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# Vibration from a Ship Owner's Standpoint

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Within this paper, various Vibration Areas will be discussed, as per our own Vessels are concerned, and some of the practicable remedies that we have employed.

Let me start out by saying that I am not a vibration expert. I know what it feels like, I know what it looks like, I know what it sounds like, and in some cases, I know what it smells like. But overall, I know as an operator, what it costs to deal with and correct it.

We will deal here only with tanker vibration. With machinery aft and a short stiff shafting system and a limited width for a substantially rugged engine foundation, all the factors for a potential vibration problem exist, unless eliminated by careful design.

It is axiomatic that a vibration pattern can be changed by changing the frequency or intensity of the vibratory force or by altering the hull response to such forces. In general, all our vibration experience has been a resultant of propeller blade frequency excitation so that to alter the vibration frequency would require either changing the number of propeller blades or to change the RPM. New propellers are expensive, and any range of barred RPM near the operating range is an unacceptable solution. Accordingly, operators turn to the palliative solution of changing the response to vibratory forces by changing the mass involved. In simple words, this means stiffening.

In Tanker Operation, it is well known that the vibration amplitudes are usually considerably less when the vessel is in a fully loaded condition than when at a light ballast draft. This has permitted some judicious varying of ballast patterns to minimize the hull response to vibratory forces. However, being faced now with a fixed ballast pattern forced by the segregated ballast regulations, this flexibility will no longer be available and will require more careful design by the naval architect.

Not being vibration experts, tanker operators are forced to deal with the symptoms of the disease rather than delving into the basic causes. Such treatment generally involves local stiffening. We list below the most frequent vibratory problems encountered and the method of dealing with them:

1. Bridge/House Configuration

It has been shown that with the increase in vessel size, and the normal progression in the state of the art in ship design, a corresponding increase of vibrations occur in and around the wheel houses of vessels.

Equipment located within the wheel house proper, e. g. Radar(s), Navigation Gear, Communication Units, and even the helm, have mostly all at times had to be shock mounted or relocated due to vibration. The underdeck area in some wheel houses, when exposed for alteration and stiffening, have been found to have cracked welds and fractured strength members. High vibration levels have rendered some navigation equipment and aids useless at various speeds solely attributable to poor design or layout in the wheel house. The relocation of some wheel house components are not practical in all instances and consequent frequent repair is necessary, all at additional owner's expense.

Added to the vibrations and related problems in the wheel houses of various vessels is the ever present problem of poor joining work of the builder. Loose paneling, improper and/or insufficient hangers on cable racks, pipe supports, etc., all have created high noise levels while vibrating. On many occasions, vessel personnel have had to be diverted from normal and prescribed maintenance programs to attend to accommodation noise maintenance and the repair of broken water pipes.

Experience has shown that P.V.C. Pipes, however, cost saving on initial construction is a continuing problem on operating vessels, chiefly through failure due to vibration. This problem exists throughout a vessel and cannot be predicted or isolated. Several shipboard instituted methods of solving the P.V.C. problem include, spring hangers, shock mounting with rubber and adding flexible connections. All of these methods have met with some success, but they require time, new expense to the owner and are all traceable to vibration.

With the old three island type of tanker, there was some difference of opinion as to the extent of vibration. Generally, the midship house was relatively quiet, even though the mess rooms aft might vibrate coffee out of the cups. Dealing with this problem involved changing ballast patterns, changing speeds or general structural stiffening of the after end.

Modern, single house aft vessels have not experienced relief from the vibration problem. To the contrary, with the increase in power, the problem has amplified. The transmission of propeller vibrations to the single-house ship is more pronounced in the modern wheel house and its related gear. The installation of additional supports is common industry practice to bridge wings, radar masts, smoke stacks, etc.

Present dry solid-state navigation and communication equipment has suffered frequent failure due to vibration. In some cases, failure problems are traceable to equipment manufacturers not having the expertise or forehand benefit of an existing knowledge that they may encounter vibration. Consequently, their hardware is not properly fastened internally, and in some cases, the circuitry is weaker, strengthwise, than that necessary to overcome some vibration. In other cases, factory shock mounts have failed after less than normal life expectancy and their replacement long delayed simply because they should not have failed and are not shelf items. In the meantime, additional damage can and has occurred.

2. Violent Excursions of the Radar Mast

The radar mast has become a rather massive structure supporting various antennae, platforms, yardarms, light and signal apparatus and is mounted on a rather flimsy wheelhouse top structure. We have one documented case of radar mast vibration sufficient to break loose and drop a radar antenna. The solution is obvious - stiffen the foundation on the wheelhouse top and fit stays as required.

3. Cantilevered Bridge Wings

We have had experience with cantilevered bridge wings flopping in the breeze like gull wings to the extent that the entire wheelhouse-chartroom area was excited and prevented writing on the chart table. While the obvious solution is to put stanchions under the outboard wings, this maybe difficult with the wings out to B/2 and bridge aft over a much finer and narrower hull below.

On one class of VLCC that we have, it became necessary to fabricate and fit twelve inch (12") vertical pipe supports to the approximate center of the bridge wings. This problem, like many such vibrating problems, was found on this class of ships during sea trials on the "first of the class" trials. Fortunately, by the time that our vessels were built, the aforementioned solution had been tried, tested and found satisfactory.

4. Hull Fractures

In general, except for rare occurrences, our experience has been that structural fractures due to vibration have been confined to the after end clear of the tank space. In one case, we found most of the after peak framing of a 40,000 ton tanker lying in a heap at the bottom of the tank. The solution was to re-frame with a heavier structure. This incident was on a relatively new vessel and could not be attributed to steel wastage.

MACHINERY SIDE

1. Economizer Failures

On several classes of ships, there was an epidemic of fractures in economizer elements very close to where the element end was welded into the header. Laboratory analysis diagnosed their failures as fatigue failure due to vibration. Two methods of repair were involved. One was to sway brace the tops of the economizer casings to adjacent structure, taking care that the braces still permitted the necessary expansion of the casing. Other methods consisted of respacing of the economizer support plates to change the frequency of response of the elements. In a few cases, fractures of generating tubes was encountered and dealt with in a similar manner by fitting intermediate supports.

2. Stern Bearing Failures

In several cases, it was found that excessive vibration tended to pound out the lignum vitae stern bearing, requiring rewooding on an annual basis. Fortunately, we have noted none of this type of problem with oil-lubricated white-metal stern bearings.

3. Condenser Vibration

We have one classic example of the European practice of mounting the main condenser on springs rather than supporting same from the L.P. turbine flange. On this particular vessel, at just below normal operating RPM, the bottom of the condenser would vibrate in blade frequency with an amplitude of about two inches (2"). This was cured by sway braces fitted with brake bands, which permitted thermal growths and restrained the vibration.

4. General Vibration in Engine Room

Vibration of miscellaneous local handrails and small pipes are taken for granted and are dealt with easily by bracing or additional hangers. During sea trials, areas of heavy or unusual vibration are marked with tape, and depending on location or service, additional brackets, hangers or spring-loaded hangers are fitted. Not nearly enough work on vibration has been carried out from the operator's standpoint. When the conscientious operator reviews his plant and finds that major control consoles, switchboards, etc. are located on adequate foundations, which are attached to common decks, or in some cases, decks not properly supported, hangers and stiffeners are frequently and properly provided on equipment and are then secured to vent duct supports or other hangers already in use. In some cases, only a tack weld is used on one hanger foot and vibrations readily take care of the rest. Major failures have occurred in switchboards, which have not been properly located and supported.

5. Alarm Panels

Alarm panels are frequently activated through vibrations experienced while changing power requirements and/or entering shallow water or port areas. Normally, this problem is self correcting once the power adjustment is made or the draft conditions stabilize with speed, but, for the moment, the operator is distracted from his duties. This time interval can have some consequence should the alarm origin be from some remote location and require movement to that area.

6. Pump Problems

On several occasions, it has been found necessary to rebuild or renew pumps where foundations have become loose from vibrating. Pump castings have cracked on some units where fasteners have loosened thereby permitting cast chocks (non-metallic) to work and waste away due to vibration. Man-power complements on today's vessels are not sufficient to combat the total effects of vibration and still maintain and operate the vessel.

7. Vibration in Steering Gear Locations

Vibration in steering gear location is a continuing problem with present day operators. It is quite common for the operator to have to refasten flanged pipe connections at the same location on repeated occasions, even when new bolting and locking devices are used. Sometimes, even to the point of frustration, the operator will contemplate welding the nuts to the bolts. Broken hangers on steering Hydraulic lines, especially when they are attached by welding to the overhead are an everyday occurrence. Much valuable time and money are spent in this repair problem. In some cases, it has been found that the original weld was defective or non-existent.

One vessel had lost its steering due to a poorly designed motor pump coupling locking device, which vibrated out of location allowing the coupling to disengage. This incident was corrected without casualty only because the ship was at sea without local traffic. Had the vessel been in confined waters, her 90 degree course change would have been a disaster, all due to vibration.

Constant attention is required to all electrical connections of power and control units of steering engines due to their location in a high vibration area. Frequent connections, which are tight on one inspection are loose on the next inspection.

CONCLUSION

From the operator's view, everything put aboard a ship should be considered to be moving, not only from Point A to Point B, but at all times.

It is nothing new to the operator to have an object as small as a machine screw to as large as a valve wheel fall in the engine spaces. Aside from a safety viewpoint, it requires constant and alert attention by the operator that he is in a vibrating environment in order to properly maintain his plant. Once again, personnel are directed to correct problems arising from vibration at additional costs to the owner who never knew he paid for the problem in the first place.

In conclusion, we should note that there should be more feedback of operating experiences with vibration to the shipbuilder and to the naval architect so that the mistakes of today will not be tomorrow's.