ClearSign
Better Solutions

The Clear Path to Ultra Low NO_x Reduction

Cost-Effective Solutions for Refineries and Process Heaters

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Webinar
Tulsa, OK
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Company Overview

- Leading producer of cost effective, ultra low emission combustion products
- Offices in:
  - Tulsa, OK (Headquarters)
  - Seattle, WA
- Technologies provided with the support of our OEM partners
  - Boiler Burner = Rogue Combustion
  - Process Burner = Zeeco
- ClearSign Eye™ Sensor
- Publicly Traded NASDAQ: CLIR

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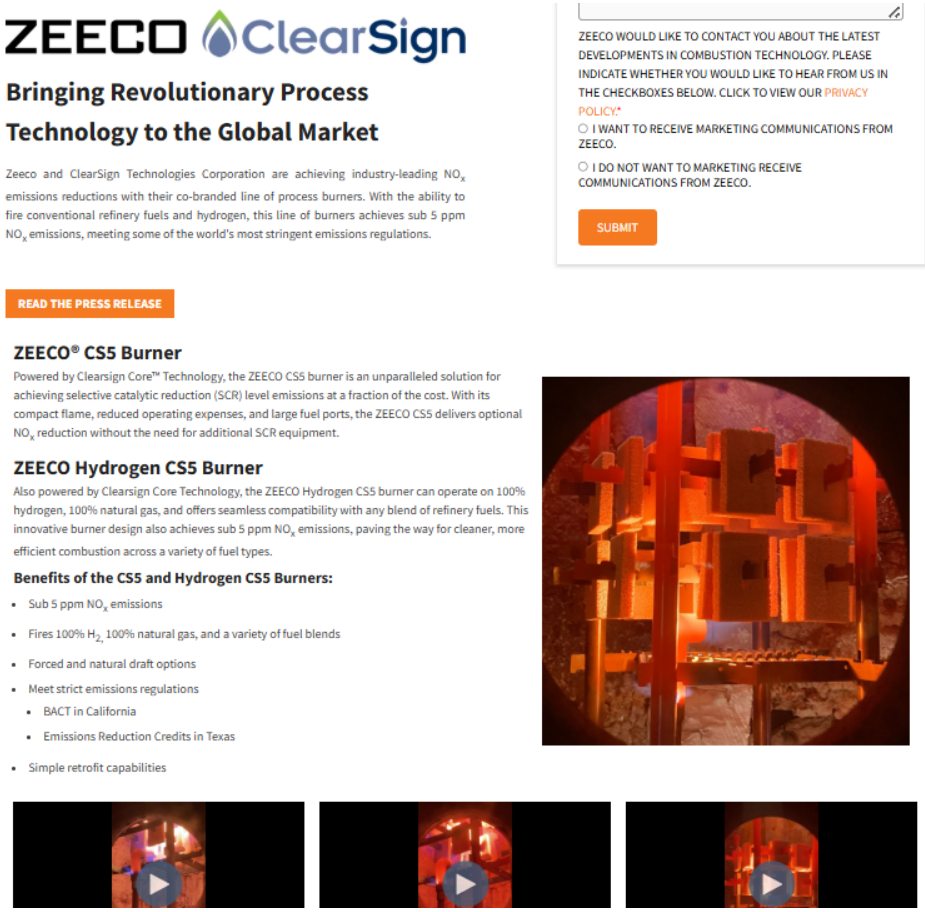
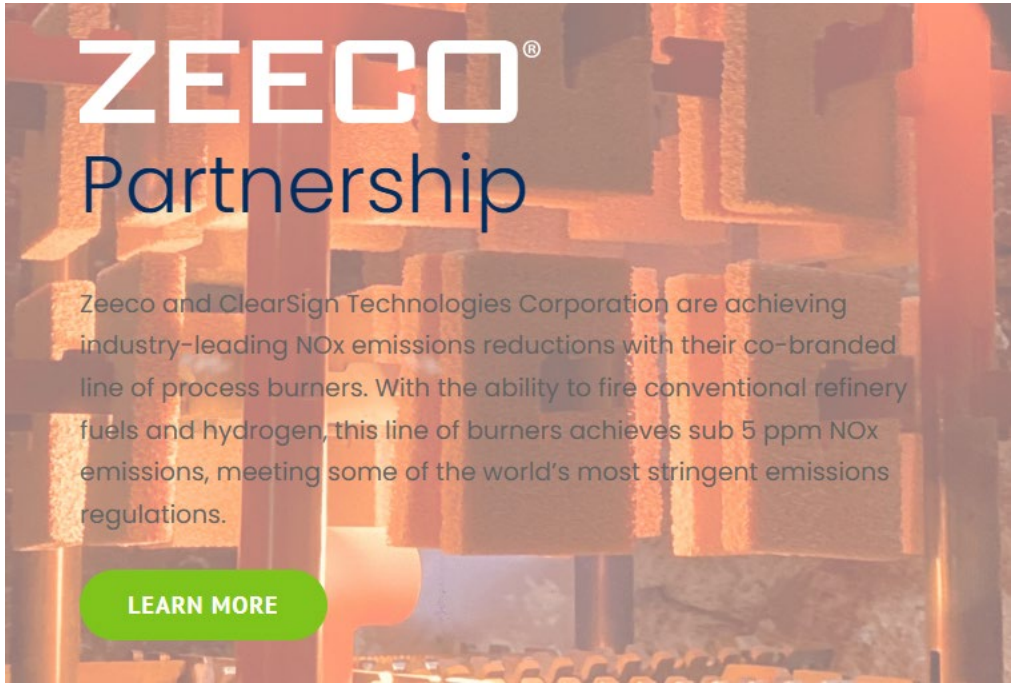
ClearSign Zeeco Partnership



Co-Branded Landing Page

- Press Release Announcement of Co-Branded Burner Line December 2024
- Co-Branded Landing Page Launched March 2025



CLIR Website Feature

Available Burner Products

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Process Burner

- Single or multi-burner heaters
- NOx Emissions from 5-15ppm
- Nat Gas, RFG, 100% H2
- 1-20 MM BTU/hr per burner
- Upfired orientation
- Natural or forced draft

Forced Draft (Boiler) Burner

- Horizontally fired, forced draft
- Boilers and similar equipment
- NOx emissions as low as sub 2.5ppm
- Nat Gas proven, other fuels tested
- 1 – 100 MM BTU/hr

Enclosed Flare/Combustor

- Upfired, natural or forced draft
- Regular services only
- 0.5-40+ MM BTU/hr
- Sub 15ppm NOx emissions
- 99.9%+ DRE
- No visible pollution – light, smoke, etc.

NOx emissions vary by product and service but in all instances offer industry leading performance with potential additional benefits

ClearSign Core Technology

Three technologies combined to achieve superior NOx performance.

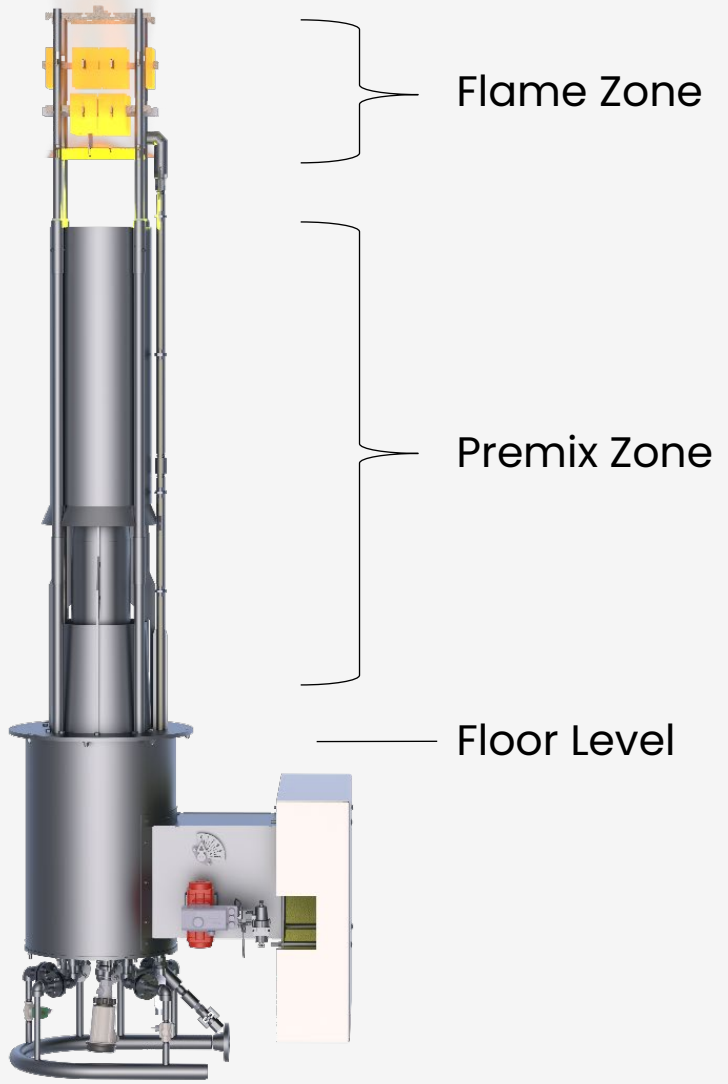
- Fuel air premix
- Internal flue gas entrainment
- Downstream flame holder

ClearSign Core burners operate like conventional burners and fit into existing equipment

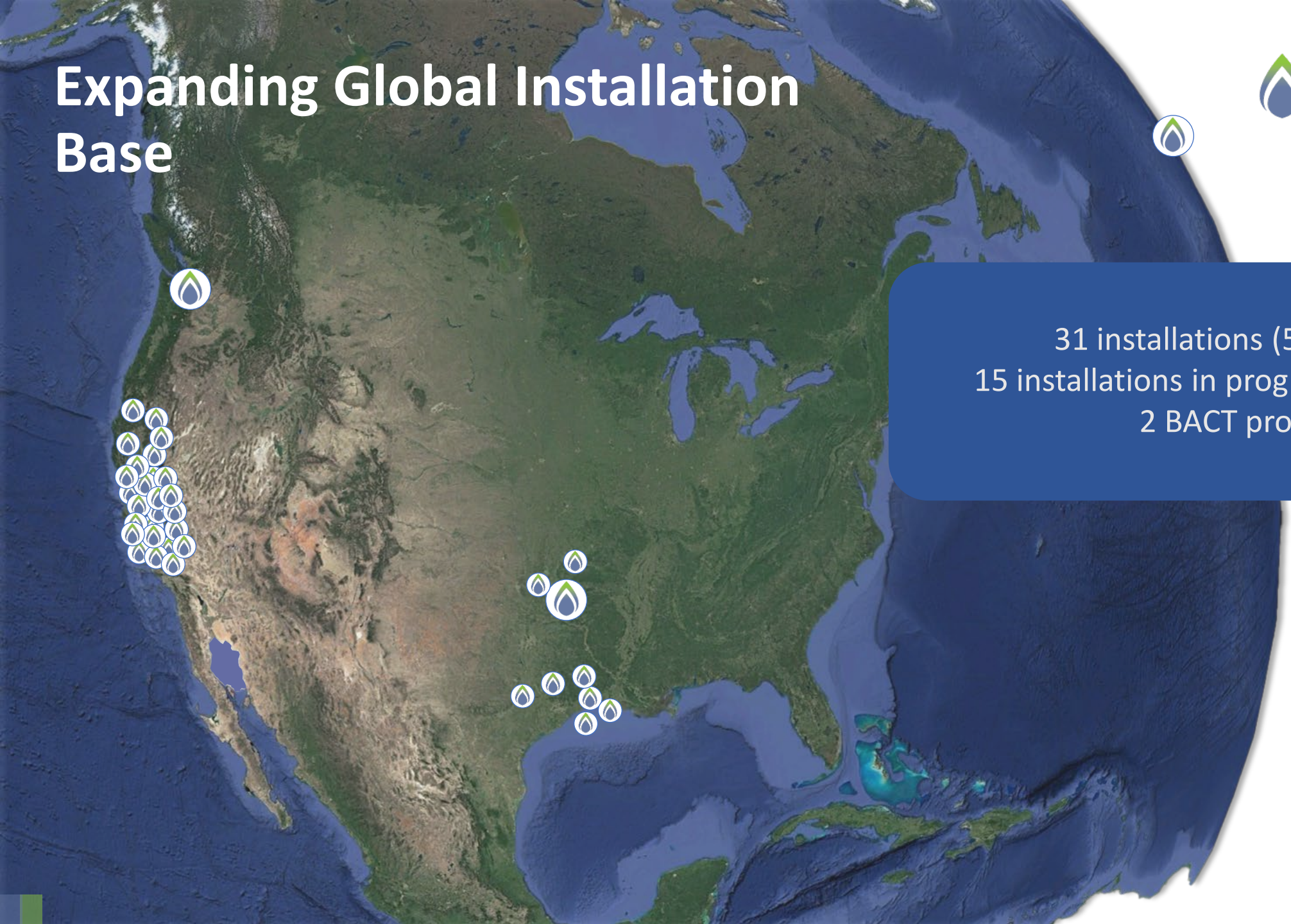
NOx emissions as low as sub 2.5 ppm have been achieved in field installations

No catalysts or chemicals

Doesn't merely treat emissions – reduces their creation in the first place



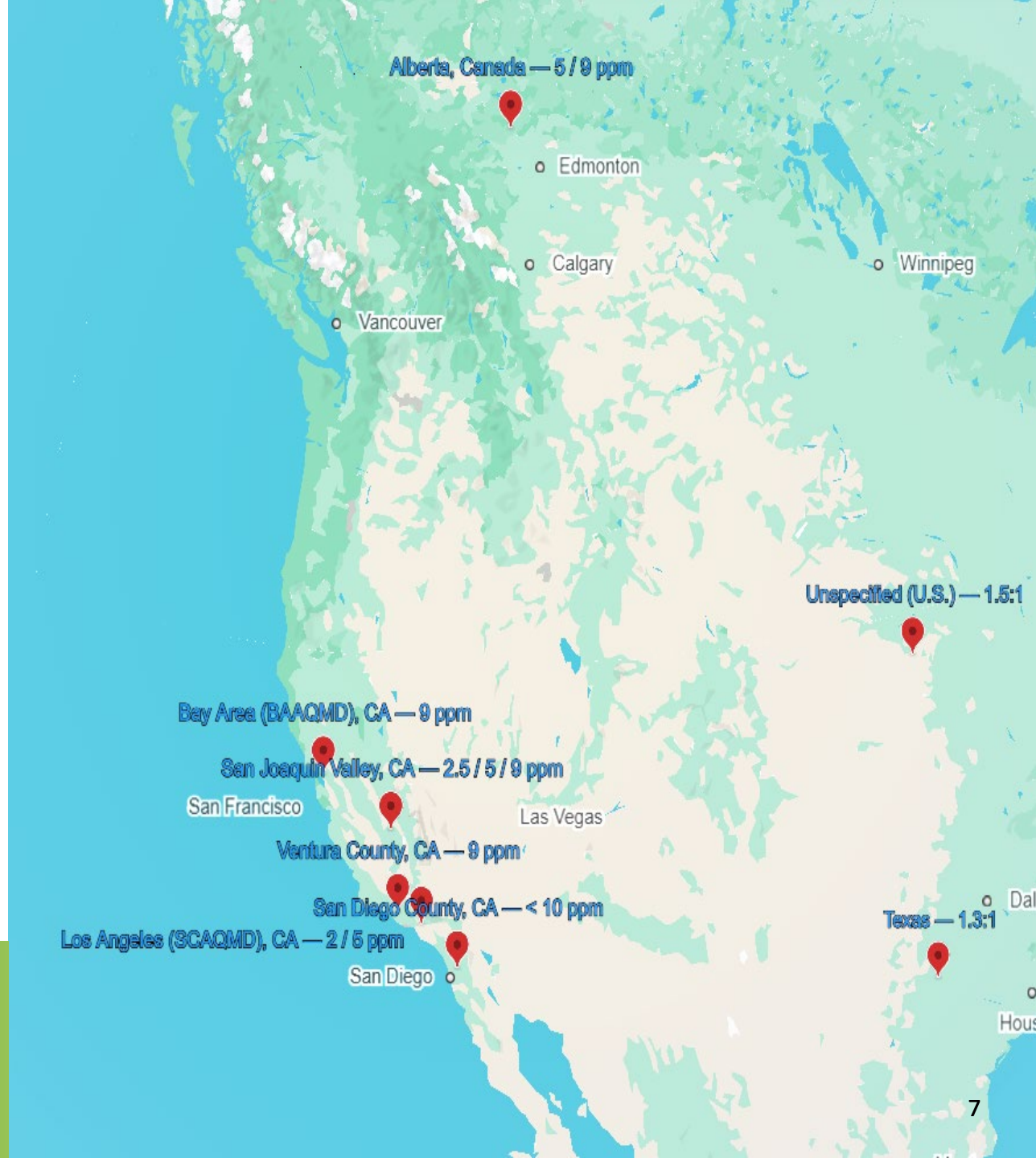
Expanding Global Installation Base



31 installations (50 burners)
15 installations in progress (57 burners)
2 BACT projects

Who Needs Low NO_x?

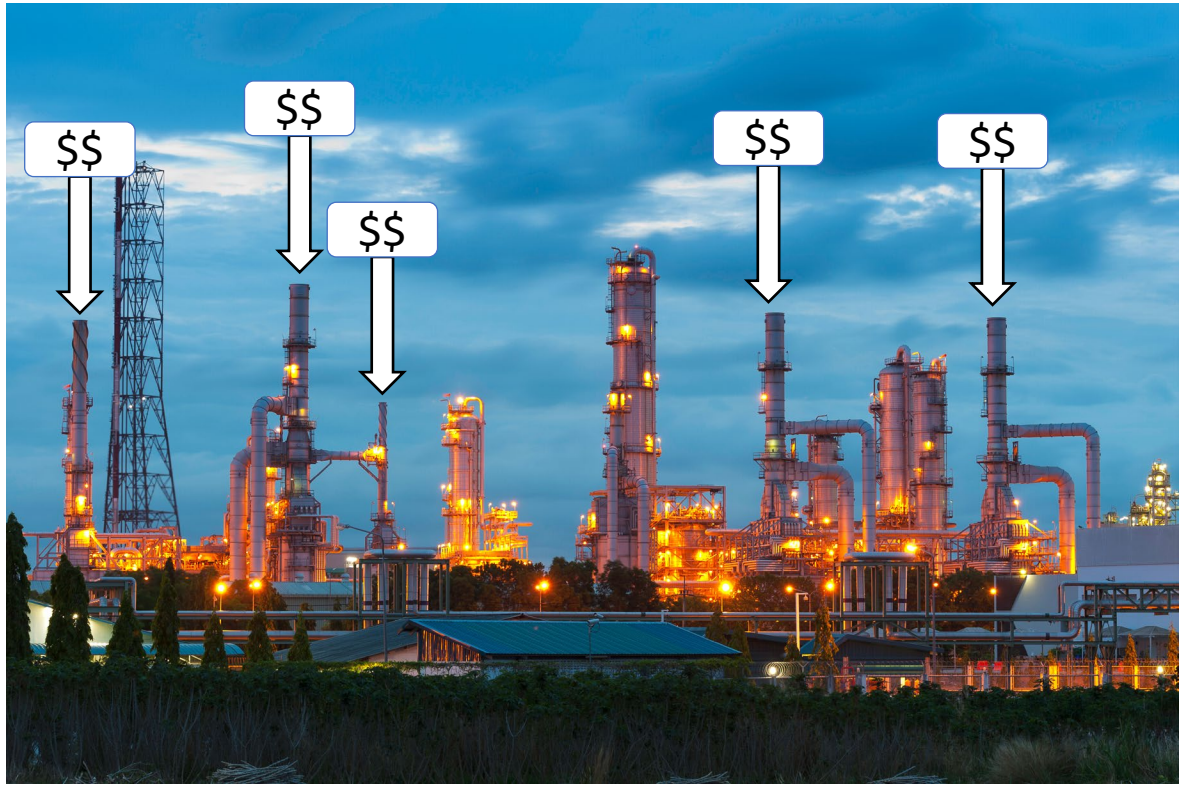
- California: 2 – 9 ppm
- Alberta: 5 – 9 ppm
- Texas: 1.3:1 - New Capacity
- USA: Up to 1.5:1 - New Capacity



New Capacity Additions – Highest Profitability

Why Prefer a Combustion Solution?

- Selective Catalytic Reduction (SCR) is effective
  - 90-95% effective
  - New burners still required
  - Retrofits are expensive
  - Ammonia handling introduced
- Burners only
  - Lower capital cost
  - Lower operational cost



Air Permit Compliance Required for Continued Operations

Cost-Effective Solution - Process Burners

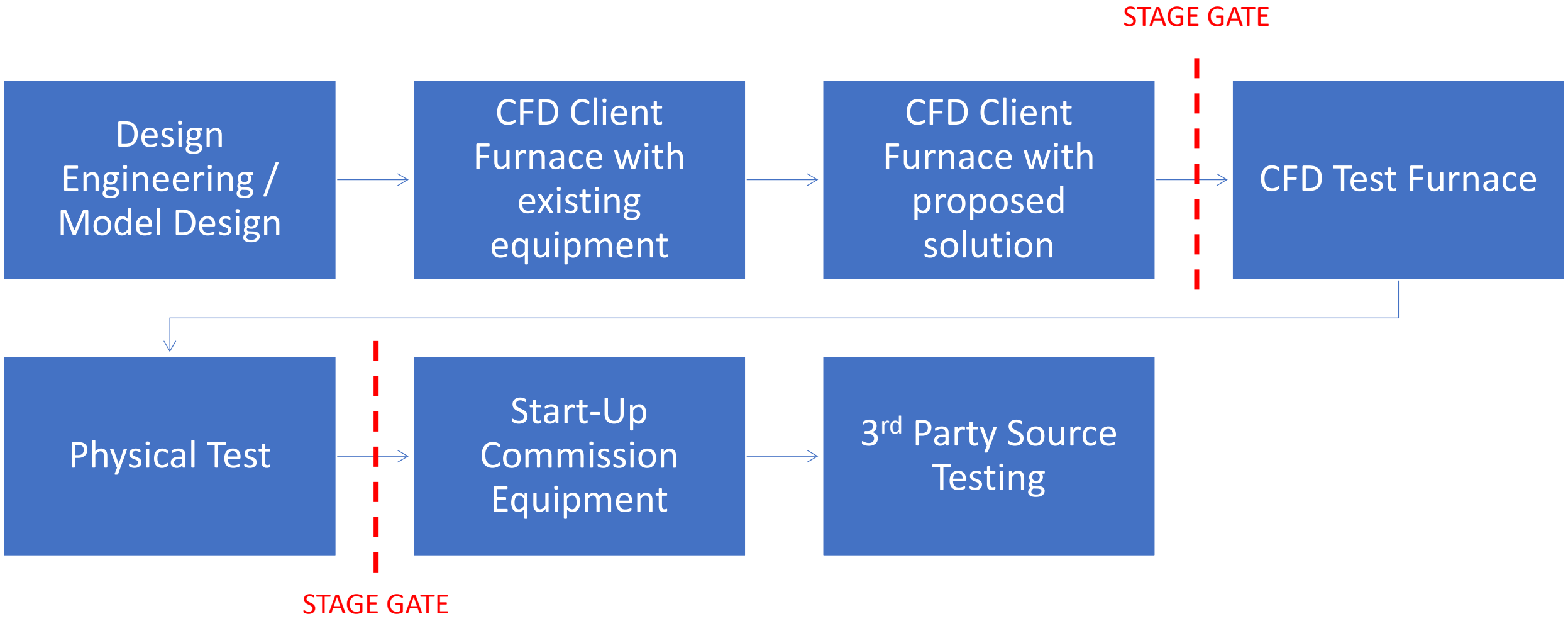
Infrastructure Client
Los Angeles, CA

- Small process heater
- Original NOx = 30 ppm
- New permit NOx requirement = 7ppm

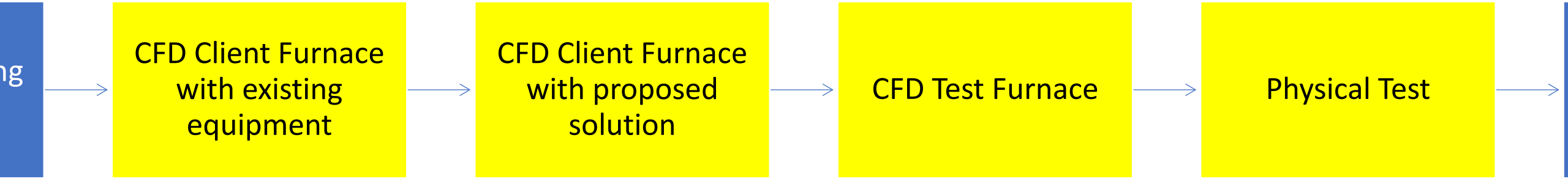
Economics	CLIR (Pre-combustion tech)	SCR (Incumbent, post-combustion tech)
NOx, ppm	6	5
Capital Cost	$450,000	$2,200,000
5 Yr Operating Cost	$25,000	$500,000
Total Cost	**$475,000**	**$2,700,000**
Cost Ratio	**1.0**	**5.7**

Provides a cost-effective solution versus additional cap-ex and op-ex costs associated with existing methods

Project Timeline

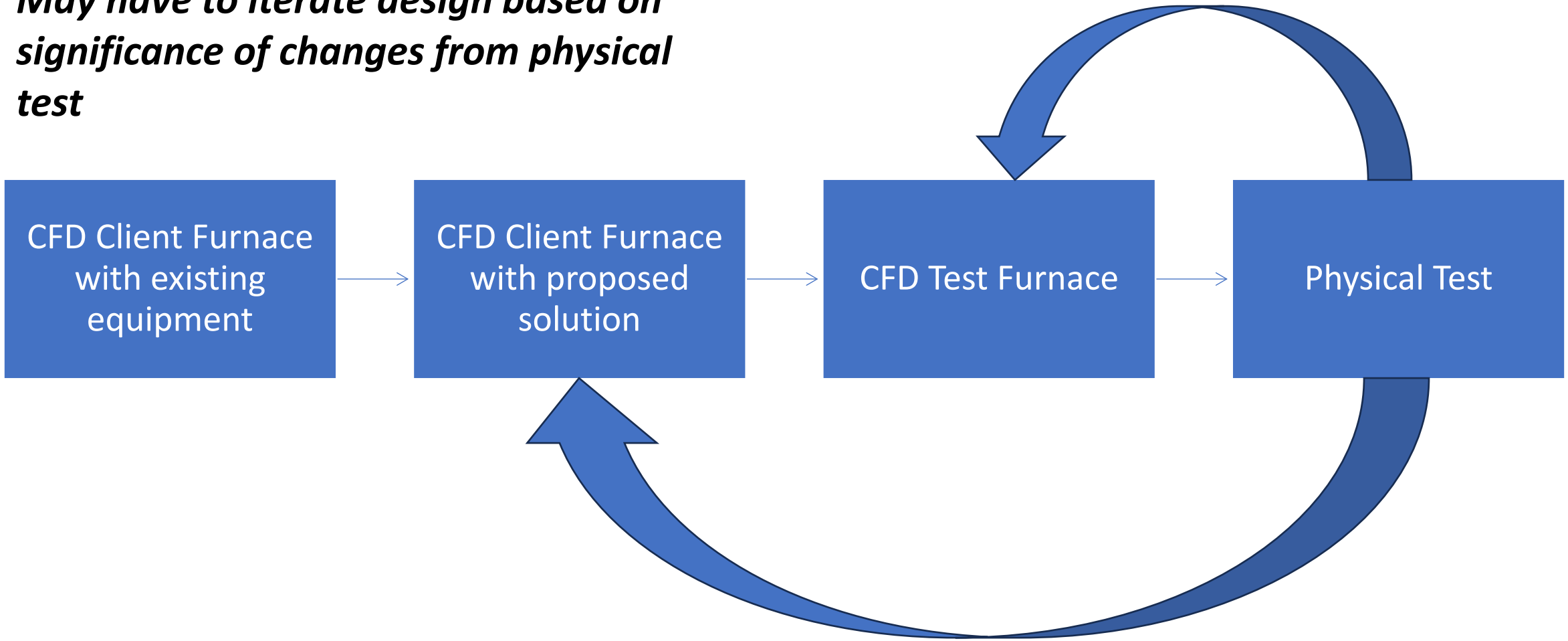


Project Timeline – Design Validation



Project Timeline – Design Validation

May have to iterate design based on significance of changes from physical test



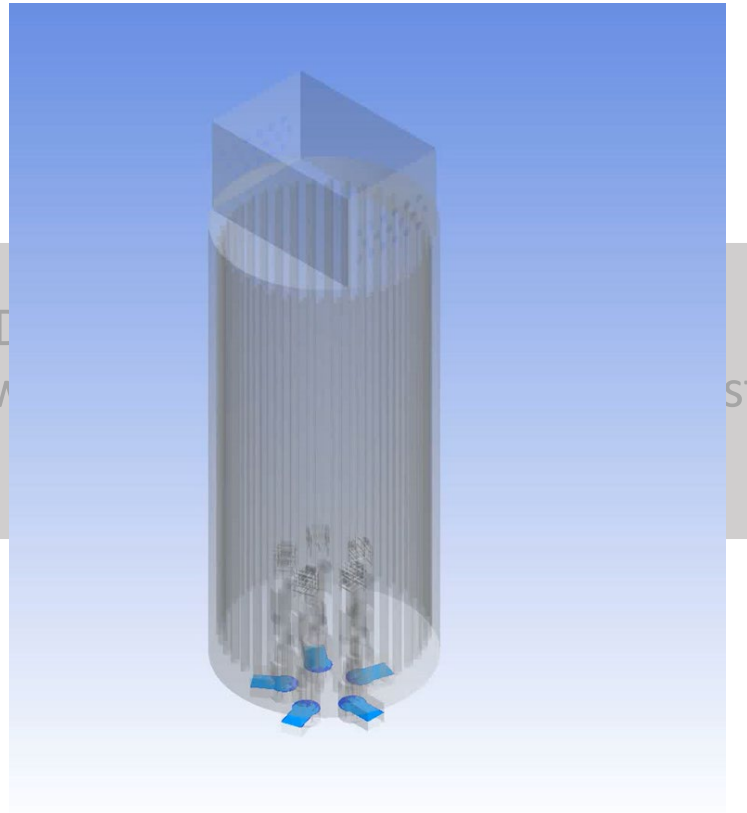
Project Timeline – CFD Client Furnace (existing)

(OPTIONAL STEP)

However, this step can:

- Identify existing issues
- Establish a quantitative basis for comparison to the proposed solution
- Field data for comparison may be hard to obtain

CFD Client Furnace with existing equipment

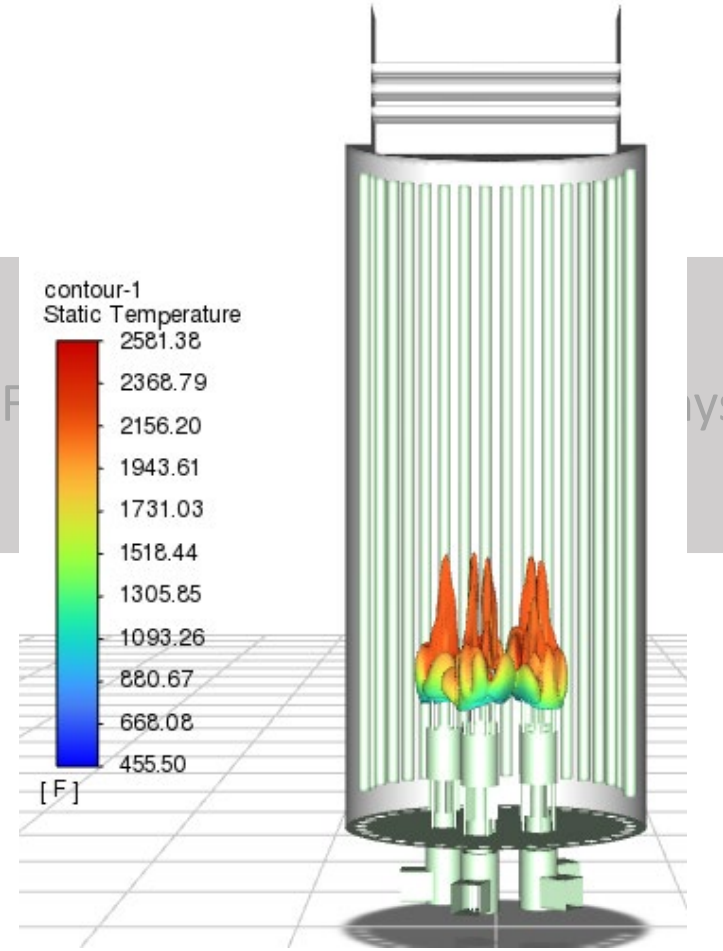


Project Timeline – CFD Client Furnace w/ Solution

CFD of Client Furnace Evaluates

- Tube Metal Temperatures (TMT)
  - Radiant Tubes
  - Shock Tubes
- Flame Impingement
- Heat Flux Profile
- Radiant Efficiency
- Emissions
  - NO_X
  - CO
- Flame Envelope
  - Length
  - Diameter

CFD Client Furnace with proposed solution



Project Timeline – CFD of Test Furnace

Differences in physical dimensions of test furnace and client furnace may impact test results on:

- Stability
- Emissions Performance
  - NO_X
  - CO
- Flame Dimensions
  - Diameter
  - Length
- Burner to Burner Interaction

CFD of Test Furnace allows for benchmarking against Physical Test results and ultimate comparison to Client Furnace

CFD Test Furnace

TEST FURNACE

ACTUAL FURNACE

Project Timeline – Physical Test

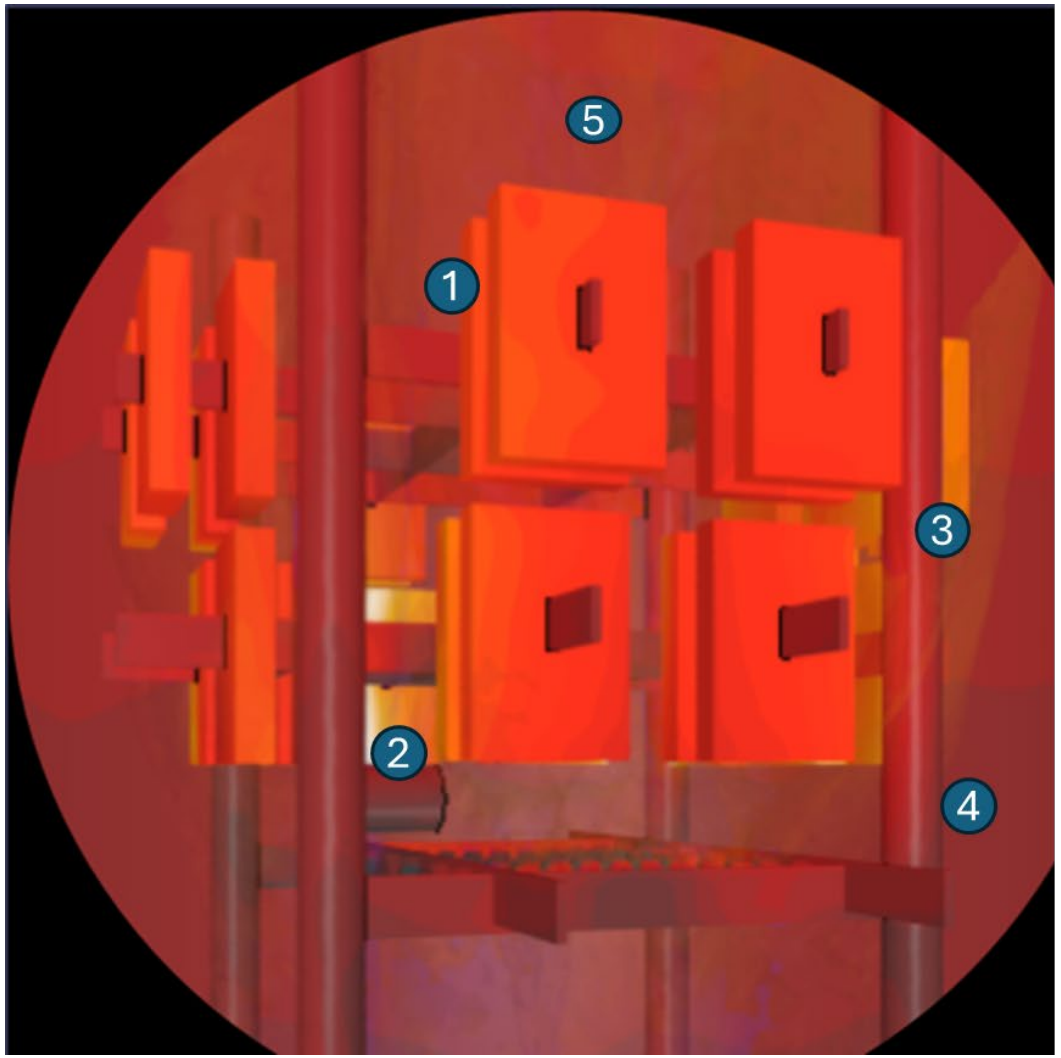
CO PROBE FOR FLAME HEIGHT / DIAMETER

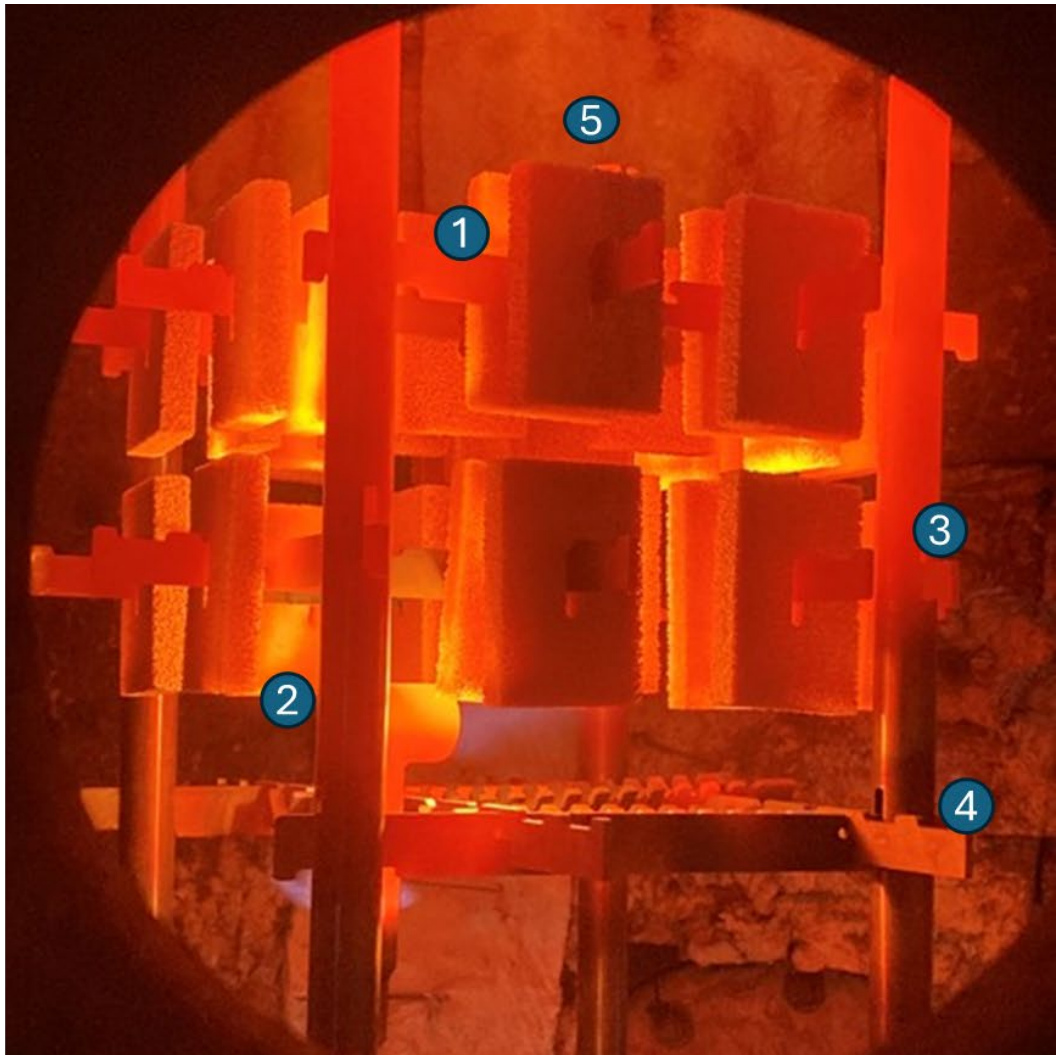
Physical testing collects data to compare to the Test Furnace CFD

- Flame Stability
- Flame Dimensions
- Emissions
  - NO_X
  - CO
- Operating Envelope

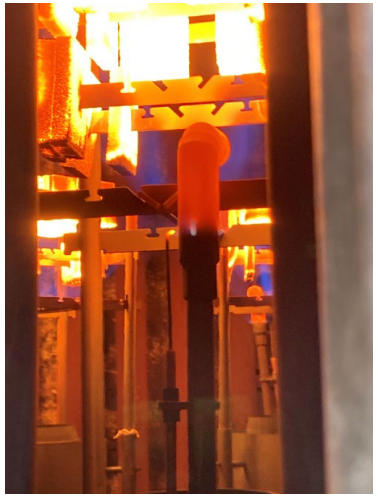
→ Physical Test

Design Validation





Installations






Questions?