QUIET HEAVY VEHICLES FOR THE 1990s

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1. INTRODUCTION

This paper starts by outlining the steps taken by the UK Government to demonstrate the technical and economic feasibility of reducing noise from heavy goods vehicles. The results from this work contributed, via the Armitage Inquiry (1) and the Government White Paper "Lorries, People and the Environment" (December 1981) (2), to the decision by the European Community to require vehicles to be quieter by the end of the decade. (EEC Directive 84/424, September 1984). Finally a brief description is given of the QHV90 Project which was a direct outcome of the White paper and the anticipated EEC Directive.

For the class of vehicle concerned in this paper, 7.5 to 38 tonnes gross vehicle weight, the external noise levels required to be achieved by 1989/90 range from 81-84 dB(A) compared to the present requirement of 86-88 dB(A).

2. THE TRRL QHV

The Quiet Heavy Vehicle Project (QHV) (3,4,5) was initiated by the Transport and Road Research Laboratory (TRRL) in 1971 following a report by an independent working group set up by the Minister for Transport to examine and review existing research into traffic noise and to recommend further research (6). The Report recommended that research and development was needed to build a heavy articulated lorry aiming at a sound level at least 10 dB(A) below the then current levels, to demonstrate the feasibility and commercial viability of such a lorry. This led to a target noise level of 80 dB(A) being adopted.

The principal objective of the TRRL QHV Project was to enable British manufacturers of engines and vehicles to produce quiet, diesel engined, heavy articulated vehicle tractors for demonstration, one at the weight and power conforming to the then current regulations, ie 32.5 tonnes gross vehicle weight and 158kw (212 bhp) and the other capable of working up to 44.8 tonnes and with an engine power of some 262kw (350 bhp).

Research prototypes of these vehicles were built by Leyland Vehicles (now Leyland DAF) and Foden Ltd (now Foden Trucks) together with Rolls Royce Motors Ltd (Diesel Division) (now Perkins Engines Group Ltd) respectively, and achieved drive-by levels of 79.5 dB(A) and 83.5 dB(A) under the BS 3425:1966 test procedure. The Foden vehicle ended up somewhat lighter at 38/40 tonnes as this appeared to be the way maximum weight legislation appeared to be going at the time; in the event this was the legislative weight limit agreed upon in the latest regulations.

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The research on the vehicle components was carried out by the Motor Industry Research Association (MIRA), (exhaust and cooling system and the prototype research vehicles); National Engineering Laboratory (NEL), (cooling system); Institute of Sound and Vibration Research (ISVR), (quieter engines); and TRRL who carried out work on tyre/road surface noise. For work on the exhaust system design MIRA used the computer based silencer design methods being developed at ISVR. The manufacturers cooperated closely with ISVR, MIRA and TRRL during the research phase and provided specialised facilites and advice to ensure that the outcome would be economically viable in production. This industrial involvement assisted a smooth transition from the research phase to the development phase involving the construction of the final demonstration vehicle.

As an example of the kind of results obtained during this research, Fig 1 shows the reduction in noise level over the frequency spectrum achieved by ISVR with the Rolls Royce engine. A broad band of noise reduction was achieved above 500Hz at rated power with a maximum of 12 dB(A) at 2.5kHz. This was achieved by design changes which included a restructured cylinder block and crankcase, a decoupled sump, laminated close fitting damped panels attached to the block and a quieter fuel injection pump. Similar success with the design of the exhaust and cooling systems enabled MIRA to achieve a noise reduction of nearly 10 dB(A) with the prototype compared to the original Foden vehicle.

Based on this research prototype, Foden/Rolls Royce developed a demonstration vehicle built to production standards and achieving a drive-by noise level of 81/82 dB(A) when tested to BS 3425:1966. The maximum C weighted noise level recorded was 87 dB(C), a reduction of 8 dB(C) compared to the unmodified vehicle. Fig 2 compares the spectra of the QHV and a standard Foden vehicle of the time. Noise inside the cab was reduced to 72 dB(A).

The demonstration vehicle was put into service with a haulage contractor and, between November 1979 and October 1981, covered 118,000 km and carried 11,000 tonnes of payload in normal service (6). The vehicle performed well during this test and apart from some temporary problems with the exhaust system there was no deterioration in the performance of the noise reduction measures in the vehicle. The increased capital cost of the QHV was estimated at 7.5% while the increase in total maintenance and servicing costs during the trials amounted to about 1.5%. This represented less than 0.2% of the total operating costs of the vehicle.

The significance of the QHV demonstration vehicle was to show that the technology existed to build a maximum weight goods vehicle to produce less than 82 dB(A) without excessive penalties on capital or operating costs.

3. THE QHV90 PROJECT

3.1 Background

After the TRRL QHV had demonstrated the feasibility of a maximum weight vehicle emitting less than 82 dB(A), the Armitage Inquiry into Lorries, People and the Environment (1) recommended that "The Government should adopt as explicit aims of policy that an EEC Directive should be agreed requiring lorries to be manufactured to a maximum noise level of 80 dB(A) and that the new limit should be introduced as soon as practicable in the light of discussions with manufacturers and operators, and not later than 1990". The Government then published in December 1981, a White Paper "Lorries, People and the Environment" in which it stated its target "progressively to reduce the perceived noise from new heavy lorries coming on to the road to less than half the 1981 level, so that by 1990 they would be no noisier than 1981 model new cars ..... The Government will therefore set in hand a collaborative programme of research, involving vehicle and engine manufacturers ..... The new programme is intended to lead to the development of a "production" quiet heavy vehicle for the 1990s - the QHV90".

3.2 Organisation and content

The QHV90 Project (8,9) started in 1982 with discussions with manufacturers to select the vehicles and engines which would represent the products they would be marketing in the 1990s. Since the QHV90 Project is intended to assist the whole of the British commercial vehicle industry to meet the new noise limits, and to reduce the noise as perceived by the public, the project is much broader than the original QHV. Thus the programme includes the quietening of some maximum weight vehicles, some medium weight vehicles and research on the components that contribute to overall vehicle noise.

The vehicle manufacturers involved include ERF, Foden Trucks, IVECO Ford and Leyland DAF while quieter engines are being developed by Cummins Engines, Ford Motor Co, Perkins Engines and Leyland DAF. In addition to the work being carried out by the manufacturers, research on specific aspects of vehicle noise is being done by the Motor Industry Research Association (MIRA), Loughborough University of Technology and the British Hydromechanics Research Association (BHRA) (exhaust and air inlet noise); Institute of Sound and Vibration Research (ISVR) (reduction of noise from engine covers and the design of engine enclosures) and MIRA (computer model for vehicle noise prediction).

The QHV90 programme is being funded half by Government and half by industry. The Government funding comes about equally from the Department of Transport (DTp) and the Department of Trade and Industry (DTI) and the project is overseen by a Steering Committee of officials from the two Departments which is itself serviced by an Advisory Group of senior representatives from the manufacturing industry, since the overall programme is primarily to benefit the industry. The project will cost up to £10m over a period of six years.

3.3 Progress

The QHV90 Project is just over halfway completed at the time of writing (January 1988) and although a great deal of successful work has been done, commercial confidentiality precludes any detailed discussion of results at this stage. However it can be told that all but one of the engine programmes have been completed and have achieved their noise targets. The vehicle manufacturers, who started their development programmes using standard, unquietened engines, are now using the quietened versions to determine the final amount of shielding and enclosure required to meet the new EEC noise limit. They are also engaged on considerable further development of other vehicle systems such as cooling, engine installation and cab, in order to produce commercially viable production prototype vehicles.

An important part of the QHV90 project has been the establishment of research and development programmes on specific aspects of venicle and engine design, not tied to a particular manufacturer and providing benefits to industry as a whole. These were mentioned earlier in the paper and an example of the work is given below.

3.3.1 Vehicle external noise prediction When designing a prototype vehicle it would be invaluable for the manufacturer to be able to calculate the drive-by noise level of the vehicle with sufficient accuracy before the first build so that low noise can be designed in at an early stage.

This can be done to a certain extent by logarithmic summation of the noise from individual components, if these are known, but the effects of directivity of noise output due to the masking effects of the cab, chassis and any shielding are difficult to estimate. Also the problem is complicated by the need to know how the noise output, as measured at the trackside microphone, of each component varies as the vehicle is accelerated past the microphone so that the correct set of levels can be summed.

What is required is a computer model of drive-by noise where the performance characteristics of the vehicle together with the noise output of the various components can be combined to evaluate the peak noise level at the microphone during a type approval drive-by noise test. Such a model would allow the effect of changing engine characteristics, transmission components and degrees of shielding to be assessed without the need to initially build a vehicle and test it.

MIRA developed such a computer program for cars and vans some years ago but it had not been validated for use with heavy goods vehicles. Thus the DTp commissioned MIRA to further develop and validate their program for use with the classes of vehicle which are the subject of the QHV90 project. This work is now complete and the program is in use by member companies. In brief, the program predicts the external noise of the vehicle from a pediction of its performance through the test area and sums the contribution of the various noise sources taking into account their respective positions on the vehicle, their distance from the microphone, the variation in sound power with speed of each source and the directivity of each source. If required the interference between sources can be predicted and a broad band noise spectrum modelled.

Figure 3 shows the accuracy of prediction of vehicle performance during the test acceleration and Figure 4 shows the prediction of external noise with and without the inclusion of directivity effects. In each case the performance and noise data during the actual test run were telemetered to a trackside laboratory. The accuracy of the noise prediction can be seen to be of the order of 1 dB(A).

4. CONCLUSIONS

QHV90 is a successful collaborative programme of research and development between Government and industry which includes research on the noise from heavy goods vehicles and the development and testing of prototypes of quiet vehicles, engines and systems components. As a result of this work and its own in-house research British industry will be enabled to build vehicles that will meet the more rigorous noise limits that will be in force by 1989/90.

5. ACKNOWLEDGEMENTS

The work described in this article forms part of the programme of the Transport and Road Research Laboratory and the article is published by permission of the Director.

6. REFERENCES

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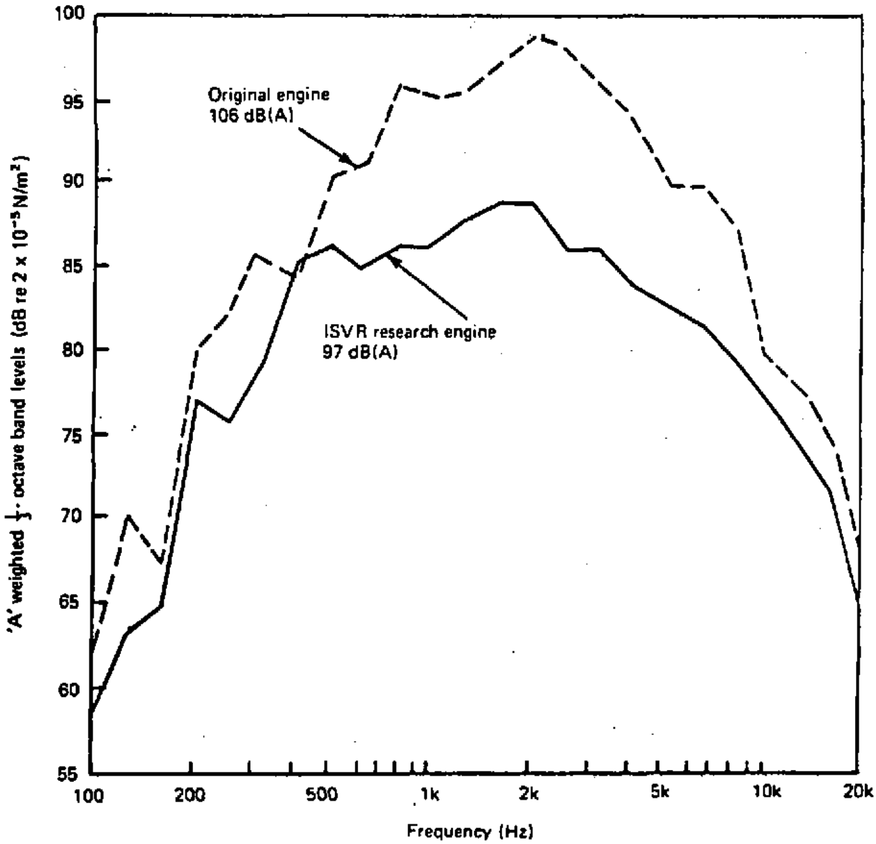

Fig. 1 COMPARISON OF SPECTRA OF ORIGINAL AND RESEARCH ROLLS ROYCE EAGLE ENGINE AT RATED CONDITIONS (Near side)

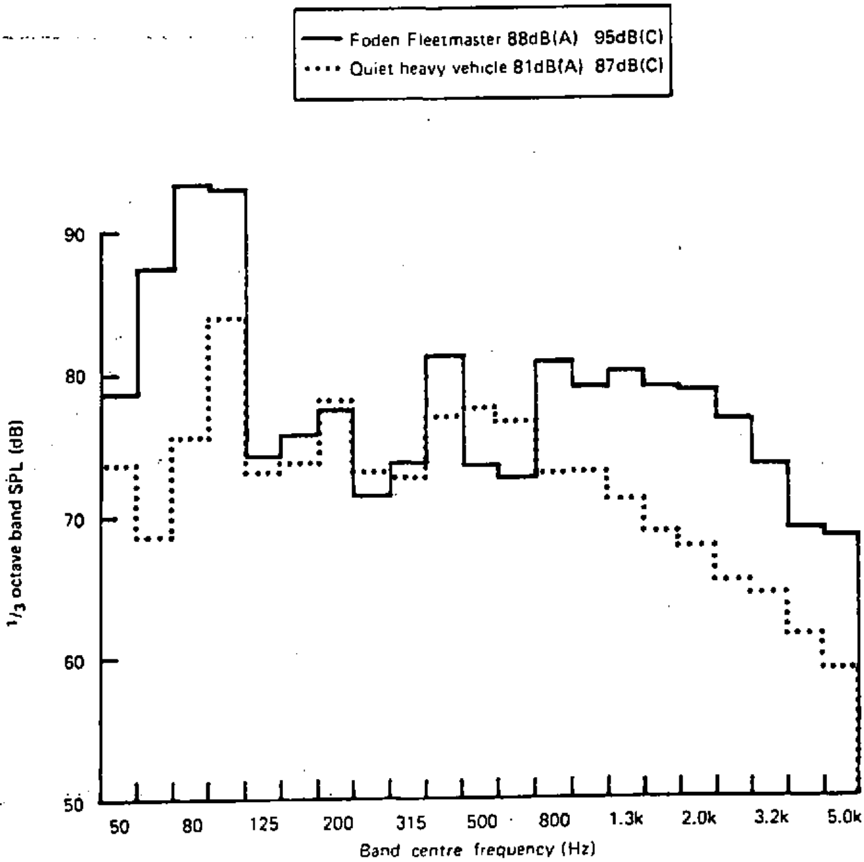

Fig.2. Comparison of one-third octave band spectra for QHV and Foden Fleetmaster during standard test condition 81/334/EEC. (The spectra were obtained by sampling the total drive-by noise in each case and displaying the maximum levels in each ⅓rd octave band)

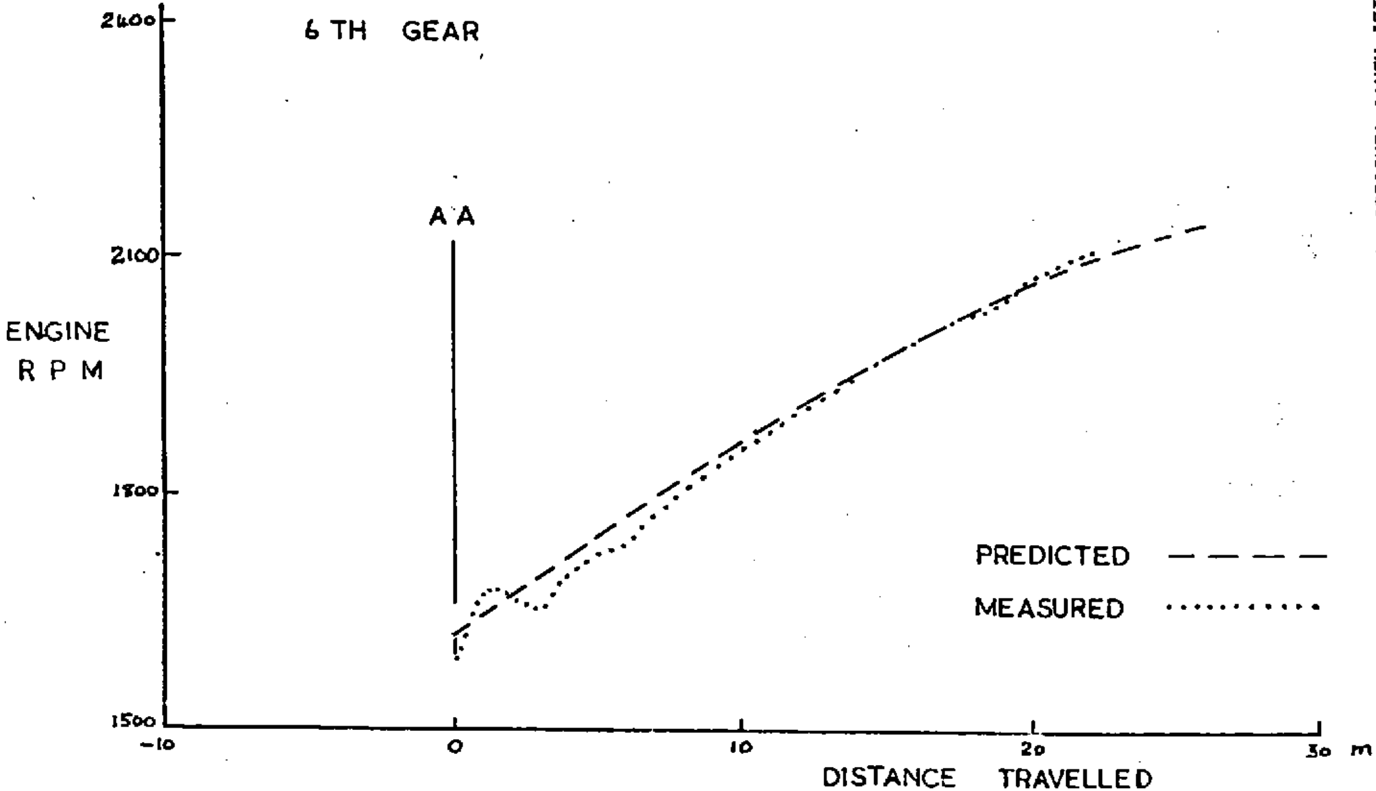

Fig.3. Predicted and measured engine speed

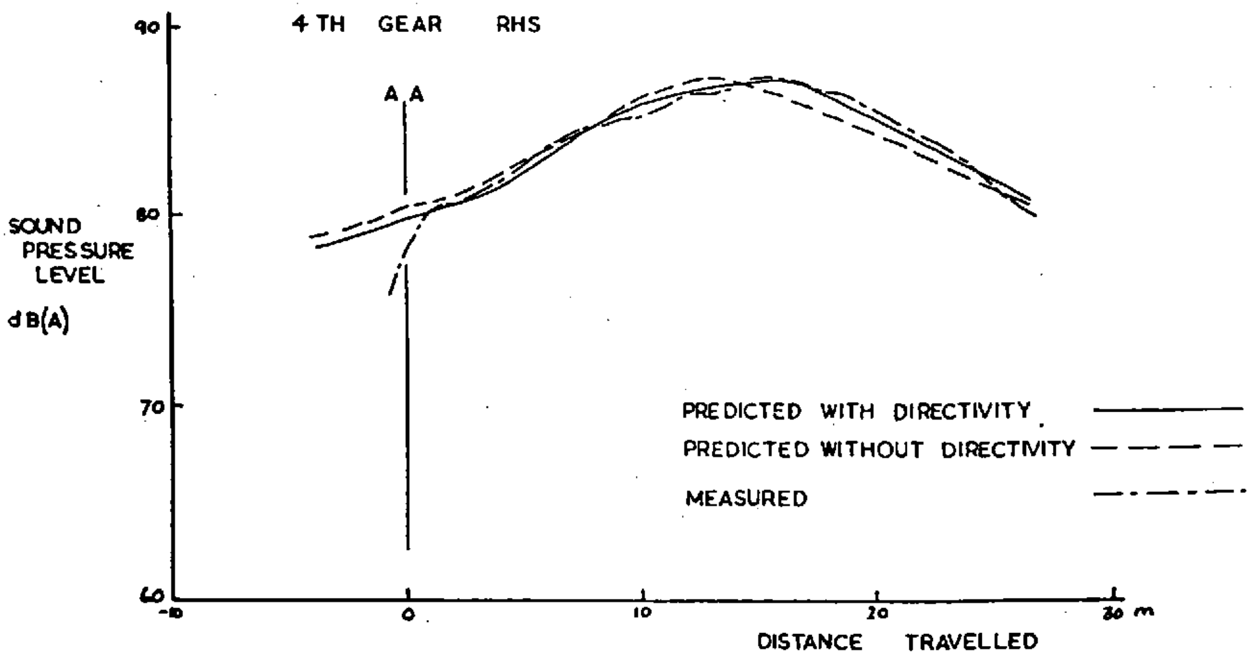

Fig.4. Vehicle drive-by noise