SIMPLE *A PRIORI* SELECTION OF SOUND POWER MEASUREMENT STANDARDS

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1. INTRODUCTION

Workplace noise is a major occupational health problem resulting in thousands of disability claims per year. Noise emission declarations assist in the purchase of quieter machinery by enabling manufacturers to formally provide sound level data in an agreed format.

Canadian standard CSA Z107.58-2[1] contains guidance on provision and verification of noise emission declarations. The guidance is based on standards from the International Organization for Standardization (ISO), and is consistent with European Union (EU) Directives.

There are 10 basic ISO standards for measurement of sound power and 5 standards for measurement of emission sound pressure. The CSA document summarizes trade offs in measurement situations to provide the optimum solution for a given situation.

In this paper an excerpt of the CSA standard is explained, based on the relative dimensions of the machine and the measurement environment.

2. METHOD

The relative sizes of a noise source and measurement environment are often the most significant influence on the ability to make an accurate measurement. Figure 1 shows the required size of the room as a function of the absorption coefficient, α, for four ISO standards, and also includes background noise requirements. The accuracy of these standards is engineering grade with a standard deviation of ± 1.5 dB in the A-weighted sound power level. The CSA guidelines refer to additional standards and provide details for characterizing room α values (used on the abscissa of Figure 1). The derivation of Figure 1 follows.

2.1 Free Field Environments

The normal intensity through an enclosing measurement surface is the primary quantity required for determination of sound power. Pressure measurements in free field sound power standards[2] overestimate this quantity due to background noise and room reflections. Background noise is discussed in clause 2.5. The magnitude of the remaining overestimate is given by K_2:

$$K_2 = 10 \log\left(1 + 4\, S/S_V \alpha\right) \text{ dB} \tag{1}$$

where S is the area of the measurement surface, S_V is the total area of the room surfaces, and α is the average sound absorption coefficient in the room.

It is difficult to visualize surface areas, so equation (1) was simplified using the average dimension of the room, L_{Vavg}, or source, L_{avg}. These values are simply the average of the length, width and height of the room or source. For the measurement surface, the minimum possible area is $S = 5L_{avg}^2$, and the absorbing area of the room boundaries is $S_V = 6L_{Vavg}^2$. By substituting in equation (1) we obtain:

$$L_{Vavg}/L_{avg} = \sqrt{10/3\alpha\left(10^{0.1K_2} - 1\right)} \tag{2}$$

Equations (1) and (2) are strictly only applicable to uncluttered rooms with uniform absorption. The rooms should also be roughly cubical in shape, (i.e., the ratio of largest to smallest dimension should be less than 4). If these conditions are not met, L_{Vavg} will overestimate the size of the room. In this case K_2 should be obtained by measurements using either a reference sound source, or the reverberation time. To compensate for deviations from ideal conditions, Figure 1 uses equation (2) with K_2 values reduced by 10%.

ISO3744[2] allows measurements if K_2 is less than 2 dB. This requirement is shown as a function of α in Figure 1. In this figure L_{avg} actually defines the measurement surface dimension, so that the smallest surface lies on the surface of the source. This makes the number of measurement points prohibitively large. To reduce the number of measurement points to 40, reevaluate Figure 1 with L_{avg} increased by 1.5 times. For 10 measurement points reevaluate Figure 1 with L_{avg} increased by 3 times (note also that ISO3744 requires the measurement surface to be at least 0.25m from the source).

2.2 Reverberant Environments

The reverberant room standard, ISO3743-1[3], requires the room volume to be at least 40 times the volume of the source and α must be less than 0.2.

Changes to ISO3747 in 2000[4] were not incorporated in the CSA guidelines. In this standard[4], accuracy is determined by examination of measurement results. A conservative estimation of requirements was obtained in Figure 1 by comparison with ISO3743-1 and ISO3744.

2.3 Intensity standards

For the ISO 9614 series of intensity standards [5,6], K_2 approximates the pI index (if background noise is treated separately as in clause 2.4). The average pI index (and thus K_2) cannot exceed the measuring equipment dynamic capability, which is typically limited to 10-13 dB.

2.4 Background Noise

In a reverberation room, measurements are made far from the source, and the source must dominate background noise everywhere in the room. For free field measurements the source need only dominate the background noise on the measurement surface. In intensity measurements the allowable background noise is limited by the dynamic capability of the measuring equipment and at high levels can reduce the allowable K_2. Background noise must be evaluated by measurement since allowable levels can exceed the noise produced by the source.

3. CONCLUSIONS

Figure 1 can be used to estimate which standards can be used in a given measurement situation. The Figure also shows how a measurement can be improved. For example, by changing rooms, or by increasing the absorption in a room, it may be possible to significantly improve a measurement. Additional information can be found in the CSA guidelines.

REFERENCES

1. CSA Z107.58-02:2002, Noise emission declarations for machinery
2. ISO3744:1994, Acoustics -- Determination of sound power levels of noise sources using sound pressure -- Engineering method in an essentially free field over a reflecting plane.
3. ISO3743-1: 1994, Acoustics -- Determination of sound power levels of noise sources -- Engineering methods for small, movable sources in reverberant fields -- Part 1: Comparison method for hard-walled test rooms.
4. ISO3747:2000, Acoustics -- Determination of sound power levels of noise sources using sound pressure -- Comparison method in situ.
5. ISO9614-1:1993, Acoustics -- Determination of sound power levels of noise sources using sound intensity -- Part 1: Measurement at discrete points.
6. ISO9614-2:1996, Acoustics -- Determination of sound power levels of noise sources using sound intensity -- Part 2: Measurement by scanning.

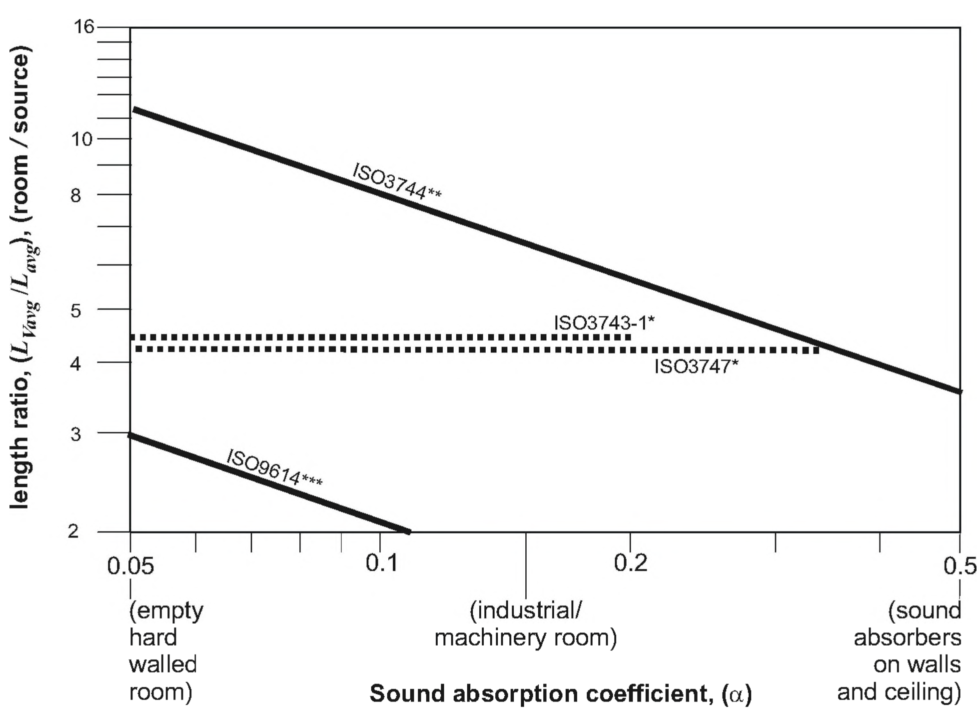

Fig. 1. Minimum average room length to average source length ratio, L_{Vavg}/L_{avg}, as a function of the room's mean sound absorption coefficient, α for engineering grade standards. Background noise limitations are: *source dominates background noise at all points in the room; **source dominates background noise on measurement surface, (i.e., near source); ***background noise dominates source (source must be audible on measurement surface)