Main Engine Performance

FOR INFORMATION

Information on Cylinder condition:
There are many conditions that affect the main engine performance. This document explains internal and external conditions which have influence on engine performance and consequently on cylinder condition.

Challenge:
It is often not clear how various internal and external conditions affect the main engine performance. This may lead to frustration among the engine room crew, as issues are not handled properly.

Solution:
This document explains what internal and external conditions typically affect the main engine performance and how. This will allow the engine room crew to conduct the necessary adjustments, to ensure optimal main engine performance.

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1 Introduction

The document goes over possible Main Engine (ME) issues and causes sorted by system. Table 1 shows the ME issues and causes sorted by issue. This document serves as a guideline for the most common correlations and is not a exhaustive list.

Table 1: Overview by issue.

Issue	Possible Cause/Related To	Reference
Poor combustion	Scavenge air amount	Section 2.1
	Fuel oil pressure	Section 5.1
	Fuel oil injection pumps	Section 5.2
	Compression pressure	Section 6.1
High fuel oil consumption	Scavenge air temperature	Section 2.2
	Cooling water for the air coolers (Low temperature)	Section 2.4
	Combustion pressure	Section 6.2
Scuffing	Water/condensate in the scavenge air	Section 2.3
	Water mist catchers	Section 2.7
	Cylinder liner, Exhaust valve and Cylinder cover	Section 3.1
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High wear of cylinder liner and piston rings	Water/condensate in the scavenge air	Section 2.3
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	Over-lubrication	Section 10.6
Blow-by	Piston ring condition	Section 7.1
High wear of fuel pumps and valves	Wear particles	Section 8.2

Reservations. The guidelines found within this document are general recommendations based on experience. Many engine specific conditions may influence the engine condition and Hans Jensen Lubricators A/S cannot be held accountable for any consequences when following these recommendations. Only the user will be able to assess the engine condition continually and therefore, **the final responsibility lies with the user.**

2 Scavenge air

2.1 Scavenge air amount

In order always to have the necessary excess of combustion air it is very important that the turbocharger and air cooler performance is kept. Lack of scavenge air will lead to raising heat load of normal heat loaded parts and poor combustion.

2.2 Scavenge air temperature

The scavenge air temperature to be as low as possible; however, care must be taken in order to avoid excess of condensation of water in the air cooler. The scavenge air temperature has influence on the fuel oil consumption.

2.3 Water/condensate in the scavenge air

Water in the scavenge air entering the cylinder liner must be avoided as this might lead to scuffing, sudden high wear, of cylinder liner and piston rings

2.4 Cooling water for the air coolers (Low temperature)

The desired temperature of the cooling water for the air coolers to be kept without fluctuation, as fluctuation in temperature can lead to unwanted excess of condensation and to high scavenge air temperature

2.5 Turbochargers

In order to keep the turbocharger performance, air intake filter, compressor wheel, gas nozzle ring and turbine wheel must be kept cleaned and in order.

2.6 Air coolers

In order to keep the air cooler performance, it is important to keep the air cooler clean on both water and air side.

2.7 Water mist catchers

Water mist catcher to be kept in order and correctly installed, incorrectly installed and damage to lamellas will allow water to pass with the scavenge air into the cylinder liner which can lead to scuffing of cylinder liner and piston rings

2.8 Drain system from air coolers and water mist catchers

The drain system must be kept in order and free of blockage, typical from rust scales, blocked drain system can lead to water ingress to the cylinder liners.

2.9 Drain system from scavenge spaces

In order to avoid sludge collection in the scavenge space the drain system to be kept in order and free of blockage.

3 Heat loaded parts

3.1 Cylinder liner, Exhaust valve and Cylinder cover

The temperature of the heat loaded parts is primarily set by the engine designer with a desired cooling water temperature, an excess in heat load due to insufficient cooling can lead to burning away of material and formation of cracks Further excess of heat load will lead to break down of cylinder oil film between cylinder liner and piston rings which again will lead to scuffing.

3.2 Piston

The piston is cooled by oil from the engine lubrication system. The temperature of the piston is primarily set by the engine designer with a certain degree of cooling. In case of excess heat load a layer of oil coke from overheated oil can form in the cooling space, this layer of coke will reduce the cooling effect, and the piston top will be overheated and burning away of material and crack formation will take place. Building up of coke layer in the cooling space will accelerate when the system oil is contaminated with fuel oil.

4 Cooling water (High temperature)

4.1 Cooling water temperature

The cooling water temperature for the heat loaded parts must be kept at the desired level without fluctuation as fluctuation in the temperature can lead to excess heat load on cylinder liner with possible risk of scuffing, crack formation might also take place.

5 Combustion

5.1 Fuel oil pressure

The fuel oil pressure before the fuel oil injection pump must be kept at the desired level without fluctuation in order to obtain a good filling of the fuel oil injection pump, lack of pump filling will give poor pump performance and consequently give poor combustion.

5.2 Fuel oil injection pumps

The fuel oil injection pump must be kept in good order, worn out pump and sticky pump regulating system will give poor pump performance and consequently give poor combustion.

5.3 Fuel oil injection valves

It is very important that the fuel oil injection valves are kept in good order with correct spray formation and opening pressure.

Please note!
Insufficient, pore combustion can cause piston rings to stick in the grooves.

6 Pressures

6.1 Compression pressure

In order to obtain a good combustion, it is very important that the correct compression pressure, P_{com}, for the engine is kept at all time. Reduced compression pressure can be a result of lack of performance of turbochargers and air coolers, and fouled air intake filters.

6.2 Combustion pressure

It is important for the fuel consumption and good combustion that the correct maximum pressure, P_{max}, for the engine is kept at all time.

6.3 Pressure differences

It is always a good idea to compare Scavenge air pressure, Compression pressure and Combustion pressure with the results for same obtained during engine shop test and vessels sea trail at the same load. Also the pressure raise P_{com} - P_{max} (ΔP) must not be exceeded, as too high ΔP will lead to breakage and collapse of the piston rings.

7 Piston rings

7.1 Piston ring condition

In order to keep a good cylinder liner condition, the piston rings must be kept in a good condition, broken and/or sluggish piston rings are causing blow-by resulting in overheating of cylinder liner and piston, and brake down of the cylinder oil film. Blow-by can also initiate crack formation in the cylinder liner.

7.2 Piston ring profile

New piston rings are having a certain profile on the running surface, pending on the philosophy of the engine designer

Well running piston ring will create its own profile however the most important is that the corners are kept with certain roundness and without burrs. Burrs on the corners indicate high wear and possibly lack of sufficient cylinder oil film.

Lack of sufficient cylinder oil film can be caused by:

- Over-lubrication causing building up of residues on the piston crown wiping of the cylinder oil from the cylinder liner.

- Incorrectly timed lubrication.
- Insufficient dosing of cylinder oil.

7.3 Piston ring material

The base material of the piston rings and the cylinder liner must match its other in order to obtain a good running condition. Not matching material can lead to high cylinder liner wear or high piston ring wear.

7.4 Piston ring coatings

Some piston rings have coated running surface, some of the coating enabling a safer running in, other coatings have anti scuffing abilities.

8 Fuel oil

Heavy fuel oil is an oil product with a high variation in density, viscosity and content of impurities, and it also contains a high number of different products where sulphur is the most important parameters. The fuel oil can also contain a high number of highly abrasive particles of Aluminium (Al) and Silicon (Si), also named as catalytic fines or cat fines which are remains of catalyst used during the refining process

8.1 Purification

In order to reduce the level of impurities and cat fines to an acceptable level for the engine it is very important that the fuel oil is properly purified and filtrated before it is burned in the engine.

It is very important that the fuel purifier is correctly adjusted to the fuel oil being purified and with a flow rate as low as possible, if more purifiers are available, it is highly recommended to have all purifiers in use adjusted to lowest possible flow rate.

It is also recommended to have the performance of the purifiers checked at regular intervals by having oil samples before and after the purifiers analysed.

8.2 Wear particles

Wear particles as cat fines in the fuel oil can, depending on number and size of the particles, create high wear of the fuel injection pumps, the fuel oil injection valves and cylinder liner/piston rings, leading to reduced performance of fuel pumps and injection valves and scuffing of cylinder liner/piston rings.

9 Cylinder lubrication oil

Cylinder lubricating oil is high formulated oil, this in order to obtain the necessary abilities such as:

9.1 Viscosity

The viscosity is adjusted for injection purposes.

9.2 Base Number (BN)

The base is a detergent added to the oil for the purpose of neutralisation of acid formed during the combustion, as acid will create corrosive wear of the cylinder liner. The base also prevents lacquer and varnish formation on the piston, piston rings and liner surface.

9.3 Spread ability

A good spread ability of the oil is needed in order to have the oil to spread easily on the liner running surface.

9.4 Dispersions

Dispersions are added to the oil for the purpose of preventing coagulation of combustion residues and wear particles, as larger particles will lead to accelerated wear. The dispersant keeps the colloid particles suspended in the oil, flushing them out with the drain oil and thus keeping the piston, piston rings and liner surface clean.

9.5 Thermal stability

A certain thermal stability of the cylinder oil is needed in order to keep the lubricating ability at a temperature as high as possible and keep the oil from evaporating and create carbon formation.

10 Cylinder lubrication

10.1 Cylinder lubrication

The purpose of cylinder lubrication is to:

- Create a stable oil film between cylinder liner and piston rings.
- Keep the cylinder liner and piston rings clean from combustion residues.
- Neutralise acid formed during the combustion.

10.2 Cylinder oil feed rate

The cylinder oil feed rate to be kept as low as possible as over-lubrication will lead to building up of residues from unused additives from the cylinder oil on the piston crown top land.

10.3 Oil film thickness

With a given engine load and temperature level the oil film thickness will be constant regardless of over-lubrication.

10.4 Cylinder oil injection timing

In order to secure a well lubricated cylinder liner and a wear rate of the cylinder liner and piston rings as low as possible, the cylinder oil must be injected in a timed manner.

10.5 Cylinder lubricating principle

More cylinder lubrication principles are available.

- Mechanical timed lubricator Hans Jensen Lubricators A/S (HJL) type via non return injection valves and RPM dependent Regulation Algorithm (RPM-RA). The cylinder oil will in this case be distributed to the combustion space via the piston rings.
- Mechanical timed lubricator HJL type via Hans Jensen's Swirl Injection Principle (HJ SIP) injection valves and RPM-RA. The cylinder oil will, when using the HJ SIP principle be distributed to the combustion space by means of the spray, assisted by the scavenge air swirl.
- Electronic timed lubricator HJL type HJ Lubtronic via non return valve or HJ SIP injection valve allowing for Sulphur Regulation Algorithm (S-RA), BHP dependent Regulation Algorithm (BHP-RA), MEP dependent Regulation Algorithm (MEP-RA) or RPM-RA.
- Electronic timed lubricator MAN Energy Solutions (MAN-ES) Alpha type via non return valves or HJ SIP valves allowing for S-RA or BHP-RA.

The MAN-ES Alpha lubricator adjusts the feed rate via intermittent injection.

The most efficient way of lubricating the cylinder is by HJ SIP injection valves.

10.6 Over-lubrication

Using to much cylinder oil (over-lubrication) will in many cases lead to excessive cylinder liner wear, and consequently scuffing, stock and breakage of piston rings.

11 Scuffing and sudden high wear

There are many factors, which alone or in combination will lead to cylinder liner scuffing.

Scuffing will only happen when there is metallic contact between cylinder liner and piston rings.

Scuffing is a "Micro Welding" between the cylinder liner and piston rings due to the metallic contact and will, due to the created heat, leave a very hard spot.

Metallic contact happens only due to break down of the normal hydrodynamic oil film between cylinder liner and piston rings.

A Glossary

Below is a complete list of all the abbreviations used in this Service Letter.

Abbreviations

BHP-RA BHP dependent Regulation Algorithm
BN Base Number

HJ SIP Hans Jensen's Swirl Injection Principle
HJL Hans Jensen Lubricators A/S

MAN-ES MAN Energy Solutions
ME Main Engine
MEP-RA MEP dependent Regulation Algorithm

RPM-RA RPM dependent Regulation Algorithm

S-RA Sulphur Regulation Algorithm