16 AIChE
Spring Meeting, Houston, TX

12TH GLOBAL CONGRESS ON PROCESS SAFETY

Low-NOx Burner Retrofit Challenge

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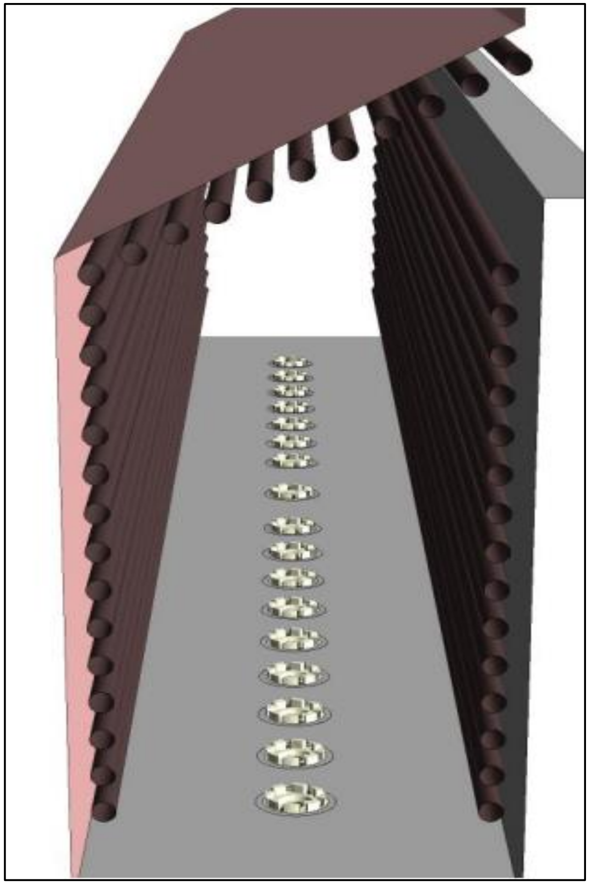
Topics of Discussion

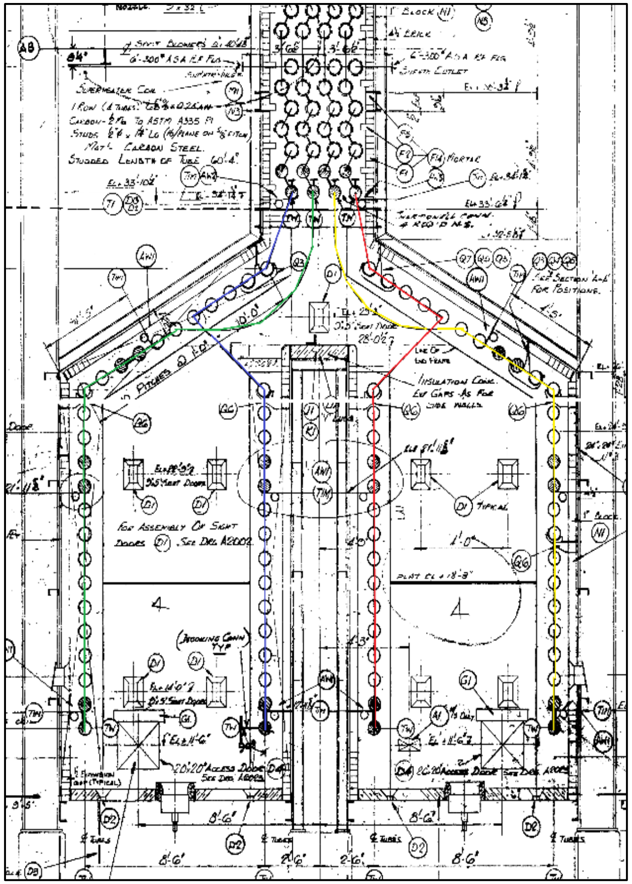
- Project Background
  - Existing System – Design Challenges
- Project Phases
  - **Phase 1:** Burner Design & CFD Modeling – GLSF Minimum Emissions Burner
  - **Phase 2:** Combustion Testing
  - **Phase 3:** Installation & S.A.T.
- Conclusion

Project Background

- Existing Burners: Conventional Raw Gas Burner
- Average Yearly NOx Level: **244 ppmv** [500 mg/Nm3]
- Heater roof tubes are 16.4 ft above furnace floor
  - Existing burners were impinging on roof tubes causing hot spots and tube coking.
- Poor Combustion Air Distribution to Burners

Heater Geometry





- Twin Celled, Crude Oil Heater
- 17 Burner per Cell
- Forced Draft, Pre-Heated Air

New Burner Requirements

Thirty Four (34) Ultra Low NOx Burners

- Required Emissions:

NOx	40 ppmv [82 mg/Nm3]
CO	40 ppmv [49 mg/Nm3]

- Required Heat Release:

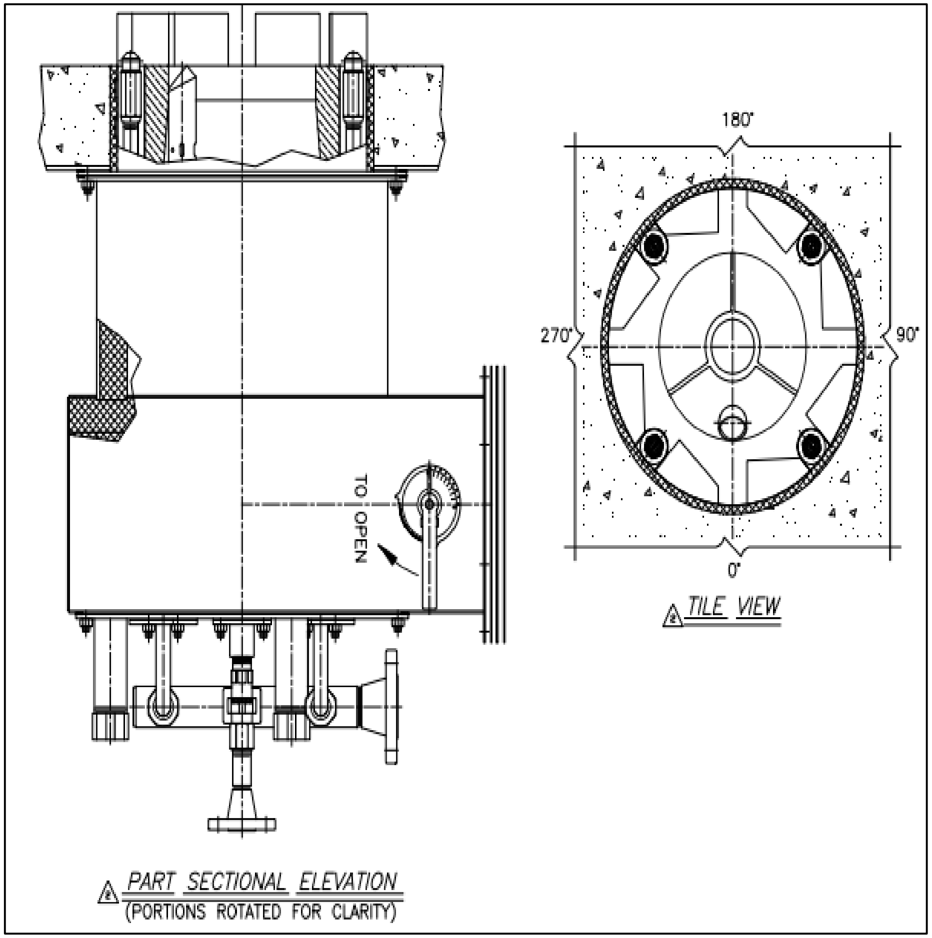
Maximum	6.980 MMBtu/hr [2.04 MW]
Normal	6.070 MMBtu/hr [1.78 MW]
Minimum	1.390 MMBtu/hr [0.407 MW]

- Required Flame Dimensions:

Maximum Length	9.60 ft [2.92 m]
Maximum Width	2.51 ft [0.765 m]

Project Phases – Phase 1

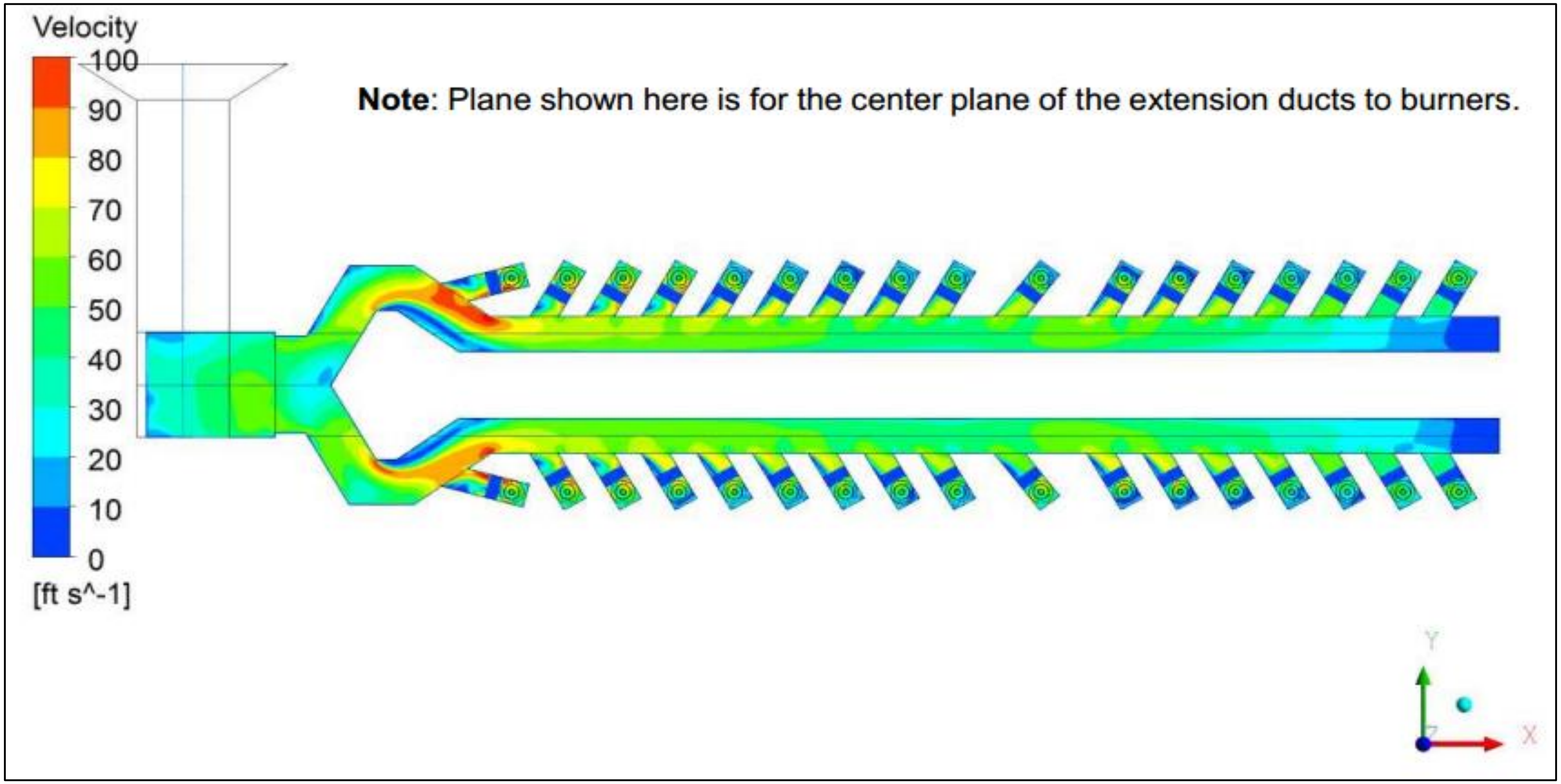
Burner Design & CFD Modeling



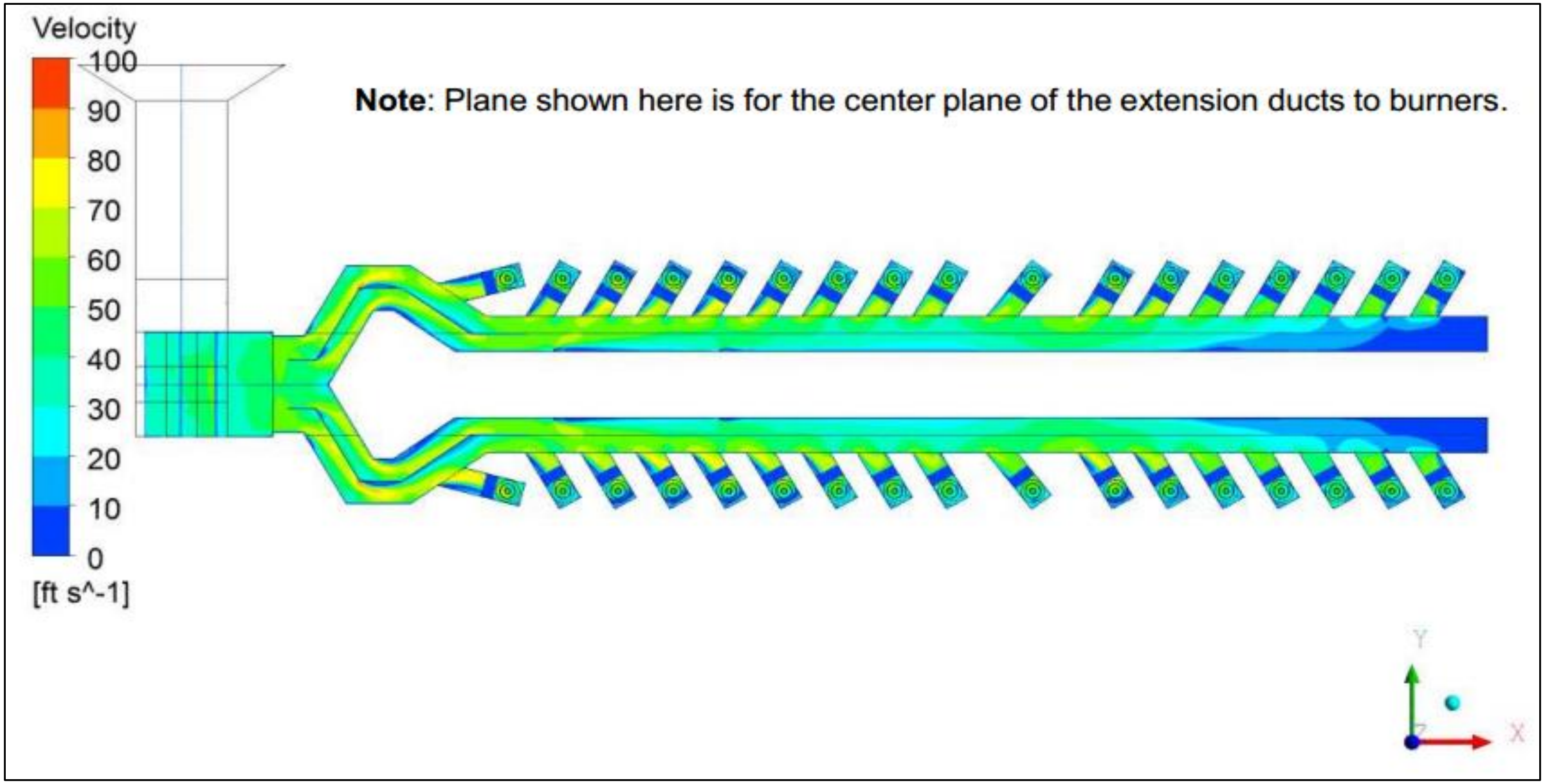
Zeeco GLSF Minimum Emission Burner

- Custom burner geometry to match existing forced draft ducting and heater mounting
- Full furnace ducting modeling to improve combustion air flow
- Combustion modeling to ensure proper flame geometry

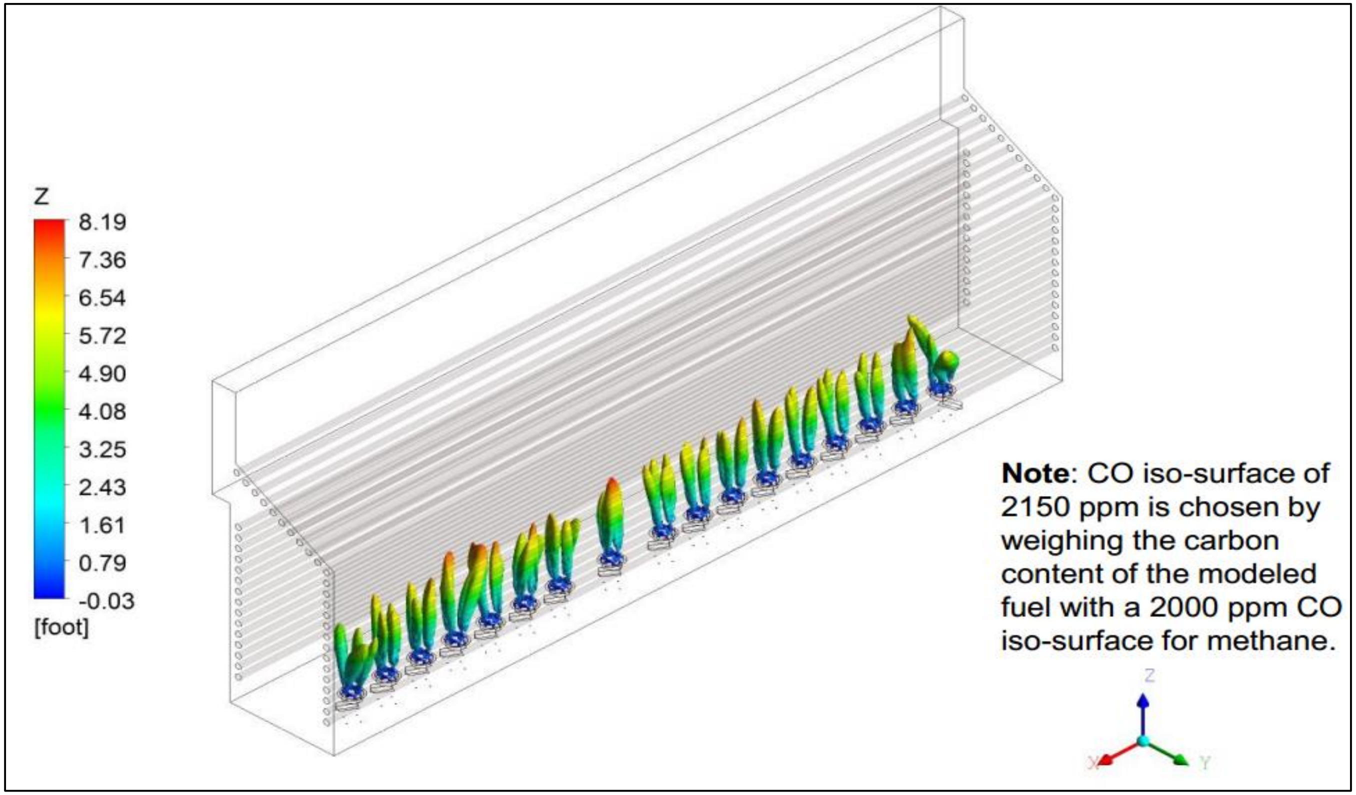
- GLSF Round Flame Minimum Emissions Burner was chosen for its ability to achieve Ultra Low NOx emissions while maintaining compact flame shapes and high flame stability on all fuels.



- CFD proved uneven air distribution to each burner. Air flow varied by +13% to -30% mass flow [kg/hr]



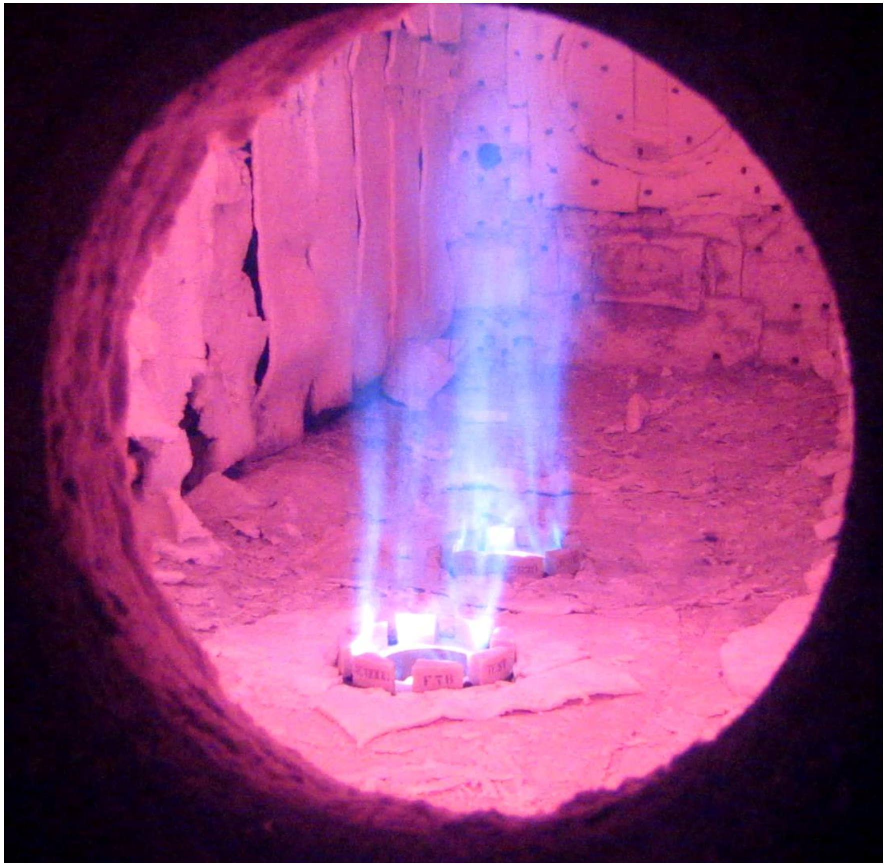
- Baffle plates and turning vanes were added to the simulation to improve the air flow to an acceptable level of +/- 3% [kg/hr] to each burner



- Combustion CFD proved acceptable flame dimensions and proper furnace heat distribution. No flame to flame interaction & No flame to tube interaction

Project Phases – Phase 2

Combustion Testing



- Two test burners were installed in one of Zeeco's cabin style heaters
- Actual site heater conditions were matched in Zeeco's Testing Facility to prove burner performance

- Results

BURNER TEST FUELS

GAS FUELS	LHV	SP.GR.	FUEL B	FUEL E	FUEL F	FUEL G
NATURAL GAS	937.4	0.5982	60	46	32	100
HYDROGEN	273.8	0.0696	26	24	48	
PROPANE	2314.9	1.5226	14	30	20	
TOTAL			100	100	100	100
LHV (BTU/SCF)			957.7	1191.4	894.4	937.4
SP. GR.			0.590	0.749	0.529	0.598
MW			17.09	21.68	15.33	17.33

Fuel Case	Heat Release [MMBTU/HR]	Measured Furnace Temperature [F]	Measured O2 %	Measured NOx [ppmv]	Corrected NOx [ppmv] @ 3% O2 and 1790F
Fuel B	6.98	1776	3.0	27.0	27.5
Fuel E	6.98	1759	2.9	27.4	27.9
Fuel F	6.98	1740	3.0	30.4	31.6
Note: A single Fuel G test point was tested to prove flame stability on N.G.					

Project Phases – Phase 3

Installation & Site Acceptance Testing

- Site supervision was provided by Zeeco engineers to ensure proper fit up and installation.
- Burner start up was performed in June, 2015
- Burner performance acceptance testing was performed in July, 2015
- Heater operation inspection at the time of acceptance testing showed tramp air inlets had not yet been sealed, excess oxygen was higher than the designed value of 15%. Both leading to higher NOx levels.
- NO x levels were still confirmed to be below the 49 ppmv [100 mg/Nm3] local legislation requirement. Tramp air and excess air reduction will reduce NOx further.

- Conclusions
- High NOx production, poor air distribution, uneven flame & furnace heating patters, and heater tube coking prompted a revamp of the combustion system and burners.
- The GLSF Minimum Emissions Burner design was selected to meet the new burner performance requirements.
- Bespoke burner geometries were utilized to match existing heater mounting and preheated combustion air ducting. Leading to minimal installation costs to the customer.
- CFD modeling of combustion air ducting was performed. CFD modeling of burner combustion was performed.

- Conclusions
- Multi-Burner combustion testing was performed in Zeeco's Testing Facility to accurately simulate on site conditions.
- Burners were delivered to site and installed with Zeeco's supervision.
- On site burner performance testing was conducted and proved that the burners were meeting all required performance goals.
- Further heater operation improvements can be performed to improve the burner performance even further.

Questions?

ZEECO