# 707 - Cylinder Condition

## Documents in this chapter

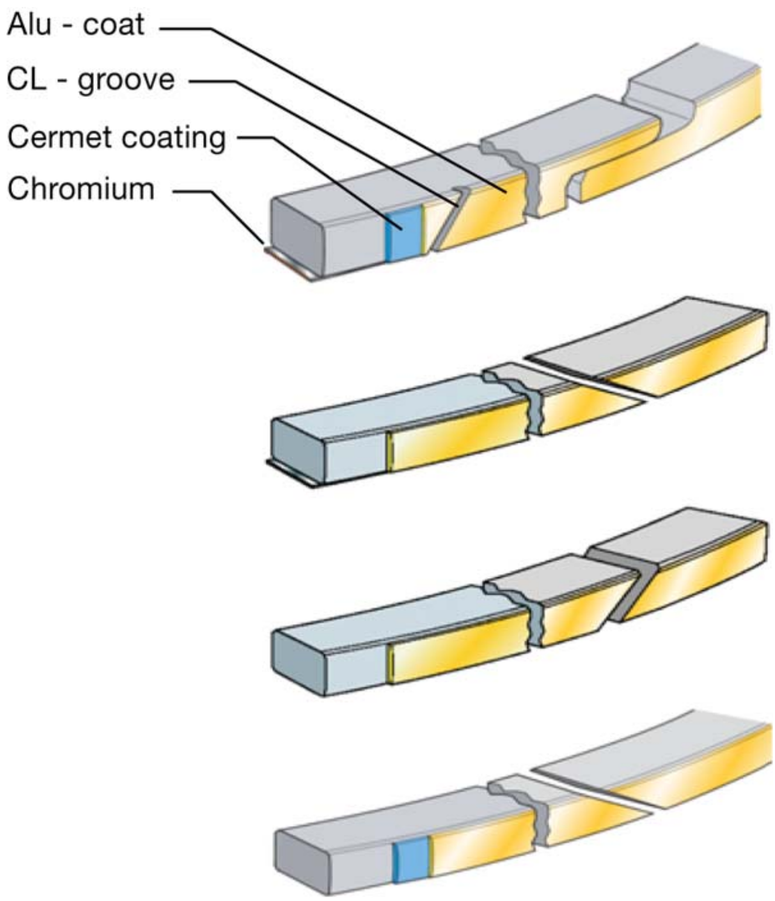
## 1. General

It is important to keep the engine crew updated with information from the latest Service Letters issued by MAN Diesel & Turbo.

To obtain and maintain a good cylinder condition involves the control of many factors. Since most of these factors can change during the service period – and can be influenced by service parameters within and outside the control of the engine room staff – it is of great importance that running conditions and changes are followed as closely as possible. By means of continual monitoring, it is normally possible to discover abnormalities quickly and thereby, take countermeasures at an early stage. In particular, it is advisable to regularly check the cylinder condition by means of inspection through the scavenge ports from the scavenge air receiver (35-98 bore) and via the small covers on the manoeuvring side as well – especially concentrating on the piston ring condition.

## 2. Piston Ring Function

All MAN B&W two-stroke engines are equipped with four piston rings made in a cast iron alloy. The function of the piston ring is to give a gas-tight sealing of the clearance between the piston and cylinder liner. This seal is brought about by the gas pressure above and behind the piston ring, which forces it downwards, against the bottom of the ring groove, and outwards against the cylinder wall. In order to ensure optimum sealing, it is therefore important that the piston rings, the grooves, and the cylinder walls, are of proper shape, and that the rings can move freely in the grooves (since the piston will also make small horizontal movements during the stroke). The lubrication of the piston rings influences the sealing as well as the wear and deposits.




Large bore ring pack configuration (most 80-98 engine types): Four rings with Alu-coat for running-in, a CPR top ring, Cermet coating on ring Nos. 1 and 4 and Chromium on the lower face of ring Nos. 1 and 2. Most other engine types are normally configured without Cermet coating and Chromium, but always with Alu-coat as standard.

Experience has shown that unsatisfactory piston ring function is one of the main factors contributing to poor cylinder condition. For this reason, regular scavenge port observations are strongly recommended as a means of judging the ring condition.

The ring pack consist of one high ring with double S-lock (the uppermost) and three low rings with oblique cut ring ends.

In order to make the uppermost piston ring more resistant against ring breakage, especially at the ring lock, it is approx. 30 % higher than ring 2 – 3 – 4 which are all of the same height, and alternating cut left and right.

## Coating

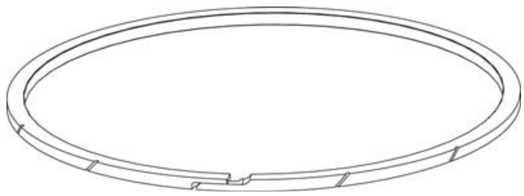
To ease running-in, all piston rings have a 0.3 mm layer of aluminium bronze. This reduces the running-in time considerably, on the test-bed, at the sea trial and in service, as well as after piston overhaul.

Large bore engines (80-98) have hard coating on the uppermost ring and on ring No. 4, so as to ensure a long-term satisfactory cylinder condition and to increase the tribological stability / scuffing margin, see Plate 70715.

Furthermore, some rings have Cr plating on the lower face on ring No. 1 (uppermost) and ring No. 2 to endure higher levels of abrasive particles. By hard-chrome plating the lower face, the surface structure becomes smooth and prevents abrasive particles from being trapped, thereby reducing the ring groove wear.

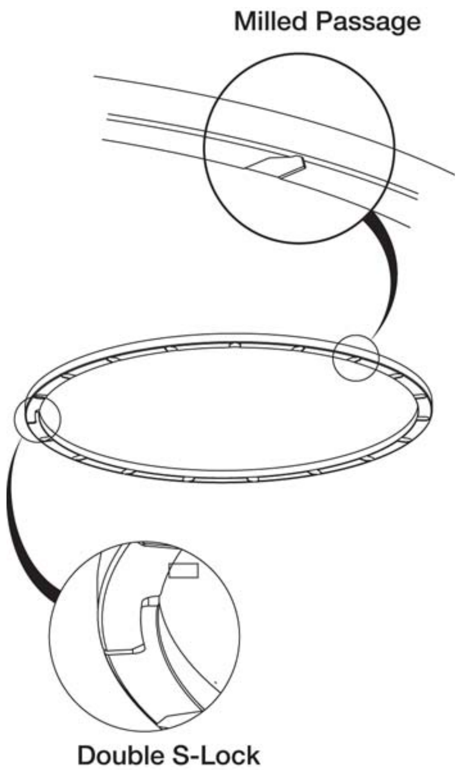
The hard coating (cermet coating) on the uppermost piston ring is introduced to reduce the wear on the top ring and to ensure that the CL (controlled leakage) grooves in extreme cases are not prematurely worn out.

CPR (controlled pressure relief) Ring, CL and POP Versions



### CPR-CL

In order to control the pressure drop across the ring pack and, especially, to avoid too high pressure a drop across the upper most ring socalled CL (controlled leakage) grooves are used on the uppermost piston ring on all large bore engines (60 -98). The number of grooves, the distribution on the circumference and the depths depend on the cylinder bore.




### CPR-POP

For small bore engines (26-50), the depths of the grooves would not be deep enough to accept a reasonable wear potential. Instead, rings with grooves placed on the lower face are used. The designation for this ring type is POP. (port on plane).

# 3. Scavenge Port Inspection

## 3.1 General

The scavenge port inspection provides useful information about the condition of cylinders, pistons, skirts, piston rods and rings.

The inspection consists of a visual examination of the piston, piston skirts, rods, piston rings and the lower part of the cylinder liner directly through the scavenge air ports, and measurements of the ring clearance, the CL grooves, the POP grove opening and the thickness of possible piston ring coating.

To reduce the risk of a scavenge box fire, even though this phenomenon is very rare on modern engines, remove any oil sludge and carbon deposits in the scavenge air box and receiver in connection with the inspection. With the relevant pumps running an evaluation can be made of the fuel valves sealing tightness, the piston tightness for lube oil and the cylinder cover's sealing tightness for cooling water.

The port inspection should be carried out at the first stop after a long voyage, e.g. by anchoring if possible, to obtain the most reliable result with regard to the effectiveness and sufficiency of the cylinder lubrication and the combustion cycle (complete or incomplete). A misleading result may be obtained if the port inspection is carried out after arrival at harbour, since manoeuvring to the quay and low-load running, e.g. river or canal passage, requires increased cylinder oil dosage, i.e. the cylinders are excessively lubricated. Further, during low load, the combustion cycle might not be as effective and complete as expected, due to the actual fuel oil qualities and service (running) condition of the fuel injection equipment. It is highly recommended to take this information into consideration when evaluating the cylinder condition.

The inspection must take place at least twice a month. If in port anyway.

## 3.2 Procedure

For the Inspection procedure see Vol. II - Maintenance, Procedure M902-01.

Scavenge port inspections are best carried out by two persons. The more experienced person inspects the surfaces and states his observations to an assistant, who records them and later enters them in MAN Diesel & Turbo standard forms. Keep cooling water, fuel oil and cooling oil circulating, so that possible leakages can be detected.

**WARNING**

**ALWAYS bring the turning gear switch into the scavenge air receiver during inspection.**
**Block the starting air supply to the main starting valve. Open the indicator valves. Block the hatch cover to the receiver to prevent it from closing by accident. Bring in bottles with drinking water for consumption in the scavenge air receiver. Take care when moving around in the receiver and bring proper lighting. Pockets for thermometers are placed in head level. Hard hat is also recommended. Remember to take breaks to replenish fluid lost from sweating, especially in hot climates.**

Engage the turning gear. Remove the inspection covers on the fuel pump side of the cylinder frame, and clean the openings. Open the doors or the cover(s) on the scavenge air receiver. Do not enter the scavenge air receiver before it has been thoroughly ventilated. Begin the inspection on the cylinder with the piston nearest BDC. Inspect the piston, skirts, rods, rings, and cylinder wall. Wipe the running surfaces clean with a rag to ensure correct assessment of the piston ring condition.

Use a powerful lamp to obtain a true impression of the details. Bring in a small camera to make documentation of the condition of the scavenge port inspection etc. Instead of flash use the lamp as the light source.

Record the results on Plate 70702 and use the symbols shown on Plate 70703 to ensure easy interpretation of the observations.

Keep the records to form a log book of the cylinder condition. Measure the total clearance between the piston rings and the ring grooves. Measure the CL-groove depths and the thickness of the ring coating, if applicable. Continue the inspection on the next cylinder with its piston nearest BDC, and so on according to the firing order. Note down the order of inspection for use at later inspections. Check the non-return valves (flap valves/ butterfly valves) in the auxiliary blower system for easy movement and possible damage and inspect the condition of the water mist catcher. Remove any oil sludge and carbon deposits in the scavenge air boxes and receiver. If fuel oil or excessive system oil is found, the fuel valve or pulled pistons should be pressure tested. Record the observations on Plate 70702.

## 3.3 Observations

### 3.3.1 Scavenge Receiver Condition

Check and note the condition of the scavenge receiver.

**Scavenge Receiver, NO SLUDGE**

Note: Water washing from defect water mist catcher could cause a very clean scavenge air receiver.

**Scavenge Receiver, SLUDGE – S**

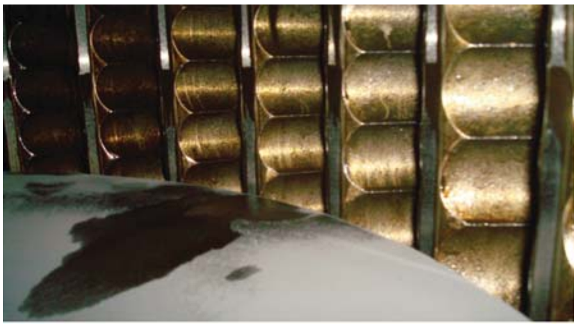
Normal picture. Indicates good cylinder condition.

**Scavenge Receiver, MUCH SLUDGE – MS**

Remove any oil sludge and carbon deposits in scavenge receiver.

### 3.3.2 Leakage

Check the piston crown top for any leakages (remember to keep cooling water, fuel oil and lubricating oil circulating during the inspection).



**Leaking oil - LO**

If oil is found on the piston, determine if it is fuel oil or lube oil. Fuel oil will be black and sticky, indicating a fuel valve is leaking. Lube oil will be brown and non-sticky, indicating it could be from an exhaust valve.

**Leaking water - LW**

Water on a piston indicates a cooling system leak. If water is found, it is important to determine what the cause is. Use either a mirror or photo, to establish if the leak is from the cylinder cover, exhaust valve or a cracked liner.

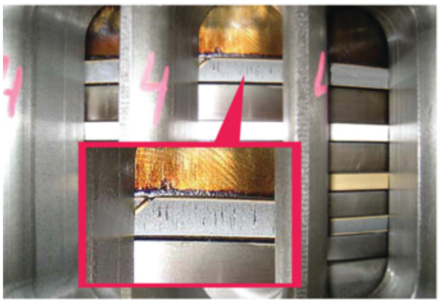
### 3.3.3 Piston rings: in good condition

When good and steady service conditions have been achieved, the running surfaces of the piston rings and cylinder liner will be worn bright (this also applies to the ring undersides and the “floor” of the ring grooves which, however, cannot be seen until a piston is pulled).

In addition, the rings will move freely in the grooves and also be well oiled, intact, and not unduly worn. The ring edges will be sharp when the original roundings have been worn away, but should be without burrs.

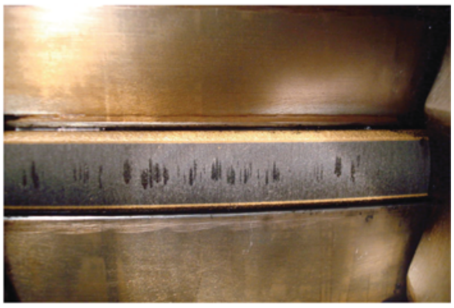
### 3.3.4 Piston rings: micro-seizure

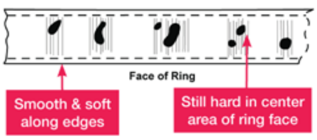
LOCAL & ALL OVER MICRO-SEIZURES



LOCAL MICRO-SEIZURES – mz

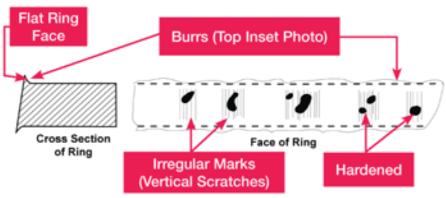
STILL ACTIVE MICRO-SEIZURES – MAZ






OLD MICRO-SEIZURES – OZ

ACTIVE & INACTIVE MICRO-SEIZURES


Temperarily increase the cylinder oil dosage; If seizures are observed.

If micro-seizures as observed on the piston rings are not properly attended, by reducing the $p_{max}$ and engine load on the respective unit, and by increasing the lubrication feed rate, according to instructions (1.2 g/kWh), scuffing of the cylinder liner can occur, causing momentarily high wear of all combustion chamber parts.

If, over a period of time, the oil film is partially interrupted or disappearing, so that dry areas are formed on the cylinder wall, these areas and the piston ring surfaces will, by frictional interaction, become finely scuffed and hardened, i.e. the good “mirror surface” will have deteriorated.

In case of extreme micro-seizures (for scuffing see item 5.6.1) , sharp burrs may form on the edges of the piston rings.

A seized surface, which has a characteristic vertically-striped appearance, will be relatively hard, and may cause excessive cylinder wear. Due to this hardness, the damaged areas will only slowly disappear (run-in again) if and when the oil film is restored.

As long as the seizure is allowed to continue, the local wear will tend to be excessive. Seizure may initially be limited to part of the ring circumference, but, since the rings are free to “turn” in their grooves, it may eventually spread over the entire running face of the ring.

The fact that the rings move in their grooves will also tend to transmit the local seizure all the way around the liner surface.

If extreme seizures (for scuffing see item 5.6.1) have been observed, it is recommended that the cyl. oil feedrate is temporarily increased to 1.2 g/kWh.

If load reduction of more than one unit is required, please contact MAN Diesel & Turbo for advice.

### 3.3.5 Piston rings: scratcing

Scratching is caused by hard abrasive particles originating from the ring itself or, more likely, from the fuel oil or air intake. With regards to liner and ring wear, the actual scratching is not necessarily a serious problem, but the particles can have serious consequences elsewhere (see Item 5.5).

### 3.3.6 Piston rings: sticking

If, due to thick and hard deposits of carbon, the piston rings cannot move freely in their grooves, dark areas will often appear on the upper part of the cylinder wall (this may not be visible at the port inspection). This indicates a lack of sealing, i.e. combustion gas blow-by between piston rings and cylinder liner.

The blow-by will provoke oil film breakdown, which in turn will increase cylinder liner wear. Sticking piston rings will often lead to broken piston rings. The free movement of the rings in the grooves is essential and can be checked either by pressing them with a wooden stick (through the scavenge ports) or by turning the engine alternately clockwise and counter-clockwise to check the free vertical movement.

### 3.3.7 Piston rings: breaking/collapse

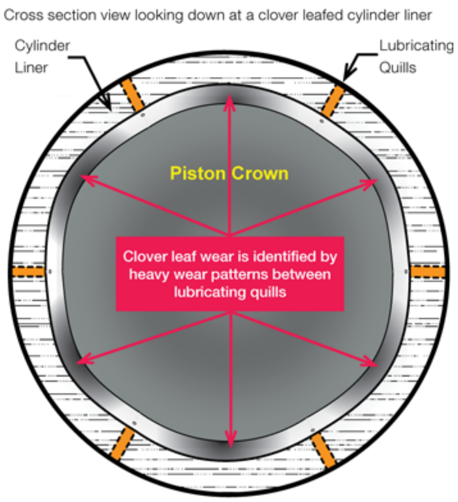
Broken piston rings manifest themselves during the scavenge port inspection by their:

- lack of elastic tension when the rings are pressed into the groove with a stick
- blackish appearance
- fractured rings
- missing rings or missing ring parts.

Piston ring breakage is caused by a phenomenon known as “ring collapse”. However, breakage may also occur due to continual striking against wear ridges on the cylinder liner TDC area, or other irregularities on the cylinder wall. Collapse occurs if the gas pressure behind the ring is built up too slowly and, thereby, exerts an inadequate outward pressure. In such cases, the combustion gas can penetrate between the liner and ring, and violently force the ring inwards in the groove. This type of sudden “shock” loading will eventually lead to fracture – especially if the ring ends “slam” against each other. This phenomenon is, however, seldomly observed on modern engines.

The mentioned slow pressure build-up behind the rings can be due to:

- carbon deposits in the ring groove
- too small vertical ring clearance
- partial sticking
- poor sealing between the ring and the groove floor
- “clover-leafing” (see below).




CLOVER LEAF WEAR – CL

"Clover-leafing" is a term used to describe longitudinal corrosive liner wear at several separate points around the liner circumference – i.e. in some cases the liner bore may assume a "clover-leaf" shape.

### 3.3.8 Piston Rings: Blow-by

Leakage of combustion gas past the piston rings (blow-by) is a consequence of sticking, collapsed or broken of rings.

At the later stages, when a complete blow-by occurs, it is usually due to sticking rings or ring breakage caused by collapse.

Blow-by is indicated by black, dry areas on the rings and also by larger black dry zones on the upper part of the liner wall. This can only be seen when overhauling the piston or when exchanging the exhaust valve.

### 3.3.9 Deposits on pistons

Usually, some deposits from the cylinder oil will accumulate on the side of the piston crown (top land). Carbon deposits on the ring lands (the area on the pistons between the piston rings) indicate lack of gas sealing at the respective rings, see Plate 70703. The piston cleaning ring between the cylinder cover and liner normally remove superfluous and harmful deposits on the pistons.

If the deposits are abnormally thick, their surfaces may be smooth and shiny from rubbing against the cylinder wall. Such contact may locally wipe away or absorb the cylinder oil film, resulting in bore polish, micro-seizure and increased wear of liner and rings. In some instances, mechanical clover-leafing can occur, i.e. vertical grooves of slightly higher wear in between the lubricating quills.

Such conditions may also be the result of a combustion condition which overheats the cylinder oil film. This could be due to faulty or defective fuel valves or insufficient turbocharger efficiency.

### 3.3.10 Lubricating Condition

Note if the "oil film" on the cylinder wall and piston rings appears to be adequate, see Item 3.1. Black or brownish coloured areas may sometimes be seen on the liner surface. This indicates corrosive wear, usually from sulphuric acid (see Item 5.4), and should not be confused with grey-black areas, which indicates blow-by.

These deposits are often only of cosmetic nature and will not lead to wear issues. The phenomenon is often connected to humidity in the scavenge air and may disappear when the vessel enters cold and less humid areas.

See Item 5.4 and Chapter 707-02

### 3.4 Replacement of piston rings

It is recommended to replace the complete set of piston rings at each piston overhaul to ensure that the rings always work under optimal service conditions, thereby giving the best ring performance. Stretching the rings lead to stress and care must be taken not to open the rings more than necessary when installing them on the piston.

## 4. Cylinder Overhaul

To ensure correct recording of all relevant information, it is recommended that the "Cylinder Condition Report" (Plate 70711) is used.

### 4.1 Intervals between piston overhaul

It is recommend to decide the interval between piston overhaul based on the condition of the units observed at scavenge port inspections and not on fixed intervals. In other words: It is not a good idea to pull piston No. 4, based on running hours, if it is piston No. 6 that needs overhaul.

Also base the actual intervals between piston overhauls on the previous wear measurements and observations from scavenge port inspections. Often the guiding intervals between piston overhauls can be prolonged considerably without any harm to the cylinder condition, provided frequent scavenge port inspections are carried out.

Regarding procedures for the dismantling and mounting of pistons, see Vol. II - Maintenance, Procedure M902-2.1 and M902-2.2. Remove the piston cleaning (PC) ring between the liner and the cylinder cover, and mark the position of the ring to allow fitting of the PC-ring in the same position as it is worn together with the liner. Carefully remove any coke deposits and wear ridges from the upper part of the liner before fitting the piston.

Regarding procedure for checking the PC-ring, see Vol. II - Maintenance, Procedure M903 -1.1. The PC-ring is part of the liner and will not need to be exchanged unless it is broken.

### 4.2 Initial inspection and removal of the piston rings when the piston has been pulled

Only use the standard MAN Diesel & Turbo ring opener for fitting and removal of piston rings. Only expand the rings sufficiently to fit over the piston. This opener prevents local overstressing of the ring material, which in turn would often result in permanent deformation causing blow-by and broken rings. Straps to expand the ring gap, or tools working on the same principle, should never be used.

### 4.3 Cleaning

Clean the piston rings. Clean all ring grooves carefully. If carbon deposits remain, they may prevent the ring from forming a perfect seal against the floor of the groove. Remove deposits on the piston crown and ring lands. Remove any remaining coke deposits from the upper section of the liner.

### 4.4 Measurement of ring wear

Please refer to Vol II - Maintenance, procedure M902-1.1

### 4.5 Inspection of cylinder liner

The aim is to obtain controlled corrosive wear (0.03 - 0.05mm / 1000h) of the liner surface by applying different cylinder oil feed rates, depending on the fuel oil sulphur content (Alpha ACC lubrication algorithm), to avoid liner polishing and subsequent seizures.

#### 4.5.1 Cylinder wear measurements

See Plate 70711 and Vol II - Maintenance, procedure 903-1.1

Before measuring the cylinder wear with a pin gauge:

- ensure that the tool and cylinder liner temperature values are close
- record the tool and cylinder liner temperatures on Plate 70711 to enable correction
- Íf possible take a “zero” measurement

Measure the wear with the pin gauge at the vertical positions marked on the guide rail. Measure in both transverse and longitudinal directions. The guide rail ensures that the wear is always measured at the same positions. Record the measurements on Plate 70711.

Tools with electronic measurement equipment can be used through the scavenge ports if dismantling of the cylinder cover is not possible.

### 4.5.2 Correction of wear measurements

Correct the actual wear measurements by multiplying with the following factors, if the temperature of the cylinder liner is higher than the temperature of the tool. This enables a comparison to be made with earlier wear measurements.

| Δt° (Tliner - Ttool) | C Factor |
|---|---|
| 10 | 0.99998 |
| 20 | 0.99976 |
| 30 | 0.99964 |
| 40 | 0.99952 |
| 50 | 0.99940 |

Example (90 bore):

Δt measured: 30 °C

Corrected value: 901.3 × 0.99964 = 900.98 (i.e. a reduction of 901.3-900.98 = 0.32 mm)

However, a zero measurement can be made in the top of the cylinder liner, above ring No. 1 (TDC), where there is no wear. The wear can then be calculated.

### 4.5.3 Maximum wear

The maximum allowable wear of cylinder liners is in the interval of 0.4% to 0.8% of the nominal diameter, depending on the actual cylinder and piston ring performance. When the interval between necessary piston overhauls becomes too short, for instance due to ovality, it is time to renew the liner and the PC ring.

### 4.5.4 Checking liner surface

Inspect the liner wall for scratches, micro-seizures, wear ridges, corrosive wear, and surface structure if possible.

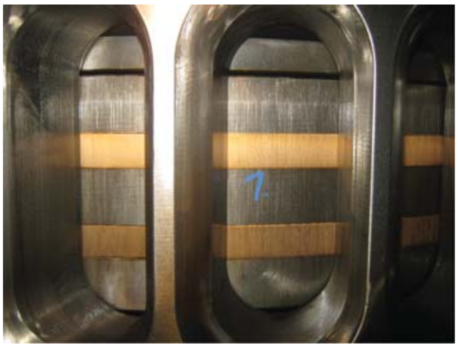
If corrosive wear is suspected, or if a ring is found broken, take extra wear measurements around the circumference at the upper part of the liner. Press a new piston ring into the cylinder. Use a feeler gauge to check for local clearances between the ring and liner. This can reveal any “uneven” corrosive wear, see Item 3.3.

Be aware that if the liner is not ovally worn and the highest wear does not exceed 0.3% of the liner diameter, it is possible to increase the expected service life of the liner by re-establishing the wave cut shape on the running surface by machining either in situ or at one of the MAN Diesel & Turbo service centres. However, please note, wave-cut machining (by grinding) does not compensate for liner ovality. To compensate for liner ovality, causing premature ring breakage, liner honing is recommended.

Black shiny areas are often found on the liner surface just above the scavenge air ports. These areas of black deposits, called lacquer formations, are harmless and are formed by a combination of water in the scavenge air and cylinder oil. The layer can be rather difficult to remove and can be left as it is.

### 4.6 Piston skirt, crown and cooling space

The piston skirt is made of cast iron and is equipped with two bronze rings to reduce the risk of scuffing. Some engines have a special molybdenum coating on the skirts instead of the two bronze rings.



Scuffing of the skirt is rare and mostly of cosmetic nature, and is not always a sufficient reason for exchange.

If the burning/corrosion condition of the piston crown exceeds the maximum permissible, send the piston crown for reconditioning. The maximum permissible burning, see Vol II - Maintenance, procedure M902-1.1

Inspect the crown for cracks by dye checking or similar.

Pressure-test the piston assembly to check for possible cooling oil leakages.

If the piston is taken apart, for instance due to oil leakage, check the condition of the joints between the crown, the piston rod, and the skirt. Inspect the cooling space and clean off any carbon/coke deposits.

Replace the O-rings. Check that the surfaces of the O-ring grooves are smooth. This is to prevent twisting and breakage of the O-rings. Polish the grooves with emmery paper if leakages are found and new O-rings must be installed. Pressure test the piston after assembling.

For safety reasons, the measurements of the burning of the crowns must not take place with the piston and cylinder cover in situ by placing the template on the crown via the scavenge ports. The cylinder cover must be dismantled or the piston pulled.

### 4.7 Piston ring grooves

Check the piston ring grooves as described in Vol II - Maintenance, procedure M902-1.1

If the ring groove wear exceeds the values stated in Vol II - Maintenance, Data D102-01, send the piston crown ashore for reconditioning (new chrome plating).

If the ringgroove wear is exceeding the limits the ring grooves may need re-welding and machining before re-chroming.

#### 4.7.1 Chrome plating macro cracks

The hard chrome plating of the ring groves is defined to be micro cracked. This ensures that the strong tensile residual stresses in the plated chrome layer are partly released.

During operation (thermal influence), the chrome plating in the piston ring grooves may crack into a macro pattern. This is normal and acceptable and not expected to cause further deterioration. More macro cracks may develop during operation.

### 4.8 Reconditioning of the running surfaces of liner and skirt

If there are micro-seized areas on the liner or skirt:

- Scratch-over manually with a coarse carborundum stone (grindstone), moving the grindstone crosswise at an angle of 20 to 30 degrees in horizontal direction. This is done to break up the hard surface glaze.
- Leave the “scratch marks” as rough as possible. It is not necessary to completely remove all signs of “vertical stripes” (micro-seizure).

If horizontal wear ridges are found in the cylinder liner, by the top ring TDC position it is recommended to create a circumferential groove by milling or grinding. The groove serves to prevent the build-up of a new wear ridge and protect the new top ring from breakage.

Two methods (grinding and milling) of removing wear ridges are described in Vol II - Maintenance, procedure M903.

### 4.9 Piston ring gap (new rings)

Check the gap as described in Vol. II - Maintenance, procedure M902-01.

### 4.10 Fitting of piston rings

Fit the piston rings. See also item 3.4. Push the ring back and forth in the groove to make sure that it moves freely.

Only use the MAN Diesel & Turbo standard piston ring opener and do not open the gap excessively, see also item 4.2.

### 4.11 Piston ring clearance

When the rings are in place, check and record the vertical clearance between the ring and ring groove.

Furthermore, insert a feeler gauge of the thickness specified in Vol II - Maintenance, procedure M902-01, and move it all the way round the groove both above and below each piston ring. Its free movement will confirm the proper clearances as well as cleanliness.

### 4.12 Cylinder lubrication (Alpha and ME Lubricator) and mounting of piston

Before mounting the overhauled piston, remove any remaining deposits from the upper part of the liner.

- With the piston dismantled, press Pre-lubrication on the HMI panel and check that pipes and joints are leak-proof and that oil sprays out from each lubricating orifice on the liner.
- If any of the above-mentioned inspection points have indicated that the cylinder oil amount should be increased or decreased adjust the feed rate accordingly as described in Chapter 707-02.
- Coat the piston and liner with clean cylinder oil.
- Before mounting the overhauled piston, remove any remaining deposits from the upper part of the liner.

See the separate instruction book for Alpha Lubricator.

Mount the piston,see Volume. II Maintenance, procedure M902-01.

### 4.13 Running-in

If new or reconditioned cylinder liners and/or piston rings are installed, allowance must be made for a running-in period.

#### 4.13.1 Running-in of cylinder liners and rings

The following text refer to plate 70710 and the mentioned feed rates are valid for a cylinder oil of BN70 standard. The actual obtained feed rate should always be corrected according to the actual BN. In the following the terms “High topland” and “Semi high topland” are used for the pistons. The topland is the designation for the top of the piston crown from the uppermost piston ring groove to the top of the piston.

For the semi high topland the whole area from the uppermost piston ring groove to the top of the piston can be observed at the same time through the scavenge ports. For the high topland pistons only part of the topland can be observed. The previous engine types were in many cases equipped with pistons with low topland, where the whole topland and a number of the rings could be observed at the same time through the scavenge ports.

##### 4.13.1.1 Large bore engines (60-98)

Running-in periods are classified in three categories:

1. Breaking-in (0-500h)
2. Running-in, phase 1. (500-1500 h)
3. Running-in, phase 2. (1500-2500 h)
4. After conclusion of running in

The purpose of adding extra lubricating oil during the running-in period is to:

- flush away wear particles
- build up an oil film in a not yet run-in cylinder

The running-in process has been eased and shortened considerably with alu-coat running-in coating on all four piston rings. Cylinder liner running-in is facilitated by semi-honed liner surface.

It is recommended to carry out frequent scavenge port inspections during the first 2500 hours.

### Breaking-in (0-500 hours)

Piston ring and liner breaking-in takes 500 running hours maximum. A fixed, relatively high lubrication feed rate during the breaking-in period is recommended.

During breaking-in, the running-in coating on the piston rings will gradually wear off, and the plateaus of the wave shape of the cylinder liner running surface will smoothen. During this process extra lubricating oil is required to flush away wear particles and build a satisfactory oil film between the still relatively rough sliding surfaces.

During breaking-in, it is recommended to check the piston rings through the scavenge ports every 100 hours. Do not proceed to the next lubrication step if the scavenge air port inspection reveals seizures or other irregularities.

A five hour stepvise load increase from 50% load to max load is recommended. When running in new piston rings in well running liners, 5-hour load-up from 50% load to max load is also recommended. The load limitation can be set for a single cylinder unit by adjusting the individual fuel pump index.

### Running-in phase 1 (500-1500 hours)

After the first 500 running hours, standard sulphur-dependent lubrication can be applied and the Alpha ACC algorithm can take over the lubrication control.

For a BN70 oil, MAN Diesel & Turbo recommends a running-in phase 1 feed rate of 0.26 g/kWh x fuel oil sulphur content in %.

At approx. 1500 hours, alu-coating is usually worn through and the base material or the cermet coating on the top and bottom rings is visible.

When reaching 1500 running hours, carefully check the piston rings and the cylinder liner through the scavenge ports. If the alu-coating is worn through, proceed to running-in, phase 2.

### Running-in phase 2 (1500 – 2500 h)

If no irregularities are found, a feed rate reduction to 0.23 g/kWh x sulphur % (BN70 oil) is reccommened.

Inspect the piston rings and the cylinder liner through the scavenge air ports at 2500 running hours. If no irregularities are found, it is recommend to reduce to a feed rate of 0.20 g/kWh x sulphur % (BN70 oil).

If, at any point, signs of micro-seizures or high wear are found it is recommended to switch to the previous setting, i.e. 0.26 g/kWh (BN70 oil).

### After conclusion of running in

After reaching the actual final feed rate setting this should be continuously verified by regular inspections of the components wear condition. If signs of micro seizures or high wear is found, it is recommended to switch to the previous setting providing established stable conditions.

#### 4.13.1.2 Small bore engines (26-50 bore)

The following text refers to plate 70710, and the feed rates are valid for a cylinder oil of BN70 standard. The actual feed rate obtained should always be corrected according to the actual BN as stated in the mentioned table.

Running-in

During the first running-in, a relatively high fixed dosage is recommended: 1.5 g/ kWh for the first 250 hours succeeded by 1.2 g /kWh for another 250 hours. After these 500 hours of initial running-in, where ample oil is used for flushing away wear particles from the sliding surfaces, ACC running with the factor 0.34g/kWh x S% should be introduced.

The next 2000 hours should be used for a gradual reduction towards the basic setting, i.e. the ACC factor 0.26 g/kWh x S%.

Regulation from the upper ACC factor of 0.34 g/kWh x S % to the basic setting of 0.26 g/kWh x S% should take place stepvise over a 2000 hour period. The size of the steps may depend on the evaluation of the actual lubrication and deposit condition appearing from scavenge port inspections.

After reaching the actual final feed rate setting, this should be continuously verified by regular inspections of the components wear condition. If signs of micro-seizures or high wear are found, it is recommended to switch to the previous setting providing established stable conditions.

### 4.13.2 Running-in of a single cylinder

If only one cylinder has been overhauled, the fuel pump index for the cylinder in question can be decreased in proportion to the required load reduction, under the condition that the torsional vibration in the propeller shaft will allow it.

As the vibration condition due to the reduction of the fuel pump index of one cylinder is very similar to running the engine with one cylinder in misfire, a barred engine speed range may apply. Consult the class-approved report on the torsional vibration of the actual propeller shaft system and avoid any barred speed range during running-in.

Before starting the engine, fix the fuel rack for the pertaining cylinder at 16% of MCR index.

Increase the index stepwise in accordance with the breaking-in schedule.

Regarding the pressure rise $p_{comp}$ - $p_{max}$, see comp. max., see chapter 703-04. If the engine is fitted with the Turbo Compound System (TCS), the TCS must be out of operation if running-in with reduced index is chosen so as to safeguard the TCS gear equipment.

Manoeuvring and low load

See Plate 70714

In practice, the engine must be able to operate freely in the whole manoeuvring range. The situation where a low load has to be maintained for an extended period, the breaking-in programme should be suspended until higher loads are continued. At this point the running in programme should also be continued.

### 4.13.3 Running-in of rings after a piston overhaul

When running-in new piston rings in already run-in and well running liners based on standard BN70 cylinder oil, the breaking-in time is recommended to 5 hours from 50% to 100% load. **The cylinder oil feed rate should be increased by 25% for the first 24 running hours.**

### 4.13.4 Feed rates

Feed rate recommendations for different engine types may be found in our latest service letters.

Current latest service letter:

| Cylinder oil feed rate | |
|---|---|
| **Engine type** | **Service letter** |
| 60-80 bore types MC/MC-C and ME/ME-C with high top-land and Alpha Lubricator or ME Lube. | **SL2013-571**<br>"Guiding ACC Feed Rates for Alpha Lubricator and ME Lube" |
| 26-50 bore types MC/MC-C and ME/ME-B/ME-C and 60-98 bore types MC/MC-C and ME/ME-C without high top-land, and with Alpha Lubricator or ME Lube. All mk.6 and higher. | **SL2013-571**<br>"New ACC Guidelines, all MC/MC-C and ME/ME-C type engines Mk6 and higher, with Alpha ACC system" |
| 26-98 bore types MC/MC-C with mechanical lubricator. 26-50 MC/MC-C engines with low topland. | **SL00-385**<br>"Cylinder Oil Dosage, Marine MC-Engines" |
| 26-50 MC/MC-C engines with high top-land and mechanical lubricator. | **SL12-553**<br>"Cylinder Lubrication Guidelines, Small bore MC/MC-C engines" |
| **NOTE: Always check for the latest service letters from MAN B&W.** | |

## 5. Factors Influencing Cylinder Wear

### 5.1 General

Plate 70706 gives a summary of the most common causes of cylinder wear. The following gives a brief explanation of the most important aspects, and of the precautions to be taken to counteract them.

### 5.2 Materials

Check that the combination of piston ring type and cylinder liner material complies with the engine builder's recommendations. For engines in guarantee, always follow the engine builder's recommendations.

### 5.3 Cylinder oil

Check that the quality and feed rate are in accordance with the recommendations in this chapter 707-02.

### 5.4 Corrosive wear

#### 5.4.1 The influence of sulphur in the fuel

Corrosive wear is caused by formation and condensation of water and sulphuric acid on the cylinder wall.

In order to minimise condensation, the engine design incorporates optimised temperature level of the liner wall, based on the actual engine layout.

To reduce the risk of corrosive attack:

- Keep the cooling water outlet temperatures within the specified interval, see Chapter 709
- Use only approved alkaline cylinder lubricating oils, see chapter 707-02
- Preheat the engine before starting, as described in Chapter 703
- Check that the drain from the water mist catcher(s) functions properly, and water droplets are prevented from entering the cylinders, see item 5.4.4.
- Check the condition of the water mist catcher(s) for cracks in the frame and correct mounting at every inspection through scavenge ports. Check for correct mounting through inspection and mounting covers twice a year.

It is important that any corrosion tendency is ascertained as soon as possible. If corrosion is prevailing:

- Check cylinder feed rate, see item 5.3.
- Increase feed rate
- Check alkalinity, see item 5.3.
- Check timing of the cylinder oil injection.
- Check cooling water temperatures and the drain from the water mist catcher, as above. The amount of described condensate can be read from Plate 70712

In case of too small cylinder oil feed rate or too low alkalinity, the alkaline additives may be neutralised too quickly or unevenly, during the circumferential distribution of the oil across the liner wall. This systematic variation in alkalinity may produce “uneven” corrosive wear on the liner wall, see item 3.3.7 regarding ‘clover-leafing’.

### 5.4.2 Sodium chloride (salt)

Seawater (or salt) in the intake air, in the fuel, or in the cylinder oils, will involve the risk of corrosive cylinder wear. The corrosion is caused by sodium chloride (salt), which forms hydrochloric acid.

To prevent salt water from entering the cylinder, via the fuel and cylinder oil:

- Centrifuge the fuel carefully (run two centrifuges in parallel with reduced flow)
- Do not use the bunker tanks for ballast water.

### 5.4.3 Cleaning agents (air cooler) (to be used with stopped engine only)

The air side of the scavenge air cooler can, if the necessary equipment is installed, be cleaned by means of cleaning agents dissolved in freshwater.

Follow the supplier’s instructions strictly for:

- Dosage of the agent
- Use of the cleaning system

After using chemical agents, flush with clean freshwater to remove the agent from the cooler and air ducts.

Cleaning of the air side of the air cooler must only be carried out during engine standstill. During cleaning care should be taken to avoid cleaning agents from entering the scavenge air receiver and air box, causing condensation and piston rod corrosion.

### 5.4.4 Water condensation on air cooler tubes

Depending on the temperature and humidity of the ambient air and the temperature of the seawater, water may condense on the coldest air cooler tubes.

Water mist catchers are installed directly after the air coolers on all MAN B&W engines to prevent water droplets from being carried into the cylinders.

If water enters the cylinders, the oil film may be ruptured and cause scuffing and wear (clover leafing) on the liner surfaces between the cylinder lube oil inlets. It is very important that the water mist catcher drains function properly!

## 5.5 Abrasive wear

### 5.5.1 Particles

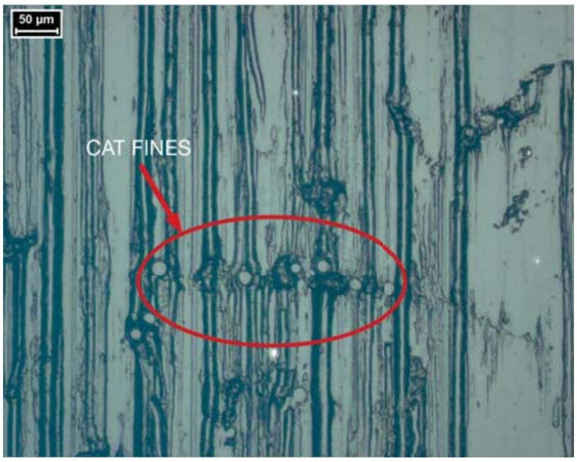
Abrasive cylinder wear can be caused by hard particles entering the cylinder via the fuel oil, e.g. catalytic fines, or air, e.g dust/sand, or the cylinder oil due to insufficient cleaning of the storage tank, see item 5.5.2, ‘Fuel Oil Treatment.

Catalytic fines originating from the refinery process are in fact one of the most common reasons for abrasive liner wear as well as piston crown ring groove wear. These particles consist of aluminium oxide and silicon oxide, which are both heavily abrasive. The catalytic fines are in fact reused as mush as possible at the refineries, but it may happen that a batch disappeares at the final link in the refinery process, i.e. into the residual heavy fuel.

The size of the particles vary from submicron up to 30 micron, and the shape is often close to being circular.

The limit for catalytic fines in fuel oils (aluminium + silicon) delivered onboard is 60 ppm (weight) according to the latest ISO 8217 fuel standard. By using the fuel cleaning systems onboard (centrifuges), the amount of catalytic fines should be reduced by 80%, i.e. a fuel containing 60 ppm should not contain more than 12 ppm at the engine inlet. For bunkers containing less cat fines we expect a proportional reduction at the engine inlet.

A suspicion that catalytic fines are the reason for a sudden liner and ring wear can be confirmed (or be denied) by taking replicas of worn liner and/or piston ring surfaces. PrimeServ, Copenhagen can assist with expertise in such matters. The investigation also include judgement of the liner surface structure (open graphite, closed graphite).




The occurrence of the particles is unpredictable. Therefore, always clean the fuel oil as thoroughly as possible by centrifuging with a slow flow rate, to remove the abrasive particles, i.e. if two centrifuges are running they should run in parallel.

Abrasive wear can occur on:

1. The running surfaces of the liner and piston rings.

   Scratching on the piston ring running surface is one of the first signs of abrasive particles and can be observed during scavenge port inspections or piston overhauls. Scratching is often seen as a large number of rather deep “trumpet shaped” grooves (see plates 707-15).

   Usually, micro-seizures do not occur, i.e. the ring surface remains soft. However, if excessive micro-seizures (scuffing) do occur, the ring surface becomes hard. This can be checked with a file (a file test can only take place when the piston is pulled, and rings have been dismantled).

2. The upper and lower sides of the piston rings.

   Particles caught between the upper horizontal ring/groove surfaces will cause pitting – “pock-marks” – on the upper ring surface (see plate 707-15). “Pock-marks” may also arise during a prolonged period of ring collapse. Even if the running surface of the top ring has a satisfactory appearance, the condition of the ring's upper surface will reveal the presence of abrasive particles coming with the fuel.

3. The upper edge of the piston rings.

   When particles pass down the ring pack via the ring joint gaps, they will cause a “sand blasting” effect on the upper edge of the ring below, that protrudes from the piston ring groove, i.e. this is only seen on ring No's. 2, 3, and 4.

### 5.5.2 Fuel oil treatment

Correct fuel oil treatment and proper maintenance of the centrifuges are of the utmost importance for cylinder condition, exhaust valves and fuel injection equipment. Water and abrasive particles are removed by means of the centrifuges:

- The ability to separate water, depends largely on the specific gravity of the fuel oil relative to the water at the separation temperature. Other influencing factors are the fuel oil viscosity (at separation temp.) and the flow rate. Keep the separation temperature as high as possible, i.e. always above 98 degrees
- The ability to separate abrasive particles depends on the size and specific weight of the smallest impurities that are to be removed and, in particular, on the fuel oil viscosity (at separation temp.) and the flow rate through the centrifuge.
- Keep the flow rate as low as possible. Run centrifuges in parallel.
- If in doubt about the efficiency of the centrifuges call in a service engineer from the manufacturer. It is worthwhile.
- It should be noted that the viscosity of the fuel have a high impact on the separation. For example, if the fuel temperature is lowered by approximately 3 degrees celcius, the efficiency of the cleaning drops to almost half.

For more information on fuel oil see chapter 705.

## 5.6 Adhesive wear

### 5.6.1 Scuffing

Apart from the factors mentioned under item 3.3 (blow-by, deposits, cylinder oil deficiencies, etc.) scuffing can be due to:

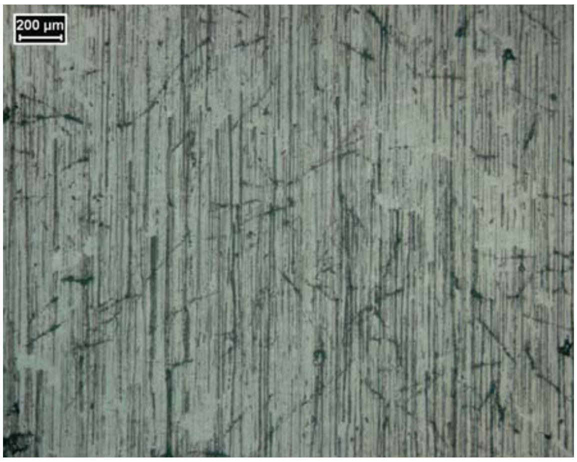
- Unsatisfactory running-in conditions (especially if previous micro-seizures have not been successfully counteracted during a cylinder overhaul). As regards running-in, see item 4.13
- Incorrect and too high lubrication feed rate (chemical bore polish)
- Too rapid changing of engine load
- Water intrusion
- Presence of vast amounts of particles, e.g. cat fines
- Excessive wear of CPR top ring CL-grooves, beyond minimum depth
- PC-ring malfunction, topland deposits interacting with cylinder liner surface (mechanical bore polish).

### 5.6.2 Bore polish

Bore polish as a result of over-lubrication and excessive neutralisation of the sulphuric acid, or as a result of top land deposits, will result in a closed graphite structure and reduce the ability of the running surface to maintain a proper oil film. A closed graphite structure will furthermore be less capable of reducing the extension and spreading of seizures, compared to an open structure.

When there is limited corrosive liner wear, e.g. 0.03-0.05 mm/1000 hours, the structure normally becomes open and, hereby, the risk of seizure is drastically reduced. Therefore, it is an advantage to have a certain amount of controlled corrosive wear.

Cylinder liner surface




Closed grafite structure


Open grafite structure

## 1. Lubricators

Each cylinder liner has a number of lubricating quills, through which oil is introduced from the Lubricators.

There are three different types of lubricators available for B&W engines:

- ME-lubricators (integrated with the ME engine ECS system).
- Alpha lubricators for MC engines.
- Mechanical lubricators for MC engines.

For the specific lubricator system installed, please see individual instruction book. The oil is pumped into the cylinder (via non-return valves) when the piston rings pass the lubricating orifices, during the upward stroke.

## 2. Cylinder Oil Film

The purpose of cylinder lubrication is as follows:

1. To create a hydrodynamic oil film separating the piston rings from the liner. The oil amount needed to create an oil film is more or less independent of the fuel 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, the optimum is kept safely down to a feed rate of 0.60 g/kWh.

2. To clean the piston rings, ring lands and ring grooves. 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 0.60 g/kWh.

3. Control of cylinder liner corrosion, i.e. neutralisation of sulphuric acid. The combustion process creates highly corrosive sulphuric acids depending on the sulphur content in the fuel. To obtain an optimal corrosive level of the cylinder liner, the ACC factor for the cylinder oil feed rate must be set according to instructions. The ACC (Adaptive Cylinder oil Control) concept ensures a correct cylinder oil feed rate level in relation to the fuel oil Sulphur content.

If a satisfactory cylinder condition is to be achieved, it is of vital importance that the oil film is intact. Therefore, the following conditions must be fulfilled:

1. The cylinder lubricators must be correctly timed.

2. The cylinder oil type and BN must be selected in accordance with the fuel being burned.

3. New liners and piston rings must be carefully run-in, see Plate 707-10.

4. The oil feed-rate (dosage) under normal service must be in accordance with the engine builder's recommendations. Furthermore, the dosage feed rate must be adjusted in accordance with the service experience for the actual trade (obtained from the scavenge port inspections).

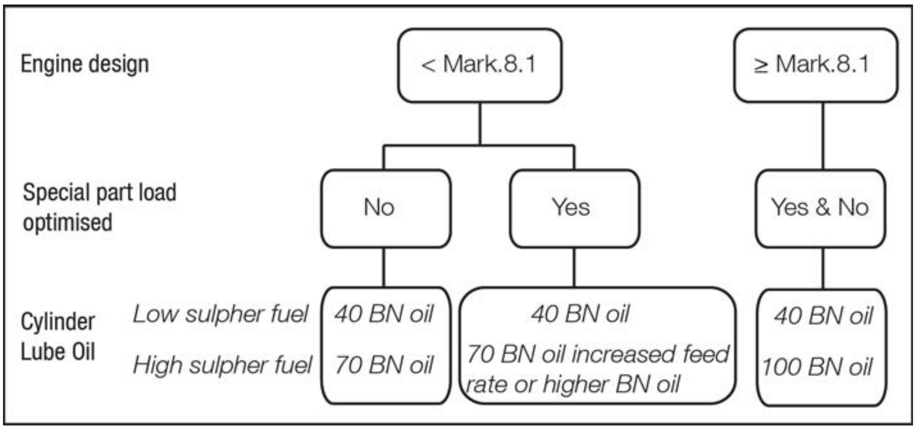
## 3. Cylinder Oils

The tables below indicates international brands of cylinder oils that have been tested in service with acceptable results, and some of the oils have also given long term satisfactory serivce during heavy fuel operation in MAN B&W engines.

Do not consider the list complete, as oils from other companies can be equally suitable. Further information can be obtained by contacting the engine builder or MAN Diesel & Turbo, Copenhagen.

MAN Diesel & Turbo recommend the use of cylinder oils with the following main properties:

- SAE 50 viscisity
- High detergency
- Alkalinity (BN) must be chosen according to the applied fuel sulpher content and engine design




For Mark 8.1 engines and higher the following oils are recommended:

| Cylinder oils | | |
|---|---|---|
| **Oil company** | **Oil name** | **Specified BN level** |
| Aegean | Alfacylo 540 LS | 40 |
| | Alfacylo 100 HS | 100 |
| BP | CL-DX 405 | 40 |
| | Energol CL 100 ACC | 100 |
| Castrol | Cyltech 40SX | 40 |
| | Cyltech CL 100 ACC | 100 |
| Chevron | Taro special HT LS 40 | 40 |
| | Taro Special HT 100 | 100 |
| ExxonMobil | Mobilgard L540 | 40 |
| | Mobilgard 5100 | 100 |
| Gulf Oil Marine | Gulfsea Cylcare DCA 5040H | 40 |
| | Gulfsea Cylcare 50100 | 100 |
| JX Nippon Oil & Energy | Marine C405 | 40 |
| | MC-1005-8* *internal code* | 100 |
| Lukoil | Navigo 40 MCL | 40 |
| | Navigo 100 MCL | 100 |
| Shell | Alexia S6 | 100 |
| Sinopec | Marine Cylinder Oil 5040 | 40 |
| Total | Talusia LS 40 | 40 |
| | Talusia Universal 100 | 100 |

## 1. Introduction

These instructions are a supplement to “Procedure 908-2”, in our Volume II, Maintenance” instruction book, and should be used in combination with that Procedure during inspection and overhaul of all Nimonic spindles on MAN B&W engines.

All general data, including specified wear limits for the spindle used on your engine type, are given in Procedure 908-2, DATA. Note down the actual engine data in the “DATA”-box in the relevant chapters of these instructions.

The procedure is divided into the following eight sections:

1. Spindle identification
2. Inspection intervals
3. Inspecting the contact condition of the seat
4. Checking the seat for gas leakage
5. Cleaning and evaluation
6. Inspecting the valve stem wear layer
7. Grinding the spindle seat
8. Exhaust Valve Condition Report

Sections 3 to 7 are each divided into four steps:

- What to do
- Acceptance criteria
- Remarks
- Further action

## 2. Spindle Identification

Markings:

The tops of Nimonic spindles are marked: “Nim”, “Nim80A”, “N80A”,”N80”, or “NCF80A”.

If in doubt, please contact MAN Diesel & Turbo, Copenhagen.

## 3. Inspection Intervals

| Inspection intervals | Inspections: | | |
|---|---|---|---|
| | Initial | Second | Subsequent |
| Normal hours of service: | After 6,000 hours | After 16,000 hours *) | Every 16,000 hours *) |
| Recommended: | After 6,000 hours (50-60MC 3-6,000 hours) | Based on condition at initial inspection | Based on condition at initial and second inspections **) |

*) The normal hours of service between overhauls for Nimonic exhaust valve spindles is 16,000 hours (see instruction book Volume II, Chapter 900).

**) If the spindle condition is very good, the condition of other exhaust valve parts may prove to be the decisive factor in determining the future overhaul/inspection intervals.

## 4. Inspecting the Contact Condition of the Seat

What to do

*Do not clean the spindle disc before inspection.*

Visually check that there is inner contact.

Fig. 1 shows inner contact between the seats of the spindle and bottom piece, corresponding to slow/low-load/manoeuvring condition.

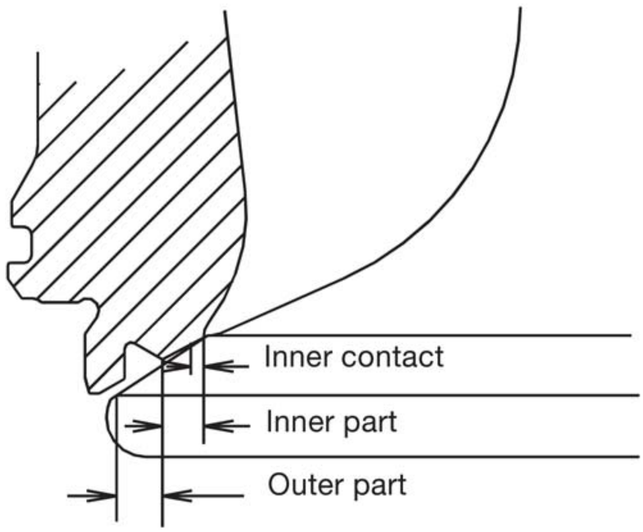



*Fig.1: Inner contact, and zone designation*

**Acceptance criteria**

There must be contact around the entire **inner** circumference of the seat.

**Remarks**

When the valve heats up in service, the angular difference between the spindle and bottom piece seatings will decrease. At steady, full load, the seatings will be parallel, as shown in Fig. 2.

Thus, inner contact must be maintained in order to be sure of parallel contact during running.

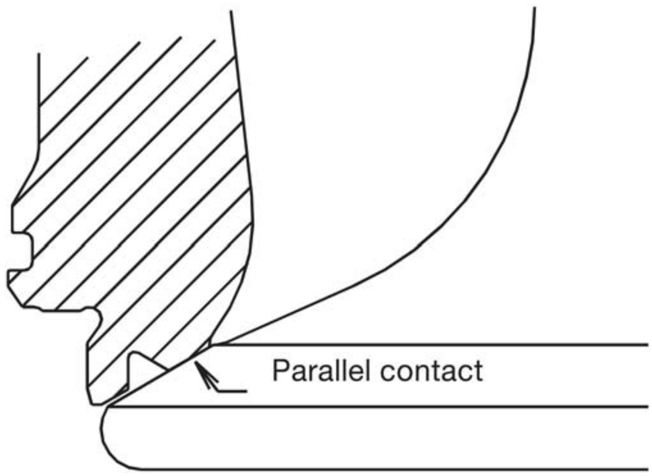



*Fig.2: Contact condition during running*

If there is no inner contact, outer contact (Fig. 3) will occur during running, and this will increase the risk of blow-by.

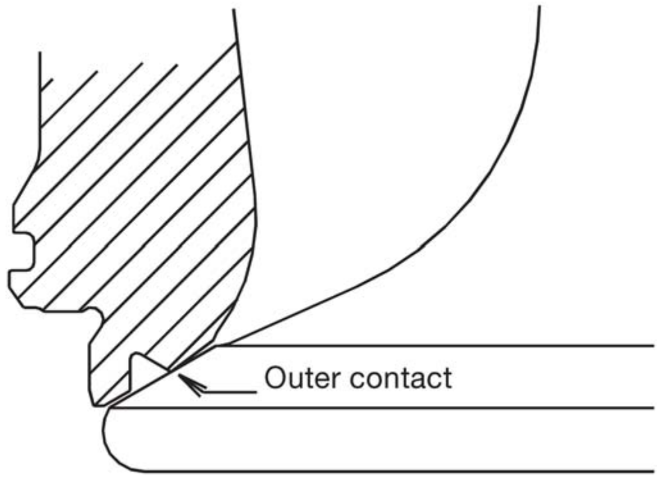



*Fig.3: Outer contact, increased risk of blow-by*

Further action:

✍ Fill in Page 11 'Exhaust Valve Condition Report'.

If the seat contact is incorrect, grind the spindle seating, as described in Step 7. However, before grinding, proceed to Steps 4, 5 and 6.

## 5. Checking the Seat for Gas Leakage

What to do

! *Do not clean the spindle disc before inspection*

Visually check the inner part of the seating for blow-by (Fig. 4 and Photo 1).

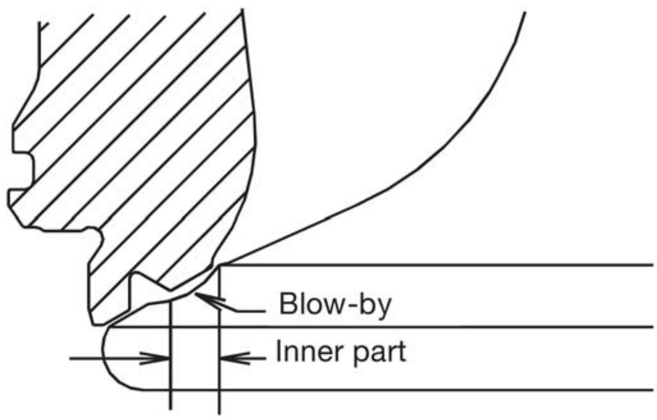



*Fig.4: Blow-by*


*Photo 1:Blow-by*

Acceptance criteria:

There must be no blow-by "tracks" across the inner part of the seat *(Figs. 1 + 4, and Photo 1).*

Remarks:

Blow-by indications may be associated with large/deep dent marks, and will often form a "gas-jet-fan" in the deposits on the disc cone (Photo 1).

The surface of a serious blow-by track/groove will usually show signs of hot corrosion, i.e. it will have an "elephant skin" texture.

Minor leakages. Small, faint, fan-shaped leakage indications on the spindle cone, just inside the seat area (Photo 2), are harmless.

*Photo 2: Minor leakages, and "fans"*

Further action:

✍ Fill in Page 11, 'Exhaust Valve Condition Report'.

If blow-by has been found, then grind the seat, as described in Step 7. However, before grinding, proceed to Steps 5 and 6.

## 6. Cleaning and Evaluation

### What to do:

- Clean the seat with coarse emery cloth. Observe and note down the size and number of dent marks. Also note any possible crack indications.
- Check the outer part of the seat for high temperature corrosion (Fig. 1 and Photo 3).

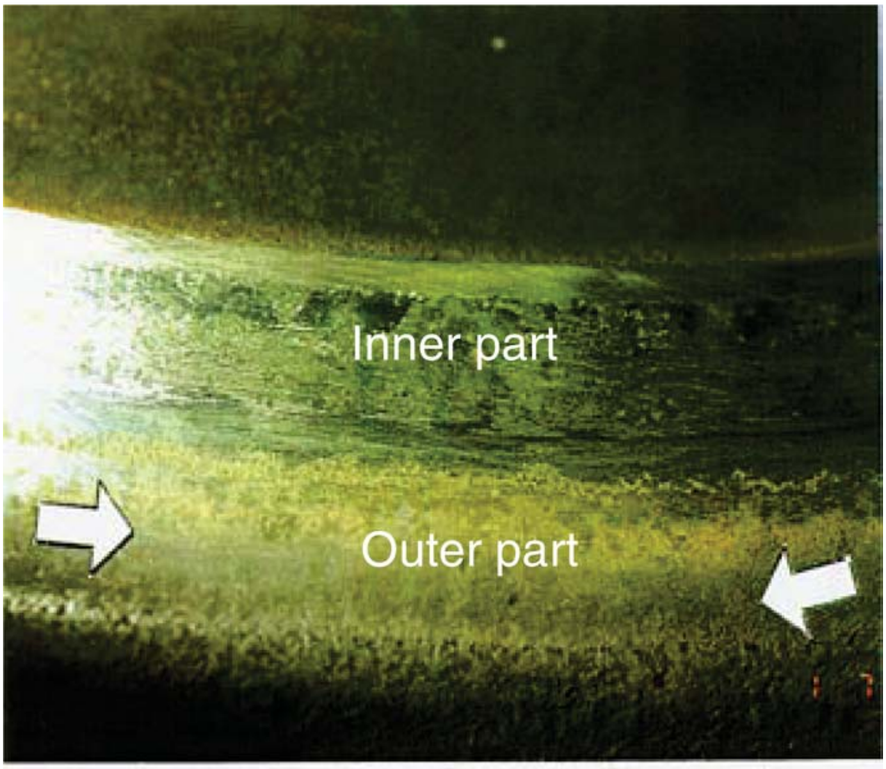



*Photo 3: Example of high-temperature corrosion at outer part after 33,000 hours*

- Clean the contact faces on which the measuring template is to be applied, and measure:

  – the burn-off on the disc underside,
  – the total amount the seat has been ground.

*(See work card 2265-0201)*

### Acceptance criteria:

**Dent marks,** of varying number and size (up to 8-10 mm), will be seen on the seating after a few thousand service hours. The first marks may appear as early as after testbed running. In general, dent marks are acceptable and should not necessitate grinding of the seat. If, however, the marks have caused blow-by, then the seat must be ground/reconditioned.

**Cracks.** Any indications of cracks in the seat area should be checked carefully. If cracking is confirmed, contact MAN Diesel & Turbo.

**High-temperature corrosion** on the outer part of the seat may result in a measurable difference in level between the inner and outer seat zones. In that case the spindle must be ground. However, this will not normally happen before 20 – 30,000 hours after the previous grinding.

Wear Allowances:

*Fill in data from 908-02*

- Burn-off on disc underside, (F1)
- Total grinding of seat, (G1).

### Remarks:

Burn-off rate (disc underside). The number of service hours before shore-side reconditioning usually depends upon the burn-off rate of the disc underside

| Engine type: *) | Max. permissible burn-off (mm) |
|---|---|
| 26MC | 5 |
| 35MC<br>35ME-B | 6 |
| 40ME-B | 6 |
| 42MC | 7 |
| 46MC-C | 8 |
| 50MC/MC-C<br>50ME/ME-C | 8 |
| 60MC/MC-C<br>60ME/ME-C | 9 |
| 65ME-C | 9 |
| 70MC/MC-C<br>70ME/ME-C | 10 |
| 80MC/MC-C<br>80ME/ME-C | 14 |
| 90MC/MC-C<br>90ME/ME-C | 17 |
| 98MC/MC-C<br>98ME/ME-C | 20 |

**) Also valid for stationary engines (power plants)*

### Further action:

✍ Fill in section 8: ‘Exhaust Valve Condition Report’.

If the burn-off or grinding limits have been reached, contact MAN Diesel & Turbo for advice on reconditioning.

If the seat and the disc underside are acceptable with respect to section 3, 4, and 5, then the spindle can be reinstalled without grinding after section 6 has been carried out. Otherwise, proceed to section 6 and 7.

## 7. Inspecting the Valve Stem Wear Layer

**What to do**

- Clean the valve spindle stem.
- Measure the diameter of the spindle stem in the area shown in *Volume II, Procedure 908-2.*
- Check the surface condition of the chrome-plated/HVOF-coated area.

**Acceptance criteria:**

**Min. diameter:** Must not be less than that stated in Vol. II, Procedure 908-2, DATA**Cracking ("network cracking") of chrome/HVOF:** Slight cracking of the lowermost part of the chrome plating/HVOF-coating (Photo 4) has no significance, and is therefore acceptable.

| |
|---|
| Fill in data from<br>DATA 908-2 |
| D-__________:<br>min. diameter of<br>spindle stem: |

**Peeling-off:** The chrome plating/HVOF-coating must not show peeling-off.

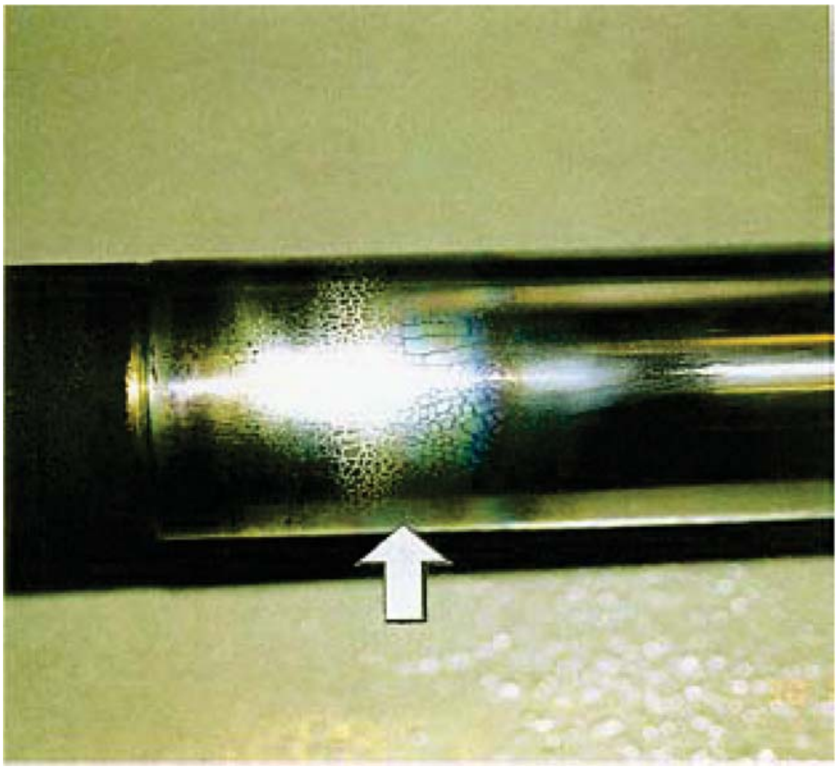


*Photo 4: Slight cracking ("network cracking") of wear layer*

**Further action:**

✍ Fill in Page 11, 'Exhaust Valve Condition Report'.

If the spindle stem is acceptable, proceed to Step 7. Otherwise, contact MAN B&W Diesel A/S for advice on reconditioning.

## 8. Grinding the Spindle Seat

What to do

- Mount the spindle in the grinding machine and, using the dial-gauge positioned just inside the area of inner contact, (see Fig. 5), true-up to within a maximum of 0.05 mm. This is done in order to minimize the amount of material removed during grinding.

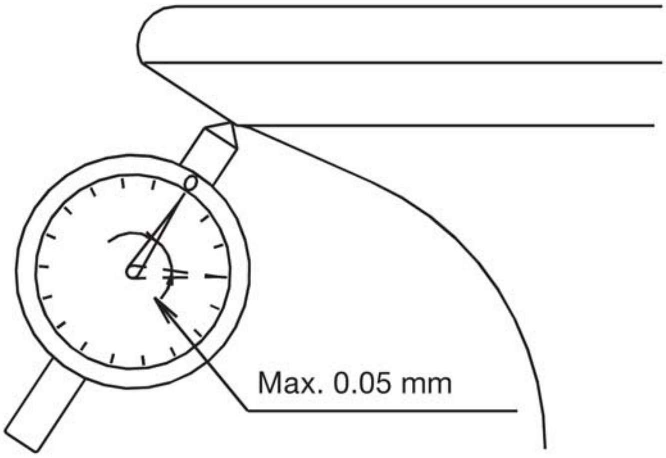



*Fig. 5: Truing-up the spindle*

- Grind the seat according to the special instructions from the grinding machine supplier.

  *See also MAN B&W Service Letter SL95-332/UM, "Grinding of Nimonic Exhaust Valve Spindles".*

| |
|---|
| Fill in data from<br>DATA 908-2 |
| D-_________:<br>Offset angle: |

**Keep the grinding to a minimum!**

| After full contact between grindstone and seat is reached at the beginning of the grinding process: | |
|---|---|
| Normally | Limit the grinding to 0.2 mm. |
| Rare cases | Remove 0.3 mm or more. |
| Blow-by | Continue the grinding until the blow-by marks are removed. |
| Dent marks | It is not necessary to continue grinding until all dent marks<br>have been removed. |

Photo 5 shows an overhauled Nimonic valve spindle which is ready for further service.

*Photo 5: Acceptable seat condition after grinding*

**Acceptance criteria:**

The ground surface. The grindstone must have removed material from the whole width and the whole circumference of the seat. There must be no signs of blow-by.

| Fill in data from<br>DATA 908-2 |
|---|
| G1: |

Max. grinding depth: must not exceed the limit (G1) stated in Vol. II, Procedure 908-2, DATA.

If the seat surface is still not acceptable when the max. grinding depth has been reached, contact MAN B&W Diesel A/S for advice on reconditioning.

## 9. Exhaust Valve Condition Report

# Exhaust Valve Condition Report

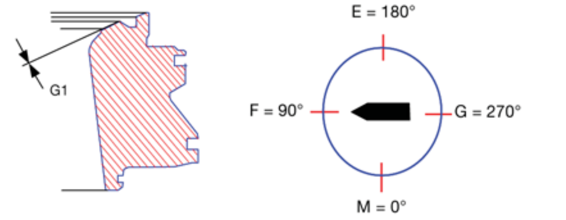
| | | | |
|---|---|---|---|
| Plant: | | Engine type: | Builder/no.: |
| Valve dismounted from cyl.: | Date: | Engine hours (total): | Valve no.: |
| Valve checked/overhauled by: | Date: | | Remarks: |
| Valve mounted on cyl.: | Date: | Engine hours (total): | Kept as spare (yes/no): |

### BOTTOM PIECE

| | | |
|---|---|---|
| Marking: | Base material: | Hours after overhaul: |
| Type: | Seat material: | Hours total: |

| | | |
|---|---|---|
| Seat contact (inner/outer/parallel): | | No. of dent marks larger than Ø = 7 mm: |
| Cracks (yes/no): | Blow-by (yes/no): | Maximum deposit thickness in duct (mm): |
| Deposit in chamber, extent (mm): | | at position (degrees, 0° = Manoeuvreside): |

| | |
|---|---|
| Total grinding, G1 (mm): | |
| Note! Max grinding, G1 = 2.0 mm | |
| Remarks: | |

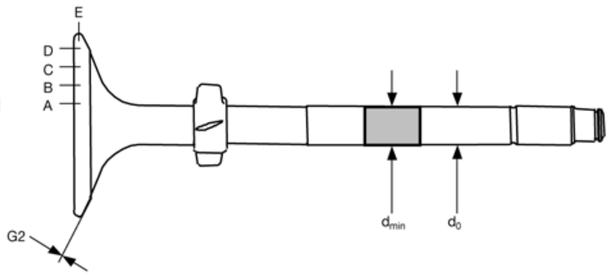



### SPINDLE

| | | |
|---|---|---|
| Marking: | Base material: | Hours after overhaul: |
| Disc coating: | Seat material: | Hours total: |
| Cracks (yes/no): | Seat contact (inner/outer/parallel): | Blow-by (yes/no): |
| Spindle disc max burn-off (mm): | at position (A, B, C, D or E): | Burn-off rate (mm/1000h): |

| | |
|---|---|
| No. of dent marks larger than Ø = 7 mm: | Total grinding, G2 (mm): Note! Max grinding, G2 = 2.0 mm |
| Stem diameter $d_0$ above sealing area (mm): | |
| Min. stem diameter $d_{min}$ at sealings (mm): | |

| Extent of reconditioning | | 1st | 2nd | 3rd |
|---|---|---|---|---|
| Welding of seat (Tick off) | | | | |
| Seat welding material: | | | | |
| Welding of disc (Tick off) | | | | |
| Disc welding material: | | | | |
| Stem recond. (Tick off) | Chr.-plating | | | |
| | HVOF-Cermet | | | |




Remarks:

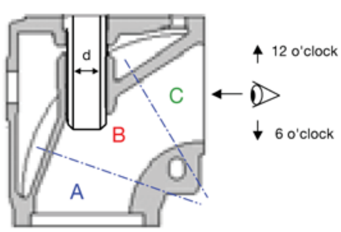
### HOUSING

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Marking: | | | | | | | Hours after overhaul: |
| Spindle guide diameter, d | Top | Bottom | Extent of reconditioning | | 1st | 2nd | Hours total: |
| Minimum (mm) | | | Repair welding (Tick off) | | | | Max coke deposit thickness (mm): |
| Maximum (mm) | | | Coating: | | | | |

**Corrosion**

| Area | A | | B | | C | |
|---|---|---|---|---|---|---|
| mm | | | | | | |
| position (o'clock) | | | | | | |

Remarks:

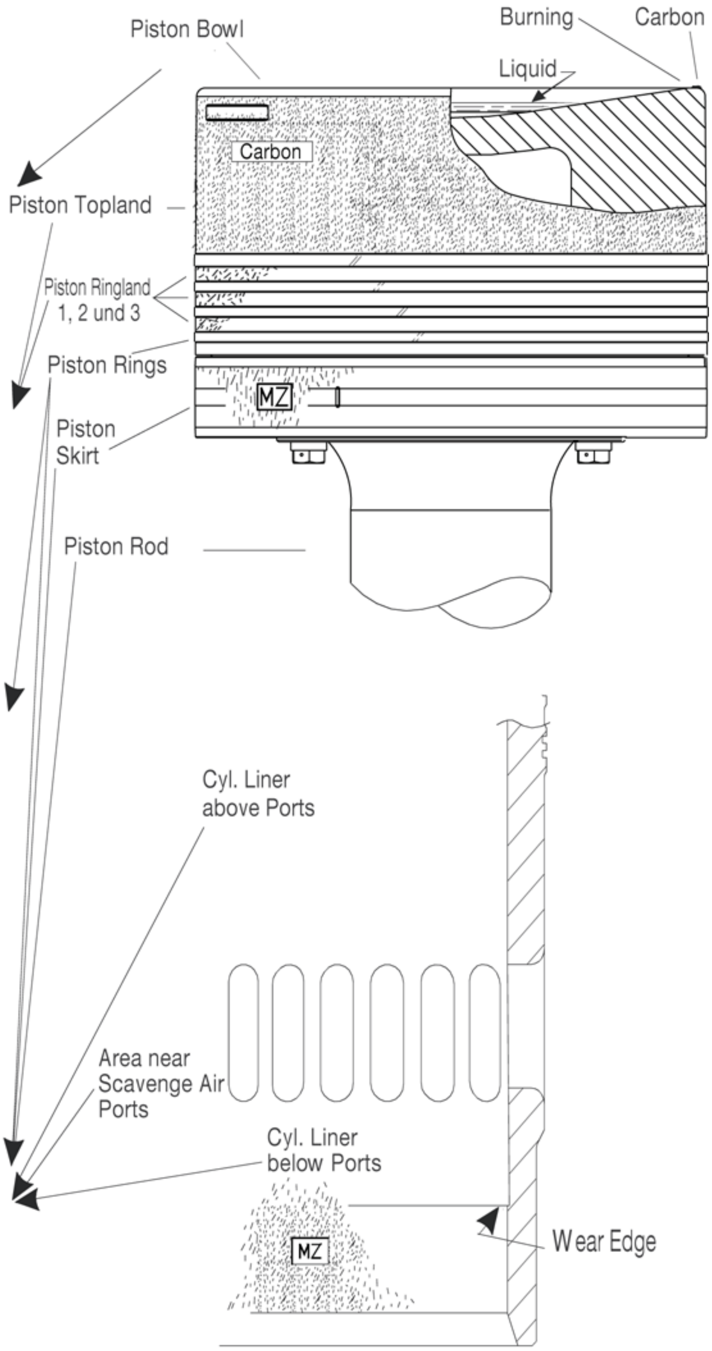


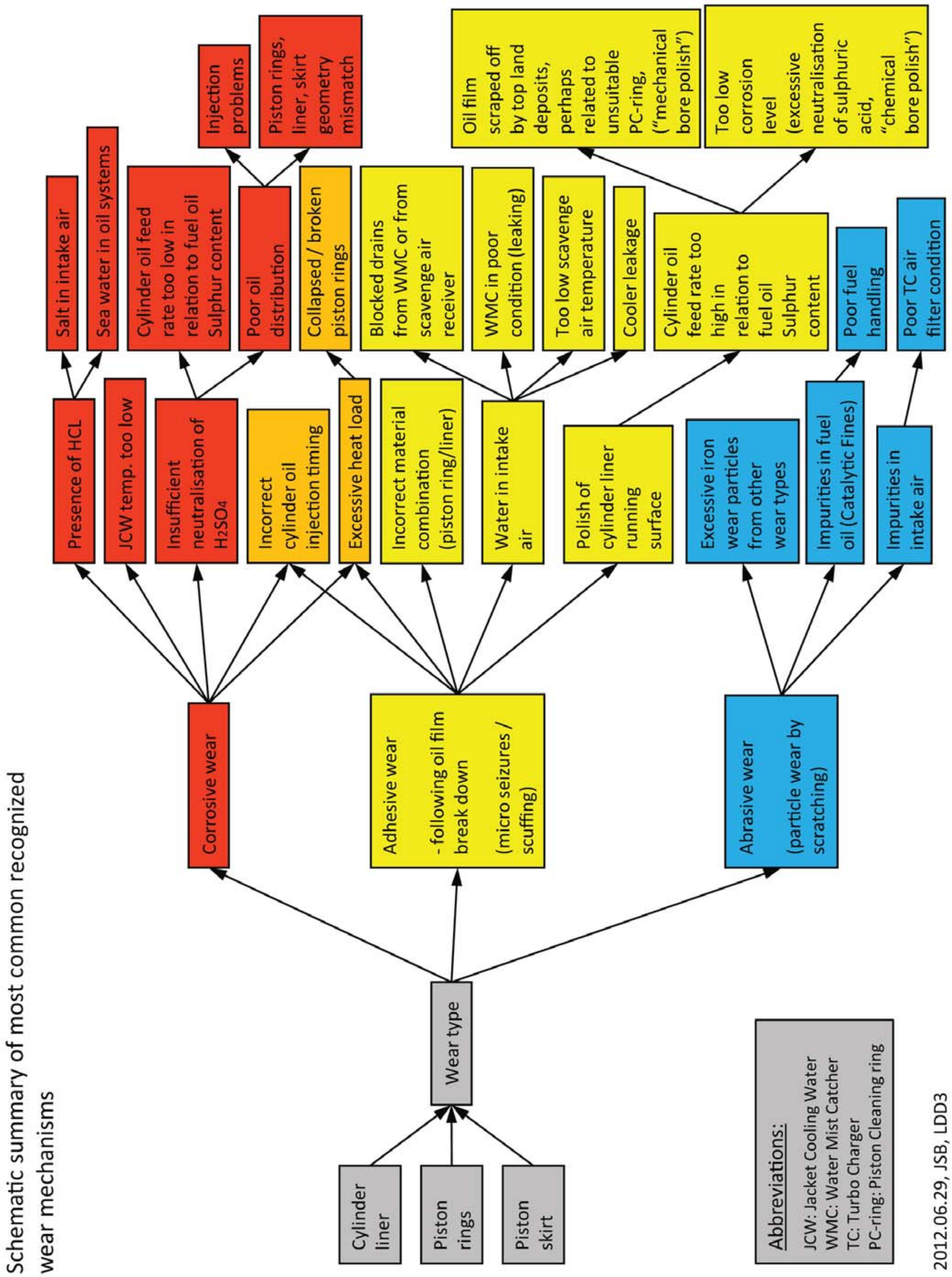
# Inspection through Scavenge Ports

| | | | | | |
|---|---|---|---|---|---|
| Vessel: | | IMO nr.: | | Builder/no.: | |
| Number of cylinders: | Eng. type: | Eng. hrs.: | Checked by: | Date: | |
| Weeks pr. port calls: | Normal service load (% of MCR): | | | MEP lubricator type (Y/N): | |
| Cyl. oil consump. (l/24 hrs): | at load % | Cyl. oil type: | | Position: ☐ Exhaust | ☐ Manoeuvre |

| | Condition and Symbol | Engine Part | Cylinder No. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Intact - *<br>Burning - BU<br>Leaking oil - LO<br>Leaking water - LW | Piston crown | | | | | | | | | | | | |
| Deposits | No deposit - *<br>Light deposit - LC<br>Medium deposit - MC<br>Excessive deposit - EC<br>Polished deposit - PC | Topland | | | | | | | | | | | | |
| | | Ringland 1 | | | | | | | | | | | | |
| | | Ringland 2 | | | | | | | | | | | | |
| | | Ringland 3 | | | | | | | | | | | | |
| Ring breakage | Intact - *<br>Collapsed - C<br>Broken opposite ring gap - BO<br>Broken near gap - BN<br>Several pieces - SP<br>Entirely missing - M | Ring 1 | | | | | | | | | | | | |
| | | Ring 2 | | | | | | | | | | | | |
| | | Ring 3 | | | | | | | | | | | | |
| | | Ring 4 | | | | | | | | | | | | |
| Ring movement | Loose - *<br>Sluggish - SL<br>Sticking - ST | Ring 1 | | | | | | | | | | | | |
| | | Ring 2 | | | | | | | | | | | | |
| | | Ring 3 | | | | | | | | | | | | |
| | | Ring 4 | | | | | | | | | | | | |
| Surface condition | Clean, smooth - *<br>Running surface, Black,overall - B<br>Running surface, Black, partly - (B)<br>Black ring ends > 100 mm - BR<br>Scratches (vertical) - S<br>Micro-seizures (local) - mz<br>Micro-seizures (all over) - MZ<br>Micro-seizures, still active - MAZ<br>Old MZ - OZ<br>Machining marks still visible - **<br>Wear-ridges near scav. ports - WR<br>Scuffing - SC<br>Clover-leaf wear - CL<br>Rings sharp-edged Top/Bot. - T/B | Ring 1 | | | | | | | | | | | | |
| | | Ring 2 | | | | | | | | | | | | |
| | | Ring 3 | | | | | | | | | | | | |
| | | Ring 4 | | | | | | | | | | | | |
| | | Piston skirt | | | | | | | | | | | | |
| | | Piston rod | | | | | | | | | | | | |
| | | Cylinder liner abv. scav. ports | | | | | | | | | | | | |
| | | Cylinder liner near scav. ports | | | | | | | | | | | | |
| Lubrication condition | Optimal - *<br>Too much oil - O<br>Slightly dry - D<br>Very dry - DO<br>Black oil - BO | Ring 1 | | | | | | | | | | | | |
| | | Ring 2 | | | | | | | | | | | | |
| | | Ring 3 | | | | | | | | | | | | |
| | | Ring 4 | | | | | | | | | | | | |
| | | Piston skirt | | | | | | | | | | | | |
| | | Piston rod | | | | | | | | | | | | |
| | | Cylinder liner | | | | | | | | | | | | |
| Deposits | No Sludge - *<br>Sludge - S<br>Much sludge - MS | Scavenge box | | | | | | | | | | | | |
| | | Scav. receiver | | | | | | | | | | | | |
| | Intact - * | Flaps and nonreturn valves | | | | | | | | | | | | |
| Running hours since last overhaul | | | | | | | | | | | | | | |

| | Condition and symbol |
|---|---|
| | Intact - *<br>Burning - BU<br>Leakage Oil - LO<br>Leakage Water - LW |
| Diposites | No deposit - *<br>Light deposit - LC<br>Medium deposit - MC<br>Excessive deposit - EC<br>Polished deposit - PC |
| Ring breakage | Intact - *<br>Collapsed - C<br>Broken opposite ring gap - BO<br>Broken near gap - BN<br>Several pieces - SP<br>Entirely missing - M |
| Ring movement | Loose - *<br>Sluggish - SL<br>Sticking - ST |
| Surface condition | Clean, smooth - *<br>Burning surface, Black, overall - B<br>Burning surfase, Black, partly - (B)<br>Black ring ends > 100 mm - BR<br>Scratches (vertical) - S<br>Micro-seizures (local) - mz<br>Micro-seizures, (all over) - MZ<br>Micro-seizures, still active - MAZ<br>Old MZ - OZ<br>Machining marks still visible - **<br>Wear-ridges near scav. ports - WR<br>Scuffing - SC<br>Clover-leaf wear - CL<br>Rings sharp-edged Top/Bot. - T/B |
| Lubrication condition | Optimal - *<br>Too much oil - O<br>Slightly dry - D<br>Very dry - DO<br>Black oil - BO |
| Diposites | No Sludge - *<br>Sludge - S<br>Much sludge - MS |
| | Intact - * |




Schematic summary of most common recognized wear mechanisms
Cylinder liner
Piston rings
Piston skirt
Wear type
Corrosive wear
Adhesive wear - following oil film break down (micro seizures / scuffing)
Abrasive wear (particle wear by scratching)
Presence of HCL
JCW temp. too low
Insufficient neutralisation of H2SO4
Incorrect cylinder oil injection timing
Excessive heat load
Incorrect material combination (piston ring/liner)
Water in intake air
Polish of cylinder liner running surface
Excessive iron wear particles from other wear types
Impurities in fuel oil (Catalytic Fines)
Impurities in intake air
Salt in intake air
Sea water in oil systems
Cylinder oil feed rate too low in relation to fuel oil Sulphur content
Poor oil distribution
Collapsed / broken piston rings
Blocked drains from WMC or from scavenge air receiver
WMC in poor condition (leaking)
Too low scavenge air temperature
Cooler leakage
Cylinder oil feed rate too high in relation to fuel oil Sulphur content
Poor fuel handling
Poor TC air filter condition
Injection problems
Piston rings, liner, skirt geometry mismatch
Oil film scraped off by top land deposits, perhaps related to unsuitable PC-ring, ("mechanical bore polish")
Too low corrosion level (excessive neutralisation of sulphuric acid, "chemical bore polish")
Abbreviations:
JCW: Jacket Cooling Water
WMC: Water Mist Catcher
TC: Turbo Charger
PC-ring: Piston Cleaning ring
2012.06.29, JSB, LDD3

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

| | Standard BN 70 Cylinder oil | |
|---|---|---|
| Viscosity range | SAE 40-50 (SAE 50 for Mk 9 and newer) | |
| ACC setting | 0.34 - 0.20<br>g/kWh x S% | |
| Guiding minimum feed rate | 0.60 g/kWh | |
| Maximum feed rate during running-in | 1.7 g/kWh | |
| Part-load control | Proportional with the load, at lower loads, control is automatically changed to proportional with rpm.<br>On Mk 8 and newer, the break point is set at 50% load as default. The break point may be changed based on actual service experience. | |
| 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<br>ACC Factor | Starting at 0.34 g/kWh x S%<br><br>Reducing in steps of 0.04 g/kWh x S% after minimum 600 hours where the feed rate has been sulphur dependent (above minimum feed rate) or using feed rate sweep or continuous drain oil analysis | |
| Running-in new rings in already run-in and well running liners | From 50% to max. load in 5 hours<br>Feed rate 0.9 g/kWh for 24 hours.<br>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.<br><br>If irregularities are observed, adjustments of the lube oil feed rate should be considered.<br><br>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.<br><br>In case of high corrosive wear, the part-load break point from power to rpm is to be set at 50% load, and the ACC factor is to be increased to the highest ACC factor (0.34 for BN 70) and be reduced in steps of only 0.02 g/kWh x S% when the wear has been confirmed as normal. | |

*Table 5: Guiding cylinder oil feed rates*

**Breaking-in New Liners**

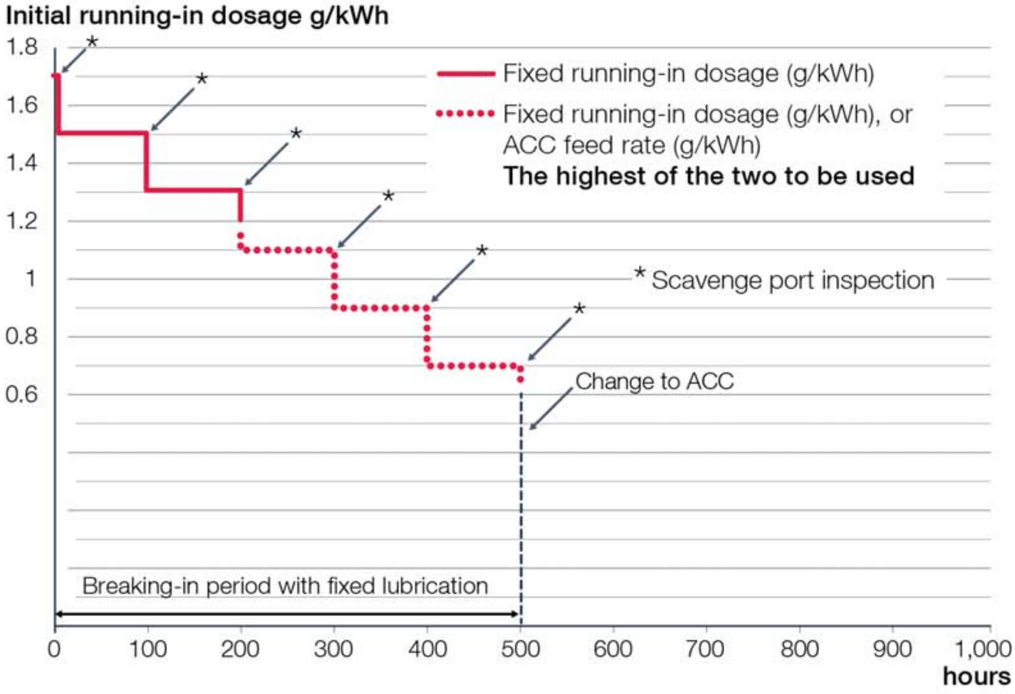



*Fig. 5: Breaking-in schedule*

**New ACC Running-in Schedule (liner and rings)**

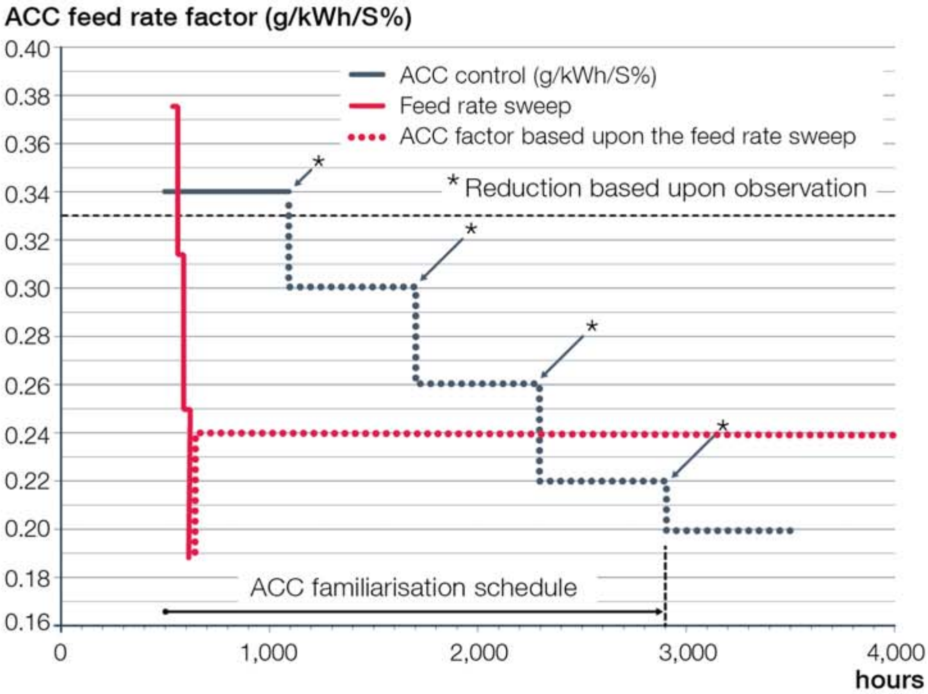



*Fig. 6: ACC familiarisation schedule*

If a liner or piston crown is exchanged, two reports must be filled-in!

# Cylinder Condition Report

MAN B&W

| | | | | |
|---|---|---|---|---|
| Vessel: | IMO no.: | Eng. builder: | Eng. no.: | Checked by: |
| No. of cyl.: | Eng. type: | Eng. hrs.: | Date (yymmdd): | **Inspected unit no.:** |

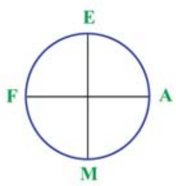
***Voyage info***

| | | | |
|---|---|---|---|
| Weeks pr. port calls: | Normal service load (% of MCR): | Lub. part load control: | Lub. type: |
| Cyl. oil consumption (l/24 hrs): | at load %: | Cyl. oil type: | |

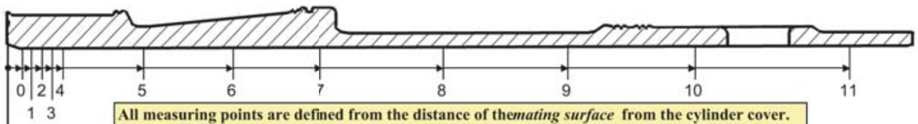
***Cylinder liner***

| | | | |
|---|---|---|---|
| Liner hours: | Insulation pipe (Y/N): | PC ring (Y/N): | Liner material: |
| Drawing no.: | Frame type: | | Liner cool type: |
| Producer/Marking: | Wear type: | | Liner honed (Y/N): |
| Cyl. cover tightened (Y/N): | Temp. between liner and measuring tool (°C): | | Shims (mm): |

| **Measuring point** | | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **A1** (Additional) | **A2** (Additional) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (mm) | | | | | | | | | | | | | | | |
| Diameter (mm) | F-A | | | | | | | | | | | | | | |
| | E-M | | | | | | | | | | | | | | |




E: Exhaust M: Manoeuvre
A: Aft F: Fore




**All measuring points are defined from the distance of the *mating surface* from the cylinder cover.**

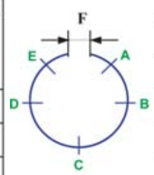
| | |
|---|---|
| **Pos. 0:** | **The middle of the none sliding part above the top piston ring at TDC.** |
| **Pos. 1-4:** | **The middle of the rings at TDC.** |
| **Pos. 5 & 6:** | **Equally positioned between pos. 4 and 7 (1/3 of distance).** |
| **Pos. 7:** | **Lubrication quill level.** |
| **Pos. 8 & 9:** | **Equally positioned between pos. 7 and 10 (1/3 of distance).** |
| **Pos. 10:** | **100 mm. above the scav. air ports.** |
| **Pos. 11:** | **The middle of the none sliding part below the bottom piston ring at BDC.** |

| | |
|---|---|
| Liner remarks | |

***Piston rings***

| | Base material | Coating | Profile | Manufacturer | Lock type | CL grooves | Broken |
|---|---|---|---|---|---|---|---|
| Ring 1 | | | | | | | |
| Ring 2 | | | | | | | |
| Ring 3 | | | | | | | |
| Ring 4 | | | | | | | |
| Ring 5 | | | | | | | |

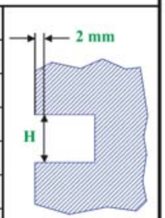
| | Width of ring (mm) | | | | | Free ring gap "F" (mm) |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| Degrees | | | | | | |
| Ring 1 | | | | | | |
| Ring 2 | | | | | | |
| Ring 3 | | | | | | |
| Ring 4 | | | | | | |
| Ring 5 | | | | | | |




"F" to be measured before dismantling

***Ring grooves***

| Height, H (mm) | | | |
|---|---|---|---|
| F | E | A | M |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

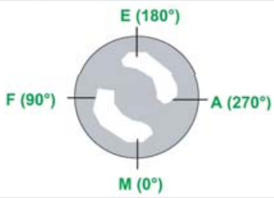



**Hours since last overhaul:**

***Piston***

| | |
|---|---|
| Crown hours: | High topland (Y/N): |
| Bronze ring (Y/N): | Oros piston (Y/N): |

| | | |
|---|---|---|
| Max burning 1 | (mm) | |
| Position 1 | (degree) | |
| Max burning 2 | (mm) | |
| Position 2 | (degree) | |
| Max burning 3 | (mm) | |
| Position 3 | (degree) | |



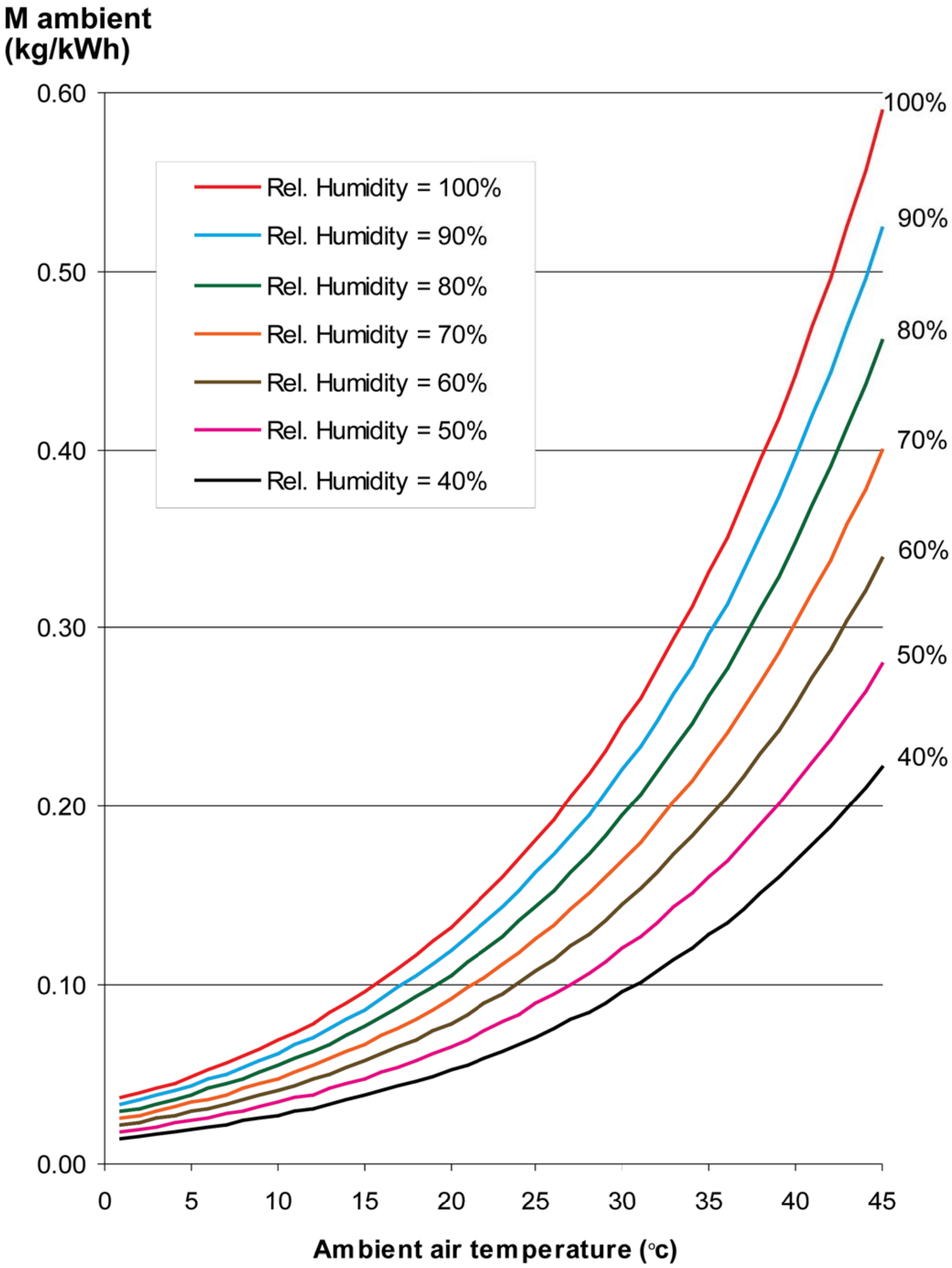

***Reason for examination***

Routine piston overhaul ☐
Test ☐
(If either of these boxes are ticked, below boxes must be kept blank)

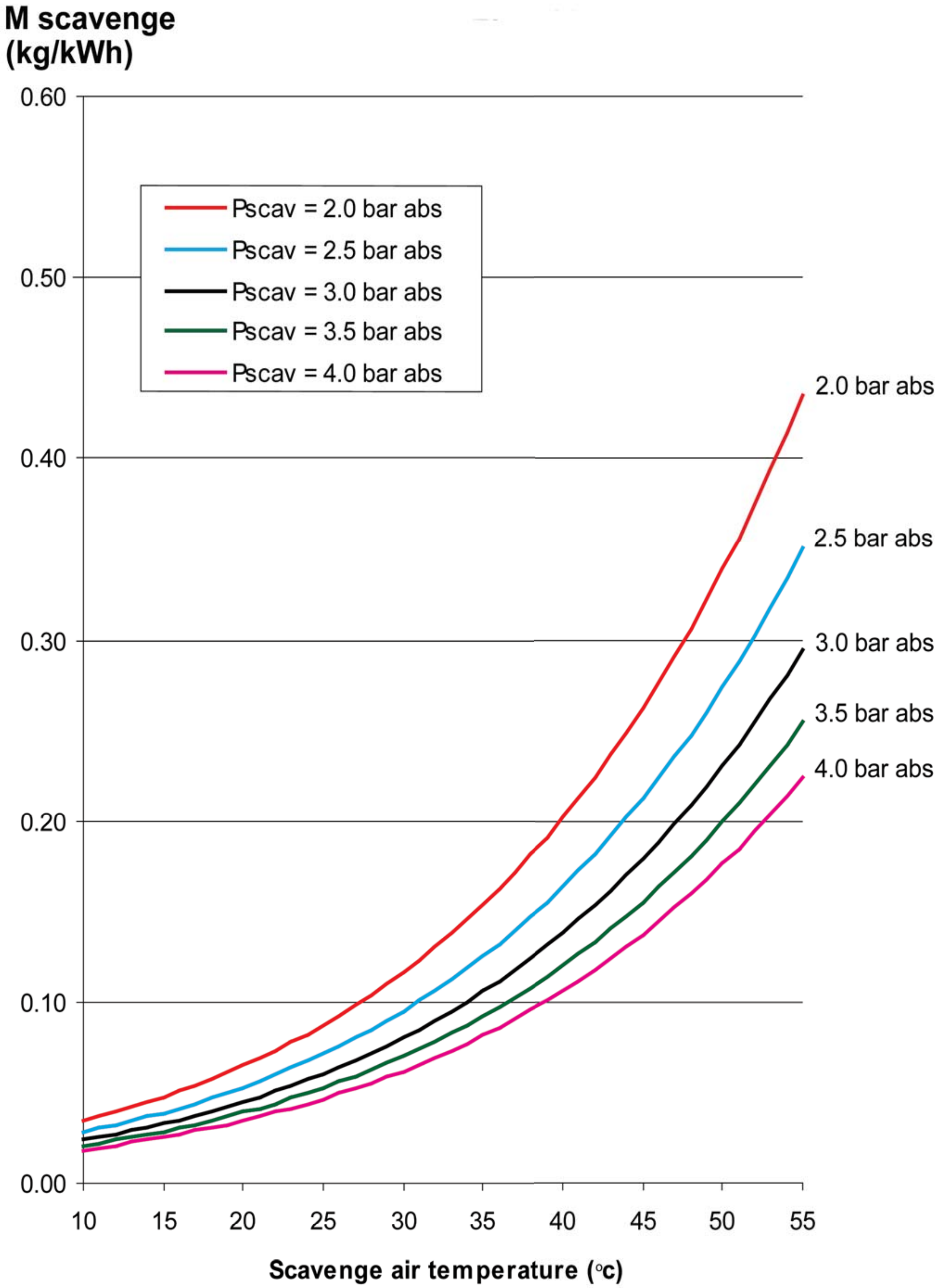
| Liner | | Piston Crown | | Piston Rings | | Piston Skirt | |
|---|---|---|---|---|---|---|---|
| Cracks | ☐ | Burning | ☐ | Broken | ☐ | Leaking | ☐ |
| Scuffing | ☐ | Cracks | ☐ | Collapsed | ☐ | Scuffing | ☐ |
| Leak | ☐ | Leaking | ☐ | Scuffing | ☐ | Piston Rod | |
| | | High Groove Wear | ☐ | Sticking | ☐ | Stuff. box | ☐ |

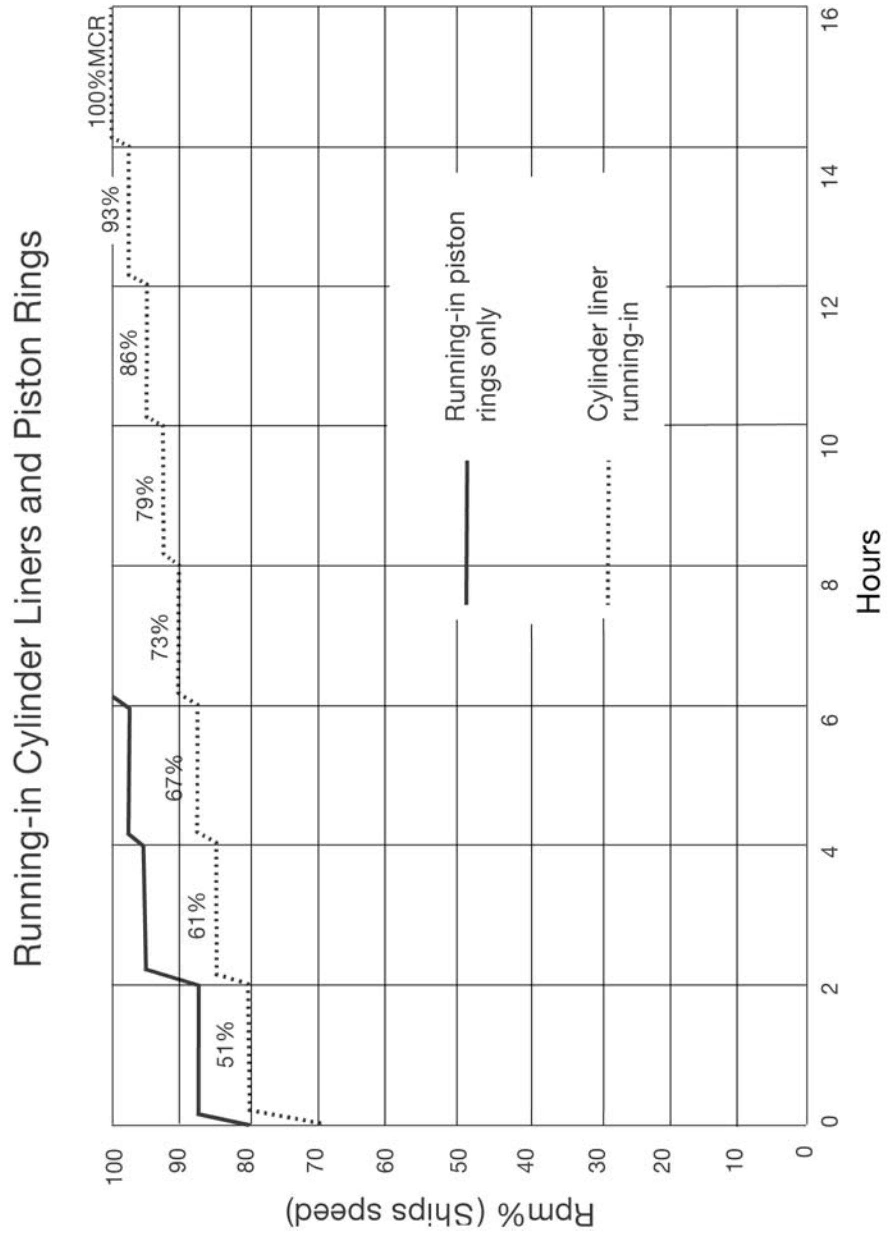
| | |
|---|---|
| Piston remarks | |

Water vapour in intake



**Maximum water vapour in scavenge air**



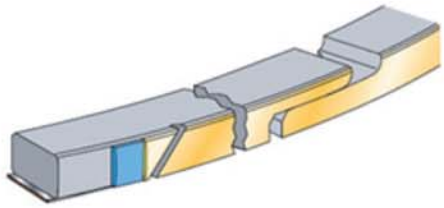

Running-in Cylinder Liners and Piston Rings
Rpm% (Ships speed)
Hours
51%
61%
67%
73%
79%
86%
93%
100%MCR
Running-in piston rings only
Cylinder liner running-in
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16

## Large Bore Ring Configuration:

### K80 Mk. 9, K90 & K98, S90 Mk. 8-9

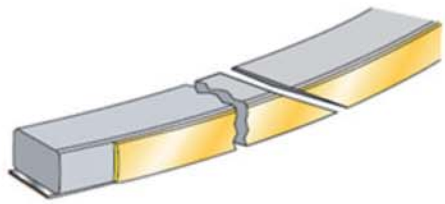
**1st ring**

| | |
|---|---|
| CL-grooves: | CPR E4-180 |
| Base material: | Vermicular cast iron, CV1 |
| Hard coating: | Cermet coating |
| Run-in coating: | Alu coating |
| Bottom face: | Crome plating |



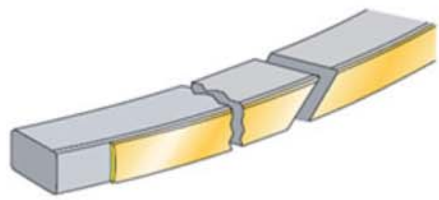
**2nd ring – left cut**

| | |
|---|---|
| Base material: | Grey cast iron, CF5 |
| Run-in coating: | Alu coating |
| Bottom face: | Chrome plating |



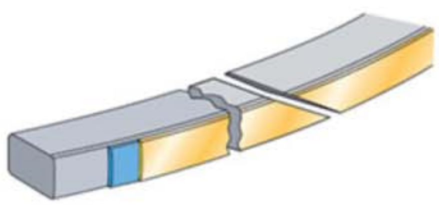
**3rd ring – right cut**

| | |
|---|---|
| Base material: | Grey cast iron, CF5 |
| Run-in coating: | Alu coating |



**4th ring – left cut**

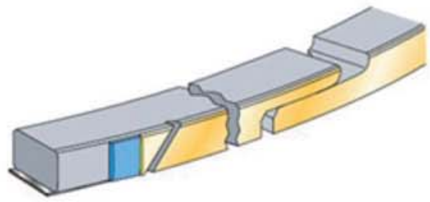
| | |
|---|---|
| Base material: | Grey cast iron, CF5 |
| Hard coating: | Cermet coating |
| Run-in coating: | Alu coating |



## Alternative Heavy Duty Ring Configuration:

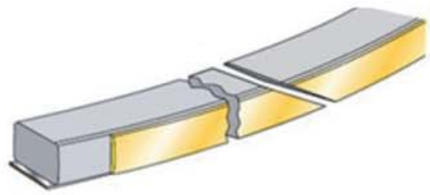
**1st ring**

| | |
|---|---|
| CL-grooves: | CPR E4-180 |
| Base material: | Vermicular cast iron, CV1 |
| Hard coating: | Cermet coating |
| Running-in coating: | Alu coating |
| Bottom face: | Crome plating |



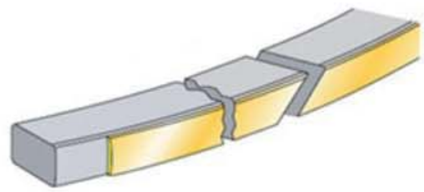
**2nd ring – left cut**

| | |
|---|---|
| Base material: | Grey cast iron, CF5 |
| Running-in coating: | Alu coating |
| Bottom face: | Chrome plating |



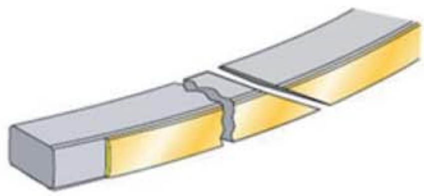
**3rd ring – right cut**

| | |
|---|---|
| Base material: | Grey cast iron, CF5 |
| Running-in coating | Alu coating |

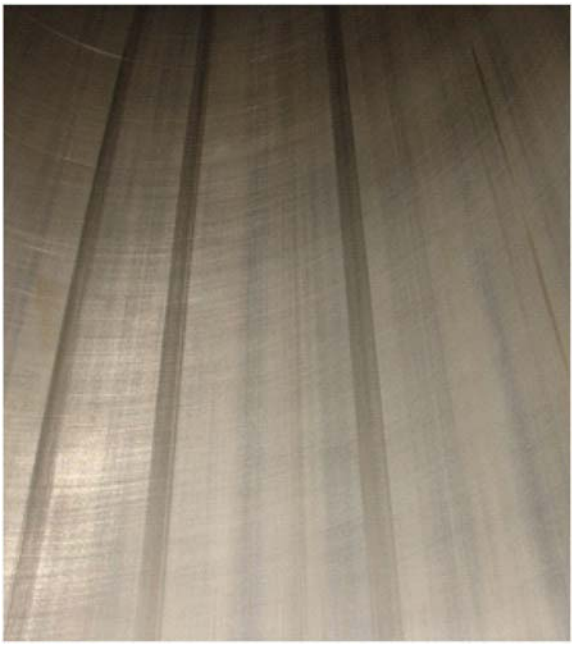


**4th ring – left cut**

| | |
|---|---|
| Base material: | Grey cast iron, CF5 |
| Running-in coating: | Alu coating |



| Normal Condition | Cold Corrosion |
|---|---|
|  |  |
| **Normal** liner condition. Light corrosive surface. Wave cut machining marks still visible on the lower part of the liner. | **Cold Corrosion.** Normal cold corrosion on the lower liner part, the corrosion facilitate good lubrication oil film, and the liner wear rates are acceptable. |
| Top cold Corrosion | Liner Black Deposits |
|  |  |
| **Excessive Corrosive** top part of the liner. Heavily corrosive surface, may lead to high liner wear and high ovality. | **Black Deposits** (black lacquer). The result of high humidity in the scavenging air, impacting the cylinder oil, producing alkaline material, forming a patch of deposits. Harmless to the engine and will be worn away when the air becomes dryer. |

| Bore Polish | Port Rib Marks |
|---|---|
|  |  |
| **Liner Polish.** Excessive piston top land deposits will eventually lead to liner polish and oil film break down. Possibly related to missing or malfunctioning PC-ring in combination with too high oil feed rates. | **Port Rib Marks.** Often seen in connection with exessive top land deposits due to too high cylinder oil feed rates, in combination with a cooler liner port area by cold climate and low load operation. (Not harmful). |
| Seizure stripe | Scuffing (Macro seizures) |
|  |  |
| **Micro Seizures.** Deriving from local oil film break down, must be treated with increased oil feed rate to make the rings run in again. May otherwise evolve into scuffing. | **Scuffing** (Macro seizures). The result of complete oil film break down is high friction and seizures leading to heavy liner wear. **The liner must be exchanged or machined.** |