BRITISH ACOUSTICAL SOCIETY

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SPRING MEETING

NOISE AND VIBRATION IN TRANSPORTATION

'INTERNAL NOISE REDUCTION IN HOVERCRAFT'

by

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INTRODUCTION

The general public all over the world are showing a rapidly increasing awareness of the noise environments to which they are exposed. This awareness is evident from the increasing amount of Noise Legislation being implemented by the various Governments concerned. Transportation noise is particularly prominent in this and in this country, aircraft, commercial vehicles, cars and motor cycles are all subject to noise level limitations. So far this legislation has been aimed at external noise, but it cannot be long before regulations governing the internal noise of public and private transport is introduced.

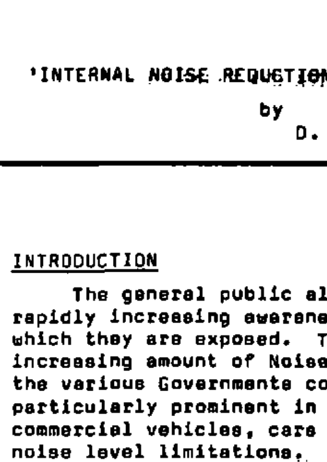

Fig 1 - Comparison of Internal Noise of Various Types of Passenger Transport.

Manufacturers are increasingly finding that design for low noise cannot be achieved by the use of palliative measures for long and that the noise of machines and structures is intimately bound up with the fundamental design of the machines. As the initial design configuration is laid out on the drawing board then the resultant noise which the design will produce has already been specified. It is therefore very important that the designer should be aware at the outset of the factors which control noise.

Figure 1 shows a comparison of the internal noise levels of hovercraft in comparison with other forms of transport. The levels for Hovercraft are high but modest reductions in overall level of 4 - 6 dBA bring them to the level of present day short haul jet aircraft, and 10 dBA would bring them to the level of public service vehicles. This latter comparison is the more valid since the time that a passenger will spend in a hovercraft is very similar to that spent in a bus i.e. 10 minutes to a half an hour.

Comparison of the levels shown for hovercraft in Fig.1 with data given in Richards and Sharland's excellent paper on hovercraft noise shows the substantial noise reduction achieved between prototype and first generation commercial hovercraft.

Noise can reach the passenger space of transport vehicles only by the vibration and subsequent noise radiation of the walls, floor and roof of the space (assuming that no major air gaps are present). The excitation of the walls, etc. is achieved by two main mechanisms. Firstly, direct airborne noise forcing the walls from outside, with subsequent re-radiation into the passenger space, and secondly, structure borne vibration fed from various machines into the walls, with subsequent re-radiation into the passenger space.

In the machine spaces the resultant noise level is determined by the sound power of the machine and the acoustic characteristics of the space and the well developed and known methods of Building Acoustics can be used to calculate the levels which will be transmitted to other parts of the structure.

The parameters which control the direct airborne noise path are the noise level in the machine space, the transmission loss properties of the dividing wall, the area of the wall and the acoustic absorption of the passenger space.

Adequate data is available in the literature for the calculation of cabin absorption, as is also the case for the prediction of the transmission loss of simple panels according to mass law. It is in the prediction of machinery noise where information is urgently needed, although the levels of some machines, notably diesel engines, can be predicted.

The power to weight ratio of Hovercraft is as critical as it is in aircraft and much current work is aimed at achieving a high stiffness - low weight structure. This has resulted in the introduction of composite structures such as honeycomb and fibreglass/rigid foam/fibreglass panels of high stiffness/weight ratio. The transmission loss properties of a number of structural materials have been tested in an acoustic suite at the I.S.V.R., and results show that the acoustic attenuation provided by these composite materials can be very much lower than that of a simple panel of the same surface weight.

Structure borne noise has long been recognised as a problem both in building acoustics (where it often contributes to flanking transmission) and large machine foundation isolation. However, it is in transportation, where a high power to weight ratio is necessary, that the problem is most pronounced.

In a diesel powered sidewall hovercraft (Hovermarine HM-2) it was found that no acoustic treatment applied could reduce the internal levels by more than 1 or 2 dBA. The problem was fundamental to the craft design and an extensive programme was started to investigate the problem.

A large part of the programme was concerned with a resonance test, over the whole audio-frequency range, to assess the combined acoustic and structural properties of the complete structure.

The predominant acoustic response in the low frequency range was found to be due to structural and not acoustic resonances although at higher frequencies (above 200 Hz) the acoustic response of the cabin did contribute. The major craft structure resonances were found to be similar to those of a plate with a preference for the longitudinal modes to predominate.

Damping measurements showed that the structure had low damping with typical 'Q' factors of 60 - 100.

In the complete craft the main drive gear boxes were the only rigidly attached machine elements and a complete redesign of the system to include vibration isolation resulted in cabin noise reductions of about 10 dBA (Fig.2).

It is thus clear that in transport vehicles which have a high stiffness weight ratio structure, combined with low damping, structure borne noise can be a major factor in controlling internal noise levels, and can produce as much as 95 dBA overall noise level.

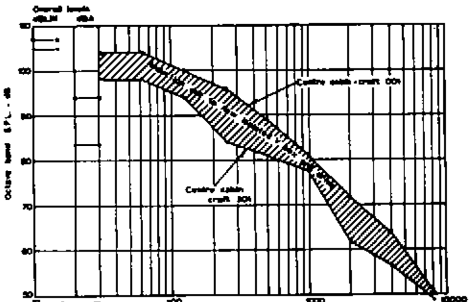

Fig.2.

Comparison of passenger cabin noise - Craft 001 and 301.

Isolation of all machine elements from the main structure is necessary if the structure borne noise is to be kept at a tolerable level.