Emulsified Fuels in Western Europe – An Overview

ARB/CEC Alternative Fuel Symposium
The ADEPT Group, Inc.
Mr. Alex Spataru

Aug 19, 2003
What are Water - Emulsified Fuels?

- Adding water to diesel dates back to the early 1900’s. There are hundreds of patents issued on water-diesel blends.

- Emulsified diesels are defined as emulsions of water in diesel.
- Typically made of 10-20% mass/mass water mixed with specific additives.
How do emulsified diesels work? And with what results?

- Water in diesel yields the following effects:
  - Water vaporization increases fuel dispersion in the form of smaller droplets.
  - Contact surface between fuel and air is increased.
  - Combustion is more efficient.

- Net results:
  - Reduces combustion temperature peaks (lowers NOx).
  - Particulate formation is reduced (lowers PM).
What are the benefits?

- Lower emissions:
  - Up to 25% NOx reduction.
  - Up to 60% PM reduction.
  - Up to 80% smoke reduction.
  - Up to 5% CO₂ reduction.

- Better lubricity.

- Increased thermal efficiency.

*Emulsified diesel is only emission-control fuel technology that simultaneously lowers both PM and NOx.*
Qualification of emissions reduction advantages.

- The magnitude of the emissions reductions advantage from emulsified diesels is a function of:
  - Engine type,
  - Operating conditions,
  - Properties of the baseline diesel fuel, and
  - Properties of the diesel fuel that is blended into the emulsion.
### European vs. EPA NOx and PM requirements for HD Diesel engines

<table>
<thead>
<tr>
<th></th>
<th>European Standards (g/bhp-hr)</th>
<th>EPA Standards (g/bhp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>5.22</td>
<td>3.73</td>
</tr>
<tr>
<td>PM</td>
<td>0.11</td>
<td>0.07</td>
</tr>
</tbody>
</table>

1. Test Cycle ECE R-49.
2. Test Cycle ESC, ELR.
3. For regular engines.
4. For urban buses.
5. NOx + HC at 2.5 g/bhp-hr; HC contribution cannot exceed 0.5 g/bhp-hr.
European emulsified fuel applications

- **On-Road**
  - Public fleets.
  - Mass transit fleets.
  - Private fleets.
  - Garbage collection fleets.

- **Off-Road**
  - Marine engines.
  - Locomotives.
  - Power generation.
  - Construction equipment.

- **Other**
  - Large institutional combined heat sites (apartment complexes, hospitals, universities, etc).
  - Industrial boilers.
Emulsified diesel providers in Europe

- There are four (4) companies who commercially sell emulsified diesels in Europe.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Distribution Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cam Tecnologie*</td>
<td>With own fuel</td>
</tr>
<tr>
<td>2. Clean Fuels Technology</td>
<td>Additives Package + System</td>
</tr>
<tr>
<td>3. Lubrizol*</td>
<td>Additives Package + System</td>
</tr>
<tr>
<td>4. TOTAL*</td>
<td>With own fuel</td>
</tr>
</tbody>
</table>

* Members of the European Emulsified Fuel Manufacturers’ Association (EEFMA)
EEFMA* Objectives

- Promote the market image of emulsion fuels in Europe.
- Identify and seek to remove market barriers.
- Define and maintain high standards within the industry.

* European Emulsified Fuel Manufacturers’ Association (EEFMA)
EEFMA’s Goals

- EEFMA’s market barrier removal goals are:
  - Unified European standard for emulsified diesels,
  - Favorable and unique fiscal treatment across the European Community.
# Emulsified diesel technology providers

<table>
<thead>
<tr>
<th>Company</th>
<th>Based in</th>
<th>Countries where sold</th>
<th>In-Field Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAM Tecnologie</td>
<td>Pero (MI), Italy</td>
<td>France, Italy, Switzerland</td>
<td>5 yrs</td>
</tr>
<tr>
<td>Clean Fuels Technology</td>
<td>Reno, NV, USA</td>
<td>Italy</td>
<td>10 yrs</td>
</tr>
<tr>
<td>Lubrizol</td>
<td>Wickliffe, OH, USA</td>
<td>Italy, UK</td>
<td>3 yrs</td>
</tr>
<tr>
<td>TOTAL</td>
<td>Paris, France</td>
<td>France, Italy</td>
<td>8 yrs</td>
</tr>
</tbody>
</table>
## Products overview

<table>
<thead>
<tr>
<th>Company</th>
<th>Product Name</th>
<th>Distributor/s</th>
<th>OEM Warrantee*</th>
<th>Water Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Fuels Technology</td>
<td>Aquadisel</td>
<td>IPLOM S.p.A.</td>
<td></td>
<td>13%</td>
</tr>
<tr>
<td>Lubrizol</td>
<td>PuriNOx™, Qwhite, Aspira</td>
<td>BP, Q8, Blanco Petrol, Green Oils, Kuwait Petroleum Italia</td>
<td>Mack, Caterpillar, Man</td>
<td>10-20%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>Aquazole™</td>
<td>Own network</td>
<td>Irisbus, Iveco, Scania, Man</td>
<td>14-17%</td>
</tr>
</tbody>
</table>

* On Engine and/or Vehicles; not exhaustive.
Equipment related market barriers*:

- Limited acceptance by engine manufacturers.
- Limited acceptance by equipment manufacturers.
- Limited acceptance due to lack of a European standard.
- Limited fleet acceptance.

* as reported by EEFMA.
Fiscal regimes in seven (7) European countries.

<table>
<thead>
<tr>
<th>Favorable</th>
<th>Neutral</th>
<th>Unfavorable</th>
</tr>
</thead>
<tbody>
<tr>
<td>France* Italy*</td>
<td>UK Switzerland Netherlands</td>
<td>Germany Spain</td>
</tr>
<tr>
<td>Special fiscal classification</td>
<td>No tax on water content</td>
<td>Taxed as diesel fuel</td>
</tr>
</tbody>
</table>

*National Standard established*
The Italian model

- Tax incentive* - 36%
- Bus and Coach market size ~ 34,200
- Running on emulsified diesels ~ 8,100
- Bus and Coach market share ~ 24%

* Italian taxes on diesel fuel are ~ 5.7 x U.S. taxes
Mass Transit use: Emulsified diesels in Europe vs. Natural Gas in U.S.

<table>
<thead>
<tr>
<th></th>
<th>Part of Europe: (France, Italy, UK, Switzerland)</th>
<th>U.S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Mass Transit Buses</strong></td>
<td>~9,900 on Emulsified Diesel</td>
<td>~ 7,300 on Natural Gas (~6,200 on CNG; ~1,000 on LNG)*</td>
</tr>
<tr>
<td><strong>Total Population</strong></td>
<td>~ 180 M</td>
<td>~ 290 M</td>
</tr>
</tbody>
</table>

* Source: American Public Transportation Association
There are ~ 36% more buses (9,900 vs. 7,300) on emulsified diesels in four European countries than in the entire U.S. on both CNG and LNG.

Conversion of mass transit fleets in Europe to emulsified diesels was conducted at lower cost than equivalent U.S. conversion to CNG and LNG.
Remaining emulsified diesel challenges

- Shelf life (stability).
- Power loss.
- Torque loss.
- Compliance with new engine technologies (Common rail, EGR).
- Extension to individual vehicle use (intermittent miscibility with regular diesel).
Europe vs. US comparison

- Diesel use is more prevalent in Europe.
- Fuel costs are higher in Europe (due mainly to much higher taxes).
- Impending EEC-wide tax incentive/s for use of emulsified diesel.
- $\text{CO}_2$ is a European primary air quality concern.
- There is nothing like EEFMA in the U.S.
Pertinent trends

- Much $ will continue to be spent on R&D to:
  - Satisfy engine manufacturers requirements for warrantee coverage.
  - Address Common Rail and/or EGR challenges.
  - Develop intermittent miscibility with diesel capability for use by non-fleet vehicles.
- Sustained growth due to increased competition in Europe and to synergies between European, US and Asian markets*.
- Harmonization of European and North American Standards.

*3 out of 4 entities are active in both Europe and North America.
Q & A