PROPERTIES OF URBAN TRAFFIC NOISE

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INTRODUCTION

The noise emission caused by urban traffic flow could be characterized by a specially perceived noise level. The measurement point takes place up to $d_0 = 7.5$ m from the center line from the outermost stripe of the road and $h = 1.2$ m above the ground. The noise annoyance of this point is defined by the A-weighted equivalent noise level ($L_{Aeq,1hour}$ [dBA]) caused by the given traffic flow. The measurement point defines a reference point and the previously equivalent noise level of 1 hour is defined as reference noise level. Our aim is to create a noise model that correctly describes the reference noise level due to urban traffic flow (cruising speed is between 20-60 km/h).

THEORETICAL BACKGROUND

In general

A wide range of vehicles takes part in urban traffic flow. The reference equivalent noise level is given by its average noise emission. Let's deduce the case of real traffic to the case of traffic of just one type of vehicle. To make things easier we think of a fictive type of vehicle. We substitute this vehicle for real vehicles in urban traffic flow so the reference equivalent noise level of fictive traffic should be equivalent to the equivalent noise level of the real traffic.

The Q[vehicle/hour] traffic flow intensity and v[km/hour] cruising speed are the same in the fictive and the real case. We define this fictive vehicle as statistically equivalent vehicle. It appears to be practical to categorize statistically equivalent vehicle as real vehicles so we define light and heavy vehicles. In this way the reference equivalent noise level can be calculated according to the logharitmic summing-up rule the part equivalent noise level of each category.

The noise model

Let's see the noise model that consists of just one type of vehicle. When a vehicle passes the reference point at $v = \text{const}$ speed, the momentary noise level versus time is given by the following formula:

$$1: \quad L(t) = L_{max} + 20\, \mathrm{LOG}\left[\frac{d_0}{d(t)}\right]$$

and $d_0 = 7.5$ m, $\min(d) = d_0$, $d \neq 0$.

If the viewing angle is $\theta = \pi$ then $\max(d) = \infty$. The indicated distance damping corresponds with geometric damping. The momentary distance versus time is given by:

$$2: \quad d(t) = \left[d_0^{\,2} + (v\ t)^2 \right]^{1/2} \quad \text{(straight motion)}$$

and the equivalent noise level (over T measuring time) will be:

$$3: \quad L_{eq1} = 10\ \mathrm{LOG} \left[\frac{1}{T} \int_{(T)} 10^{L(t)/10}\, dt \right]$$

(in the case of one vehicle),

$$4: \quad L_{eqQ} = 10\ \mathrm{LOG} \left[Q\ 10^{L_{eq1}/10} \right]$$

(in the case of Q identical vehicle).

Substituting the integral and supposing that we use the following parameters: $[Q]=\text{vehicle/hour}$, $[v]=\text{km/h}$, $[d]=\text{km}$, $[\theta]=\text{rad}$, $T=1\text{hour}$, and by simplifying the formula, the result will be:

$$5: \quad L_{Aeq,1hour} = \underbrace{L_{Amax}(v,P)}_{}+10\underbrace{\mathrm{LOG}(d_0)+10\mathrm{LOG}(\theta)+10\mathrm{LOG}(D)}_{}$$

where A means the A-weightning.

In the equation (5) above L_{Amax} is the maximal value of the momentary pass-by noise level. The value of L_{Amax} is primarily depends on the velocity (v), but the loading of the engine (P) also has an important influence.

The traffic density [D, can be found in equation (5)] is connected to traffic intensity through the fundamental equation related to the given route. The fundamental equation is given by the following well-known formula: $D = Q/v$.

The equivalent noise level curve

In the case of a given machine the so-called Heirmann-diagram shows the revolution of the engine [$n(\text{rev/min})$] versus cruising speed: $n(v)$. As the noise level caused by the engine versus revolution is given by a linear function, the $L_{Amax}(v)$ - diagram is the same as the Heirmann - diagram (acoustical Heirmann - diagram or saw - diagram [1]).

The position of the domain of acoustical Heirmann - diagrams of the statistically equivalent vehicle depends on the revolution and the load of the engine. The form of this domain determined by the possible difference between the highest and the lowest value of the load of the engine belongs to the given cruising speed.

The upper boundary of the domain of the acoustical Heirmann - diagrams given by the equivalent noise level curve belongs to the maximum load, and the lower boundary determined by the equivalent noise level curve belongs to the minimum load. The application of the equivalent noise level curve is necessary, because the acoustical Heirmann - diagram is discontinuous, so this function is unsuitable for equation (5). This discontinuous curve is substituted by the smooth equivalent noise level curve.

Let's say that the acceleration is constant, thus you can modify the scale of the axis of the independent variable (v) based on the formula $t = v/a$, by this the new independent variable will be the time: t. Because of this there is no obstacle to replace the section between the limit-point os the discontinuous part of the saw - diagram with such a point whose ordinate is equal to the equivalent level of the section mentioned above. The equivalent noise level curve is fitted using this point.

MEASUREMENTS

We determined by measurements the $L_{Amax}(v)$ acoustical Heirmann - diagram for the statistically equivalent light vehicles according to the Hungarian vehicle statistics (Fig.1.). The Fig.1. also shows the equivalent noise level curves in the cases of $a = 0$ and $a = \max(a)$. To determine the shape and the position of the domain defined by the limit mentioned above a large number of pass-by noise level measurements were carried out. The limit curves given in Fig.2. are the same as those in Fig.1. The measured L_{Amax} values are also represented in Fig.2. Only 7.2 % of all 842 measured points are located outside the limit curves.

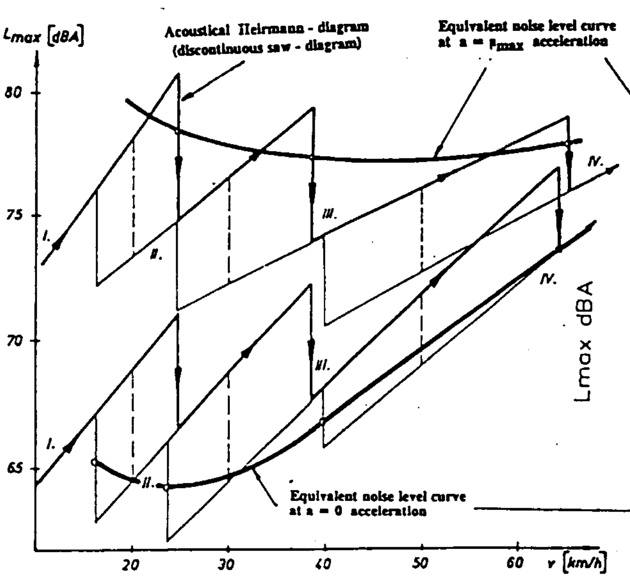

FIG. 1.

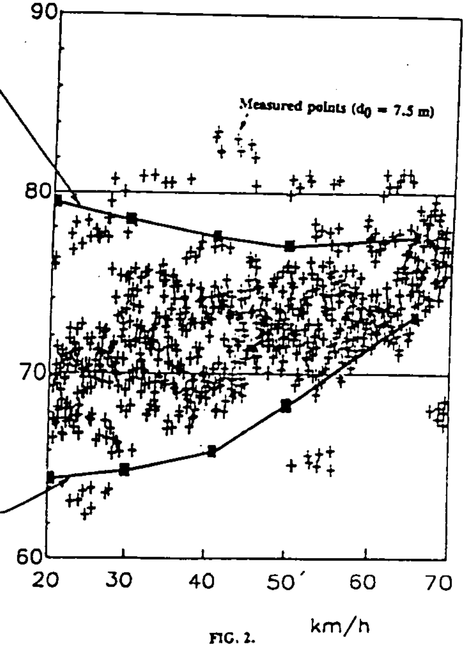

FIG. 2.

CONCLUSIONS

1. The equivalent noise level you can indicate at the reference point is determined by the pass-by noise of each car the first part of eq.5. geometrical circumstances, second part of eq.5. shows this. (The parts of the eq.5. are signed, see on the p.2.)

2. By introducing the definition of the statistically equivalent vehicle and the equivalent noise level curve, the position of the domain containing the $L_{Amax}(v)$ points measured under real circumstances is predicable on the $L_{Amax}-v$ plane.

3. The expectable values of L_{Amax} depend on the real difference between the highest and the lowest engine load belonging to the given cruising speed. The domain of the measured L_{Amax} values is relatively if the speed range is between 20 - 60 km/h and as the cruising speed increases, this domain becomes more and more narrower. The lower limit curve is ascending, the upper limit curve is nearly constant.

4. It's an important conclusion, based on results mentioned above, that reducing the cruising speed is not enough alone to reduce the reference equivalent noise level caused by urban traffic noise. For example, a free traffic flow may cause lower noise level than an obstacled traffic flow where the average speed and the traffic intensity are lower, than in case of the free traffic flow.

5. As the equivalent noise level curve of the heavy vehicles equipped with multi-grade gearbox is nearly constant and located by more than 10 dBA above the curve of light vehicles the noise emission caused by the urban traffic highly depends on the presence and number of heavy vehicles. So, limiting the speed does not result in a lower noise level if heavy vehicles are involved. Only using quiet vehicles or warning off the traffic heavy vehicles give good solutions.

REFERENCES

1. S. Hajdu: Upgrade of the Hungarian Standard MSZ 07-3720 for calculate of the influence of the low vehicle speed on traffic noise. Research Report KTI Rt. Budapest, 1994.