RELIABILITY 'ON THE QUIET'

BY

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The Passive Sonar era has dawned and in the towed array frigates the Marine Engineering Branch now has a direct involvement with the ship's primary sensor.

In all our surface warships of frigate size and above the MEO is responsible for noise reduction. However this need not be the additional burden it would at first appear to be, and in some respects MEOs may even find their lives made a little easier.

There are two aims of surface ship noise reduction. The first is to reduce the radiated noise, that is the general level of broadband noise radiated into the water, which will lead to detection, and the tonals of noise which will lead to classification; the second is to reduce self-noise, that is the noise made by the ship which affects the ship's own sensors.

A ship's acoustic signature results largely from the excitation of the hull or underwater fittings which transmit vibrations of noise into the surrounding water. Noise can also find its way into the hull-mounted sonars, degrading their performance in the active as well as the passive role.

Machinery and Hull

In a ship or submarine the propellers are a major source of noise. They must therefore receive the greatest attention in order to reduce this noise source as much as possible. They are significant not only because of the noise they generate but also because of the excitation they will cause of other equipments in the ship. Attention to pitch accuracy, blade weights (in CPP ships), and quality of finish (especially at the leading edges) is paramount. Attention must also be paid to any hull defects early in a docking or refit; the Foreman of the Yard will not be pleased to hear the MEO complain about such items as he breaks staging before undocking! Below cavitation inception speed machinery noise assumes greater significane than propeller noise and below about 7 knots the boundary layer breaks down and increased acoustic coupling with the sea takes place; hull protrusions, roughnesses, loose fittings, and loose gratings must therefore be checked thoroughly with the aim of achieving as 'yacht-like' a finish as possible—surface roughness of the underwater hull coating should not exceed 30 microns.

Main and and auxiliary machinery is another major source of radiated noise. A Jaguar V12 automobile may be quieter than a Mini and in ships too the design and quality of manufacture and the maintenance of machinery have a fundamental effect on noise. The MEO at sea can do little about improving the design of the equipment fitted but the quality of maintenance is something which is under his control and a little extra effort can not only achieve quite dramatic results, but give him a valuable addback in reliability.

The balance, alignment, tuning, and general mechanical health of machinery can all have a significant effect on the vibrations transmitted to a ship's hull and thus to the radiated and self-noise. Vibration Analysis (VA) and vibration monitoring must not only be looked upon as a diagnostic technique for sick machinery but as a checking and early warning system for healthy specimens too. A clean bill of vibration health will mean that a machine will be a minimal source of noise and, provided the machine is lubricated and looked after in all other respects, trouble-free running can best be guaranteed. One very significant noise source picked up in *Sirius*'s noise ranging before commissioning was the main circulating pump. The pump was surveyed and the gearbox and turbine bearings inspected. Every bearing was worn out!

Many of the noise shortcomings picked up at noise rangings are due to mechanically imperfect machinery—they are therefore within the MEO's power to improve. Irrespective of the usual problems and pressure to complete work to schedule during a refit or maintenance period, insistence on quality and action being taken on post-installation or setting-to-work vibration analysis recommendations will pay dividends. Rectification action is often straightforward at this time and the facilities and resources are to hand. If left however, there is the risk of embarrassing failures in service, when such support is not available, and an unnecessarily noisy ship; and the noise signature would certainly not get better.

Reciprocating machinery, diesels, compressors, etc. can be optimized for minimum noise by attention to balance. This involves checking valve timing and exhaust temperature scatter as well as mechanical balance. The torsional analysis techniques now being developed allow a closer look at noise sources than was possible with the 'linear' instruments previously available. Already, seizing of viscous dampers with potentially catastrophic results has been prevented in one frigate's diesel generators by close investigation after a report of high vibration. Recently 'de-lobing', i.e. checking the roundness of bearing journals, has been introduced; the journal is honed to a high degree of accuracy in roundness before bedding the bearings to it. *In situ* multi-plane balancing of steam machinery is also being introduced more widely, having been developed recently for new SSNs[1]. The results have shown a marked reduction in noise and this illustrates the point that noise reduction is directly proportional to the quality of engineering standards applied.

Electrical Problems

Electrical noise and the mechanical noise associated with it can be reduced by ensuring good earthing throughout with flexible earthing straps, and care must be taken to ensure that an efficient earthing arrangement does not introduce a noise short. Bad earths are by far the greatest source of electrical noise, especially in hull-mounted sonars. The best possible screening of electrical cables also reduces interference.

Ventilation Systems

Ventilation systems are much quieter when clean. To keep them quiet closer attention may be necessary than the planned maintenance system dictates; if this is so an amendment should be proposed. The majority of ventilation fans are solidly mounted and if the fundamental speed of the fan motor coincides with the natural frequency of the supporting structure then a resonant noise source will exist.

Noise Isolation

Our forefathers had the noise problem licked. Massive cast iron machine structures have excellent internal damping characteristics as well as a large absorbent mass. The demands for high power, smaller size, and lower weight and cost have resulted in lighter, smaller machines with low damping coefficients, and a large amount of vibration energy going spare. Thinner plating and welded, rather than riveted, hulls provide less secondary damping and thus more noise radiates into the water. We are left therefore with the requirement to isolate the noise from the hull.

Machinery must be mounted on soft absorbent material which dissipates movement between the machine and bedplate, and assists the deflection under shock. Flexible pipes between machines and fluid systems and generous bights of power cables in electrical connections are necessary to prevent secondary paths. All these efforts can however be seriously undermined if a direct path is presented between the machine and hull—a noise short. Noise is like electricity and any rigid connection between the hull and the machine will transmit. Earthing straps, conduits secured to both bedplate and hull, gauge connections, and machinery space guardrails, stanchions, and bedplates, are all potentially serious shorting paths.

Even when a machine is well mounted and has no noise shorts there will be some residual vibration present on the hull side of the machine. This should be damped out by the frames, plating, etc, but if a loose item is present nearby it will be excited by these residual vibrations and this has the effect of concentrating the energy again at a single point and a noise as loud as the original can be generated. To prevent such rattles and knocks, standards of securing must be watched; deckplates, ladders, hatches, doors, drawers, pipe runs, etc. all need to be kept tight and, if feasible, rubber used to isolate them. 'Pop' riveting rubber strips on deckplate bearers eliminates the crashing sounds which result from men moving around machinery spaces, and also any rattling of those plates in sympathy with adjacent machinery. The ship's company can cause a great deal of unwanted noise in this way by a careless attitude to everyday activities and poor husbandry of the noise isolation mechanisms and systems fitted. All this has great relevance to shock protection too.

Noise Monitoring

Getting things to run quietly should be one of the aims of the setting-to-work period. Maintaing that state is the aim of noise monitoring.

There are several portable test equipments. Initially, in *Sirius*, the passive sonar analysis of the Seaman Branch produced the Sonar 189 to monitor machinery, whereupon the MEs produced the VISIN and said they were already doing so. To add to the confusion at the time, an IRD 820 and an IRD 810 were issued for trial.[2]

The Maintenance Management System (MMS) at present calls for monthly monitoring of vibration levels at the bearings of each machine and these are plotted to allow the maintainer to detect trends towards wear-out. The Operations Department analysts monitored differences in vibration levels across machinery mountings, drawing attention to reductions of less than 50%. The next step was to combine these activities, by including the monitoring of mounts at the same time as monitoring of bearing vibration levels.

At first each machine was monitored monthly with the 820, but this was found impracticable and unnecessary. The best solution appears to be for the 820 to be used as required to update and check any readings highlighted on the VA surveys, monitoring frequencies at the points suggested by the Fleet VA team, or to investigate any worsening trends. The 811 should be used to monitor vibration levels at sensible intervals. Assistance in diagnosis can be obtained from the Fleet Noise and VA teams by signal.

The 820 really came into its own during noise ranging. A quick survey taking one reading from each machinery seat was sufficient to be of great assistance to the Ranging Officer in the identification of the sources of frequencies at which high noise levels were revealed. This was easier than attempting to discern the culprits from the standard frequency profiles. If possible the Range Officer should have a copy of the base level VA reports as well. Fully instrumented hull vibration continuous monitoring systems are being developed for the future.

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	JOB INFORMATION CARD	**SCHEDULE No**	**M Op No**
	SCHEDULE TITLE NOISE MONITORING		
	JOB DESCRIPTION COMPARTMENT CHECK OFF LIST		

1. Check Machinery in compartment is being vibration monitored correctly.
2. Check Security of the following as applicable:
   - Machinery Deck Plates
   - Fire Extinguishers
   - Ladders including treads, back and handrails
   - All securing arrangements
   - Hatches, when pinned in open position do not rattle
   - Tool boxes
   - Wire mesh grilles
   - Shelf battens in storerooms
   - Transformers (mounted on rubber)
   - Gas cylinders
   - Pipework in brackets secured (with rubber lining)
   - Gauge pipework secured
   - Cable Carrier plate secured
   - Emergency cables
   - Machinery covers
   - All portable gear—drums, shackles, tools stores
3. Check earthing straps correct pattern and have good bight of cable.
4. Cables between machinery and Ship side has sufficient bight.
5. Mountings on machinery in good condition. Jacking bolts wound back and locked.
6. Flexible pipes in good condition, not distorted/kinked and lay line on the outside radius of bend.
7. Shock clearances not compromised.
8. DC Equipment secured *but immediate use not compromised.*
9. When possible arrange for ventilation to be shut down to allow any other noises masked by it to be identified (Flow noises etc.).
10. Restart ventilation and check for any areas where vent noise appears to have increased.

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FIG. 1—A TYPICAL 'HOME-MADE' JIC FOR NOISE MONITORING CHECK-OFFS

Regular routines of noise rounds and inspections were implemented in *Sirius*. Experiments with self-made JICs to help compartment owners tick off their areas have proved to be quite successful; an example is shown in FIG. 1. The general life of the ship (NBCD, RASing, storing, etc.) tends to upset the fine nuances of rattle prevention, etc., and a monthly cycle of checking was found to be necessary. A log is kept and compartment owners sign daily for these checks. This log is a monthly Captain's ship's book. It remains the responsibility of the department owning a particular compartment to check that compartment for problems. Captain's rounds provide the biggest incentive in this area.

All the above requires close co-operation between departments and although the MEO has now assumed responsibility for radiated noise, being the owner of the largest noise-making machines onboard, all departments must fully accept their noise responsibilities.

Quiet States

A quiet state is a way of reducing noise but is of little use if it results in the ship being in the middle of the ocean with a severe limitation on manoeuvrability and every sensor and weapon system shut down. The surface ship is different to the submarine because there are additional threats to consider. The aim should be to get to a state where operational readiness is high and radiated noise is low. When there is alternative machinery, the quieter should be run, while the noise of the other is investigated. By this process an ideal can be approached. It takes time and conscientious effort, but it can be done.

There is a generally held belief that passive operations involve long periods of restrictions on machinery operation, training, and life onboard generally. This has been found not to be the case. Normal daily life can go on, including maintenance and machinery breakdown drills. The key is communication and co-operation between departments so that a controlled environment is maintained and the passive operations remain uncompromised. If the whole ship is noise-conscious then there is no reason why the commitment to achieving low levels of radiated noise should become a burden. It is all common sense and good engineering practice. For the MEO it can be the means of getting his ship running smoothly.

At Portland the range results are given in terms of a Class average. The spread can be as much as 12 dB. A decibel is a logarithmic unit and in noise power 12 dB means the higher level is 16 times the lower level and the detection range is quadrupled. Noise also affects the Active performance of a hull-mounted sonar, in some cases reducing the range by a factor of 10 so that even a torpedo may not be heard! By attention to detail and conscientious noise husbandry some spectacular results have been achieved—even with old ships and old sonars.

The Royal Marine dressed in dayglow orange would look stupid on a battlefield—a noisy ship is really a rather stupid thing in which to be at sea today. Noise reduction should be as important to the MEO as his firemain.

In the passive scenario the quieter combatant survives.

References

1. Wilkinson, J. B., and Cooke, A. V.: Balancing turbo machinery on board or ashore; *Journal of Naval Engineering*, vol. 29, no. 1, June 1985, pp. 153-160.
2. Thorne, R. W.: Good vibrations—bad vibrations; *Journal of Naval Engineering*, vol. 29, no. 1, June 1985, pp. 147-153.