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TRANSACTIONS (TM)

HEALTH MONITORING OF MARINE MACHINERY AND ITS IMPLICATIONS FOR MANAGEMEN

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Health Monitoring of Machinery and its Effects on Minimum Manning Levels

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SYNOPSIS

It might be said that the health of the crew depends on the health of the machinery, which in turn depends on the health of the crew—a possible Catch 22 situation. With today's high operating costs and low freight rates, it makes sense to be as operationally efficient as conditions permit. Where minimum manning levels are being used it is essential that the plant being used is efficient and that necessary support and monitoring equipment is available to maintain this plant with the minimum of effort and cost. Owners, marine engineers, naval architects, shipbuilders, etc. must be more aware of current trends in the areas of totally integrated maintenance management systems and the advantages that can be obtained both onboard ships and in the office ashore. Machinery manufacturers must also play their part by ensuring that the performance of their equipment can be monitored to a greater degree than is currently the norm, and that this monitoring can be performed reliably and easily. Machinery design must take into account ease of maintenance and should incorporate all the latest innovations, so as to ensure that the maintenance can be carried out by a limited number of staff. Owners will need to be more aware of new technology and, through careful planning, ensure that third parties meet their requirements. These third parties, ie shipbuilders, machinery suppliers, etc., must be involved in greater discussion before stipulating what will be fitted to these vessels. This paper highlights the latest technical aids and ideas as to how equipment manufacturers can assist the shipowner, and shows how an onboard computer can be used to the benefit of ships' staff.

INTRODUCTION

It might be said that the practical skills of the marine engineer of 60 years ago were better than those of the present day seagoing engineer. This is not due to any fault of either era but the nature of the environment in which they found or find themselves.

Sixty years ago we did not have the communication networks of today and machinery maintenance or breakdowns were handled locally by the Chief Engineer and his staff. Spare parts certainly could not be expected to be received by the next flight! In fact maintenance, as we know it today, was very primitive and predictive maintenance virtually non-existent.

Until about 20 years ago ships enjoyed quite high manning levels. This included staff employed as watchkeepers and others as dayworkers, and related to both officers and crew. Any form of maintenance that did take place was mainly based on the experience and knowledge of the senior staff, whose time at sea had been long and in some cases quite arduous.

However, despite all this, the expression 'planned maintenance' was slowly creeping onto the vocabulary. 'What does the book say' indicated the necessity to operate and maintain machinery as per the manufacturers instructions. Marine engineering examinations were also starting to ask questions on what the candidate would consider to be a planned maintenance system and what would be its benefit to a company.

Those companies who were slow or reluctant to act in this manner found that the savage rise in costs and reductions in income either drove them out of business or forced this new way of thinking on them. Gone were the days of the following:

1. Large crews, both in deck and engine departments.
2. Drydock every nine months.
3. Slow cargo discharge and loading.
4. Unreliability in ship operation.
5. Slow office response to ship requirements.
6. Lack of management information.

With increased knowledge of planned maintenance and all its advantages, management was getting a clearer picture of the total operation in terms of cost, ie with respect to man-hours, spare-part usage, etc., being expended in maintaining and overhauling certain items of equipment. This has led to the following:

1. Smaller, more highly trained and integrated crews.
2. Drydock at the maximum permissible range.
3. Rapid in-port turn rounds.
4. Improved vessel performance and reliability.
5. Rapid communication and response between ship and office.
6. More management information.

In fact, almost a total reversal.

THE PRESENT SITUATION

If the changes of the last 20 years are considered then they are quite astounding. There has been an advance from excessively manned and operationally cumbersome ships with

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high repair/maintenance levels to lightly manned, highly automated and reliable ships and machinery and cost-conscious operation.

However, the following questions must be considered:

1. Are they all that they are purported to be?
2. Is the equipment used as sophisticated and reliable as the manufacturers state?
3. Is the equipment doing the work for which it was intended?
4. Have the crew manning levels been reduced to a level of increased inefficiency?
5. Are planned maintenance systems too cumbersome and is all the required information being obtained from such systems?
6. Is management understanding and interrogating the system correctly?
7. Is the cost analysis income/expenditure improving?

The statement 'the health of the crew depends on the health of the machinery, which in turn depends on the health of the crew', a possible Catch 22 situation, should also be considered. Today vessels have highly sophisticated equipment and for the most part control is carried out automatically by electronic, pneumatic, etc. means. There are also rapid communications by satellite and a rapid air transport system. The engineers of today are trained in this new technology, where in most cases logic is the order of the day. Where spares are more readily available, and because of the complexity of some of today's electronics, replacement has become cheaper than attempted repair.

Many owners now operate maintenance systems which have already given them improved reliability and associated cost savings. This reliability allows them consistently to meet voyage requirements and to ensure cargoes are carried in the best manner.

Today, as in the past, owners are concerned with profit and service, but high operating costs and confused freight rates, because of the peaks and troughs in trading patterns, are presently being experienced. There are also various sophisticated forms of tonnage, ie container vessels, car carriers, sheep carriers, heavy lift, etc., and this high degree of dedication makes it very difficult for owners to replace vessels for a voyage should major problems occur with the one nominated for that particular voyage. Consequently it is extremely important for owners or ship managers to ensure that their vessels are at the maximum levels of efficiency and reliability at all times.

Another major change forced by this high-cost climate is the reduction in the number of crew members. In the majority of cases the personnel costs for staff onboard vessels is the owners' highest cost element in ship operation. In reducing the levels of seagoing staff substantial savings are made but the owners must satisfy themselves that the operational efficiency of their vessels is in no way impaired.

Although there are unmanned machinery spaces (UMS), planned maintenance systems, surveys at sea, modern technology, ie computers, satellite communications, etc., already in operation, the question of whether the situation has been properly addressed must still be asked.

OPTIONS FOR OWNERS

There are still instances where ships at sea are 20 or more years old, and when they were built there was no planning for UMS or operation by minimum crew levels. Machinery was large, cumbersome and required a lot of effort to overhaul and maintain, and various components were heavy, awkward and in some cases extremely inaccessible. There is no doubt that a limited number of crew would find it extremely difficult to maintain these vessels to the currently required operational efficiency.

Spare parts for the machinery are becoming progressively more difficult to obtain and so it is essential to ensure that it operates with the minimum of effort. The options open to the owners are four-fold, all being based on cost:

1. Sell or scrap the vessel and repurchase or build tonnage more suitable to the present operational conditions.
2. Make allowance for the vessel to remain longer in port whereby the use of shore facilities can be utilised to carry out repairs otherwise beyond the scope of the ship's staff.
3. Invest in new machinery to replace that which is no longer able to meet today's requirements or where spares are virtually impossible to obtain on a short-term basis.
4. Install systems and equipment which can effectively monitor the operation of all machinery on board and which will alert the owner to inefficiencies of plant and the costs associated with these inefficiencies.

All these areas require investment in some form or another. To some owners this would be extremely difficult to consider unless careful economic planning of costs and materials had taken place, based on proposed benefits and payback periods.

With point 1, the selling price is around $100/t, secondhand purchases at anything from $20 to $200/t depending on size and shape, and newbuilding costs about $1000/t.

Regarding point 2, because of the requirements for higher efficiency the shore authorities in ports now look for quicker turn rounds of vessels. It has been known for VLCCs to be quite heavily fined for not completing their discharge within 24 h. Certain other vessels probably also operate on a similar basis, but more for keeping to owners' or charterers' schedules rather than individual port requirements. In comparison with tankers, which require little shore involvement in their cargo operation, container ships are labour intensive.

General cargo and other similar vessels can remain in port for longer depending on the method of discharge, but these varying lengths of time become a factor when owners are considering whether to use shore labour to carry out repairs. For example, if the port authorities do not allow main engine isolation during cargo operations or whilst on cargo berths, or if hotwork is required in areas where rules do not permit this operation, then the vessel has to be moved to a safe berth within the port area where this remedial work can be completed. These in-port moves are expensive in both time and cost.

There is the opportunity for repair squads to sail with the vessel and complete a programme of work during the voyage. However, if the squads are landed elsewhere in the world rather than their homebase then repatriation costs are levied on the owner.

There are instances where machinery is just about impossible to maintain because of either the total lack or extended delivery time of spare parts. This, coupled with the physical size and old maintenance techniques, makes it extremely difficult to meet owners' requirements when limited by the number of staff available.

There can be no doubt that in order to meet current requirements in operational efficiency with the limited manpower available there is no time for doing repairs that would have been considered the norm 20 years ago. The fitting of replacement parts is now easier and cheaper in the long term. What should be concentrated on is ensuring that each component is used for its maximum working life before it is replaced. Where calendar maintenance is used there are cases

TABLE I: Maintenance manhours reduction using condition-based system compared with calendar system

Equipment	*Calender system* (h)	*Condition system* (h)	*Reduction* (%)
Inert gas fan	568	256	55
Cargo pumps	541	424	21
Feed water pumps	569	423	26
Alternators	186	69	63
Average	466	293	**37**

where components are replaced unnecessarily. This is not meant to decry this form of maintenance, but it should be considered whether it is right for the particular piece of equipment or whether condition monitoring and predictive maintenance should be investigated (see Table I).

There is a lot of sense in the comment 'if it's operating satisfactorily, leave it alone'. All that has to be done is to ensure there is nothing detrimental to its operation.

CONDITION MONITORING

Condition monitoring can be stated to be

> 'An assessment on a continuous or periodic basis of the mechanical condition of machinery, equipment and systems from the observations and/or measurements of selected parameters.'

The following is a list of equipment which can be used:

1. The human senses.
2. Thermometers.
3. Pressure gauges.
4. Strain gauges.
5. Megger tester.
6. Avometer/multimeter.
7. Oil analysis.
8. Ultrasonic thickness tester.
9. Fibre optics.
10. Flowmeters.
11. Portable tachometers.
12. Shock-pulsemeter.
13. Vibration analysers.

There is also specialised equipment that can be used for monitoring steam turbine and diesel engine performance.

By careful use of all these items a condition history of all equipment onboard the vessel can be built up. Some of the items can be found permanently installed, eg pressure gauges, thermometers, etc., with means to record the information, locally, in control rooms or in other areas. This technique is used to show trends in the machinery's condition. The portable equipment must be used on a regular basis, by a suitably trained person, and the information stored in a logical manner for easy reference.

Shock-pulse and vibration analyses are now playing more important roles than ever in condition monitoring. This field of technology has improved to the degree that there are now hand-held devices that not only store information but can also perform spectrum analysis. These instruments can be programmed by a computer to cover various routes. That is to say

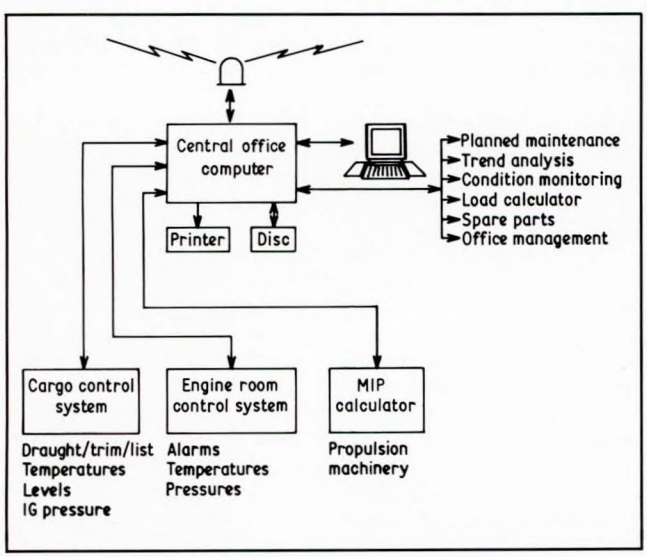

FIG. 1: Computer-based communications between ship and shore.

that the machinery of the vessel is divided into small areas and given route designations, eg route 1 could be the lower level port side engine room. The instrument would show each reading required for each machine on that route be it pressure, temperature, current, shock-pulse, vibration or even an observation of condition, eg leaking seal, gland, etc. Once the route has been completed the information is fed back to the computer. The files would then be updated and should any variances be apparent the user would be automatically advised.

Classification Societies are now very much involved with condition monitoring, especially vibration analysis. Providing owners can show a good planned maintenance and condition monitoring system and that it is all in regular use with proper records being maintained, then credits for machinery surveys will be issued without the need for exposure of machinery parts. This in itself is a major step forward because it is known that the majority of failures occur during the first two or three months after an overhaul.

On a lighter note, a move must be made from the situation where the Chief Engineer says to his staff:

> 'We have to overhaul the steam windlass today because you can get the peak of your cap in the bearings, the reversing gear now requires a 6ft tube to change the motion gear and the last operator suffered second degree burns due to steam leaks. Apart from that it is purely routine and we need it tonight.'

to one where he says:

> 'Our information requires us to examine the LO gear pump on the forward winch as the CM readings show slight deterioration in the gear teeth assembly. Pressure is still okay but we have time in our operation to do it this week'.

This is not so much a new approach, but rather a better one, showing more understanding of the situation. There are improvements being made in the field of diagnostics every day and attempts to ensure that the latest equipment is fitted to newbuildings prior to delivery.

Where items of equipment are fitted in areas of hazard or difficult access, sensing equipment can be fitted to relay information to a central point. Accelerometers can be hard-wired to provide vibration readings at a more easily accessible area or to give permanent display in control rooms. They can be linked directly to a computer where the update can be done on a regular basis.

Manufacturers can play their part by ensuring that their products are designed to be maintained with the minimum of effort. For example, with large pumps put the cover on some form of hinge. This will preclude the necessity of having to rig chain block equipment or other lifting means. They could also consider having all the relevant information concerning its operational efficiency displayed on a single panel, which in turn could have an adaptor to allow this information to be transferred to a data collector. There is equipment available to allow the performance of diesel engines and steam turbines to be monitored, which precludes the need for indicator cards. Central processors can display this information in the manner required by the ship's staff to operate the plant efficiently.

ACTION ASHORE

So far this paper has dealt with ships and their environment. However, it is essential that the office ashore is also fully aware of this information to enable them to make sensible decisions.

In this age of fast and efficient communications it is not difficult to have one computer talk to another (see Fig. 1). Spare-parts' registers can be held in the office and cover all the vessels of the fleet. If one vessel requires a part that has a long delivery time, and it is an operational requirement, the office can scan the total fleet spares' register and possibly locate a spare on another vessel.

This system can also be used to examine spare-part usage by

machine. High spares' usage can indicate that the machine is not capable of carrying out the work for which it was intended. Should it be one machine of a similar series it could mean that it is a rogue machine, that its physical location is in error or that some defect has occurred in relation to its location, eg poor steelwork.

Above all, the facility can assist in cost analysis. The register can give total stockholding costs and also by vessel. This enables a survey to be made of the fleet stockholdings, and ensures that the spares on the shelf meet the requirements for a time period set by management.

The same philosophy applies to planned maintenance. Excess hours maintenance soon indicate either the poor reliability of the equipment or possibly the ability of the staff carrying out such work. It is possible to determine whether the routine maintenance is being carried out too frequently or not often enough. This would show how the number of manhours available for maintenance can be best apportioned to suit the number of staff available.

With the new sophisticated tonnage now being designed and produced with limited crews in mind it is essential that the staff are fully supported with all these aids to ensure that they can carry out their tasks quickly and with the maximum efficiency. If planned maintenance systems do not exist it would be prudent for owners to stipulate this requirement during the construction stage.

Should this not be feasible, then it would be essential to correlate the routines as laid down by the various machinery manufacturers and set them out into some logical form for use onboard the vessel in a manner which ensures an even daily workload on board the vessel.

Finally, the maritime workstation assists the seagoing management team to provide fast information for the office. The following are some examples of what can be achieved:

1. Master's accounts.
2. Crew lists.
3. General stores.
4. Fuel consumption and status.
5. Spare parts.
6. Word processing.
7. Voyage repairs.
8. Main-event information.

CONCLUSIONS

It must be noted that reduced manning can and does work. Management has a very active role to play in ensuring that the reliability and efficiency of the vessels can be maintained without excessive efforts on behalf of these crews. This requires careful analysis of the aids currently on the market or being proposed.

There is also a need for management to clarify their requirements in terms of ship/shore information and not increase the workload as time passes without recognising the limitations they have initially imposed.

There is no doubt that future tonnage will have changes that might, at present, be difficult to understand, but with the new ideas and systems being devised are we so far away from a totally automatic, non-manned vessel by the twenty-first century?