Bearings

The MC engines were originally designed with white metal bearings for the crosshead, crankpin and main bearings. The main bearings were of the so-called thick shell design, whereas the crosshead and crankpin bearings were of the thin shell design.

Thin shell main bearings

The development towards higher specific engine outputs has resulted in the gradual introduction of the thin shell design for the main bearings, too. All new engine types, small bore as well as large bore, introduced since the late eighties, have thus been provided with a modern thin shell bearing design, offering the possibility of using stronger lining materials.

Sn40Al (tin-aluminium), which has been applied with great success on the main bearings for the smaller two-stroke engines, has been introduced on the S46-70MC-C engines, on which good service has been experienced since the first engines of this type entered service approx. two years ago. On the small bore engines (26-42MC), the Sn40Al main bearings have been in service for up to 30000 hours, with good results.

In addition to the above, an advantage of the thin shell design is the reduced risk of fretting-corrosion between the main bearing saddle and shell when the bearing housing is well designed.

Running-in on testbed and during sea trials has in a number of cases caused light seizure of Sn40Al main bearing shells on the S-MC-C engines. This seizure can be avoided either by pre-lubrication with grease or high-viscosity oil, or by PTFE-coating of the running surface of the shells.

The Sn40Al bearings have been introduced on the engine with the same well-proven specific load level as that for white metal bearings. However, the stronger bearing metal will provide the possibility to increase the specific load in the future, whereas today it is solely used to enhance the safety margin.

Thick shell main bearings

The design of the thick shell bearings has been updated in order to ensure reliable performance. The major updates are summarised in the following.

Optimum Lemon Shape (OLS) shells, Fig. 1, have been introduced to increase the minimum oil film thickness.

Elasto-hydrodynamic bearing analysis shows that the minimum oil film thickness is increased by 30-40% compared to the previous standard.

Furthermore, service experience has confirmed that OLS-shells are less sensitive to development of fatigue cracks in the bearing metal.

Vertical guide pins, Fig. 2, have been introduced in order to guard against misalignment between the upper and lower shells, which otherwise might create an oil scraper-edge.

Design update:

Oil film thickness in the high pressure areas of the bearings was not optimal

Optimised (reduced) side and top-clearances introduced based on good experience with the MC-Compact engines

Optimal 'lemon-shape' will give a minimum oil film thickness increase of 30-40%

Future spare bearings will be of revised design and delivered as a set.
The set is fully exchangeable with previous designs

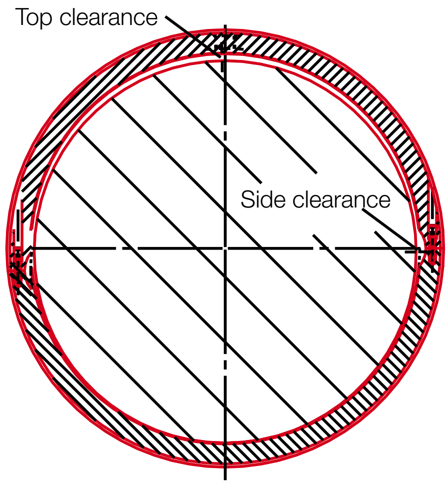

Fig. 1: Main bearing, thick shell design

Design update:

Risk of misalignment between upper and lower shells giving an oil scraper edge

Vertical guide pins introduced, avoiding misalignment

Future spare bearings will be of revised design and delivered as a set. The set is fully exchangeable with previous designs

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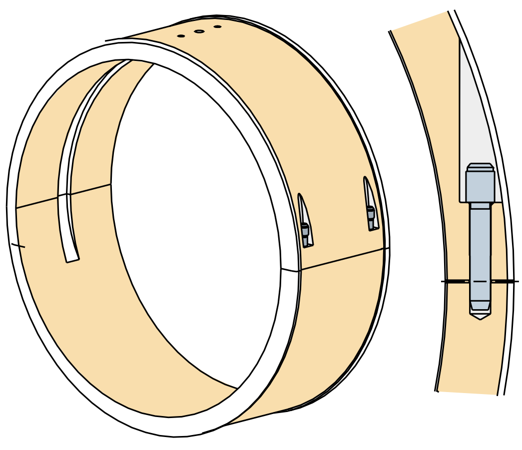

Fig. 2: Main bearing, design update

A further design update involves the introduction of stricter symmetry tolerances at the sidewise guides for the main bearing cap. Adherence to these tolerances will prevent bulges in the shells caused by non-symmetrical positioning of the main bearing cap.

Alignment aspects in relation to main bearings

In the past few years, difficulties have been experienced in aligning the crankshaft of large diesel engines, in particular in large tankers. Traditionally, crankshaft alignment on large tankers, as well as on other vessels, has been performed based on a precalculated vertical position of the bearings, as well as of the main engine as such and, possibly, also involving an inclination of the entire main engine.

Upon completion of the precalculated alignment procedure, it has been the normal practice to check the alignment by means of a bearing load check (normally a so-called jack-up test) and by measuring crankshaft deflections. Such checks are normally carried out either in a dry dock or afloat alongside at the yard in a very light ballast condition.

Owing to repeated cases of bearing damage, presumably caused by a lack of static bearing loads in normal operating conditions (ballast and design draught), we have introduced modified alignment procedures for bedplate and shafting (crankshaft and propulsion shafting) as well as modified vertical offsets of main bearing saddles.

The modified bedplate alignment procedure is described in a new quality specification in which the so-called sag of the bedplate is introduced in order to counteract hog caused partly by hull deflections due to loading down of the vessel, and partly by deformations due to the heating-up of the engine and certain tanks.

Fig. 3 shows bedplate deformations measured by the piano-wire method, on the topflange of the bedplate on the exhaust side and on the camshaft side

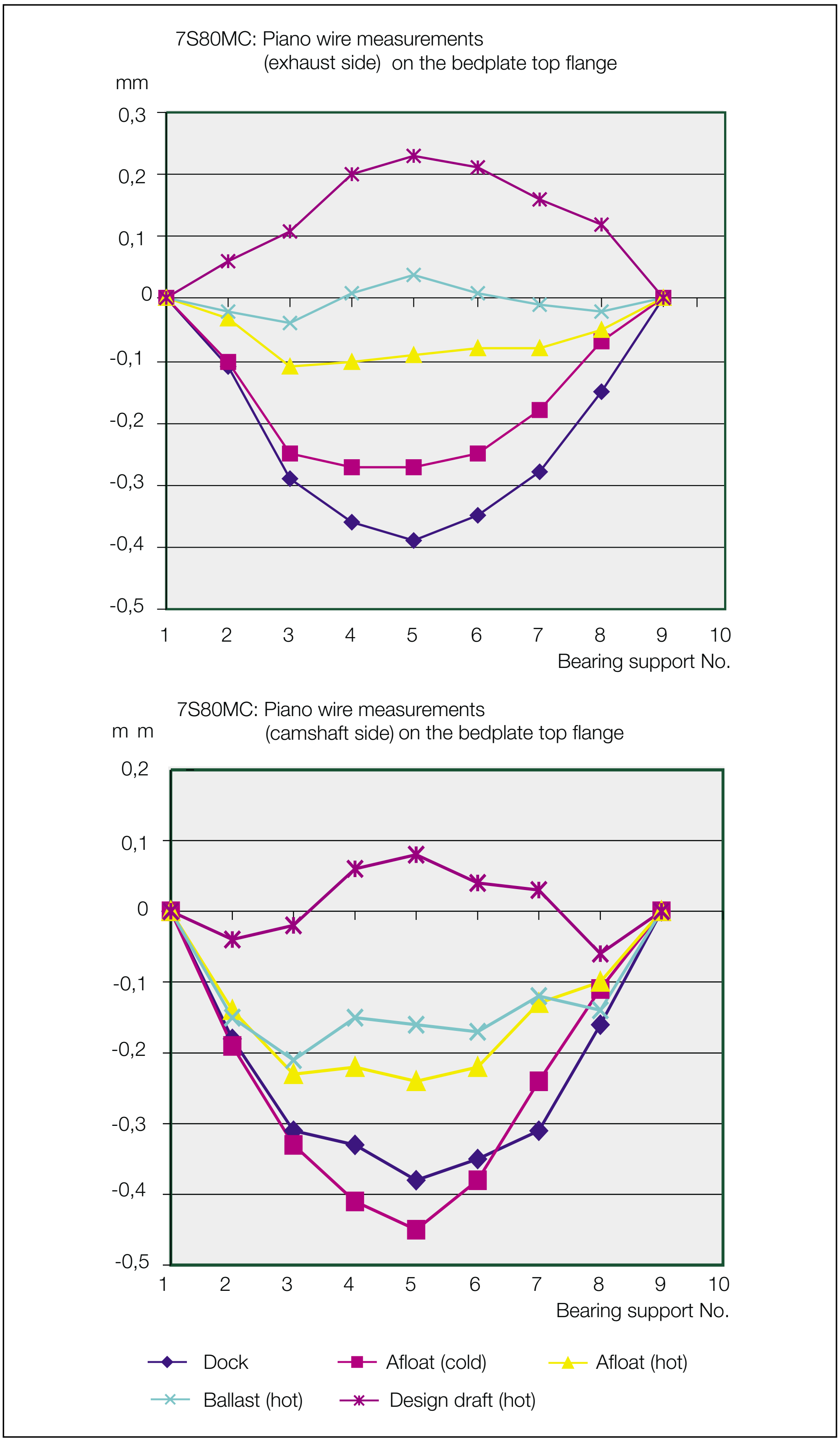

Fig. 3: Bedplate alignment for 7S80MC for VLCC

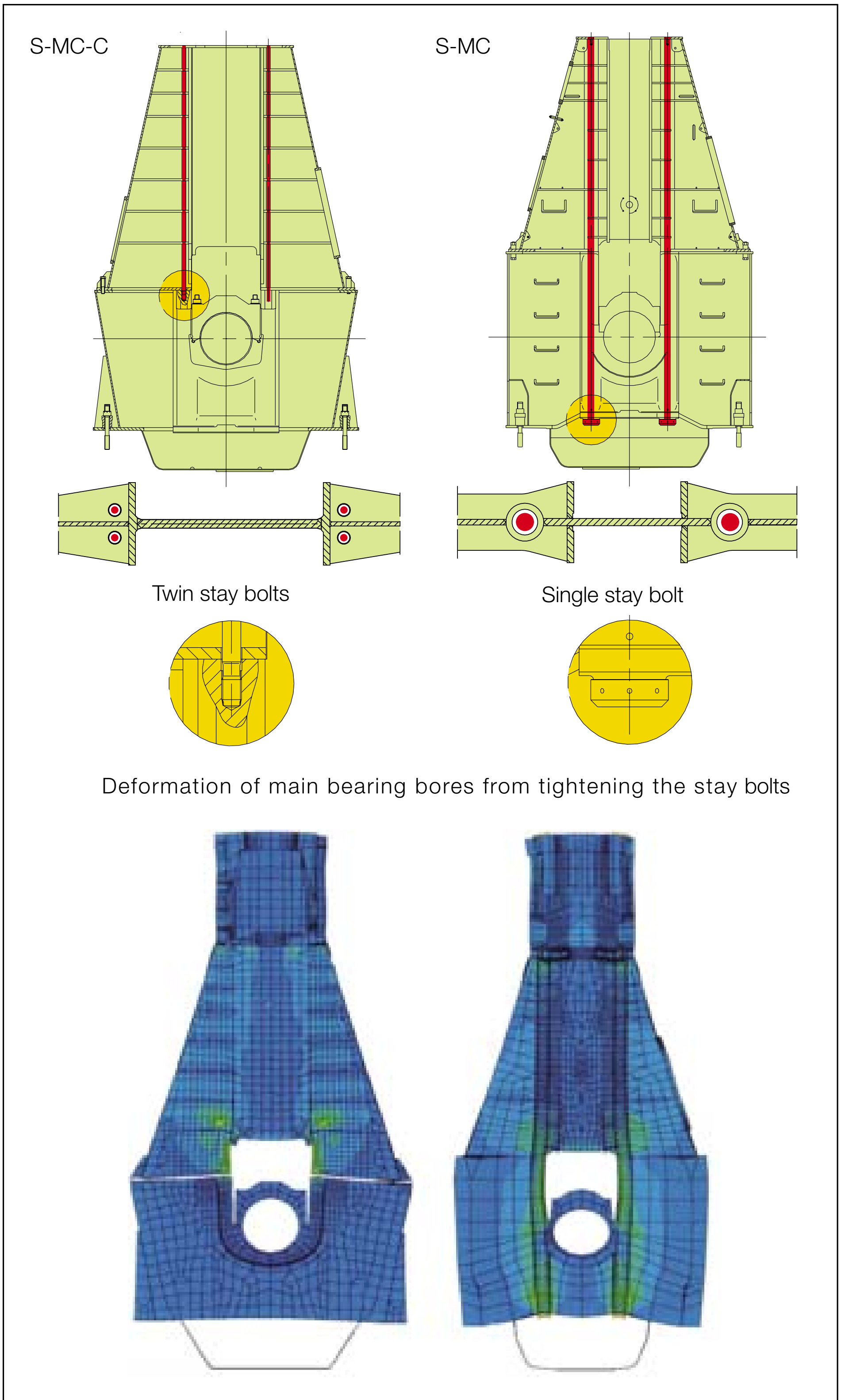

Fig. 4: Two alternative designs of staybolts

of a 7S80MC installed in a VLCC. For this engine, a bedplate sag of 0.4 mm was the aim during alignment in dry dock.

As can be seen in the diagrams, no major change was recorded between the alignment conditions in dry dock

and in the afloat condition. Therefore, our quality specification allows for bedplate alignment and the pouring of chockfast supporting chocks in dry dock for vessels where shipyards have such experience. Previously, we recommended aligning afloat.

Furthermore, it is seen that when the engine is in hot ballast and in hot design draught conditions, an optimal compromise with respect to bedplate alignment in service conditions is obtained with the pre-chosen sag of 0.4 mm during alignment.

In the quality specification, we have included recommendations for bedplate sag for all engine types in the MC/MC-C programme.

The quality specification also contains guidelines for the shaft alignment procedures necessary to obtain an equal bearing load distribution among the main bearings in operating conditions on large vessels.

Furthermore, in order to facilitate this optimum load distribution among the main bearings, the previously mentioned offsets in the bedplate at the main bearing saddle have been introduced in the aft end of all MC/MC-C engines.

Fig. 4 shows deformations as a result of staybolt tightening for the two alternative designs of staybolts:

A: The traditional long ‘single’ staybolts used until a few years ago on all major two-stroke engine makes

B: The short ‘twin’ staybolts introduced on newly designed MC/MC-C engines

Both designs cause deformation of the main bearing bore. However, as can be seen, the twin staybolt design causes much smaller deformations.

Apart from ovalising of the main bearing bore, the tightening of staybolts results in elevation of the bore. This elevation is much smaller on engines with twin staybolts.

We have introduced offsets for some main bearing bores to counteract different elevation caused by staybolt tightening, especially in the aft end of the engines where the thrust bearing structure provides extra resistance to this elevation. Furthermore, offsets have been introduced at main bearing bores where staybolts are omitted, i.e. on some designs where the aftmost main bearing bore (the so-called journal bearing position) does not have staybolts adjacent.

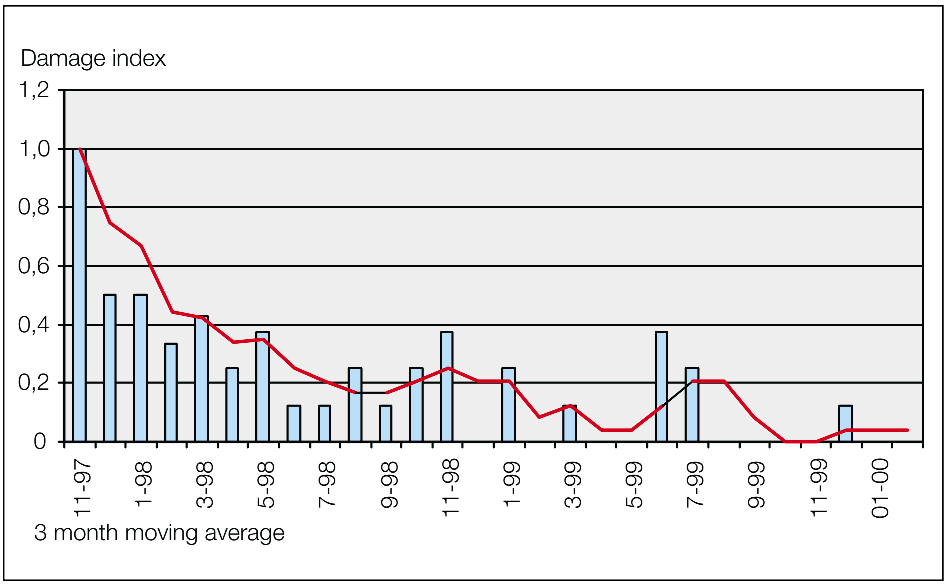

Fig. 5: Container vessel series (8 ship)Main bearing, thick shell design

Service improvements

Service improvements resulting from the use of thick shell main bearings can be illustrated by the service history of a large series of container vessels equipped with S70MC engines. In positions where damage occurred, the following modifications were introduced:

1: Optimum Lemon Shape shells with vertical guide pins

2: Offset journal bearings

3: Re-alignment of the shaft line on one (1) vessel

As will be seen in Fig. 5, modifications have significantly improved the main bearing condition.

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