Achieving Ultra Low NO\textsubscript{x} Emissions in Boiler Burner Retrofits

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Retrofits – Success is in the details

When it comes to retrofits, details provide the roadmap to success:

- Overall knowledge of the retrofit
- Operations knowledge
- Current boiler issues
- Plant needs and goals
Project Background - Boiler Retrofit

- Project was based to be an emission reduction project:
  - Retrofit existing boilers with ultra low emission technology
  - Minimize Costs
    - Installation
    - Operation
    - Maintenance
Boiler Challenges

- 1930s Marine-style Boiler
  - +60% refractory furnace
  - Limited waterwall heat transfer surface
  - Boiler in-leakage (balanced draft operation)
  - Older controls
  - Boiler construction and limited details
Considerations during the retrofit

- Accurate and complete data from existing operation for retrofit design
- Steam into fuel not required for NO\textsubscript{x} control
- Added only due to fuel out of spec.

- Maximize use of available air pressure drop
- Reuse existing windbox and fuel gas train
Retrofit Project

- Keep project as simple as possible
- Two new Zeeco Free-Jet Ultra Low NOₓ gas burners
- Reused existing windbox
- Updated controls philosophy and lower balanced draft point
- Balance combustion air to each burner
Field Data Free-Jet Boiler Application

- Two burners at 75 MM Btu/hr per each boiler
- Boiler Dimensions (17’ H x 8’ W x 14’ D)
- Volumetric Heat Release at 78k Btu/ft³
- Refinery fuel gas (variation from -30% to +290% Btu/SCF of natural gas)
- NOₓ = 24 ppmv with 0.3 lbs steam / lbs fuel
  - Equivalent to 5% external FGR
  - 32 ppm with no external FGR
Field Data Free-Jet Boiler Application

- Four burners at 63 MM Btu/hr
- Boiler Dimensions (17’ H x 11’ W x 18’ D)
- Volumetric Heat Release at 74K Btu/ft³
- Refinery fuel gas (variation from -25% to -7% Btu/SCF of natural gas)
- \( \text{NO}_x = 30 \text{ ppmv} \)
- Steam Injection in air by 0.5 lb steam / lb fuel to compensate for fuel variation
Project Review-Boiler Retrofits

Conclusions

- Challenging retrofit due to age of boilers
- Lack of accurate design data
- Tramp air leakage had to be addressed
- No external FGR required
- Steam into air stream ~ 0.3 – 0.4 lb steam / lb fuel
- Met emission guarantees for NOₓ (<0.03 lb / MM) and for CO (<50 ppmv)
- Third party verified
Zeeco Free-Jet Technology
Fuel Reconditioning for Lower Thermal NO$_x$

• Simple design for a complex problem.

• The fuel gas is mixed with inert products of combustion before combustion occurs, thus “reconditioning the fuel gas”
Free-Jet Technology

- 9 ppm NOₓ
- IFGR versus EFGR
- More efficient use of FGR – no external recirculation, use what's in the furnace
- Less boiler impacts – convective sections
- Smaller fans – less electricity, lower CO₂ – “greener” project
- Less (or no) Ductwork, hangers, exp. joints, etc.
- “Born” on refinery gas – NG relatively easy – dual fuel
- 20-1 turndown
Free-Jet Multi-Burner Applications
Minimal Flame Interaction – No Swirl
First Stabilization Ledge
Second Stabilization Ledge

As the boiler load is increased, excess oxygen level is reduced to ~7% range, the flame moves up from the first ledge to the second.
Second Stabilization Ledge
Final Stabilization Ledge

- As the high boiler loads (MCR) is achieved, excess oxygen level is reduced to approximately 2-3% and lower.

- By the time the flame front has reached the top of the tile, the resulting reconditioned fuel composition is 80 to 90% inert.
Final Stabilization Ledge

- The resulting reconditioned fuel gas produces significantly lower thermal NO\textsubscript{x} emissions
Free-Jet Stabilization

- The Free-Jet concept is similar to conventional burners which uses a tip next to a ledge to stabilize a gas/air mixture on a refractory tile ledge.
Low Maintenance Cost and Downtime

- Since the gas tips do not stick into the furnace more than 1” (25 mm), they are not as exposed to the thermal heat and last longer.
- Port plugging is also reduced due to the lower temperature and the use of single firing.
- Results in a larger diameter firing port.
- Metal flame stabilization devices, reducing downtime and maintenance requirements.
Single Piece Tile
THANK YOU

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