Boilers Burning High Iron/High Sulfur Coals: Fuels Risk Mitigation

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Areas Covered

• Key Technologies
• Background
• Industrial Boiler Case Study
• Utility Boiler Case Studies
Key Technologies

• Computational Fluid Dynamics (CFD)
• Injection Technology
• Chemical Technology
• Combustion Expertise
Predicting what will form, where it will form and how to get the proper chemical to the correct place. Result: Lower Fuel Risk + Lower Fuel Cost
Virtual Reality CFD
Inside Furnace View
• Boiler Designed to Burn Coal with Ash Fusion Temp = 2500°F (Green)

Coal With Ash Fusion Temp = 2100°F Less Costly (Blue)
Untreated ILB Coal Slag
Slag Transformation Using TIFI Technologies

- Nano Technology & Eutectics Are Key
- New Technology is Highly Responsive
- Slag Changes Begin in Less Than 12 Hours
True Cost of Coal Switching

- Δ Contract Terms
- Δ BTU Content
- Δ Grindability
- Δ Volatility (Housekeeping)
- Δ Scrubbing
- Δ SO₃ mitigation
- Δ Ash Handling/Revenues
- Δ Coal Handling Costs
- Δ Higher Chlorides and/or Sulfates
- Δ Freight

Total Cost
Coal Prices

Historical Average Weekly Coal Commodity Spot Prices
(Dollars per Short Ton)
Business Week Ended June 12, 2009

Key to Coal Commodities by Region:

- **Central Appalachia:** Big Sandy/Kanawha 12,500 Btu, 1.2 lb SO2/mmBtu
- **Northern Appalachia:** Pittsburgh Seam 13,000 Btu, <3.0 lb SO2/mmBtu
- **Illinois Basin:** 11,800 Btu, 5.0 lb SO2/mmBtu
- **Powder River Basin:** 8,800 Btu, 0.8 lb SO2/mmBtu
- **Uinta Basin in Colo.:** 11,700 Btu, 0.8 lb SO2/mmBtu
Changing Conditions

- Pacific (China) Imports of U.S. Coal Move Up/Down
- Spot Market Prices CAPP Close to ILB
- Contract Prices of CAPP Up $20 vs. ILB
- Dozens of CAPP Permits Denied (97 in Limbo)
- Price Spread Expected to Widen
- Economy Up, But Unsettled
The ACALAT Concept

Manage the SLAG RISK box

Any Coal
Any Load
Any Time
Results of Using TIFI Technologies

- Ability to Burn Less Expensive (More Problematic) Fuels
- Avoid Derates due to Slag/Fouling
- Better Heat Absorption
- Overall Increased Efficiency (2%)
Beta Site Selected in 2008

Client Highly Motivated to Reduce Fuel Cost

Δ Price Between CAP & ILB $25 - $80/ton (at the time)
## Typical Coal: Case History I

<table>
<thead>
<tr>
<th>Component</th>
<th>Before Treatment</th>
<th>After Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe$_2$O$_3$</td>
<td>26.7%</td>
<td></td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>21.59%</td>
<td></td>
</tr>
<tr>
<td>SiO$_2$</td>
<td>43.43%</td>
<td></td>
</tr>
<tr>
<td>CaO</td>
<td>2.04%</td>
<td></td>
</tr>
<tr>
<td>Na$_2$O</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>K$_2$O</td>
<td>2.17%</td>
<td></td>
</tr>
<tr>
<td>S (dry)</td>
<td>4.4%</td>
<td></td>
</tr>
</tbody>
</table>
TIFI Technology in High Fe/S Coal Environment Case History I

STEAM FLOW & GENERATING BANK dP VS TIME

UNTREATED

TREATED

- STEAM FLOW A
- GEN BANK DP B
- STEAM FLOW B
- Linear (GEN BANK DP A)
- Linear (GEN BANK DP B)
TIFI XP in High Fe/S Coal Environment Case History I

ID FAN AMPS VS STEAM FLOW

- UNTREATED
- TREATED
- Linear (UNTREATED)
- Linear (TREATED)
PSH & RH dP Vs % MCR
Case History II

![Graph showing the relationship between PSH & RH dP and % MCR. The graph includes data points and trend lines for different scenarios.]
Calculated % Flue Gas Flow Vs % MCR (Case History II)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fuel Blend 1</th>
<th>Fuel Blend 2*</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN #1</td>
<td>67</td>
<td>71</td>
</tr>
<tr>
<td>RUN #2</td>
<td>74</td>
<td>78</td>
</tr>
<tr>
<td>No Treatment</td>
<td>81</td>
<td>86</td>
</tr>
<tr>
<td>(Fuel Blend 1)</td>
<td>88</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>100</td>
</tr>
</tbody>
</table>

* 7% Lower Heat Content

9 % Lower CO₂
(Fuel Blend 1)
Total Fuel Flow (%) Case History II
Steam Temperature Recovery
Case History III

Untreated

Frequency

Cumulative %

Bin

Frequency

Cumulative %

0%

10%

20%

30%

40%

50%

60%

70%

80%

90%

100%

910 920 930 940 950 960 970 980 990 1000 1010 1020 More
Steam Temperature Recovery
Case History III

Treated (+ 20°F)
# Comparison of Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Feature</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Feed to Fuel Belt</td>
<td>Applied to Fuel Belt</td>
<td>Simple to Use Not Precise</td>
</tr>
<tr>
<td>Conventional Feed to Fuel Belt</td>
<td>Kerosene Carrier</td>
<td>Adds BTU Content to Fuel</td>
</tr>
<tr>
<td>Conventional Feed to Fuel Belt</td>
<td>Economical Application</td>
<td>Not Successful at Economical Doses</td>
</tr>
<tr>
<td>Conventional Feed to Fuel Belt</td>
<td>Kerosene Carrier</td>
<td>Flammable Toxic Fumes</td>
</tr>
<tr>
<td>TIFI-XP (Targeted In Furnace Injection)</td>
<td>CFD Modeling &amp; Multi-Injector Feed Required</td>
<td>Near 100% Coverage &amp; High Performance at Low Doses</td>
</tr>
<tr>
<td>TIFI-XP</td>
<td>Modifies Crystal Structure of Ash</td>
<td>Reduces Deposit Hardness</td>
</tr>
<tr>
<td>TIFI-XP</td>
<td>Cleans 90%+ Heat Transfer Surfaces</td>
<td>2% Efficiency Increase &amp; More MW w/Lower Cost Fuels</td>
</tr>
</tbody>
</table>
Conclusions

• Supply/Demand Economics Complements TIFI Technologies
• TIFI Technologies Outperformed Conventional Chemical Programs
• Clean SHs Mean Downstream Heat Transfer Surfaces Remain Clean
• Additional Benefits of the New Technology = 1.5 – 2.0% Efficiency Increase
Photos Confirm Numbers

UNTREATED

TIFI-XP TREATED
• 3% MORE MW
• 2% MORE EFF.
• 9% LESS CO₂