Flameless Oxidizer Discussion

Presented to:

South Coast Air Quality Management District

World Leader of Custom Designed, Integrated Solutions for Industrial Pollution.
Introductions

- Mike Foggia – PCC Business Development Manager
- Nick DiSanti – Flameless Thermal Oxidizer Product Manager
- Scott Fernbach – Southland Environmental, Inc.
A New Era: PCC is Employee Owned

• PCC formed in 1969 as joint venture
  ✓ Bloom Engineering Company (USA)
  ✓ Urquhart Engineering Company (UK)

• Sterling Industries PLC (UK) Acquired PCC, Urquhart, and Bloom in 1984

• In 2012 Management initiated Product Line Expansion

• In 2017 PCC became an Employee Owned Company via a Management buyout
Custom Designed & Fully Integrated Air Pollution Control Solution Provider

PCC’s “Technical Offering”

Thermal Oxidation

Bio Oxidation

Process Evaluation & Technology Selection

Match Process With Best Control Technology

Scope Identification & Process Design

Proposal Development

Detailed Engineering & Construction

Commissioning & Start-Up
What is Flameless Oxidation?

Flameless oxidation is a thermal treatment that premixes waste gas, ambient air, and auxiliary fuel prior to passing the gaseous mixture through a preheated inert ceramic media bed. Through the transfer of heat from the media to the gaseous mixture the organic compounds in the gas are oxidized to innocuous byproducts, i.e., carbon dioxide (CO$_2$) and water vapor (H$_2$O) while also releasing heat into the ceramic media bed.

The reason why a flame is not generated in the media bed is because the gas mixture is kept below the lower flammability limit based on the percentages of each organic species present.

Waste gas streams experience multiple seconds of residence time at high temperatures leading to measured destruction removal efficiencies that exceed 99.9999%. Premixing all of the gases prior to treatment eliminates localized high temperatures which leads to thermal NOx as low as 1 ppmv.
### Where is the FTO Technology best used?

<table>
<thead>
<tr>
<th>Project Parameter</th>
<th>Regenerative Thermal Oxidizer (RTO)</th>
<th>Catalytic Oxidizer (CO)</th>
<th>Thermal Oxidizer (TO)</th>
<th>Carbon Adsorption Technology</th>
<th>Bio Oxidizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Concentration</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Low Concentration</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Halogenated Service – Cl, Fl, Br</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Sulfur, Mercaptans, thiols, etc.</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>DRE 99.99% +</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
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<tr>
<td>Continuous Process</td>
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<td></td>
<td>x</td>
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<tr>
<td>Batch Process</td>
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<td>x</td>
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<tr>
<td>NOx &lt; 1 ppmv</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
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</table>
How do we achieve a DRE of 99.9999%?

3 T’s of Destruction: Time, Turbulence (mixing), Temperature

- Premixing of waste gas, natural gas, and oxidizing air
- Bed operating temperature ~1800°F (1500 kJ/Nm³)
- Excess oxygen level of ~12%
- Multiple seconds of residence time at high temperatures
How do we achieve NOX emissions < 1 ppm?

Yakov Zel’doovich determined the correlation between temperature and NOx formation in a combustion system. Temperatures >2300°F cause an exponential growth rate in NOx generation.

Thermal Oxidizer Flame Temperature Profile

- Combustion Air
- Natural Gas
- Waste Gas

3500°F 3000°F 2500°F 2300°F

Flameless Oxidation Temperature Profile

- Hot Combustion Products ≈ 1800°F
- Cold Premixed Reactants ≈ 60°F
- Laminar Reaction Speed
- Flow Velocity

Combustion Air
Natural Gas
Waste Gas
Comparative NOx Performance

The PCC FTO achieves 50x less NOx than the Industry Standard Burner!
Competing Control Technologies
NO\textsubscript{x} v.s. DRE

FTO: 99.9999% DRE <2ppm NO\textsubscript{x}

Indication of an underserved market
Flameless Technology Evolution

Electric Model
Intended for small emission sources

Planar Model
Cylinder Reaction Wave
4x the reaction surface area of a Planar FTO
Hot Shell Design
(Invented by PCC owner Will Huebner)

Elliptical Model
Spherical Reaction Wave

Fume
Air
Fuel
Waste flow and composition are measured prior to the FTO in order to control the air and fuel feeds. Controlling in this manner allows the control valves to modulate prior to accepting fume stream to ensure that a constant operating temperature and flowrate is achieved. Simple and yet effective control scheme for controlling multiple batch vent streams or constantly changing vent streams.

- **FTO is a Smart Feedforward Reactor**
- **No More High/Low Temp Trips....**
- **No More Nuisance Shutdowns....**
- **Great for Sold Out Products!**
- **Maximize Production Time!**
Example FTO Installations

14’ Ø Elliptical FTO (Ireland)
Chemical Reactions In Air

NO2

HNO3

O2

NO

VOC’s

Acid Rain

O3 (Ozone)
Smog

Combustion Activities

Accumulation

N2O
Performance Beyond Compliance

- Installing a high performance Flameless Thermal Oxidizer will generate Emission Reduction Credits (ERC’s).
- ERC’s can be used to offset new emissions for a site expansion.

Typically ERC’s are sold for ~$40,000 per ton but can be as high as $400,000 per ton in non-attainment areas!

Treating emission sources with a PCC FTO will:
1) Generate emission credit revenue for your manufacturing site.
2) Allow for plant expansions without modifying an existing air permit.
# Flameless Oxidation

## Values

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
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<tbody>
<tr>
<td>Low NOX</td>
<td>Low Temperature Premixed Oxidation</td>
</tr>
<tr>
<td>High DRE</td>
<td>Premixed Oxidation; 3-4 seconds RT;</td>
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## Up-Time

Stable/Resilient Oxidation Environment; Feed forward control; No Moving Parts; No thermal cycling of media bed (Long ceramic Life)

<table>
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<th>Benefit</th>
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<tr>
<td>&gt; 99% Uptime</td>
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## Easy Permitting

Eliminate requirement for CEMS (High Performance Oxidizer Reactor)

<table>
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<tr>
<td>Less time to permit</td>
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## ROI

Lower emissions; Emission Trading opportunity; Ease of site expansion

<table>
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<th>Benefit</th>
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<tr>
<td>Lower Permitting Costs, Emission Credits, Added Reliability (More Production)</td>
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## Operational Flexibility

Multiple control set points; 100% Waste gas turndown; Accept varying waste compositions

<table>
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<th>Benefit</th>
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<tbody>
<tr>
<td>“Ready-Idle” mode to limit fuel use &amp; Stable Operation</td>
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