NEW COAL BURNERS
AND LOW NOx CONTROL TECHNOLOGIES

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Dalian, China
AGENDA

1. Company Information
2. NOx Control Philosophy
3. Capability (Layered Technology Approach)
   a) Combustion Optimization
   b) Low NOx Burner
   c) CFD
   d) OFA
   e) T-fired Boiler
   f) HERT
4. Experiences and Cases
5. ACT Layered Approach Summary
COMPANY INFORMATION

- ACT: Headquarters in New Hampshire, USA; Offices in Baton Rouge (LA), Raleigh (NC), Oxnard (CA), Hamburg (NJ), and Marlborough (CT)
- ACT China: A subsidiary company of ACT; Offices in Baton Rouge (LA) and Nanjing, China
- Designs, supplies and installs low NOx combustion systems on utility and large industrial boilers
- Extensive combustion and emission control expertise and experience
- over 100 NOx control projects planned, designed, and implemented (25 to 1100 MW)
- Proprietary Low NOx Burner Hardware
- HERT - ACT Patented Technology
NOx CONTROL PHILOSOPHY

- Custom Solution
  Design a plant-specific layered technical approach for NOx reduction tailored to client's specific needs

- Minimize Operational Impact
  Evaluate each layer of NOx reduction technology with minimal impact on unit operation and/or performance.

- Lowest Cost Per Ton Ratio
  Achieve the client's NOx emissions objectives at the lowest cost per ton ratio

- Performance Guarantee
CAPABILITY (Layered Technology Approach)

- Layer 1 - Boiler Optimization
  - Combustion Airflow Testing (CAT)
  - Coal Flow Balancing

- Layer 2 - Low NOx Burner Upgrades and New Low NOx Burner
  - 燃烧器改造或完全采用ACT的低NOx燃器

- Layer 3 - Over Fire Air (OFA)

- Layer 4 - High Energy Reagent Technology (HERT)
  - Advanced SNCR (Selective Non-Catalytic Reduction)

- Computational Fluid Dynamics (CFD) Modeling

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ACT Layered NOx Reduction System

ACT NOx 分 控制系

80%+ NOx reduction at the lowest cost/ton
以最低价位 到80%以上 率

Layer 4 HERT System
第四 高能量反 技

Layer 3 Overfire Air
第三 燃 系

Layer 2B Low NOx Burner (LNB)
第二 低NOx燃 器

Layer 2A LNB Modification
第二 燃 器改造

Layer 1 Boiler Optimization
第一 化

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IMPACTS ON NO\textsubscript{x}

- Burner zone heat release
- Outer zone secondary air to primary air velocity ratio (1.5 to 1.0)
- Primary air & coal velocity (75 to 80 ft/s)
- Burner throat diverging angle (30 deg)
- Throat diameter to diverging length ratio (4 to 1)
- Burner swirl number (0.6 to 0.7)
- Excess O\textsubscript{2} (impacted by coal fineness)
- Position of coal pipe in throat
IMPACTS ON LOI

- Burner zone heat release
- Excess $O_2$
- Position of coal pipe in burner
- Primary air velocity
- Coal fineness
- Burner swirl number
- % Ash in coal
COMBUSTION OPTIMIZATION
COMBUSTION OPTIMIZATION

- Coal Flow Balancing
  - Rotor Or ASME Probe
  - Dirty Air Testing
- Secondary Airflow Balancing
- Combustion Airflow Testing (CAT)
Combustion Air Test (CAT)

A test probe is inserted along the burner centerline. A sensing element is raised up and rotated around the burner perimeter. Data is collected around the perimeter to determine the burner average and distribution. An average of all burners determines the boiler mean.
Large flow deviations around the burner can lead to burner instability and high CO, O2 and NOx emissions. These are caused by vortex flows in the windbox. Correcting this problem often requires CFD modeling.

This graph illustrates the point deviations from the burner mean around the CAT grid at the burner throat.
CAT Test Results

- Inlet register area of high flow burners is reduced to increase burner resistance. Airflow is forced from the high flow to the low flow burners.
- Testing is repeated to ensure the balance criteria is met.
- This graph illustrates baseline and post balancing testing of a 12 burner unit.
LOW NOx BURNER
第二 低 燃 器
ACT Low NOx Burner Hardware

VH600K LOW NOx BURNER
采用ACT 完全替 OEM燃料器

BURNER UPGRADE COMPONENTS
OEM提供的常低燃器升改造到ACT的低燃器，用ACT的燃料嘴替OEM的
Typical OEM Low NOx Burner
典型的OEM燃烧器
OEM Coal Burner Dynamics

Swirl Number (Sn), Swirl Effects & IRZ

TOO LITTLE SPIN
Sn 0.3

JUST RIGHT
Sn 0.6

TOO MUCH SPIN
Sn 0.9
ACT’s low NOx swirler establishes a strong IRZ.

Coal is injected into the IRZ at the burner outlet to deeply stage combustion.

Airflow flowing around the swirler mixes downstream to complete combustion.
Swirling airflow from the swirler creates a strong IRZ at the burner outlet.

Air register is typically operated in the 40% to 60% to increase the strength of the IRZ.
Coal Burner Upgrade Hardware

Coal Distribution Disk

Low NOx Swirler

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ACT’s low NOx coal nozzle is manufactured from 309 SS with AR500 wear strips on the main wear surface. The nozzle ensures the primary air and coal stream is injected with a purely axial flow into the IRZ at the burner exit. Four small flame holders are positioned around the nozzle discharge for flame attachment. The nozzle is welded to the oil gun guide tube and can be adjusted from the burner front.
Low NOx Burner Upgrade

OEM Burner

ACT Modified Burner
Low NOx Burner Upgrade

Existing OEM Burner Cut View  ACT Modified Burner Cut View
ACT New Burner

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Low NOx Burner

Baseline Burner

Upgraded Burner
Upgraded Burner
Upgraded Burner
CFD MODELING
CFD MODELING & DESIGN PROCESS
(Seeing the Problem is half way to solving it)

- COMPUTATIONAL FLUID DYNAMICS (CFD) MODEL OF BASELINE BURNER
  - BURNER DESIGN
  - FURNACE DESIGN
  - FUEL TYPE
- INCORPORATE NEW DESIGN INTO CFD MODEL
  - NOx
  - CO
  - O2
- REVIEW RESULTS AND MODIFY DESIGN AS REQUIRED

CFD MODELING IS USED TO VALIDATE ALL DESIGNS PRIOR TO MANUFACTURING

RELEASE DESIGN FOR FABRICATION

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Furnace Section

- Furnace Section
- Model Area
- Burners
Temperature Contour

Baseline

Upgraded
Coal Particle Path

Baseline

Upgrade

COAL PARTICLES

IRZ

PARTICLE PENETRATION INTO THE IRZ

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NOx Formation

Baseline Case

Upgrade Case

HIGH NOx FORMATION ZONE
OVER-FIRE AIR (OFA)

第三 燃 系
OVER-FIRE AIR (OFA) PROCESS

- Burner CFD model inputs into furnace model
- Mixing must be complete before the gases exit the furnace
- NOx reduction can be limited by LOI and CO
OFA Process

Penetration/Mixing Optimization
### OFA Process

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**FLUENT 5.4 (3d, segregated, spe3, ke)**

Aug 11, 2000

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Furnace Model – OFA

Before Modification

After Modification
OFA System Port Design
OFA System Port Design
OFA System
T-FIRED BOILER
Coal Burner Dynamics
*T-fired - Swirl Number (sn), Rotation & IRZ*
Low NOx Dynamics
T-fired – NOx Reduction Techniques

- MAINTAIN Swirl Number
- SEGMENT THE FUEL STREAM
- INCREASE COAL VELOCITY
- STRENGTHEN Vertical IRZ
- IMPROVE COAL DISTRIBUTION
ACT T-fired Boiler Burner Upgrade

- Coal Flow Distributor
- Coal Pipe Tip Insert
  - Increase Coal Injection Velocity
- New Fuel Bucket
  - Segmentation Of Fuel Stream
Typical T-fired Burner Corner
ACT T-fired Burner Upgrade & SOFA Addition

TYPICAL NOx REDUCTION

50 to 60% Burner Mods & OFA

Virtually No Change In LOI
MODEL OUTLET @ BOILER NOSE – ELEV 672’-2”

SOFA ELEV 650’-10”

UPPER BURNER ELEV 642’-4”

BOTTOM ASH HOPPER

EAGLE VALLEY 4 FURNACE MODEL
Grid (27 X 65 X 32)
FIGURE 9
Temperature Contour

Baseline

Upgraded
NOx Formation

Baseline Case

Upgrade Case

PEAK NOx ZONE REDUCED
EAGLE VALLEY UNIT 4 FIRING CIRCLE
EAGLE VALLEY 4 FURNACE MODEL
Surface Of Constant 30% OFA Mole Fraction
FIGURE 10
EAGLE VALLEY 4 FURNACE MODEL
Velocity Vectors (Ft/S) @ SOFA Elevation
FIGURE 11
ACT Low NOx T-Fired Fuel Bucket
Designed To Mate With Existing Coal Pipe And Sealing Arrangement
Coal Pipe

ACT Rope Breaker positioned inside existing coal pipe

ACT Coal Pipe Inserts positioned inside existing coal pipe
ACT Low NOx Burner Upgrade
Advanced Overfire Air
Advanced Overfire Air

OFA System Port Design
Advanced Overfire Air

OFA System Port Design
Advanced Overfire Air

OFA System Port Design
Typical NOx Reductions
Coal Firing - Burner

- Wall Fired Boilers
  - 45% - 65%
- Opposed Fired Boilers
  - 40% - 55%
- Tangentially Fired Boilers
  - 45% - 60%
Low NOx Coal Burners
(Engineering and Design Summary)

- Baseline Testing
- CFD Modeling
- Hardware Design
- Hardware Manufacturing
- Hardware Installation
- Air And Coal Flow Testing
- Optimization
HIGH ENERGY REAGENT TECHNOLOGY (HERT)

第四 高能量反应 技
HERT- ADVANCED SNCR

- Over Fire Air (OFA) is coupled with Urea or Ammonia injection to control nitrogen oxide emissions. Up to 65% NOx reductions achievable.
- OFA reduces NOx by staging combustion. Urea breaks down to NH3 and reacts with NOx in the proper temperature window, 1600 F to 2100 F, to form H2O and N2. Multi-level injection scheme controls NH3 slip below 5 ppm.
- Fewer injectors are required than a typical SNCR system.
- CFD modeling is used in conjunction with test data to design the OFA system and predict NOx reduction potential and NH3 slip levels.
Large wall injectors coupled with a high momentum OFA injection stage combustion and produce an optimum chemical agent coverage at the furnace outlet.
HERT – Advanced SNCR

Injection Skid

The skid mounted control system meters urea from storage tank to injectors throughout the load range. Optimum chemical usage with minimal ammonia slip is maintained.
EXPERIENCES AND CASES
EXPERIENCE SUMMARY

- Over 100 boilers (25 to 1100 MW) upgraded or replaced with new burners
- 45 coal fired boilers (36 coal fired boiler in the past four years)
- 24 OFA systems (17 OFA systems in the past four years)
- Over 1000 burners supplied
- Over 500 coal fired burners
## Low NOx Upgrades & OFA Experience

### Coal Fired Boilers (2001-2004)

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<th>Firing</th>
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## Low NOx Upgrades & OFA Experience
### Coal Fired Boilers (2001-2004)

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<td>0.4</td>
<td>0.28</td>
</tr>
<tr>
<td>Project 31, Syracuse, NY</td>
<td>B&amp;W</td>
<td>Front</td>
<td>4</td>
<td>25</td>
<td>250</td>
<td>0.6</td>
<td>0.35</td>
<td>---</td>
</tr>
<tr>
<td>Project 32, Syracuse, NY</td>
<td>B&amp;W</td>
<td>Front</td>
<td>4</td>
<td>25</td>
<td>250</td>
<td>0.6</td>
<td>0.35</td>
<td>---</td>
</tr>
<tr>
<td>Project 33, Syracuse, NY</td>
<td>B&amp;W</td>
<td>Front</td>
<td>4</td>
<td>25</td>
<td>250</td>
<td>0.6</td>
<td>0.35</td>
<td>---</td>
</tr>
<tr>
<td>Project 34, Syracuse, NY</td>
<td>B&amp;W</td>
<td>Front</td>
<td>4</td>
<td>25</td>
<td>250</td>
<td>0.6</td>
<td>0.35</td>
<td>---</td>
</tr>
<tr>
<td>Project 35, Syracuse, NY</td>
<td>B&amp;W</td>
<td>Front</td>
<td>4</td>
<td>25</td>
<td>250</td>
<td>0.6</td>
<td>0.35</td>
<td>---</td>
</tr>
<tr>
<td>Project 36, Monticello, TX</td>
<td>B&amp;W</td>
<td>Opposed</td>
<td>70</td>
<td>850</td>
<td>6500</td>
<td>0.29</td>
<td>0.19</td>
<td>0.16</td>
</tr>
<tr>
<td>Project 37, Toronto, Ontario</td>
<td>B&amp;W</td>
<td>Front</td>
<td>24</td>
<td>300</td>
<td>2000</td>
<td>0.99</td>
<td>0.45</td>
<td>---</td>
</tr>
<tr>
<td>Project 38, Toronto, Ontario</td>
<td>B&amp;W</td>
<td>Front</td>
<td>24</td>
<td>300</td>
<td>2000</td>
<td>0.99</td>
<td>0.45</td>
<td>---</td>
</tr>
<tr>
<td>Project 39, Toronto, Ontario</td>
<td>B&amp;W</td>
<td>Front</td>
<td>18</td>
<td>300</td>
<td>2000</td>
<td>0.99</td>
<td>0.45</td>
<td>---</td>
</tr>
<tr>
<td>Project 40, Toronto, Ontario</td>
<td>B&amp;W</td>
<td>Front</td>
<td>18</td>
<td>300</td>
<td>2000</td>
<td>0.99</td>
<td>0.45</td>
<td>---</td>
</tr>
</tbody>
</table>
ACT RECENT PROJECTS
PRE AND POST BURNER & OFA
NOx LEVELS

UNIT NAME

NOx, lb/mmBtu

POST
PRE
PROJECT SCOPE:
Engineer, model, supply and start-up burner upgrades and Overfire Air to reduce NOx emissions 53% to 0.26 lb/mmBtu.

DESCRIPTION AND PERFORMANCE:
• Secondary airflow was balanced utilizing ACT’s combustion air testing technology. Burner upgrades included the addition of a Low NOx Swirler, Coal Nozzle, Coal Flow Distributor and Burner Barrel. Two (2) Over Fire Air ports (OFA), one (1) over each column of burners was added.

• NOx emissions were reduced to less than 0.36 lb/mmBtu at full load conditions with the burner upgrades and less than 0.26 lb/mmBtu with the OFA. Flyash Loss-On-Ignition, (LOI) decreased significantly from “Pre Upgrade” level of 37% to the “Post Upgrade” level of 15%.
PLANT NAME: Michigan South Central Power Agency (MSCPA) – Boiler 1

APPLICATION: A 550,000 lb/hr Babcock & Wilcox Wall Fired Boiler required NOx reduction under the EPA Section 126 petition.

PROJECT SCOPE: Engineer, model, supply and start-up burner optimizations and modifications to reduce NOx emissions to 0.22 lb/mmBtu.

BOILER DATA
- Manufacturer: B&W
- Type: Natural Circulation Boiler
- Capacity: 550,000 lb/hr
- Steam Conditions: 1,800 PSIG, 950 °F SH
- Fuels: Eastern Bituminous Coal
- Burners: 8 B&W circular register
- Firing Arrangement: Front Fired 2 wide x 4 high
- Baseline NOx: 0.65 lb/mmBtu
- Final NOx: 0.22 lb/mmBtu
Case Example 2
Description And Performance

MSCPA owns and operates a wall fired coal boiler. As part of Petition 126, they needed to reduce NOx to the lowest possible level. Baseline NOx was 0.65 lb/mmBtu with flyash LOI of 6%.

The project was performed in two (2) stages. In the first stage ACT upgraded burners. NOx was reduced to less than 0.34 lb/mmBtu.

ACT performed the OFA system addition in the second phase to reduce NOx to less than 0.22 lb/mmBtu. Flyash Loss-On-Ignition following the two (2) phases increased slightly to 8%.

Burner upgrades included the addition of a Low NOx Swirler, Coal Nozzle, Coal Flow Distributor and Coal Barrel. The OFA system included, flow control dampers, ductwork, expansion joints, seal boxes and nozzles.
Case Example 3

PLANT NAME
Monroe Unit 2 – Combustion Tuning - Post Burner Upgrade

APPLICATION
840 MWg boiler with 28 coal fired burners upgraded for enhanced NOx control.

PROJECT SCOPE
Tune upgraded burners for optimum combustion and Low NOx performance

BOILER DATA
Manufacturer Babcock & Wilcox
Type UP Boiler
Capacity 5,900,000 lb/hr
Steam Conditions 3,500 psig and 1,000 F
Fuels Coal Blend with Opportunity Fuels
Burners 28 Cell Burners
Baseline NOx 0.55 lb/mmBtu
Final NOx 0.35 lb/mmBtu
CO, ppm <200 ppm
Opacity 14% - 16%
Upper NOx Ports - % Open (N-S) 100/100/50 50/100/100
Lower NOx Ports 5-4, 7-1, 1-1 100/100/40

DESCRIPTION AND PERFORMANCE
DTE’s Monroe Unit 2 was upgraded with ACT low NOx burner components. Tuning was performed to optimize combustion and reduce NOx to the lowest possible level. A third party test crew to determine the emission performance conducted testing. An initial setup was performed for low NOx performance. CO emission was maintained below 200 ppm.

Table 1
Monroe Unit 2
Low NOx Test Run
(750 MWe, 60/40 Coal Blend)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>North Duct</th>
<th>South Duct</th>
<th>Unit Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx, lb/mmBtu</td>
<td>.37</td>
<td>.31</td>
<td>.34</td>
</tr>
<tr>
<td>CO, ppm</td>
<td>129</td>
<td>124</td>
<td>127</td>
</tr>
</tbody>
</table>

Tuning was conducted to reduce CO to the lowest possible level and maintain acceptable NOx emissions. These results are illustrated in Table 2.

Table 2
Monroe Unit 2
Low CO Test Run
(700 MWe, 65/35 Coal Blend)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>North Duct</th>
<th>South Duct</th>
<th>Unit Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx, lb/mmBtu</td>
<td>.37</td>
<td>.34</td>
<td>.355</td>
</tr>
<tr>
<td>CO, ppm</td>
<td>16</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>
**Case Example 4**

<table>
<thead>
<tr>
<th><strong>CLIENT</strong></th>
<th><strong>COLORADO</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLANT NAME</strong></td>
<td>Unit 1</td>
</tr>
<tr>
<td><strong>APPLICATION</strong></td>
<td>One (1) 2,000,000 lb/hr Babcock and Wilcox Coal Fired Boiler</td>
</tr>
<tr>
<td><strong>PROJECT SCOPE</strong></td>
<td>Engineer, model, supply and start-up ACT designed Low NOx burners to reduce NOx emissions from 0.40 lb/mmBtu to less than 0.26 lb/mmBtu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>BOILER DATA</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Babcock &amp; Wilcox</td>
</tr>
<tr>
<td>Type</td>
<td>Natural Circulation Boiler</td>
</tr>
<tr>
<td>Capacity</td>
<td>2,000,000 lb/hr</td>
</tr>
<tr>
<td>Steam Conditions</td>
<td>1800 PSIG, 950°F SH</td>
</tr>
<tr>
<td>Fuels</td>
<td>Western Sub Bit Coal</td>
</tr>
<tr>
<td>Burners</td>
<td>21 opposed fired circular register</td>
</tr>
<tr>
<td>Baseline NOx</td>
<td>0.40 lb/mmBtu</td>
</tr>
<tr>
<td>Final NOx</td>
<td>0.25 lb/mmBtu</td>
</tr>
</tbody>
</table>

**DESCRIPTION AND PERFORMANCE**

CSU owns and operates Nixon Boiler 1, in order to operate the Front Range combined cycle unit NOx needed to be reduced. The boiler was retrofitted several years earlier with Eagle Air burners. Following the retrofit NOx was 0.40 lb/mmBtu with high CO and severe slagging. To further reduce NOx, ACT’s low NOx burners were selected as the most cost effective technology. Baseline testing determined the flyash LOI was 2% at the full load condition. The design was required to limit flyash to less than 2% with no impact on unit opacity.

Secondary airflow was balanced utilizing ACT’s combustion air testing technology. The existing secondary air dampers were set to balance airflow to each burner to within ±5% of boiler mean.

NOx emissions were reduced to less than 0.25 lb/mmBtu at full load conditions. Flyash LOI was less than 2.0% and Opacity was not impacted.
## HERT (ADVANCED SNCR) EXPERIENCE

<table>
<thead>
<tr>
<th>Utility/Station Location</th>
<th>Boiler MFG</th>
<th>Firing</th>
<th># of Burner</th>
<th>MW</th>
<th>Steam Flow Klb/hr</th>
<th>Baseline NOx lb/mmBtu</th>
<th>LNB NOx lb/mmBtu</th>
<th>OFA NOx lb/mmBtu</th>
<th>HERT NOx lb/mmBtu</th>
<th>Total NOx Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1</td>
<td>CE</td>
<td>Tang</td>
<td>12</td>
<td>40</td>
<td>400</td>
<td>0.7</td>
<td>0.48</td>
<td>0.28</td>
<td>0.12</td>
<td>83%</td>
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<tr>
<td>Asheville, NC</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 2</td>
<td>B&amp;W</td>
<td>Front</td>
<td>6</td>
<td>55</td>
<td>550</td>
<td>0.6</td>
<td>0.34</td>
<td>0.22</td>
<td>0.15</td>
<td>75%</td>
</tr>
<tr>
<td>Litchfield, MI</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 3</td>
<td>FW</td>
<td>Front</td>
<td>15</td>
<td>180</td>
<td>1,500</td>
<td>1.1</td>
<td>0.42</td>
<td>0.35</td>
<td>0.21</td>
<td>81%</td>
</tr>
<tr>
<td>Stratton, OH</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 4</td>
<td>FW</td>
<td>Front</td>
<td>15</td>
<td>180</td>
<td>1,500</td>
<td>1.1</td>
<td>0.42</td>
<td>0.35</td>
<td>0.25</td>
<td>77%</td>
</tr>
<tr>
<td>Stratton, OH</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 5</td>
<td>FW</td>
<td>Front</td>
<td>15</td>
<td>180</td>
<td>1,500</td>
<td>1.1</td>
<td>0.42</td>
<td>0.37</td>
<td>0.22</td>
<td>80%</td>
</tr>
<tr>
<td>Stratton, OH</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 6</td>
<td>FW</td>
<td>Front</td>
<td>6</td>
<td>40</td>
<td>400</td>
<td>0.90</td>
<td>0.42</td>
<td>0.35</td>
<td>0.25</td>
<td>72%</td>
</tr>
<tr>
<td>Portsmouth, NH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 7</td>
<td>B&amp;W</td>
<td>Front</td>
<td>16</td>
<td>135</td>
<td>1,350</td>
<td>0.83</td>
<td>0.45</td>
<td>0.38</td>
<td>0.26</td>
<td>69%</td>
</tr>
<tr>
<td>West Pittsburg, PA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

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### ACT LAYERED APPROACH SUMMARY

<table>
<thead>
<tr>
<th>Layer</th>
<th>Technologies</th>
<th>NOx Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1</td>
<td>Combustion Optimization</td>
<td>10-20%</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Low NOx Burner</td>
<td>45%-60%</td>
</tr>
<tr>
<td>Layer 3</td>
<td>Over Fire Air (OFA)</td>
<td>25-40%</td>
</tr>
<tr>
<td>Layer 4</td>
<td>HERT (Advanced SNCR)</td>
<td>35-50%</td>
</tr>
<tr>
<td>Layer 2+3</td>
<td>Low NOx Burner + OFA</td>
<td>55-65%</td>
</tr>
<tr>
<td>Layer 3+4</td>
<td>OFA + HERT</td>
<td>65%</td>
</tr>
<tr>
<td>Layer 2+3+4</td>
<td>Low NOx Burner + OFA + HERT</td>
<td>80%</td>
</tr>
</tbody>
</table>
ACT Layered NOx Reduction Approach
80%+ NOx reduction at the lowest cost/ton (以最低价位 到80%以上 率)

- Baseline: 0%
- Boiler Optimization: 20%
- Low NOx Burner: 50%
- OFA: 65%
- HERT: 80%
ACT's Layered NOx Reduction Process

<table>
<thead>
<tr>
<th>NOx Emissions lb/MmBtu</th>
<th>Baseline</th>
<th>+ LNB or LNB mods</th>
<th>+ OFA</th>
<th>+ HERT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.80</td>
<td>0.36</td>
<td>0.25</td>
<td>0.16</td>
</tr>
</tbody>
</table>

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WHAT ARE YOU LOOKING FOR?

- Boiler Optimization?
- Modified Burners?
- New Low NOx Burners?
- Overfire Air?
- HERT (Advanced–SNCR)?

<table>
<thead>
<tr>
<th>NOx Reduction</th>
<th>Cost (用)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80% +</td>
<td>Low（低）</td>
</tr>
<tr>
<td>35%</td>
<td>High（高）</td>
</tr>
<tr>
<td>90%</td>
<td>Extremely High（很高）</td>
</tr>
</tbody>
</table>

**ANSWER:**
ACT Best Value NOx Reduction
HERE IS YOUR SOLUTION

- Custom Fit
- Minimize Operational Impact (Shorter Plant Outages)
- Lowest Urea Consumption
- No Catalyst Required
- Select Only the Performance You Need (Flexibility)
- Lower Capital Cost
- Lowest O&M Cost

The ACT Layered NOx Reduction Process
80%+NOx reduction at the lowest cost/ton
(以最低价位 到80%以上 率)
THANK YOU