Proceedings of the Institute of Acoustics

Natural Gas Vehicle.

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1. INTRODUCTION

The trend for inner city supermarkets continues, and trading hours are expanding to suit the changing needs of the public. To provide good quality fresh produce, chilled food deliveries have to be made in noise sensitive residential areas at particularly sensitive times of the day. The resultant noise problems have led to the use of a Natural Gas powered vehicle with articulated trailers. This paper discusses in general terms the thinking leading up to this application and outlines some of the advantages over the more conventional diesel engine.

Engines running on natural gas fuel have been said to be quieter than diesel engines. This report follows on from investigations into noise problems outside the Marks and Spencer Kings Road store where chilled food is delivered in the early hours of the morning. Excessive noise was caused by the diesel truck having to make a number of forward/reverse manoeuvres when parking the trailer in the loading bay because of very restricted road access. A quieter engine was clearly desirable.

2. BACKGROUND

Following a series of complaints from local residents, a formal notification of a noise problem was made to Marks and Spencer staff by the local Environmental Health Officer, with the possibility of an injunction being served by the Royal Borough of Kensington and Chelsea.

The Marks and Spencer store at Kings Road is situated close to an expensive residential area. The residents live about 50m away from the loading bay. In order to provide fresh produce ready on the shelves for the start of the day, deliveries need to be made during the night. These were generally made with a large diesel truck pulling a 38 tonne insulated trailer. The 40 foot trailer has to be reversed into a loading bay, the truck departs and leaves the trailer in place ready for unloading.

The first night time survey, based on a BS 4142 assessment showed that the complaints were justifiable. The fresh produce delivery at around 3 am corresponds to the quietest time of the night, with background noise levels measured as La90 of around 44 dBA. One of the major noise sources was found to be the noise from the reversing manoeuvres. Maximum levels of

around 96 dB were measured, with a duration of over five minutes. A substantial reduction in noise level and duration was obviously required.

With a revised reversing procedure put in place, and good driver instructions these noise levels were brought down to around 86 dB, but the final improvement was only made by using the Natural Gas vehicle. This achieved levels of 80 dB maximum and a reversing duration of only two minutes.

BOC Distribution Services, in conjunction with Varity-Perkins, had just completed development of an ERF articulated truck, with a Perkins engine specifically designed for use on Natural Gas. The engine is a 12 litre straight 6, of 320 hp output, with lean burn 26 to 1 air / fuel mixture, and electronic management systems.

The main advantage of natural gas engine technology over conventional diesel is the great reduction in unwanted emissions. Natural gas emits less carbon monoxide, nitrogen oxides and non-methane hydro-carbons than petrol or diesel, and is an abundantly available fuel. Natural gas combustion results in almost no atmospheric emissions of sulphur dioxide or small particulate matter, and far lower emissions of carbon monoxide, reactive hydro-carbons, and nitrogen oxides than combustion of other fossil fuels.

The main disadvantages of the Natural Gas vehicle compared to diesel are that it costs about £ 20,000 more per vehicle to build, (a 300 hp conventional diesel truck costs in the order of £ 75,000), and the running costs are higher because of the high level of duty levied on natural gas. There are moves by the industry to try to get the tax reduced on natural gas in the next budget.

The tests described in this report were made as soon as the Natural Gas engine was ready for use in routine service. The objective was to quantify the reduction in engine noise between the same type of truck; one with a Natural Gas engine and the other a standard Diesel engine.

It has been noted that when manoeuvring a trailer the truck engine runs most of the time at low rpm including a significant time at minimum speed- tick-over. The noise measurements would need to include this so the tests were planned to include running at tick over and at a series of increasing engine speeds. It was also considered that measurements should only concentrate on engine and exhaust noise. Other noise sources which contribute to the total noise of a moving vehicle when driven on a road such as gearing, transmission, tyre/road surface interaction, and aero-dynamic wind noise, would be assumed to be the same for any type of fuel being used.

There is a European directive 92/97/EEC for vehicle noise measurement, based on a drive by test, but this is conducted at a speed of over 50km per hour (greater than the UK urban speed limit), and is therefore not really representative of most slow speed urban driving conditions.

Therefore it was decided that to determine the reduction in noise from the use of Natural Gas, each truck should be stationary and without a trailer and measurements taken as a series of gradually increasing engine speeds, starting with tick -over.

BOC Distribution Services agreed to make available at their Hemel Hempstead depot the ERF articulated CNG (compressed natural gas) truck equipped with the newly developed Perkins Natural Gas engine, and one standard ERF articulated truck to Euro II spec. with a Cummins Diesel engine, for direct comparison. Both engines were of similar power, approximately 300 HP.

3. MEASUREMENTS AND OBSERVATIONS

The truck on test was parked in a large open area at the back of the Hemel Hempstead depot. The noise measurements were taken at a distance of 7.5m from the centre line of each truck, and from both sides. Each truck was positioned in the same location, and the measurements made within thirty minutes of each other, to keep all external factors constant.

CEL 593 and CEL 275 type 1 sound level meters were used for the main monitoring of noise levels, also a digital recording was made with a Sony TCD7 DAT recorder. Both meters were used at a height of 1.5m above ground on a tripod, with a wind shield. The CEL 593 meter was set in third octave sound level meter mode, measuring 15 second Leq values for all third octave frequencies, manually started at each measurement period, once the engine was running smoothly at each particular speed. The temperature was around 27° C., and the weather was calm and dry.

The Diesel truck had a tick-over of 600rpm, and would not rev above 1500 rpm due to the engine management system limiting the rpm when not in gear. The Natural Gas truck had a tick-over of 500 rpm., and would rev to 1900 rpm before the management system limit was reached.

Listening subjectively to both trucks, the Natural Gas engine was much smoother in sound quality, and much less intrusive. There was no particular tonal sound, or rattle, but more of a quiet roar; the Diesel engine had the typical pulsing, beating sound and a strong tonal content such that the engine speed was readily apparent to the ear.

4 RESULTS AND ANALYSIS

At each engine speed the 15 second Laeq measurements for left hand side and right hand side were taken, then averaged, and tabulated. The results are shown in table 1. below as Sound Pressure Level, measured as Laeq against engine speed in rpm for the Natural Gas engine and the diesel engine.

Table 1. Engine Noise Sound levels, Laeq, from Natural Gas, and Diesel trucks.

Engine Speed rpm.	Natural Gas	Diesel.	Difference, ie Noise reduction. dBA
500	(tick-over) 61 dBA	not possible. *	7 dBA (tick-over)
600	64 dBA	(tick-over) 68 dBA	4 dBA
1000	67 dBA	73 dBA	6 dBA
1200	69 dBA	74 dBA	5 dBA
1500	72 dBA	77 dBA	5 dBA
1900	75 dBA.	not possible. *	-

These results are shown as a graph in Fig 1.

The sound levels from the Natural Gas truck measured at one metre from the front grille, and at one metre from each side of the cab were all very similar at 70 dBA at tick-over.

5.0 DISCUSSION

The noise level increased steadily with engine speed, as expected see Fig 1.
The noise level was lower at all speeds with the Natural Gas engine, and was always at least 4 dBA less than the Diesel engine at the same rpm.

On the Natural Gas engine, the minimum running speed ("tick-over") was lower, at 500 rpm, compared to 600 rpm on the Diesel. Consequently the noise level at tick-over on the Natural Gas engine is significantly lower than the diesel engine by about 7 dBA. When stood near the cab at tick-over it was noticeably quieter than the diesel engine. The driver agreed and said that it was generally a much quieter truck to drive.

The Natural Gas engine develops high torque at low revs; the driver confirmed that a fully loaded trailer could be pulled away at lower rpm than with a diesel truck. Therefore the manoeuvring required when parking a trailer can be done at lower revs, and consequently the

noise level during parking would be lower with a Natural Gas truck than with a conventional Diesel truck. The average speed of traffic in London has been reported to be as slow as 11mph, and so any reduction in low rpm noise is very welcome for a quieter environment.

The sound levels at any particular speed measured each side correlated very well, in fact there was no more than 1 dBA difference from left hand side to right hand side at any engine speed for the Natural Gas vehicle. On the Natural Gas vehicle the exhaust exits at high level on the left hand side, pointing away from the truck; the small differences between left hand side and right hand side readings show that the exhaust noise is not a major contributor to the over-all engine noise.

Comparison of the frequency spectra of the two engines at tick-over show a completely different type of sound. See Figs. 2 and 3 for typical spectra at 500/600 rpm. The subjective opinion was that the Natural Gas engine produces a more pleasant and smoother type of sound.

6. CONCLUSION

These measurements have confirmed that this Varity-Perkins Natural Gas engine is much quieter than the Diesel, at all engine speeds. At low rpm around tick-over the Natural Gas engine was a significant 7dBA quieter than the Diesel.

With the recent development of more city-centre stores and night time delivery, the consequent noise levels and time spent manoeuvring at low rpm in noise sensitive residential areas is now becoming crucial. In these situations the Natural Gas truck is to be preferred.

The subjective opinion was that the Natural Gas engine produces a more pleasant and smoother type of sound, which was much less annoying or intrusive, and thus will be less likely to give rise to complaints.

The Natural Gas engine has shown a significant reduction in noise level at low rpm and is a much more environmentally friendly option to the conventional diesel engine. It has been recommended that this type of truck is considered for use in any environmentally sensitive application.

Natural Gas Vehicle.

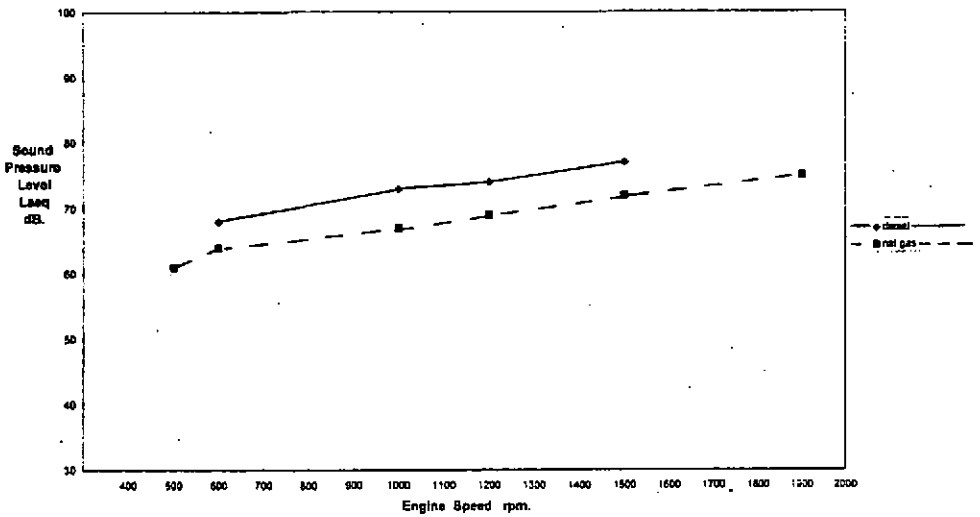

Fig.1 Graph of Engine Noise from Natural Gas Vehicle and Diesel truck.

Natural Gas Vehicle.

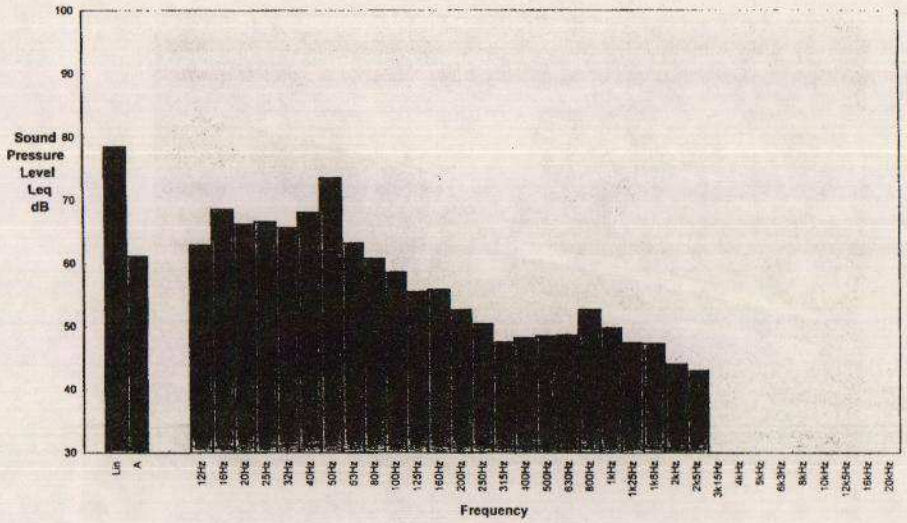

Fig.2 Frequency Spectra from Natural Gas engine, at tick-over, 500 rpm.

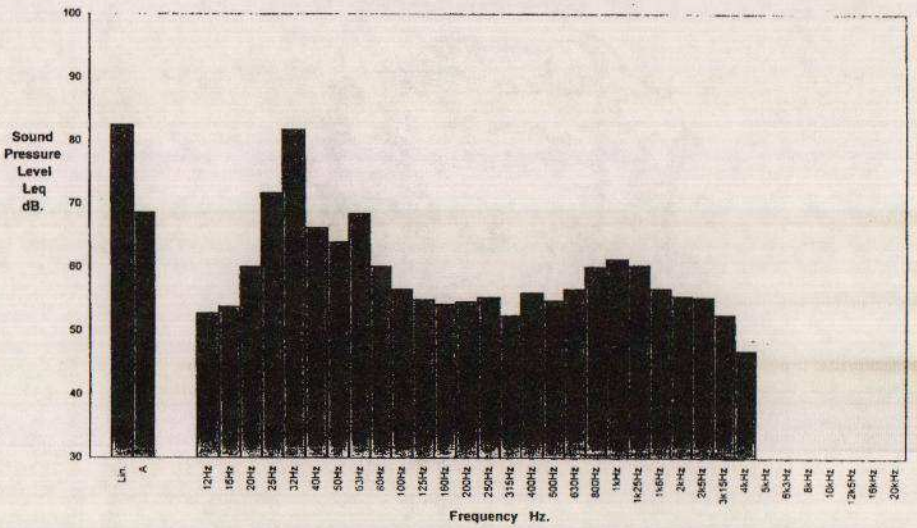

Fig.3 Frequency Spectra from Diesel engine, at tick-over, 600 rpm.

Natural Gas Vehicle.

Fig.4 Natural Gas Vehicle.

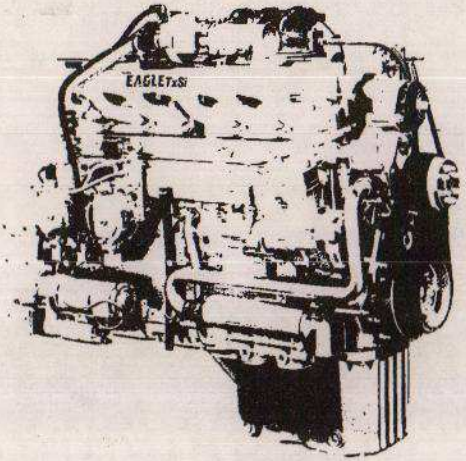

Fig.5 Varity-Perkins Natural Gas Engine