Emissions regulation compliance and low sulphur fuels

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Executive summary

- Context
- Compliance factors
- Alternative fuels
- Fuel switching & compatibility
- Port State Control
- Conclusions
Compliance factors

Alternative fuels

Fuel switching & compatibility

Port State Control

Conclusions
- Compliance factors
- Alternative fuels
- Fuel switching & compatibility
- Port State Control
- Conclusions
Risks & opportunities

- LNG Bunkering procedures
- MDO (Cheaper prices)
- Financial & logistic risks
- ECA compliance
- Others?
- Training crews
- SCRUB BER
- Risk of LOP!
How the shipping industry is reacting in ECA?

Solutions for ECA compliance

BRENT

$49.13

Day: 0.66  Week: 0.61  30-Day: -0.77

Solutions for ECA compliance
# Comparison of the different solutions in retrofit

<table>
<thead>
<tr>
<th>Compliance solution</th>
<th>CAPEX (equipt, installations &amp; dry dock immobilisation)</th>
<th>OPEX (fuel cost and additive if any)</th>
<th>Appropriateness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Gas Oil (MGO)</td>
<td>&gt; 200k€</td>
<td>&gt; 4 000k€/year</td>
<td>Short term when full time in SECA</td>
</tr>
<tr>
<td>Scrubbers</td>
<td>&gt;10 - 15 M€</td>
<td>&gt; 400k€/ year</td>
<td>Medium term : regulatory uncertainty</td>
</tr>
<tr>
<td>Installing Extra Batteries packs Li lon</td>
<td>Reduce size and power consumption of the scrubber</td>
<td>Lowering bunker consumption Lowering maintenance cost of the machinery</td>
<td>Medium – long term.</td>
</tr>
<tr>
<td>LNG as fuel</td>
<td>&gt; 30 - 40 M€</td>
<td>Depends on the difference of price from the MGO</td>
<td>Long term : High investment cost</td>
</tr>
</tbody>
</table>
The scrubber challenge on a RO PAX ferry

► Extra power consumption
  > 2 km additional pipes
  > 10 km additional electrical cable
The LNG challenge on a RO PAX ferry

► **Design** : Principle of segregation between gas dangerous spaces and safe spaces
  - No direct communication between gas spaces and non-hazardous spaces
  - Reinforced fire insulation of gas spaces (A60 + Cofferdam), structural reinforcements
  - Hazardous area classification
  - Segregation of piping systems

► **Operations** : Passengers onboard, not professionals by essence, to be informed strictly about hazardous zones (smoking areas...)
  - Simultaneous operation in bunkering QRA required to mitigate risk level / Restricted access for balconies, sun deck,
  - Quantity of LNG to be bunkered in allocated time
Other items to be installed or upgraded for LNG retrofit

- Mitigation of space devoted to LNG as fuel equipment vs available volume
- Minimization of the tank connection space
- Minimization of the tank pressure, thickness and weight of the tank with LNG pump
- Increase of the filling limit with BOG compressors
How to make the choice?

- Average monthly HFO consumption
- Yearly HFO consumption [T/year]
- Calorific value MDO
- Calorific heat value HFO
- Lower calorific heat value HFO versus MGO

SECA Compliance investment

LNG conversion investment

- Yearly gross saving with LNG
- Resell value of ship with LNG equipment

Scrubber installation cost plus extra dry docking

Resell value with scrubbers

Scrubber lifetime

Calorific value pr. year HFO • kJ/year

LNG resell value of ship with LNG equipment
- Compliance factors
- Alternative fuels: LNG
- Fuel switching & compatibility
- Port State Control
- Conclusions
GTL is a fuel obtained from refining process and therefore is considered as analogous as a conventional crude oil derived fuel, regulated under MARPOL Annex I.
LNG as fuel is one of the solutions for reducing air emissions

- NOx emissions reduced by more than 80% (for lean burn engines)
- SOx emissions eliminated (no sulphur in LNG).
- Particulate matters are close to zero.
- CO2 emissions are reduced by approx 20% (unburned methane if any should be taken into account as its global warming potential -GWP- is more than 20xCO2).
LNG as fuel will further develop if following needs are satisfied:

- A visible and understandable regulatory framework is crucial for the development of the market as investors are put at regulatory risk.
- Harmonization of standards to establish a true global market and a fair competition specifically for LNG as fuel design (IGF code will be a binding regulation but did not enter into force yet) and LNG bunkering.
- Absence of a realistic business model. The additional costs of retrofitting or new-building of LNG is perceived as too high compared to the expected long-term savings.

Development / investments in infrastructures

Legislative / regulatory binding framework

Harmonizing standards & encouraging innovation

Business model & Financials support
- Context
- Compliance factors
- Alternative fuels: HFO with Low Sulphur content
- Fuel switching & compatibility
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- Conclusions
Origin of Fuel Oil

Crude Oil

- Atmospheric Distillation
  - Straight Run Gas Oil
  - Long Residue

- Vacuum Distillation
  - Vacuum Gas Oil
  - Short Residue

- Catalytic Cracking
  - Catalytic Cracked Cycle Oil
  - Cycle Oil Slurry

- Thermal Cracking
  - Thermal Cracked Gas Oil
  - Thermal Cracked Residue

- Residual Fuel Oil
Engine Limits

Abrasive wear due to Al + Si (Cat. Fines)

Vegetable Acids (aggressive)

Acids (corrosion effects)

Abrasive wear due to Na (Sodium) in combination with V (Vanadium)

Waste lube additives (Calcium – Magnesium – Phosphorous and Zinc salts)
HFO Low Sulphur & Cat fines

Risks arising from Low Sulphur Fuel Cat Fines. Main points raised are:

- The cat fines concentration allowed is around 15ppm, much lower compared to the available fuel products (60ppm ISO8217-[2010]). About 2/3 of cat fines must be removed on board after bunkering.

- The fuel treatment process is not straightforward and becomes increasingly crucial as a result of higher demand for LSFO in the SECAs.

- No requirements exist for the performance standard of the fuel filtering and purifying.

Source: © CIMAC Congress 2013, Shanghai Paper No. 51

Onboard Fuel Oil Cleaning, the ever neglected process How to restrain increasing Cat-fine damages in two-stroke Marine Engines

Henrik Rolsted, MAN Diesel and Turbo, Denmark / Rojgaard Charlotte, DNV Petroleum Services, Singapore / Jensen Ole, NanoNord, Denmark / Englund Mats, Alfa Laval Tumba AB, Sweden
# ISO 8217 Specification

<table>
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<tr>
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<th></th>
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<tbody>
<tr>
<td>Acid Number (max)</td>
<td>---</td>
<td>Distillate fuels = 0.5 mg KOH/g</td>
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<tr>
<td></td>
<td></td>
<td>HFO = 2.5 mg KOH/g</td>
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<tr>
<td>Viscosity distillate fuels (min)</td>
<td>DMA = 1.5 cSt, DMX = 1.4 cSt</td>
<td>DMA/DMB = 2.000 cSt, DMX = 1.400 cSt</td>
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<tr>
<td></td>
<td></td>
<td>DMZ introduced (min. viscosity = 3.000 cSt)</td>
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<tr>
<td>Oxidation stability (max)</td>
<td>---</td>
<td>25 g/m3</td>
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<tr>
<td>Lubricity limit (max)</td>
<td>---</td>
<td>520 μm WSD when S below 0.05%</td>
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<tr>
<td>H2S (max)</td>
<td>---</td>
<td>2.00 mg/kg</td>
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<tr>
<td>Al+Si (max)</td>
<td>80 mg/kg</td>
<td>RMG/RMK = 60 mg/kg¹</td>
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<tr>
<td>Vanadium (max)</td>
<td>RMG = 300 mg/kg, RMK = 600 mg/kg</td>
<td>RMG = 350 mg/kg, RMK = 450 mg/kg²</td>
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<tr>
<td>Sodium (max)</td>
<td>---</td>
<td>RMG/RMK: 100 mg/kg³</td>
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<tr>
<td>Ash content (max)</td>
<td>RMG/RMK: 0.15 %</td>
<td>RMG = 0.100 %, RMK = 0.150 % ⁴</td>
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<tr>
<td>Used Lubricating Oil (max)</td>
<td>Ca&lt;30 mg/kg, Zn&lt;15 mg/kg, P&lt;15 mg/kg</td>
<td>Ca &lt;30 and Zn &lt;15 mg/kg Or Ca &lt;30 and P &lt;15 mg/kg</td>
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<tr>
<td>CCAI (max)</td>
<td>---</td>
<td>RMG/RMK = 870 ⁵</td>
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</tbody>
</table>

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1. RMA10 = 25 mg/kg, RMB30/RMD80 = 40 mg/kg, RME180 = 50 mg/kg
2. RMA10 = 50 mg/kg, RMB30/RMD80/RME180 = 150 mg/kg
3. RMA10/RME180 = 50 mg/kg, RMB30/RMD80 = 100 mg/kg
4. RMA10 = 0.040 %, RMB30/RMD80/RME180 = 0.070 %
5. RMA10 = 850, RMB30/RMD80/RME180 = 860
Context

Compliance factors

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LS Distillate Fuels in Diesel Engines

► Fuel viscosity might be outside the specification limits for the system fuel pumps so that the fuel injection pumps may not be able to develop the necessary pressure. This has particular implications for engine starting. Leakage in internal pump components may heat the fuel, making the situation worse.

► Fuel switching from HFO to LS might lead to engine failure, either as a result of overheated distillate fuels leading to vapor locks, or as a result of too rapid temperature change leading to seizure of fuel pump components.

► The CARB regulations, in force in coastal areas up to 24 nm of California, have generated engine failures associated with fuel switch-over.
Compatibility issues during switching fuels

Avoid mixing a paraffinic-type distillate fuel to a thermally cracked heavy fuel

- MGO (dens = <850 kg/m³)
- HFO (dens = >980 kg/m³)

There is chance to get compatibility issues when mixing a HFO from Singapore with a MGO from Singapore (aromatic HFO with paraffinic-type MGO)

There is less chance when mixing a HFO from US with a MGO from US (aromatic HFO with an aromatic-type MGO)
Wärtsilä and MAN Diesel recommendations

► When changing over fuels, thermal shock to the engine fuel injection system (injection pumps, piping, etc.) has to be prevented.

► Sudden temperature changes may lead to seizing of the fuel pump plungers, this may affect the manoeuvrability of the ship, or result in fuel pipe leakage with the risk of fire.

- Wärtsilä: Max. temperature decrease of 15 degC/min
- MAN Diesel: Max. temperature decrease of 2 degC/min

► A large capacity mixing unit will be of advantage in further reducing the temperature gradient. This will however increase the period for which both fuels are present together, and consequently the risk of compatibility problems occurs.

► Sustained operation on low viscosity fuels usually requires a cooler. The cooler is to be installed in the return line after the engine(s). LT-water is normally used as cooling medium.
Change-over experience - CARB

California Air Resources Board
Marine Notice 2012-1

Loss of Propulsion
Total per year

- REPORTED LOSS OF PROPULSION INCIDENTS

<table>
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<tr>
<th>Year</th>
<th>Incidents</th>
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<td>2004</td>
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<td>2012</td>
<td>63</td>
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<tr>
<td>2013</td>
<td>77</td>
</tr>
<tr>
<td>2014</td>
<td>76</td>
</tr>
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</table>
Change-over experience - CARB

Loss of Propulsion Incidents
Monthly Totals in 2014

- Total Loss of Propulsion Incidents
- Loss of Propulsion - Fuel Switching Related
- Loss of Propulsion - Suspect Fuel Related

Source - CARB
CARB: Loss of Propulsion – Change-over issues

Most incidents occur during slow speed maneuvering

Inability of the main engine, operating with MGO/MDO, to overcome the forces on the propeller from the forward momentum of the ship. The engine may turn over at higher RPM and initiate combustion; however, as the engine reduces speed to come to dead slow or slow astern there is not enough energy content in the fuel to maintain engine inertia.

Problems with controlling the temperature of the MGO/MDO (aprox. 100º difference).

Loss of fuel oil pressure to either the fuel pumps or fuel injectors.

Loss of fuel oil pressure or the loss of flow in sufficient quantities to maintain operation. Strainers and filters or the lack of a strainer and filter contribute to clogging or restrictions in the fuel oil supply system.
- Context
- Compliance factors
- Alternative fuels
- Fuel switching & compatibility

Port State Control

- Conclusions
The following means of sampling, analysis and inspection of marine fuel shall be used:

- **Inspection of ships' log books and bunker delivery notes;**

and, as appropriate, the following means of sampling and analysis:

- **Sampling of the marine fuel for on-board combustion while being delivered to ships; or**

- **Sampling and analysis of the sulphur content of marine fuel for on-board combustion contained in tanks, where technically and economically feasible, and in sealed bunker samples on board ships.**
Member States shall require the correct completion of ships' logbooks, including fuel-changeover operations.

If a ship is found by a Member State not to be in compliance with the standards for marine fuels which comply with this Directive, the competent authority of the Member State is entitled to require the ship to:

- (a) present a record of the actions taken to attempt to achieve compliance; and
- (b) provide evidence that it attempted to purchase marine fuel which complies with this Directive in accordance with its voyage plan and, if it was not made available where planned, that attempts were made to locate alternative sources for such marine fuel and that, despite best efforts to obtain marine fuel which complies with this Directive, no such marine fuel was made available for purchase.

- The ship shall not be required to deviate from its intended voyage or to delay unduly the voyage in order to achieve compliance.

A ship shall notify its flag State, and the competent authority of the relevant port of destination, when it cannot purchase marine fuel which complies with this Directive.
EU Directive - 2012 (Exemptions)

The limitations on the sulphur content shall not apply to:

- Any use of fuels in a vessel necessary for the specific purpose of securing the safety of a ship or saving life at sea.
- Any use of fuels in a ship necessitated by damage sustained to it or its equipment.
- Fuels used on board vessels employing abatement methods.
If a sample is taken as close to the engine inlet and the vessel is using MGO to comply with the 0.10% regulation, what will PSC do if:

- the sample is dark, but still a distillate fuel?
- The sample is dark and heavy?

Member States shall ensure that marine gas oils are not placed on the market in their territory if the sulphur content of those marine gas oils exceeds 0,10% by mass.
Remote sensing: Measuring emissions of sulphur from ships at sea

Measurement technologies:

► Optical
► Gas analysers
► Airborne platforms:
  ● Planes
  ● Drones
  ● Fixed platforms
  ● Bridges
  ● Port entrances
► Ship data is obtained from the AIS system

• Up to now, the sulphur content is measured through the bunkering delivery note (BDN), and, time to time, control by the PSC of the quality of the fuel from the daily tank. In the near future control by drones and sensors.
Sampling Frequency and Thetis-S

- Common database for monitoring of compliance, reporting and sharing of sulphur content inspections and sampling results.
- The ship (particulars) database existing in Thetis will be re-used to form the backbone of the Thetis-S part;
- Port call information provided by the Member States (through SafeSeaNet) will be re-used to provide accurate information on ship arrivals and departures;
- Inspection data will be stored in the system for future reference by subsequent users in different ports of call;
- Member States start recording and sharing sulphur inspection and sampling outcomes.
- Analysis of the data aiming at development of an EU risk-based targeting methodology during 2015 subject to availability of sufficient data;
- THETIS-S will be designed in a flexible manner thus being able to adjust and accommodate future requirements of the Member States (i.e. remote sensing information, alternative emission abatement methods).