

# ClearSign Technologies Corporation Update

---

ClearSign Core Process Burner



# Industry Challenges

The conventional technology available to comply with new and emerging NOx regulations is either underperforming in the case of conventional Ultra Low NOx burners or very expensive to install and operate in the case of SCR

## Conventional Ultra Low NOx

- Emissions limitations: 15-25 ppm
- Some installation as high as 40+ ppm
- Flame Shape Issues
- Reduced radiant efficiency
- Prone to tip plugging

## Selective Catalytic Reduction

- High capital cost and downtime to install
- Substantial ongoing operational and maintenance costs
- Plot space considerations
- Use of catalyst & hazardous chemicals

# ClearSign Core Solution

## Lowering Emissions

- NOx capability = sub 5ppm, corrected to 3% O<sub>2</sub>

## Increasing Efficiency

- Reduced tip plugging
- Increased radiant duty

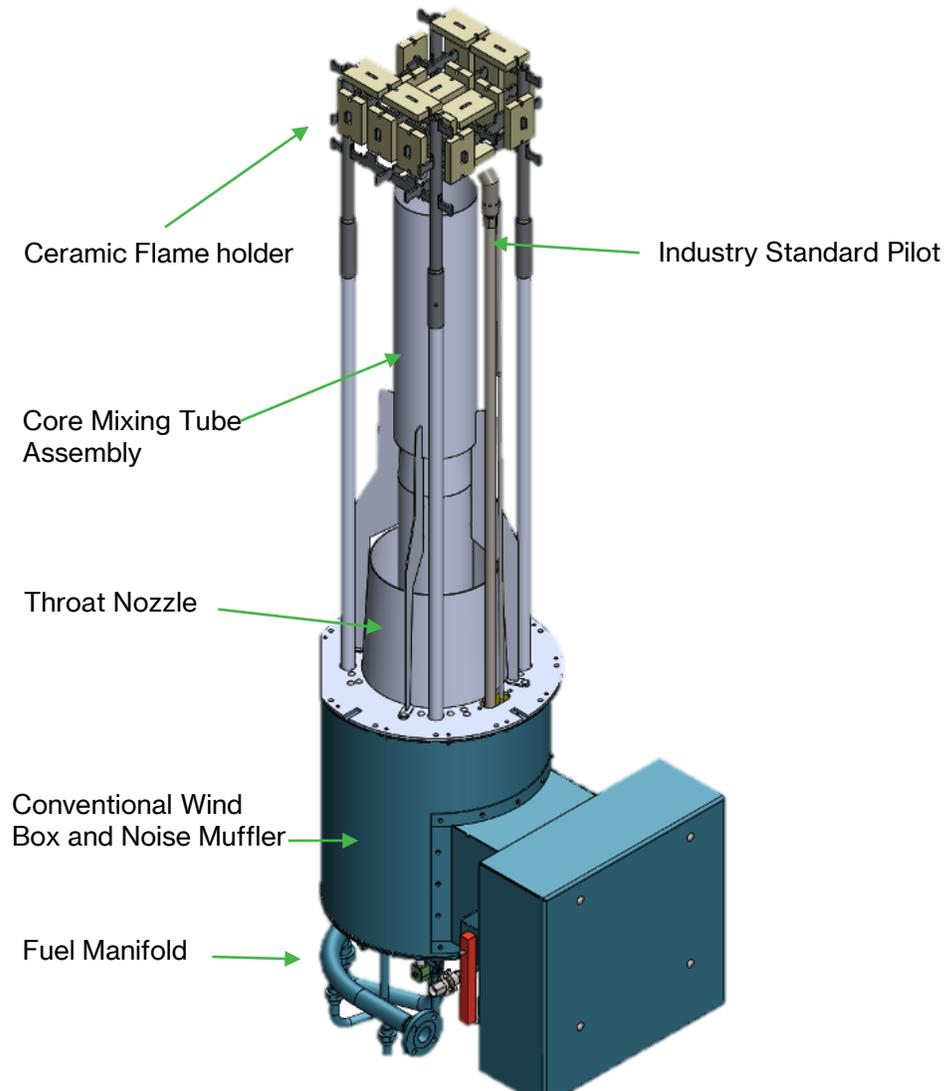


## Reducing Costs

- ~10% the cost of an SCR
- Direct burner replacement
- No incremental operating costs

## Simple Operation

- Operates like a traditional burner
- Standard continuous pilot



# ClearSign Core Solution – Theory

Our solution utilizes three technologies to achieve superior NO<sub>x</sub> performance

- Fuel air premix
- Internal flue gas entrainment
- Ceramic flame holder assembly

# Core Operating Range By the Numbers

**400-1600 Btu/scf**

NG, RFG, High H2 Fuel Gas

**90% sub-stoichiometric**

Air/Fuel Ratio Stability

**5:1**

Turndown

**Sub 5 ppm**

NOx capability

**80%**

Max Hydrogen Volume

**Sub 30 ppm**

CO Throughout Turndown



# ClearSign Core Advanced Testing



R&D Center

- Single Burner
- 5 MM BTU/hr Max
- Prototype testing



Single Burner Furnace

- Single Burner
- 10.5 MM BTU/hr Max
- Full scale testing



Multi Burner Furnace

- 4 Burners
- Wide ranging fuels
- Simulates real world conditions

Achieved 5.5 ppm corrected NO<sub>x</sub>

# ClearSign Zeeco Partnership

- Announced August 12, 2020 – see ClearSign press release
- Exclusive agreement involving:
  - Manufacturing
  - Single and Multiburner Performance Testing
  - Product Development
  - Project Execution
  - Quality Assurance / Quality Control
- Zeeco is a world leader in the design and manufacture of advanced combustion and environmental solutions with over 1300 employees and offices in 20 locations.
- Zeeco's worldwide headquarters includes a 100,000 ft<sup>2</sup> manufacturing facility and the world's largest, industrial-scale research and test facilities.



# ClearSign Core Benefits

- Capable of sub-5 ppm corrected NOx emissions vs. approximately 20ppm conventional
- Compact flames and potential for increased fired duty
- Less sensitive to ULNOx heat density & burner spacing limits
- No tip plugging or fouling
- Eliminates the need for catalysts or chemicals
- Reduces electrical consumption vs SCR
- Saves capital vs SCR
- Reduces downtime to install vs SCR

# Project Updates

## Tricor - Bakersfield

- 15 MM BTU/hr single burner vertical cylindrical heater
- 6 ppm corrected NOx
- In operation since June '19

## ExxonMobil

- Mid-sized multi-burner vertical cylindrical heater
- Extensive burner test program
- Detailed performance requirements
- 3Q21 Installation

## World Oil

- BACT Demonstration project
- 5 burner, 39 MM BTU/hr vertical cylindrical heater
- Successful multi-burner factory test Nov 2020
- Install anticipated Feb 2021

## Conf. Client – LA

- Small 3 burner vertical cylindrical heater
- 7 ppm corrected NOx
- Install anticipated Feb 2021

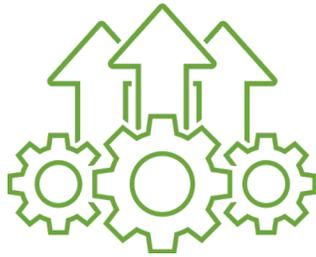
# How can ClearSign help?

- For Process Heaters under 40 MM BTU/hr
  - ClearSign offers direct burner replacement demonstrated to meet 9 ppm corrected NOx or less
- For Process Heaters over 40 MM BTU/hr
  - A combination of ClearSign Core process burners and a simple, moderately efficient SCR is a solution that can deliver on the order of 1 ppm corrected NOx, thereby providing significant comfort to deal with typical operational variations and continuously achieve below 2 ppm corrected NOx on a 24 hour rolling average
- For FireTube Boilers
  - ClearSign is scaling up our boiler burner product that has efficiently achieved as low as 2.0 ppm corrected NOx



# ClearSign

Better Solutions



**Boost  
Operational  
Efficiency**



**Reduce  
Costs**



**Decrease  
NOx  
Emissions**

Contact: [steve.sock@clearsign.com](mailto:steve.sock@clearsign.com)