Clearsign Ultra Low NOx Technology

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Agenda

• Applicability
• How it Works
• Claimed Benefits
• Installations in the San Joaquin Valley
• Reports so far
• What’s next
• Questions/comments
Applicability

• Developed to
  – Reduce NOx emissions in external combustion devices
  – Improve combustion equipment fuel efficiency
  – Overall lower operational cost

• Uses to date in in Valley
  – Oilfield steam generators
  – Refinery process heaters
  – Enclosed flares
How It Works

• Porous ceramic body installed in the firebox downstream of the burner
• Burner ignited and ceramic body brought up to temperature
• Certain fuel ports closed
• Flame transitions form burner to ceramic body
• NOx emissions sub 5 ppmv @ 3% O₂
How It Works
oilfield steam generator

Duplex™ Tile
Rail System (allows for adjustable Duplex position)
How It Works
refinery process heater
How it works

Clearsign promotional video
Claimed Benefits

• No flue gas recirculation needed
• No complex air/fuel ratio controls needed
• Energy Savings
  – No need for larger combustion blower for FGR
  – Increased thermal efficiency due to no heating of flue
• Less costly than traditional ultra low NOx controls
• No data on costs though
Two small refinery heaters

- One 15 MMBtu/hr heater
  - Working as intended but heater used very infrequently
  - NOx 6 ppmv @ 3% O₂
- One 8 MMBtu/hr heater
  - Challenges with structural integrity
  - NOx 6 ppmv @ 3% O₂
- Both fired on natural gas, not refinery fuel gas
Installations in SJ Valley

• Three 62.5 MMBtu/hr oilfield steam generators
  – Two natural gas fired units
    • Overcame problems with combustion stability
    • Ongoing challenges with structural integrity of duplex tile framework
    • Several design changes have improved durability, but challenges remain
    • Ongoing operation not yet sustainable
  – One natural gas/waste gas fired unit
    • Currently being installed
    • Required redesign of framework
Installing in SJ Valley

• Six enclosed flares
  – Oil production operation
  – Burning high Btu stranded gas
  – Proposed to be evaluated as a retrofit in existing low NOx “Coyote” flares
  – Expected NOx emissions ~ 6 ppmv @ 3% O₂
  – No operational/emission data available yet
Overall impressions

• Promising technology
• Simple design, no elaborate burner controls, no FGR required, no SCR
• Increased efficiency means can lead to lower fuel use
• Lower fuel use
  – Lower criteria emissions
  – Lower CO$_2$ emissions a benefit to operators subject to cap/trade
Overall impressions

However …

• Ongoing challenges with structural integrity
• So far, technology is not sustainable for long periods of time
• Costs of technology unknown at this time
• Claimed 2 to 3 year payback when considering ALL operational costs (fuel use, NOx emissions, cap/trade requirements)
• More testing/demonstration needed before sustainability/durability is proven
Comments/Questions