

# Low Sulphur Fuels

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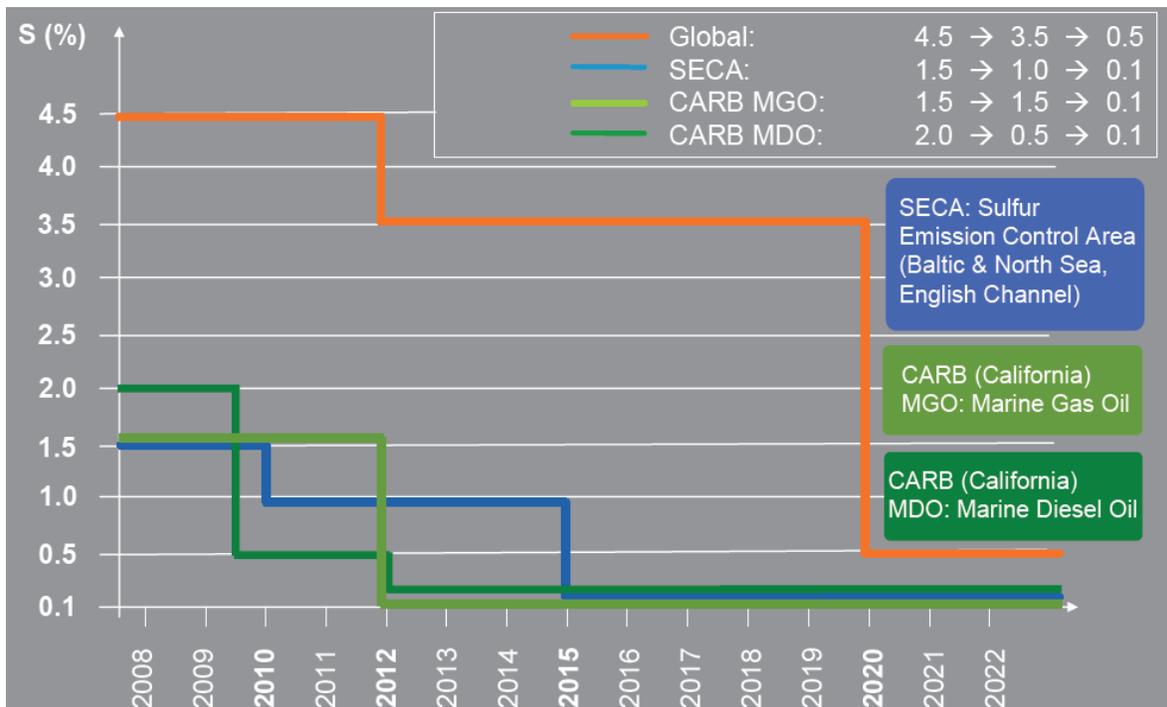
## Content

- Definition of terms and fuels
- Current- and future rules of fuel
- Fuel types and properties
- Concerns
- Field Experiences
- Products
- Thoughts

## Defining terms used for fuels

- **HFO** (Heavy Fuel Oil)
  - Sulphur > 1.5%
  
- **LSHFO** (Low Sulphur Heavy Fuel Oil)
  - Sulphur < 1.5%
  
- **LFO, MDO, or MGO** (Light Fuel Oil, Marine Diesel Oil or Marine Gas Oil)
  - Light / Distillate Fuel Oil
  - $0.2 < \text{Sulphur} < 2$
  
- **LSLFO, LSMDO, or LSMGO** (Low Sulphur Light Fuel Oil, Low Sulphur Marine Diesel Oil or Light Sulphur Marine Gas Oil)
  - $0.01 < \text{Sulphur} < 0.2$
  
- **ULSLFO etc** (Ultra Low Sulphur Light Fuel Oil)
  - Sulphur < 0.01

## Rules and Dates Dictating Fuel Sulphur Quality



## EU Directive

- For ships at Berth
  - *All ship types from 1.1.2010*
  - *All flags, including journeys from outside EU*
  - *Max sulphur content 0.1 %, when berthed in community ports*
  - *Berth defined as securely moored or anchored while loading, unloading or hotelling, including time spent when not engaged in cargo operations*
  - *Allow for sufficient time to complete fuel-changeover as soon as possible after arrival, and as late as possible before departure.*
  - *Operations recorded in logbooks*
  - *Exhaust Gas Cleaning system is permitted alternative*

## Definition of fuel types

- Marine Gas Oil (MGO)
  - Any fuel with properties (viscosity, density, etc) falling within ranges of that for DMX and DMA grades of ISO 8217
  - Where:
    - DMX is considered as an emergency fuel with a lower flash point
    - DMA is considered as a pure distillate fuel
- Marine Diesel Oil (MDO)
  - Any fuel with properties (viscosity, density, etc) falling within ranges of that for DMB and DMC grades of ISO 8217
  - Where:
    - DMB is considered as pure distillate fuel
    - DMC is considered as a blended fuel with a residual fuel constituent

# ISO 8217 Fuel Properties

Table 1 — Requirements for marine distillate fuels

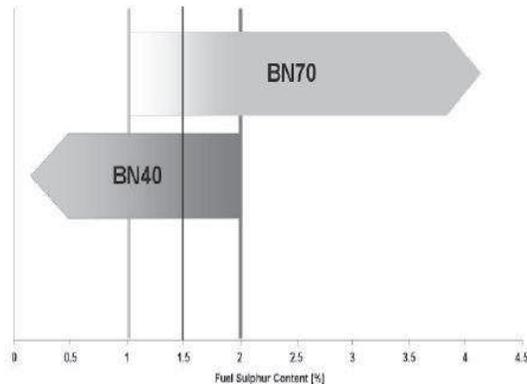
Characteristic	Unit	Limit	Category ISO-F-				Test method reference
			DMX	DMA	DMB	DMC <sup>a</sup>	
Density at 15 °C	kg/m <sup>3</sup>	max.	—	890,0	900,0	920,0	ISO 3675 or ISO 12185 (see also 7.1)
Viscosity at 40 °C	mm <sup>2</sup> /s <sup>b</sup>	min. max.	1,40 5,50	1,50 6,00	— 11,0	— 14,0	ISO 3104 ISO 3104
Flash point	°C	min. min.	— 43	60 —	60 —	60 —	ISO 2719 (see also 7.2)
Pour point (upper) <sup>c</sup> — winter quality — summer quality	°C	max. max.	— —	- 6 0	0 6	0 6	ISO 3016 ISO 3016
Cloud point	°C	max.	-16 <sup>d</sup>	—	—	—	ISO 3015
Sulfur	% (m/m)	max.	1,00	1,50	2,00 <sup>e</sup>	2,00 <sup>e</sup>	ISO 8754 or ISO 14596 (see also 7.3)
Cetane index	—	min.	45	40	35	—	ISO 4264
Carbon residue on 10 % (V/V) distillation bottoms	% (m/m)	max.	0,30	0,30	—	—	ISO 10370
Carbon residue	% (m/m)	max.	—	—	0,30	2,50	ISO 10370
Ash	% (m/m)	max.	0,01	0,01	0,01	0,05	ISO 6245

## Concerns

- **Cylinder oils**
- **Viscosity**
- **Tank arrangements**
- **Change over of fuels**
- **Compatibility**
- **Lubricity**

## Cylinder Lubricating Oils

- **BN compatibility / matching:**
  - Neutralisation vs. Detergency
- **Over-lubrication:**  
high flow rates and high BN
  - Calcium deposits on crown and behind piston rings
  - Polishing
- **Under-lubrication:**  
(low flow rates or incorrect BN when switch back to normal fuel)
  - Corrosion
  - Reduced performance of piston running



## Cylinder Lubricating Oils

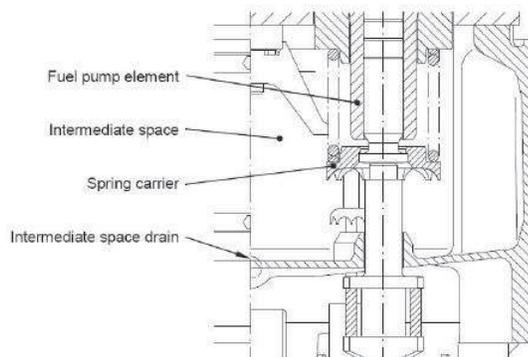
- **LSHFO clearly of no concern**
  - Slight adjustment of feed rate, experience already available
- **Solutions for distillates**
  - Operation according to recommendations, i.e. Bulletin RT-18.4
  - 2 cylinder oil day tanks with 3 way valve?
    - Compatibility of oils
    - Change over time to flush high BN oil
  - Single/Universal use oil, i.e. BN 55
  - Validation test with oil company for low BN oil currently ongoing
  - Investigation is ongoing into a non-constant feed rate across a range of sulphur content of fuels.

## Viscosity Concerns

- **Leakage concern with Distillates:**
  - At engine inlet, guidelines given as 13 – 17 cSt for HFO
    - Not feasible for distillate, therefore 2 cSt given as true minimum
  - Leakage through Plunger and Barrel on fuel pumps
    - Dependent upon wear
  - Higher load indicator
    - Difference of fuel Calorific Value in combination with Leakage
    - Cylinder oil and governor settings affected
    - Correction for prolonged periods
    - Governor settings to be reverted for HFO to prevent exceeding crankshaft torque limits
  - Engine limits
    - Torque limit / scavenge air limit can be met due to change of load indicator values

## Leakage

- Theoretically, leakage may be recovered
  - Cannot mix with system oil, although possibility of old HFO
  - Must ensure drain spaces are clean, sealing rings in good condition
  - Would require re-routing of drain piping to clean tank



## Wärtsilä Fuel Pump Benefits

- Both RTA and RT-flex
  - Timing
    - Valve, not helix type timing
    - Therefore timing unaffected on both RT-flex and RTA
  - Lateral thrust
    - No spill port therefore constant circumferential fuel distribution
    - No lateral force encountered by plunger
- RTA
  - Sealing across length of plunger, reduced leakage
- RT-flex
  - Optimised clearances of plunger and barrel

## Operational Concerns

- **Heating through closed system pumping**
  - Will further reduce viscosity
  - Possibility of return to service tank rather than mixing unit
  - Un-insulated tank walls would help to cool fuel
  - Tanks not adjacent to heated HFO tanks
  - Vessel specific inspection
- **Guideline of 2 cSt at inlet to engine**
  - Possibility of retrofit cooler or chillers.
  - No official recommendation for this as this should be examined on a vessel dependant basis.
  - Related to engine wear, region of operation, tanking arrangements, grade of fuel requested
- **Permanent long term storage needs consideration**

## Minimum Fuel Injection Viscosity four stroke engines

Engine type, 4-stroke	Minimum fuel injection viscosity, cSt	
	Jerk pump	Common rail
Wärtsilä 20	1,8	1,8
Wärtsilä 26	2,0	
Wärtsilä Vaasa 32/32LN	2,0	
Wärtsilä 32	2,0	2,0
Wärtsilä 38	2,0	2,0
Wärtsilä 46	2,8	2,0
Wärtsilä 46F	2,0	2,0
Wärtsilä 64	2,8	
Sulzer S20	3,0	
Sulzer Z40, ZA40, ZA40S	2,0	

Engine type, DF engines	Main / back-up fuel	Pilot fuel
Wärtsilä 32DF	1,5	1,5
Wärtsilä 34DF	2,0	2,0
Wärtsilä 50DF	2,8	2,0

## Change Over Process

- **When changing over Fuels:**
  - Temperature gradients
    - Keep to guidelines in operating manual (max. 15°C/min)
    - Relatively large clearances, lower risk of pump sticking
    - Change fuels in suitable areas. i.e. not in critical areas, entering port etc
    - Beneficial clearances with Wartsila 2-stroke fuel pumps
  - Fuel incompatibility is a concern
    - Possibly test on board
    - If of concern, keep change over time as short as possible
  - Treatment should be maintained for all fuels
- See Bulletin RT-82 - Distillate fuel use

## Operation on Distillates

- Reduced Soot
- Reduced Piston Ring & Liner wear
  - Maintain normal engineering practices (inspections of rings, liners etc)
- Better combustion properties
  - Peak pressures likely to be higher
  - FQS adjustment in way not to exceed nominal firing pressures
- Sulphur as natural lubricant
  - Exhaust valve material, Weloral / Stellite

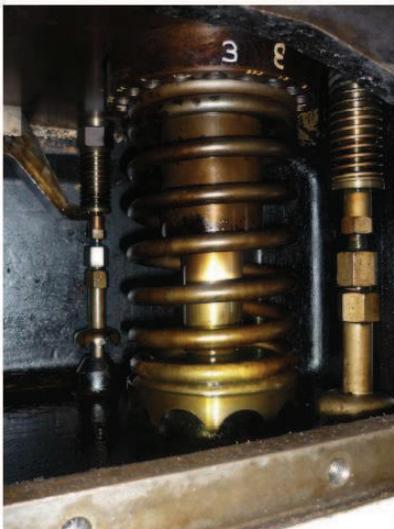
## Experience

- Our field experience with distillate fuel use
  - Extensive experience with new engines on shop tests
  - RTX Test engine; ~ 600 hours accumulated on LSHFO
  - RFA vessels:
    - NATO fuel, RND engines, Wärtsilä Gen-Sets
  - Vessels presently operating in California waters on distillate
    - So far no reported incidents

## Feedback from Test Vessels

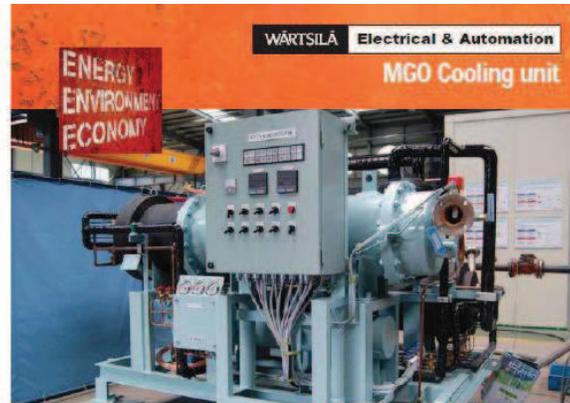
- Fuel used
  - Only road fuel available
  - 100 – 300 ppm Sulphur (0.03 % S)
  - 3 cSt
- Leakage
  - Normal dripping according to CE, no different to HFO
- Change over process
  - No problems experienced to date
  - Slow change over and mixing of the fuels; approximately 2hrs to change over, vessels now operate only on Distillate Fuels
- Starting behaviour
  - Engine is starting well, no difference of air consumption between HFO and MGO
- Fuel system behaviour
  - Feed and booster pumps operating without problem
  - Separators operating without malfunction
  - No reported problems
- Fuel temperature rise across the engine,
  - 32°C rise across the engine with distillate fuel use from pumping effect but no detrimental effects observed on engine due to low viscosity

## Feedback from Test Vessels



No significant or concerning running marks can be observed on the plungers

## Products



MGO COOLING UNIT - THE SOLUTION FOR RELIABLE OPERATION WITH MGO

- Automated switch over units are currently being developed within Wärtsilä along side further development of Distillate fuel cooler and chiller units

## Wärtsilä's Thoughts

- Many companies promoting fuel additives and retrofit packages to gain from industry concerns.
- There are reported issues such as reaching load limits and old reports of starting trouble for engines with high wear, but our experience does not correlate to US coastguard published report of vast increase in critical failures.
- Ongoing tests, research and also increased operational experience, the results of which are not causing immediate alarm. Despite this, the risks are being carefully considered and not dismissed out of hand.
- Possible update of ISO 8217 later this year with possible increase of minimum viscosity of MGO to 2 cSt. Will this alter the necessity of a cooler / chillers?
- How will the introduction of rules in 2015 of 0.1% Sulphur effect our engines?

# QUESTIONS ?

Thank you for your attention