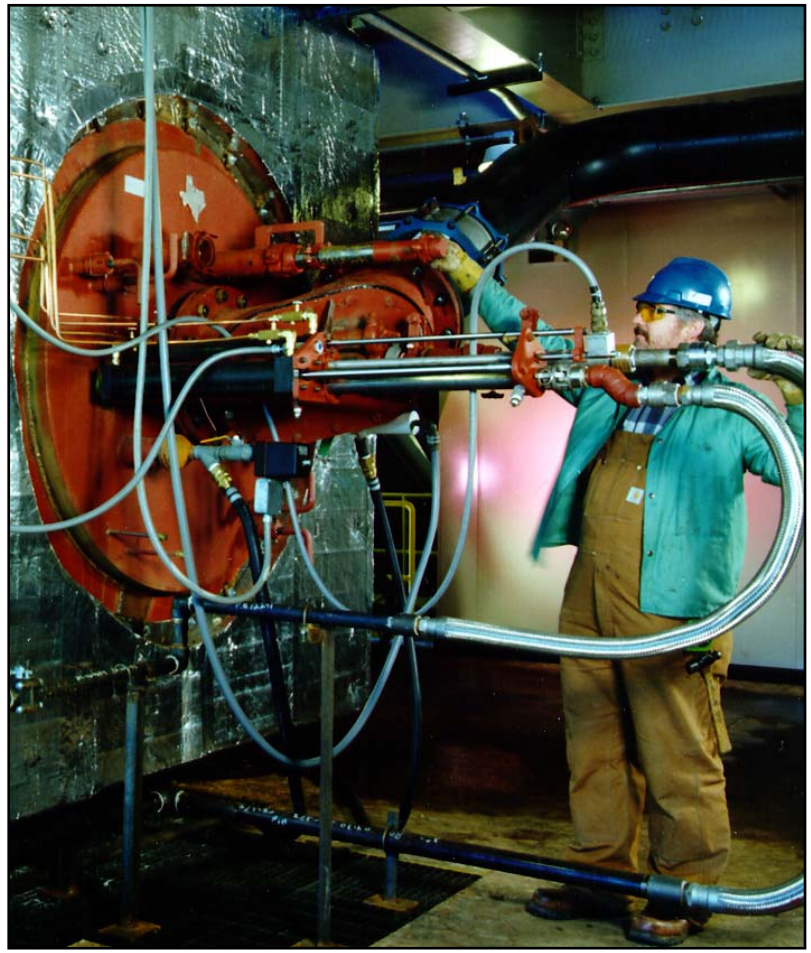
Continuing Combustion R&D

- High velocity tests on plug-in DRB-4Z on hi-volatile and medium-volatile bituminous coals

- NO_X test data on DRB-4Z firing bituminous coal
  - Unstaged ~ 0.40 lb/MBtu
  - Staged ~ 0.33 lb/Mbtu

(confirmed at full scale installation)

- Improved natural gas center fired gas spud (DRB-4Z coal burner)
  - No staging, no FGR
  - NO_X 0.11 lb/MBtu (88 ppm) and CO 13 ppm



Summary

Wall fired low NOx burners:

- NOx reductions of greater than 50% are possible
- Increases in UBC levels will most likely occur
- CO emission levels will increase slightly
- NOx emissions at 0.16-0.16 lbs/MBtu are possible
- The DRB-4Z burner has been proven in commercial operation on a wide range of coals