Presentation Outline

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

Peabody Engineering

- Founded 1920
- Locations:
  - Shelton, CT
  - Norwich, NY
  - Toronto, ON
  - Mexico City (JV)
Offices, Subsidiaries, Joint Ventures and Licensees

Products

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

Low Btu Gas/Coal/Kiln Burners

Ignition Systems

Air Heaters/Incinerators

Flame Scanning Systems

Fuel Preparation Sets

In Line Duct Burners

Package Burners - Envirojet
**Trends in NOx Emissions**

**Avg. NOx Requirement**

- **NOx,#/MMBTU**
  - 0.1
  - 0.09
  - 0.08
  - 0.07
  - 0.06
  - 0.05
  - 0.04
  - 0.03
  - 0.02
  - 0.01
  - 0

1998 1999 2000 2001 2002

**Applications Requiring FGR or Steam / Water Injection**

- **%**
  - 100
  - 90
  - 80
  - 70
  - 60
  - 50
  - 40
  - 30
  - 20
  - 10
  - 0

1998 1999 2000 2001 2002
Factors Influencing NOX Emissions

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

NO\textsubscript{X} Solutions

- Low NO\textsubscript{X} Burners
- System Solutions:
  - Flue Gas Recirculation
  - Water/Steam Injection
- Re-engineering Existing Burner Systems
- Combination of Above
- Solution is Boiler Specific
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

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
**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

**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)
ENVIROjet NOx Control

Low NOx Emissions

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

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

Envirojet Fan / Motor Design

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

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

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

ENVIROjet Burner

- Assembly
- Sight Glass
- Electrical Junction Box
- Combined Fan Inlet and Motor Silencer
- Burner Cover
- Ignition Assembly
- Gas Manifold
- Oil Pump
- Modulation Motor
ENVIROjet Burner
Minimize Power Consuming Accessories

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

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
**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
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'

United Hospital

United Hospital
NOx vs. Load
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

Bridgestone Tire

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

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

MSC LOW NOₓ BURNER

- Fuel Staging
- Air Staging
- Precise Flame Fit
**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 NOₓ
**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

**Case History**

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

- Peabody Solution
  - New Precision Flame Shape Low NO\textsubscript{x} Burner
  - Eliminated FGR Fan
  - Modified FGR Ducting

Results

<table>
<thead>
<tr>
<th>Guarantees</th>
<th>NO\textsubscript{x}</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>66 ppm</td>
<td>134 ppm</td>
</tr>
<tr>
<td>No. 2 Oil</td>
<td>78 ppm</td>
<td>128 ppm</td>
</tr>
</tbody>
</table>

Note: Original burner designed for 20% Forced FGR

<table>
<thead>
<tr>
<th>Actual</th>
<th>NO\textsubscript{x}</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas (10% IFGR)</td>
<td>20 ppm</td>
<td>9 ppm</td>
</tr>
<tr>
<td>Natural Gas (No IFGR)</td>
<td>36 ppm</td>
<td>11 ppm</td>
</tr>
<tr>
<td>No. 2 Oil (10% IFGR)</td>
<td>39 ppm</td>
<td>17 ppm</td>
</tr>
</tbody>
</table>
**Case History:**

**System Solution**

- **Background:**
  - Louisiana Paper Mill
    - 225 K PPH Stoker Fired Boiler
    - Natural Gas Fired
    - Four Burners (Arranged 2 over 2)
    - 425°F Combustion Air
    - Existing NO\textsubscript{X} Emissions 0.38 #/MMBTU

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**Louisiana Paper Mill**

- **Peabody Solution**
  - Installed Four New Low NO\textsubscript{X} Burners
  - Added Steam Atomized Water Injection
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%

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
Case History

- Peabody Solution
  - Installed Six New Low NO\textsubscript{x} Burners
  - Reused Existing Windbox (w/o Modeling)
  - Reused Existing Waterwall Openings
  - Reused Existing Forced Draft Fan (Original Burner RDL less than 6” WC)

Case Study

- Results:
  - Actual Measured NO\textsubscript{x}: 0.063 #/MMBTU
  - Actual Measured CO: 0.034 #/MMBTU
  - Actual Burner RDL: 5.5” WC (@ 10% XS Air)
Case History:

MSC Burner

**BASF / Beaumont, Texas**

15% FGR Design - 8% FGR Actual

- NOx Guarantee
- NOx Actual

![Graph showing NOx levels for different steam flows.](image1)

Case History:

MSC Burner

**SPSA / Portsmouth, VA**

15% FGR Design / 12% FGR Actual

- NOx Guarantee
- NOx Actual

![Graph showing NOx levels for different % MCR.](image2)
Re-engineering

- Reuse:
  - FD / ID Fans
  - Windbox
  - Register / Ignitor
  - Waterwall Openings
  - Throat Configuration

- New:
  - Fuel Manifold
  - Fuel Nozzles
  - Swirler

Re-engineering

- Approach NO\textsubscript{x} Levels of New Burners
- Minimal Impact to Existing Operation
- Installation By In-House Personnel
- Lowest Installed Cost
- Ideal when SCR is a necessity
Summary

- Low NO\textsubscript{x} Solution is Boiler Specific
- Burner Solutions Can Meet Most Low NO\textsubscript{X} requirements
- Burners / Burner Modifications Can Minimize NO\textsubscript{x} Entering Post Combustion Apparatus (SCR), thus Minimizing Size of SCR

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