SJVAPCD Rule Changes

Burner Technologies

AJ Feliz

Director of Engineering

R.F. MacDonald Co.

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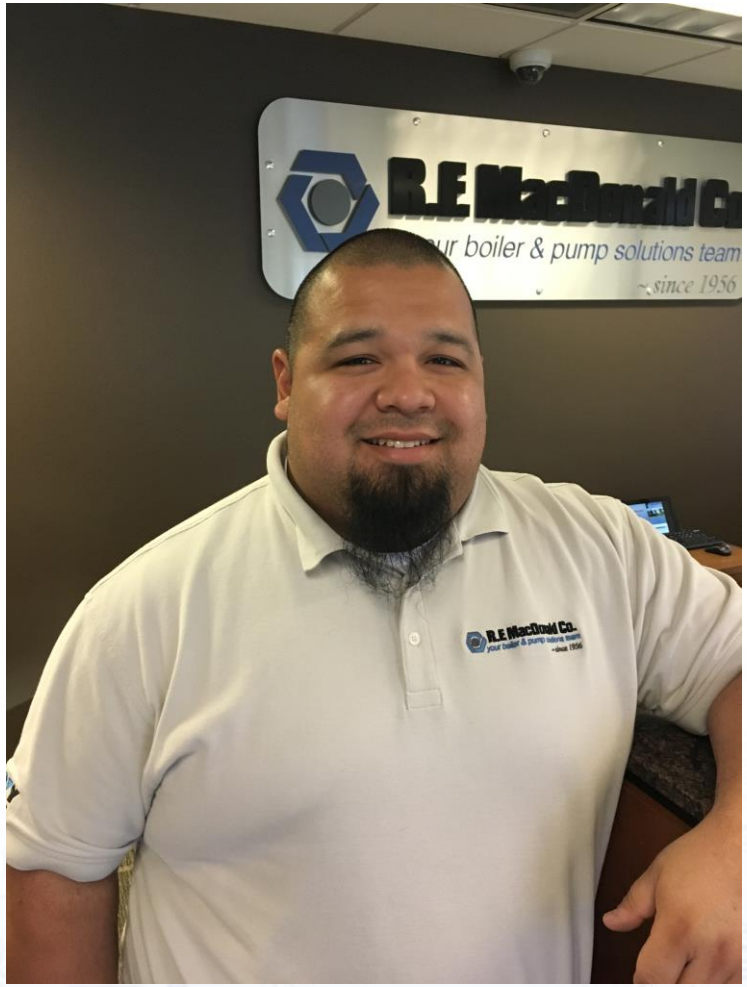
Introduction



- AJ Feliz
- Director of Engineering
- ME degree out of Cal Poly Pomona
- With R.F. MacDonald Co. for 18 years
- Specializing in custom emission control systems utilizing SCR

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Applicability

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

- Central Valley Counties
- Applies to:
  - Boilers
  - Steam Generators
  - Process Heaters
- Sizes >5 MMBtu/hr
- Approximately 1,273 units effected
- First deadline is May 1, 2022
- Compliance with both rules 4306 and 4320 is required

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Agenda

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- Overview of Boiler NOx Formation
- NOx Reduction Strategies
- NOx Compliance Options
- Low NOx Burners and Controls
- Combining Energy Efficiency With Boiler NOx Upgrades
- Q&A

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Overview of NOx Formation

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- Boilers have burners which use combustion to produce heat to make hot water or steam
    - NOx is a by-product of combustion
- NOx is a pollutant contributing to:
    - Ozone, Particulate Matter, Acid Rain
- 3 Types of NOx Formation:
    - Thermal NOx
    - Prompt NOx
    - Fuel Bound NOx (not a concern if PUC gas)

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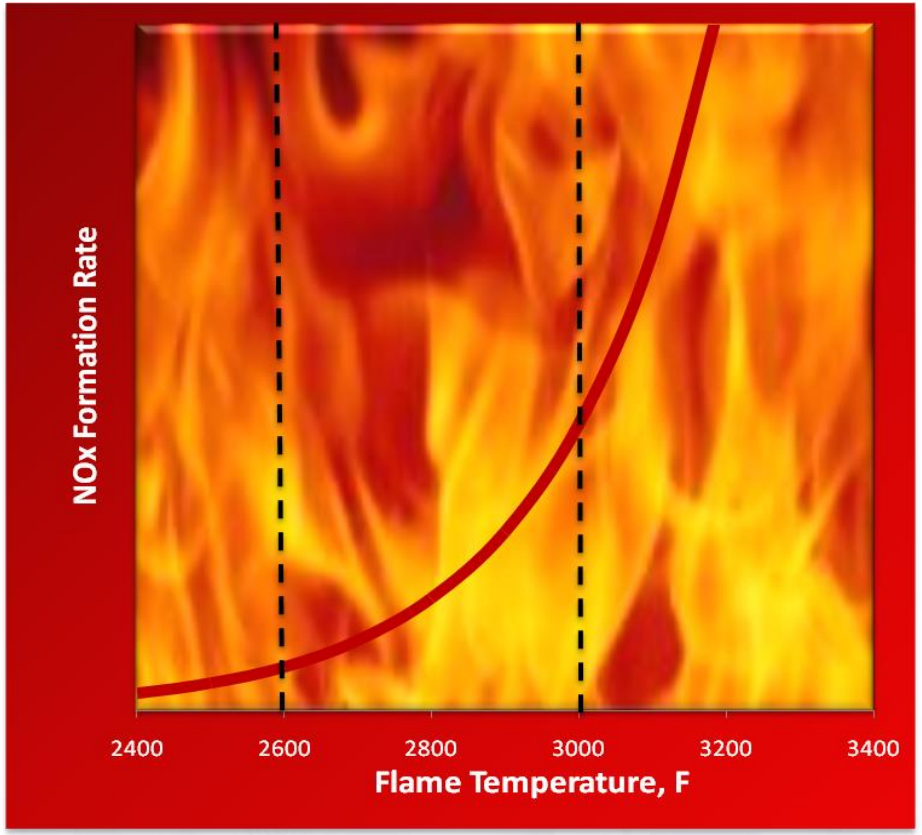
Overview of NOx Formation

- Thermal NOx is the largest contributor to the overall total NOx
- Combustion: Fuel + Air(O_2+N_2) + Ignition
  - Ideal Combustion:
  - CH_4 +O_2+N_2 =>CO2 +H_2O+N_2+O_2 +Heat
- Under high temperatures of combustion (> 2600F), Thermal NOx is formed:
  - N_2 + O_2 + Heat => NOx
- Thermal NOx is an exponential function of flame temperature



NOx Reduction Strategys 1 and 2

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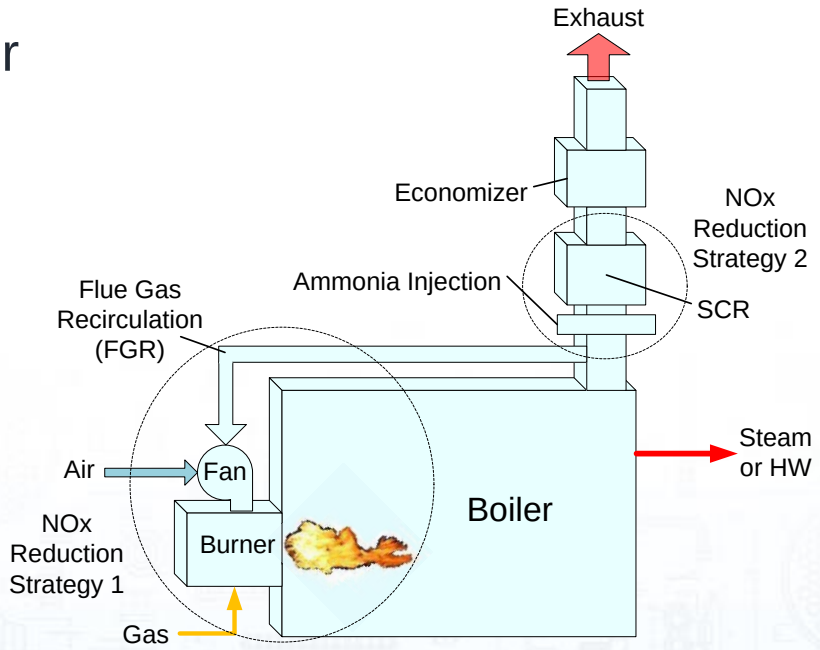
- (1) Burner Modifications or New Burner:
  - Available down to 5 ppm NOx
  - Less expensive than exhaust treatment solutions like SCR
  - Cost effective on boilers < 20 MM Btu
  - Can decrease efficiency depending on the NOx level & burner type, without additional upgrades
- (2) Exhaust Treatment (SCR):
  - Selective catalytic reduction (SCR) equipment added to treat the NOx after combustion
  - NOx reduction less than 2.5 ppm
  - To date, installed on water-tube boilers >8 MMBtu
  - More initial cost and continued maintenance than burner options
  - Less impact on efficiency

Future Workshop



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Strategy 1: Low NOx Reduction

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- Burner NOx Reduction Methods:
  - Flue Gas Recirculation (FGR)
  - Altering the fuel / air ratio and excess O_2
  - Improve the fuel / air distribution & mixing
  - Improve the flame distribution (reduce hot spots)
  - Using staged combustion (both fuel & air)
- Most burner designs are focused on lowering the flame temp
- Challenge: lowering flame temp. w/o reducing efficiency & flame stability
  - Increased excess O2 will decrease efficiency
  - FGR has less impact on efficiency but can increase fan HP

Excess Air / O2, %		DOE Combustion Efficiency: Exhaust Stack Temperature Minus Combustion Air Temperature, °F				
Air	O2	200	300	400	500	600
9.5	2.0	85.4	83.1	80.8	78.4	76.0
15.0	3.0	85.2	82.8	80.4	77.9	75.4
28.1	5.0	84.7	82.1	79.5	76.7	74.0
44.9	7.0	84.1	81.2	78.2	75.2	72.1

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Strategy 1: Low NOx Reduction

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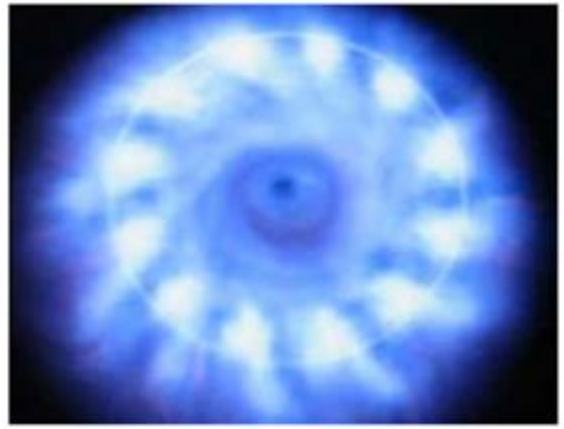
Low NOx Burners: 30 ppm NOx

- No FGR required-SBR 30 Burners
- Can maintain 3% excess O_2 with good controls
- Good turndown > 5 to 1 and flame stability



Ultra Low NOx Burners: 9 to 5 ppm NOx

- Uses FGR and different fuel/air ratios & staging
- Some designs may have:
  - Higher excess O_2 (can range from 5 to 9%)
  - Larger fan HP (15% to 50% more)
  - Less turndown (3 or 4 to 1) & flame stability
- Improvements made & will continue
  - Many now at 4% to 7% excess O2

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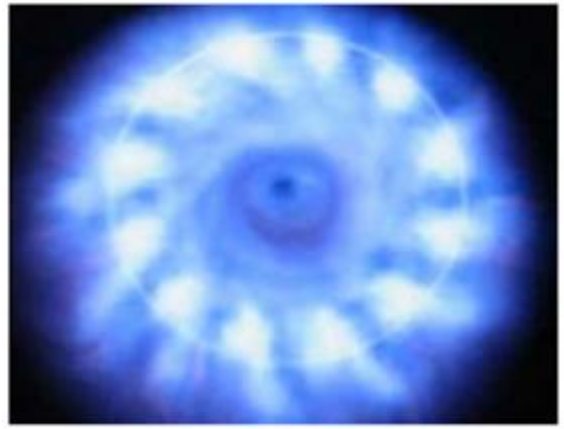
Strategy 1: Low NOx Reduction

Common Conventional Designs:

- Utilize higher FGR & lean mixture designs:
  - *Lean Premix – Gas Nozzles & Metal Fiber*
  - *Lean Rapid Mix – Gas Nozzles*



New Designs Aimed at Improving Efficiency:

- Lower excess O_2 (3 to 5%), FGR & fan HP
- One Example: Staged Combustion
  - *Fuel/air combusted in multiple stages (rich & lean)*
  - *Low NOx in each stage of combustion*

Strategy 2: Summary NOx Reduction with SCR Exhaust Gas Treatment

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- SCR – custom engineered, new or existing equipment solution
- Large Boilers: recommendation for SCR vs ULN Burners for higher efficiency & lower NOx capabilities
- Good application for non-standard fuel applications or process heaters
- Now developed for Fire-tube applications
  - *To handle lower stack temperatures*

- More information will be presented at the next Workshop

Future Workshop

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Summary of NOx Compliance Options

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1. Existing Burner Retrofit / Modification
   - May be applicable if going from 15 to 9 ppm or from 9 to 5 ppm
2. Install New Burner (Replacement)
   - For 30, 15 or 9 ppm NOx
   - Availability for less 5 ppm NOx on certain sizes
3. Install New Boiler (Future Workshop)
   - New boiler vs. new burner will depend on the age of the boiler

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Low NOx Burners

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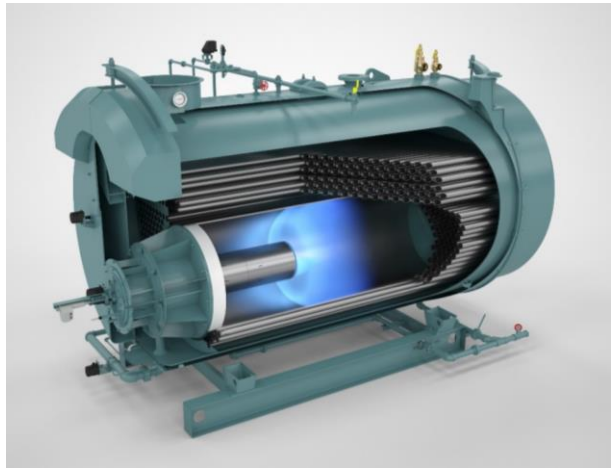
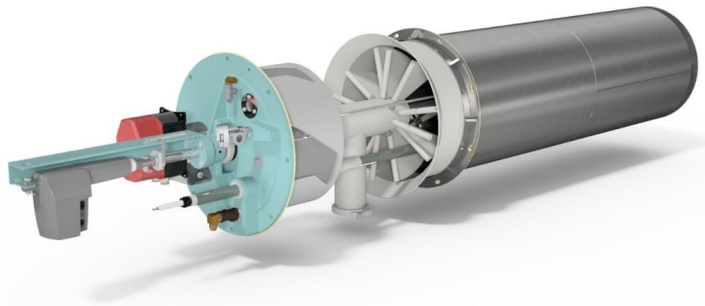
CB LNO Series Burners





- Burner head design enables the highest combustion efficiency at sub-5 ppm NOx of any burner in the industry
- Patent-pending technology
- Premixed fuel and air are delivered to the burner head
- Mixture is discharged radially deeper within the furnace
- Outward velocity is actively controlled
- Single-stage combustion eliminates hot spots that produce NOx emissions
- Flame is anchored on furnace inside diameter
- Size range of 250 to 700 HP
- Can be retrofitted onto some existing units
- Natural gas (additional gaseous fuels to come)

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Low NOx Burners

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Pro-Fire SBR Series Burners

- Low-NOx Emissions as low as 5 ppm achieved with FGR
- Maximum Efficiency provided by standardized parallel positioning
- Uniform Flame for equal heat transfer allowed by premix fuel
- Easy Access air housing for internal components
- Silent operation with an advanced combustion air fan wheel using less horsepower and less noise
- Lower maintenance cost with no air filters needed
- Low-NOx/CO achieved without a fragile surface combustion burner head, making it safer and more reliable, and requires less maintenance

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Low NOx Burners

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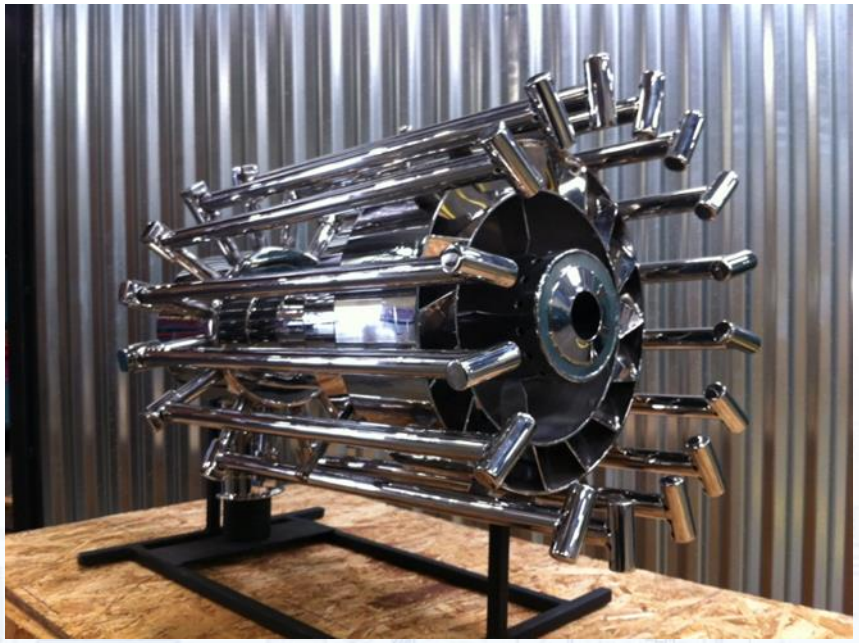

Pro-Fire NT Series Burners
Axial Flow Burner

- Low NOx lance style hammerhead design
- Utilizes low to moderate swirling air jet aerodynamics
- Intensive mixing with counter flow injection
- Swirl and center core bluff body to stabilize the flame
- Stainless Steel Internals
- Low Excess Air Burner
- Typical O_2% 4.0 – 5.0%
- <9 PPM NOx
- <50 PPM CO
- Utilizes FGR
- Dual Fuel: Gas/Oil
- Turndown: 5:1

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Low NOx Burners

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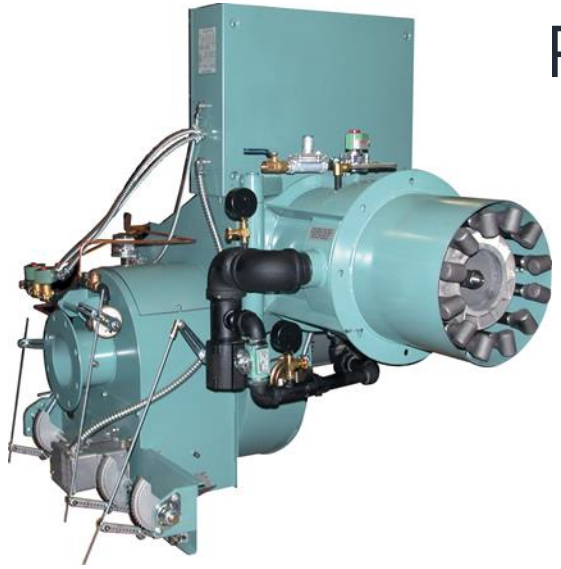
Pro-Fire NT Series Burner Family



Pro-Fire NTH Burner

Pro-Fire NTXL Burner

Pro-Fire NTD Burner

- Firetube and Watertube applications up to 92MMbtu
- 5:1 turndown
- <9-7ppm NO_x throughout the entire firing range
- <50ppm CO
- Low excess air
- Available with advanced HAWK PLC based controls
- Can be custom configured for any application

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Low NOx Burners

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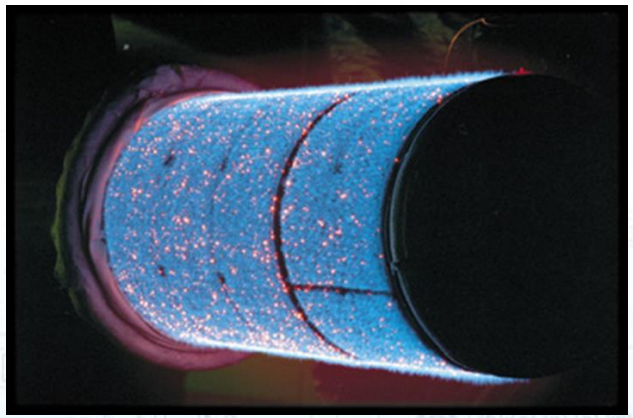
Pro-Fire MTH Series Burners



Metal Fiber Burner

- Pre-Mix Surface Stabilized
- Metal Fiber Element
- High Excess Air Burner
- Typical O_2% 7.5 – 9.0%
- Requires Filter Element
- <9 PPM NOx
- <50 PPM CO
- Natural Gas
- Low Gas Pressure
- No FGR required
- Turndown: 3:1

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Advanced Controls

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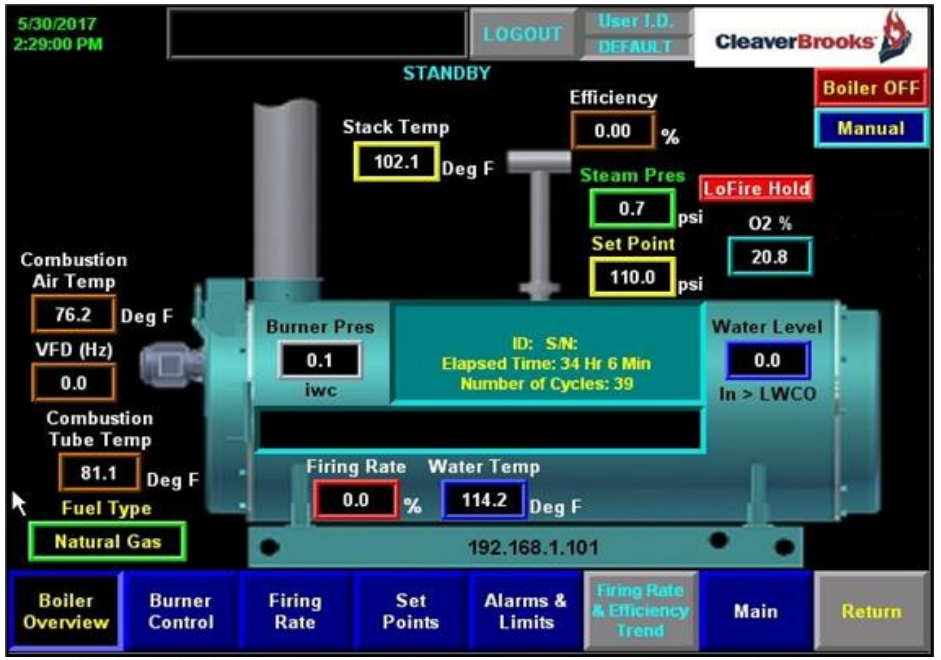
- All Burner Options includes a completely integrated burner control system designed by Cleaver-Brooks specifically for the boiler and burners for seamless integration
- Digital-positioning feedback from actuators ensures precise control, repeatability, and reliability
- Includes programming for O_2 trim to maintain proper fuel-to-air ratio across the firing rate
- Incorporates flue gas recirculation (FGR) trim to monitor FGR rate and trim FGR valve to maintain consistent levels
- Certain 9ppm CB boilers NOx can be lowered to 7PPM with just a controls upgrade, see an RFM representative for more details



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Why try and combine Boiler Energy Efficiency with NOx Upgrades

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- Mitigate efficiency decrease & increased operating cost from NOx reduction
- Energy & utility cost savings
  - *Increase efficiency beyond existing*
  - *1 to 5% efficiency improvement possible*
- If done as a single project:
  - *Reduced downtime*
  - *More cost-effective for implementing energy efficiency upgrades than if done separately*
  - *Create a payback that otherwise might not exist*

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Why try and combine Boiler Energy Efficiency with NOx Upgrades

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- Reduced greenhouse gas emissions (AB-32, potential carbon emissions regulations)
- Rebates / incentives may be available for the energy efficiency upgrades
- May increase boiler output capacity
- If aged energy recovery equipment exists, replace end of life equipment

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Recommendations for Evaluating Boiler NOx Upgrades

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- Every customer is different
- RFM can evaluate site specific conditions and propose customized options
- Evaluation will look at costs:
  - Energy
  - Operations
  - 4320 Fee compliance
- Competitive analysis available to make sure you are making the most of your investment

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Rule Change Milestones Reminder

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May 1, 2022

- 4306 – Non-Deferred Units Submit Emission Control Plan/Authority to Construct
- 4320 – Submit Emission Control Plan/Authority to Construct

Dec 31, 2023

- 4306 – Non-Deferred Units Compliance Date
- 4320 – Compliance Date

May 1, 2028

- 4306 – Deferred Units Submit Emission Control Plan/Authority to Construct

Dec 31, 2029

- 4306 – Deferred Units Compliance Date

Jan 1, 2025

- 4320 – Invoices for those choosing the fee method will be issued for 2024 opearations

Conclusion

- When navigating the new rule changes, each user will have options to evaluate to see what makes the best sense for them
- Some early adopters have the ability to defer compliance until Dec. 31, 2029
- Regardless of the course of action, all users must have compliance plans submitted to the district by May 1, 2022

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Contact Information

Thank you for joining us today. A follow up email will be sent to you with your R.F. MacDonald Co. customer service rep's contact information and a link to our workshops.

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