INSTRUMENTATION AND TERMINOLOGY FOR NOISE INVESTIGATIONS

INSTRUMENTATION

The subject noise investigation has been conducted using a Bruel and Kjaer (B & K) Model 2230 precision integrating sound level meter calibrated externally at the beginning and end of each period of measurement using a B & K Model 4230 acoustic calibrator. In combination, these instruments yield sound level measurements accurate to within 0.1 decibel (dB). The Model 2230 fulfills standards of relevant sections of IEC (International Electrotechnical Commission) 651 and ANSI (American National Standard) S1.4.1971 for Type 1 (precision) integrating sound level meters.

The microprocessor of the Model 2230 computes and stores/displays the following measurements:

The sound pressure level (SPL) is updated once each second on the digital display at a resolution of 0.1 dB, and 64 times per second on the analog display at a resolution of 2 dB. The mechanism of averaging levels during the display interval may be “fast” or “slow.” The setting is normally “fast,” as this is required for Leq and SEL discussed below.

The sound equivalent level (Leq) is the average sound pressure level for the period of measurement based on equal energy. The meter internally computes a new Leq from the SPL (RMS) and updates the digital display once each second. The measurement period is limited only by battery life, which is approximately 8 hours. This parameter is used primarily to describe environmental noise.

The sound exposure level (SEL) is the constant level which if maintained for one second would have the same acoustic energy as the total noise for the period of measurement. This parameter is used primarily in determining the noise exposure in unusually noisy working environments or for measuring specific events such as an individual aircraft flyover or a train passage.

The maximum (Max.) and minimum (Min.) sound pressure levels during the period of measurement are updated once each second from the RMS average sound pressure level. For periods of measurement in the range of 1 to 10 minutes, these values are reasonable approximations of the sound pressure level exceeded 1% of the time and 99% of the time, respectively.

All of the above can be measured using frequency weightings of the “A” or “C” scales in accordance with IEC 651, or a “linear” (20 Hz to 20 kHz) or “all pass” (10 Hz to 50 kHz) filter settings. The “A” scale is weighted to most closely approximate the response of an average human ear, and is the setting most used in conducting measurements of environmental noise.

TERMINOLOGY

Noise, as used herein, is defined as unwanted sound. However, because the instruments that detect the small changes in atmospheric pressure that are perceived as sound cannot distinguish between that which is wanted (e.g., birds singing, waves on a beach, etc.) and that which is not (e.g., traffic noise), measurements of "noise" are more accurately described as measurements of sound pressure.

Changes in sound pressure normally experienced in the human environment extend across a very large range. The sound pressures in an average room are in the range 1,000 times the sound pressure at the threshold of hearing, and the sound pressure of a large truck is about 100,000 times that threshold. Because of this large range, it is convenient to describe sound in terms of its energy level with respect to that of the threshold of hearing. This method of description is called the decibel scale (dB). In mathematical terms, the sound pressure level, SPL = 10 Log $(p/p_o)^2$ dB, where p_o is the sound pressure at the threshold of hearing (20 microPascals). In practical terms, it is adequate to note that the decibel scale is logarithmic (like the Richter scale for earthquakes), that it conveniently compresses the numbers involved from a range of 20-200,000,000 to a range of 0-130, and that it is oriented to human response in that an increase of about 10 dB is normally perceived as a doubling of the sound level.

In recent years, various methods and "scales" have been devised to describe noise in the human environment. These methods have had two basic objectives: 1) to represent a physical condition that is constantly changing over a wide range of values by a single numerical descriptor; and 2), to adjust that descriptor in a way that most reasonably reflects the degree of annoyance of the varying noise levels.

1. Statistical Descriptors

Statistical descriptors most often used to describe variations in noise level include:

L_{90} The level exceeded 90% of the time during a specified period, usually 1 hour, 24 hours, or during the day or the night. In some instances, this value may be considered the background level.

L_{50} The level exceeded 50% of the time during a specified period as noted above. This value has sometimes been considered the average or median noise level.

L_{10} The level exceeded 10% of the time during a specified period as noted above. For traffic noise, this value has been considered the peak period level.

L_1 The level exceeded 1% of the time during a specified period as noted above. This value may be considered the peak noise level.

The most significant drawback to the use of these descriptors, particularly L_{50} as representing an average, is that they do not take into account the logarithmic nature of the decibel scale and the relatively higher energy content of higher decibel levels. That is, the average energy content of

50 dB and 60 dB for equal periods of time is not 55 dB, but rather 57.4 dB (i.e., the log of the average of the antilogs).

A parameter that more accurately describes average noise is the Equivalent Continuous Sound Level (Leq), which is the continuous sound level having the same energy content as the varying level for the period of measurement. Prior to the availability of microprocessors at reasonable cost, the hand-computation of Leq from a series of individual measurements was a tedious task. However, meters are now available that internally compute Leq, continuously as with the Model 2230 discussed above, or for a specified period usually one minute. Because of this technical advance, measurements of Leq for various periods of time have become the basic parameter in evaluating environmental noise.

2. <u>Weighted Noise Levels</u>

Because the same level of noise is more annoying to people if it occurs at night, scales have been devised that weight nighttime noise at a higher level than daytime noise. The scales most commonly in use are:

CNEL Community Noise Equivalent Level weights evening noise (7 p.m. to 10 p.m.) by a factor of 5, and nighttime levels (10 p.m. to 7 a.m.) by a factor of 10. Mathematically, evening levels are increased by 5 dB, and nighttime levels are increased by 10 dB in computing a 24-hour geometric average.

dBA A-weighted Noise Level is the sound level obtained by using the A-weighting filter of a sound level meter, expressed in decibels. A-weighting de-emphasizes the very low and very high frequencies of sound in a manner similar to the human ear.

Ldn Day-Night Equivalent Level is similar to CNEL but it does not include a weighting factor for evening noise levels.

Of the above, CNEL came into use first, and it is the standard in regulating noise levels in the vicinity of airports. Ldn is a simplification of CNEL, and is more commonly used in regulating land use where traffic noise is a potential problem. These levels apply for a minimum period of 24 hours, but may be applied for periods as long as one year. The difference may be significant where noise levels are near regulatory limits, and where there are seasonal or weekly variations in a noise source of concern.

3. <u>Practical Applications</u>

From a practical standpoint, the Ldn noise level is essentially equivalent to the peak-hour noise level for most situations involving noise from vehicular traffic, and the peak-hour Leq can be used as the Ldn level, avoiding the costs of 24 hours of measurement.