Course: MSc in Environmental and Architectural Acoustics
Unit: Measurement and Behaviour of Sound
Subject: Measurement of Environmental Noise

Aim

- To obtain a practical knowledge about basic environmental noise quantities.
- To obtain practical experience of measuring environmental noise using modern sound level meters.

Additional Literature

1. BS7445 Part I: 1995. Description and measurement of environmental noise. Part I. Guide to quantities and procedures.
2. J. R. Hassall, K. Zaveri. Acoustic Noise Measurements. Bruel and Kjaer, 1988, %th Edition. ISBN 8787355213.

Instrumentation

1. CEL 593 Sound Level Meter
2. B&K 2236 Sound Level Meter

Introduction and Theory

A. L_{Aeq}

The L_{eq} is the equivalent continuous sound pressure level (in decibels) within a time interval. This is the value of the SPL of a continuous, steady sound, that, within a specified time interval t_2-t_1 has the same root mean square as the sound under consideration whose level varies with time.

In the field of environmental noise, most measurements are performed using the "A" weighting network. L_{Aeq} is the equivalent A weighted SPL.

The calculation of LAeq from the SPL is given by the formula

$$L_{Aeq,T} = 10\log\left(\frac{1}{t_2 - t_1}\int_{t_1}^{t_2}\frac{P_A^2(t)}{P_0^2}dt\right)$$

where $L_{Aeq,T}$ is the equivalent continuous sound pressure level, in dB, determined over a reference time interval T starting at time t_1 and ending at time t_2
p_0 is the reference SPL (20 micro pascals)
$p_{A(t)}$ is the instantaneous A weighted sound pressure of the sound signal.

Notes:

1. LAeq is sometimes called the interval averaged LA,T
2. The measurement time interval should always be stated e.g. $L_{Aeq,15min}$=65.4 dB

B. L_{AE}

L_{AE} is the sound exposure level in A weighted decibels. Th is equal to the energy of a noise event over a selected time period normalised to a 1 second time interval. It is sometimes called SEL.

L_{AE} is given by the formula

$$L_{AE} = 10\log\left(\frac{1}{t_0}\int_{t_1}^{t_2}\frac{P_A^2(t)}{P_0^2}dt\right)$$

Where t_2-t_1 is a stated time interval long enough to encompass all the significant sound of a stated event,
t_0 is the reference duration equal to 1 second.

C. Percentile level $L_{AN,T}$

The A weighted SPL obtained by using time weighting "Fast" that is exceeded for N% of the time interval considered. For example, $L_{A95,\ 15min}$ is the weighted level exceeded for 95% of a 15 minute measurement period.

D. L_{max}, L_{min} and L_{peak}

L_{max} is the maximum SPL that occurs during a time period.
L_{min} is the minimum SPL that occurs during a time period
Moderen SLM calculate L_{max} and L_{min} for short term L_{eq} s measured during the relevant time period. Thus the L_{max} value is the highest short term L_{eq} measured for each time interval and the L_{min} value is the lowest value.

The peak level is the maximum absolute value of instantaneous sound pressure within a time interval. It is expressed in dB (ref 20 micro pascal)

A weighting equivalent will have as usual subscript A (L_{Amax}, L_{Amin}).

On LCD screens of some SLM an abbreviation might be used:

Lmax	=	MAXL
Lmin	=	MINL
Lpeak	=	MAXP

Difference between L_{max} and L_{peak}

L max is the RMS value, while L peak refers to the amplitude value. For a steady sinusoidal signal (only) they should differ by around 10 log ($1^2/0.707^2$) = 3 dB. As calculations of RMS involves integration over a period of time, if during this period a very short impulse occurs, than the difference will be significantly higher than 3 dB.

E. Notes about measurement procedures

i) Make sure that the dynamic range is sufficient to cover the whole range of SPLs.

ii) When it is desired to minimise the influence of reflections then measurements should whenever possible, be carried out at least 3.5m from the reflecting structure other than the ground. When not otherwise specified, the preferred measurement height is 1.2m to 1.5m above the ground.

iii) Outdoor measurement near building shall be carried out at places where the noise to which a building is exposed is of interest. If not otherwise specified, the preferred measurement positions are 1m to 2m from the façade and 1.2m to 1.5m above each floor level of interest.

iv) Inside buildings, if not otherwise specified, the preferred measurement positions are 1 to 2m from the walls or other major reflecting surfaces, 1.2m to 1.5m above the floor level and about 1.5m from windows.

Measurement and data to be presented

Measure road traffic noise at 3 different microphone positions over 10 minute intervals. Choose positions at different distance from the noise source, for example at the curbside; 2m and 4m from the curb. If possible, do not place the microphone near reflecting surfaces (if you do you will need to correct your measurement to allow for façade reflections).

Measure the following values:

L_{Aeq}
$L_{A1,\ 10min}$
$L_{A90,\ 10min}$
$L_{A95,\ 10min}$
$L_{A99,\ 10min}$
L_{Amax}
L_{Amin}
L_{peak}

If possible measure the L_{AE} and L_{Amax} for different type of vehicle, e.g motorcycle, car, bus.

Record:

- microphone position
- distance from source
- type of instrument
- time intervals
- atmospheric conditions
- nature and state of the ground between source and measurement positions

- nature of sound source
- character of sound, traffic conditions (ideally speed fast, slow, crawl, stationary etc)

Questions

1. How do the different parameters vary with distance from the source?
2. How do the L_{AE} of different sources compare?
3. Do you think dB(A) is an adequate descriptor of road traffic noise?
4. Can you see any relationship between L_N and L_{eq} levels; the L_{peak} and L_{Amax} levels; the L_{Amax} and L_{AE} levels?
5. Assuming the traffic flow remains constant from 8am to 6.30pm, and the noise level is more than 10 dBA below the measured levels for the rest of the time, what would the 24 hour L_{Aeq} at the three positions?
6. How would you express L_{Amax} and L_{Amin} in terms of L_{AN}?