



DECARBONIZATION PATHWAYS FOR PROCESS BURNERS IN REFINERIES

John Zink Hamworthy
Combustion Equipment





SPEAKER INTRODUCTION

John Zink Hamworthy
Combustion Equipment



SPEAKER –AVINASH SHARMA

Been with John Zink for 5 years

Role: Burner process engineer for APAC region

Managed testing and troubleshooting



AGENDA

- ❑ KOCH AT A GLANCE
- ❑ KOCH INDUSTRIES
- ❑ KES (KOCH ENGINEERED SOLUTIONS)
- ❑ DECARBONIZATION STRATEGIES FOR PROCESS HEATERS
 1. OXY-FIRING
 2. HYDROGEN AS FUEL
 3. AMMONIA AS FUEL
- ❑ JOHN ZINK HAMWORTHY COMBUSTION
(Combustion training)



KES- JOHN ZINK INTRODUCTION

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Combustion Equipment



KOCH AT A GLANCE


Global Scale

- 120,000+ employees in 70+ countries
- Headquartered in Wichita, Kansas

Private Ownership

- One of the largest privately held companies in America with > \$125 Billion in annual revenues*
- Principle-Based Management™

*Koch's revenues fluctuate with the price of commodities. They have been as high as \$125 billion.



**\$125 BILLION
IN ANNUAL
REVENUES**

KOCH AT A GLANCE

Industries

- Refining, chemicals & biofuels
- Forest & consumer products
- Fertilizers
- Polymers & fibers
- Process & pollution control systems
- Electronics, software and data analytics
- Minerals
- Glass
- Automotive components
- Ranching
- Commodity trading
- Investments



KOCH INDUSTRIES

A Parent with a Broad Spectrum of Capabilities and Markets



- Equipment technologies and licensing
- Turnkey EPC and Project Management
- Field Services and Installation
- Solar and Storage Solutions



- Leading provider of electronic components and solutions
- Owns Phillips-Medisize, offering end-to-end medical and pharma solutions



- Leading manufacturer of tissue, pulp, paper, packaging, and building products
- Select brands include Brawny®, Dixie®, Quilted Northern® and Angel Soft®



- Global leader in business cloud software products
- Serves industries ranging from aerospace to fashion



- World-class crude oil refining
- Operates 4,000 miles of pipelines



- One of the world's largest glass manufacturers
- Owns SRG, a leader in automotive plating and coating



- Leading manufacturer of nylon intermediates and polypropylene polymers, and fibers
- Products serve flooring, automotive components, medical devices, food packaging and other essential markets



- Global provider of products and value-add solutions for agriculture, energy, and chemical markets



- Global trading and investment firm, specializing in commodity products and services and investment development



- KII investment groups providing unique capital solutions
- From early-stage venture to structured investments to new platform M&A

ONE-SOURCE SOLUTIONS DELIVERING SUPERIOR VALUE

SERVICE & INSTALLATION

KOCH.
SPECIALTY PLANT SERVICES

**OPTIMIZED PROCESS
DESIGNS LLC**

LICENSING

KOCH.
TECHNOLOGY SOLUTIONS

MASS TRANSFER

KOCH-GLITSCH.

COMBUSTION

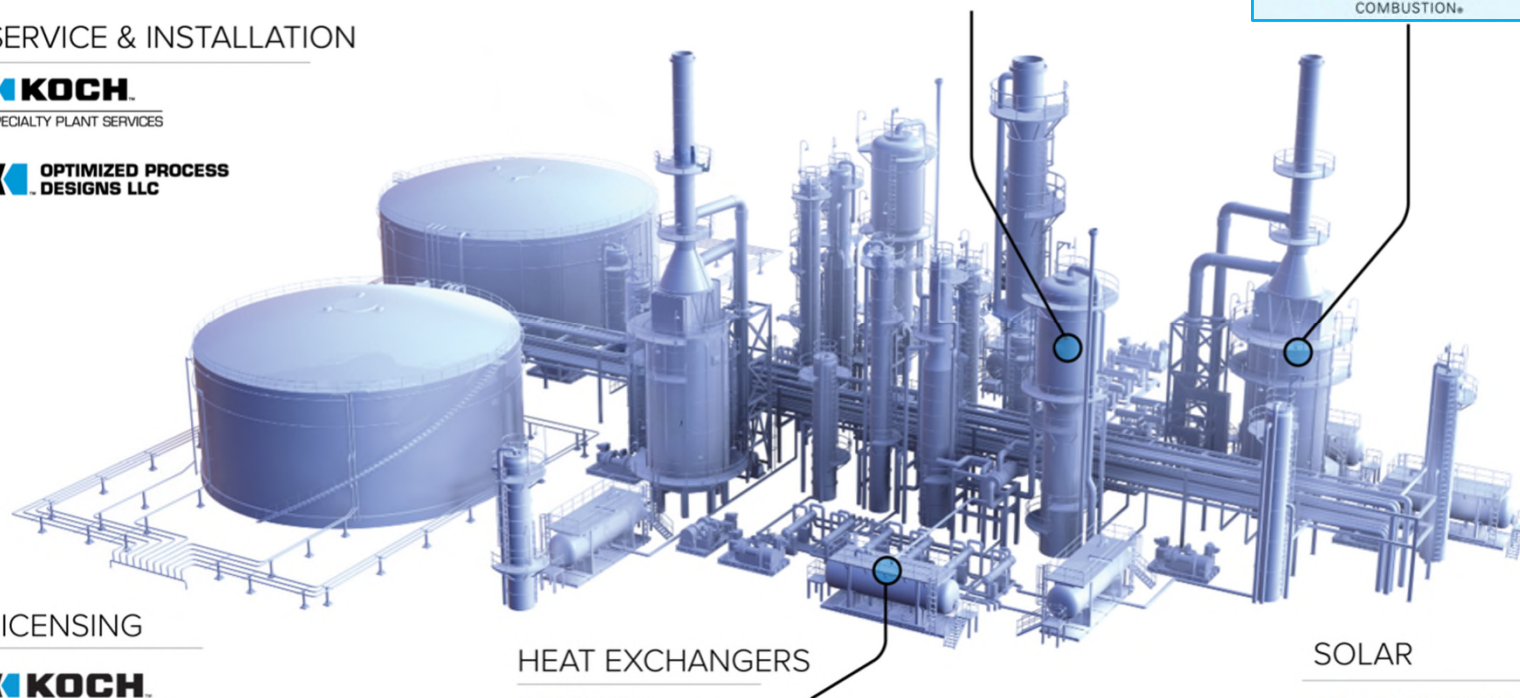
**JOHN ZINK
HAMWORTHY
COMBUSTION®**

HEAT EXCHANGERS

KOCH.
HEAT TRANSFER

SOLAR

**DEPCOM
POWER®**



JOHN ZINK HAMWORTHY COMBUSTION



The Single Source for Combustion and Emission Control

Capabilities

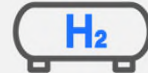
- Process Burners
- Flares
- Vapor Control
- Thermal Oxidizers (Thermal, Catalytic, Regenerative & Recuperative)
- Gas Recovery Systems
- Flue Gas Treatment
- Landfill & Biogas
- Steam Solutions
- Oil & Gas Processing
- Air Heater & Recuperators



DECARBONIZATION STRATEGIES IN PROCESS HEATERS



OXY-FIRING



HYDROGEN AS FUEL



AMMONIA AS FUEL



OXY-FIRING

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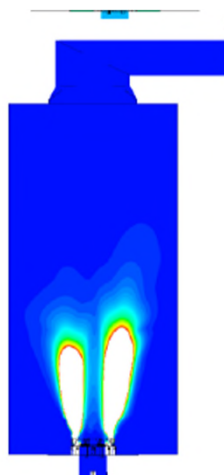
INTRODUCTION

**JOHN ZINK
HAMWORTHY**
COMBUSTION®

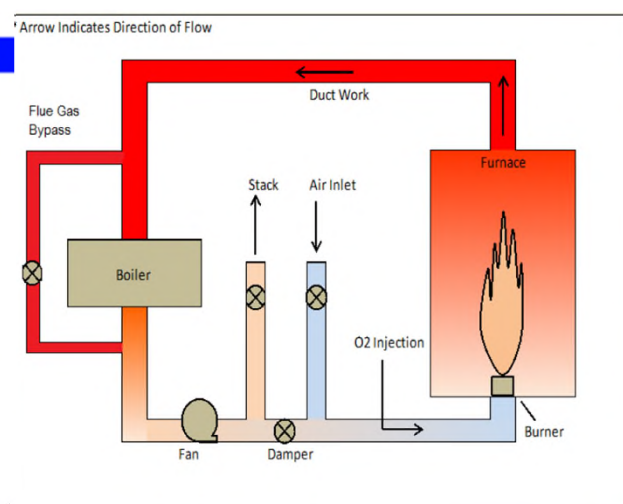
- Oxy-firing is the concept of combustion with increased amount of oxygen when compared with ambient air.
- Recent partnership with local client to check feasibility of oxy-firing (study ongoing).
- Our CFD team continually works with process team and has advanced models that can predict combustion performance under Oxy-firing to a high degree of agreement with the test data.

Co-Mole Fraction
Contour 1

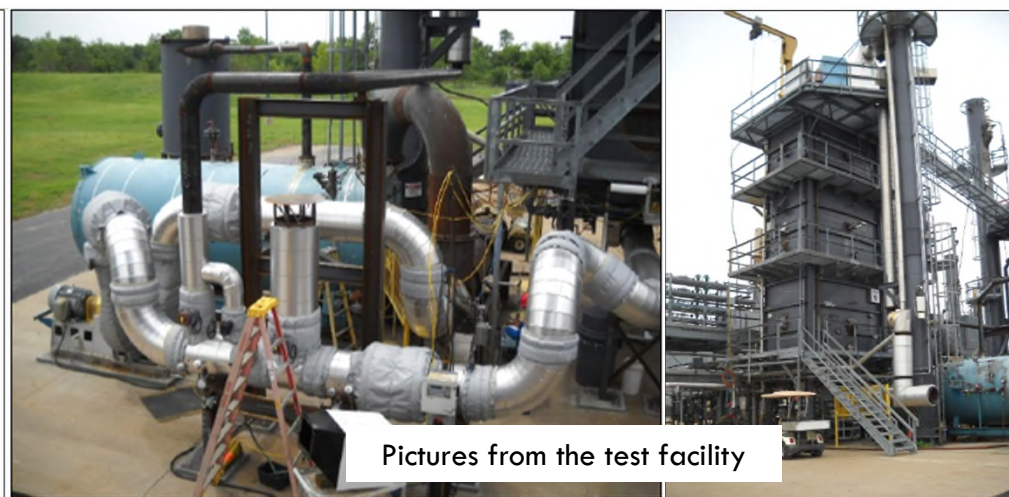
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CO ISO surface prediction in
the test furnace



Schematic of the test setup



Pictures from the test facility

ADVANTAGE AND DISADVANTAGE OF OXY FIRING

Advantage

- Reduction of NO_x emissions (Closed loop).
- Allows easier of capture of CO₂
- Better efficiency in case of closed loop system.(marginal improvement in efficiency in case of open system)

Disadvantage

- High cost of O₂ generation
- High equipment cost especially if current set up is natural draft burner

JOHN ZINK EXPERIENCE WITH OXY-FIRING



John Zink has conducted Oxy-firing testing at its world class test facility at Tulsa, Oklahoma and co-authored a paper.

Image of the research paper on the right

“PLEASE VISIT THE BOOTH FOR DETAILED INFORMATION AND/OR DISCUSSION”

Technology Assessment of Oxy-Firing of Process Heater Burners

Cliff Lowe^a, Nick Brancaccio^a, Jamal Jamaluddin^b -
Jaime A. Erazo, Jr.^c, Charles E. Baukal, Jr.^c

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^b *Shell Projects and Technology, Houston, TX, USA*

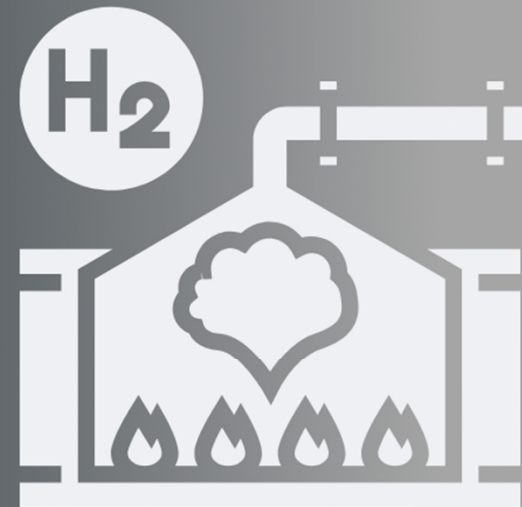
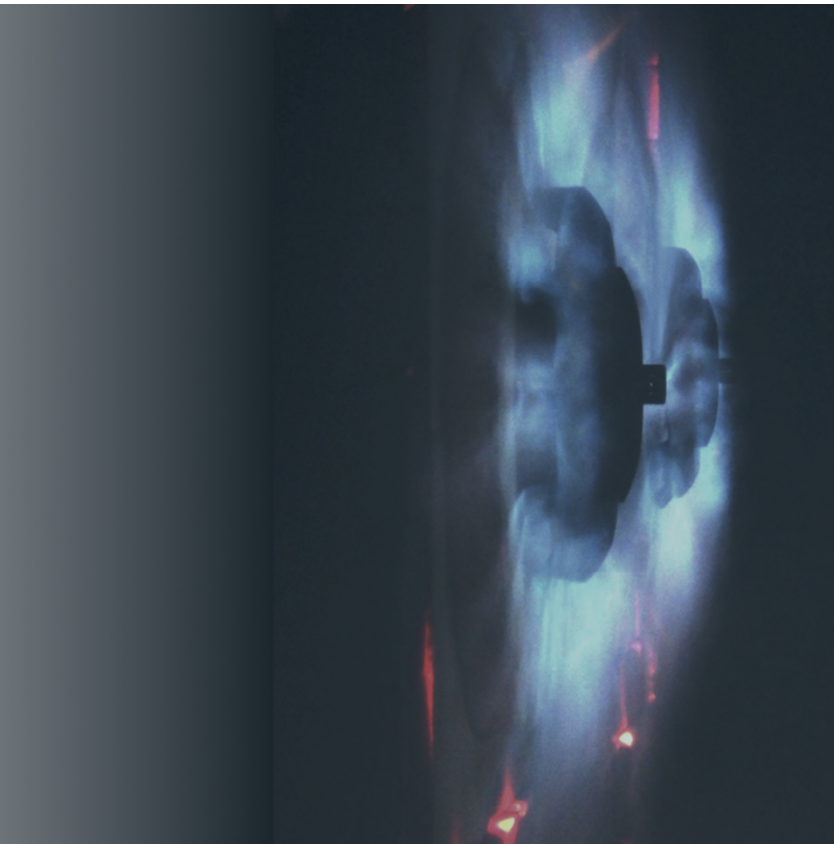
^c *John Zink Co., LLC, Tulsa, OK, USA*

Abstract

The objective of this development program is to assess the feasibility of retrofitting burners for oxy-firing in process heaters. A secondary objective is to confirm this feasibility assessment by conducting single burner oxy-fired testing with flue gas recycle.

The CO₂ Capture Project commissioned the John Zink Company to conduct oxy-fired testing on two of their conventional process heater burners, a PSFG staged gas low NO_x burner and a COOLstar[®] Ultra-Low NO_x burner.

Keywords: Oxy-firing; refinery; heaters; burners;



HYDROGEN AS FUEL

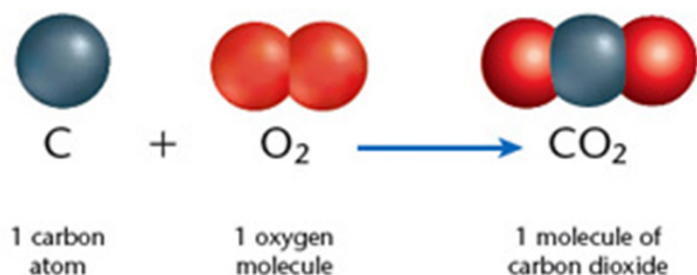
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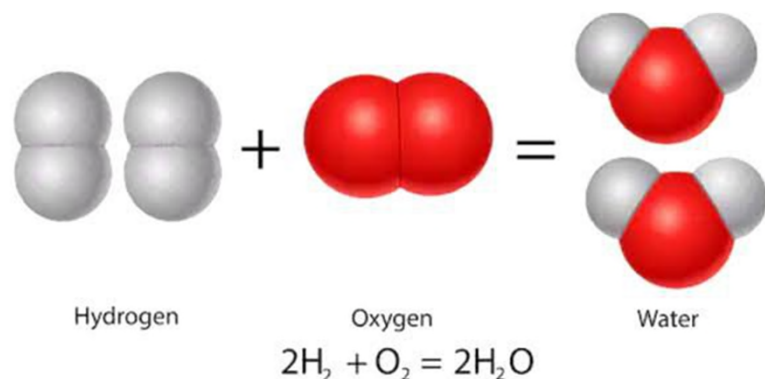
INTRODUCTION

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HAMWORTHY**
COMBUSTION®

Normal Combustion of carbon base fuel



Combustion of H₂



Properties of H₂ as fuel

- Higher flame speed when compared to NG.
- H₂ has a lower heating value on volume basis when compared to NG.
- Higher flame temperature
- Smaller molecule is easy to leak.

ADVANTAGE AND DISADVANTAGE OF H₂ AS FUEL



Advantages

- Hydrogen has a higher flame speed compared to natural gas
 - Higher flame speed helps in stabilizing the burner.
- Greater turn down possible.
- No CO₂ emissions.
- Needs lesser stoichiometric air for combustion compared to NG. Little to no modification in the burner air side design for existing burners.
- Reduction of prompt NOx.

Disadvantages

- Hydrogen has a higher flame speed compared to natural gas which can lead to flashback in pre-mix burners.
- Lower Volumetric heating value of H₂
 - H₂ gas tips tends to be larger drilling and not advised to be used when firing heavy fuel gas.
 - Larger volume flow needs bigger pipe sizing.
- Stringent material selection due to hydrogen embrittlement. (Carbon steel -> Stainless Steel)
- Increased thermal NOx emissions.
- Higher Noise emissions.
- Decreased life span of burner parts like gas tips, pilot tips and tile.
- Difficult to transport.

JOHN ZINK EXPERIENCE WITH H2 FIRING



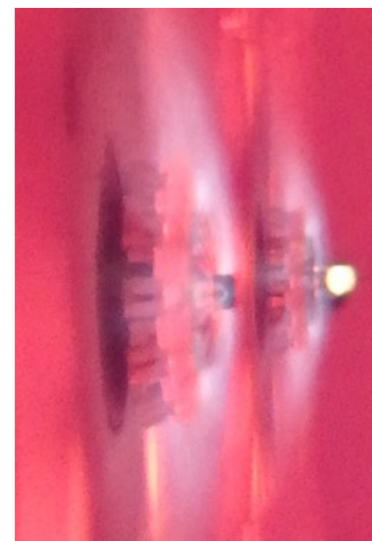
Radiant Wall burner (WALFIRE Burner)

- Diffusion technology
- Fires up to 100% H₂
- Low Noise Emissions*
- Large turndown*
- Low Fuel Pressure Requirement*
- Designed to retro-fit in the existing tile for most of the premix type burners.

(* When compared to a premix type radiant wall burner)

Diffusion Burner (COOLstar)

- Diffusion technology
- Fires up to 100% H₂
- Low Noise Emissions
- Staged fuel and folded flame to reduce NO_x



Radiant WALFIRE
FIRING 100% H₂

COOLstar BURNER
FIRING 100% H₂





AMMONIA NH_3

AMMONIA NH_3 AS FUEL

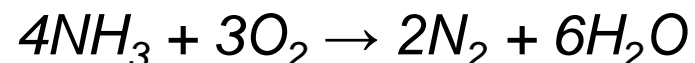
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INTRODUCTION



Normal Combustion of NH_3



Properties of NH_3 as fuel

- NH_3 flame speed is 6x slower when compared to NG.
- Ammonia has lower heating value on volume basis compared to NG.
- Ammonia is a precursor to NO_x and therefore NO_x is high.
- Staged air technology required to mitigate high NO_x .
- Boiling point is -33.6°C . Much higher temperature than boiling point of NG (-164°C)

ADVANTAGE AND DISADVANTAGE OF NH_3 AS FUEL

Advantage

- Ammonia is easier to transport compared to hydrogen as it is easy to liquify.
- Large and well-established storage network for Ammonia
- Cost of Ammonia per volume of stored energy is lower than hydrogen
- No CO_2 emissions
- Easily detectable in case of leakage due to odor.

Disadvantage

- Ammonia is toxic and corrosive.
- Slow Flame speed and high auto ignition temperature
 - Support fuel might be required (Like H_2 or NG)
- Increased NO_x emissions due to direct conversion of NH_3 into NO_x
- Flame detection needs to be reviewed. Limited test data available right now.
- Replacement of burner parts due to corrosiveness of ammonia.
- Larger piping systems required due to lower volumetric heat release of ammonia.

JOHN ZINK EXPERIENCE WITH NH₃ FIRING

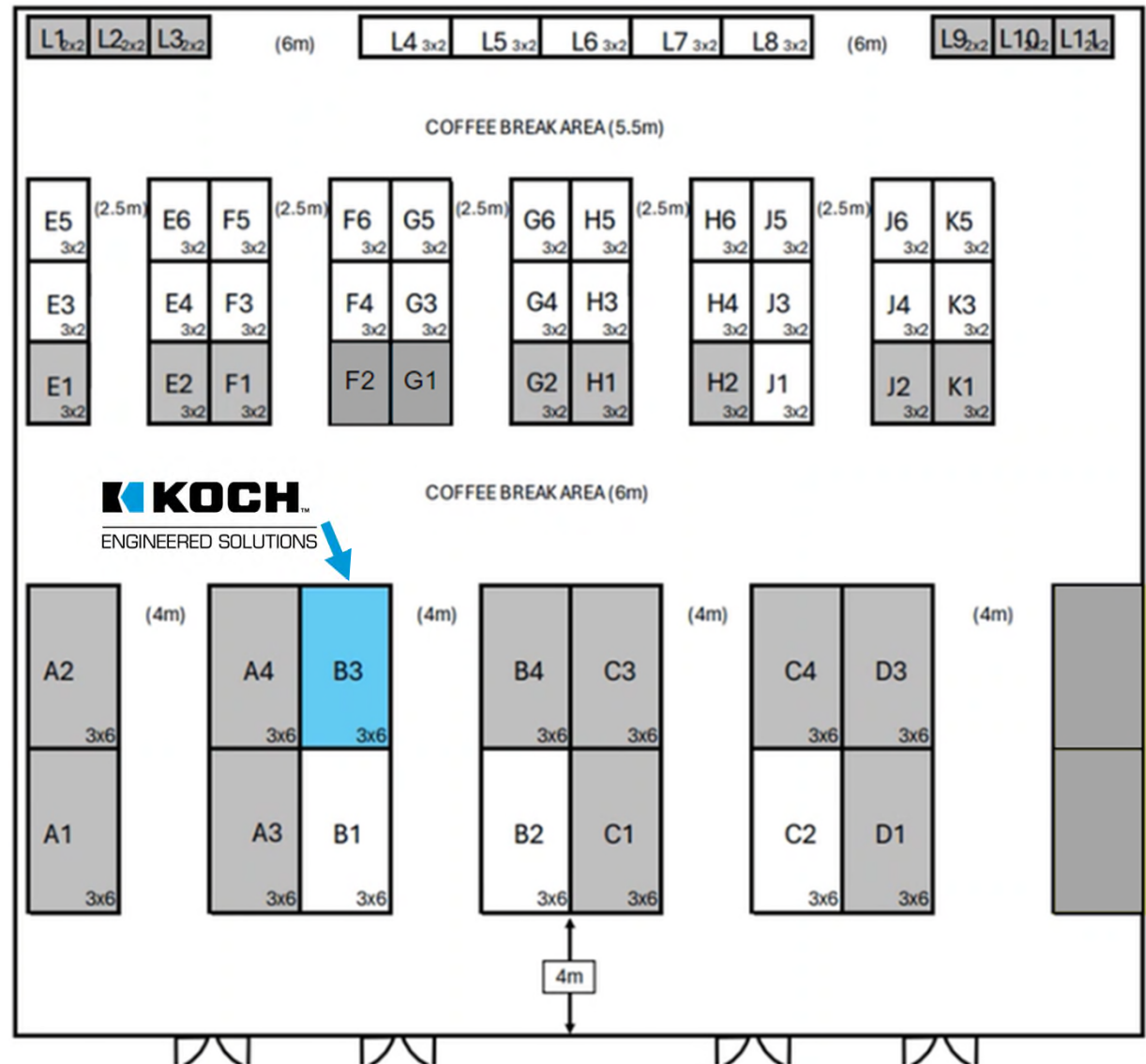


- NH₃ is NO_x precursor (fuel bound NO_x)
- Fuel NO_x >> Thermal NO_x
- Staged fuel burner technology has shown the best results with NO_x reduction in case of ammonia firing.
- Typical NO_x:
 - Several thousand ppm when not optimized
 - SNCR and/or SCR are required for most applications.



Down fired DFR (staged-air) burners firing 100% NH₃ as our test facility in Luxembourg.

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INFORMATION,
WE
ENCOURAGE
TO COME AND
DISCUSS WITH
US AT OUR
BOOTH AT B3.





WE CONDUCT THE COURSES!

REGISTRATION IS OPEN!

2024 REGISTRATION IS OPEN!

All 2024 courses will be held in person at our Tulsa, Wichita, and Luxembourg training facilities. Broaden your knowledge, earn CEUs, and gain insight on burners, flares, vapor control, thermal oxidizers, biogas, and more.

See the full course schedule and register here 

Download 2024 course schedule here. 



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YES, WE WROTE THE BOOKS

