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# *Overview of Low NOx Burners*

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Energy Solutions Center
Low NOx Boiler Workshops
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## Outline

- NOx Theory Review
- NOx reductions methods
- Low NOx burners
  - DAF
  - Delta NOx
  - QLN
  - QLA
  - ULN

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## NOx Comparison Table

| Industrial Boilers Gas Fired | | |
|---|---|---|
| Capacity | CCME / Policy A-9 NOx | Houston NOx |
| >100 MMBtu/hr | 0.092 #/MMBtu 76.3 ppm | 0.01 #/MMBtu 8.3 ppm |
| 40–100 MMBtu/hr | 0.06 #/MMBtu 49.6 ppm | 0.015 #/MMBtu 12.5 ppm |
| 10-40 MMBtu/hr | 0.06 #/MMBtu 49.6 ppm | 0.036 #/mmBTU 30 ppm |

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## Factors affecting Thermal $NO_x$

- Firing rate
- Furnace size
- Furnace type (refractory, front wall construction, etc.)
- Air preheat
- Excess air

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## Fuel $NO_x$

- Formed during the combustion of fuels containing bound nitrogen
- Typical fuels with bound nitrogen:
  - No. 6 oil & residual oils
  - Coal
  - Gases containing ammonia

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## Reducing $NO_x$

- Identify the major $NO_x$ contributor
  - Apply the proper technique in relation to the reduction objective

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## Flue Gas Recirculation

Advantages:

- Very effective at reducing thermal $NO_x$ on gas and light oils
- Minimum effect on flame length
- Reasonable excess air throughout firing range
- Easily added to any boiler installation
- Can be combined with other low $NO_x$ techniques

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## Flue Gas Recirculation

Disadvantages:

- Increase in mass flow through boiler - higher system losses
- May require review of superheater design for possible effects on steam temperature

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## Steam Injection

- Reduces flame temperature by adding mass at cool temperature, similar to FGR
- Cheaper to install than FGR lines
- Involves a de-rating of the boiler
- Decreases dew point of stack flue gases
- Will tend to shield flame from scanners

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## Fuel $NO_X$

- Approaches to reducing Fuel $NO_x$
  - Create fuel rich zone - very little $O_2$
  - Slow mixing of secondary air to complete combustion
  - Primary zone residence time > .2 seconds

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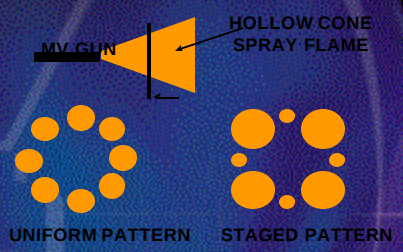
## Spray Staging

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## Performance Considerations

**OPERATIONAL**

- Maximum Firing Rate
- Turndown
- Stability
- Repeatability
- Reliability

**EMISSIONS**

- $NO_x$
  - Fuel
  - Thermal
- CO
- Particulates
- Opacity / Smoke

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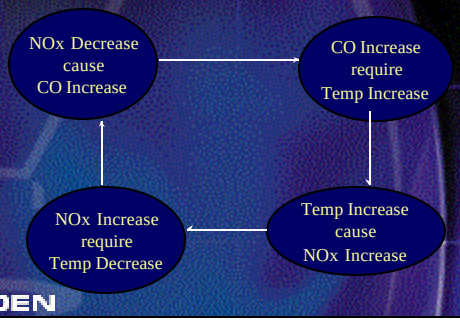
## The NOx - CO Loop

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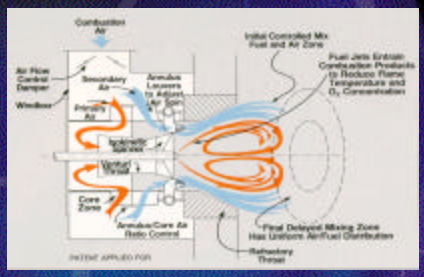
## DAF burner



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## Delta $NO_x$ burner

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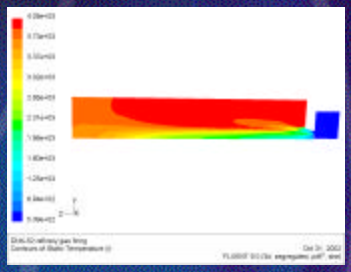
## Delta NOx Burner



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## QLN Burner

- Fuel Staging & Premix Design
- < 76 ppm w/o FGR
  - Boilers w/ High SHRR
- < 30 ppm w/o FGR
  - Boilers w/ Low SHRR
- < 30 ppm w/ FGR
  - In Most Package Boilers

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## QLN Flame

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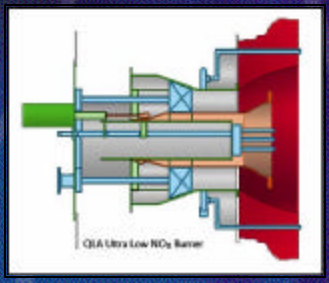
## QLA Ultra Low NOx Burner

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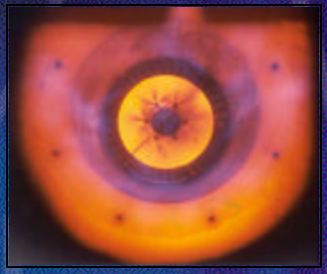
## QLA Flame



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## QLA Design Concept

- Variable Air Zone Geometry For Improved Turn Down
- Separate Core Zone For Improved Flame Stability
- Secondary Gas Spuds For Improved Performance
- Pre-Mix Primary Fuel Zone for low Prompt NOx

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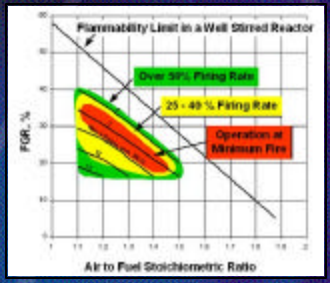
## Typical Ultra Low NOx Performance

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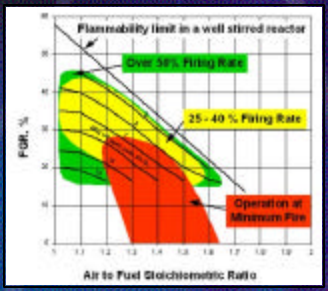
## QLA Burner Performance

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## Benefits of QLA with FGR

- <0.01 Lb/mmBtu NOx
- Stable Combustion
- High Turndown
- Very Low CO
- Low Excess Air
- Multi-Burner compatible

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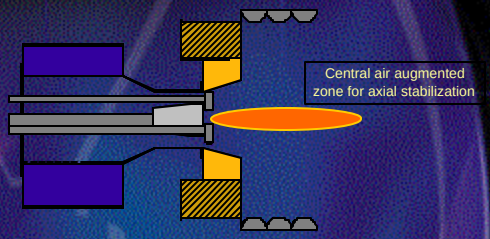
## Design Concept – ULN

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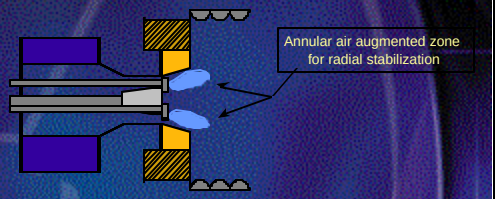
## Design Concept – ULN

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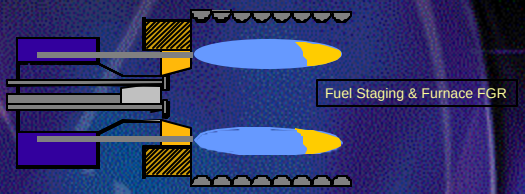
## Design Concept – ULN

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## Benefits of ULN Technology

- High Turndown
- Flexible Performance
  - 0.015 – 0.03 Lb NOx/MMBtu
- Wide Flame Stability
- Simple Controls
- Robust Operation
- Refinery Gas Compatible

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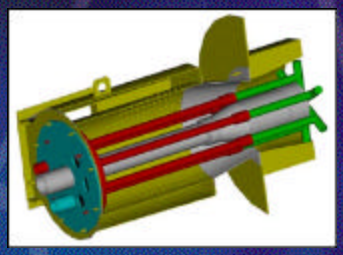
## Coen's New ULN Burner



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## Low $NO_x$ Solutions in Package Boilers

- 76 ppm - "Delta-$NO_x$" with No FGR
- 49 ppm - "Delta-$NO_x$" with No or Minimal FGR
- 49 ppm - "QLN" with No FGR
- 20 ppm - "QLN" with Minimal FGR
- 12 ppm – "Delta-NOx ULN" with FGR
- < 9 ppm - "QLA" with FGR

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