10K98MC-C and 6S35MC on the same Testbed

L/74236-1.0/0402

San Pedro Bay Ports Vessel Fuel Incentive Program Workshop – May 21, 2008

Low-Sulfur-Fuel Standard Operating Procedures for MAN B&W Engines

Svend Henningsen
MD-C, R&D, Process Development, Emission

Low-Sulfur-Fuel
Standard Operating Procedures

Background:

- **The fuel specification will change in the future due to Legislation requirements**
- **Low-Sulfur HFO or Distillates will be used in near coastal areas**

Goal:

- **Safe operation of the engine with easy maintenance and low operation costs**

What to look out for

- **Incompatibility of fuels**
- **Ignition and combustion characteristics**
- **Lower fuel viscosity, flash point & increased level of cat fines**
- **Matching of low-Sulfur fuel, cylinder lube-oil BN and cylinder lube-oil feed rate**
- **Fuel change-over procedures**
- **Fuel and cylinder lube-oil systems**

Incompatibility of fuels

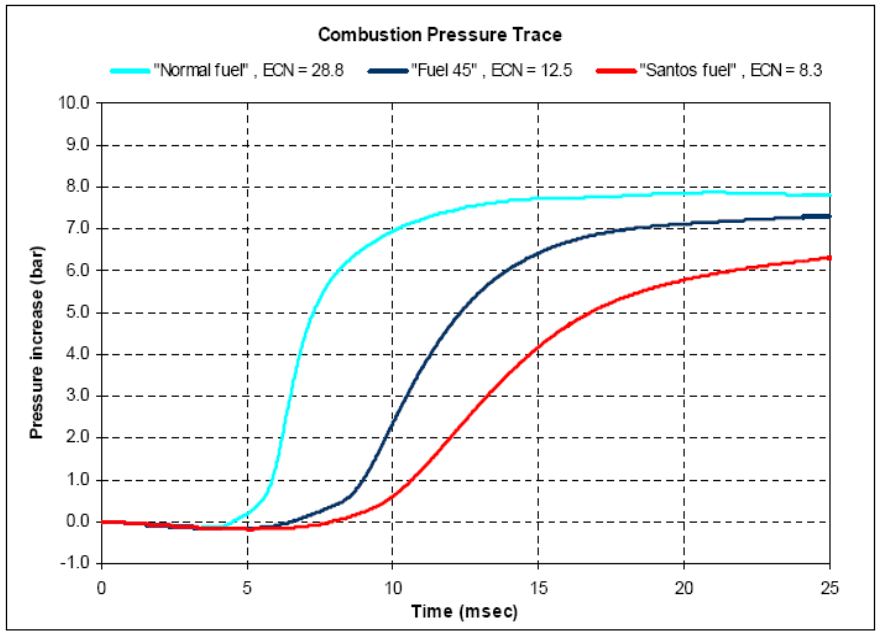
- **When switching from HFO to a distillate fuel with low aromatic hydrocarbon there is a risk of incompatibility**
- **The asphaltenes of the HFO are likely to precipitate as heavy sludge with clogging filters as result**
- **Use of test compatibility kit on board or guarantee from fuel supplier that fuels used can be blended**

2100/KEA/BRO

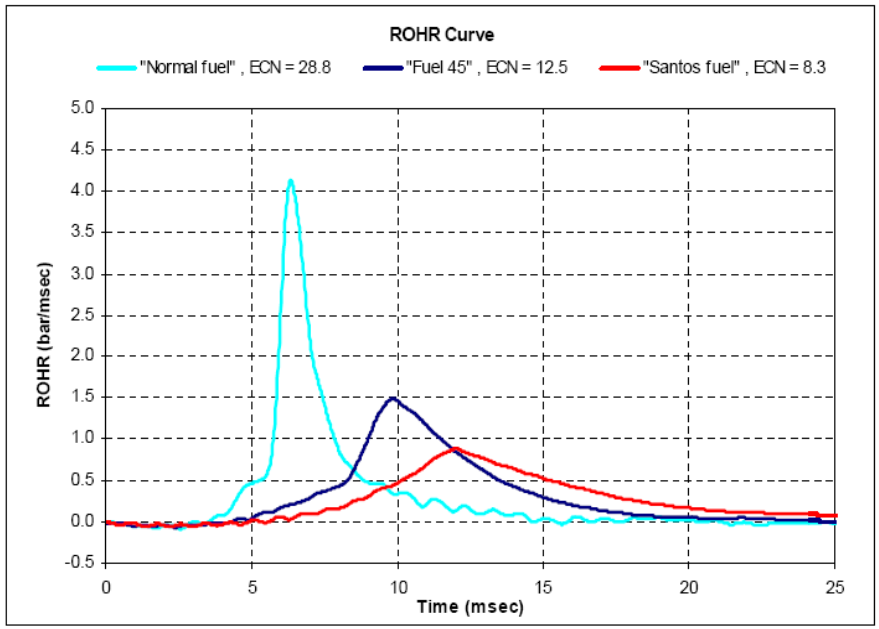
Ignition characteristic

FIA – 100 FCA: Constant volume spray combustion chamber with Tinit = 800K and Pinit = 45bar

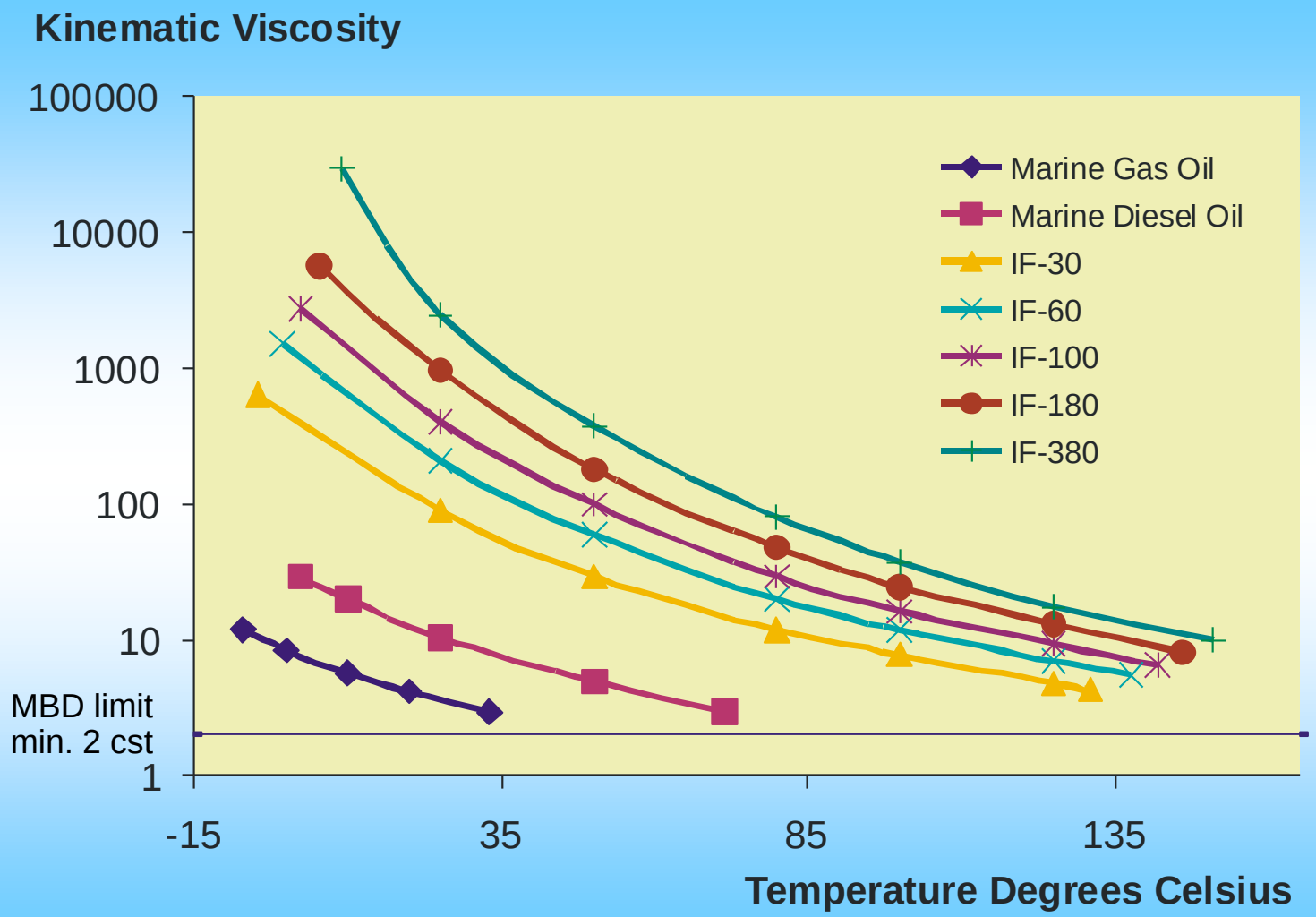
Pressure trace



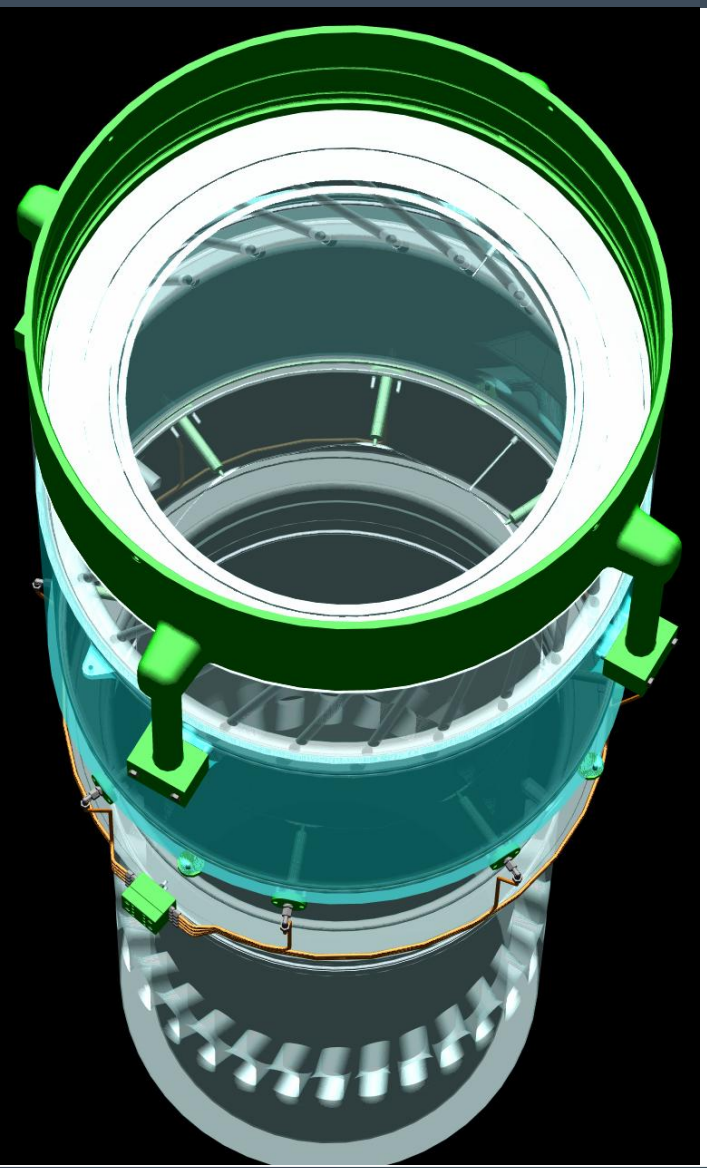
Heat release rate

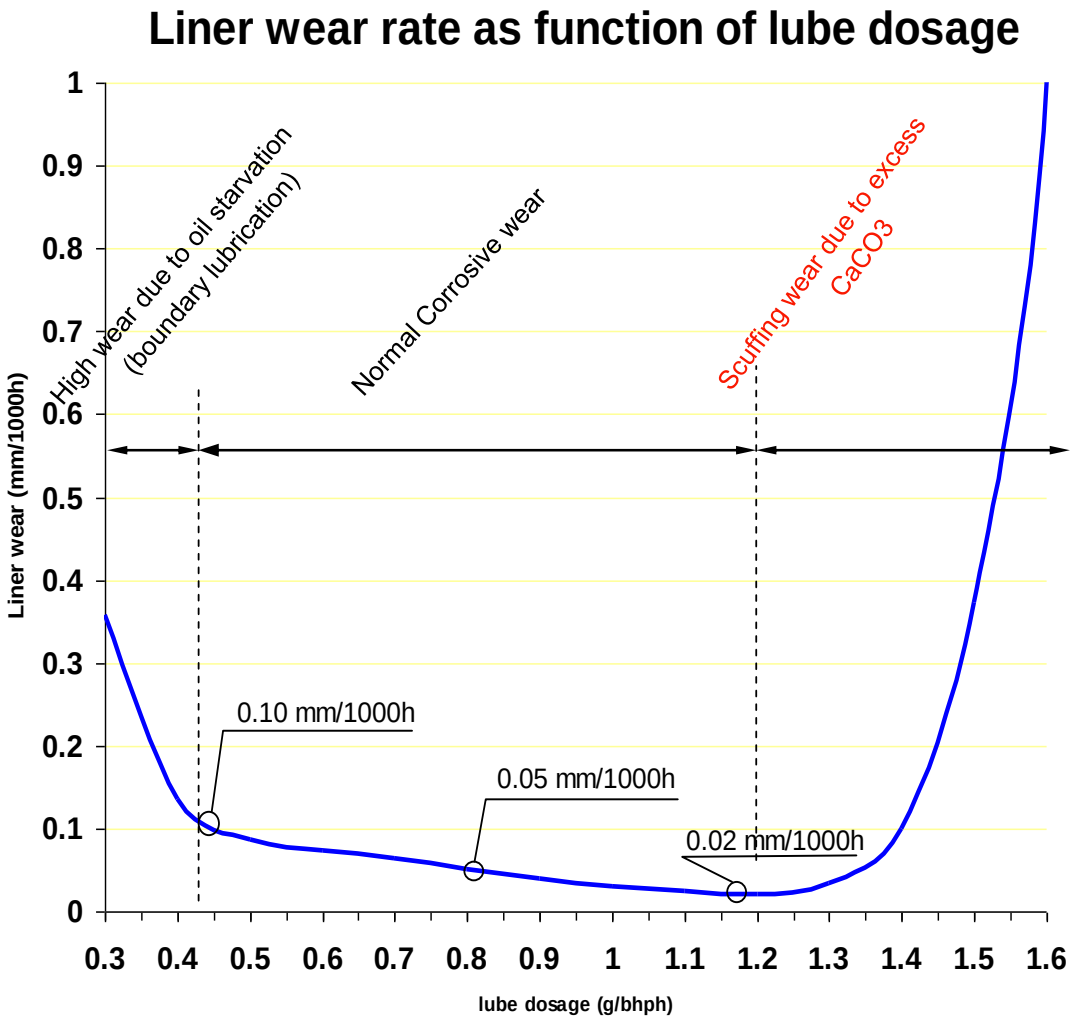


Viscosity of Marine Fuels



Optimizing the Cylinder Condition – Lubrication versus Maintenance

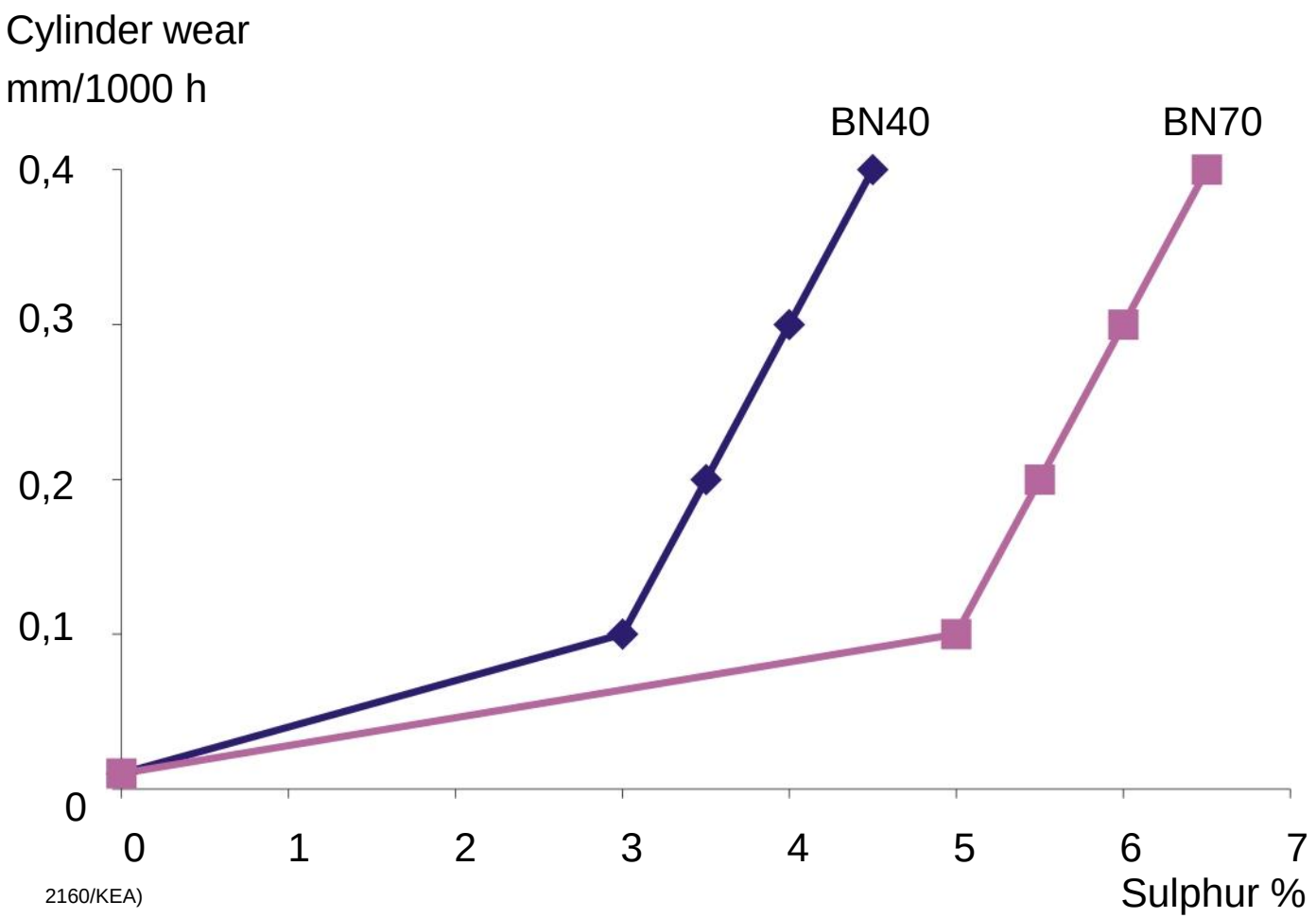




CIMAC, Oslo 25th January 2006 Henrik Rolsted

Comparison of Sulphur Content and Lube-Oil TBN

Cylinder wear for equal cylinder-oil feed rates



L/71510-0.1/0301 2160/KEA)

Use of BN40 Cylinder oil feed rates Low S fuel, Alpha ACC

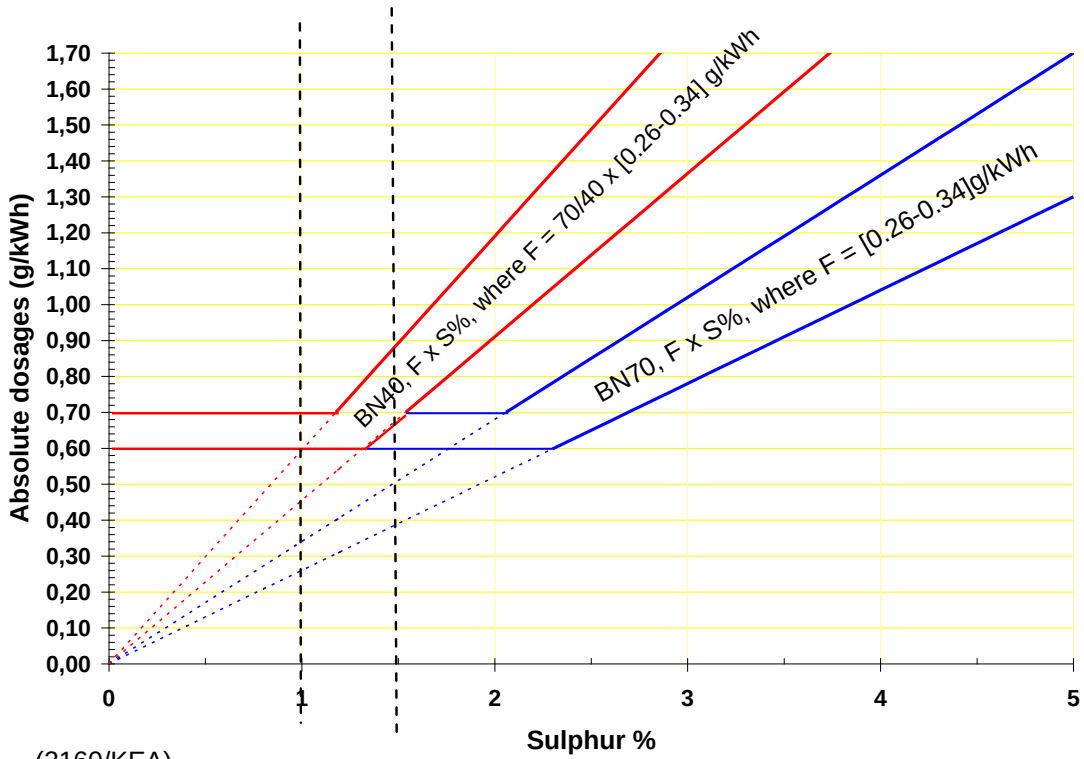
The correlation between fuel sulphur level and cylinder oil can be shown as follows:

Fuel sulphur level <1%: BN40/50 recommended

Changeover from BN70 to BN40/50 only when operating for more than one week on <1% sulphur

Fuel sulphur level 1-1.5%: BN40/50 and BN70 can be used

Fuel sulphur level >1.5%: BN70 is recommended



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Cylinder-Oil Feed Rates

Guiding Cylinder-Oil Feed Rates S/L/K-MC/MC-C engines with Alpha Lubricators, based on a BN 70 cylinder oil		
	Standard guidelines (ref. to MCR load)	Alpha Adaptive Cylinder oil Control (Alpha ACC)
Basic setting	**0.8 g/bhph** **1.1 g/kWh**	**0.25 g/bh ph x S%** **0.34 g/kWh x S%**
Minimum feed rate	0.6 g/bhph 0.8 g/kWh	0.5 g/bhph 0.7 g/kWh
Maximum feed rate during normal service	1.25 g/bhph 1.7 g/kWh	1.25 g/bhph 1.7 g/kWh
Part-load control	Proportional to mean cylinder pressure	Proportional to engine load
	Below 25% load, proportional to engine speed	

L/74455-3.0/0203 (2300/MCJ)

Change over procedure to prevent fuel pump sticking/poor combustion/fouling of the gas ways

Change over from HFO to Diesel Oil during operation	Change over from Diesel to HFO during operation
▪ Preheat the diesel oil in the service tank to about 50°C, if possible ▪ Cut off the steam supply to the fuel-oil preheater and heat tracing ▪ Reduce the engine load to ¾ of MCR-load ▪ Change to diesel oil, when the temperature of the heavy fuel oil in the preheater has dropped to about 25°C above the temperature in the diesel-oil service tank, however, not below 75°C	▪ Reduce engine load to ¾ of MCR ▪ Heat the diesel oil to max. 60-80°C ▪ Raise the temperature about 2°C per minute ▪ The recommended min. viscosity of the diesel oil is 2 cSt ▪ Keep HFO in the service tank max. 25°C higher than diesel oil in the system at change over

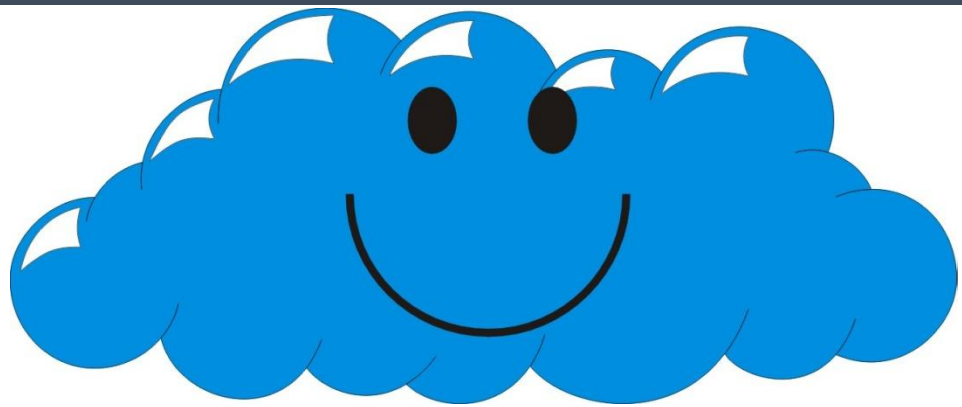
3330184/20030423 (2160/KEA)

Summary – Low-Sulphur Fuel Operation

- **Two-stroke engines can operate on HFO, GO, DO** (and all kinds of more exotic fuels, if necessary)
- **When fuel is mixed to control Sulphur content in fuel oils, compatibility becomes important**
- **Large two-stroke engines are largely non sensitive to fuel quality,** however
- **Fuel viscosity and cylinder lube-oil base numbers are to be considered – MAN guidelines to be followed**
- **Automated switch-over procedures are being commercialized**

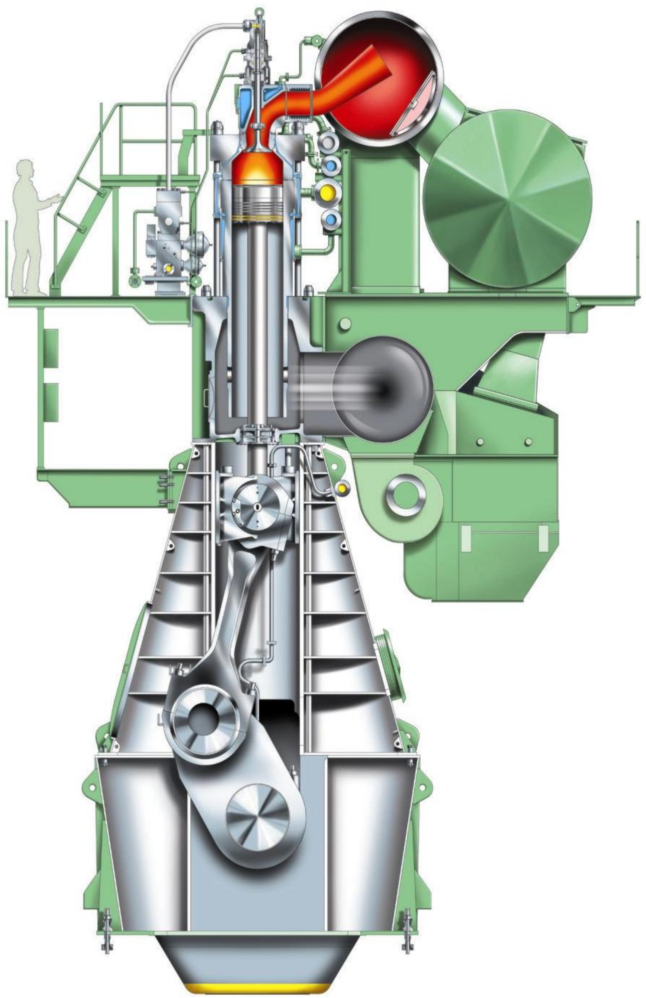
- **More fuel and cylinder lube-oil storage tanks to be implemented on new buildings**

DISCUSSION



Svend Henningsen
MD-C, R&D, Process Development, Emission

Influence of Fuel Spec Parameters

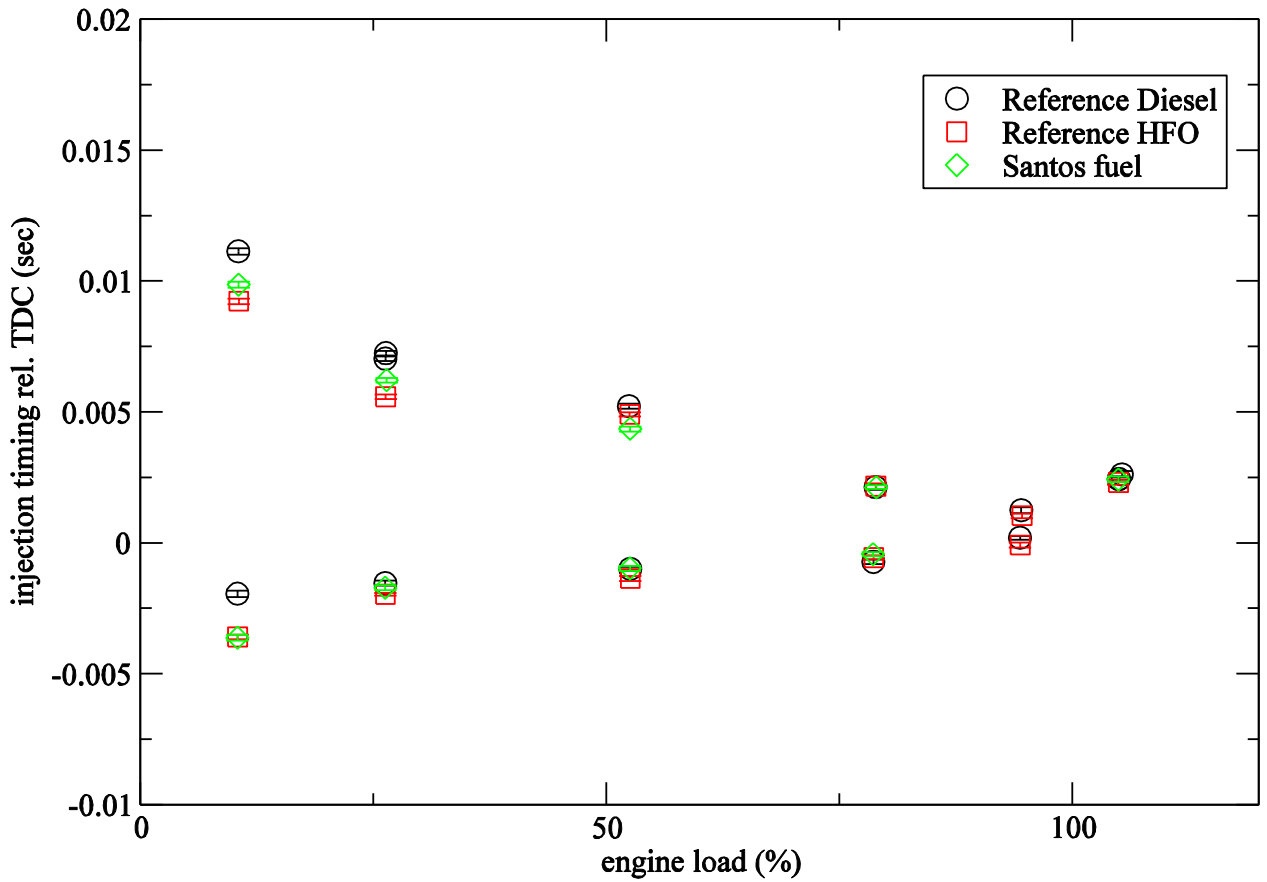


- Density – Centrifuges
- Viscosity – Reheating
- Flash point – Safety
- Pour point – Handling
- Carbon Residue – Fouling of gas ways
- Ash – Can be abrasive
- Vanadium and sodium – Corrosion and T/C deposits
- Sullfur – Corrosion
- Water – Centrifuges
- Catalytic fines – Centrifuges
- Off-spec. Fuels – Natural gas, Bitumen, Orimulsion
- Bio fuel

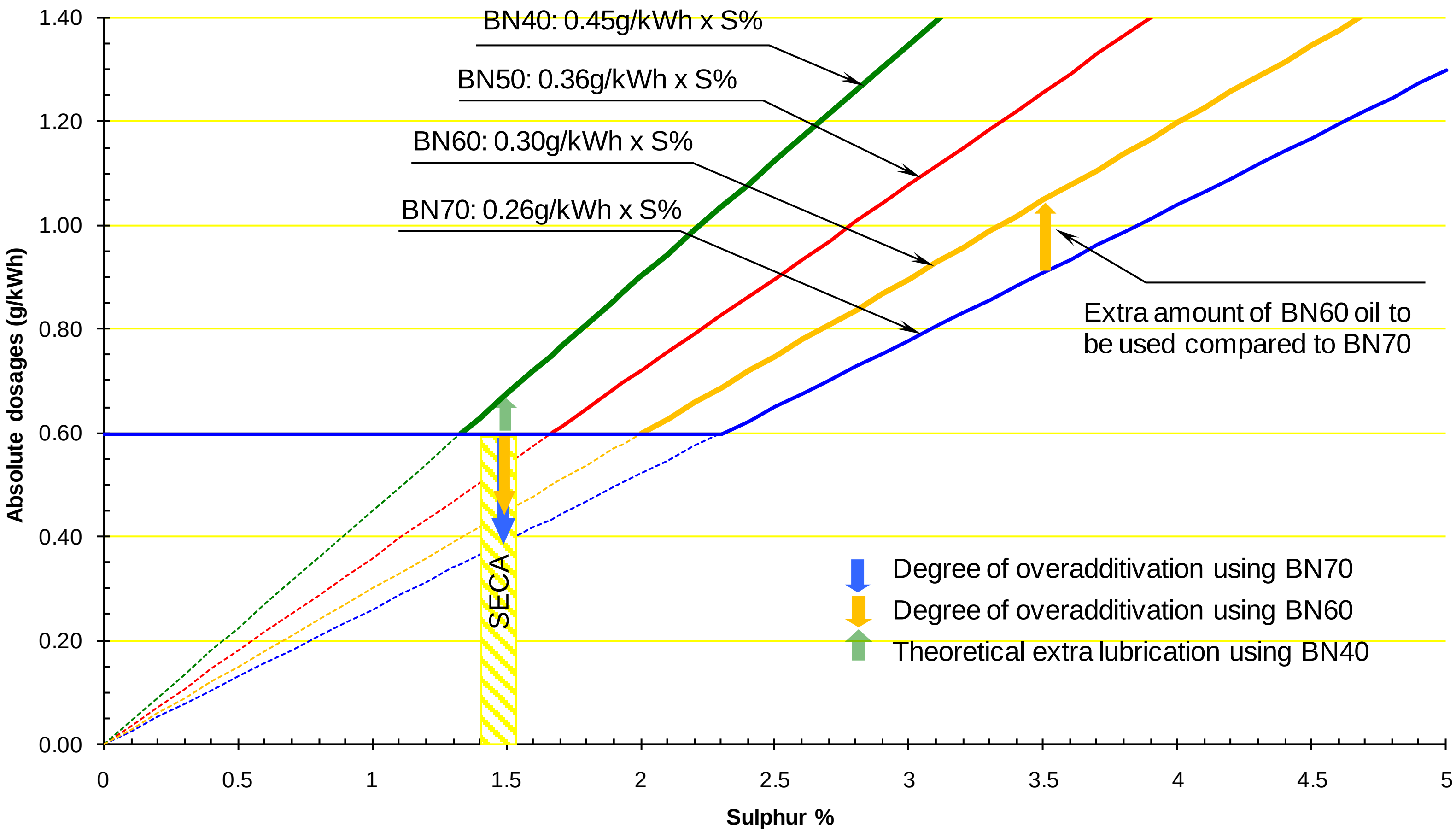
Injection timing
on the 4T50MX test engine

Test series: **Propeller curve:** **10, 25, 50, 75, 100 % load**

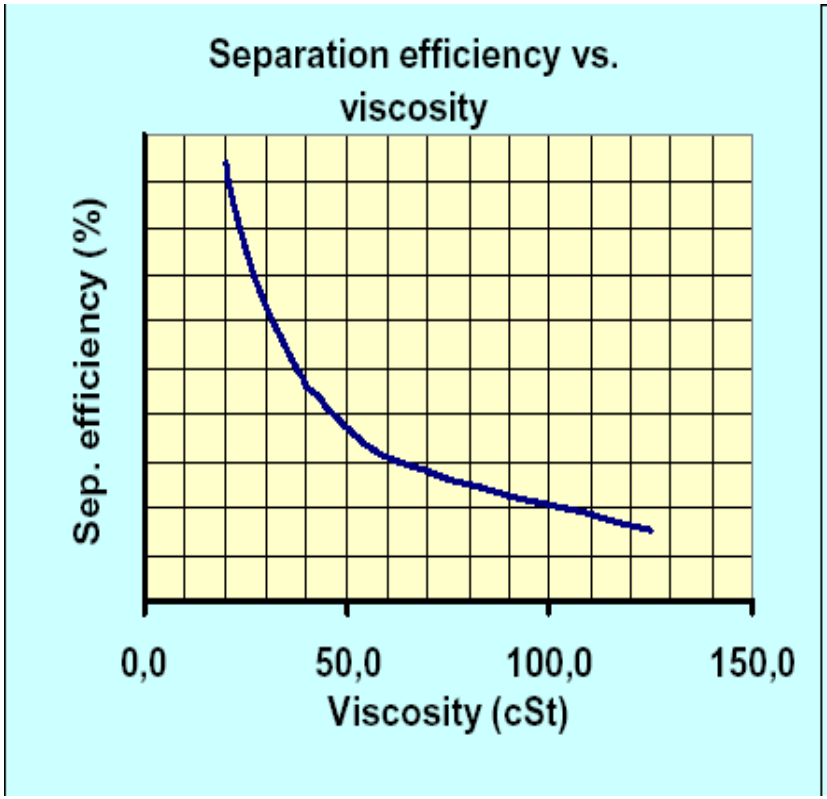
Generator curve: **10, 25, 50, 75, 100 % load**

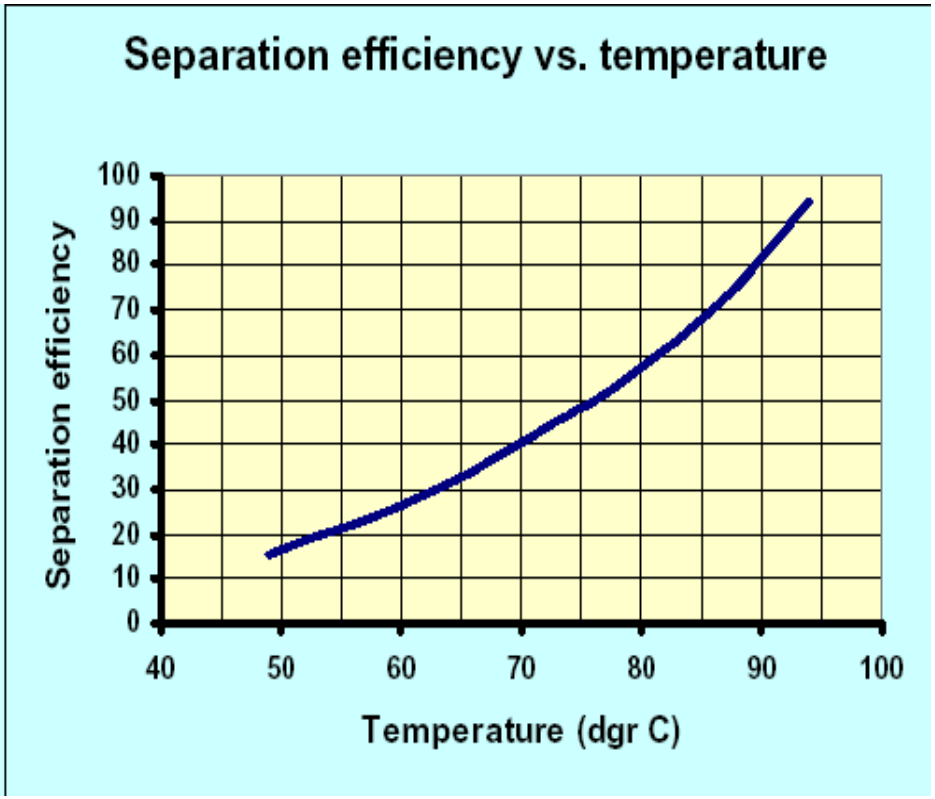


Comparison of Lube BN Performance (New Licencee Letter)



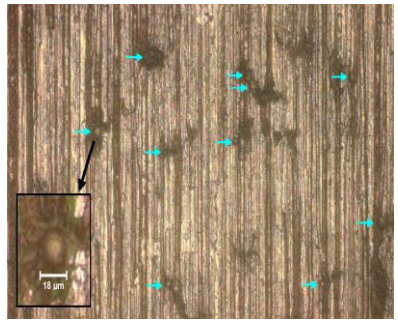
Centrifuge efficiency





External factors which influences engine condition

- Cylinder lube oil
  - Quality
  - Type (BN)
  - Dosage
- Fuel oil
  - Viscosity
  - Contaminants
  - Cat fines (treatment, purification)
- Ambient condition
  - Humidity
  - Water mist catcher
- Exhaust gas boiler
  - Pressure drop in exhaust system



Cylinder-Liner Surface

‘Open’ graphite structure with good tribological abilities

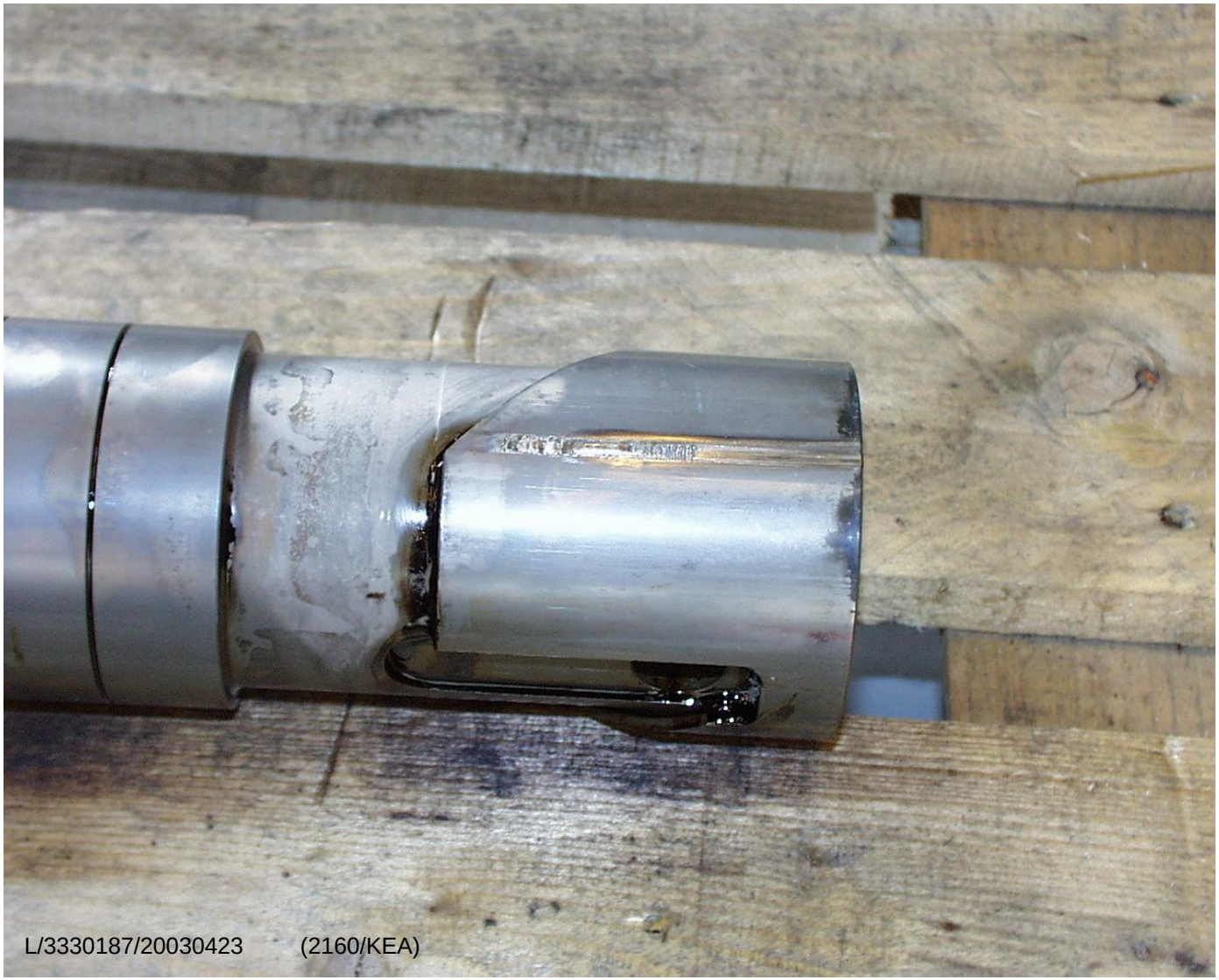
1.6 mm

‘Closed’ graphite structure with reduced tribological abilities

1.6 mm

L/71509-0.0/0301 (2160/KEA)

Damage to Fuel-Pump Plunger



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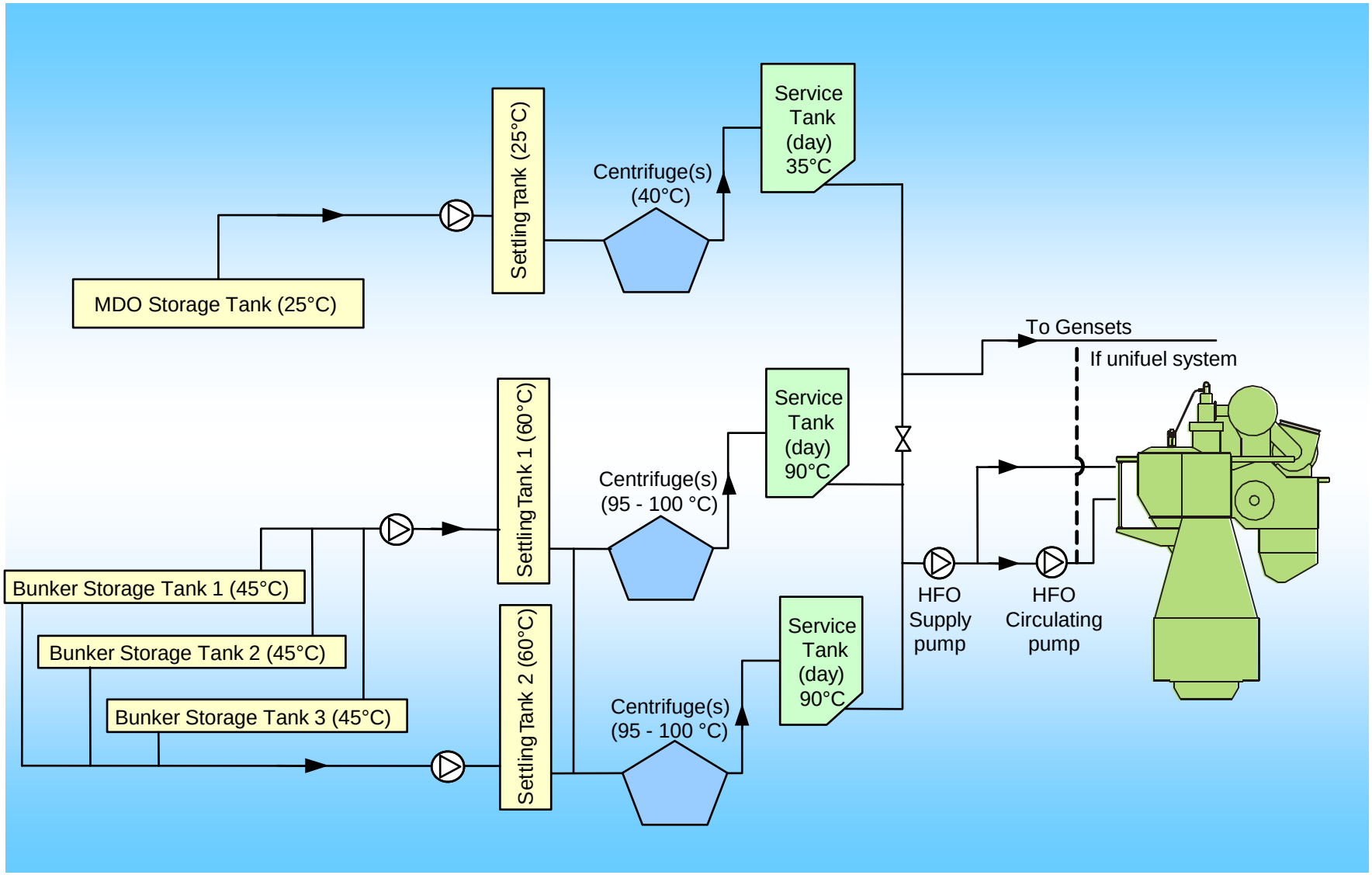
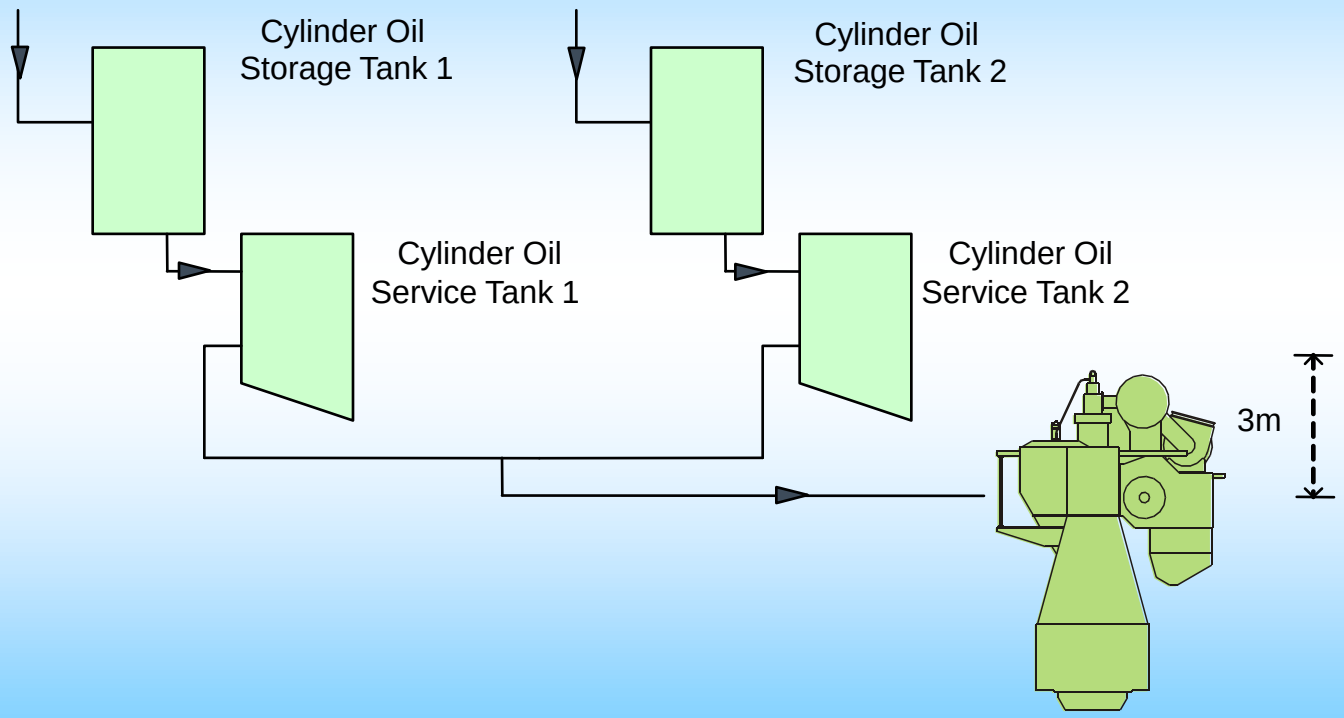
One MDO Settling Tank and Two Sets HFO Settling Tank and Service Tanks



Two Independent Cylinder-Oil Systems



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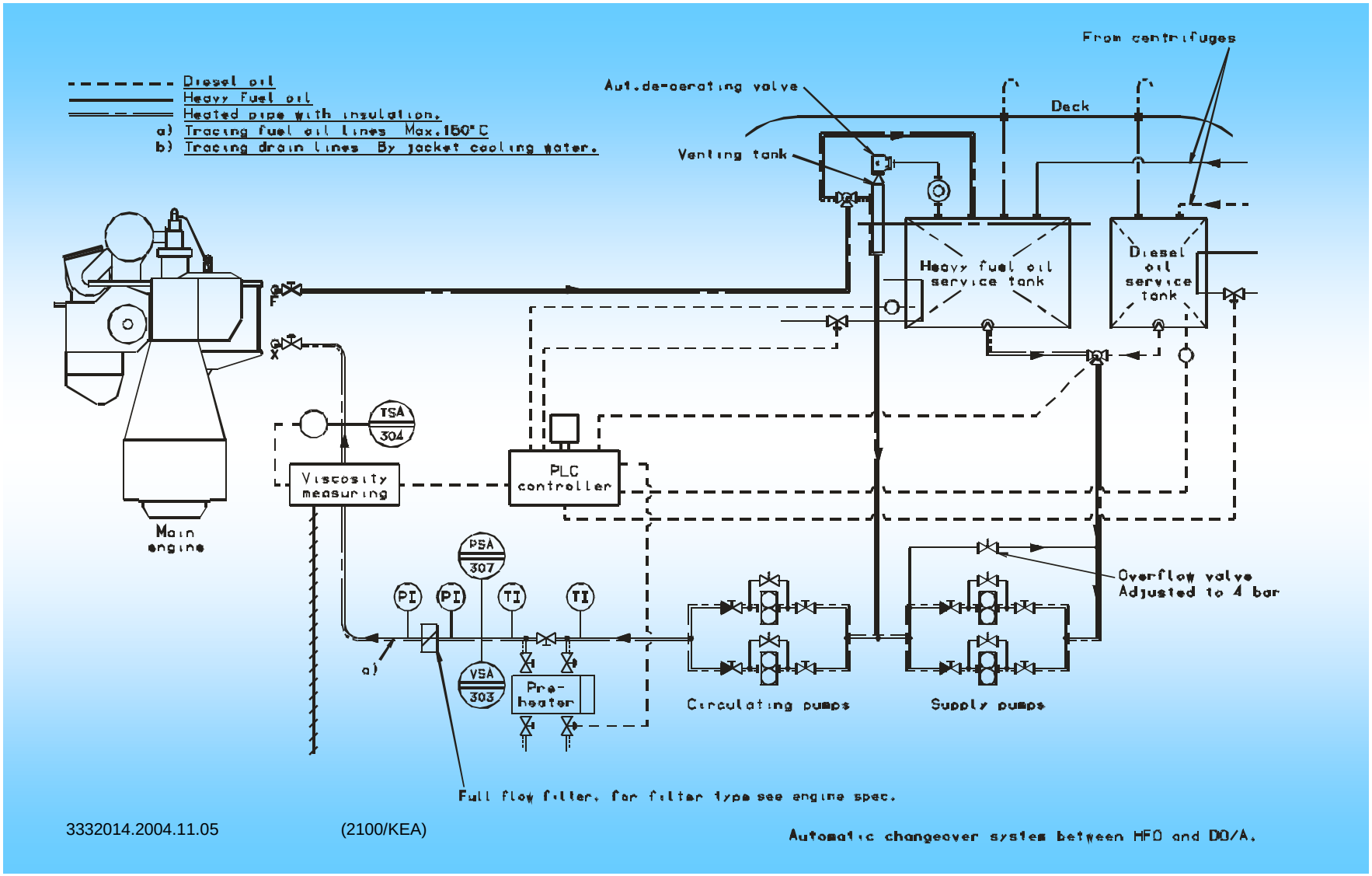
Fuel-Oil System



MBD test of different fuels

Fuel No	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Units
Viscosity	3.8	84	85	141	198	255	470	520	560	690	710	800	1200	50,000	-	cSt/50°C
Density	968	995	970	993	938	977	985	983	1,010	1,008	1,030	935	998	1,040	1.01	kg/m³ at 15°C
Flash point	98	84	80	103	100	106	90	95	90	79	84	>40	80	>60	>70	°C
Conradson Carbon	0.3	17.2	12.1	13.3	9.4	14.5	16.8	14.8	17.3	22.1	24.7	9.4	14,1	24.2	11.7	% weight
Asphalt	0.78	15.1	8.9	9.2	3.7	10.0	11.3	12.8	14.6	19.3	29.0	1.02	12	-	-	% weight
Sulphur	0.10	2.72	1.16	0.91	0.83	0.87	0.90	1.18	2.22	3.52	3.30	0.37	4	4.8	2.8	% weight
Water	0.01	0.01	0.01	0.00	0.01	0.02	0.02	0.01	0.00	0.00	0.00	-	0,65	0.05	-	% weight
Ash	0.00	0.065	0.025	0.03	0.03	0.025	0.03	0.035	0.04	0.07	0.09	0.043	-	0.035	0.18	% weight
Aluminium	-	-	-	-	-	-	-	-	-	-	-	-	12	2.0	1	mg/kg
Vanadium	0	220	20	23	12	17	24	45	122	300	370	415	312	149	-	mg/kg
Sodium	0	27	23	24	25	40	35	22	22	24	50	9	-	-	-	mg/kg
CCAI	912	874	849	866	807	843	844	841	868	864	885	-	-	-	-	-