Task 3

Traffic noise measurement

3.1 Task

1. Measure in selected sector of road A-weighted equivalent sound pressure level for at least five minutes. Determine distribution function and probability function from measured data.

2. Calculate an estimate of A-weighted sound pressure level in the same point.

3.2 Theory

3.2.1 Equivalent level

In measurement of time varying sound fields so called equivalent (sound pressure or intensity) level is used. The word equivalent means permanent level of measured quantity that has the same effect as the time varying noise during the same interval. From physiological point of view, this equivalence is best fulfilled for energetic mean value. It is defined for sound pressure as

$$L_{\mathrm{eq}} = 10 \log \left[\frac{1}{T} \int_0^T \frac{p^2(t)}{p_0^2} \mathrm{d}t \right] \tag{3.1}$$

where T is the measured time interval.

In practice one can meet with situation when time distribution of levels is given, e.g. L_i level occurs during the measurement for the total time of t_i. We can use this data to plot the probability density function (or percent occurrence) of particular levels during the whole measurement. The equivalent sound pressure level is then given by equation

$$L_{\mathrm{eq}} = 10 \log \frac{\sum_{i=1}^{N} t_i 10^{0,1 L_i}}{\sum_{i=1}^{N} t_i} \tag{3.2}$$

that represents weighted energetic average of all levels occurred.

From the probability density function we can easily calculate the distribution function. It is defined for selected sound pressure level as sum of percent occurrence of all lower pressure levels up to the selected one (including it). The shapes of probability density and distribution functions are characteristic for particular noises (e.g. traffic noise is different at a cross-road, straight street or when the road ascent etc.).

For noise evaluation, we can also use quantity called Sound Exposure Level (SEL)

$$\mathrm{SEL} = 10 \log \left[\int_0^T \frac{p^2(t)}{p_0^2} \mathrm{d}t \right] . \tag{3.3}$$

In hygiene control L_{eq} is preferred rather than SEL, but both quantities are related:

$$L_{eq} = \mathrm{SEL} - 10 \log T \tag{3.4}$$

where T is measuring time. It follows, that for $T = 1\,s$ both quantities are the same. We can find both quantities integrated to sound level meters on the market.

3.2.2 Calculation of traffic noise

For traffic noise prediction during urban development several methods can be used. There are lot of commercial software products that draw noise maps of the area. Beside that some empirical formulas exists for estimation of various noise caused by road traffic, rail traffic, tramways, trolleys, air traffic or combinations.

For example, the traffic noise caused by road traffic only the sound pressure level at a distance 7.5 m from the closest traffic lane axis (assuming two-way road, with maximum longitudinal slope of 1 %) can be calculated from empirical formula

$$L_{\mathrm{x}} = 40 + 10 \log F_1 F_3 \frac{S}{16} \,. \tag{3.5}$$

The F_1 coefficient is given by (3.6), F_3 coefficient depends on material of the road surface and for selected materials can be found in table 3.1. S represents an year average of traffic intensity during day, which means average amount of all vehicles that passed by in 24 hours.

The F_1 coefficient is

$$F_1 = \left(1 - \frac{N}{100}\right) \cdot 10^{\left(\frac{v-58}{60}\right)} + \frac{N}{100} \cdot \left(\frac{v-10}{5}\right) \tag{3.6}$$

where v is velocity (in town 45 km/h) and N is percentage share of truck traffic.

Material of Surface	Value of F_3
Asphalt	1
Concrete	2
Cobblestone (tiny)	4
Cobblestone (big)	6

Tabulka 3.1: The values of F_3 factor for various materials of road surface

The value of L_{x} is then revised with respect to:

- road width
- sound absorption by low-rise buildings
- sound absorption by obstacle or terrain
- influence of neighboring buildings
- disturbances in traffic continuity

- influence of vegetation

The traffic noise problem is quite extensive and correction coefficients also makes the calculations complicated. Usually the day and night-time is also distinguished in calculations. The formula presented here is only basic estimation and its results can't be taken too strictly.

3.3 Measurement procedure

1. In the proximity of crossing of the Evropská and Šolínova street, measure equivalent sound pressure level (several times). Use the A-weighting and Slow averaging in sound level meter settings. Measurement time should be at least 5 minutes (10 is recommended).
2. At the same time, count the number of cars and trucks that passed by.
3. From the measured data, plot the distribution function and probability density function in graphs.
4. Use equation (3.5) and compare the calculated value with measured one.

3.4 List of equipment

- Sound level meter Quest 1800 or Rion NL 31