MAN B&W Diesel

Service Letter

SL05-455/HRJ
September 2005

Cylinder Lubrication Guidelines
Operation on Fuels with Varying Sulphur Contents
All MC/MC-C and ME/ME-C type engines
Mk 6 and higher, with Alpha ACC System
Action Code: WHEN CONVENIENT

Dear Sirs

The sulphur content in heavy fuel oil may show large variations depending on the geographical area of origin, i.e. from 1% to 4%. A sulphur content higher than 4% is rare, in fact, less than 3% of all bunkers have a sulphur content above 4%.

Furthermore, environmentally-based sulphur restrictions, i.e. special demands for low-sulphur fuel operation in restricted areas, are now in force to limit SO_x emissions.

Since the launching of the ACC (Adaptive Cylinder oil Control) lubrication principle, see our service letter SL03-417 of January 2003, we have obtained comprehensive and very positive service feedback confirming this lubrication mode to be superior to others.

We have now established, by testing, that there is even more room for reductions in relation to the original ACC algorithm of 0.34 g/kWh x S%, with a corresponding further reduction of the operational costs.

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Therefore, we have revised our Guiding Cylinder Oil Feed Rates (see enclosures 1-3) for the purpose of optimising the cylinder lube oil consumption (CLOC).

Cylinder lubrication demands

The purpose of cylinder lubrication is as follows:

1. to create a hydrodynamic oil film separating the piston rings from the liner,
2. to clean the piston rings, ring lands and ring grooves,
3. to control corrosion, i.e. control the neutralisation of sulphuric acid.

Re 1: The oil amount needed to create an oil film is more or less independent of the fuel oil being used. Measurements of the oil film have also revealed that when the feed rate for optimum oil film is reached, no further increase of the oil film is obtained from an increase of the feed rate. This optimum is kept safely down to a feed rate of 0.55 g/kWh.

Re 2: Cleaning of piston rings, ring lands and grooves is essential, and relies on the detergency properties of the cylinder oil. All approved cylinder oils fulfil the requirements, even at a feed rate as low as 0.55 g/kWh.

Re 3: The combustion process creates highly corrosive sulphuric acids depending on the sulphur in the fuel. It has therefore been of paramount importance to design the combustion chamber and the cylinder lube oil so as to create the optimum balance of corrosion.

Cylinder lubrication dosage

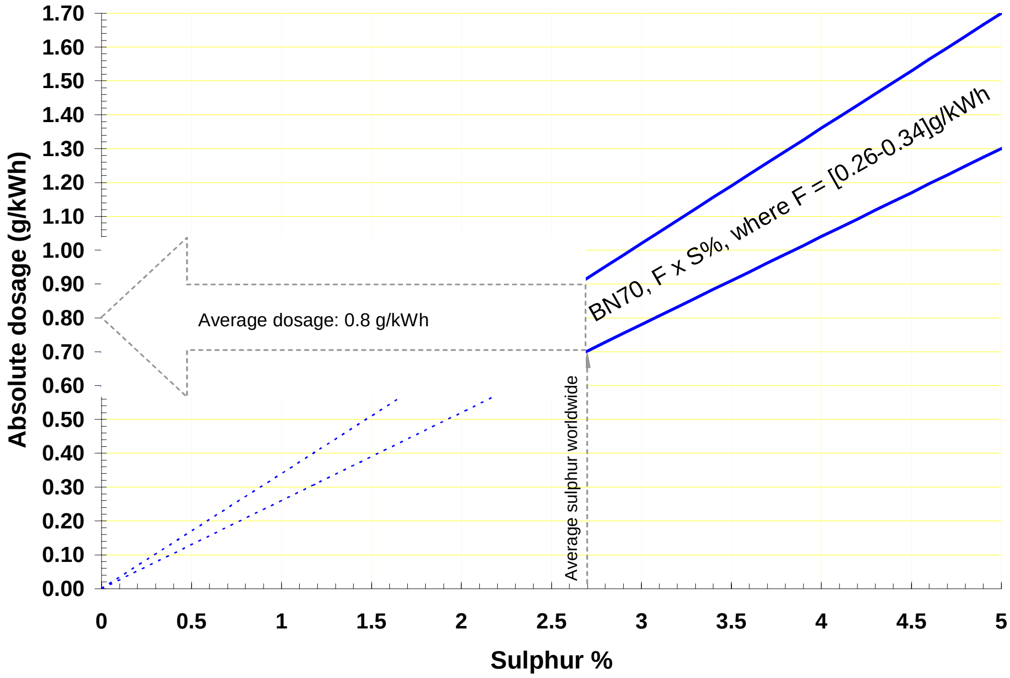
The optimal corrosion control is achieved by a combination of the cooling water design of the cylinder liner, the sulphur content in the fuel, the cylinder lube oil alkalinity, and our new lubrication principle, the ACC algorithm system (Adaptive Cylinder oil Control). The ACC system feeds the oil proportionately to the load (which is proportional to the fuel oil amount being burnt) and to the sulphur content in the fuel. By dosing the amount of oil and, thereby, the amount of alkaline additives proportionately to the total sulphur amount being burnt in the combustion chamber, a constant and controlled low corrosion level can be achieved.

The experience gained so far from a large number of vessels operating at a feed rate factor of **0.34 g/kWh x S%** has been very positive.

However, long term tests with, first **0.29 g/kWh x S%** and later **0.26 g/kWh x S%** have been successful, indicating that an optimum lubrication level is within the below algorithm:

F x S%, where "F" is in the range of 0.26 to 0.34 g/kWh

ACC algorithm with a BN 70 cylinder oil:



On the world market, the average sulphur content in fuels for large two-stroke engines is 2.7%. This would result in an average cylinder oil dosage of around 0.8 g/kWh.

The 0.8 g/kWh multiplied with the yearly production of kWh can be directly used in the calculation of the yearly cylinder oil consumption.

The ACC principle, with the algorithm F x S% where “F” is in the range of 0.26-0.34 g/kWh, satisfies the need for neutralising additives. However, due to the physical need for a certain amount of oil to create a hydrodynamic oil film, the present lower limit is set in the range of 0.60-0.70 g/kWh, which according to the above diagram will be reached with around 2% sulphur.

Running on fuels with a varying sulphur content

Although fuel sulphur levels above 4% are rather rare, running on high-sulphur fuels has accounted for a major part of cylinder wear in the past. Therefore, increasing the oil dosage according to the ACC algorithm is necessary, and very beneficial economically, to prevent the excessive wear associated with such fuels.

However, on low-sulphur fuels, below 2% sulphur content, the engine will, according to the above diagram, be overdosed with alkaline additives. This may lead to cylinder condition problems and, in severe cases, to scuffing.

Overdosing with alkaline additives has two negative effects, which may both lead to the so-called “bore-polish” phenomenon:

- A surplus of alkaline additives has a strong tendency to accumulate on the piston top land, and may grow in thickness to an extent where it interferes with the cylinder liner running surface, in spite of the PC ring (piston cleaning ring). This is most pronounced in the middle and lower part of the liner (where the liner is exposed the least to heat) and in the exhaust side (where the PC-ring is less effective). The result of this negative effect is called mechanical bore-polish.

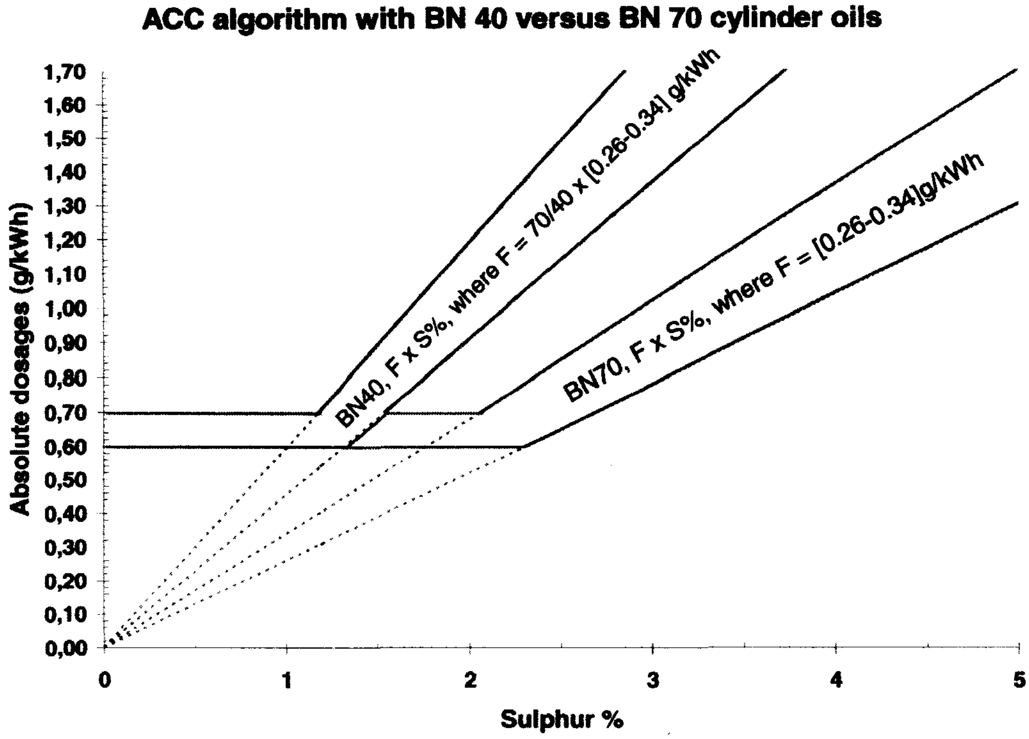
- The other negative effect of overdosing with alkaline additives may be that corrosion (so-called cold-corrosion) is suppressed completely, thereby, limiting the necessary “refreshment” (open graphite structure) of the liner surface. The result of this is called chemical bore-polish. In other words, corrosion should be controlled rather than prevented.

The occurrence of the above negative effects is time-dependent. This means that a surplus of alkaline additives can be accepted for a certain period, depending on the severity of the overdosing.

For example: when running on a fuel with 1% sulphur and using a normal BN 70 cylinder oil, theoretically, a dosage in the range of 0.26 to 0.34 g/kWh is called for according to the ACC algorithm. However, in order to fulfil the lower limit set at 0.60-0.70 g/kWh for hydrodynamic reasons, the amount of additives applied is consequently higher than needed. Such overdosing of alkaline additives should be limited to one or two weeks, and to temporary running on low-sulphur fuels in restricted areas.

If low-sulphur fuels are used predominantly, we advise using a low-BN cylinder oil, either a BN 40 or BN 50 oil.

The diagram overleaf shows the algorithm using a BN 40 cylinder oil versus a “normal” BN 70 cylinder oil.



Experience has shown that satisfactory running on fuels containing almost no sulphur (gas oil, kerosene, etc.) can be obtained using a low-BN cylinder oil.

If a BN 40 cylinder oil is used, the ACC algorithm should be:

F x 70/40 x S%, where "F" is in the range of 0.26-0.34 g/kWh

If low-sulphur fuels are bunkered regularly, in-between normal or high-sulphur fuels, a two-tank system should be considered, offering the possibility of changing between low-BN and normal-BN cylinder oils.

Questions or comments regarding this SL should be directed to our Dept. 2300.

Yours faithfully

MAN B&W Diesel A/S

Carl-Erik Egeberg

Ole Grøne

Encl.

<table>
<tr><td colspan="5">Guiding Cylinder Oil Feed Rates
S/L/K-MC/MC-C/ME/ME-C, Mk 6 and higher, with Alpha ACC lubrication system</td></tr>
<tr><td colspan="2"></td><td colspan="2">Standard BN 70 cylinder oil</td><td>BN 40 cylinder oil</td></tr>
<tr><td colspan="2">Basic setting</td><td colspan="2">0.26-0.34 g/kWh x S%
0.19-0.25 g/bhph x S%</td><td>0.26-0.34 g/kWh x 70/40 x S%
0.19-0.25 g/bhph x 70/40 x S%</td></tr>
<tr><td colspan="2">Minimum feed rate</td><td colspan="3">0.60-0.70 g/kWh
0.45-0.50 g/bhph</td></tr>
<tr><td colspan="2">Maximum feed rate during normal service</td><td colspan="3">1.7 g/kWh
1.25 g/bhph</td></tr>
<tr><td colspan="2" rowspan="2">Part-load control</td><td colspan="3">Proportional to engine load</td></tr>
<tr><td colspan="3">Below 25% load, proportional to MEP (Mean Effective Pressure)</td></tr>
<tr><td rowspan="4">Running-in new or reconditioned liners and new piston rings</td><td rowspan="2">Feed rate:</td><td>Alu-coated or hard-coated piston rings:</td><td colspan="2">First 5 hours: 1.7 g/kWh
From 5 to 250 hours: 1.5 g/kWh
From 250 to 500 hours: 1.2 g/kWh</td></tr>
<tr><td>Non-coated:</td><td colspan="2">First 15 hours: 1.7 g/kWh
From 15 to 250 hours: 1.5 g/kWh
From 250 to 500 hours: 1.2 g/kWh</td></tr>
<tr><td rowspan="2">Engine load:</td><td>Alu-coated or hard-coated piston rings:</td><td colspan="2">Stepwise increase to max. load over 5 hours</td></tr>
<tr><td>Non-coated:</td><td colspan="2">Stepwise increase to max. load over 15 hours</td></tr>
<tr><td colspan="2">Running-in new rings in already run-in and well running liners:</td><td colspan="3">Alu-coated or hard-coated piston rings : No load restrictions
Non-coated rings : Stepwise increase to max. load over 5 hours
Feed rate : Basic setting +25% for 24 hrs.</td></tr>
<tr><td colspan="2">Manoeuvring and load change situations.</td><td colspan="3">During starting, manoeuvring and load changes, the feed rate should be increased by 25% and kept at this level for ½ hour after the load has stabilised.</td></tr>
<tr><td colspan="2">Lubrication of cylinders that show abnormal conditions:</td><td colspan="3">Frequent scavenge port inspections of piston rings and cylinder liners are very important for maintaining a safe cylinder condition.
If irregularities are seen, adjustments of the lube oil rate should be considered.
In case of scuffing, sticking piston rings or high liner temperature fluctuations, the feed rate should be raised by 25-50%.</td></tr>
</table>

Adjusting Alpha Lub. using ACC, BN 40 Cylinder Oil								
ACC factor g/kWh x S%							**g/kWh**	**HMI setting**
0,26	**0,27**	**0,29**	**0,30**	**0,31**	**0,33**	**0,34**		
Sulphur content %								
0	0	0	0	0	0	0	0,61	56
1,4	1,3	1,2	1,2	1,1	1,1	1,0	0,61	56
1,5	1,4	1,3	1,3	1,2	1,1	1,1	0,65	60
1,6	1,5	1,4	1,4	1,3	1,3	1,2	0,71	66
1,7	1,6	1,5	1,5	1,4	1,4	1,3	0,77	71
1,8	1,8	1,7	1,6	1,5	1,5	1,4	0,83	77
2,0	1,9	1,8	1,7	1,6	1,6	1,5	0,89	82
2,1	2,0	1,9	1,8	1,7	1,7	1,6	0,95	88
2,2	2,1	2,0	1,9	1,8	1,8	1,7	1,01	93
2,4	2,3	2,1	2,0	2,0	1,9	1,8	1,07	98
2,5	2,4	2,3	2,2	2,1	2,0	1,9	1,13	104
2,6	2,5	2,4	2,3	2,2	2,1	2,0	1,19	109
2,8	2,6	2,5	2,4	2,3	2,2	2,1	1,25	115
2,9	2,8	2,6	2,5	2,4	2,3	2,2	1,31	120
3,0	2,9	2,7	2,6	2,5	2,4	2,3	1,37	126
3,2	3,0	2,9	2,7	2,6	2,5	2,4	1,43	131
3,3	3,1	3,0	2,8	2,7	2,6	2,5	1,49	137
3,4	3,3	3,1	3,0	2,8	2,7	2,6	1,55	142
3,6	3,4	3,2	3,1	2,9	2,8	2,7	1,61	148
3,7	3,5	3,3	3,2	3,0	2,9	2,9	1,73	160
3,8	3,6	3,4	3,2	3,1	3,0	2,9	1,70	156

Adjusting Alpha Lub. using ACC, BN 70 Cylinder Oil

ACC factor g/kWh x S%							g/kWh	HMI setting
0,26	**0,27**	**0,29**	**0,30**	**0,31**	**0,33**	**0,34**		
Sulphur content %								
0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,60	56
0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,60	56
1,0	1,0	1,0	1,0	1,0	1,0	1,0	0,60	56
1,1	1,1	1,1	1,1	1,1	1,1	1,1	0,60	56
1,2	1,2	1,2	1,2	1,2	1,2	1,2	0,60	56
1,4	1,4	1,3	1,3	1,3	1,3	1,3	0,60	56
1,6	1,6	1,4	1,4	1,4	1,4	1,4	0,60	56
1,8	1,8	1,6	1,6	1,5	1,5	1,5	0,60	56
2,0	2,0	1,8	1,8	1,6	1,6	1,6	0,60	56
2,2	2,2	2,0	1,9	1,8	1,7	1,7	0,60	56
2,4	2,3	2,1	2,0	2,0	1,9	1,8	0,60	56
2,5	2,4	2,3	2,2	2,1	2,0	1,9	0,65	59
2,6	2,5	2,4	2,3	2,2	2,1	2,0	0,68	63
2,8	2,6	2,5	2,4	2,3	2,2	2,1	0,71	66
2,9	2,8	2,6	2,5	2,4	2,3	2,2	0,75	69
3,0	2,9	2,7	2,6	2,5	2,4	2,3	0,78	72
3,2	3,0	2,9	2,7	2,6	2,5	2,4	0,82	75
3,3	3,1	3,0	2,8	2,7	2,6	2,5	0,85	78
3,4	3,3	3,1	3,0	2,8	2,7	2,6	0,88	81
3,6	3,4	3,2	3,1	2,9	2,8	2,7	0,92	84
3,7	3,5	3,3	3,2	3,0	2,9	2,8	0,95	88
3,8	3,6	3,5	3,3	3,2	3,0	2,9	0,99	91
3,9	3,8	3,6	3,4	3,3	3,1	3,0	1,02	94
4,1	3,9	3,7	3,5	3,4	3,2	3,1	1,05	97
4,2	4,0	3,8	3,6	3,5	3,3	3,2	1,10	100
4,3	4,1	3,9	3,8	3,6	3,4	3,3	1,12	103
4,5	4,3	4,0	3,9	3,7	3,5	3,4	1,16	106
	4,4	4,2	4,0	3,8	3,6	3,5	1,19	109
	4,5	4,3	4,1	3,9	3,8	3,6	1,22	113
		4,4	4,2	4,0	3,9	3,7	1,26	116
		4,5	4,3	4,1	4,0	3,8	1,29	119
			4,4	4,2	4,1	3,9	1,33	122
			4,5	4,3	4,2	4,0	1,36	125
				4,5	4,3	4,1	1,39	128
					4,4	4,2	1,43	131
					4,5	4,3	1,46	134
						4,4	1,50	138
						4,5	1,53	141