Temperature Effects on Road Traffic Noise Measurements

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***Abstract*- Since 2000, the Dutch National Institute for Public Health and Environment (RIVM) carries out a noise monitoring program, commissioned by the Dutch Ministry of Infrastructure and Environment. The program involves continuous measurements along several motorways in the Netherlands. At each monitoring site, LAeq values are registered hourly, together with traffic volumes and temperature. The extensive data series allow an evaluation of temperature effects on measured noise levels. This paper gives an overview of effects seen in previous years along the A2 and N256 motorways in the Netherlands. At the N256 a distinction of effects from passenger cars and trucks is made. In addition to previous results, latest results of 2010 and analyses will be discussed and compared with guidelines at use for temperature correction.**

Keywords- Tire Road Noise; Traffic Speed; Measurement; Temperature

I. INTRODUCTION

Temperature is well-known to be of influence on noise measurements of road traffic noise [1, 2]. In practice, one finds that at higher temperatures noise levels caused by road vehicles decrease. Figure 1 shows an example of results that were obtained from the RIVM noise monitoring site along the A2 motorway at Breukelen in the Netherlands in 2005 [3].

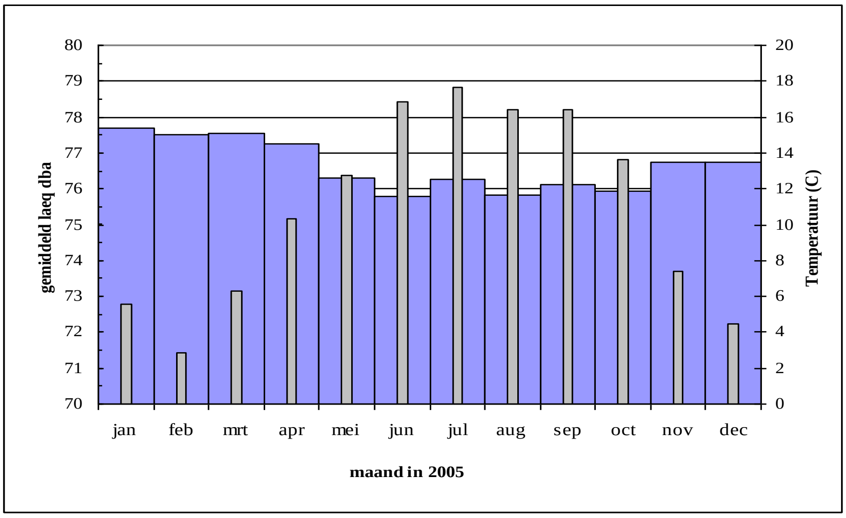

Fig. 1 Seasonal trend in noise levels measured at Breukelen in 2005

The temperature effect is probably caused by an increase of stiffness of the tires at lower temperatures, which results in more tyre-road impacts, stronger tire vibrations and higher noise emission levels. The temperature effect must be taken into account before evaluation of test measurements. For example, when testing the acoustic performance of road surfaces, we use Statistical Pass By-measurements (SPB, ISO 11819-1) or the Close ProXimity Method (CPX, ISO/CD 11819-2[4]). In order to compare different roads or cars one needs to correct the measured noise levels to standard temperature conditions. The correction that is usually applied, is given by a constant times the difference of the average temperature during the measurements and a standard reference temperature of 20°C [5]:

$$L_{A\max}(20) = L_{A\max}(T) - \alpha \cdot (T - 20) \quad (1)$$

In Eq. (1), α is the (negative) temperature coefficient in dB/°C and L_{Amax} is the maximum noise level measured in 'Fast' during drive-by in dB(A). When measurements of L_{Amax} are carried out at temperatures below 20 °C, Eq. (1) results in a negative correction and the measured levels are lowered. The problem is that in practice one finds different values for the constant, depending on the road surface or vehicle type. Also, some measurements seem to indicate that the effect only occurs above a certain threshold temperature, as shown in Table 1 for measurements along Dutch highways in 2006 [6].

TABLE 1 TEMPERATURE EFFECTS FOR THE TOTAL TRAFFIC FLOW MEASURED ALONG DUTCH MOTORWAYS IN 2006

Site	Temperature Effect	Range
Amsterdam A10	−0.1(T − 6)	T > 6 °C
Rotterdam A20	−0.1(T − 14)	T > 14 °C
Utrecht A12	−0.12(T − 10)	T > 10 °C
Voorburg/ The Hague A12	−0.12(T − 10)	T > 10 °C

The Dutch standard for calculation of road traffic noise correction now uses a temperature coefficient $\alpha = -0.05$ dB/°C for passenger cars and $\alpha = -0.03$ dB/°C for trucks [7]. However, values for α found in practice can range from −0.02 to −0.12 dB/°C [8, 9] and it is not fully clear if a linear correction below 5-10 °C is really justified in all situations (see Table 1). The ISO working group 27: "Tyre/road noise - Temperature effects" in ISO/TC 43/SC 1 "Noise", has recently studied this issue in order to obtain a standardized method that can be used to take into account different factors that can be of influence. This paper presents an analysis of extensive noise measurements that were carried out in 2010 in the Netherlands along the N256 motorway at Collijnsplaat. The paper discusses the influence of temperature on the noise levels as was found at this site.

II. MEASUREMENT SET UP

The measurements were done at the N256 motorway near Collijnsplaat in the southwest area of the Netherlands. The data comprises Leq-data for each hour of measurement over the year 2010. The noise monitor consists of a microphone LD 2541 microphone manufactory with a statistical analyser LD870 and a GSM-modem with antenna with battery and charger. The measurement set-up is shown in Figure 2.

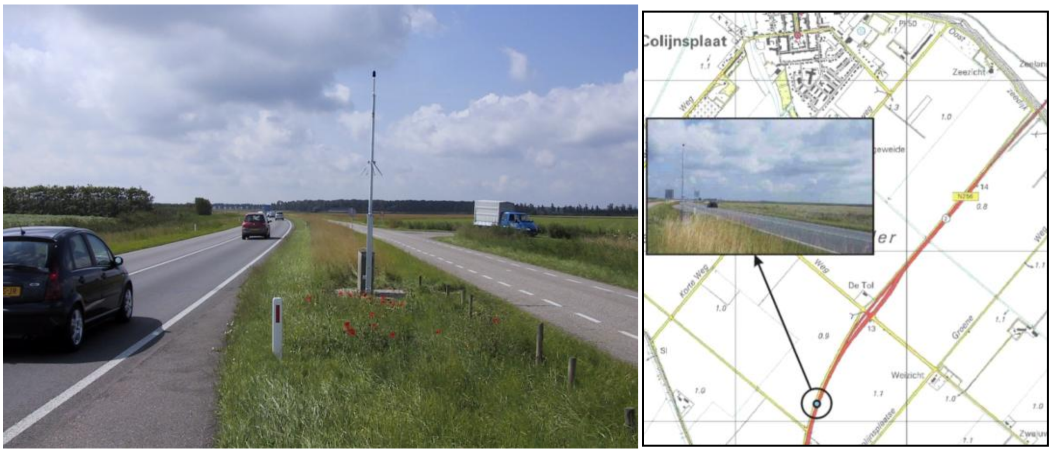

Fig. 2 RIVM noise monitoring site along the N256 motorway at Collijnsplaat

The pavement of the N256 consists of Dense Asphaltic Concrete (DAC). Apart from noise measurements, traffic volume and speed are also monitored. Traffic cables under the road surface allow determination of the type and speed of each individual vehicle passing by. Temperature data is continuously measured by a weather station of the Dutch Royal Meteorological Institute (KNMI). The KNMI station 'Wilhelminadorp' is located at approximately 8 kilometers south of the noise measurement site at the N256. The difference in location between the KNMI station and the noise site causes an uncertainty in temperature in the order of ± 2 °C, which at α= 0.1 causes an additional inaccuracy of 0.04 to 0.2 dB(A) to the microphone inaccuracy. The temperature range of all the pass-by measurements in 2010 varied between -6 to 19 °C.

III. DATA ANALYSIS

For data analysis, only the hours in the night between 2:00 and 4:00 were considered. In these hours the spacing between the cars is so large that the noise event of each individual vehicle could be matched with the traffic data (speed and type of vehicle). Measurements during rain or strong winds were not taken into account. Over 2010, 8750 noise events were measured and suitable for analysis. Of these events 68% were from passenger cars, 16% medium trucks and 16% heavy trucks. For each rounded temperature value, all corresponding measurements were collected and plotted into a scatter diagram. An example is given in Figure 3 for passenger cars in 2010 at a rounded temperature value of T = 4 °C. For each scatter diagram, a regression was applied and the best fit logarithm coefficients a_T and b_T were determined for the equation:

$$L_{A\max}(v,T) = a_T + b_T \log(v) \tag{2}$$

with v speed in km/h and T temperature in °C. Next, Equation (2) was used to determine the influence of temperature for all passenger cars passing by at a certain constant speed. We looked at $L_{Amax(T)|v=const}$ and determined the temperature coefficient α_v, by linear regression in the equation:

$$L_{A\max}(T) = L_{A\max}(20) - \alpha_v \cdot (T - 20) \quad (3)$$

This enabled us to estimate the temperature coefficient αv for passenger cars depending on speed. The results are given in Table 2.

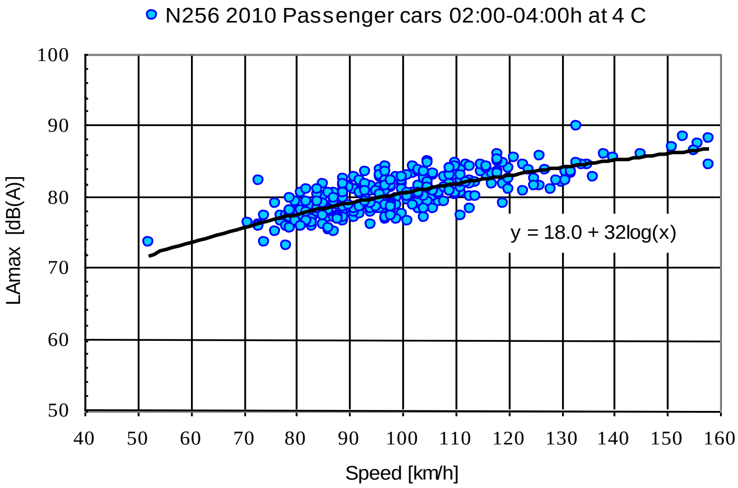

Fig. 3 Example of a scatter diagram. LAmax (measurement setting ‘fast’) versus speed for passenger cars at nearby lane; Collijnsplaat 2010. All pass-by measurements during 02:00 - 04:00 hours at T = 4 °C

TABLE 2 TEMPERATURE COEFFICIENT DEPENDING ON SPEED FOR PASSENGER CARS AS FOUND IN 2010 AT THE N256 MOTORWAY AT COLLIJNSPLAAT IN THE NETHERLANDS

Speed km/h	*a*, dB/°C
50	–0.03
60	–0.05
70	–0.06
80	–0.07
90	–0.08
100	–0.09
110	–0.10
120	–0.11
130	–0.12
140	–0.12

For middle weight and heavy weight trucks, there is much less data available, because the majority of the traffic flow consists of passenger cars. Also the variance in speed is much less than for passenger cars. Therefore, we looked at all truck events in the range of 70-100 km/h only and determined the temperature coefficient for this entire range. For middleweight trucks we found $\alpha_{\text{middelweight\_trucks}}$ = –0.04 dB/°C and for heavy trucks no clear temperature effect: $\alpha_{\text{heavy\_trucks}}$ = 0 dB/°C. When both categories are undistinguished and treated as single vehicle type, $\alpha_{\text{all\_trucks}}$ = –0.02 dB/°C, which is comparable with the coefficient for passenger cars at 50 km/h. It should be noted that these results were found on a DAC pavement and do necessarily also apply for other types of pavements, such as porous pavements.

IV. DISCUSSION

The analysis of the data obtained in 2010 at Collijnsplaat indicates that the temperature effect for passenger cars depends on speed. As the speed increases, noise emissions from passenger cars increasingly depend on temperature. In practice, this could be important. It means that for measurements conducted along urban roads at average speeds of 50 km/h, a smaller correction should be applied than for measurements conducted along motorways at speeds of 120 km/h. For trucks, the picture is more complicated. Because the speed range was much smaller, reliable determination of speed dependence was difficult. In any case, if one looks at the range between 70-100 km/h the average coefficient for trucks is –0.02 dB/°C, which is much lower than for passenger cars at the same speeds. Possibly this has to do with a larger contribution of engine noise for trucks. Another reason could be that a larger tire radius leads to a smaller temperature effect. This is still not clear.

As to the ‘threshold effect’ that we found from measurements on the total traffic flow along several highways, as shown in Table 1, this could be because noise emissions of trucks hardly seem to depend on temperature. The lowest temperatures occur during the night, in which the percentage of trucks and their contribution to the total noise level that is monitored, is relatively high compared with the day. Consequently, noise levels measured obtained for motorways during the night – at lower temperatures – will depend less on temperature.

V. CONCLUSIONS

The temperature effect on noise emissions for passenger cars depends on the speed;

At higher speeds the temperature effect on noise from passenger cars is larger than at low speeds;

For measurements on passenger cars, conducted along urban roads at average speeds of 50 km/h a smaller correction should be applied than for measurements conducted along motorways at speeds of 120 km/h;

For trucks, the temperature effect is much smaller than for passenger cars and for heavy trucks no significant speed dependence could be determined from the data reliably;

Noise emissions from trucks seem hardly to depend on temperature. This may explain why at lower temperature (night) noise emission from motorways seems to be less dependent on temperature.

These results were found on a DAC pavement and do necessarily also apply for other types of pavements, such as porous pavements.

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