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VEHICLE NOISE EMISSION AT LOW SPEED

J Kragh

Delta Acoustics & Vibration, Danish Acoustical Institute, Lyngby, Denmark

1. INTRODUCTION

A revised Nordic prediction method for road traffic noise will be published in 1996. An essential part of the revision is an update of vehicle noise emission.

The latest revision of the Nordic prediction method was made in 1989, but source noise emission has remained unchanged since the method was originally published in 1978. The relevant changes in the 1996-version proposed in [1] are, cf. Fig. 1:

- 2 or 3 dB reduction of heavy vehicle noise levels below 50 km/h. At speeds between 50 km/h and 90 km/h this noise level reduction gradually decreases to zero.
- 6 dB reduction of light vehicle noise levels at 30 km/h, while at 50 km/h there is no reduction.

These changes should be seen in connection with a change in the method: until now the *posted speed* limit has been used, but in the future the *actual speed* shall be used as an input.

In this paper some results of measurements made by DELTA Acoustics & Vibration are presented.

2. BACKGROUND

Users of the Nordic prediction method for road traffic noise have often questioned whether the basic noise levels could still be valid, as they have remained unchanged since the late 1970s while vehicle noise limits have been tightened considerably over the years. We have looked into this by a special series of measurements made in Denmark, Finland, Norway, and Sweden [2]-[5] in 1993-94 at roads with low-speed traffic and also by analysing other available evidence from measurements made since the mid-1980s.

A total of 7000 individual light vehicle and 1700 heavy vehicle pass-by noise levels were available. They had been recorded - together with the individual vehicle speed - since the mid-1980s at about 50 different sites with speed limit 30-60 km/h. Also, data from 3400 light and 2100 heavy vehicle pass-bys with medium

speed were available. These had been recorded at 15 sites on rural main roads with vehicle speed 60-120 km/h.

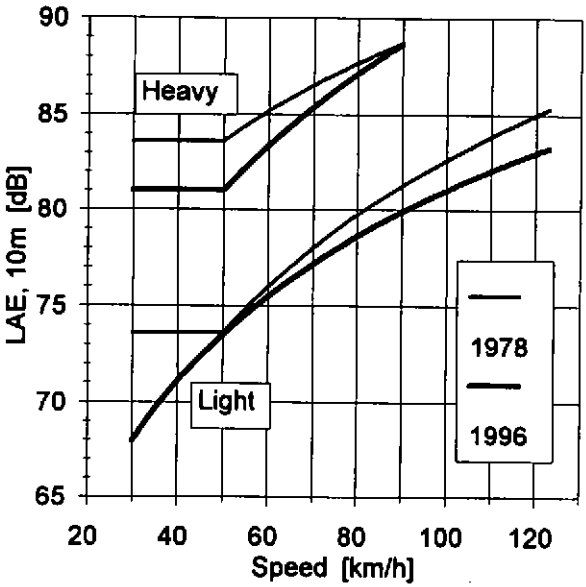

Fig. 1. *Basic noise levels in the Nordic prediction method for road traffic noise. In 1978 the* ***posted speed*** *limit should be used, in the 1996 proposal the* ***real speed*** *shall be used.*

3. LOW SPEED DRIVING PATTERN

In the series of measurements at low-speed sites we measured pass-by noise as well as the speed of individual vehicles in the normal traffic. We noted for each vehicle whether the vehicle was accelerating or driving at constant speed or decelerating during pass-by. We normalized all results to a distance of 10 m.

The low-speed sites were chosen at roads with various speed limits and with a variety of traffic regulation (bumps, narrowing roads, etc.) so that a variety of driver's behaviour ("driving pattern") would be represented in the data. We aimed at collecting data from at least 50 light vehicles at each site and as many heavy vehicles as possible within the time it took to record the noise from the light vehicles. Heavy vehicles do not often drive in streets with the kind of traffic regulation we deal with here. We gave priority to measuring at as many different sites as possible rather than to measure noise from many vehicles at just a few sites.

In the Danish part of the investigation we tried in collaboration with the Danish Road Directorate to classify the measurement *sites* into sites with "even" and "uneven" driving, respectively. We could not obtain support for measuring actual driving patterns. Instead we based the classification on an assumption that driving is "even" on local roads and in efficiently traffic regulated streets while driving is "uneven" on through roads, especially in the vicinity of traffic lights. This classification

of ours did not correlate well with the measured noise levels. In some cases the average noise level at a site with "uneven" driving was higher than the noise level at a site with "even" driving at the same average speed, but just as often the opposite was the case. We concluded that our "intuitive" site classification was not valid and that further investigations of driving pattern as a function of road design would have to be made.

Fig. 2 shows, as an example, "raw" measurement results from one site with reduced road width and 40 km/h posted speed limit (Marksvinget Ø, Køge). For 111 light vehicles we have shown the maximum noise level (with time weighting S) at 10 m distance as a function of speed, classified according to driving behaviour during each pass-by: Accelerating, Constant speed, or Decelerating vehicles.

The results are widespread especially at the lowest speeds. The speeds were between 24 and 53 km/h with an average of 37 km/h, A-weighted noise levels were between 55 and 70 dB with an average of 62 dB. Both the highest and the lowest noise levels were recorded at the lowest speeds.

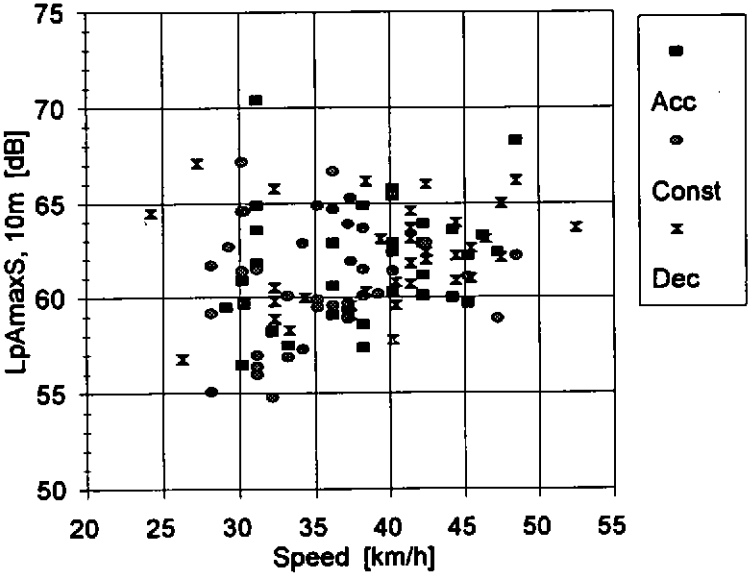

Fig. 2. Example from one Danish site. Noise level as a function of speed for 111 light vehicles grouped according to driving behaviour.

Low Speed Results

The general trend in the Danish low-speed data is summarized in Fig. 3 based on all recorded data. The bottom three curves in Fig. 3 show averages for 953 vehicles at 13 measurement sites. For each speed (in steps of 1 km/h) we have shown a "running" average noise level, i.e. the energy average for all vehicles passing with that speed plus and minus 2.5 km/h. We used this running average to smooth the curves. Noise levels from accelerating light vehicles were 2 or 3 dB higher than noise levels from constant speed light vehicles below 50 or 60 km/h while noise levels from decelerating light vehicles were 2 or 3 dB lower.

The upper three curves in Fig. 3 show the results for 101 heavy vehicles from the 13 sites, indeed a small number of vehicles. Indications are that below 40 or 50 km/h noise levels from accelerating heavy vehicles are 2 or 3 dB higher than noise levels from constant speed heavy vehicles while noise levels from decelerating vehicles are up to 8 dB lower.

Driving behaviour is important for vehicle noise emission, and there is a need for us to be able to distinguish between various types of driving behaviour in order to obtain accurate prediction of traffic noise levels. At each measurement site there was a mix of the three types of driving behaviour. Unfortunately we were unable within the given frame of work to identify relevant types of road associated with such different average driving behaviour.

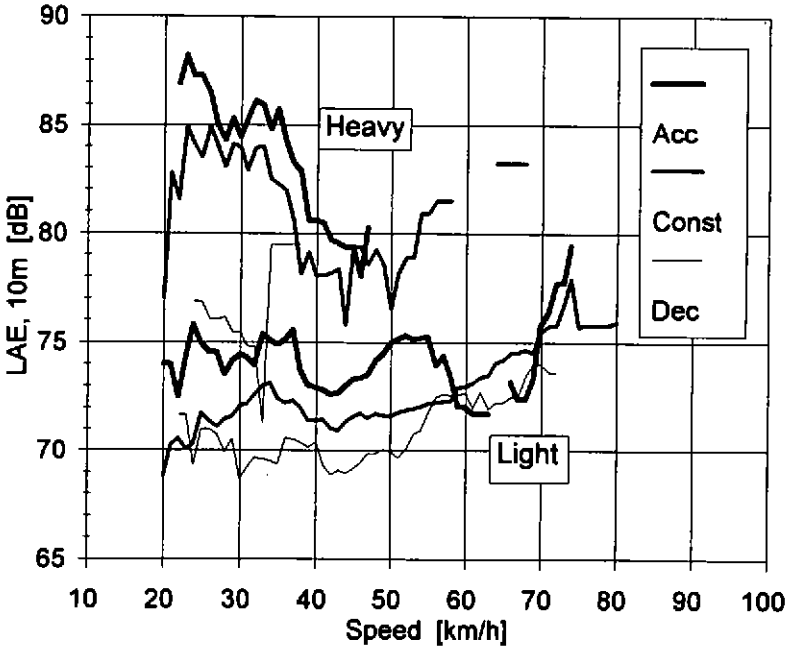

Fig. 3. Average noise levels from heavy vehicles and light vehicles with different driving behaviour, as a function of the speed, cf. text.

4. MEDIUM SPEED DRIVING ON RURAL MAIN ROADS

A summary of data on medium-speed pass-by noise levels measured at rural main roads is given in Fig. 4. All results have been normalized to Sound Exposure Levels at 10 m distance and to a speed of 80 km/h. Heavy vehicles contain 70% multi-axle and 30% dual-axle vehicles, light vehicles are 90% passenger cars and 10% delivery vans.

The figure shows average measurement results as a function of the year of the measurement. Numbers labelling data points in Fig. 4 refer to literature not includ-

ed as references here due to lack of space. Data from 3400 light and 2100 heavy vehicle pass-bys at 15 sites recorded since 1985 are included, mainly with a speed of 60-120 km/h. The road surfaces were dense asphaltic concrete in good condition, with maximum chipping size 12 or 16 mm. At two of the sites DELTA Acoustics & Vibration has measured each year during a 6-year period. The results of these measurements are labelled 10-15 in Fig. 4.

Almost no change in medium-speed pass-by noise levels has taken place over the years. The main reason for the variation in noise levels in Fig. 4 measured in 1985 or later is believed to be variation in road surface condition. E.g. the data points labelled 10-15 in Fig. 4 illustrate the development in average noise levels at the same two test sections of a main road during their first 6 years in service. Light vehicle noise levels have increased by 2 or 3 dB during these 6 years, while heavy vehicle noise levels have increased by 1 or 2 dB.

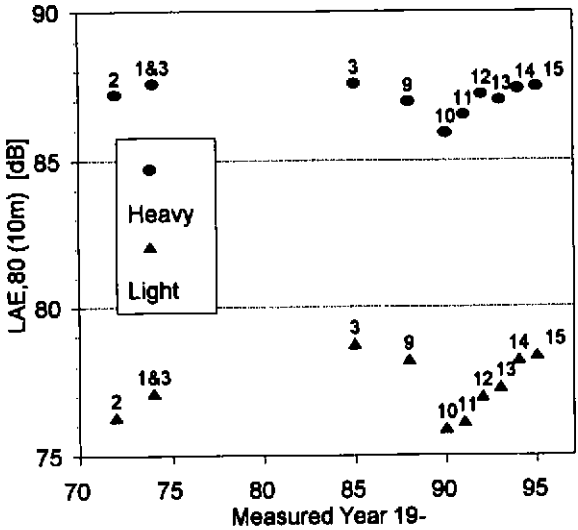

Fig. 4. Average medium-speed pass-by noise levels at rural main roads as a function of the year of measurement.

5. COMPARISON WITH PROPOSED BASIC NOISE LEVELS

In Fig. 5 the proposed basic noise levels from Fig. 1 are compared with the measurement results from Fig. 3 and 4. For heavy vehicles the proposed new Nordic basic noise levels are in reasonable agreement with the DELTA measurement results for constant speed driving although a 2 or 3 dB increase at the lowest speeds would improve the fit. For light vehicles the trend in our measurement results is that the noise levels are higher and less speed dependent at low speeds than the proposed new Nordic basic noise levels. The revised final version of the Nordic prediction method will be based on measurement results from the other Nordic countries as well as on our data

6. CONCLUSIONS

We conclude that there is a need for future development of methods to identify the driving pattern on various types of road. Until we can identify such driving patterns we must accept an uncertainty of 2 or 3 dB in results of noise level predictions

caused by variations in this parameter. Our measurement results indicate a need to reconsider the proposed new Nordic basic noise levels. Especially at low speeds there appears to be substantial differences. The new Nordic prediction method could perhaps contain the information that when many vehicles in the traffic accelerate, then higher noise levels should be expected. This increase in noise level should be decided upon after analysing data from Norway, Sweden, and Finland as well as ours.

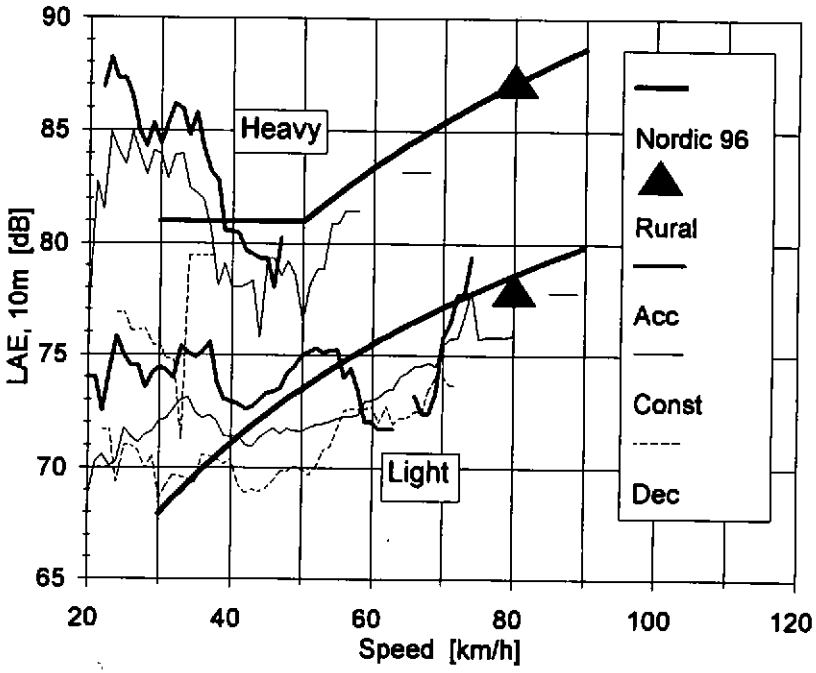

Fig. 5. Comparison between results in Fig. 1, 3, and 4. For each vehicle category the full drawn curve is the proposed new Nordic basic noise levels, the thinner lines are DELTA Acoustics & Vibration measurement results from low-speed roads with various driving conditions, and the triangular points are from medium constant-speed rural roads.

References

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