WATER LUBRICATED BEARINGS

AN UPDATE

BY

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ABSTRACT

The need to emergency dock ships for excessive underwater bearing wear should be avoided with the solutions described in this article.

History

My first involvement in underwater bearings came as AMEO (Assistant Marine Engineering Officer) in HMS *Rothesay* in 1979 when a junior Stores Accountant grabbed me in the Burma Road and said he could smell burning in his store aft. I followed him into the store and there surely was a strong smell of burning. A general search of the compartment revealed nothing except some warm deck plates (odd in February in the North Sea) directly above the stern tubes. The plates were lifted to reveal paint blistering off the tubes. I realized immediately that something was wrong (it's not easy to fool an AMEO). The space was flooded and we limped home to Chatham. Two emergency dockings and a shaft straightening later, we were operational. Those bearings were Neox-lubricated white metal.

My second personal involvement came when I was the MEO of HMS *London*. A dive in Cyprus by the ship's diving team gave clear evidence that my intermediate 'A' brackets had worn dramatically since the previous dive. It had been some time since we had dived, as a scheduled dive in Mombasa had been cancelled due to a man-eating shark having eaten the Chief Kenyan diver for lunch—in the harbour. Needless to say it was difficult to persuade the ship's diving team to take poker gauge readings. The signal traffic between the ship and 'home' was always interesting if at times unpleasant and, once, unhelpful. The clearance diving team in Gibraltar confirmed the readings with feeler gauges and we were subsequently docked on arrival in Devonport in December 1988. Those bearings were Railko WA82. Nearly 20 ships have been emergency docked for similar reasons both before and after *London*'s experience, at enormous cost to the Crown both in money and ship availability. After these experiences it was really a matter of 'Chickens coming home to Roost' when I was appointed Head of the Shafting/UW Bearings/Propellers and CPP section ME112 at Foxhill.

Bearing

I joined the section in June 1990 to find a fairly intensive test programme underway at British Maritime Technology Ltd (BMT) Hythe who have a five year contract to run the Royal Navy's seals and bearings testing. What the programme lacked in quality it certainly made up for in quantity, with different configurations of bearing being tested and a plethora of new materials all undergoing a rigorous test programme.

After discussions with the manager of the BMT Hythe site it was clear that the wide arc (140°) configuration fitted in Type 23 would not be suitable for the Type 22 and Type 42 frigates and destroyers. Whereas it is clearly satisfactory for low-speed low-pressure running, the wide arc did not perform well in a higher pressure configuration (TABLE I).

TABLE I—*Bearing pressures in frigates and destroyers*

Type 21	'P' bracket	3·12 bar
	Main 'A' bracket	4·42 bar
Type 42	Intermediate 'A' bracket	2·5 bar
	Main 'A' bracket	5·34 bar
Type 22	Intermediate 'A' bracket	4·69 bar
	Main 'A' bracket	5·58 bar
Type 23	Intermediate 'A' bracket	2·3 bar
	Main 'A' bracket	2·3 bar

TABLE II—*Bearing material combinations*

Rubber staves on hardened Inconel
Rubber staves on gunmetal
Tenmat T12 wide-arc 150° on gunmetal
Orkot wide-arc 150° on gunmetal
Railko NF21 wide-arc 150° on gunmetal
Thordon XL Pametrada on gunmetal
Thordon SXL Pametrada on gunmetal
Tenmat T12 Pametrada on gunmetal
Railko NF21 Pametrada on gunmetal (etched)
Railko NF21 Pametrada on gunmetal (non-etched)
Railko NF21 Pametrada over-limit
Railko CY160 Pametrada on gunmetal
Railko CY170 Pametrada on gunmetal
ACM Pametrada on gunmetal

Having eliminated that, it was really down to the choice of materials and journal surface finish. The testing of the materials (TABLE II) had been undertaken on different journals and did not necessarily prove to be a good indicator for the in-service problems, but it did show a clear way ahead for further applications.

The bearing test rigs held at BMT on behalf of the MOD are a 200 mm rig (FIG. 1), used as the quick comparator, and the 21·5 inch frigate rig (FIG. 2) on which the main trial is undertaken. The test specification is shown in the Appendix (p. 625). The trial is necessarily vigorous as we are attempting to telescope real time in an effort to accelerate the wear experienced in a three-year

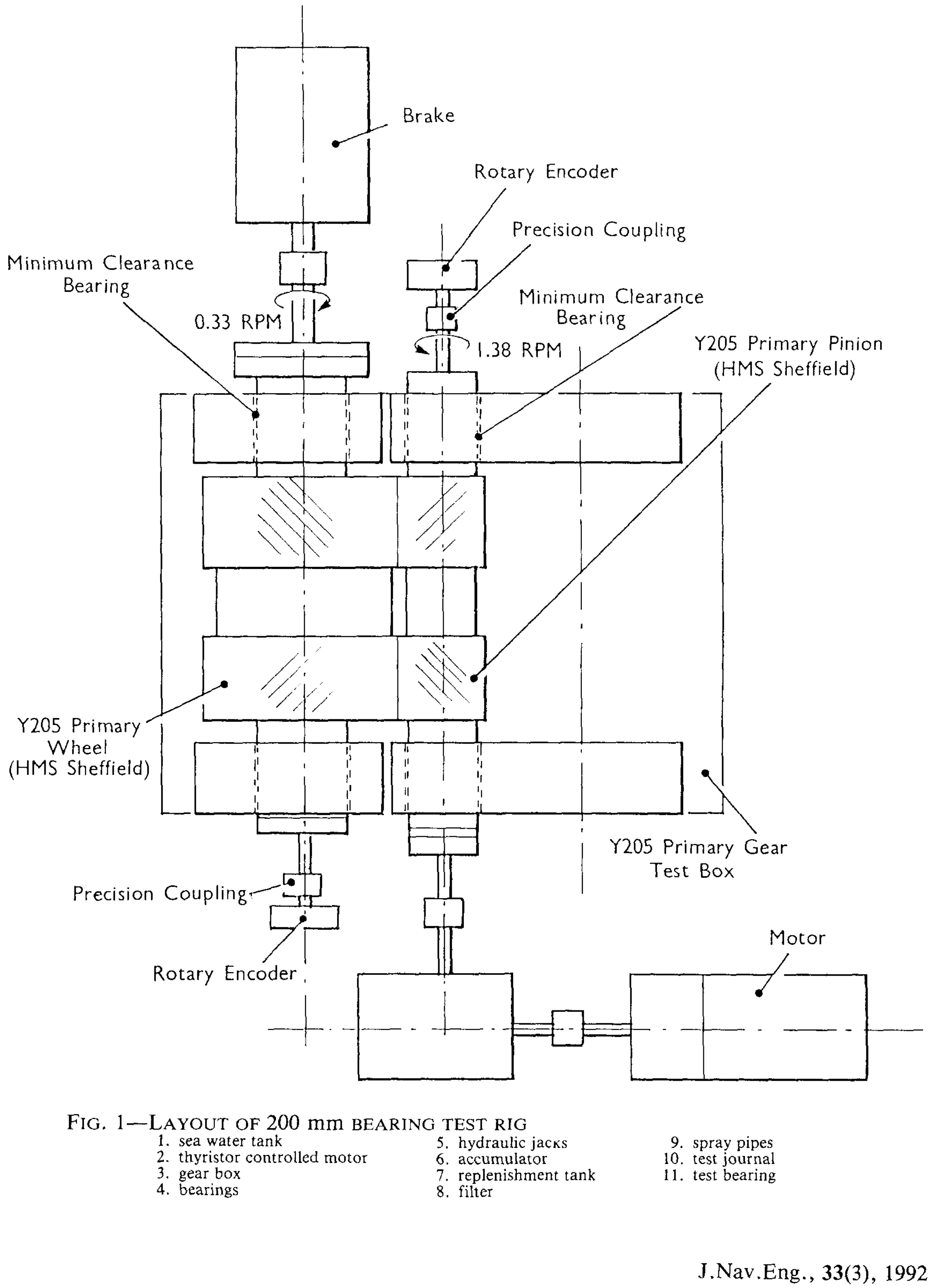

FIG. 1—LAYOUT OF 200 mm BEARING TEST RIG

1. sea water tank
2. thyristor controlled motor
3. gear box
4. bearings
5. hydraulic jacks
6. accumulator
7. replenishment tank
8. filter
9. spray pipes
10. test journal
11. test bearing

FIG. 2—THE 21.5 INCH FRIGATE BEARING TEST RIG

commission to a trial of about 500 hours. Uniformity of the trial is paramount so that a comparison of like with like is ensured. To date there have been some six materials tested in three configurations on two different liners. In addition, minor trials have taken place in HM Ships *Cardiff, London* and *Sheffield*, all adding something to our knowledge of underwater bearings. In parallel with this activity, regular meetings with the DGSS, C-in-C Fleet (ME), and materials manufacturers have been held to brief and inform of progress in the extensive testing.

After close examination and study of the NES and the defined limits therein (something which previously had never been challenged) it was decided to open the limits dramatically and use much more of the material available to wear. This decision was not taken without some risk and a rapid shore trial was arranged to see if shaft whirling was induced at the greater limit or to see if there were any noise/vibration implications. There were thoughts that with the greater clearance we might get into a 'runaway wear' situation which would have been totally unacceptable. None of these fears was realized in the trial, which gave much greater confidence in the new limits. (None of the limits has yet been reached at sea.)

The final selection of material was a choice between Tenmat T12 (a cured phenolic resin matrix carrying a synthetic fibre incorporating molybdenum di-sulphide evenly dispersed throughout the matrix) and British Tyre and Rubber Company (BTR) rubber staves. Both showed up very well indeed on the test. However the Tenmat was kinder to the gunmetal journal and, providing the material was used in the current PAMETRADA* configuration (FIG. 3), the replacement cost was relatively inexpensive. The final deciding factor was the

*PAMETRADA: the former Parsons and Marine Engineering Turbine Research and Development Association.

cost of modifying the bearing housings to take the BTR staves. In these days of taut financial control the additional cost with apparently little advantage over its rival eliminated the rubber staves. Hence Tenmat was selected and is now at sea in a minor trial. If it proves successful, a material supersession will be introduced to replace existing destroyer and frigate bearings at the first fitting opportunity.

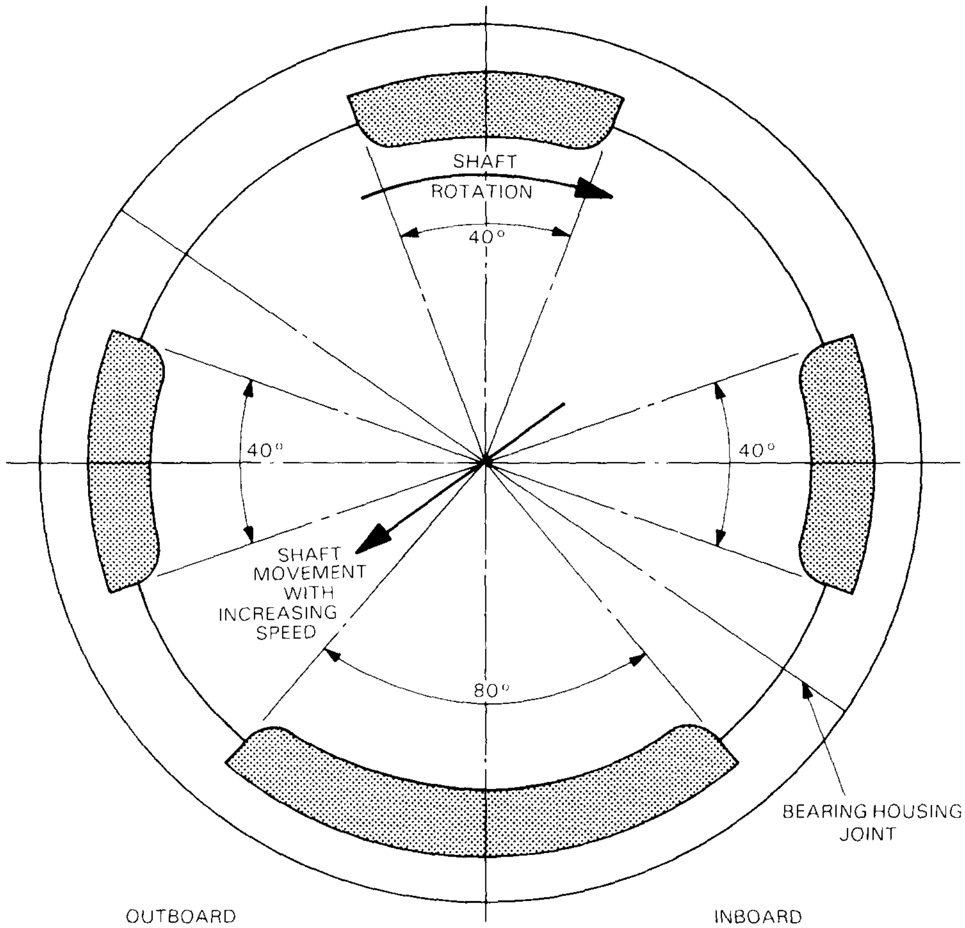

FIG. 3—PAMETRADA MAIN AND INTERMEDIATE 'A' BRACKET BEARING, LOOKING FORWARD

Journal Finish

In parallel with the materials development we have been pursuing a method of machining the gunmental journals *in situ*. For some time it has been thought that many of our problems after bearing renewal in DED and Refit have been associated with marine growth on the journals and the general deterioration of the surface finish. We would normally expect a surface finish of 32 CLA (Centre Line Average units). It only takes one barnacle to upset that standard. There have been some spectacular examples of bearing wear post Refit/DED due to marine growth and the lack of turning shafts for prolonged periods. Classic examples are *Sheffield* (1981) 150 thou in a basin trial, and *Intrepid* (1990) 166 thou in three months. The importance of turning at every opportunity has never been better demonstrated! There is no criticism implied here of the respective MEOs—in both these cases, ships were simply unable to turn, because of physical engineering constraints.

Our initial attempts at producing an *in situ* tool foundered due to a poor design not achieving the desired finish in the conditions required. We turned to another company, Silk Engineering, a bright, innovative, specialist, *in situ* tool manufacturer and they, we believe, have developed the answer (FIG. 4). This is to be trialled in the near future and for the first time we are confident that we have a tool which can be used in the harshest of environments (the dock-bottom in February) and give the results that we desire.

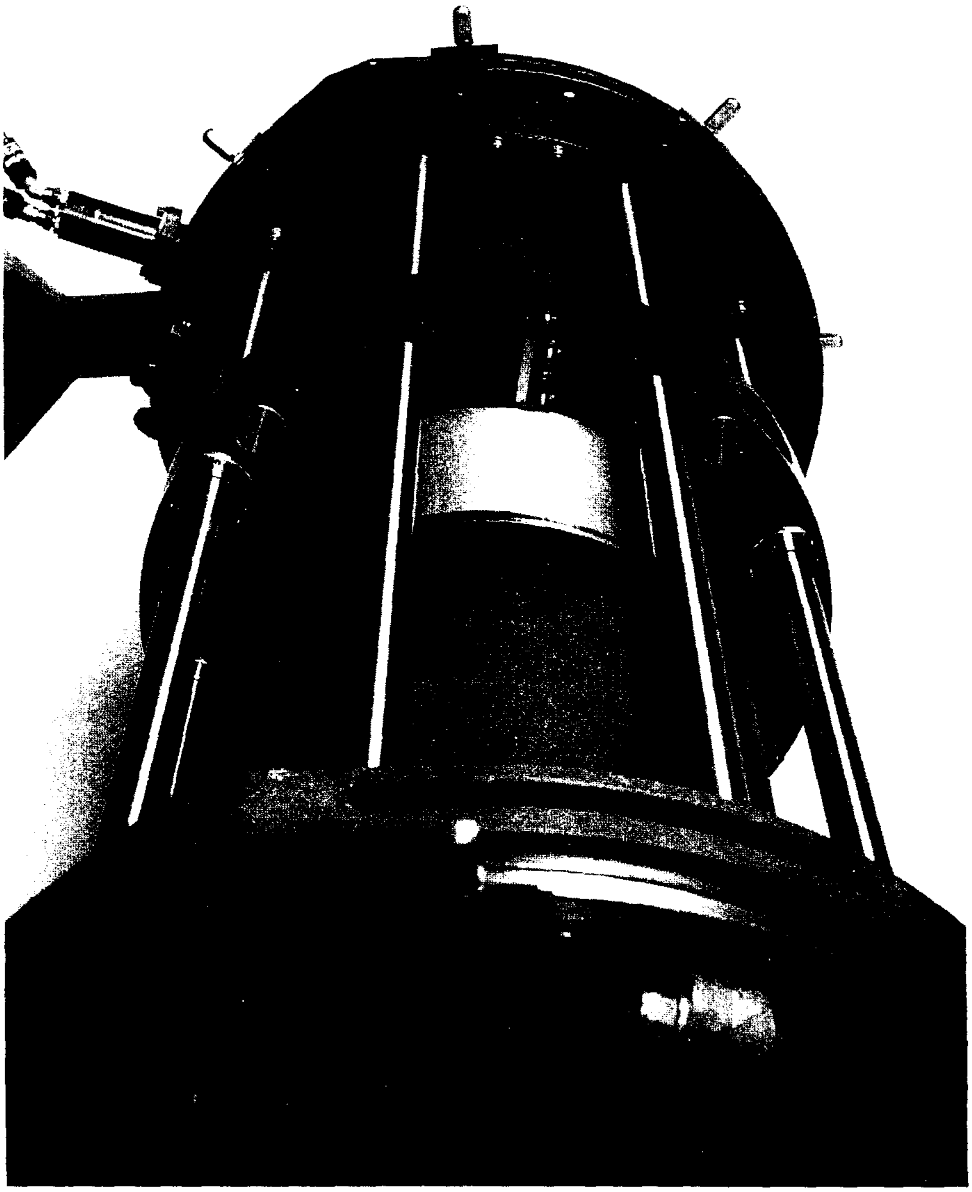

FIG. 4—TOOL FOR IN SITU MACHINING OF PROPELLER SHAFT JOURNALS

Measurement

The vagaries of the poker gauge are well known to MEOs, be it collars unscrewing, divers dropping the gauges or 2nd class artificers with a hangover taking the measurements. Hence in all our work it was equally important that we developed a better method of measuring weardown. It has to be simple, robust and able to operate in an environment where high vibration and turbulence is the norm. Several designs have been studied including an interesting pneumatic design from RNEC Manadon; however the most promising idea being pursued is that of a fibre optic poker gauge buried in the bearing material. This will have a remote read-out inside the ship which the MEO will be able to observe at his leisure. This device is being fitted in an MCMV in 1992 as a minor trial. The simplicity and practicality of its design could only have been produced by a former engine room senior rating and Jim Hatchard of BMT Hythe deserves full credit. Further design details cannot be given here as there are clearly commercial applications and a patent pending—needless to say it is early days but we have great hopes for its application. However do not throw your poker gauges away just yet as its introduction into the Fleet is still some time away and the poker gauge will be retained as a back-up.

The Future

Should all the above ideas and schemes prove successful and we do get a minimum of three years life out of our bearings (and we have every reason to expect that we will) then the next stage is to stretch the life of bearings to refit intervals. This inevitably will mean a change of liner which probably means we will not achieve this aim in existing ships. The obvious candidates are the Future Frigate, LPD replacement, etc. The hardened journals which are candidates for this long-life application are Inconel (with a hardened surface) and possibly ceramics. These may have to be compatible with composite shafts, composite propellers, state-of-the-art seals and so on. But that, as they say, is another article . . .

References

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2. Blackman, M. T.: Water lubricated propeller shaft bearings—Report of visit by RAE staff to HMS *Cardiff* in November 1985, NM4/8 1986.
3. Blackman, M. T.: Water lubricated propeller shaft bearings—Report of visit by RAE staff to HMS *Nottingham* in February 1986, NM4/8 1986.
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APPENDIX—500 HOUR BEARING TRIAL SPECIFICATION

Running-in period consisting of:
40 rev/min @ 4·5 bar for 10 hours
20 rev/min @ 4·5 bar for 5 hours
10 rev/min @ 4·5 bar for 4 hours
6 rev/min @ 4·5 bar for 1 hour

Torque Test

Bearing Inspection and Dimensional Check

Run 200 hours in clean water @ 6 rev/min @ 4·5 bar pressure

Carry out 20 changes of direction in rotation

Carry out Torque Test

Bearing Inspection and Dimensional Check

Add grit to water in a concentration of 250 ppm

Run 200 hours in gritted and stirred water @ 6 rev/min @4·5 bar bearing pressure

Carry out 20 changes of direction of rotation

Carry out Torque Test

Carry out Bearing Inspection and Dimensional Check

Run 80 hours in gritted but unstirred water @ 6 rev/min @ 6 bar bearing pressure

Carry out Torque Test

Remove Bearing and carry out final inspection