Main Engine Operating Guidance

Updated 21/12/2016

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Subject	Main Engine Power & CLO Instruction
Name of Vessel	British Respect, British Renown, British Reliance, British Resource, British Rigour, British Resolution, British Regard, British Restraint, British Reason
Type of Vessel	Aframax Tanker
Engine Make & Type	MAN B&W 6G60ME-C9.2 Tier 2
Engine Builders	STX Heavy Industries Co., Ltd.
IMO Number	9683001, 9683013, 9683025, 9683037, 9683049, 9683051, 6983063, 9683075, 9683087
Engine Builder No	SB6G60-12990 (Respect)
Yard Building No	S1611
Date of Shop Trial	2015-04-13 (first engine)
Prepared by	FST Mechanical

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Power Instruction

Objective

The objective of this instruction is to provide guidelines for safe, reliable and economical operation of the main engine. For reasons of best economy and lowest emissions, the engine has to be operated, throughout the load range, as close to the shop test values as possible at all times.

Layout of Propeller

Power:	10, 701 kW
Torque:	1, 357 kNm
Speed:	75.3 RPM

The above layout equals a light-running margin of 5 %.

Critical or Barred Speed Ranges

Barred speed range: 34 - 42 rpm
One Cylinder misfiring: Max 66 rpm

Main Engine Rating at shop trial

Power:	11, 890 kW (brake power, 100 % MCR)
Torque:	1, 456 kNm
Speed:	78 RPM

Definition: MCR = **M**aximum **C**ontinuous **R**ating

Normal Running Procedure

Until updated instructions are issued, except for testing, the maximum engine shaft power in service is limited as follows:

11, 296 kW corresponding to 95% of MCR,

provided that none of the following parameters are exceeded:

Engine Speed	76.7	RPM,
Engine Torque	1, 407	kNm
MEP (**M**ean **E**ffective **P**ressure),	20.1	bar,
PMax (Maximum Combustion Pressure) (+/-3)	185	bar,
Exhaust Gas Temperature before TC (max)	500	ºC,
Turbocharger Speed	15,500	RPM

Chief Max Speed limit to be set in normal operation at	**79.3**	**RPM (105%)**
Chief Index limit to be set in normal operation at	**98.5**	**%**

Please observe that Chief Limits are non-cancellable.

The load diagram below shows the permissible range of engine power, engine speed and mean effective pressure indicated by the hatched field. However, note that the hatched field to the left of the line indicating the nominal propeller curve can only be used for transient operating conditions such as acceleration and is to be avoided for continuous operation.

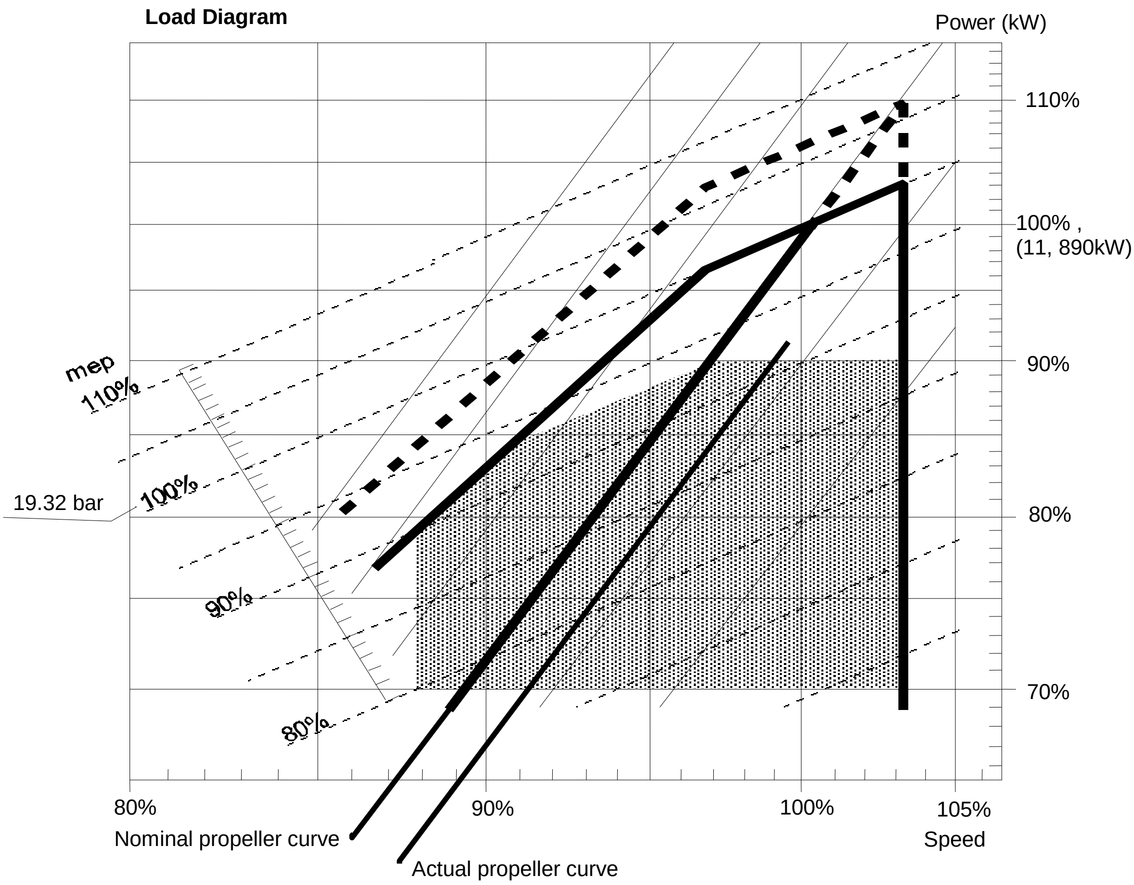

Figure 1: Load Diagram, MAN B&W 6G60ME-C9.2

The engine load cannot be increased beyond these limits without permission from your superintendent, unless the ship and/or complement is in danger, in which case the Master in conjunction with the Chief Engineer can use their own judgment with due regard to their responsibility for the crew, the vessel and the cargo.

Load control - The engine load is controlled in three ways.

Load Program

The load-up program prevents mechanical and thermal overload during load-up and ensures sufficient time for the auxiliary systems to adapt, by controlling the load-up rate.
A load program in the engine ECS (**E**ngine **C**ontrol **S**ystem) limits the engine load change during running-up as detailed below, measured in percent MCR speed (rpm).

80% (62.4 rpm) to 90% (70.2 rpm): 30 minutes
90% (70.2 rpm) to 100% (78 rpm): 60 minutes

The run down program is controlled by the Kongsberg Bridge Control System as MAN Diesel does not specify a run-down program. The engine can be run down instantly to any load level without restriction. However, it is recommended to always slow down the engine in a controlled and cautious run-down. The engine ECS (**E**ngine **C**ontrol **S**ystem) limits the engine load change during running-down as detailed below, measured in percent MCR speed (rpm).

80% (62.4 rpm) to 90% (70.2 rpm): 5 minutes
90% (70.2 rpm) to 100% (78 rpm): 5 minutes

Engine Torque limit

The torque limiter prevents excessive torque/mechanical overload by ensuring that the engine load never exceeds the boundaries of the load diagram.

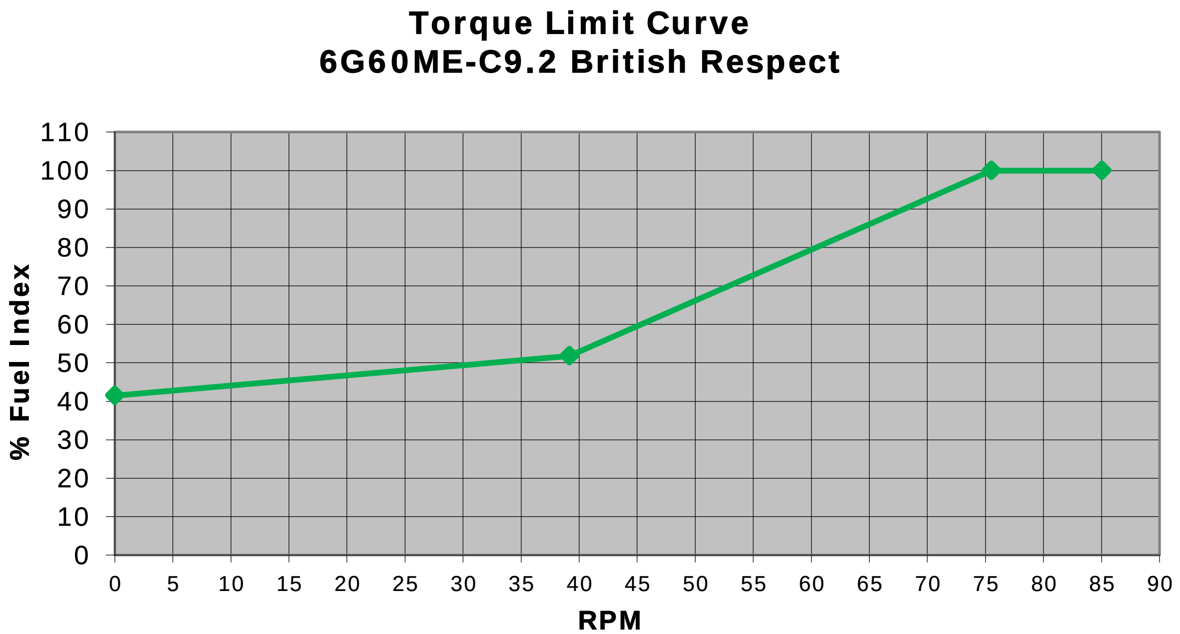

Figure 2: Torque Limit Curve

Scavenge Air limiter

The scavenge air limiter ensures sufficient scavenge air supply for maintaining an efficient and smoke-free combustion. The scavenge air limiter balances the air/fuel ratio by limiting fuel injection in case of insufficient air supply.

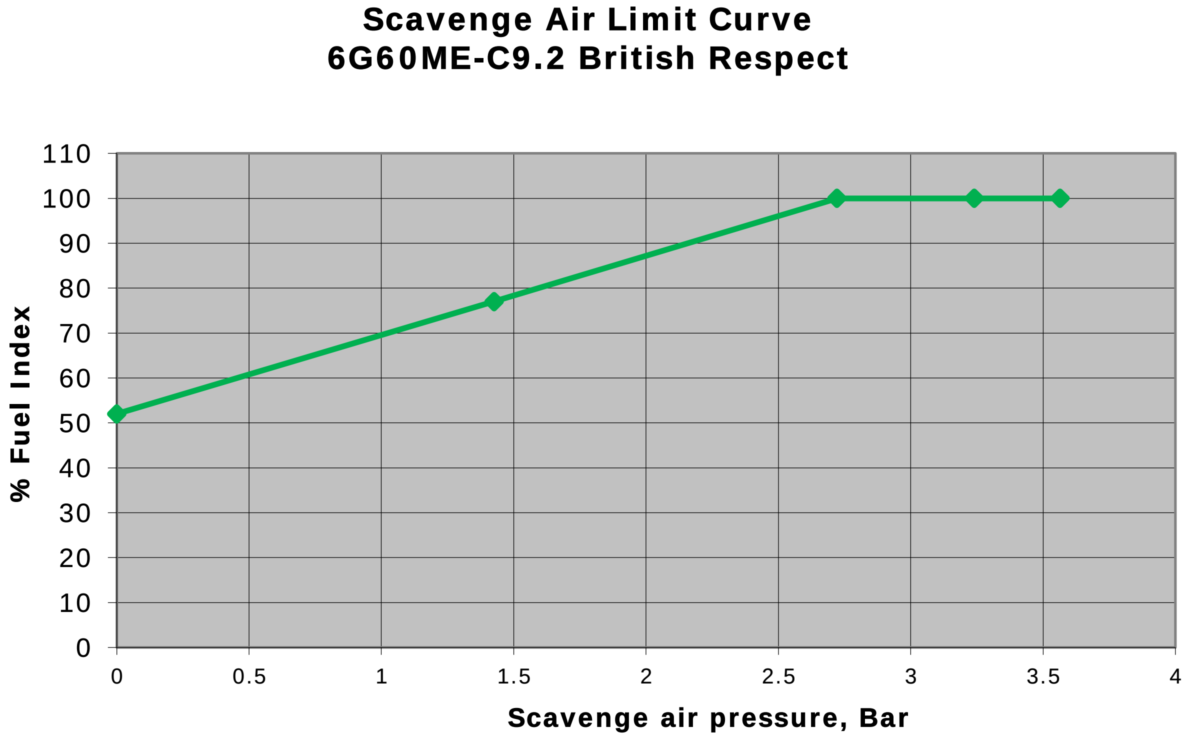

Figure 3: Scavenge Limit Curve

Increase limiter button

The increase limiter button cancels the load-up program and increases the scavenge air and torque limiter settings by 10%.
The increased limits are only to be used when required and not to be left continuously switched on.

Maximum Combustion Pressure

The below diagram shows the combustion & compression pressures during shop trial. The PMax curve represents the maximum pressure allowed under NOx compliance. During operation, PMax should be kept as close to the curve as possible to improve fuel efficiency.

The engine is fitted with auto tuning which can continually optimise the actual values. Therefore, the PMax and PComp (Compression Pressure) may deviate from the below curves and it is recommended to avoid interfering as long as the systems work normally.

Main Engine shall be balanced at the given load such that ΔP = PMax – PComp = 40 bar. An engine is considered well balanced when all cylinders are firing within ± 3 bar of 40 bar. That means some cylinders may experience a higher pressures rise than 40 bar. This is acceptable, but ΔP should under no circumstances exceed 45 bar.

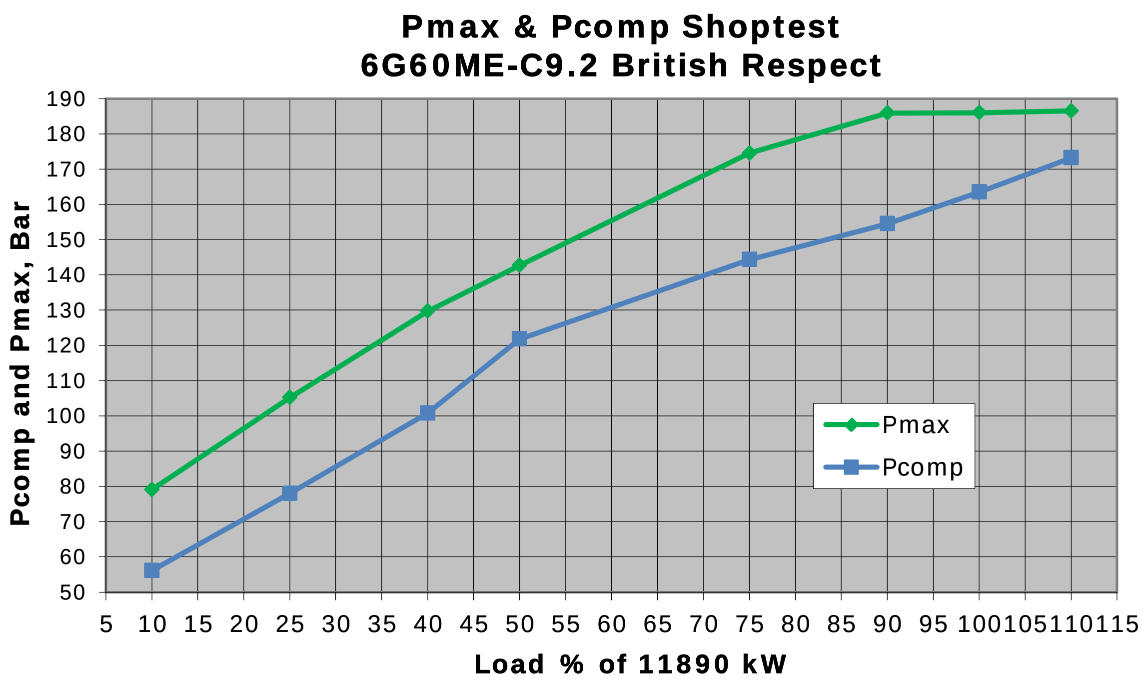

Figure 4: PMax & PComp Shop test

Please note that EIAPP (NOx) tolerance for PMax is ±3 bar, measured at 25, 50 75 & 100% load.

SFOC (Specific Fuel Oil Consumption) model curves

The below curve shows the shop test consumption with a corrected LCV (Lower Calorific Value) of 42700 kJ/kg. When comparing to actual consumption ISO correction must be applied.

This will be done automatically by the updated BPOSS system – please refer to the reports from BPOSS. The actual fuel consumption is expected to be in the range 103 to 106%.

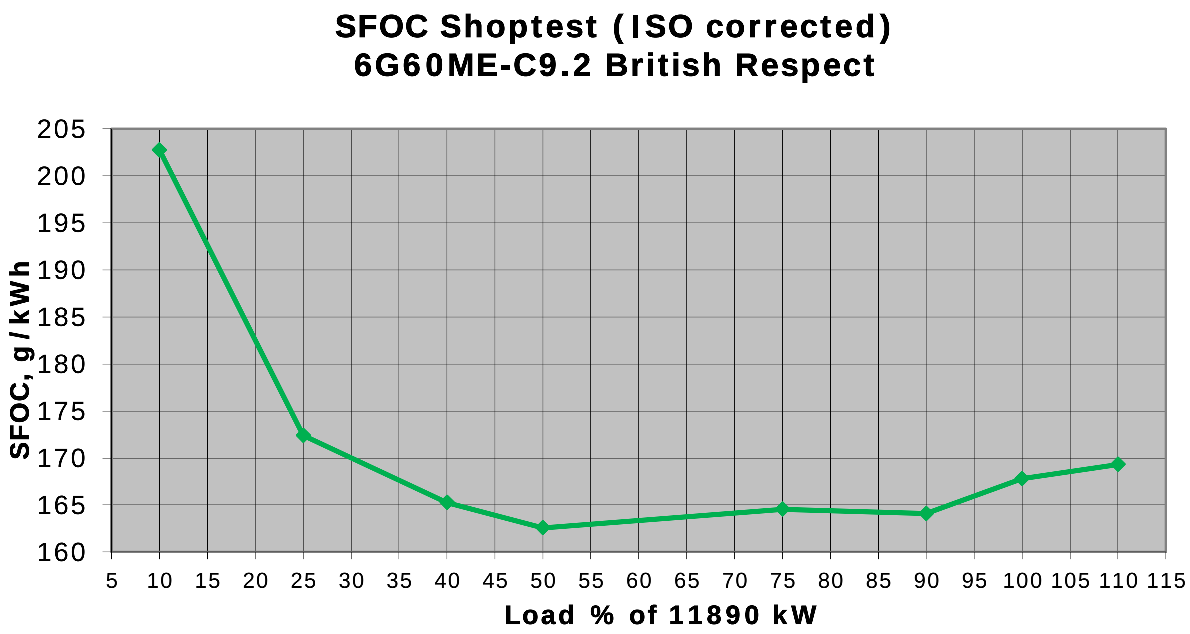

Figure 5: SFOC Shop test (ISO corrected)

Engine Cylinder Balance Check & Performance Optimisation

The PMI auto-tuning system has three adjustment modes;

1. Continuous Automatic
2. User control Automatic and
3. Manual.

While, mean PComp and PMax can be adjusted automatically, the balancing of Pi (**I**ndicated **P**ressure) has to be manually done. It is recommended to manually tune the Pi at least once per day. Please refer PMI Auto-tuning operation guide for detailed instruction.

The maximum permissible deviations from the engine average values are:

PComp (Compression Pressure)	± 3 bar
PMax (Maximum Combustion Pressure)	± 3 bar
MIP (Mean Indicated Pressure)	± 0.3 bar

If these deviations are exceeded, adjustments must be made in the following order:

1. FQS (**F**uel **Q**uality **S**etting) as per the separate guideline.
2. Pi per cylinder (controlling injected fuel amount).
3. Pi all (controlling injected fuel amount).
4. PComp per cylinder (controlling the exhaust valve closing timing).
5. PComp all (controlling the exhaust valve closing timing).
6. PMax per cylinder (controlling the fuel injection timing).
7. PMax all (controlling the fuel injection timing).

Engine cylinder balance check and necessary adjustments must be carried out daily, when possible and always prior to any performance test – at the load required for the vessels schedule.

In order to achieve the best possible SFOC scavenge air temperatures should always be maintained as low as practically possible. In addition to improving the SFOC the cooler scavenge air reduces the quantity of water entering the cylinder, in turn reducing the moisture available for acid formation and cold corrosion.

Abnormal Running Procedure

In emergency cases, where the engine is required to be run with one or more cylinders out of operation, reduced coolant flows etc., the engine load has to be reduced in order to prevent thermal overloading. In some cases the engine speed is the limiting factor to protect the crankshaft against excessive torsional vibration.

When a cylinder unit is out of operation, i.e. not firing, for more than 4 hours, the cylinder lubricating oil dosage on the liner in question has to be reduced to 0.60 g/kWh.

The main engine instruction book deals with a number of such emergency cases and their countermeasures. In case of an emergency, your superintendent has always to be informed by phone and in writing as soon as possible.

If it is necessary to operate the engine with one exhaust valve locked shut the engine power will be restricted to 30% MCR due to too high compression pressure.

If damage occurs to the engine that makes abnormal running necessary, precautions have to be taken to protect the engine. Due to their sometimes complex nature, these precautions are to be agreed with your superintendent on a case-by-case basis. Extended running with increased scavenging air temperatures is not allowed unless explicitly agreed by your superintendent.

Low Load operation

When running at low load, the Exhaust Gas Temperature after the TC has to be maintained above 180 ºC.

To reduce the risk of cold corrosion the engine is installed with the LDCL (**L**oad **D**ependent **C**ylinder **L**iner cooling) system. The system is made up of additional piping, one extra three way valve and an additional cooling water pump, all mounted on the engine and automatically controlled by the ECS. The system is designed to maintain the cylinder liner cooling water at higher temperatures than normal for loads below 90% MCR.

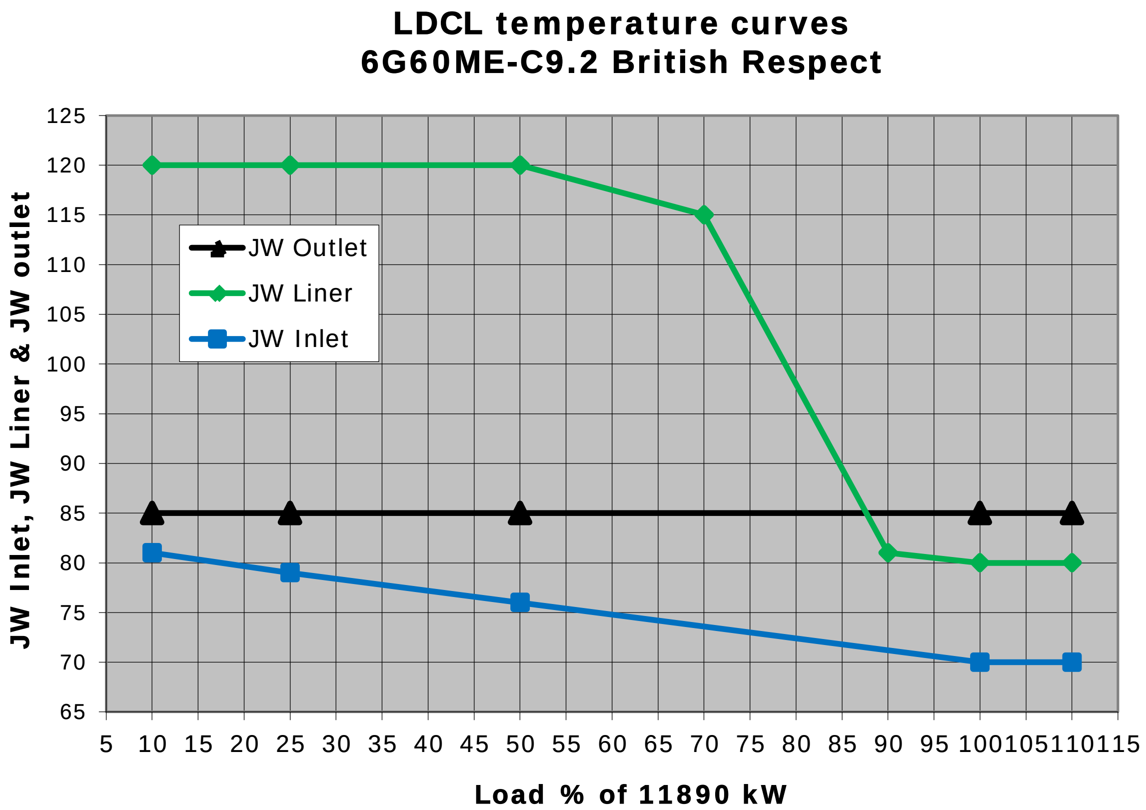

Figure 6: LDCL Temperature Curve

Operation with Auxiliary Blowers running

In case longer periods of low load operation with auxiliary blowers running are needed, a spare auxiliary blower electric motor and impeller(s) is to be kept on board or dispensation obtained from your superintendent. Any failure to an auxiliary blower or lack of spare parts has to be reported to your superintendent immediately for correction and risk evaluation before continued operation at low load. Whilst operating with auxiliary blowers running the point at which the auxiliary blowers are frequently switched ON and OFF, has to be avoided. It is recommended to keep the exhaust gas temperatures before turbocharger under thorough surveillance and in the range 200 – 340 °C.

Auxiliary Blower cut-in set point: 0.55 bar g
Auxiliary Blower cut-out set point: 0.75 bar g

Continuous operation (more than 24 hours) below 30% power is not allowed except when passing channels.

Exhaust Gas By-pass

The main engine is fitted with an exhaust gas by-pass, which at high load allows excess exhaust gas to by-pass the turbocharger. The valve s is controlled automatically by the main engine software.
In the event of a failure to this valve the turbocharger RPM, while operating at high load, has to be monitored to prevent over speed.

The turbocharger over speed set point is 17 640 rpm.

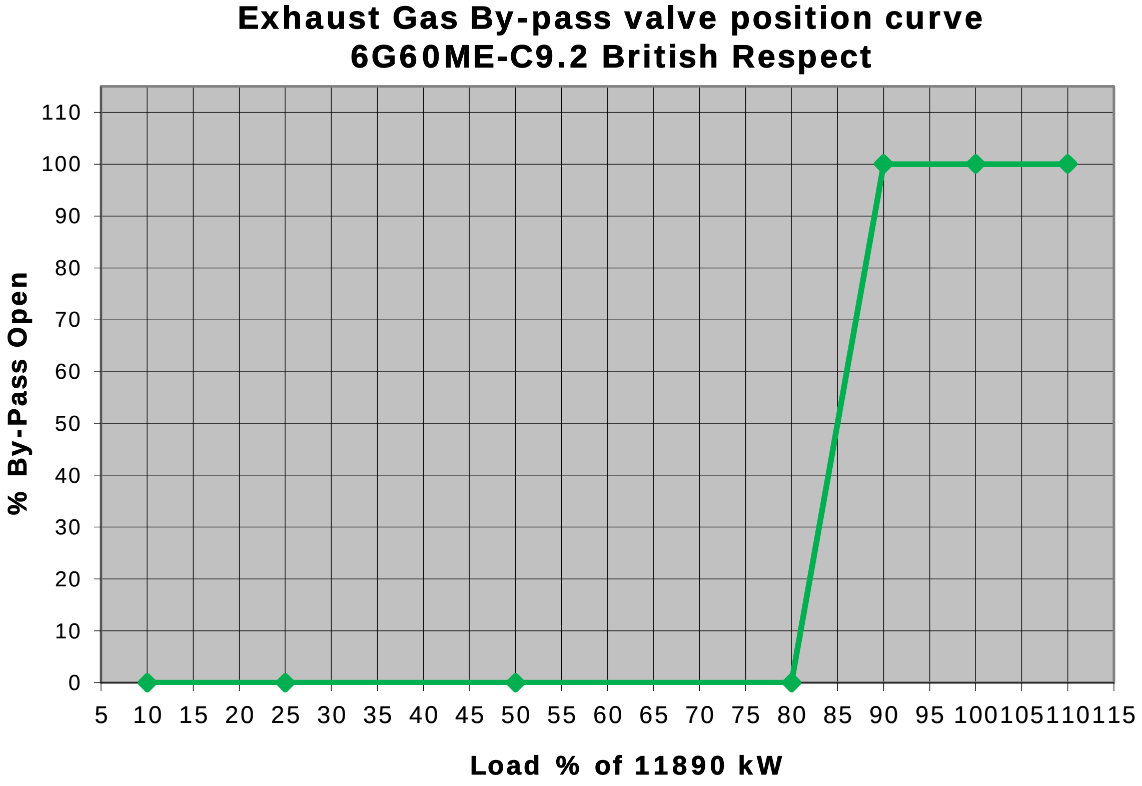

Figure 7: Exhaust Gas By-pass valve position

Cleaning of Turbochargers

Cleaning of turbochargers has to be carried out according to following table; where "engine load" is the actual continuous load for the previous 24 hours:

Engine load	Action	Load during cleaning	Interval Days
10 - 50%	Turbine dry cleaning	50%	1-2
50 – 85%	Turbine dry cleaning	Actual load	1-2
> 85%	Turbine dry cleaning	85%	1-2
10 - 25%	Compressor, water cleaning	25%	2
25 - 85%	Compressor, water cleaning	Actual Load	2
> 85%	Compressor, water cleaning	85%	2

Figure 8: Compressor cleaning intervals

- When operating on fuel oil near or above specification with respect to V (Vanadium), Na (Sodium) and MCR (**M**icro **C**arbon **R**esidue) - see fuel analysis, the turbine cleaning interval has to be chosen in the lower end of the range.
- In order to maintain best possible compressor performance and highest possible compressor cleaning interval, all air intake filters and water drains have to be checked and confirmed on a weekly basis.

Cleaning medium - Water - 2 litres
Cleaning medium – Walnut shell – 1.5 litres - grain size 1.2 to 2.0 mm (marine grit #12)

Economical Operation

To obtain the most economical operation, the main engine has to always be operated in torque mode at the lowest possible constant output throughout the voyage, necessary to maintain the vessel's required speed.

Cylinder Lubrication Instruction

The objective of this instruction is to provide guidelines for safe, reliable and economical operation of the main engine with a particular view to the cylinder condition.

The individual feed rate ACC (**A**daptive **C**ylinder oil **C**ontrol) factor will be evaluated for each engine using scrape down oil analysis and frequent scavenge port inspections.

Final cylinder lubrication guidance will be given after running-in has been completed. Until verified by in service testing, it is recommended that the ACC feed rate factor be kept at 0.4 g/kWh/S% with 100 BN cylinder oil.

Type of Cylinder Lubricating Oil

When running on HFO (**H**eavy **F**uel **O**il) with “normal” sulphur content, i.e. in the range between 1% and 3.5%, the engine cylinder liners need to be lubricated with cylinder lubricating oil having a TBN (**T**otal **B**ase **N**umber) of 70 or higher.

In cases where the engine will be operated permanently on fuel with sulphur content below 1%, a cylinder lubricating oil with a TBN of 40 or lower.

Mixing of different grades in one tank needs to be agreed in advance with your superintendent.

Dosage during Normal Operation

During normal operation, running on HFO with sulphur content in the range between 1% and 3.5%, the cylinder lubricating system is to be adjusted to provide a dosage that is related to the HFO sulphur content.

The relation between cylinder lubricating oil dosage and HFO sulphur content is determined after in service testing. The HFO sulphur content can be found in the bunker laboratory analysis, and every time there is a change in fuel sulphur content of the fuel in use, the ECS screen is to be updated accordingly.

The ACC feed rate factor and the minimum feed rates are set by the office based on Class wide experience gained from in-service testing. In case of questions please contact your superintendent.

Under normal conditions the cylinder lubricating oil ACC feed rate factors are not to be changed without instruction from your superintendent.

The following graph (figure 6) shows examples for an ACC feed rate factor of 0.2, with 100 BN cylinder oil and 3.0% sulphur fuel and ACC feed rate factor 0.35, with 70 BN cylinder oil and 3.0% sulphur.

Target feed rate = ACC x sulphur %

Where the target feed rate is below the minimum feed rate, the minimum feed rate applies.

It is recommended that the cylinder lubricating oil consumption is cross checked by flow meters and/or day tank measurements on a daily basis.

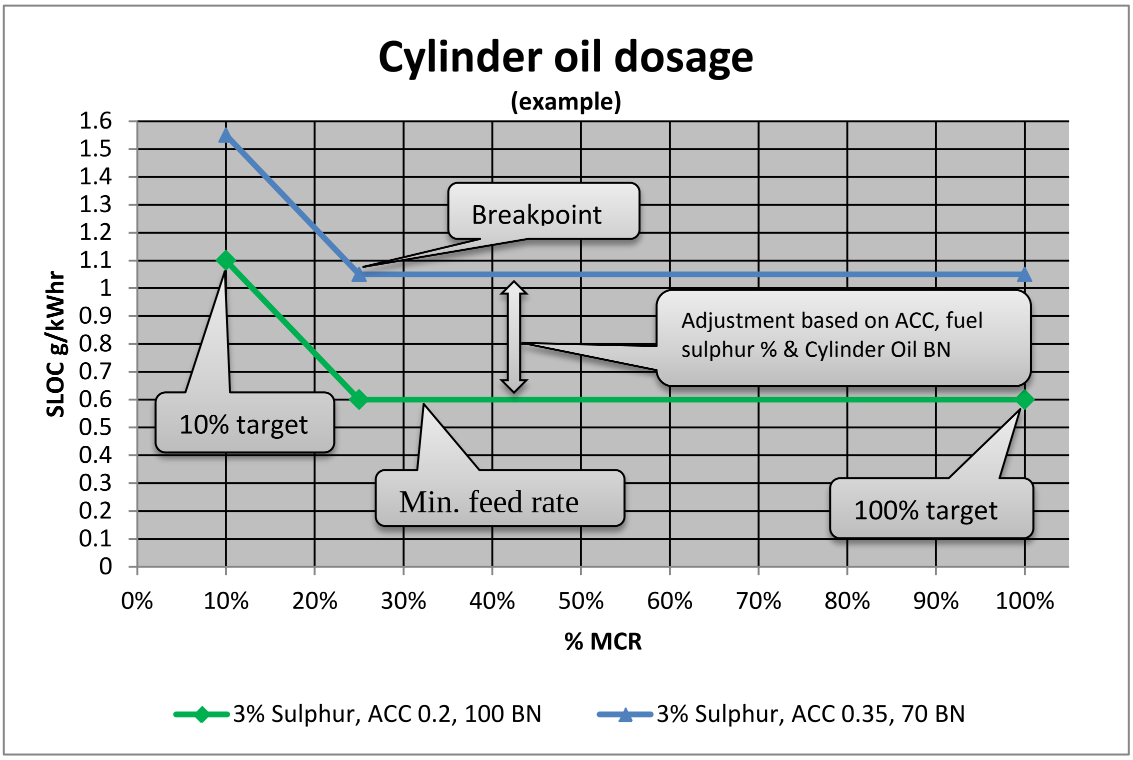

Figure 9: Cylinder Oil Dosage (example)

Dosage on Cylinder Units not Firing

In emergency cases it might be necessary to take one or more cylinder units out of operation by interrupting the fuel injection. When running the engine in such condition for more than 4 hours, the cylinder lubricating oil dosage on the liner(s) in question has to be reduced to 0.60 g/kWh.

This lower dosage will maintain the necessary oil film to separate the piston rings from the cylinder liner and minimize contamination of the exhaust gas system and the turbochargers with un-burned cylinder lubricating oil, reducing the risk of consequential damage.

Scavenge Port Inspections

Inspection of pistons, rings and liners through the scavenging ports in the scavenging air receiver are to be carried out in line with the planned maintenance system.

During the scavenge inspection, where accessible, the CL-groove depths are to be measured and sent to GBPSFLEETOPSFSTMECH@bp.com. The minimum CL-groove depth for a 60 cm bore engine is 1.3mm.

In each quarter, please complete the scavenge inspection report, filling in all necessary details and photos before forwarding to your superintendent and GBPSFLEETOPSFSTMECH@bp.com

If lubrication system irregularities are found, the faults have to be corrected immediately.

If micro seizures are found, the cylinder lubricating oil dosage can be temporarily increased by 25-30% and inspection intervals shortened. When the condition is found normal again, the dosage is to be set back to normal.

All irregularities are to be informed in writing to your superintendent.

Running-in lubrication

During the initial running-in, extra oil is needed, in order to flush away wear particles, and in order to ease building up the oil film when the surfaces are relatively rough. In that period, relatively high lubrication is necessary.

The running-in process is eased and shortened considerably by the use of alu-bronze as a "running-in" coating on all 4 piston rings. The liner surfaces need only little run-in due the semi honed surface. Please refer to the below "Figure 6: running-in", corresponding to MAN SL2014-587.

Hours	g/kWh
0 - 5 hours	1.70
5 - 100 hours	1.50
100 - 200 hours	1.30
200 - 300 hours	1.10
300 - 400 hours	0.90
400 - 500 hours	0.70

Figure 10: Running-in

The feed rate during breaking-in cannot be set lower than the target feed rate. The higher of the two must always be used.

Until verified by in service testing, the ACC feed rate factor has to be kept at 0.4 g/kWh/S% with 100 BN cylinder oil.

During running-in, regular scavenge inspections are recommended to be carried out, and where practical before any feed rate reduction. It is not recommended for the feed rate to be reduced further if the inspection reveals seizures or other irregularities.

Running-in load

Please refer to “Figure 12: Guiding Cylinder oil feed rates” corresponding to MAN SL2014-587.

Sweep testing and SDA (Scavenge Drain Analysis)

After the 500 hour running-in period, in order to determine the correct ACC feed rate factor the vessel is recommended to conduct a sweep test.
The full sweep test takes six days, during this time; the vessel will ideally be running on fuel with sulphur content ideally 2.7%. It is vital that during the testing period the engine load remains constant. The feed rate of the cylinder oil is set to fixed steps and drain oil samples are taken after 24 hours, before lowering to the next step.
It is recommended prior to reducing to the next feed rate, the BN of the scavenge drain is checked. If the BN reserve is lower than 10 do not proceed with further feed rate reduction.
Once the sweep test is completed it is recommended that ACC feed rate factor is returned to 0.4 g/kWh/S% with 100 BN cylinder oil.
For full details about the sweep test procedure please refer to MAN Diesel & Turbo service letter SL2014-587.

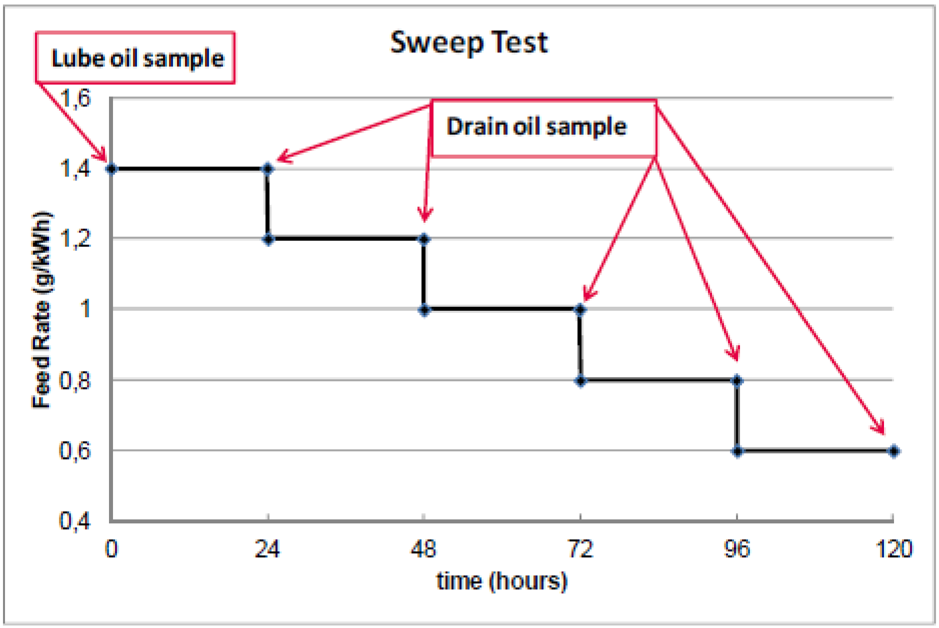

Figure 11: Sweep test schedule

If there is insufficient time to carry out the full sweep test, please conduct as many steps as possible.

For the full duration of the guarantee period it is recommended to take a single set of SDA samples approximately every three months at an engine load above the cylinder lubrication breakpoint. If the engine load required for the voyage is below the breakpoint the SDA sampling can be postponed until the next voyage. These samples are to be taken (as far as practical) under steady conditions.

Sweep test and quarterly SDA samples, with correctly completed paper work are to be landed to Castrol for full analysis.

Running-in checks

The alu-coat surface on the piston rings is for running-in only. After 500 to 1500 running hours the running-in coating will normally start to be worn through, and the base material or the cermet coating on the top and bottom rings, will be exposed.

Around 1500 running hours, the piston rings are to be carefully checked via the scavenge air ports. During the entire running-in period and afterwards, it is recommended to carry out frequent scavenge port inspections. After a total of 2500 hours, and if rings and liners are found free from micro seizures or other irregularities, the liner and piston rings are considered fully run in.

Operating on low sulphur fuels

When dosing the cylinder oil proportional to the sulphur content of the fuel, the right amount of alkali additives are provided. This means that most of the sulphur acid created by the combustion process will be neutralised. This balance, with a little controlled corrosion, ensures a healthy liner surface and a low wear rate is obtained.

However, when the target feed rate falls below specified minimum feed rate, the minimum feed rate must be respected. This means a surplus of alkalinity is applied when using normal BN70-100 cylinder oil.

Excess alkalinity is harmful to the cylinder condition, due to accumulated unused additives on the piston top land and due to the lack of corrosive refreshment of the liner surface, both leading to so-called “bore polish” and latent risk of micro seizure and SSW (Sudden Severe Wear).

This negative influence is time based. It takes some time to build up the deposits, and it takes some time to polish the liner surface. The negative influence also becomes worse the lower the fuel sulphur content is.

In case of SECA fuel with about 0.1% sulphur, high BN cylinder oil can normally be used up to two weeks without adverse effects.

In case of longer time operating inside SECA areas or on low sulphur fuel, change to lower BN cylinder oil is recommended. The vessel will need to contact their superintendent if such operation is planned.

Guiding cylinder oil feed rates
All ME/ME-C/ME-B/ME/MC/MC-C and ME-GI engines
With electronically controlled lubrication system

	Mk 8-8.1 and newer Standard BN 100	Mk 7 and older Standard BN 70-100
Viscosity range	SAE 50	SAE 50
ACC setting	0.40-0.20 g/kWh x S%	0.34-0.20 g/kWh x S%
Guiding minimum feed rate	0.60 g/kWh	0.60 g/kWh
Maximum feed rate during running-in	1.7 g/kWh	1.7 g/kWh
Part-load control	Proportional with load. At lower loads control is automatically changed to proportional with rpm. Breakpoint from power to rpm-dependent lubrication to be set to 25% load.	
Running-in new or reconditioned liners and new piston rings	**Feed rate:** First 5 hours: 1.7 g/kWh From 5 to 500 hours: Stepwise reduction from 1.5 - 0.6 g/kWh or ACC factor x fuel sulphur (using the highest feed rate) **Engine load:** Test bed: Stepwise increase to max. load over 5 hours In service: 50% to max. load in 16 hours	
Familiarizing ACC Factor	Starting at 0.40 g/kWh x S% (Fig. 6a)	Starting at 0.34 g/kWh x S% (Fig. 6b)
	Reducing in steps of 0.04 g/kWh x S% after min. 600 hours where the feed rate has been sulphur dependent (above min. feed rate) or using feed rate sweep or continuous drain oil analysis. If the engine is retrofitted with means to improve part or low-load fuel consumption, the ACC factor must be reassessed.	
Running-in new rings in already run-in and well running liners	From 50% to max. load in 5 hours Feed rate 0.9 g/kWh for 24 hours. If the fuel sulphur and applied ACC factor combination results in a specific feed rate higher than 0.9 g/kWh (use the calculation feed rate), no extra lubrication is needed.	
Manoeuvring and load change situations	During starting, manoeuvring and load changes, increase feed rate by means of the “LCD” by 25% of the actual figure and kept at this level for ½ hour after the load has stabilised.	
Lubrication of cylinders that show abnormal conditions	Frequent scavenge port inspections of piston rings and cylinder liners are very important for maintaining a safe cylinder condition. If irregularities are observed, adjustments of the lube oil feed rate should be considered. In case of scuffing, sticking piston rings or high liner temperature fluctuations, raise the feed rate to 1.20 g/kWh and lower the pmax and mep. As soon as the situation has been stabilised, set the lubrication feed rate and pressures back to normal. In case of high corrosive wear, the ACC factor is to be increased to the highest ACC factor (0.40 g/kWh x S% for BN 100)) and be reduced in steps of only 0.02 g/kWh x S% when the wear has been confirmed as normal.	

Figure 12: Guiding Cylinder oil feed rates