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DIESEL ENGINE NOISE IN SMALL SHIPS

by

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Introduction

The problems associated with noise in Merchant ships have been given attention by several authorities for many years. Recently the emphasis has changed from the investigation of particular problems to a general appraisal of the noise environment found in working and living spaces in the various types of ships e.g. passenger, cargo, ferry, diesel engined, turbine engined, etc. and methods of reducing the noise where necessary.

Understandably, perhaps, the greater part of the work has been concerned with sea-going ships. The problem is, however, particularly acute in small ships firstly because a large majority of them are powered by medium or high speed diesel engines and secondly because their physical size dictates that the watchkeeping and accommodation spaces are in close proximity to the engine. The word small in this context does not refer to any rigid classification. In general it describes those vessels employed in docks and harbours or close inshore e.g. tugs, dredgers, hoppers, floating cranes, salvage vessels. It also includes the smaller type of sea-going ship, say up to three hundred feet in length, which has a deckhouse at the after end of the ship.

At the instigation of the National Ports Council, the British Ship Research Association investigated the noise environment in these ships with the object of giving to their owners and builders an assessment of the magnitude of the problem with which they are confronted in order that the necessary solutions may be sought at an early stage in the design of new vessels and palliative treatment applied to those already in service.

Engine Room Noise

The great variety of tasks performed by ships employed in docks and harbours is reflected in the wide range of diesel engine installation with which they are fitted. In the more common vessels covered by this survey the speed and power of the main engines ranged from 500 rev/min to 1800 rev/min and 150 brake horsepower to 3000 brake horsepower. With the exception of a few diesel electric installations the main engines drive a propeller via gearing which provides the necessary speed reduction and, in many cases, facilities for reversing the direction of rotation of the propeller. In addition to the propulsion machinery all engine rooms are equipped with diesel driven auxiliary machinery for the generation of electricity.

As a first apporach to obtaining some quantitative assessment of the noise environment in the engine rooms of this class of ship, twelve vessels were selected as being representative of the more common types employed in docks and harbours i.e. tugs, hoppers and dredgers. In each of the twelve, octave band sound level measurements were carried out at the engine room control platform (or an equivalent position) with the main engines operating at "full ahead" conditions and auxiliary diesel generators running.

The twelve octave band spectra showed marked similarity in both character and level, (see accompanying figure) the lowest Noise Rating number being NR 96 and the highest NR 103. The corresponding measured dB(A) sound levels are 100 dB(A) and 106 dB(A).

These results provided a useful indication of the noise environment which may be expected to exist in many of the vessels with which the survey was concerned. It was obviously desirable, however, to obtain a larger sample of noise measurements taken in these types of ship and to extend the examination to include some of the less common craft. Fortunately a useful source of data was provided by the results of noise measurements carried out by the Port of London Authority and the British Transport Docks Board. Altogether the dB(A) sound levels measured at the control position in the engine rooms of forty ships were available. It was found that twentyfive of these were in the range 100 dB(A) - 106 dB(A) and thirty in the slightly wider range 100 dB(A) - 108 dB(A). Whilst this sample does not cover every type of vessel it does include some of the less common craft such as a floating crane, a floating grain elevator, a survey launch, a high speed launch and a small sea-going ship. It would seem reasonable, therefore, to expect that a large proportion of the vessels currently employed in docks and harbours will have engine room noise levels in this range. (It is of interest to compare this noise environment with that found in the large sea-going ships. In a survey carried out by the British Ship Research Association some years ago the range of noise levels measured in the engine rooms of twenty-nine diesel engined ships was 90 dB(A) - 104 dB(A)).

Of the remaining ten ships, five had engine room noise levels in the range 96 dB(A) - 98 dB(A) and five in the range 109 dB(A) - 112 dB(A). The two groups of ships are very different in size, power and function but in general these differences may be summarised by describing the ships in the quieter group as older, less powerful vessels and those in the noisier group as recently built (1969), powerful ships which are technically advanced members of their class. These results are in accord with a general trend which has led to an increase in speed and power of the diesel engines fitted in the more recent vessels. If this trend continues it may be expected that a significant proportion of the small ship population will have engine room noise levels near to or above the upper limit of the range 100 dB(A) - 108 dB(A).

In order to provide some estimate of the noise levels which might obtain in future vessels attempts were made to correlate those levels measured in the engine rooms of existing craft with the speed and power of their engines. It was found that, for twenty vessels for which the necessary information was available, good agreement between measured and calculated dB(A) sound levels was obtained by using a very much modified version of an expression derived by Slavin. The resulting expression is:

$$M = 30 \log (n) + 12 \log (B) - 16 \text{ dB}$$

where M = dB(A) sound level at the manoeuvring position in the engine room,

n = number of revolutions per minute,

B = rated maximum brake horsepower.

This is, of course, based on a fairly small sample and although it has proved reliable in several recent cases where an estimate has been required it is hoped that further data, particularly for engines running at speeds above 1500 rev/min, will allow a more precise expression to be determined.

All the noise levels so far discussed have been measured as the ships operated under "full ahead" conditions. In most vessels it may be taken that the major noise source is the main diesel engine. However, in almost all of these ships some contribution to the noise is provided by an auxiliary diesel engine and in a large number of them a further contribution is provided by the main engine reduction gearing. Although no detailed investigation was made into the relative importance of these separate noise sources results from several ships suggested that when only the auxiliary machinery is running, the dB(A) sound level in the engine rooms of the more common type of vessel will be between 5 dB and 10 dB lower than that measured under "full ahead" conditions. Measurements in some of the less common types, however, showed that in some cases the difference might be either much larger (20 dB) or much smaller (2 dB).

Noise measured during shop trials showed that the 250 Hz, 500 Hz and 1000 Hz octave band noise levels produced by a main engine were 2 dB higher than those produced by the associated reduction gearing driven by a comparatively quiet electric motor. Further measurements carried out during the trial established that the gearing noise increased when the direction of rotation was reversed, a phenomenon which is subjectively noticeable in many small ships.

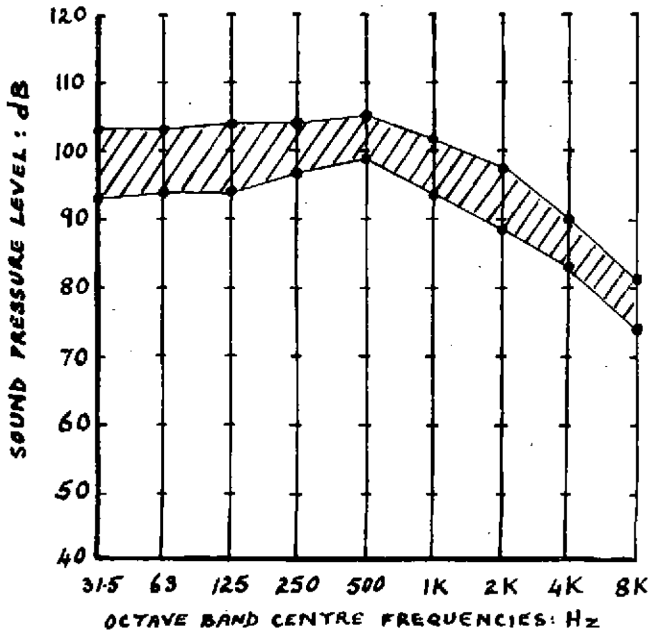
There are, of course, other sources of noise in an engine room e.g. small pumps or compressors, and there are no doubt several factors, such as the size of engine room and the siting of main and auxiliary engines, which have some influence on the distribution and characteristics of the noise field. None of these aspects were examined during this survey. However, even without information on these factors it is felt that the results outlined above provide a useful quantitative description of engine room noise in small ships.

Noise in Other Spaces

Because of the physical size of the ships with which this survey is concerned the working and living spaces are in close proximity to the engine room. The arrangement of the accommodation within the hull or deckhouse depends upon the size and type of ship but in the great majority there are several such spaces which are immediately adjacent to the engine room i.e. the two are separated by only one steel bulkhead. Noise measurements in several ships showed that the NR values for this type of accommodation are about 26 dB lower than the corresponding engine room NR values. A further reduction of 6 dB - 10 dB may result if the engine producing the noise is mounted on anti-vibration mountings. Generally then, the noise in a large number of inshore craft will have noise levels in working and living spaces corresponding to NR 70 - NR 80.

With the exception of some of the larger "small" ships the only working accommodation which is not immediately adjacent to the engine room is the Wheelhouse. However it is often tied, structurally, to the funnel and thus to the main and auxiliary engine exhaust uptakes. The noise spectrum is consequently different to that previously discussed in that it has a greater, low frequency and a smaller high frequency content but in terms of NR values this working space may be expected to have a noise environment similar to that discussed above i.e. NR 70 - NR 80.

From the results so far presented and from others covering more detailed aspects of the less common ship, it is possible to prepare a reasonably good estimate of the noise environment in existing ships and in those which are in the early stages of design. To what extent this noise will constitute a problem can only be judged by comparing it with those noise levels which can be considered to provide an acceptable noise environment for those on board. This in itself presents some difficulty. In large sea-going ships the noise levels and times of exposure remain fairly constant for the duration of a voyage. In the ships employed in docks, harbours and other confined waters engine conditions can vary frequently and over a wide range during a working day. Consequently, acceptable levels must be defined for each vessel (or type of vessel) individually. However, even without regard to this complication, the levels quoted above are considerably higher than are desirable. Limited noise reduction methods have been used on some vessels but an economical, comprehensive treatment capable of being incorporated in the early stages of design has yet to be developed.



ENGINE ROOM NOISE: OCTAVE BAND SPECTRA FOR 12 SHIPS IN SHADED AREA.