Ethylene Producers' Conference (EPC)

Burner Applications in Ethylene Cracking Furnaces Operating at Significantly Less Than 90 mg/Nm^3

Presenter:

Ryan Roberts
Project Engineering Manager
Process Burners


BURNERS


FLARES


INCINERATORS


PARTS & SERVICES

Introduction

- Ultra Low NOx Emissions of less than 90 mg/Nm3 can be difficult in Ethylene Cracking
- Typical NOx Reduction Methods Can Lead to Longer Flame Lengths
- Longer Flame Lengths Cause:
  - Flame Rollover to Process Tubes
  - Flame Impingement on Process Tubes, and Hot Spots
  - Shorter Run Time Between Decoking
  - Reduced Ethylene Production

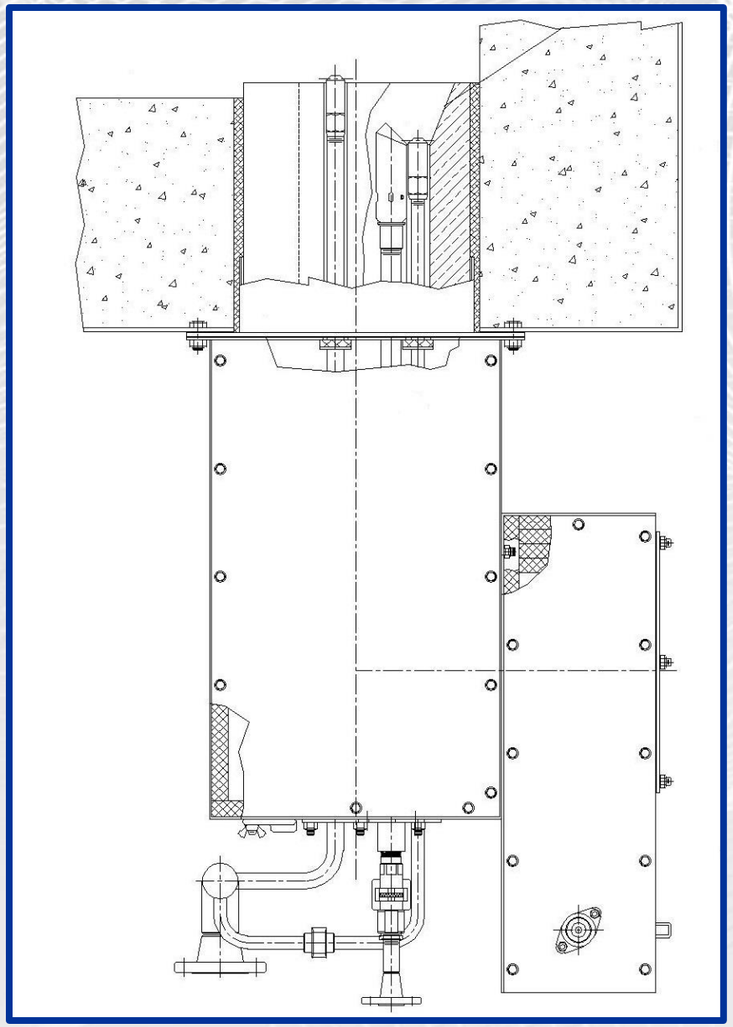
Introduction (cont'd)

- Zeeco's GLSF Enhanced-Jet Flat Flame Floor Mounted Burner
- Burner entrains unburned fuel next to furnace wall
- Mixes inert flue gas products of combustion with unburned fuel gas
- Results:
  - Lower peak flame temperature
  - Reduced NOx emissions
  - Reduction in tendency for flame rollover because mixture is kept close to furnace wall

Description of Application

- (8) New Ethylene cracking furnace train
- (7) Twin cell furnaces with:
  - (64) burners per furnace
  - Furnace 210-F-1110 to 210-F-1170
- (1) Single cell furnace with:
  - (24) burners
  - Furnace 210-F-1180

Description of Application (cont'd)



- Twin Cell Furnaces
  - (32) Burners per Cell
- Single Cell Furnace
  - (24) Burners
- Tubes in Center of Furnace
- Burners Fire Up the Furnace Wall
- Close Spacing Between Burners

Summary Information for Bottom Burners

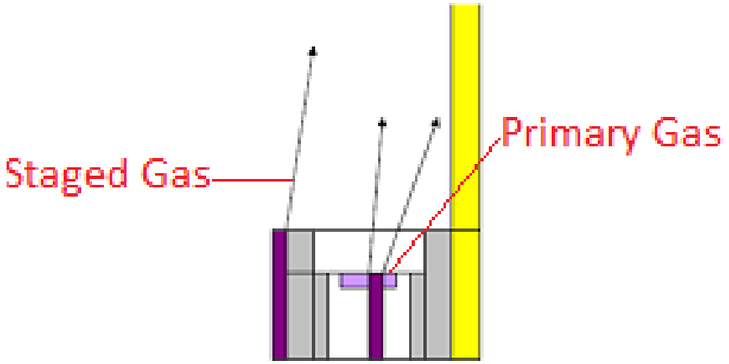
Summary Details for Furnaces 210-F-1110 to 210-F-1170	
Number of burners	7 Furnaces x 64 per furnace 2 Cells per furnace (32 per cell) (2 rows × 16 per side)
Type of burner	GLSF Enhanced Jet Burners complete with internal fuel gas recirculation
Type of fuel (gas/oil/dual oil-gas)	gas only
Location in furnace (roof/floor/side wall)	floor
Firing orientation (down-firing/upshot/radiant wall /against wall)	upshot (against wall)
Flame shape (round flame/flat flame)	flat flame gas burner assembly
Air supply system (natural/forced/induced/balanced/GTE)	induced draft fan with natural draft burners
Max. available combustion air pressure at burner, mm H2O	13
Ambient temperature (normal), ℃	16
Relative humidity, %	82%
Altitude above sea level, m	674
Flue gas temperature at cross-over ℃	1115
Maximum Heat Release (Gcal/hr)	1.830
Normal Heat Release (Gcal/hr)	1.530
Minimum Heat Release (Gcal/hr)	0.230
Turndown	7.96
Available Fuel Pressure (MPa(g))	0.27
Design Excess Air	10%
Flame Shape	Flat Flame
Maximum Predicted Flame Length (m)	6.01
Maximum Predicted Flame Width (m)	0.79

Summary Information for Bottom Burners

Summary Details for Furnaces 210-F-1180	
Number of burners	1 Furnaces x 24 per furnace 1 Cell per furnace (24 per cell) (2 rows × 12 per side)
Type of burner	GLSF Enhanced Jet Burners complete with internal fuel gas recirculation
Type of fuel (gas/oil/dual oil-gas)	Gas only
Location in furnace (roof/floor/side wall)	floor
Firing orientation (down-firing/upshot/radiant wall /against wall)	Upshot (against wall)
Flame shape (round flame/flat flame)	flat flame gas burner assembly
Air supply system (natural/forced/induced/balanced/GTE)	induced draft fan with natural draft burners
Max. available combustion air pressure at burner, mm H2O	13
Ambient temperature (normal), ℃	16
Relative humidity, %	82%
Altitude above sea level, m	674
Flue gas temperature at cross-over ℃	1115
Maximum Heat Release (Gcal/hr)	1.850
Normal Heat Release (Gcal/hr)	1.540
Minimum Heat Release (Gcal/hr)	0.230
Turndown	8.04
Available Fuel Pressure (MPa(g))	0.27
Design Excess Air	10%
Flame Shape	Flat Flame
Maximum Predicted Flame Length (m)	6.01
Maximum Predicted Flame Width (m)	0.80

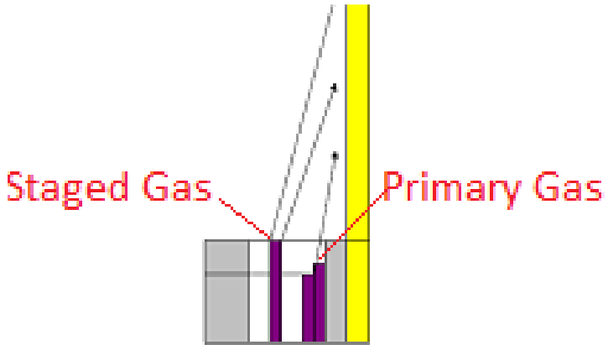
Comparison to Low Emissions Burners

Low Emissions Staged Fuel Burner

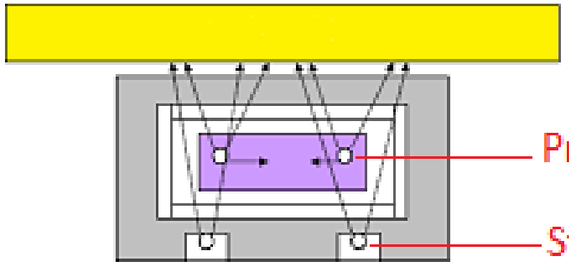


Side View of Burner

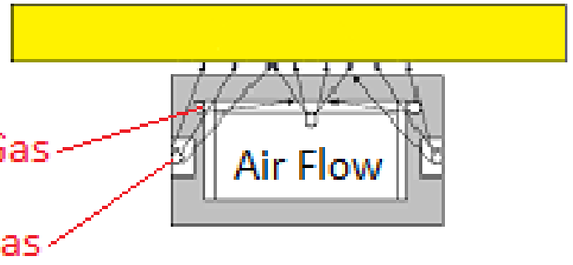
Zeeco GLSF Enhanced Jet Flat Flame Burner



Side View of Burner

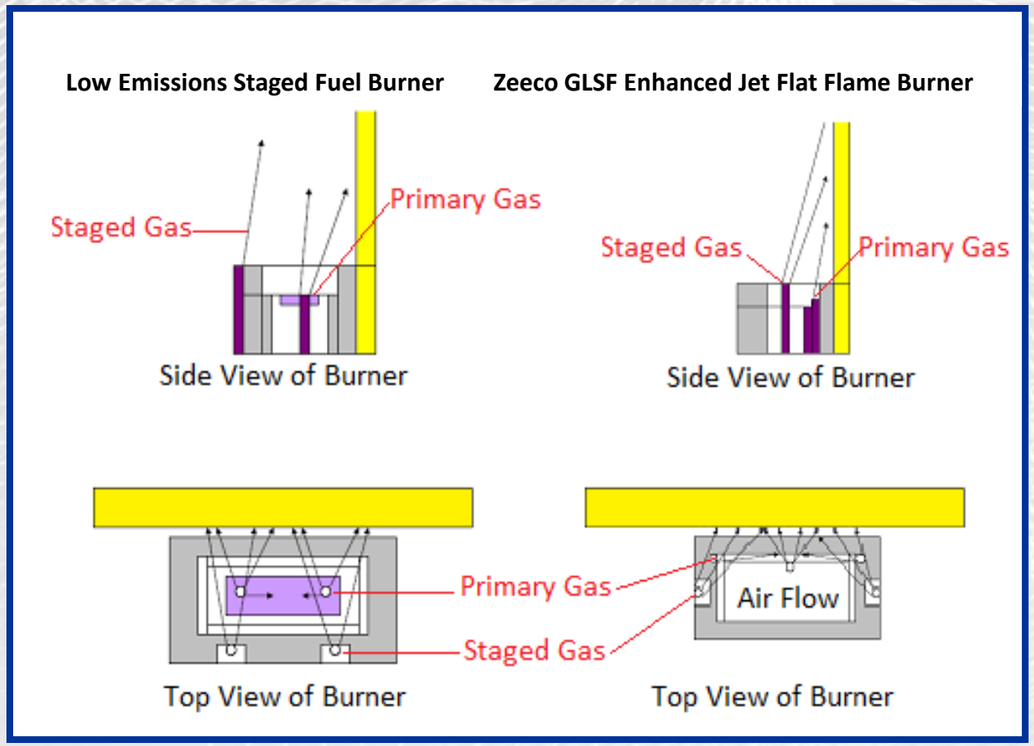


Top View of Burner



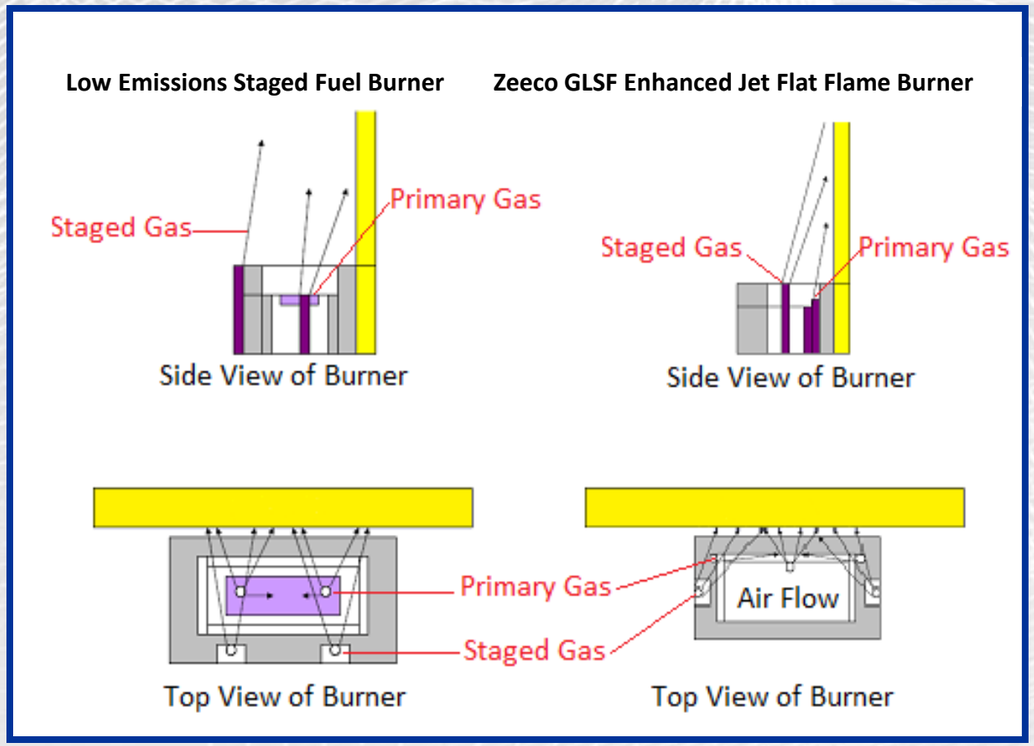
Top View of Burner

Comparison to Low Emissions Burner (cont'd)



- Typical Low Emissions Burner
  - ~70% of Fuel in Staged Gas Tips
  - Fires Across the Air Stream at Abrupt Angle
  - Fast Mixing of Fuel Gas and Combustion Air
  - Generates Much Higher NOx Emissions

Comparison to Low Emissions Burner (cont'd)

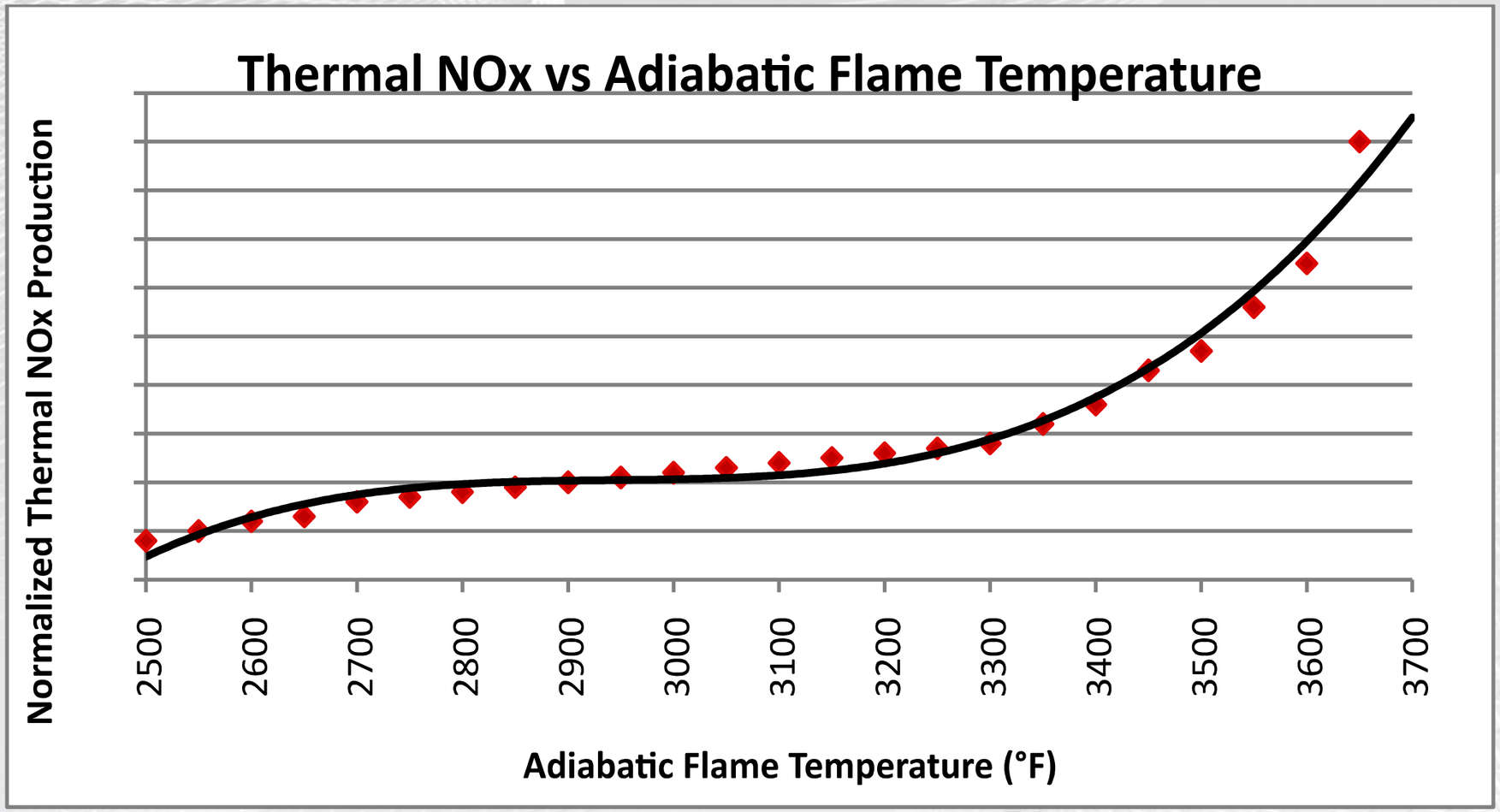


- Zeeco GLSF Enhanced-Jet Flat Flame Burner
  - ~70% of Fuel in Staged Gas Tips
  - Staged Tips Located on Side of Burner Throat
  - Delayed Mixing of Fuel Gas and Combustion Air
  - Induces Mixing of Inert Flue Gas Products Into Unburned Fuel
  - Reduction in NOx Emissions

GLSF Enhanced Jet Flat Flame Burner

- Staged Ports on Side of Burner Tile Allow:
  - Fuel Gas to Avoid Passing Directly Over Combustion Air Stream
  - Delayed Fuel and Air Mixing to Reduce Peak Flame Temperature
  - Reduction in Peak Flame Temperature to Decrease NOx Emissions
  - More Fuel and Air Momentum on Furnace Wall to Reduce Potential for Flame Roll Over
  - Better Control of Flame Width and Length
  - Uniform Heat Flux Profile in the Middle and Upper Regions of the Burner Flame
  - Even Heat Transfer and Reduction in Possibility of Tube Hot Spots

NOx Reduction



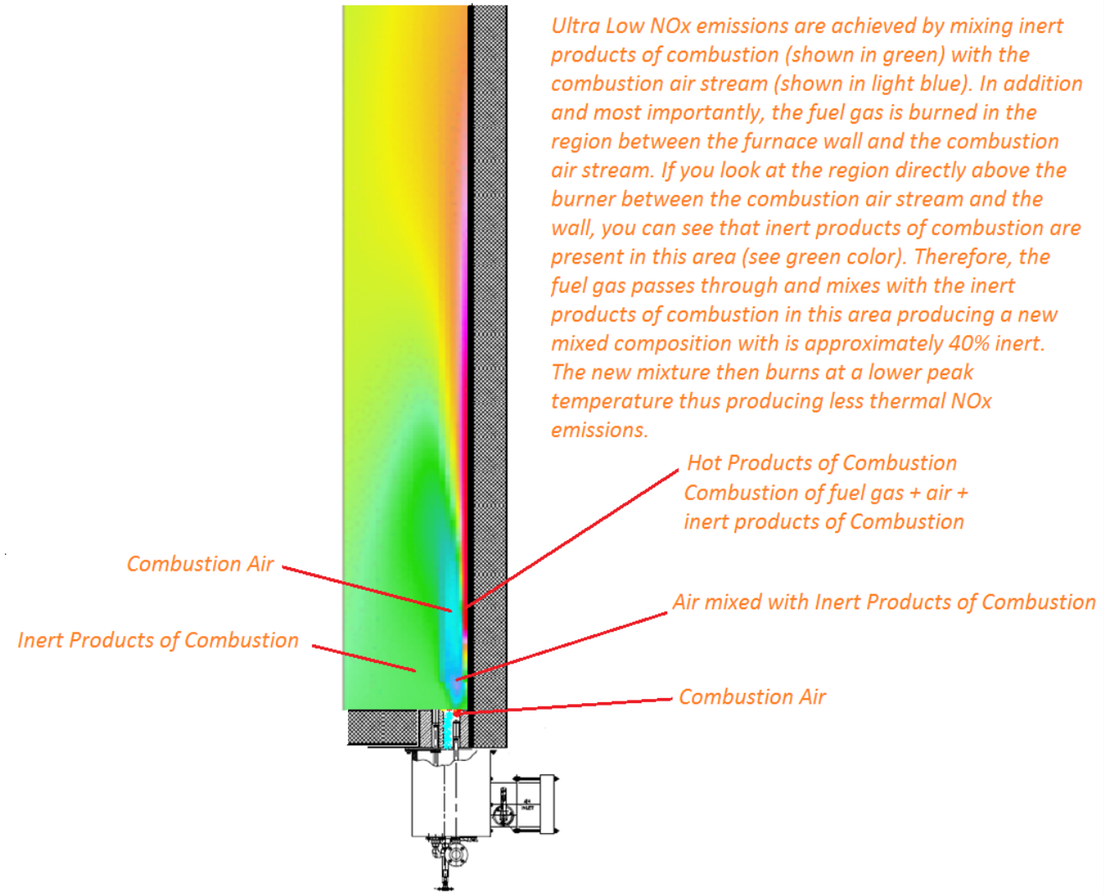
Reduction in Peak Flame Temperature = Reduction in NOx Emissions

NOx Reduction (cont'd)

- 2 Types of NOx Reduction Used in Project
  - Delayed Mixing of Fuel and Combustion Air with Staged Tip Location
  - Internal Flue Gas Recirculation (IFGR) of Flue Gas Into Staged Fuel Stream
- Both Methods Are Used Together to Reduce NOx Emissions without Compromising Flame Shape
- Mixture of Inert Flue Gas and Fuel Gas Is Between 15% And 50% Inert
- Results in Lower Peak (Adiabatic) Flame Temperature

NOx Reduction (cont'd)

Ultra Low NOx Emissions



Ultra Low NOx emissions are achieved by mixing inert products of combustion (shown in green) with the combustion air stream (shown in light blue). In addition and most importantly, the fuel gas is burned in the region between the furnace wall and the combustion air stream. If you look at the region directly above the burner between the combustion air stream and the wall, you can see that inert products of combustion are present in this area (see green color). Therefore, the fuel gas passes through and mixes with the inert products of combustion in this area producing a new mixed composition with is approximately 40% inert. The new mixture then burns at a lower peak temperature thus producing less thermal NOx emissions.

- Large Amounts of IFGR
- Flame Stays Along the Furnace Wall
- No Flame Rollover
- Uniform Heat Flux Profile
- Reduced NOx Emissions

Emissions Guarantees

Guarantees for NOx, CO, UHC, and Particulate Emissions:

- NOx Emissions Will Not Exceed 90 mg/Nm3
- CO Emissions Will Not Exceed 30 mg/Nm3
- Particulate (PM10) Emissions Will Not Exceed 10 mg/Nm3
- UHC Emissions Will Not Exceed 11 mg/Nm3
- Burner Noise Level Will Not Exceed 85 dBA at 1 Meter From the Burner

Conclusions

- (8) New Ethylene Cracking Furnaces Needed to Operate at Less Than 90 mg/Nm3 Nox Emissions
- After Retrofit, Closely Mounted Burners Showed No Signs of Flame Interaction or Rollover
- Burners Achieved Desired Emissions, and Normally Operate Well Below Guaranteed Levels
- Field Measured NOx Emissions Were 35 mg/Nm3 (17 ppmv) to 65 mg/Nm3 (32 ppmv) at Designed Heat Release

QUESTIONS?