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Achieving Ultra-Low NO_x Emissions in Methanol Downfired Reformer Applications

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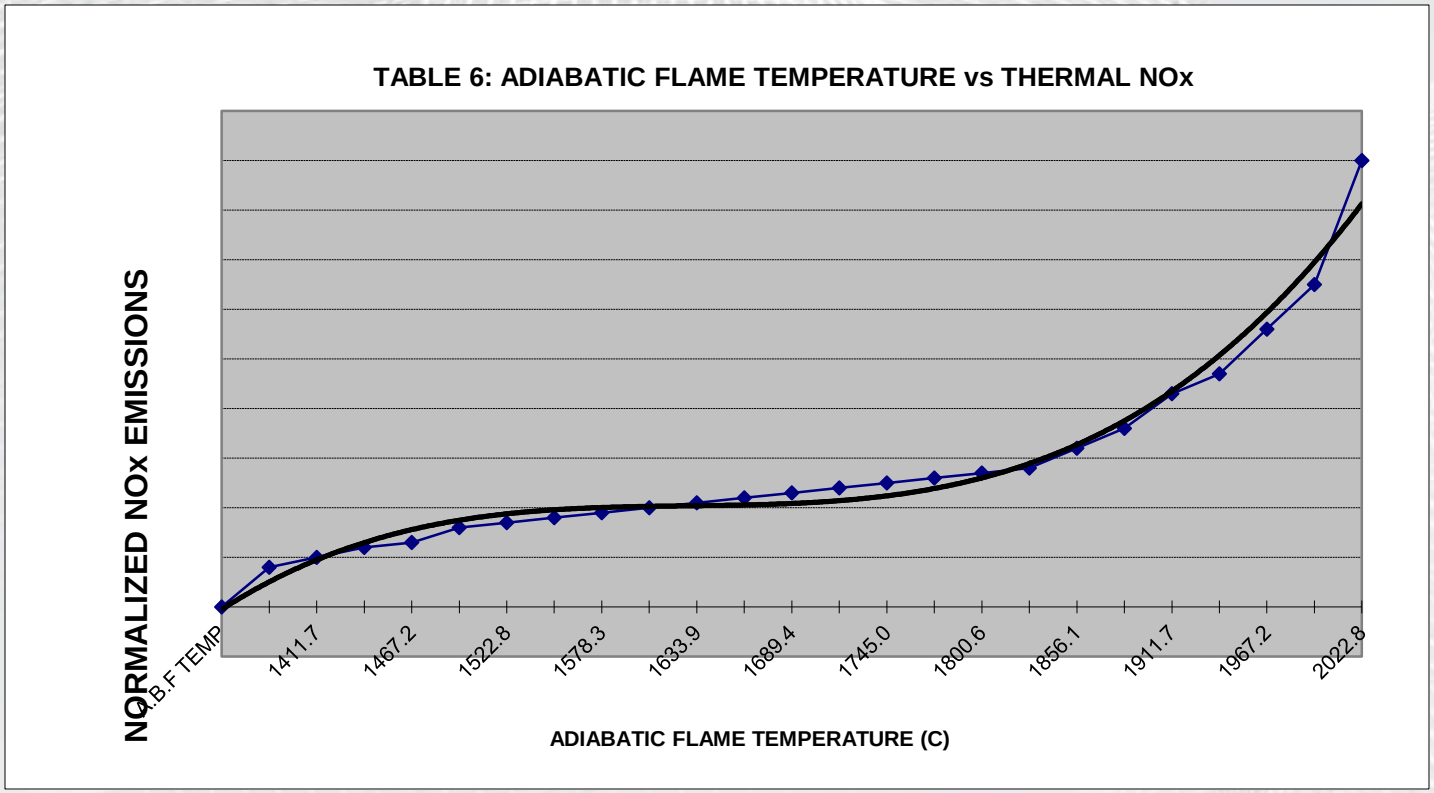
Introduction

- Burner retrofits in downfired applications have proven to be challenging projects due to burner spacing requirements and resulting effects on burner flame quality.
- As the stringent environmental regulations continue to increase in the Kingdom of Saudi Arabia (KSA), there is a need to replace previous generations of burners with ultra-low NO_x burners.
- Zeeco's latest Ultra-Low NO_x Free-Jet burner was selected to replace the 234-burner steam methane reformer.

Flame Temperature vs. Thermal NO_x

For gaseous fuels with no fuel-bound nitrogen (N_2), thermal NO_x is the primary contributor to overall NO_x production.



Calculated Peak Flame Temperature and Thermal NO_x production

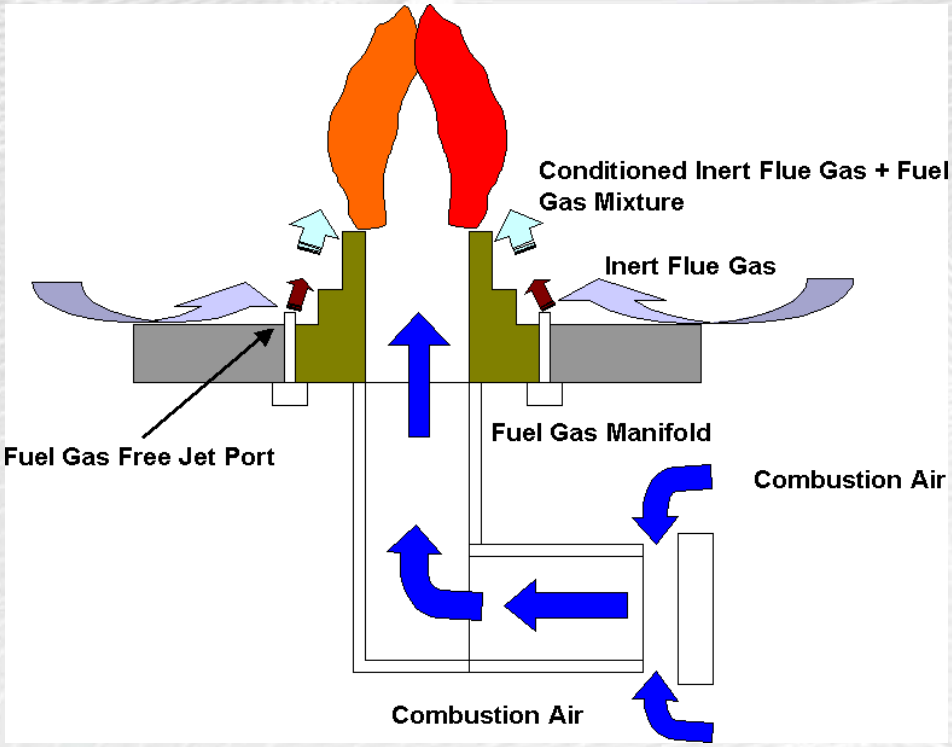
Description of Application

- The NO_x emission limit in the KSA at the time of the application was 43 ng/J (90 ppmv).
- The previous burners that were installed in the methanol reformer have NO_x emissions consistently above 70 ng/J (130 ppmv) with occasional excursions to 110 ng/J (205 ppmv).

Description of Application Cont.

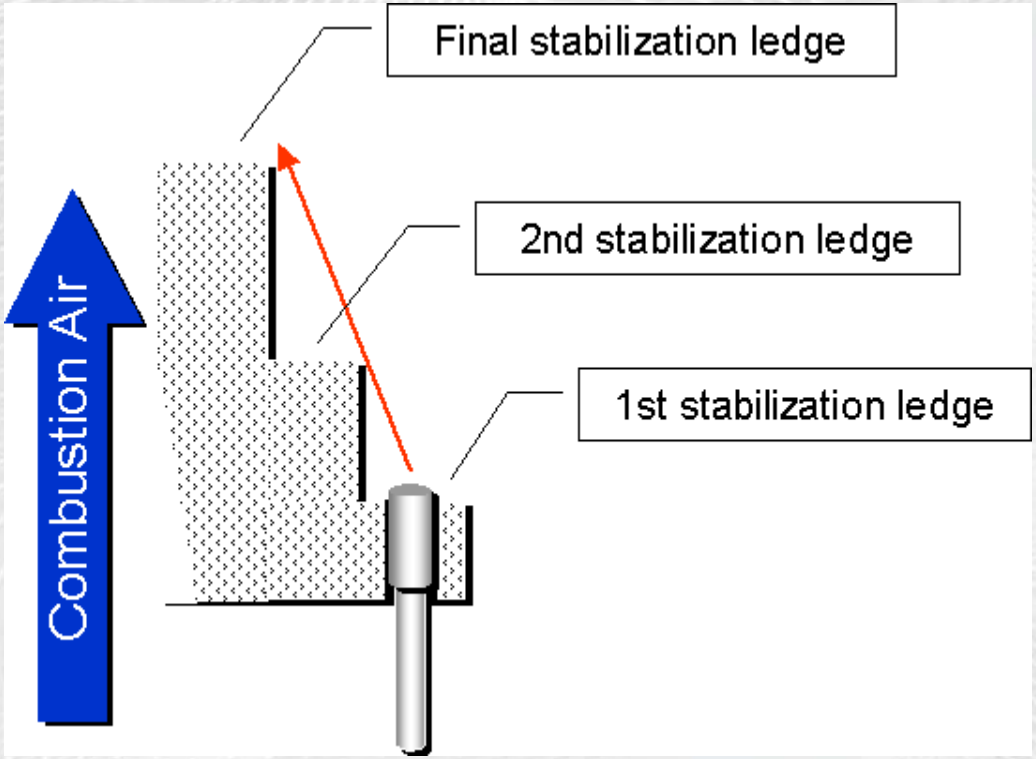
- After a comprehensive evaluation, Zeeco's Ultra Low NO_x Free-Jet Burners were selected.
- The proposal was to meet a NO_x emission target of with 198 GLSF-10 Downfired Free-Jet Burners for the inner rows, and 36 GLSF-7 Downfired Free-Jet Burners for the outer rows, and no change to the existing burner footprint.

Description of Application Cont.



- The compact size of the Free-Jet Burner, shown above, allows the distance between burners to be maximized when placed in conventional spacing. More space between burners decreases the likelihood of flame interaction and decreases NO_x emissions.

Free-Jet Stabilization Technique



Phase 1

- The first phase of the project called for Zeeco to fabricate two GLSF-10 Downfired Free-Jet Burners.
- One of these burners would be installed in Zeeco's Test Facility for test firing under simulated field conditions, the other would incorporate any combustion test changes and be shipped to the job site for trial fit into the steam reformer.
- The target NOx emissions guarantee for the project was 43ng/J (~80 ppmv on Natural Gas).

Phase 1 Testing

Natural Gas Test Fuel

NOx	Corrected O2	Firebox Temp.	Combustion Air Temp.
25.5 ng/J	1.5% O2	1204ºC	522ºC
23.5 ng/J	3.0% O2	1204ºC	522ºC

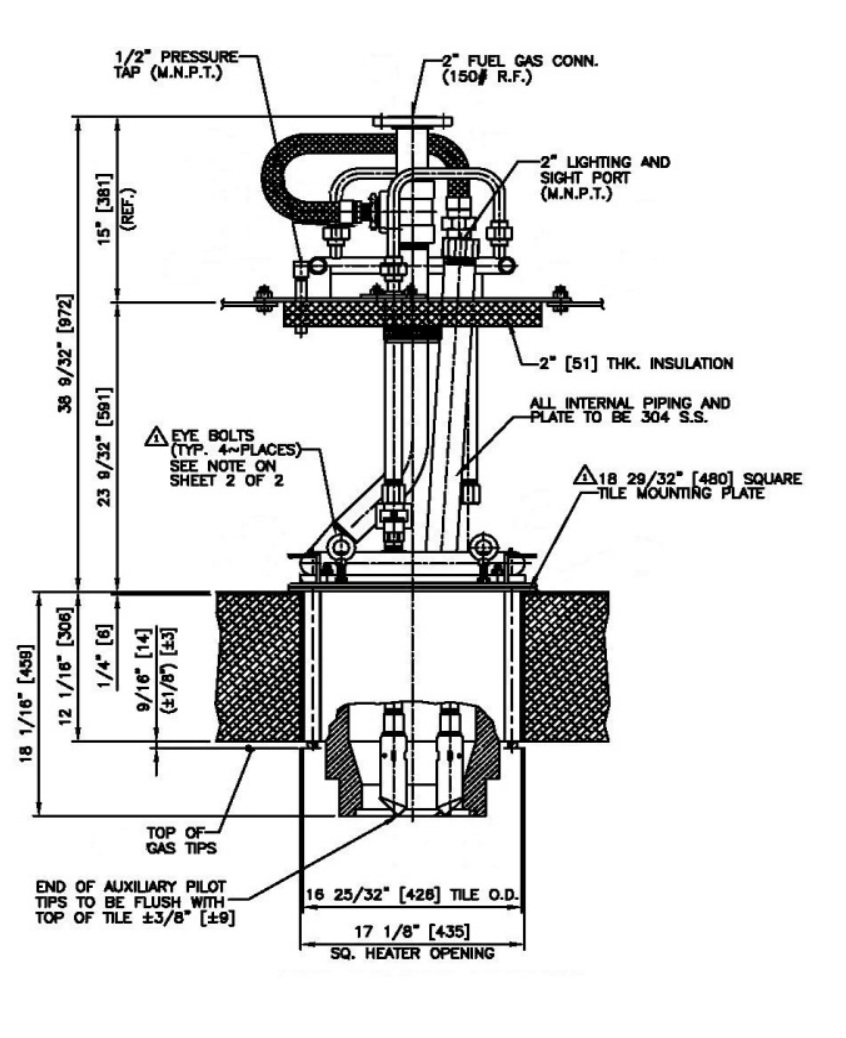
Table 1. Natural Gas Corrected Emissions

High Hydrogen Test Fuel

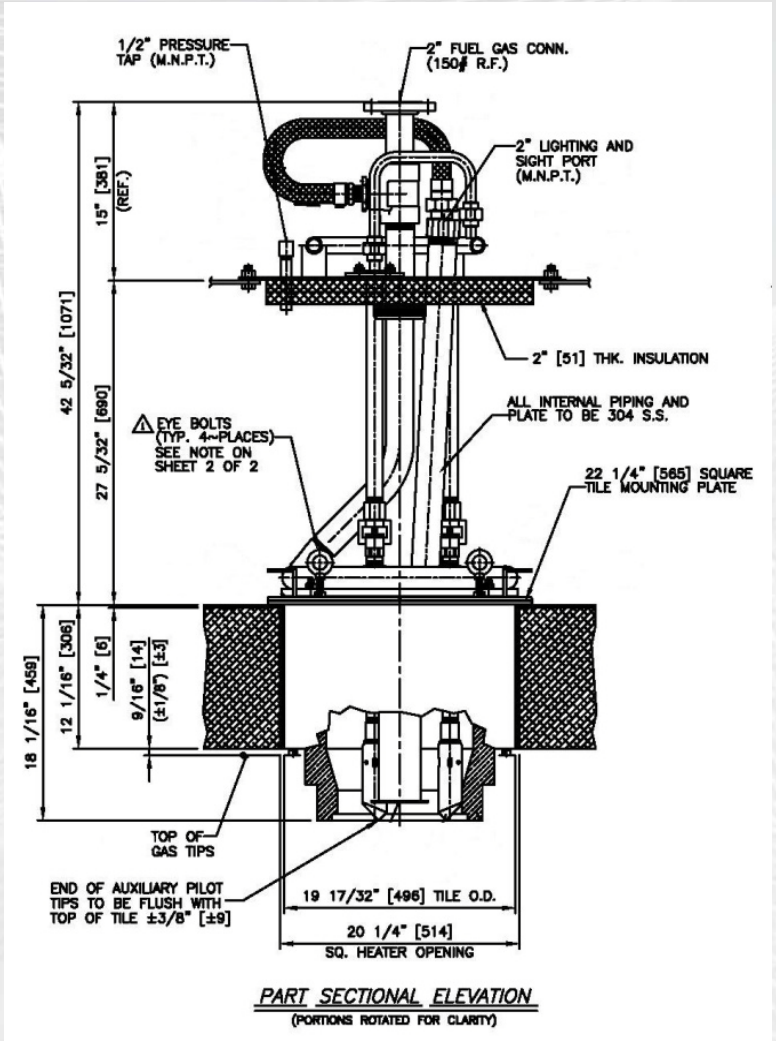
NOx	Corrected O2	Firebox Temp.	Combustion Air Temp.
24.3 ng/J	1.5% O2	1204ºC	522ºC
22.5 ng/J	3.0% O2	1204ºC	522ºC

Table 2. High Hydrogen Corrected Emissions

GLSF-7 and GLSF-10 Free-Jet Burners



GLSF-7



GLSF-10

Phase 2

- After the trial fit up, the fabrication of the 198 GLSF-10 36 GLSF-7 Downfired Free-Jet Burners commenced. These burners were to be installed in the methanol reformer during a planned plant shutdown.

Start-up and Operation

- After an initial operating period with the burner firing a natural gas fuel, the plant started to produce the mixed fuel gas with high Hydrogen content (approximately 20% methane and 75% hydrogen).
- When the GLSF Downfired Free-Jet Burners were switched over to fire, the mixed fuel gas the flame quality was very good.

Start-up and Operation Ctd.

- The flame from the mixed fuel gas produces a proper, transparent flame pattern with even heat transfer to the process tubes.
- The flames were straight with no evidence of flame impingement on the process tubes.

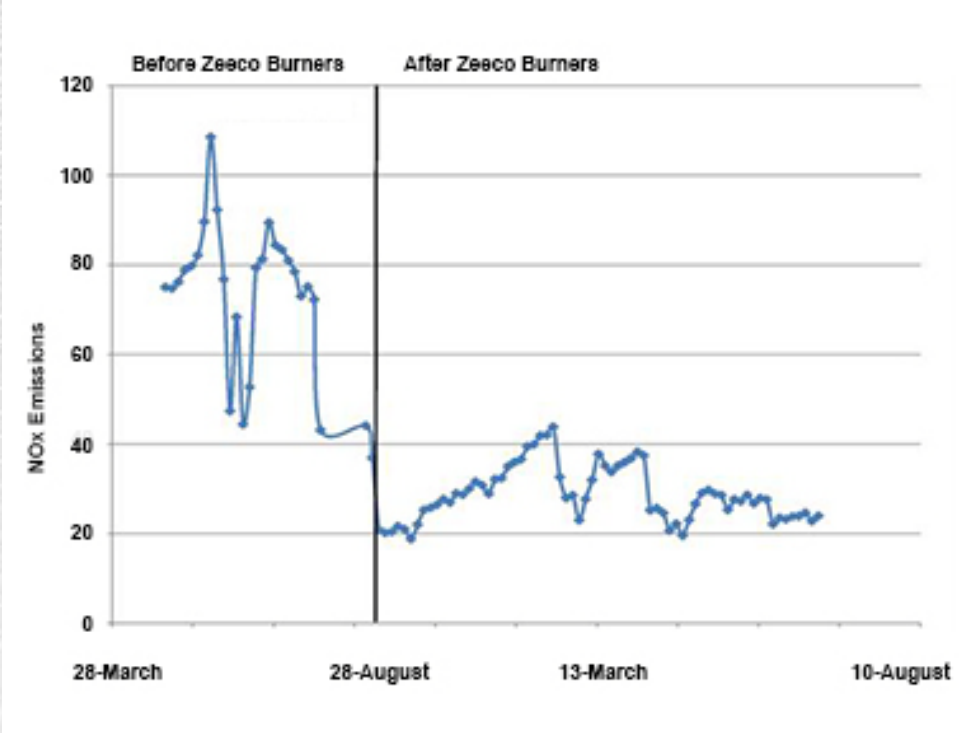
Start-Up and Operation Ctd.

- Even heat transfer to the process tubes is shown with even coloring and no hot spots.

- Uneven coloring and hotspots may represent flame impingement.

- The even heating allows the owner to meet the necessary process flowrate requirements for the methanol reformer.

Start-Up and Operation Ctd.



The graph represents NO_x emissions before and after the Zeeco GLSF Downfired Free-Jet Burner installation.

Conclusion

- The GLSF-7 and GLSF-10 Downfired Free-Jet Burners installed in the methanol reformer resulted in a decrease in NO_x emissions.
- After the Zeeco Free-Jet Burners were installed, the NO_x emissions from the methanol reformer were consistently below 43 ng/J, meeting the KSA's emissions requirements.