

TEST CODES FOR MACHINES WITH VARIABLE REPETITION FREQUENCY

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1. INTRODUCTION

Many machines such as percussion tools and staplers can operate at different frequencies. Depending on the practical use the number of operations can be anything from one a week to several per second. In the past test codes have often specified a certain number of operations per second. This number has been selected rather arbitrarily by the test code writers. Because of the impulsiveness of the noise only measurements under hemi free conditions have been allowed.

In this paper more practical procedures will be discussed. It will be shown that the use of the single event sound pressure level(also known under the name sound exposure level) when measuring is very practical. The measurements can either be carried out on one single event or on a specified number of events. The result can be used to calculate the L_{eq} for an arbitrary number of operations during a specified time period.

Comparisons have also been made between reverberation room measurements according to ISO 3741, [3], and hemi-anechoic measurements according to ISO 3744, [2]. The results indicate a complete equivalence between the two methods. The traditional requirement to measure in a hemi-anechoic environment seems to be unnecessarily restrictive.

In the paper some practical applications on different types of machines will be shown.

2. ABOUT DEFINITIONS

According to [1] the single-event emission sound pressure level, $L_{p,1s}$, is defined as follows:

Time-integrated emission sound pressure level of an isolated single sound event of specified duration, T(or specified measurement time T), related to $T_0=1$ s; it is given by the following equation:

$$L_{p,1s} = 10 \lg\left(\frac{1}{T_0}\right) \int_0^T \frac{p^2(t)}{p_0^2} dt = L_{peq}T + 10 \lg\left(\frac{T}{T_0}\right) \quad (1)$$

NOTE - The above equation is identical to that for the familiar ISO environmental noise descriptor "sound exposure level". However, the emission quantity defined above is used to characterize a noise source and assumes that a controlled environment and specified operating conditions are used for the measurements.

In analogy with (1) it would be logical to define the quantity single-event sound power level, $L_{w,1s}$, determined from measurements of the single-event sound pressure level using the traditional sound power standards.

The quantities given above are practical to use as they are easily related to the normal sound pressure and sound power levels. However, from the physical point of view it would have been more reasonable to use the names sound exposure level and sound energy level in stead. It is a bit strange to apply the single event sound pressure level on a measurement of something which could very well be several "single events" and to call a measure of the sound energy level single event sound power level.

3. ADVANTAGES AND DISADVANTAGES OF THE SINGLE EVENT SOUND PRESSURE LEVEL

The practicability of the single event sound pressure level is obvious from the fact that the equivalent continuous emission sound pressure level during the time T can be calculated from the single event emission sound pressure level and the number of work cycles:

$$L_{pAeq,T} = L_{pA,1s} - 10 \lg\left(\frac{T}{T_0}\right) + 10 \lg(n) \quad (2)$$

where n is the number of events during the time T . (2) can also be written in the form

$$L_{pAeq,T} = L_{pA,1s} + 10 \lg\left(\frac{n T_0}{T}\right) \quad (3)$$

where n/T is the number of events per time period T . By choosing $T = 8$ hours as reference time and $n =$ the number of events during this reference time (3) gives the typical daily noise exposure at the work place providing that all sound reflections from other room boundaries or obstacles than the floor and table are neglectable and the operating conditions are those of the actual use.

One obvious disadvantage of $L_{p,1s}$ is connected to the European directive on safety of machinery. In this directive there are two limit values, $L_{pA} = 70$ dB and $L_{pA} = 85$ dB, the first being the limit value for the declaration of the emission sound pressure level and the second being the one for declaring not only the emission sound pressure level but also the sound power level. In order to

determine these limit values somebody has to determine the number of events per time period to use in order to use eq. (3) above. This should be decided upon by some government authority and not by a standardisation working group which is normally dominated by manufacturers who have a tendency of preferring the lowest possible requirements.

4. DO WE HAVE TO MEASURE IN A HEMI-ANECHOIC ROOM?

In the past impulsive noise have been measured in hemi anechoic environments only, normally according to ISO 11201 and ISO 3744. ISO 3741 has not been allowed for sound power determinations. Is this restriction really necessary now that we normally are interested in L_{eq} only, or, when the level is very high, L_{pCpeak} ? In figure 1 the results of measurements on an electric stapler (Rapid 100 Electronic) are reported. The results reported are the average $L_{p,1s}$ of 5 stapling events. In the hemi-anechoic room the measurement surface was a hemisphere with 10 microphone positions. We can see that the results are equivalent above 125 Hz. The differences below 160 Hz are not specific to impulsive noise. They will also occur for sources emitting continuous noise.

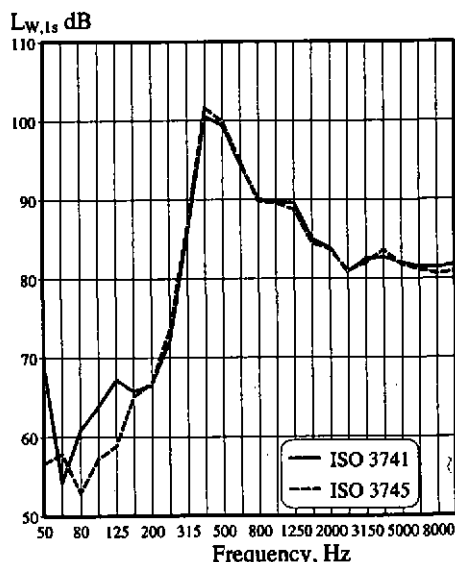


Figure 1 Comparison between measurement in a reverberation room and that of a hemi-anechoic room.

L_{pCpeak} was measured 5 times at a distance of 1 m in a reverberation room and a hemi-anechoic room. The mean peak value was 115,3 dB and 115,4 dB with a standard deviation of 0,8 dB and 1,1 dB respectively. For short impulses it is obviously possible to make good hemi-anechoic measurements in a reverberation room. The impulse of the example given is shown in figure 2.

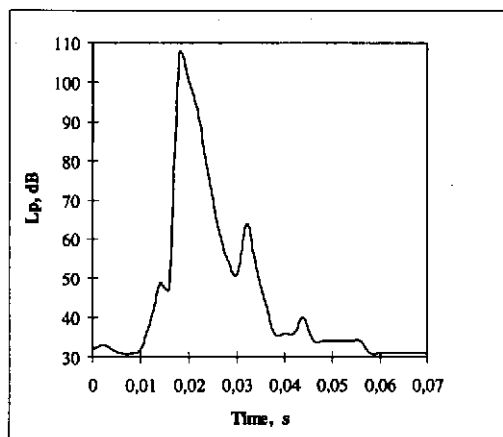


Figure 2 The time history of the impulse of the stapler of figure 1.

5. DO WE HAVE TO MEASURE ON ONE EVENT AT A TIME?

Some experiments have been carried out to test if there is a difference between taking the energy average of 5 single events or, which is simpler, the single event sound pressure level of 5 events and then subtracting $10 \lg(5)$. Electrical staplers, pneumatic fastening tools and toy rattles have been tested. In all cases identical results were obtained by the two methods.

6. APPLICATIONS

So far there are no finalized international standards based on single event sound pressure levels. However, there are a few documents on draft levels.

7. CONCLUSIONS

For sources emitting impulsive noise and the repetition frequency of which can be varied the single event sound pressure level (sound exposure level) and the single event sound power level (sound energy level) are convenient to use. For many types of such sources measurements in hemi-anechoic rooms and reverberation rooms will yield comparable results. The average sound power level of one single event will normally equal the sound power level of n events - $10 \lg(n)$ dB. For sources emitting short impulses it is possible to determine the C-weighted peak sound pressure level accurately even if the measurement environment is very reverberant.