Proceedings of the Institute of Acoustics

NOISE EMISSION LEVELS FROM PASSENGER CARS - PAST, PRESENT AND FUTURE

Truls Berge

Acoustics Research Center/SINTEF DELAB N-7014 Trondheim Norway

1. INTRODUCTION

For more than 100 years motor vehicle noise has been a source of annoyance to the public. Despite the imposition of noise legislation and developement of quieter vehicles, traffic noise levels have increased during this century, because of the general increase in traffic density.

In some countries legal requirements for vehicle noise go back as far as the 1930's. In UK the first sosiological studies on road traffic annoyance were performed in 1933 and the the first limits for maximum permissible noise levels from vehicles were proposed in 1935. However, it was not before the late 60's and early 70's that most industrialised countries decided on a joint strategy to fight traffic noise.

In most European countries, the control of vehicle noise emission levels by legislation was introduced around 1970. Within the EC, the first limit for passenger cars was 84 dBA, measured according to ISO 362. This method was developed a few years earlier (1960- 64). The basic principles of this method still are maintained; full acceleration over a distance of 20 m - the maximum noise level measured at a distance of 7.5 m. Only gear specifications have been changed over these years. However, there are now proposals for a further tightening of the measurement conditions, especially regarding the specification of the test track surface, (1).

The proposed limit of 74 dBA from 1995 means a reduction of 90% of the noise energy from a 1970-car of 84 dBA, which is a considerable reduction. This tightening of noise limits must clearly have influenced the design of engine and exhaust systems of vehicles.

The main question to be asked is:

Do we experience a similar reduction of the actual noise levels from vehicles under normal urban driving conditions?

To be able to predict what the consequences of a 74 dBA limit will be, we must try to find a sensible answer to the above question.

Evaluation of the consequences of tightening the noise limits is important in many ways. One of them is traffic noise prediction models.

In many countries these prediction models are used to define any need for additional screening, improved sound insulation, economical compensation, etc., when a new road is planned or an existing road is improved. Because of the economical consequences involved it is very important to predict noise levels as accurately as possible. All prediction models have vehicle noise emission levels of some sort as main input parameter. These input levels are empirically based, i.e. reflecting the actual noise levels measured in real traffic at a given time. From this it is obvious that if one can observe any reduction of general traffic noise levels from individual vehicles as a consequence of legislative measures, any traffic noise prediction model has also to be changed as well.

In this paper I will present some noise emission levels from past and present passenger cars, as a foundation for evaluating future trends.

2. VEHICLE NOISE CONTROL

It is well documented that one of the most cost-efficient methods of reducing traffic noise levels, is to reduce the noise emission levels from individual vehicles. This will benefit the total environment and not only local improvement, as given by for example screening.

Vehicle noise control by legislation can be described by the following steps:

Step 1: A decision on a political level (national or international) to lower the noise limit for vehicles is taken.

Step 2: New noise limits are introduced from a specific date.

Step 3: All new vehicles are type approved according to the new regulations.

Step 4: A general reduction of traffic noise levels is obtained as a result of quieter vehicles.

This simple model describes what we all like to see, that a given political decision gives the desired effect.

However, this model has some weaknesses that must be considered:

- there is a considerable time-delay involved, because it takes quite a number of years to replace old noisy vehicles (in Norway about 15 years at the moment!)
- the model is based on the assumption that all new vehicles which comply with the new noise regulations are equally quiet under normal urban driving conditions. The present situation is that the type approval method used in Europe (ISO 362) has several weaknesses. In particular, the driving conditions for passsenger cars during the test are poorly correlated with normal traffic conditions
- the model is based on the assumption that new vehicles are well maintained in use. To ensure this, in-service noise test routines must be introduced.

3. THE PAST

Any prediction of what will happen in the future with respect to the effect of more stringent noise limits for vehicles, must be based on some historical experiences.

Vehicle noise levels have been measured in basically two ways:

- type approval levels
- real traffic conditions

Figure 1 shows the mean value for type approval levels from passenger cars in the period 1970-1990, depending on production year. This data is collected from measurements performed in Sweden, Germany and Norway, as well as data collected from vehicle manufacturers, (2,3,4).

The mean value has been reduced in the order of 5-6 dB, i.e. in agreement with the reduction of the limits. These results are also confirmed by de Veer and Ullrich, (5), which states that the type approval levels in Germany for passenger cars were reduced with 2 dB in both the periods 1970-80 and 1980-90, i.e. a total of 4 dB.

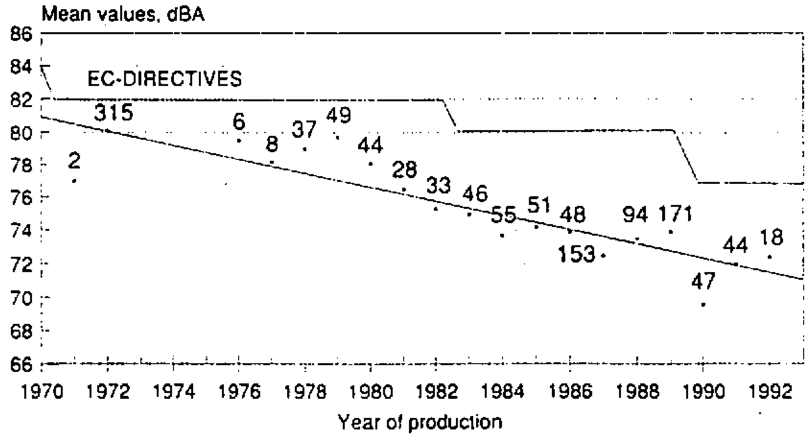

Figure 1. Noise emission levels measured according to ISO 362 for passenger cars in the period 1970-1992. Mean values are given for each year.
Numbers above points are total number of measured cars.

Figure 2 shows Norwegian type approval measurements (mean values) of passenger cars in the period 1980-92. These are measurements performed by the same organisation, using the same equipment and on the same location (Gardermoen/Oslo).

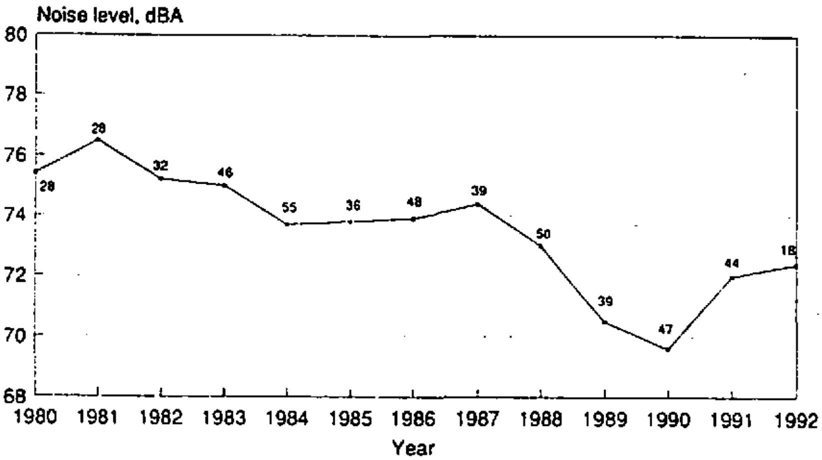

Figure 2. Mean values of type approval levels (ISO 362) from passenger cars in the period 1980-1992. Measured by Norwegian Authorities at Gardermoen/Oslo. Numbers above points are total number of measured cars.

From 1980 to 1987 there is only a minor change (1-2 dB) in the mean level. From 1987 to 1990, however, the level is reduced more than 4 dB. It is doubtful if the reason for this is caused by the tightening of the limit from 80 to 77 dBA in 1989.

A more likely explanation is that up to 1990, cars with 5 speed gearbox were measured in 3rd gear only and the number of these cars were increasing rapidly in the latter part of the 80's.

A reason for the extreme low levels in 1990 can be caused by the fact that a new test surface was laid in the summer of 1990 and this surface satisfies the new ISO requirements for test tracks. A closer analysis of this test surface confirms that it is a very quiet surface (6). It reduces not only rolling noise but gives type approval levels 1-2 dB lower than other ISO test tracks. From (7), we know that ISO test tracks on average gives roughly 1 dB lower homologation test values than compared to frequently used 0/11 asphalt concrete road surfaces.

From 1991 all cars with 5 speed gearbox were measured in both 2nd and 3rd gear and this explains why the mean value in figure 2 increases approx. 2 dB, for the last two years.

So what has happened with real traffic noise level in this period?

Unfortunately, there is not much data available. Monitoring vehicle noise emission levels in real traffic over a long period of time is a difficult task. The measurements can be influenced by any changes in the road surface or other physically changes at the measurement spot. Also the influence of tyres can be significant on pass-by levels, even at moderate vehicle speeds (40-60 km/h).

de Veer and Ullrich have published an investigation which tries to avoid the latter problem, (5). Pass-by levels from approx. 2-300 cars have been monitiored at the same location at three different periods from 1975 to 1990. The road has a grade of 18% and thus mainly driveline noise should be monitored.

The results are given in table 1. In the period 1975-82 the noise levels were unchanged (as well as the limit). A reduction of approx. 2 dB was found in the period 1982-90, which is equivalent to the reduction of noise limit.

Table 1. Average pass-by noise levels from passenger cars on a road with 18% grade. From (5).

Measuring date	7/1975	4/1982	5/1990
$\bar{v}$ in km/h	42	43	45
$\bar{L}$ in dBA 35< v < 60 km/h	71.6	72.2	70.6
$\bar{L}$ in dBA 40< v < 50 km/h	72.2	72.7	70.5
Noise limit in dBA	82	82	80

No change in noise levels on a highway with an average speed of 120 km/h, were found in the period 1975-90.

Another investigation in Sweden by Sandberg found that in the period 1974-88 the noise level increased with 1 dB at low speeds (35-70 km/h) and 2 dB at higher speeds, (8).

These investigations indicates that even if type approval levels from passenger cars seem to have decreased on average 6-8 dB over the last twenty years, only moderate changes in emission levels can be found in actual traffic situations.

The reasons for this are, in this authors opinion, mainly caused by the fact that there is a poor correlation between the type approval test conditions and normal urban driving conditions. But also the increasing influence of tyre noise, which masks most of the efforts by the manufacturers to bring down engine and exhaust noise.

Another aspect is that any reduction of external noise level has more been a result of the competition to produce a quieter and more comfortable interior environment for the driver and passengers, than as a result of more stringent noise limits.

On the other hand, the noise limits have probably avoided any increase in noise levels as the average engine size and performance has increased considerably the latest twenty years.

4. THE PRESENT

The present noise limit of 77 dBA was introduced in october 1989. The cars manufactured the last 3-4 years is therefore considered representative for the current situation.

In the figures 1 and 2 we presented only the mean values from type approval measurements. In figure 3 we can see the cumulative distribution of two sets of data from figure 1 and 2:

- type approval measurements on 69 cars performed by the Norwegian Authorities in 1991/92 at the Gardermoen test track
- type approval levels of 116 cars (1989 models), supplied by a wide range of manufacturers, (4).

The difference in distribution is approximately 2 dB over the whole range. As stated above, the Gardermoen test track is approximately 2-3 dBA quieter than a standard asphalt concrete surface and this is most likely to create this difference. Another reason is that the Norwegian measurents are performed on only one car of each model, while the manufaturers data must take into account the conformity of production, when they present their noise levels.

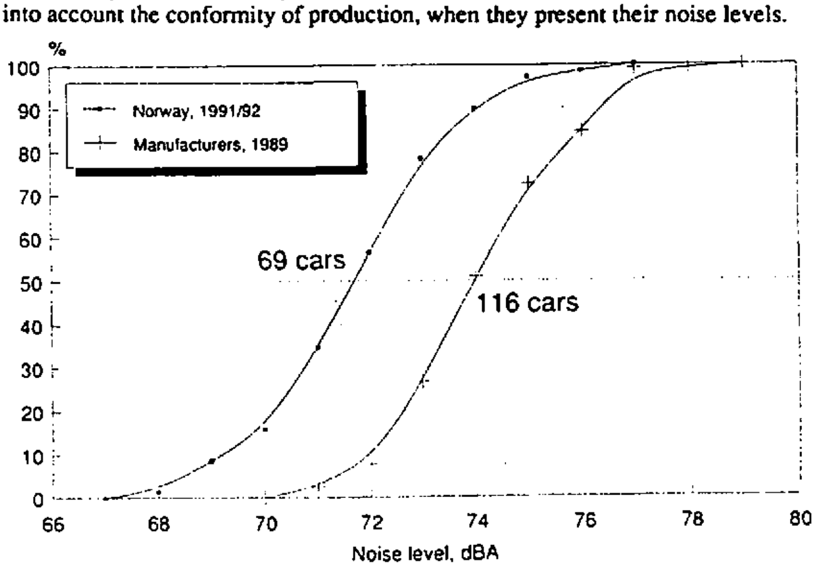

Figure 3. Cumulative distribution of noise emssion levels from passenger cars measured according to ISO 362. Comparison of noise levles as submitted by manufacturers (116 cars, model year 1989) and levels measured in Norway (69 cars, model years 1991/92).

Figure 3 illustrates, however, the importance of the location and test conditions for homologation measurements. Using the Norwegian distribution, already 90% of the present cars are below the coming limit of 74 dBA.

The poor correlation between the ISO-test and urban driving is also demonstrated in the following investigation, (9):

5 passenger cars were equipped with a microphone in the engine compartment and the noise signal was recorded, along with engine speed, load and vehicle speed. The engine noise signal was calibrated to an external level at a distance of 7.5 m.

All cars were driven through an urban drive cycle of approx. 5 km, which consisted of a wide range of different traffic conditions. The total sound energy level (Leq) was calculated as well as the Lamax-level. The cars were driven by the same driver using both an economical (low revs) and an aggressive (high revs) driving style.

The results are summarized in table 2, where Leq and Lamax-levels are compared with ISO 362-levels. The most noisy car during the ISO-test is clearly the quietest car during urban driving, regardless of driving behaviour.

Table 2. Comparison of Leq- and Lamax-levels with ISO 362- levels of 5 passenger cars. Leq- and Lamax-levels measured during an urban drive cycle of approx. 5 km, using two different drive styles. From (9).

Vehicle type, model year	Transm. system A=autom. M=man.	Leq-levels in dBA Drive style		Lamax-levels in dBA Drive style		ISO 362 levels in dBA
		Econ	Aggres.	Econ.	Aggres.	
VW Golf 1.6 1986	4M	71.3	75.2	74.7	85.6	76.0
MAZDA 323 1986	5M	71.3	73.2	71.7	81.8	72.5
FORD FIESTA 1.1 CL, 1987	4M	71.6	73.7	75.4	83.0	73.0
FORD FIESTA 1.1 CTX, 1987	CTV*	70.8	72.9	72.6	83.8	74.5
BMV 735i 1987	4A	69.9	72.4	74.3	78.9	79.0

* Continous Automatic Transmission.

These results illustrates the need for improvement or replacement of the ISO 362 test, which is now close to 30 years old! The results also indicates why the use of a single type approval level as a definition of a low noise vehicle for tax relief should be avoided.

5. THE FUTURE

It is this authors opinion that most of the present cars already meet the coming 74 dBA limit, when tested under "normal" conditions concerning test surface, temperature and tyre selection.

Any furher noise reduction measures concerning vehicle design will probably be concentrated on:

- cars with diesel engine
- high powered sportscars

Some high powered cars presently benefits by the "Lex Ferrari" (cars with engine size above 140 kW, engine/weight ratio > 75kw/t and end speed during the ISO-test > 61 km/h are tested in 3rd gear only) and probably won't need any further noise reduction.

Truck noise has not been considered in this paper, but to predict any reduction of overall traffic noise levels, we must consider this category as well. Truck noise limits have been tightened more than 12 dB (including the effect of changes in the measuremet procedure), which is quite considerable.

Both the present 84 dBA and the proposed 80 dBA limit for heavy trucks already have and will introduce quite extensive noise control measures (improved engine design, encapsulation,etc.). Most of the present generation of heavy trucks will need some sort of encapsulated engine to reach an 80 dBA limit. Such encapsulation will give an overall noise reduction, regardless of driving condition.

An investigation by Sandberg, (10), where he compared two 84 dBA trucks with two 80 dBA trucks under different driving conditions indicates that the effect of the 80 dBA limit to some extent will be masked by tyre/road noise. He has predicted a reduction of truck noise input levels to prediction models in the order of 3 dB at vehicle speed < 50 km/h and 2 dB > 50 km/h, as soon as these vehicles dominate the fleet.

6. CONCLUSIONS

Despite a considerable reduction of the permissible vehicle noise limits over the past twenty years, the reduction of traffic noise levels have been moderate in comparison. If we shall change this negative trend for the next 10-15 years, a much higher priority on vehicle noise control must be put forward on an international level. Not only to lower the noise limits, but also to increase the effort to reduce tyre/road noise, which is of growing importance.

NOISE EMISSION LEVELS FROM PASSENGER CARS

The amount of reduction in general traffic noise levels will depend on a wide range of necessary actions:

- international harmonization of vehicle noise regulations
- increase the annual removal of old, noisy vehicles, for example by introducing an age-dependent tax refund system when you scrap your old car
- introduce a common definition of a low noise vehicle and tax incentives to stimulate customers
- introduce noise tests of vehicles in-use (is about to happen in most European countries)
- improve the present type approval test procedure ISO 362 (test surface, temperature, gear/rpm-specifications), or even replace it
- introduce separate tyre/road noise regulations (there are proposals for this within the EC and standardisation work within ISO is about to start)

If all (or most) of these measures are introduced within the next 3-4 years, we have the following predictions for a reduction of the general Leq-levels (24hrs in the Nordic countries) around year 2006, compared with the levels in 1978:

* Vehicle speeds < 50 km/h: - 4 dB
* Vehicle speeds 50 km/h: - 2 dB

Kragh et al., (11), have predicted the following reduction of Lmax-levels from individual vehicles in year 2006, compared with levels in 1978:

* Light vehicles: - 2 dB
* Heavy vehicles: - 5 dB

These are reductions at low and medium speed ranges. At higher speeds no reduction of Lamax-levels are expected (unless quieter tyres/roads are introduced to a wider extent).

In general, we can expect quieter engines, but more cars, higher road speeds, wider tyres and dominating tyre/road noise.

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ISBN 1 873082 44 4