Reducing Operating Costs by Over 35% at a CAT 3520 LFGTE Facility

LMOP 2014
Mark Hill - Regional Operations Director
DTE Biomass Energy is a subsidiary of DTE Energy and owns/operates landfill gas to energy projects nationwide.

- DTE Energy is an $9 billion/yr S&P 500 company.
- DTE Biomass Energy owns and operates landfill gas to electricity, direct use, and high-BTU sites across the country. These sites include (12) CAT 3520 engines.
- DTE Biomass Energy has internal financing, construction, wellfield operations, and plant operations capabilities.
- 30 MW of new landfill gas to electricity capacity coming online in 2014.
The Spoiler Slide

Cost Reduction Percentage 2010 to 2013
CAT 3520 Site
0-100 Scale  2010 = 100

- Spark Plugs: 32% (68% Cost Savings)
- Oil: 34% (66% Cost Savings)
- Major Maintenance*: 51% (49% Cost Savings)
- Turbos: 35% (63% Cost Savings)

On-stream Rate increase from 93.2% (2010) to 96.2% (2013)

*Includes Cylinder Head Cleanings, Top-end Overhuals, In-frame Overhuals, and Major Overhuals

Results of Oil Trial and Better Oil Management
Agenda

• Spark Plug Program

• Oil Program (Infineum Trial Oil)

• Major Maintenance Cost Savings

• Turbo Cost reductions

• Recruiting the Right People
Study Objectives

1. Determine best spark plug type
2. Determine best cleaning practices
3. Determine best gapping scheme based on LFG and engine conditions

A study was done comparing different spark plug performance under different cleaning intervals to determine the lowest cost per operating hour plug.

A box of $11,000 worth of dirty spark plugs found in a cabinet.
Trials have shown that spark plug life of over 3,000 hours is achievable. Spark plug changes were timed with other maintenance to reduce engine down-time.

### Spark Plug Set #1

<table>
<thead>
<tr>
<th>Run #</th>
<th>Run life (hrs)</th>
<th>Total Plug Life (hrs)</th>
<th>Reason for change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 1</td>
<td>523</td>
<td>523</td>
<td>Estimate 1/2 life of oil</td>
</tr>
<tr>
<td>Run 2</td>
<td>666</td>
<td>1189</td>
<td>Oil change</td>
</tr>
<tr>
<td>Run 3</td>
<td>620</td>
<td>1809</td>
<td>Estimated 1/2 life of oil change</td>
</tr>
<tr>
<td>Run 4</td>
<td>601</td>
<td>2410</td>
<td>Oil Change</td>
</tr>
<tr>
<td>Run 5</td>
<td>528</td>
<td>2938</td>
<td>2 Failures</td>
</tr>
<tr>
<td>Run 6</td>
<td>87</td>
<td>3025</td>
<td>Top-end interval</td>
</tr>
<tr>
<td>Run 7</td>
<td>429</td>
<td>3454</td>
<td>Frequent failure - end of life</td>
</tr>
</tbody>
</table>

### Spark Plug Set #2

<table>
<thead>
<tr>
<th>Run #</th>
<th>Run life (hrs)</th>
<th>Total Plug Life (hrs)</th>
<th>Reason for change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 1</td>
<td>525</td>
<td>525</td>
<td>Estimate 1/2 life of oil</td>
</tr>
<tr>
<td>Run 2</td>
<td>304</td>
<td>829</td>
<td>Estimate 1/2 life of oil</td>
</tr>
<tr>
<td>Run 3</td>
<td>673</td>
<td>1502</td>
<td>Oil Change</td>
</tr>
<tr>
<td>Run 4</td>
<td>561</td>
<td>2063</td>
<td>Oil Change</td>
</tr>
<tr>
<td>Run 5</td>
<td>282</td>
<td>2345</td>
<td>Other maintenance issues</td>
</tr>
<tr>
<td>Run 6</td>
<td>535</td>
<td>2880</td>
<td>Estimate 1/2 life of oil</td>
</tr>
<tr>
<td>Run 7</td>
<td>87</td>
<td>2967</td>
<td>Top-end interval</td>
</tr>
<tr>
<td>Run 8</td>
<td>453</td>
<td>3420</td>
<td>Frequent failure - end of life</td>
</tr>
</tbody>
</table>

Current single plug record holder – 4,200+ hours (porcelain failure)
Cleaning spark plugs takes about 3 minutes per plug and requires less than $1000 in tools.

1. Determine when plugs need cleaning (frequent failures or high transformer temps)
2. Shutdown engine– change plugs using ½ inch impact gun
3. Bead blast using #8 glass bead
4. Clean threads with wire wheel
5. Tap ground strap flush against electrode to ensure highest point of electrode is where spark occurs
6. Re-gap to .007” to .011” depending on methane quality and engine temperature
7. Discard if frequent failures
A change in spark plug philosophy from “use and toss” to experimentation to find the best value plug and the best re-use techniques led to a 68% decline in spark plug costs.

<table>
<thead>
<tr>
<th>2010 Situation</th>
<th>2013 Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM Spark Plug</td>
<td>3rd Party Spark Plug</td>
</tr>
<tr>
<td>Change at 1,000 hrs</td>
<td>Change based on transformer voltage</td>
</tr>
<tr>
<td>Throw plugs away</td>
<td>Clean and Re-use</td>
</tr>
<tr>
<td>No Gap Changes</td>
<td>Re-gapping based on methane levels</td>
</tr>
<tr>
<td></td>
<td>and other considerations</td>
</tr>
</tbody>
</table>

Drivers of 68% lower Spark Plug costs:
- 35% Lower Spark Plug Pricing
- 65% Extend Spark Plug Life
Agenda

• Spark Plug Program

• Oil Program (Infineum Trial Oil)

• Major Maintenance Cost Savings

• Turbo Cost reductions

• Recruiting the Right People
Oil sampling evolved from a monthly test report from the oil vendor to a weekly program designed to diagnose problems early.

<table>
<thead>
<tr>
<th>2010 Situation</th>
<th>2013 Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Oil Sampling</td>
<td>Weekly Oil Sampling</td>
</tr>
<tr>
<td>Oil Vendor Testing</td>
<td>3rd Party Testing</td>
</tr>
<tr>
<td>Oil changes based on expected interval (up to 5,000 hours)</td>
<td>Oil changes based on condemning limits in oil testing</td>
</tr>
<tr>
<td>Synthetic Oil</td>
<td>Non-synthetic oils</td>
</tr>
<tr>
<td>Un-trained technicians</td>
<td>Trained Subject Matter Experts</td>
</tr>
</tbody>
</table>
Both the salicylate “head” and long linear “tail” of the unique Infineum detergent contribute to the deposit control and acid neutralization required for LFGTE performance.
Better control of cylinder head deposits, due to enhanced detergent technology, reduces valve torching and increases time required between top-end overhauls.

Reference Oil 1
4028 hours

Reference Oil 2
4730 hours

Infineum Oil
8024 hours
Control of Acid Number Increase reduces corrosion and suggests possibility to increase oil change interval (for this test, oil change interval was kept constant for all oils).
By switching from synthetic oil to conventional oil (and eventually the Infineum Oil), oil costs dropped by 66% from 2010 to 2013.

Drivers of 66% reduction in engine oil costs:

- Lower Oil Pricing: 98%
- Less Oil Usage: 2%

While the savings from lower conventional oil pricing was expected, the drop in oil consumption was not. While synthetic oil was run 5 times longer than conventional oil between changes, the daily burn was 5 gallons per day with synthetic oil instead of 2 gallons per day with conventional oil. Switching to conventional oil actually decreased the amount of oil used.
Agenda

• Spark Plug Program

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• Recruiting the Right People
The Infineum oil, combined with better tuning and oil change intervals, has led to significantly better major maintenance cycles.

<table>
<thead>
<tr>
<th>Major Maintenance Cycle</th>
<th>Engine Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000 48,000</td>
</tr>
<tr>
<td>Shortened Cycle (2010)</td>
<td><strong>T</strong> <strong>T</strong> <strong>I</strong> <strong>C</strong> <strong>T</strong> <strong>I</strong> <strong>C</strong> <strong>T</strong> <strong>M</strong> <strong>C</strong> <strong>T</strong> <strong>I</strong></td>
</tr>
<tr>
<td>CAT Recommended Cycle</td>
<td><strong>T</strong> <strong>T</strong> <strong>I</strong> <strong>T</strong> <strong>M</strong> <strong>T</strong></td>
</tr>
<tr>
<td>Extended Cycle (2013)</td>
<td><strong>T</strong> <strong>T</strong> <strong>I</strong> <strong>T</strong> <strong>T</strong> <strong>M</strong></td>
</tr>
</tbody>
</table>

**C** – Cleaning of Heads  **T** – Top-End Overhaul  **I** – Inframe Overhaul  **M** – Major Overhaul

- Changing oil before condemning limits and using Infineum oil removed the need for cylinder head cleaning and restored the cylinder pack life to 24,000 hours.
- After inspecting the crank, decision was made to push major overhaul to 48,000 hrs to maximize the 24,000 hr life of the cylinder packs.
- Pushing top-end overhauls past 8,000 hrs has little benefit if you can’t also push the in-frame overhaul and major overhaul life out as well.
In addition to extending the maintenance intervals, DTE Biomass examined the part cost and time associated with the major maintenance

“Pit stop style” top-end overhauls with pre-positioned parts, tools and rehearsed jobs

**Work is DTE Biomass Energy led**

**2010 Situation**

**Labor Costs**
48hrs of 3 OEM Techs (Four 12 hour day/night shifts)
36hrs of 2 DTE Techs (Three 12 day hours shifts)

**Engine Down Time**
Approx. 55-72 hours

**2013 Situation**

**Labor Costs**
24hrs of 2 OEM Techs (Two 12 day hour shifts)
24hrs of 3 DTE Techs (Two 12 day hours shifts)

**Engine Down Time**
Approx. 30-40 hours (Record of 18 hours)
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Turbo Costs were reduced by 63% through remanufacturing turbos rather than returning them to OEM and running the turbos past the OEM recommended 8,000 hrs.

<table>
<thead>
<tr>
<th>2010 Situation</th>
<th>2013 Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changed turbos every 8,000 hours</td>
<td>Changed turbos every 11,000-23,000 hrs</td>
</tr>
<tr>
<td>Only changed OEM cartridges</td>
<td>3rd Party remanufactured housing and turbo</td>
</tr>
</tbody>
</table>

Drivers of 63% reduction in turbo costs:
- 23% Cost savings by remanufacturing turbos
- 77% Cost savings running turbos past 8,000 hrs

Turbo exhaust blades coated in siloxane after 13,000 hrs
Agenda

• Spark Plug Program
• Oil Program (Infineum Trial Oil)
• Major Maintenance Cost Savings
• Turbo Cost Reductions
• Recruiting the Right People
None of the above improvements are secrets – they were all common sense and were Technician Driven. Hiring the right people is the most important activity any manager does.

DTE Biomass continuously recruits and has developed a 3 interview process that selects fewer than 10% of those who interview

We are proud to have hired 5 veterans in the past year – bringing our operations workforce to 50% military veteran
DTE Biomass Energy continues to use cost saving techniques in its new plants, allowing profitable partnerships with host landfills.

Uwharrie National Forest – North Carolina

(6) CAT 3520 LFGTE project under construction – 10 MW of electric production online in Spring 2014
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