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Hamworthy Engineering group

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# NOx and Efficiency Solutions for Boilers

**Energy Solutions Center**
**Low NOx Workshop**
**Cambridge / Markham, Ontario**
**November 13 / 14, 2002**

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# Presentation Outline

- Peabody Introduction
- NOx Trends
- Peabody NOx Solutions
- Impact on Efficiency
- Burner Development Goals
- Burner Design Features
- Sample Field Results

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# Peabody Engineering

- Founded 1920
- Locations:
  - Shelton, CT
  - Norwich, NY
  - Toronto, ON
  - Mexico City (JV)

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## Offices, Subsidiaries, Joint Ventures and Licensees


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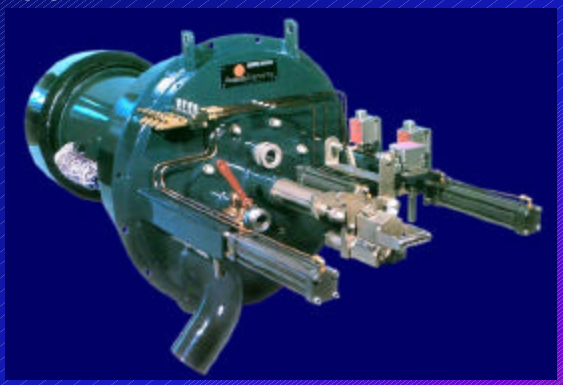
## Products

**Utility / Industrial Burners**
**Low NOx Burners**
**Low Excess Air Burners**



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# Products

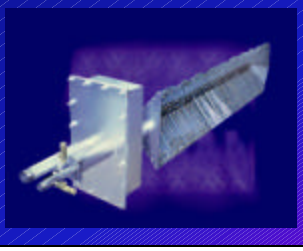
Low Btu Gas/Coal/Kiln Burners

Ignition Systems

Air Heaters / Incinerators

Flame Scanning Systems

In Line Duct Burners



Fuel Preparation Sets

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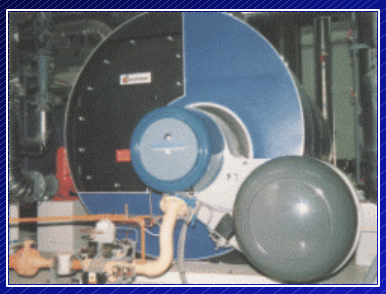
# Products

Package Burners – Envirojet



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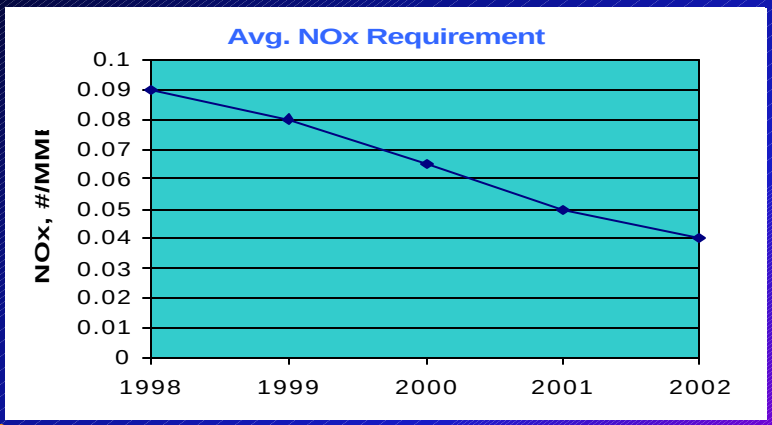
# Trends in NOx Emissions

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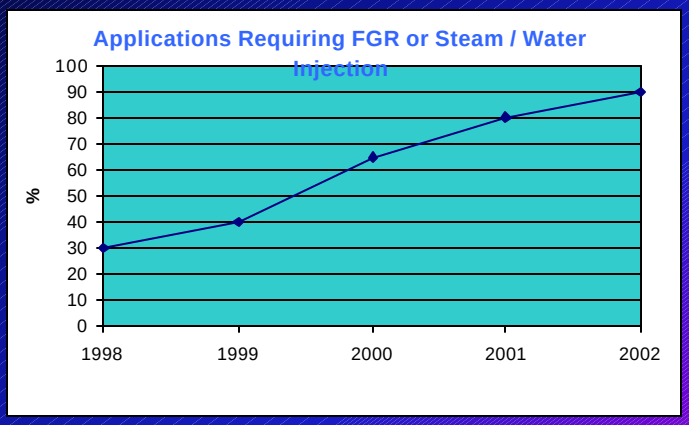
# Trends in NOx Emissions

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# Factors Influencing NOX Emissions

- Heat Input
- Combustion Air Temperature
- Furnace Volume
- Furnace Dimensions
- Burner Spacing
- Fuel Composition
- Fuel Bound Nitrogen
- Other Emission Criteria

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# $NO_X$ Solutions

- Low $NO_X$ Burners
- System Solutions:
  - –Flue Gas Recirculation
  - –Water/Steam Injection
- Re-engineering Existing Burner Systems
- Combination of Above
- Solution is Boiler Specific

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# Low Emissions = Low Efficiency

Low NOx Burners:
- Higher Burner RDL
- May operate at higher O2 levels
- Increased fan horsepower

Flue Gas Recirculation:
- Increased mass flow
- Increased system pressure losses
- Increased fan horsepower
- Boiler heating surface considerations

Water / Steam Injection:
- Water/Steam not recoverable
- Lower boiler efficiency

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# Efficiency Impact

- Example:
  - For a typical 40,000 PPH Packaged Boiler:
  - Fan Motor BHP:
    - With 15% FGR: 45
    - Without FGR: 29
  - ~50% Horsepower Penalty for FGR

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# Efficiency Impact

- What is the cost of:
  - 10 Fan HP per installation for FGR
    - Additional Electrical Costs
    - Additional Demand for the power provider (and associated power provider stack emissions)
  - 1% Boiler efficiency loss per installation
    - Additional fuel costs
  - Safety issues
    - Additional controls to assure flame stability

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# Burner Development Goals

- Applicable to Firetube or Watertube Boilers
- Dual Fuel (Natural Gas and/or Light Oil)
- Low NOx capability (30 ppm – natural gas)
- Minimize System Pressure Losses (RDL, No FGR)
- Maximize Motor Efficiency
- Minimize Power Consuming Accessories (Air compressors, silencers, fuel pressure requirements)
- Compact Design (Easy fit on the boiler front)

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# ENVIROjet NOx Control

Low NOx Emissions

- *Primary* Combustion Zone
- *Vitiation* Zone
- *Secondary* Combustion Zone
- Main Flame

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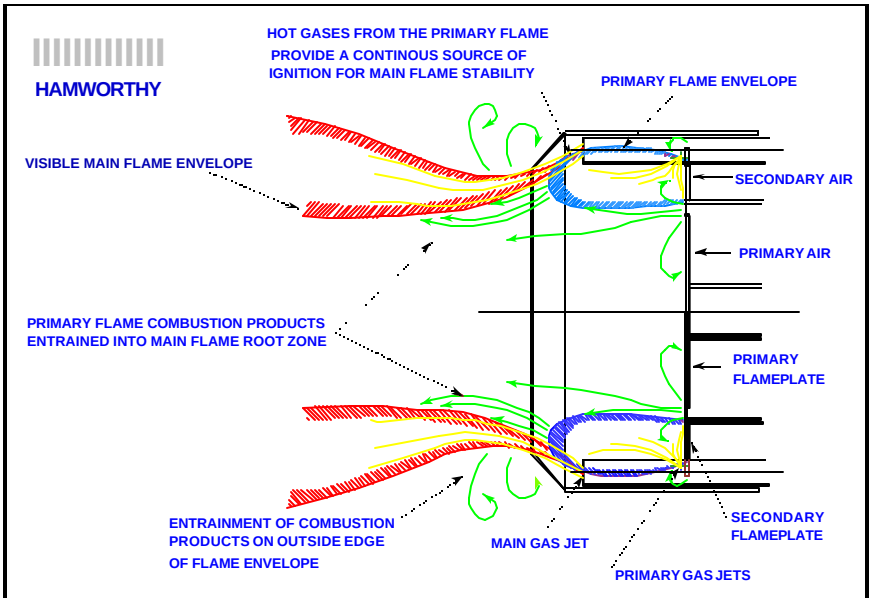
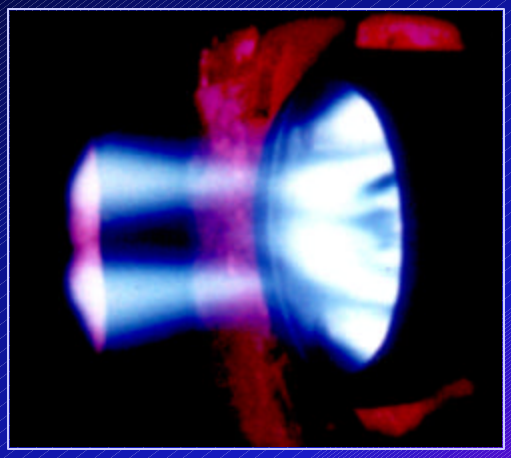



FLAME STABILITY AND GAS JET MIXING ZONES OF THE SL GAS BURNER

## Envirojet



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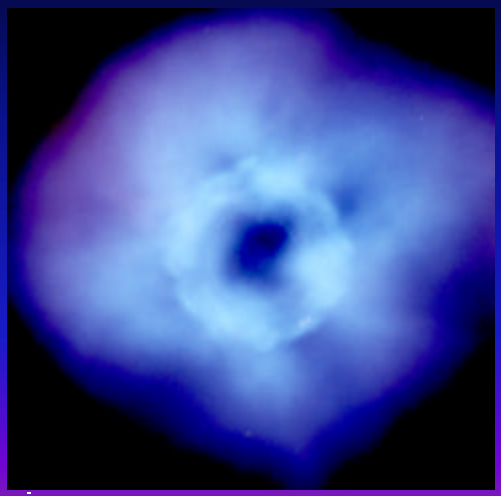
## Envirojet



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# Envirojet

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# Envirojet Fan / Motor Design

- Slip Stream Motor Design
  - More Efficient
  - Combustion air passes over motor
  - No motor cooling fan required

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# Envirojet Fan / Motor Design

- Acoustically Lined Motor Housing
  - Provides Noise Levels <85 @ 3 ft.
  - Less pressure drop than conventional designs
  - More compact

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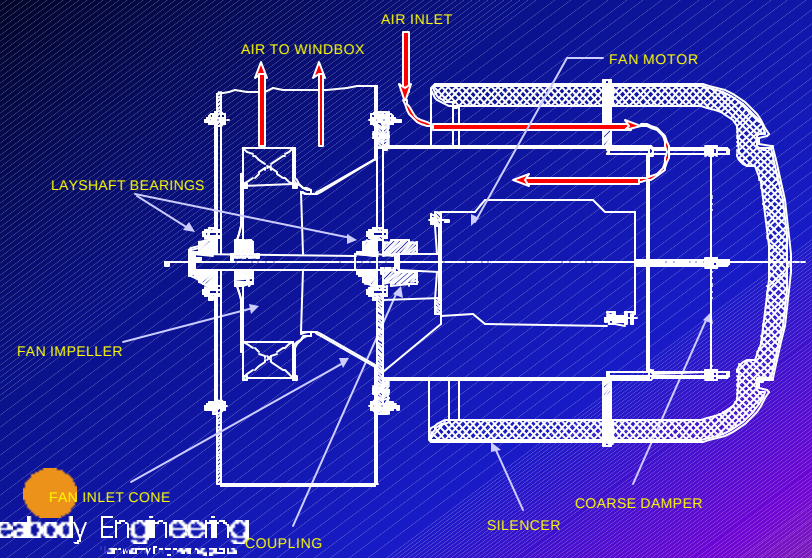
# ENVIROjet

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# Compact Design

- "Monoblock" Design
  - Integral Fan / Windbox Housing
  - Combined Motor Housing / Fan Silencer
  - Fan / Windbox Orientation is Rotatable

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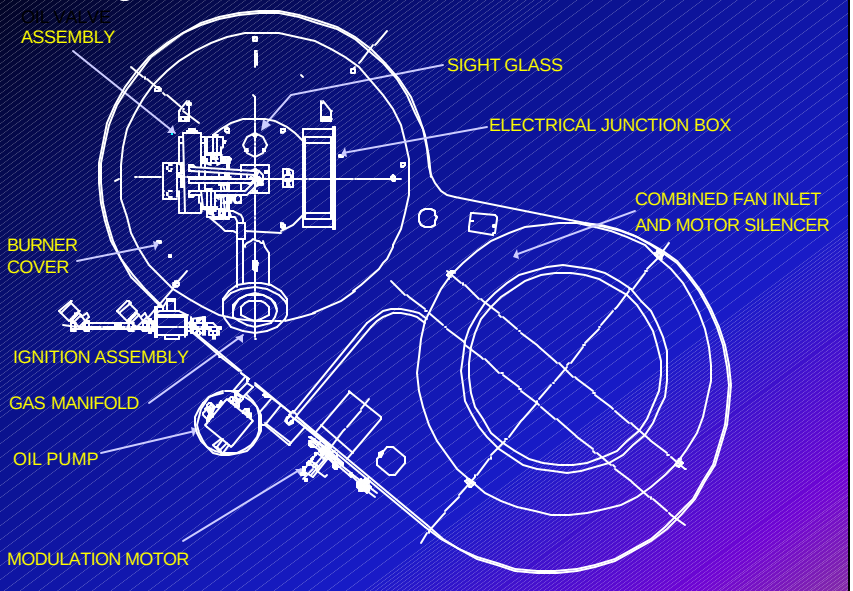
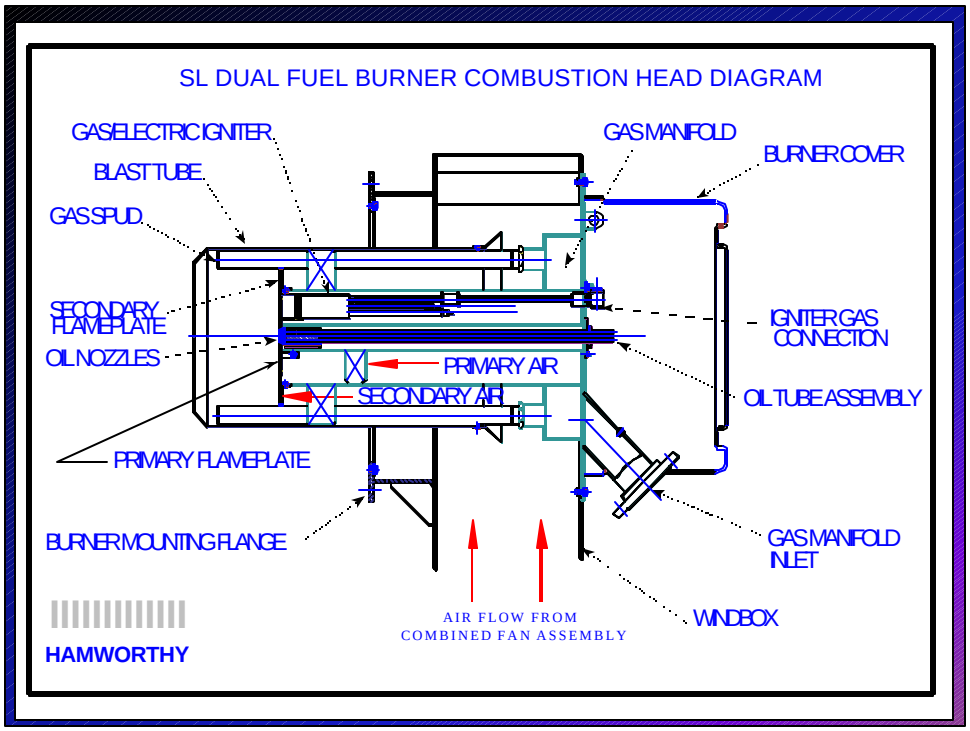
# ENVIROjet Burner




SL DUAL FUEL BURNER COMBUSTION HEAD DIAGRAM
GAS ELECTRIC IGNITER
BLAST TUBE
GAS SPUD
SECONDARY FLAMEPLATE
OIL NOZZLES
PRIMARY FLAMEPLATE
BURNER MOUNTING FLANGE
GAS MANIFOLD
BURNER COVER
IGNITER GAS CONNECTION
OIL TUBE ASSEMBLY
PRIMARY AIR
SECONDARY AIR
GAS MANIFOLD INLET
WINDBOX
AIR FLOW FROM COMBINED FAN ASSEMBLY
HAMWORTHY


ENVIROjet Burner
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# Minimize Power Consuming Accessories

- Cascade Mechanical Oil Atomizer
  - Eliminates Atomizing Steam
  - Eliminate Atomizing Air Compressor (HTHW applications)

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# Field Results – Park Place

- Park Place Resorts / Las Vegas, NV
  - 25,875 PPH Watertube Boiler
  - 33 MMBTU/HR Heat Input
  - NOx Requirement: 30 ppm (Natural Gas)
  - Fuel Fired: Natural Gas

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# Park Place

- Equipment Performance:
  - NOx Emissions: 24 ppm
  - FGR: 0 %
  - CO Emissions: <50 ppm
  - Fan Motor HP: 25
  - Noise Level: < 83 dBA @ 3'

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# Field Results – United Hospital

- United Hospital / Clarksburg, WV
  - 12,000 PPH Watertube Boiler
  - 16.3 MMBTU/HR Heat Input
  - NOx Requirement: 30 ppm (Natural Gas)
  - Fuels Fired: Natural Gas / No. 2 Oil

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# United Hospital

- Equipment Performance:
  - NOx Emissions (NG): 24 ppm
  - NOx Emissions (Oil): 55 ppm
  - FGR: 0 %
  - CO Emissions: <25 ppm
  - Fan Motor HP: 10
  - Noise Level: < 81 dBA @ 3'

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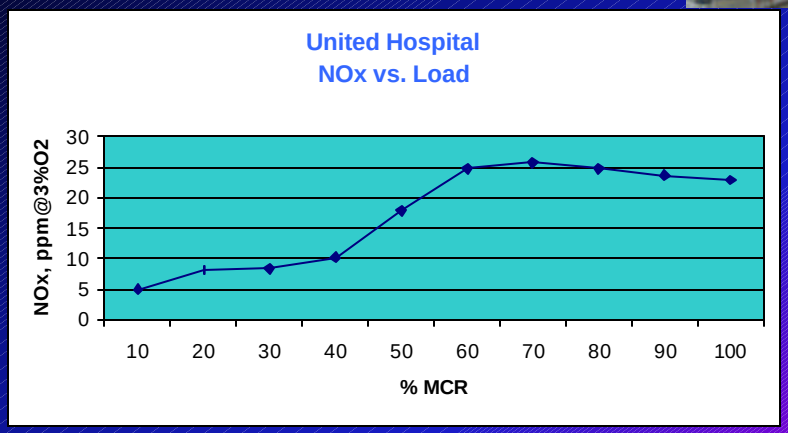
# United Hospital

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# Field Results - Bridgestone

- Bridgestone Tire / Japan (Retrofit)
  - 600 HP Firetube Boiler
  - 24.6 MMBTU/HR Heat Input
  - NOx Requirement: 35 ppm (Natural Gas)
  - Fuels Fired: Natural Gas / No. 2 oil
  - Variable Speed Drive Fitted

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# Bridgestone Tire

- Equipment Performance:
  - NOx Emissions: 30 ppm (50% Reduction)
  - FGR: 0 %
  - CO Emissions: <50 ppm
  - Electrical Consumption: 35 % reduction

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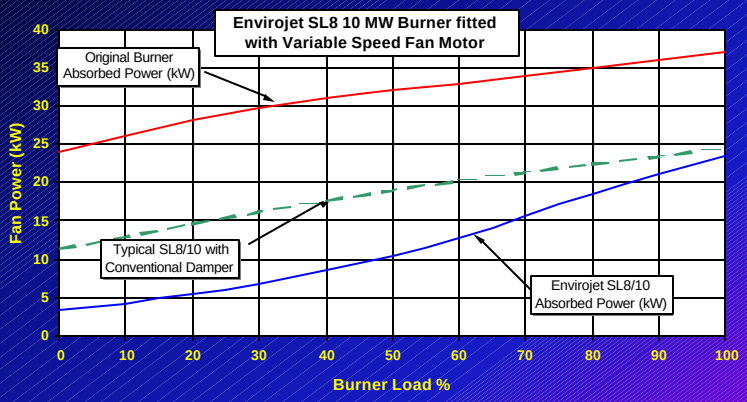
# Bridgestone Tire

Motor Power Consumption Comparison (Bridgestone Tire)




NOTES! Information supplied by Independent Source.
Tests carried out and reported by end user.
Power saving at 100% is due to improved performance by Envirojet fan system over conventional fan system with TEFC motor.

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# Summary

- Low NOx possible without FGR or water injection
  - No Efficiency Penalty:
    - Minimal Motor Horsepower
    - Maximum Motor Efficiency
    - No Wasted Steam / Water
    - Maximum Boiler Efficiency

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## Low $NO_x$ Burner Retrofit Considerations

- Fan Static Capability
- Furnace Dimensions
- Burner Spacing
- Windbox Dimensions
- Air Flow Distribution
- Waterwall Openings
- Furnace Conditions
- Air / Flue Gas Ductwork Arrangement

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## MSC LOW $NO_x$ BURNER

- Fuel Staging
- Air Staging
- Precise Flame Fit

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# MSC Burner
# Precise Flame Fit

- Custom Design Flame Geometry to Specific Furnace Dimensions/Burner Spacings
- Larger Flame Volume Minimizes Localized High Temperature Zones
- Longer Burnout Minimizes CO Emissions

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# MSC Burner
# Fuel / Air Staging

- Creates Fuel/Air Rich and Lean Zones
- Reduces Flame Temperature
- Minimizes Oxygen Availability to Reduce Thermal $NO_X$

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# MSC Burner Features

- Fixed Geometry
  - No modulating parts
  - Cannot be “accidentally” adjusted out of compliance
- External Gas Manifold
  - Eliminates potential for internal ring cracking
  - Gas spuds can be removed while firing oil

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# Case History

- Norfolk Naval Station
  - Background:
    - Package Boiler - 150,000 PPH, 250 PSIG, 700$^{O}$F Steam
    - Conversion of an Existing Low $NO_X$ Burner Retrofit
    - Existing Burner:
      - Used 20% Forced FGR
      - Could not meet Specified $NO_X$ Requirements
      - Caused excessive boiler vibration
      - Experienced frequent flame instability

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# Norfolk Naval Station

- Peabody Solution
  - New Precision Flame Shape Low $NO_x$ Burner
  - Eliminated FGR Fan
  - Modified FGR Ducting

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# Norfolk Naval Station Results

| Guarantees | $NO_x$ | CO |
|---|---|---|
| Natural Gas | 66 ppm | 134 ppm |
| No. 2 Oil | 78 ppm | 128 ppm |

Note: Original burner designed for 20% Forced FGR

| Actual | $NO_x$ | CO |
|---|---|---|
| Natural Gas (10% IFGR) | 20 ppm | 9 ppm |
| Natural Gas (No IFGR) | 36 ppm | 11 ppm |
| No. 2 Oil (10% IFGR) | 39 ppm | 17 ppm |

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# Case History: System Solution

- Background:
  - Louisiana Paper Mill
    - 225 K PPH Stoker Fired Boiler
    - Natural Gas Fired
    - Four Burners (Arranged 2 over 2)
    - 425$^0$F Combustion Air
    - Existing $NO_x$ Emissions 0.38 #/MMBTU

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# Louisiana Paper Mill

- Peabody Solution
  - Installed Four New Low NOX Burners
  - Added Steam Atomized Water Injection

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# Louisiana Paper Mill

- Results:
  - Reduced $NO_X$ to 0.23 #/MMBTU with New Burners (39% Reduction)
  - Reduced $NO_X$ to .135 #/MMBTU by Adding Water Injection (42% Reduction)
  - Overall NOX Reduction of 64%

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# Case History:

- 705,000 PPH Field Erected Boiler
  - 963 MMBTU/HR Heat Input
  - Six Burners (3 over3)
  - Natural Gas
  - Ambient Combustion Air
  - Replaced Existing Register Style Burners Originally Furnished with the Boiler

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# Case History

- Peabody Solution
  - Installed Six New Low $NO_x$ Burners
  - Reused Existing Windbox (w/o Modeling)
  - Reused Existing Waterwall Openings
  - Reused Existing Forced Draft Fan (Original Burner RDL less than 6" WC)

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# Case Study

- Results:
  - Actual Measured $NO_X$: 0.063 #/MMBTU
  - Actual Measured CO: 0.034 #/MMBTU
  - Actual Burner RDL: 5.5" WC (@ 10% XS Air)

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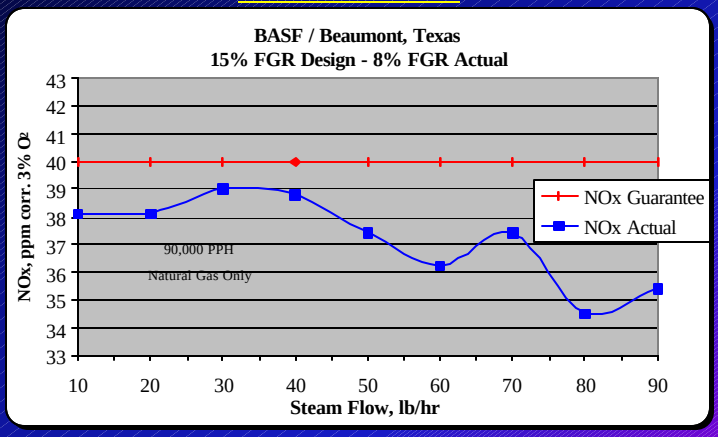
## Case History:

MSC Burner

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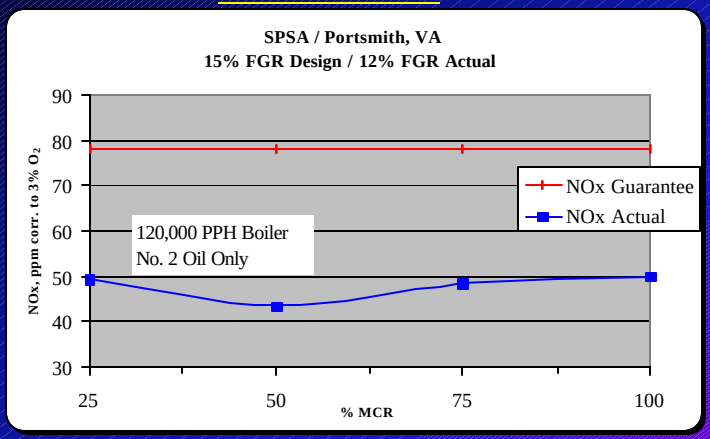
## Case History:

MSC Burner

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## Re-engineering

- Reuse:
  - FD / ID Fans
  - Windbox
  - Register / Ignitor
  - Waterwall Openings
  - Throat Configuration
- New:
  - Fuel Manifold
  - Fuel Nozzles
  - Swirler

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## Re-engineering

- Approach $NO_X$ Levels of New Burners
- Minimal Impact to Existing Operation
- Installation By In-House Personnel
- Lowest Installed Cost
- Ideal when SCR is a necessity

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# Summary

- Low $NO_X$ Solution is Boiler Specific
- Burner Solutions Can Meet Most Low NOX requirements
- Burners / Burner Modifications Can Minimize $NO_X$ Entering Post Combustion Apparatus (SCR), thus Minimizing Size of SCR

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# Contact Information

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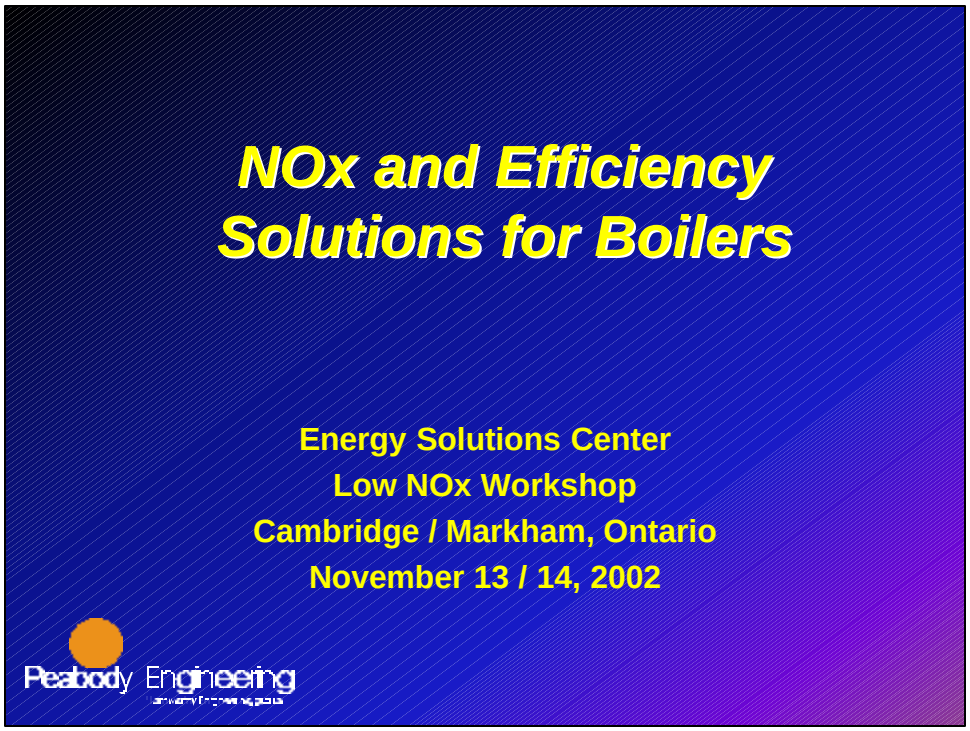
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