GREENER SHIPPING SUMMIT 2018

FUEL ADDITIVES – 2020 AND MOVING FORWARD

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Compliant Options

Fuel & Scrubber Options
• Use low-sulphur or ultra-low sulphur distillates (MGO)
• Use low-sulphur HFO, if and when it becomes available
• Install exhaust gas scrubber system and continue to use existing fuels

Additional Options
• Switch to LNG (fuel storage, transfer & injection changes)
• Switch to alternative fuel - i.e. methanol or hydrogen (fuel cells)
## Compliance: Fuel Quality vs. Scrubber

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>0.1 &amp; 0.5% sulphur</th>
<th>0.5% MGO &amp; DMA</th>
<th>LNG Retrofit</th>
<th>Fuel Scrubber Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operation</strong></td>
<td>Minimize Cost &amp;</td>
<td></td>
<td>Already a proven Technology; Substantial Reduction of NOx and SOx</td>
<td>Cheaper Fuel Allows a Quicker Return on Investment</td>
</tr>
<tr>
<td></td>
<td>Operational Difficulty</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Quality</strong></td>
<td>Quality Varies due to Different Fuel Blends per Supplier</td>
<td>Historical Operational Experience Throughout the Industry</td>
<td>Much Lower CO2 Emissions</td>
<td>Some Newer Technologies with Limited Experience Throughout the Industry</td>
</tr>
<tr>
<td><strong>Reliable Supply</strong></td>
<td>Few Suppliers can Guarantee a Reliable Supply</td>
<td>Higher Cost</td>
<td>Growing Availability, but Still Limited</td>
<td>Limited Space for Equipment; Connections to Existing Systems</td>
</tr>
<tr>
<td><strong>Globally</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operational Issues</strong></td>
<td>Potential Thermal Shock &amp; Lubricity Issues *</td>
<td>Potential Thermal Shock &amp; Lubricity Issues</td>
<td>Current Advantage compared to MGO / DMA Storage &amp; Handling</td>
<td>Sludge Removal and Disposal necessary</td>
</tr>
</tbody>
</table>

* Desulphurised Marine Gas Oil (Sulphur <0.05%) can have poor lubricity properties.
Potential issues and risks:

- Global shift from HFO with 3.5% sulphur to distillate with 0.5% sulphur
  - Triggers more fuel blending by suppliers
  - Associated higher fuel costs for sulphur removal
- Installation of Shipboard Scrubbers
  - Capital expense, but allows use of higher sulphur fuels
- Scrubber condition, performance and cost to operate
- Risk potential if sulphur levels are too high
  - Cost and voyage delay to debunker fuel
  - Potential monetary fines
Fuel Sludge Formation

- If it’s in your purifier, it’s in your tank

**Address it at the Source!**

**Costs/Revenue Loss**
- Sludge Removal
- Disposal
- Schedule Delay (ship out of service)

Initial Step:
• Ensure fuel storage tanks are stripped of HFO and remaining fuel sludge

Decision Criteria:
• Will vessel dry dock or have out-of-service time prior to January 2020 for tank cleaning?
• If “Yes”, early tank cleaning scheduling is recommended
• If “No”, alternative fuel tank cleaning will be needed and require:
  – Contracted tank cleaning service at pier side
  – Cost for cleaning service and waste disposal
  – Loss of revenue with the ship out of service
Cost-effective fuel tank cleaning during vessel operation

- Add fuel oil conditioner to bunker tanks while ship is in service
- Blend of... solvents (breakdown fuel sludge)
  - detergents (surface cleaning)
  - dispersants (mixing asphaltenes)
  - surfactants (prevent re-forming)
- Breaks down and disperses heavy hydrocarbon fractions
- Cleans fuel tanks and fuel system over time during vessel operation
- Monitor fuel purifier performance & cleaning frequency
- Move toward low sulphur fuel or ultra-low sulphur fuel
Fuel Switch-Over Preparation

- Fuel Tank Residue
  - Many ship tanks allow for up to 10% of unpumpable material to remain in storage tanks
  - Unpumpable material will contain asphaltenes, sludge and fuel contaminants (i.e. sulphur, sediment & cat fines)

- 3-Step Fuel Tank Preparation

<table>
<thead>
<tr>
<th>Step</th>
<th>In Situ Tank Cleaning Procedure</th>
<th>Typical Dosage Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prior to the next HSFO bunkering, treat all nominated fuel tanks with fuel conditioner/sludge dispersant treatment</td>
<td>1 liter to 15 m³</td>
</tr>
<tr>
<td>2</td>
<td>Prior to subsequent HSFO bunkerings, retreat all nominated fuel tanks with fuel conditioner/sludge dispersant treatment</td>
<td>1 liter to 10 m³</td>
</tr>
<tr>
<td>3</td>
<td>Inspect at least one fuel tank that would be representative of the remaining tanks, prior to switching to VLSFO</td>
<td>Retreat if Necessary</td>
</tr>
</tbody>
</table>
Clean the Entire Fuel System

In addition to cleaning fuel storage tanks, be aware of other fuel system components may need cleaning:

- Fuel purifiers
- Fuel transfer pipes
- Settling tanks
- Strainers and fuel filters
- Fuel temperature gauges (correct range for new fuels)
Uncertainties Due to Fuel Regulation Changes

• How will uncertainties impact shipowners competitive position?
  – Scrubber technology cost
  – Scrubber wash water discharge cost
  – Available discharge reception facilities
  – Availability of compliant fuels
• Refinery production capacity investment based on market expectations and demand
• Refineries claim desulphurization is technically difficult and costly; that may discourage investment
Future Market Concerns

- Global availability of new low sulphur fuel blends
- Affected by refinery decision to support low sulphur initiative
  - Substantial investment to upgrade refinery equipment
  - Customer base and potential regional market
- Moderate/Heavy fractions (asphaltic) blended with lighter cutter stock (paraffinic) could result in compatibility issues
- Ultra-low sulphur fuel requires low TBN lube oils to reduce the potential for calcium deposits
- End user cost of low and ultra-low sulphur fuels
Types of Additives:

- Pre-Combustion Treatments
  - Demulsifiers (breakdown fuel-water emulsions)
  - Dispersants (prevents tank sludge formation and improves purifier separation)

- Bacteria Growth in Distillate Fuel during Storage
  - Fuel Microbiocides preventing Bacteria Growth

- Combustion Improvers
  - Organic or Organo-Metallic compounds improve fuel and oxygen mixing that improves combustion

- Post Combustion
  - Ash Modifiers to prevent sticking
# Fuel Additives for Today’s Fuels

<table>
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<tr>
<th>Product Type</th>
<th>Product Function</th>
<th>Application</th>
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<tbody>
<tr>
<td>Fuel Stabilizer Sludge Conditioner</td>
<td>Reduce Sludge Formation&lt;br&gt;Minimizes Fuel Instability and Incomptibility in Storage Tanks</td>
<td>Heavy Fuel Oil and Distillate Fuel Oil Storage Tanks</td>
</tr>
<tr>
<td>Low-Sulphur (0.5%) Fuel Conditioner</td>
<td>Minimizes Instability during Storage&lt;br&gt;Reduces Tank Sediment Formation&lt;br&gt;Provides Lubricity &amp; Reduces Wear</td>
<td>All Low Sulphur Fuel Oils Storage Tanks</td>
</tr>
<tr>
<td>Ultra-Low Sulphur (0.1%) Fuel Treatment</td>
<td>Prevent Deposits and Corrosion of Fuel Injectors&lt;br&gt;(ECA Compliant Fuels)</td>
<td>Prevent Fuel Injector Deposits and Corrosion</td>
</tr>
<tr>
<td>Combustion Improver and Deposit Modifier (organo-metallics)</td>
<td>Improves Combustion&lt;br&gt;Prevents Vanadium Deposits&lt;br&gt;Reduces Sulphur Trioxide Formation</td>
<td>Heavy Fuel Oil and Distillate Fuel Oil Storage Tanks</td>
</tr>
<tr>
<td>Exhaust Gas Deposit Modifier and Remover</td>
<td>Catalyzes Exhaust Gas Deposits&lt;br&gt;Prevents Deposit Formation</td>
<td>Exhaust Gas Boiler Economizer</td>
</tr>
<tr>
<td>Pour Point Depressant</td>
<td>Low Temperature Flow Improver</td>
<td>Marine Gas Oil Ultra-Low Sulphur Diesel</td>
</tr>
<tr>
<td>Fuel Microbiocide</td>
<td>Inhibits Microbiological Growth in Storage Tanks and Fuel Lines</td>
<td>Heavy Fuel Oil and Distillate Fuel Oil Storage Tanks</td>
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</table>
Fuel Homogenization

Shears Asphaltenes Homogenizes Fuel Improves Stability Improves Combustion

water droplet approx. 20 microns

asphalthene approx. 120 microns

Photographs by: Aerospace Science and Technology Research Center National Cheng Kung University (Tainan, Taiwan)
Drew Marine Products and Services

- Fuel Sampling During Bunkering
- Onboard Fuel Test Kits
- Chemical Fuel Additives
- In-line Fuel Homogenization
- Engine Performance Monitoring
Working in partnership to provide improved management and use of today’s fuels, leading to cleaner air now and in the future.

Leading Marine Fuel Additive Supplier

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