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Achieving Ultra Low NO_x Emissions in Boiler Burner Retrofits

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Owned & Produced By: PennWell
Presented By: POWER Engineering
Supported By: PennEnergy

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

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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

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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

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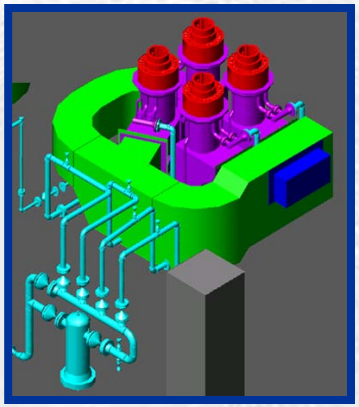
Boiler Challenges Continued

- Considerations during the retrofit
  - Accurate and complete data from existing operation for retrofit design
  - Steam into fuel not required for NO_x control
  - Added only due to fuel out of spec.
- Maximize use of available air pressure drop
- Reuse existing windbox and fuel gas train

RETROFITS



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Retrofit Project

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

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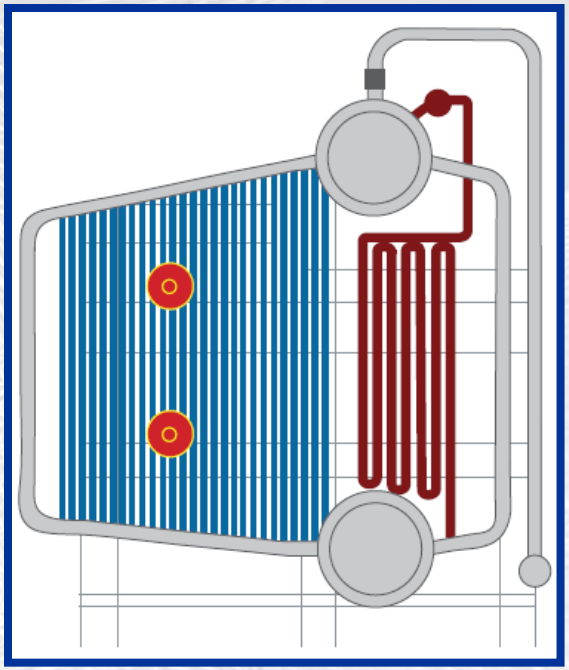
Field Data Free-Jet Boiler Application

- 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/ft^3
- Refinery fuel gas (variation from -30% to +290% Btu/SCF of natural gas)
- NO_x = 24 ppmv with 0.3 lbs steam / lbs fuel
  - Equivalent to 5% external FGR
  - 32 ppm with no external FGR



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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/ft^3
- Refinery fuel gas (variation from -25% to -7% Btu/SCF of natural gas)
- NO_x = 30 ppmv
- Steam Injection in air by 0.5 lb steam / lb fuel to compensate for fuel variation

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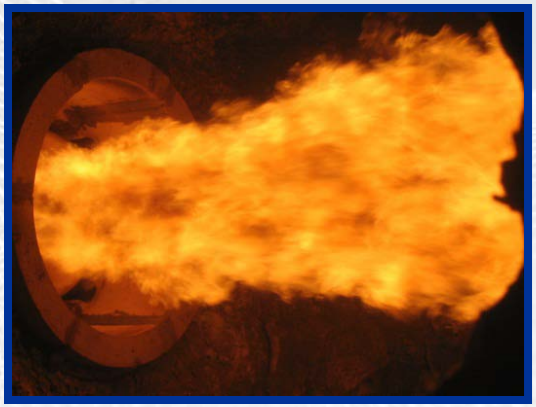
Project Review-Boiler Retrofits

- 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 NO_x (<0.03 lb / MM) and for CO (<50 ppmv)
  - Third party verified

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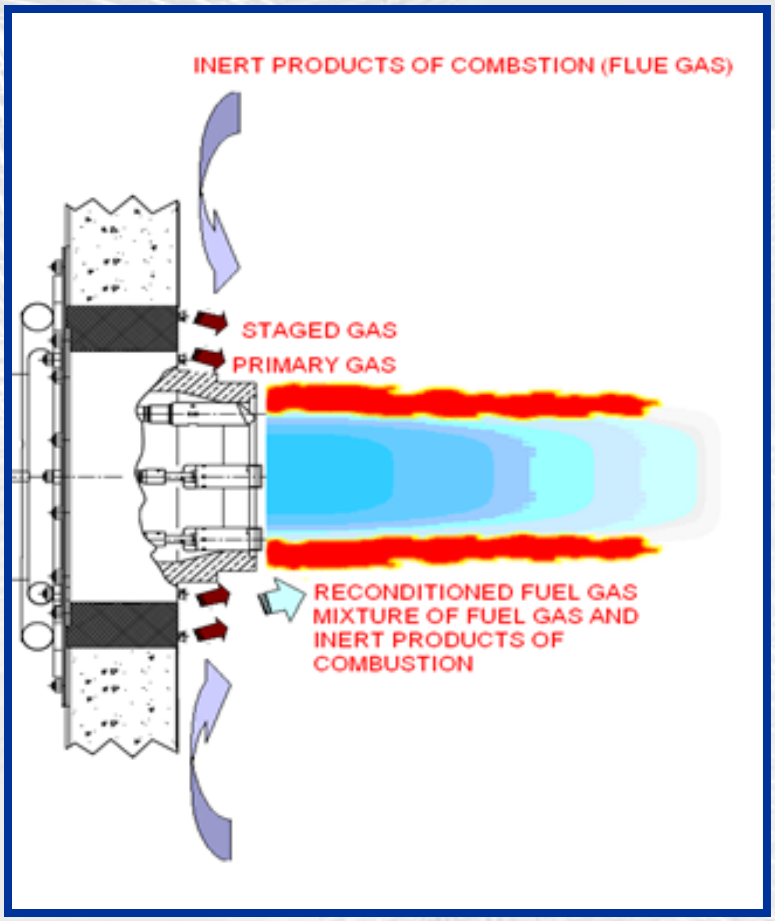
Zeeco Free-Jet Technology
Fuel Reconditioning for Lower Thermal NO_x

- Simple design for a complex problem.
- The fuel gas is mixed with inert products of combustion before combustion occurs, thus "reconditioning the fuel gas"



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Free-Jet Technology

- 9 ppm NO_x
- 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 CO_2 – “greener” project
- Less (or no) Ductwork, hangers, exp. joints, etc.
- “Born” on refinery gas – NG relatively easy – dual fuel
- 20-1 turndown

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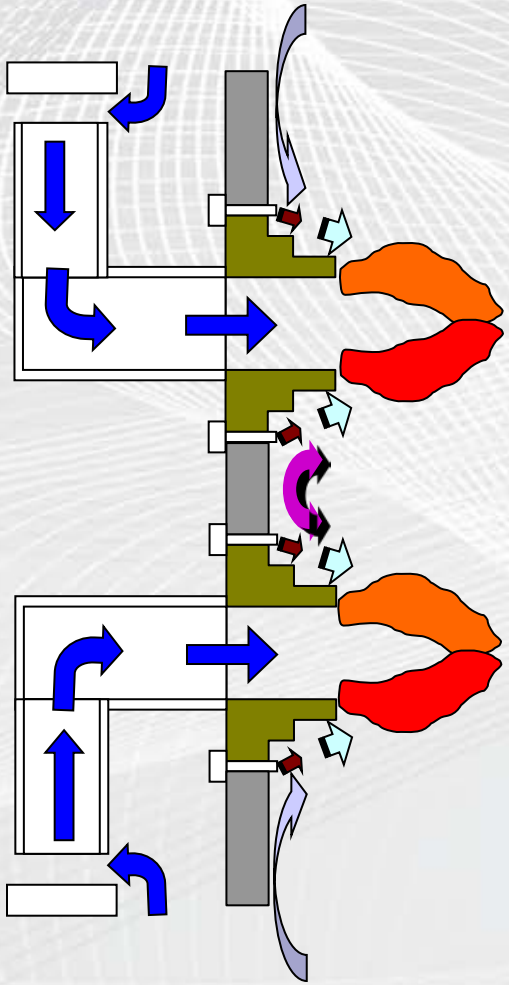
Free-Jet Multi-Burner Applications
Minimal Flame Interaction – No Swirl



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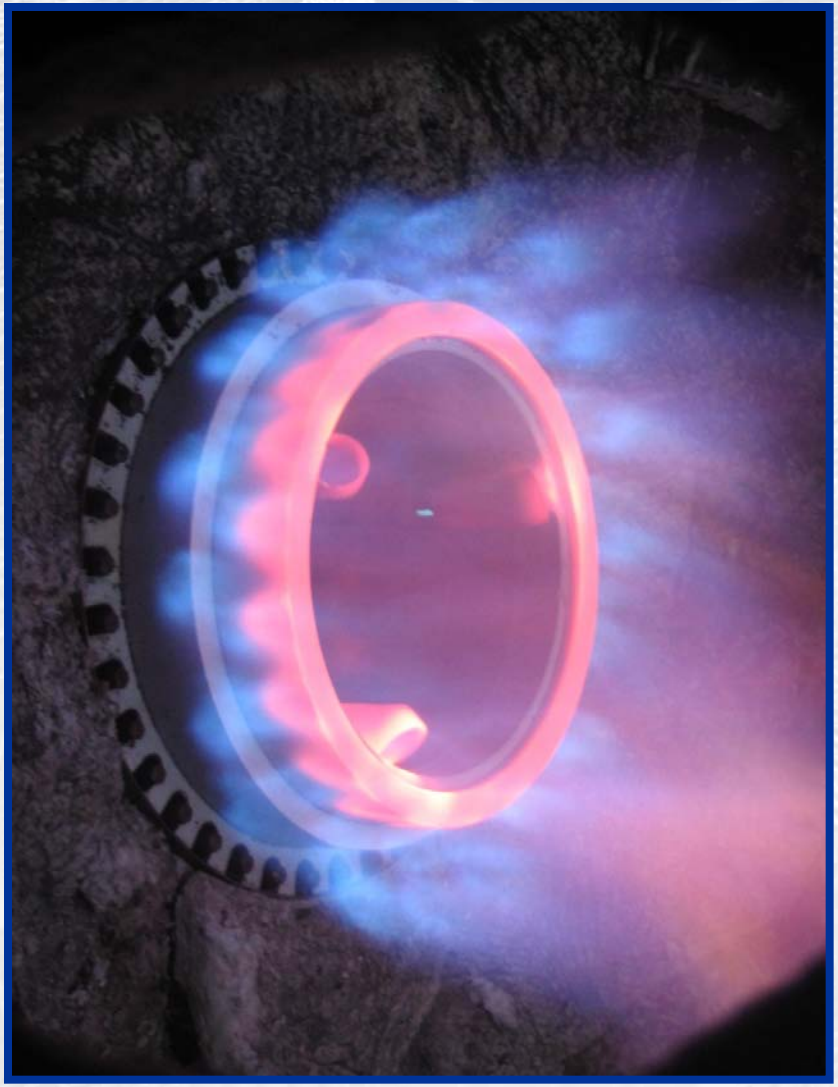
First Stabilization Ledge



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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.

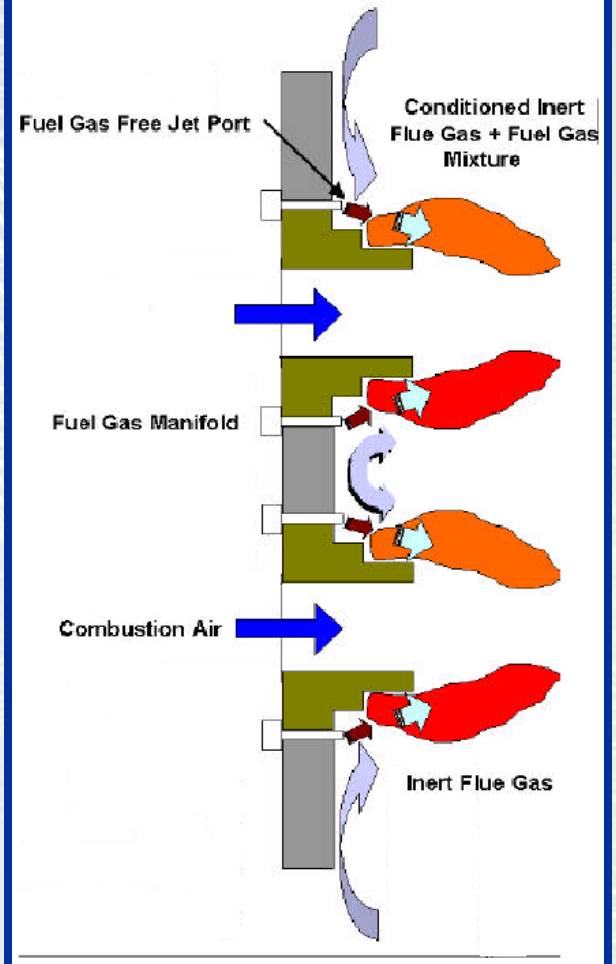

Figure 5: *Free Jet Second Stabilization Ledge*

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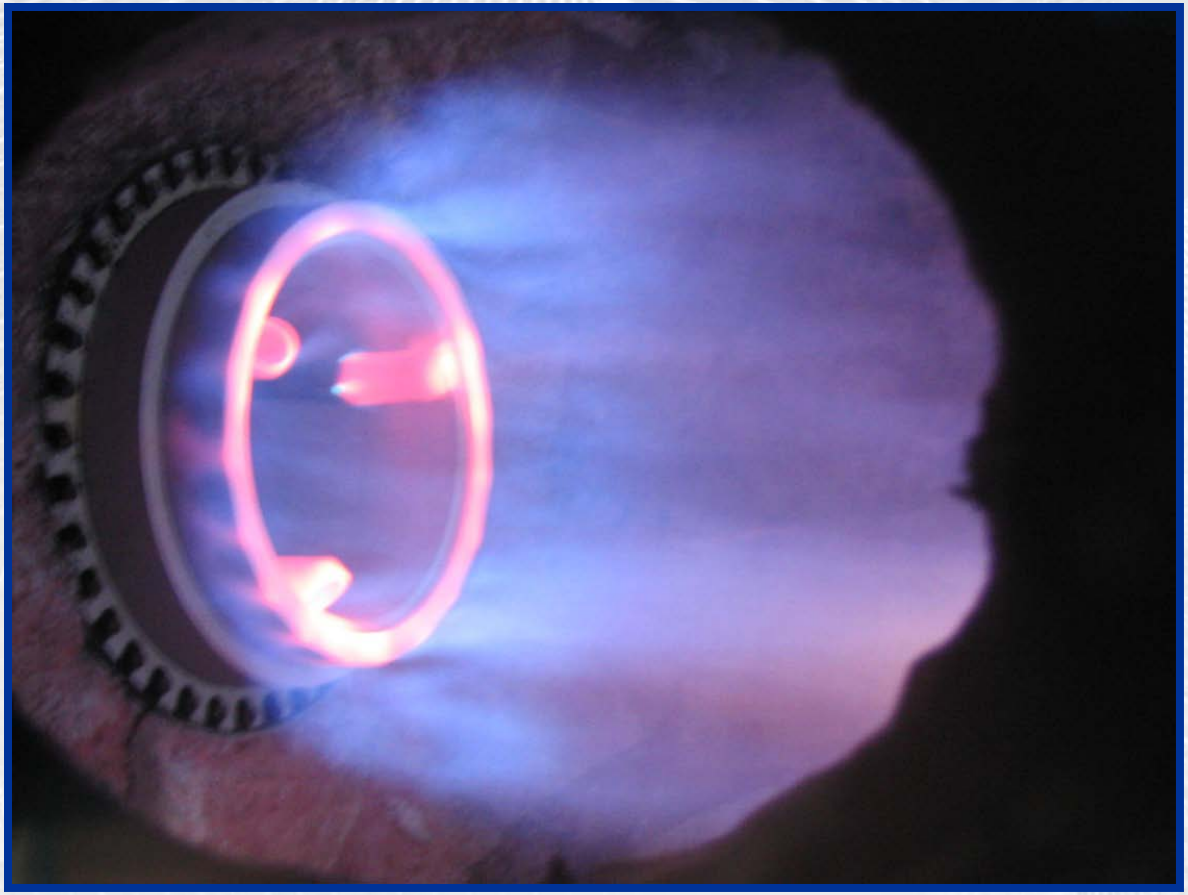
Second Stabilization Ledge



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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.

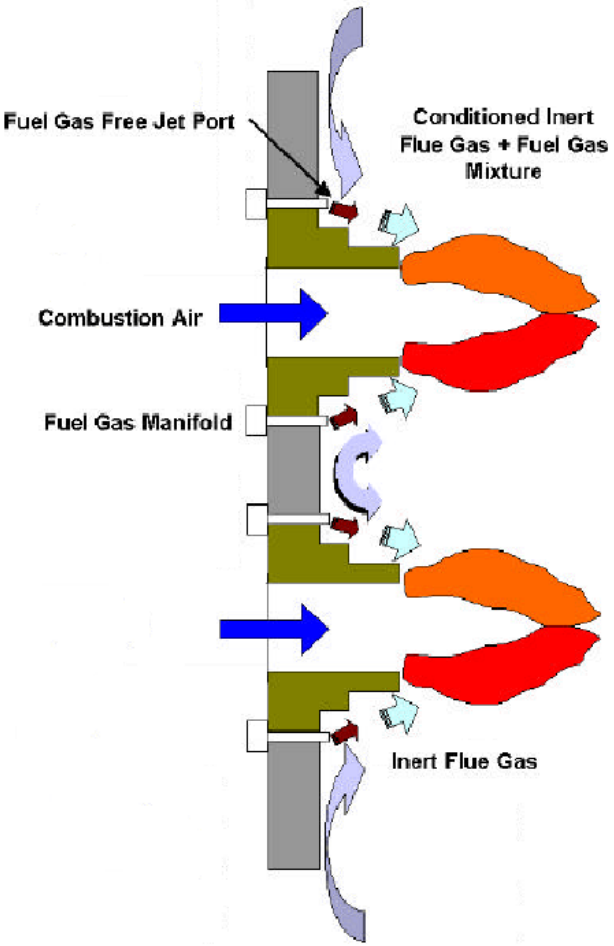

Figure 6: *Free Jet Final Stabilization*

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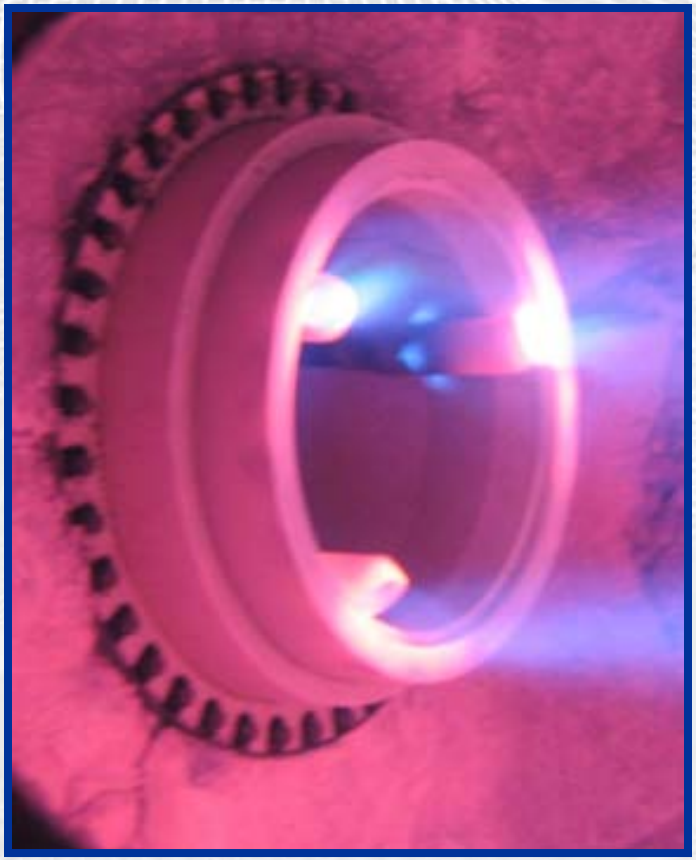
Final Stabilization Ledge

- The resulting reconditioned fuel gas produces significantly lower thermal NO_x emissions



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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

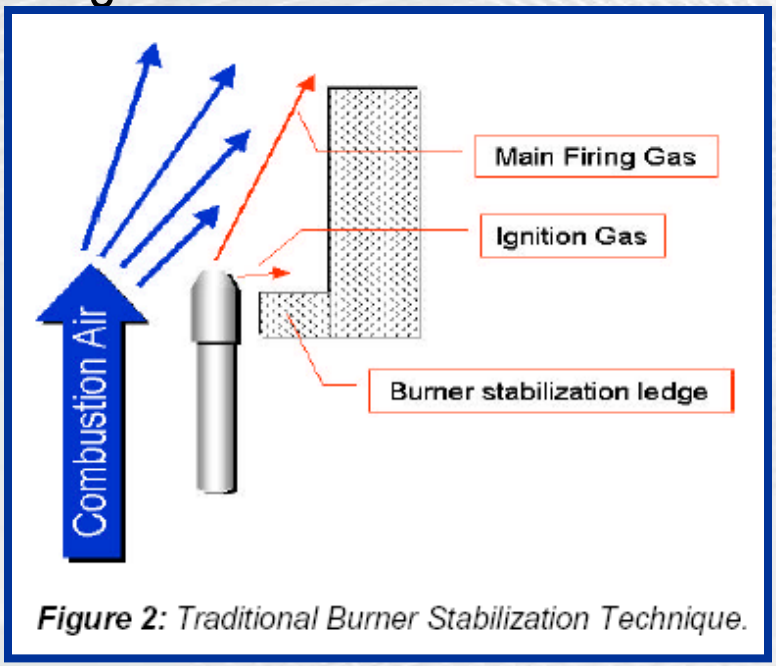
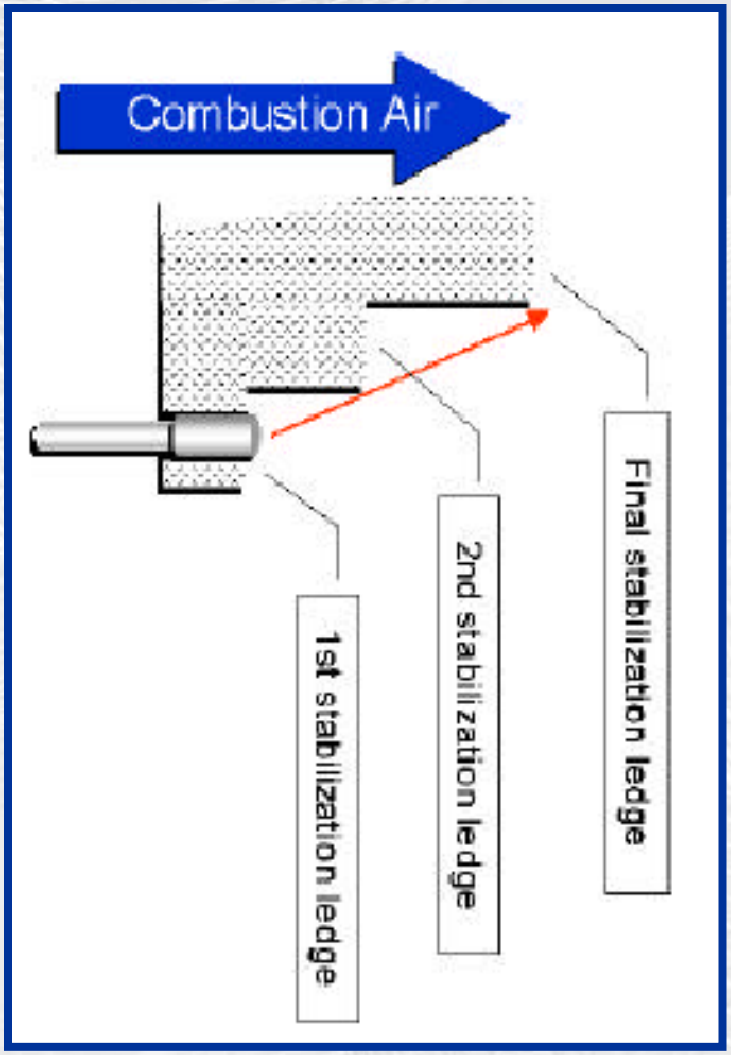


Figure 2: *Traditional Burner Stabilization Technique.*



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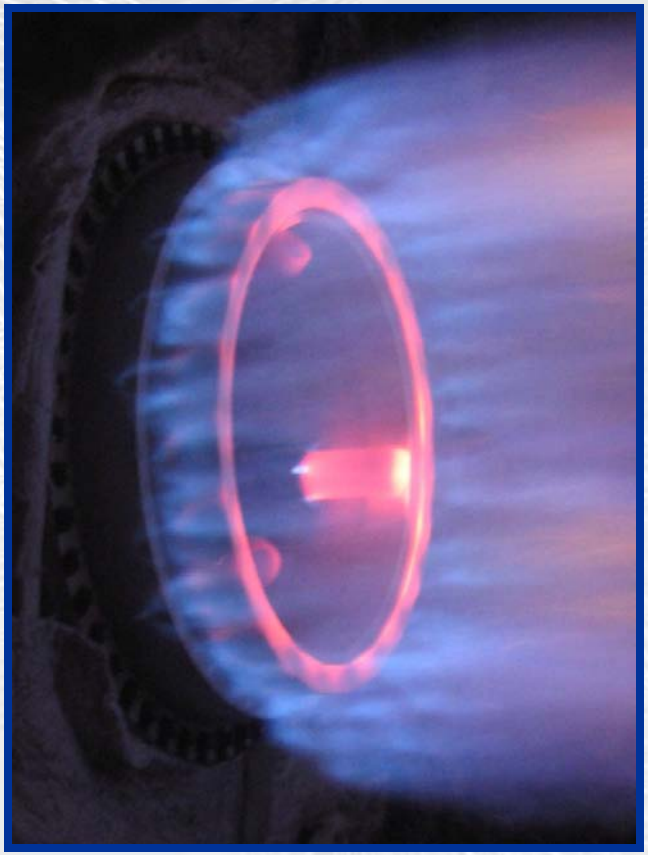
Low Maintenance Cost and Downtime

- 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



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Single Piece Tile

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