Fuel testing in a new age

26 November 2020 • 09:00-09:45 GMT

Panellist documents:

Page 2: Joshua Townley, Innospec
Page 16: Tracy Wardell, Intertek Lintec
Page 24: Steve Bee, Veritas Petroleum Services
VLSFO QUALITY IN PRACTICE
Joshua Townley, Market Specialist Marine

MARINE FUEL SPECIALTIES
Enhancing your fleet performance
VLSFO PROBLEM DISTRIBUTION

Fault Distribution

- Engine Damage: 14%
  - Liner wear
  - Piston ring breakage
  - Scavenge fire
  - Injector failure

- Handling: 59%
  - Purifier breakdown
  - Separation failure
  - Filter blocking
  - Fuel starvation

- Storage: 7%
  - Un-pumpable tanks
  - Excessive sludge
  - Wax formation
  - Co-mingling

- Cold flow: 2%
- Solids in tanks: 7%
- Blocked filters: 18%
- Separation failure: 59%

Legend:
- Blocked filters
- Cold flow
- Engine Damage
- Separation failure
- Solids in tanks
DENSITY VS. ISSUES

- Engine damage occurs when using higher density fuels
- Separation failure is seen across all density ranges, most commonly at lower densities
- Solids in tanks seen above 940 kg/m$^3$
- Filter blocking seen across all density ranges

MARINE FUEL SPECIALTIES
Enhancing your fleet performance

Solids in tanks
Seperation Failure
Engine Damage
Blocked filters

kg/m$^3$
VISCOSITY VS. ISSUES

- Lower viscosities see far more issues, mostly through blocked filters and separation failure.
- High viscosities see more engine damage.
TSP VS. ISSUES

Frequency

TSP (%M/M)

0-0.02 0.02-0.04 0.04-0.06 0.06-0.08 0.08-0.1 0.1-0.12 0.12-0.14 0.14-0.16 0.18-0.2 >0.2
FUEL QUALITY: VLSFO VS TYPICAL HSFO

Combustion Profile - Residual fuels

<table>
<thead>
<tr>
<th>Sample</th>
<th>Bunkering Port</th>
<th>Comment</th>
<th>Sulfur (%)</th>
<th>CCAI</th>
<th>Al+Sppm</th>
<th>Asphaltene (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BFO-S</td>
<td>Singapore</td>
<td>non-trouble</td>
<td>3.5</td>
<td>852</td>
<td>&lt;20</td>
<td>9.5</td>
</tr>
<tr>
<td>BFO-A</td>
<td>Los Angeles</td>
<td>scuffing for (2-stroke) container ships</td>
<td>1.3</td>
<td>849</td>
<td>&lt;20</td>
<td>4.6</td>
</tr>
</tbody>
</table>
The distribution of key combustion characteristics of (25) ISO 8217 compliant VLSFOs from around the world. The Y-axis represents units in Milliseconds (ms) except ECN, which is an index figure.
A DIFFERENT MAKEUP

Residual Marine Fuel - Composition

**Paraffinic** – straight chain hydrocarbons, often from secondary refinery streams. Paraffins are prone to rapid oxidation when heated, or drop out as wax in low temperatures. Octamar™ HF products prevents oxidisation and stabilises these components for a more homogenous fuel.

**Aromatics** – Similar benzene ring structures. Asphaltenes can remain stable when surrounded by an aromatic portion (Resins, Aromatics) over extended time periods however, in the presence of a significant paraffin mixture, the Asphaltenes begin to ‘agglomerate’; growing larger to form sludge in tanks, or attributing to poor combustion. Octamar™ HF products targets and protects vulnerable Asphaltenes.

Typical blend ratios of modern residual marine fuels show a much higher proportion of the saturate (paraffinic) component in combination with aromatics, which are structurally dissimilar, causing separation and instability.
BIO FUELS

Medium to long term

- Biofuels (Predominantly FAME) are considered to be the drop in fuel solution, particularly for older tonnage.
- It is not feasible to supply the whole market with Bio products, nor is it possible to supply bio to the marine market that meets EN14214 (spec for B100, FAME blend component in automotive fuel).
- ISO is evaluating current and future biofuels and considering allowing Biofuels into table 2 of 8217, this a separate discussion looking at technical aspects only not considering legislative challenges of Biofuels.
- We have generations of experience treating Biofuels and overcoming their limitations, including:
  - a tendency to oxidise leading to long-term storage issues
  - an affinity to water and risk of microbial growth
  - degraded low-temperature flow properties
  - FAME material deposition on exposed surfaces, including filter elements
- Octamar™ HF-10 Plus was developed for a lower sulphur future, and is BIOFUEL ready.
LABORATORY TESTS - AGED VLSFO

- 30 ml samples of two VLSFO
- Heated at 100°C for 24 hours
- Significant Asphaltenes drop out after only 24 hours

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Pre-treated RSN</th>
<th>Treated RSN</th>
<th>Saturates(%)</th>
<th>Aromatics(%)</th>
<th>Resins(%)</th>
<th>Asphaltenes(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLSFO 1</td>
<td>10.8</td>
<td>2.4</td>
<td>81.53</td>
<td>7.10</td>
<td>6.96</td>
<td>4.41</td>
</tr>
<tr>
<td>VLSFO 2</td>
<td>3.95</td>
<td>0.4</td>
<td>28.56</td>
<td>44.36</td>
<td>17.97</td>
<td>9.10</td>
</tr>
</tbody>
</table>
LABORATORY TESTS – MIXED VLSFO - AGED

- 50:50 blend of two VLSFO fuel
- Heated at 100°C for 24 hours
- 13% of the fuel turned into a solid sludge at the bottom

50:50 Blend of VLSFO 1 + 2 after 24 hours at 100°C
LABORATORY TESTS – TREATED WITH OCTAMAR™ HF-10 PLUS

50:50 blend treated with 66 ppm OCTAMAR™ HF-10 PLUS aged for 24 hours at 100°C
INNOSPEC

- The world’s largest fuel specialists covering multiple industries
- 100+ fuel and fuel blends tested with >90% improvement in SN
- Lowest reliable dose rate, for the best results at the lowest treat rate per tonne

<table>
<thead>
<tr>
<th></th>
<th>Concentration</th>
<th>Treat rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Octamar™ HF-10 PLUS</td>
<td>66 ppm</td>
<td>1 litre doses 15,000 litres</td>
</tr>
<tr>
<td>Other additives</td>
<td>166 ppm and above</td>
<td>1 litre doses &lt; 6,000 litres</td>
</tr>
</tbody>
</table>
THANK YOU!

MARINE FUEL SPECIALTIES
Enhancing your fleet performance
IMO 2020
ADAPTING TO THE NEW ‘NORM’

Tracy Wardell, Global Technical Manager
MARINE FUEL LANDSCAPE
FUEL QUALITY – RECENT TRENDS

<table>
<thead>
<tr>
<th></th>
<th>2018 Average</th>
<th>2019 Average</th>
<th>Q1 2020</th>
<th>Q2 2020</th>
<th>Q3 2020</th>
<th>Q4 2020 TD</th>
</tr>
</thead>
<tbody>
<tr>
<td>% within 95%</td>
<td>9.7</td>
<td>8.6</td>
<td>4.1</td>
<td>2.8</td>
<td>3.2</td>
<td>4.9</td>
</tr>
<tr>
<td>% Off-spec</td>
<td>6.0</td>
<td>5.8</td>
<td>4.2</td>
<td>3.8</td>
<td>4.1</td>
<td>4.0</td>
</tr>
</tbody>
</table>
OFFSPECIFICATION SEDIMENT TREND

2020 YTD

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov
OPERATIONAL ISSUES

YTD
• Piston ring failure & cylinder liner damage
• Deterioration of rubber seals
• Deposition of solids on cylinder head
• Fuels reported having unusual odour

CONTINUING
• Sludging during purification
• Cold flow issues
• Microbial contamination

<table>
<thead>
<tr>
<th>Sample</th>
<th>Pour point (°C)</th>
<th>WAT (°C)</th>
<th>WDT (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-15</td>
<td>30.9</td>
<td>57.6</td>
</tr>
<tr>
<td>2</td>
<td>-6</td>
<td>40.5</td>
<td>59.3</td>
</tr>
<tr>
<td>3</td>
<td>-15</td>
<td>51.5</td>
<td>70.0</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>39</td>
<td>54.8</td>
</tr>
</tbody>
</table>
Future Fuels

• Steve Bee
• Group Commercial & Business Development Director
Biofuels

- Drive to cut CO₂ and Greenhouse Gas emissions:
  - Carbon Intensity in 2030: 40% of 2008 levels
  - Carbon Intensity in 2050: 70% of 2008 levels
  - Total CO₂ levels to reduce by 50% of 2008 levels by 2050

- These challenging targets will require low C-content, C-neutral and eventually C-free alternative fuels.

- Biofuels are gathering much greater interest.

- Source material: Fatty Acid Methyl Esters (FAME), Hydrogenated Vegetable Oil (HVO), or Hydro-processed Esters and Fatty Acids (HEFA).

- Using biofuels made from food crops? X

- Using waste materials, eg used cooking oil (UCO), or even algae, +

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low emissions, GHG, SOx, NOx.</td>
<td>Water contamination.</td>
</tr>
<tr>
<td>CO₂ reductions from 30%-80%</td>
<td>Microbial Growth.</td>
</tr>
<tr>
<td>Can use existing infrastructure and engines</td>
<td>Long-term Storage Issues</td>
</tr>
<tr>
<td>No retrofit CAPEX</td>
<td>Cost</td>
</tr>
<tr>
<td>Low environmental risk.</td>
<td></td>
</tr>
</tbody>
</table>
LNG

- LNG cuts CO₂ emissions by 25%. Reduces S-Oxides by 100%, and reduces NOx emissions by about 85%
- The infrastructure for distribution and supply has been relatively slow to develop, although improving.
- LNG is produced in different locations around the world
- Due to differences in natural gas sources, production technologies and the target markets for LNG, the composition may vary substantially
- Handling & Storage of LNG is more complicated than traditional fuels
- Run the risk of delivering Off-Spec LNG the longer LNG is in the supply chain due to BOG:
  - Boil-off rates depend on: Gas Composition, Temperature, Heat Transfer Rate, Residence time in supply chain, Operating pressure, Motion
- Methane Slip: Methane leaks unburned by the engine. Methane has a 20-year global warming potential (GWP20), which is 86x higher than CO₂.
- 2020 - 173 LNG-fueled vessels (exc LNG Carriers). 57 on order.

<table>
<thead>
<tr>
<th>Origin</th>
<th>Nitrogen N₂, %</th>
<th>Methane CH₄, %</th>
<th>Ethane C₂H₆, %</th>
<th>Propane C₃H₈, %</th>
<th>Butane C₄H₁₀, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia – Darwin</td>
<td>0.1</td>
<td>87.64</td>
<td>9.97</td>
<td>1.96</td>
<td>0.33</td>
</tr>
<tr>
<td>Algeria – Skikda</td>
<td>0.63</td>
<td>91.4</td>
<td>7.35</td>
<td>0.57</td>
<td>0.05</td>
</tr>
<tr>
<td>Algeria – Arzew</td>
<td>0.71</td>
<td>88.93</td>
<td>8.42</td>
<td>1.59</td>
<td>0.37</td>
</tr>
<tr>
<td>Brunei</td>
<td>0.04</td>
<td>90.12</td>
<td>5.34</td>
<td>3.02</td>
<td>1.48</td>
</tr>
<tr>
<td>Egypt – Iduku</td>
<td>0.02</td>
<td>95.31</td>
<td>3.58</td>
<td>0.74</td>
<td>0.34</td>
</tr>
<tr>
<td>Indonesia – Badak</td>
<td>0.01</td>
<td>90.14</td>
<td>5.46</td>
<td>2.98</td>
<td>1.40</td>
</tr>
<tr>
<td>Indonesia – Tangguh</td>
<td>0.13</td>
<td>96.91</td>
<td>2.37</td>
<td>0.44</td>
<td>0.15</td>
</tr>
<tr>
<td>Libya</td>
<td>0.59</td>
<td>82.57</td>
<td>12.62</td>
<td>3.56</td>
<td>0.65</td>
</tr>
<tr>
<td>Nigeria</td>
<td>0.03</td>
<td>91.7</td>
<td>5.52</td>
<td>2.17</td>
<td>0.58</td>
</tr>
<tr>
<td>USA – Alaska</td>
<td>0.17</td>
<td>99.71</td>
<td>0.09</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Bio LNG</td>
<td>~ 100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Methanol

- Methanol can be produced from a broad range of feedstocks. Eg natural gas, coal, bio-mass.
  - Can be produced by biomass - Bio-Methanol
  - Or via renewable energy - Renewable Methanol
- About 80million mt sold globally of which >25million mt used as fuel/energy.
- Compared to traditional fuels, methanol very low SO\(_x\), NO\(_x\), PM, low CO\(_2\) emissions
- Available worldwide
- Liquid at Atm pressure
- Bio-degradeable
- Runs well in existing engine technology
- Very low Flash Point: 11-12\(\degree\)C
- Lower energy content.
  - 50% of HFO energy
  - 45% of MGO energy
  - 40% of LNG energy.
Ammonia NH₃

- Ammonia is a compound of two elements - hydrogen and nitrogen - which can be bonded together easily using the Haber-Bosch process.
  - \[ \text{N}_2 + \text{H}_2 \rightarrow \text{NH}_3 \] at 300 bar, 400-500°C
- Brown Ammonia - From fossil fuels such as natural gas, coal
- Green Ammonia - From renewable energy
- Blue Ammonia - From Carbon capture and storage
- NH₃ is Carbon-free
- NH₃ can also be stored as a liquid below -33.4°C, at atmospheric pressure (1 bar), or room temp at 10 bar.
- NH₃ can be burned in an internal combustion engine. Requires a catalyst to partially break down the NH₃ to H₂ & N. The pure H₂ will burn with NH₃, forming H₂O, N & NOx.
  - 3 x volume of NH₃ to equal the energy of HFO.
  - NH₃ is 2 X heavier than HFO
  - NH₃ is Toxic
Hydrogen

• Efficient decarbonisation requires financially attractive options
• Industrialisation of the hydrogen electrolysis process is vital.
• Hydrogen is used in production of Ammonia & Methanol therefore a key component of green energy
• Regulating GHG emissions and fuel change will create hydrogen demand
• Need to produce Hydrogen in sufficient quantities and affordable pricing

• Pro’s
  • Carbon-free fuel
  • Zero emissions
  • Environmental attractiveness means high investment appetite

• Con’s
  • No infrastructure as yet.
  • Safety concerns, widely flammable, low ignition energy, highly reactive.
  • Storage at very high pressures or very low temperatures, or both
Thank you for your attention!

YOUR FUEL MANAGEMENT PARTNER

Steve.bee@v-p-s.com
+44 7500 848351