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Oxidation: A Natural Process

Oxidation occurs when a substance comes into contact with oxygen molecules—almost everything, over time, reacts with oxygen...

However, in nature, oxidation is a very slow process.

Ener-Core accelerates the oxidation of methane to 2-3 seconds!

“1.5% - 2.5% methane as fuel”
How the Technology Works

The dilute gas (input) does not have a high enough energy content for combustion.

Combustion is a rapid reaction that happens in milliseconds and produces pollutants as part of output.

Ener-Core Oxidation is an exothermic chemical reaction. It has no flame, resulting in temperature that avoids the NOx formation temperature. It happens in seconds, it produces heat, and it removes the pollutants in the incoming gas.
Company Timeline

2008 - 12
$25M Invested by Venture Capital

2011 - 12
Successful 1-year Operation on Dept. of Defense Landfill

2013-14
1st Commercial unit commissioned and operating in field

2015
Scale-up & Commercially License to large turbine manufacturers

Ribbon Cutting Video
http://youtu.be/lFUWRoZ9bMA?list=UUrc1RqrzUktjFXA13reumbQ

Technology evolves from prototype to market deployment
Ener-Core goes public and ships 1st commercial system

OTCQB: ENCR
250 kW Ener-Core Powerstation

FP250 (250 kW)
Gas Energy Input: 3.6 MMBtu/hr (1042 kW)
Electric Output: 250 kW
Electrical Efficiency: 26% (LHV)
Minimal Fuel Conditioning
Siloxane Removal Not Required
H2S tolerant (up to 6500 ppmv)
NOx Emissions < 1 ppmv (no catalyst)

FP250 at Schinnen Landfill
Robust Reliable Dresser-Rand KG2-3G Gas Turbine

• All Radial; Single Shaft
• Cold End Drive
• Capacity: 2 MW ISO Shaft
• Efficiency: 25%

• KG2-3G Off Base Combustor
• Standard Configuration
• Flanges for Oxidizer Interface
KG2-3G/GO Configurations: Simple Cycle and Recuperated

Simple Cycle KG2-3G/GO (High Exhaust Heat)
Gas Energy Input: 25 MMBtu/hr (7300 kW)
Electric Output: 1750 kW
Steam Output: 12,667 lb/hr (3804 kW)
Overall efficiency: 76% (LHV)

Recuperated KG2-3G/GO (High Electrical Efficiency)
Gas Energy Input: 17 MMBtu/hr (5000 kW)
Electric Output: 1750 kW
Electrical efficiency: 35% (LHV)
Overall efficiency: 70% (LHV) (with 6 MMBtu/hr of hot water)

Minimal Fuel Conditioning; No Siloxane Removal Required; H2S up to 15,000 ppmv
Fueling Strategies

If 30% to 100% CH₄
• Ultra Low Emissions - Injected prior the Oxidizer

If < 30% CH₄
• Low BTU fuel can be introduced directly into the compressor inlet
• Independent of the strategy NOₓ < 1ppm
Two Product Configurations for Site Gas Use Solution

Ener-Core Powerstation Operating Range

Aspirated Configuration
All gas is diluted to ~15 Btu/scf for use by mixing gas (Aspirating) with Powerstation inlet air

<30% CH4

Direct Inject Configuration
Fuel gas can be externally pressurized with nominal parasitic load and delivered directly into (Direct Injection) the Gradual Oxidizer for near zero emissions

>30% CH4

Oil Fields
Tail Gas
High CO2 Associated Gas
Natural Gas
Associated Gas

Biogas
Perimeter Gas
Closed Landfills
Active Landfills
Digester Gas

Coal Mine
VAM
Abandoned
Seams/Beds/Closed/Active

Gas Calorific Value Btu/scf

OTCQB: ENCR
## Fort Benning 3rd Party Emissions Test Summary

### 2.0 RESULTS
This section presents the sampling results in tabular form. Detailed sampling results and example calculations for the test program can be found in Appendix 1.

### 2.1 Summary of Results
Table 3 presents a summary of the results from the sampling performed at the Flex Powerstation™ inlet and exhaust on October 17, 2012.

### Table 3 - Summary of Results – Flex Powerstation™, October 17, 2012

<table>
<thead>
<tr>
<th>Run</th>
<th>Time</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inlet</td>
<td>Outlet</td>
<td>Inlet</td>
<td>Outlet</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0757-0856</td>
<td>0.61</td>
<td>0.019</td>
<td>0.019</td>
<td>4.51</td>
<td>0.016</td>
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<tr>
<td>0916-1015</td>
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<td>0.0052</td>
<td>0.0052</td>
<td>0.076</td>
<td>0.011</td>
</tr>
<tr>
<td>1034-1133</td>
<td>0.17</td>
<td>0.007</td>
<td>0.007</td>
<td>4.53</td>
<td>0.077</td>
</tr>
<tr>
<td></td>
<td>0.06</td>
<td>0.002</td>
<td>0.002</td>
<td>4.40</td>
<td>0.074</td>
</tr>
</tbody>
</table>

### Test Date: October 17, 2012
- **Emission Tester:** Integrity Air who was selected by Southern Research Institute
- **Configuration:** Aspirated configuration where gas is sprayed into inlet of gas turbine.
- **Results Summary:** Low NOx achieved. CO and NMOC levels were impacted by leakage flow which bypasses oxidizer.
- **Leakage flow:** Originates in compressor then flows to the turbine seals. It is not processed by oxidizer, thus raising CO and NMOC emissions.

### Notes:
- **NMOC** = VOC minus methane.
- **DEI, %** = ((Outlet Value - Inlet Value) / Inlet Value) * 100.
Ft Benning Landfill Low Btu - Aspirated

Certified Test Data Summary from Ft Benning Project

Leakage through turbine 0.09%

Destruction efficiency
Overall – 99.992%
NMOC – 99.97%

Destruction efficiency
Overall – 99.997%
NMOC – 99.6%
Ultra-Low Btu Test for Oil & Gas Customer

- Customer is interested in utilizing Ener-Core’s Oxidation technology to generate clean power from a casing gas emitted during a proprietary in-situ combustion oil extraction process.
- The purpose of the project was to test a simulated low BTU fuel (~75 BTU/scf) with the Ener-Core test unit.

<table>
<thead>
<tr>
<th></th>
<th>1st Condition</th>
<th>2nd Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane (CH4)</td>
<td>7.75%</td>
<td>5.80%</td>
</tr>
<tr>
<td>Nitrogen (N2)</td>
<td>84.20%</td>
<td>91.15%</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>8.00%</td>
<td>3.00%</td>
</tr>
<tr>
<td>LHV (Btu/scf)</td>
<td>71</td>
<td>53</td>
</tr>
<tr>
<td>Steady run time (hr)</td>
<td>5.5</td>
<td>3</td>
</tr>
</tbody>
</table>

Ener-Core Test Machine at UC Irvine Campus
Ultra-Low Btu Test Emissions Sampling Results

Expected Emissions for Direct Inject (Low Emissions) configuration

Test 1
- 7.75% Methane
- 84.2% Nitrogen
- 8% Carbon Dioxide
- 2715 scfm air
- Simulated fuel 735 scfm 71bhv/df
- Cooling Flow Leakage 1.5%
- Air Inlet
- 1.65% CH4
- Balance of Air/CO2/N2
- Gradual Oxidizer
- <1 ppm CH4
- <1 ppm NOx
- <1 ppm CO
- Gas Turbine
- 140 ppm CH4
- <37 ppm CO
- <1 ppm NOx
- Balance of Air
- Measured 98.85% Organics Destruction Efficiency

Test 2
- 5.8% Methane
- 91.2% Nitrogen
- 3% Carbon Dioxide
- 2470 scfm air
- Simulated fuel 982 scfm 53bhv/df
- Cooling Flow Leakage 1.5%
- Air Inlet
- 1.65% CH4
- Balance of Air/CO2/N2
- Gradual Oxidizer
- <1 ppm CH4
- <1 ppm NOx
- <1 ppm CO
- Gas Turbine
- 150 ppm CH4
- <34 ppm CO
- <1 ppm NOx
- Balance of Air
- Measured 98.8% Organics Destruction Efficiency

99.99% Gas Destruction Efficiency
Attero Landfill – Schinnenen, Netherlands

- Closed landfill with below 30% methane; past problems with reciprocating engines running inconsistently and unable to run on gas
- First Commercially sold unit
- 250kW oxidizer powerstation was successfully installed and is currently operating continuously
- 250 kW oxidizer powerstation generates about 50% more electricity (kWhs) per week than reciprocating engine it replaced
- Has accrued over 1500 hours since commissioning in 2014

FP250 at Schinnen Landfill
Watch our Whiteboard video explaining the gradual oxidation process and its applications

https://www.youtube.com/watch?v=YlwJNOF-SQU