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STANDARDS FOR SOUND POWER MEASUREMENT

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1. INTRODUCTION

The numerous standards in existence describing methods for determination of sound power levels were produced originally by the international standardising body, ISO. Those based upon sound pressure level measurements have been in existence for some years, and are in process of revision. So far only one standard has been published using sound intensity measurements, though others are in preparation. This paper reviews all these standards briefly, describes their international standing, and highlights their position in relation to legislative requirements for information to be given on noise emission from machinery.

2. STANDARDS USING SOUND PRESSURE LEVEL MEASUREMENTS

2.1 Published standards

The standards in the series ISO 3740-ISO 3747 were published originally over a 12-year period beginning in 1975. Immediately the last one appeared, a major revision of them all was set in train and completely new versions are now starting to be issued. There are two reasons for the multiplicity of standards in this area. One is that separate methods are described for two broad kinds of acoustic environment, reverberant and anechoic. The other is that within this sub-division, there are separate methods for different grades of accuracy, originally referred to in descending order as "precision", "engineering" and "survey", and more recently as, respectively, grades 1, 2 and 3.

ISO 3740 [1], dating from 1980, introduces and summarises the substantive standards in the rest of the series. The frequency range covered by all standards in the series is that of the 125-8000 Hz octaves. ISO 3741 [2] and ISO 3742 [3] were both revised in minor ways in 1988 but are essentially unchanged since 1975, and give precision methods for use in reverberation rooms of volume at least 200 m^3. The former is for sources emitting sound over a broad frequency range, without pronounced tonal content, while the latter applies to sources with discrete frequencies and/or narrow bands of noise. The quantities derived, according to both standards, are sound power levels in frequency bands, either octave or 1/3 octave, and the best standard deviations of reproducibility are 1.5 dB in the 500-4000 Hz octaves.

ISO 3743 [4], also revised in minor ways in 1988 but originating from 1976, defines an engineering method, for "special" reverberation test rooms. It is supposed to be a relatively simple method for obtaining A-weighted and octave-band sound power levels of small noise sources in a reverberant sound field in rooms of minimum volume 70 m^3. The reproducibility standard deviation, both in the 500-4000 Hz octaves and A-weighted, is 2 dB. ISO 3743-1 [5] , published in 1994, is the first in a set of completely new issues under the original numbers. Conceived as a complete replacement of the old ISO 3743, it is again an engineering method for small, movable sources in reverberant fields, but the test room is described as hard-walled, with a volume of at least 40 m^3. In this case, the reproducibility standard deviation in the 500-4000 Hz octaves and A-weighted is 1.5 dB.

ISO 3744 [6], now in the new 1994 version, is an engineering method in an essentially free field over a reflecting plane, that is in a hemi-anechoic environment. It can be applied in either a flat outdoor area with no sound-reflecting objects, or a laboratory room with sound-absorbing walls and ceiling, in both cases having a suitable hard floor. A limit of 2 dB is imposed upon the allowable environmental correction, K_2. Intended for the determination of frequency-band and A-weighted sound power levels, the reproducibility standard deviation in the 500-4000 Hz octaves and A-weighted is 1.5 dB.

ISO 3745 [7], published in 1977, is a precision method for frequency-band sound power levels in anechoic and semi-anechoic rooms. In this case, detailed specifications are given for the design and qualification of the test room, and the reproducibility standard deviations in the 1000-4000 Hz octaves are 0.5 dB in anechoic rooms and 1.0 dB in semi-anechoic rooms.

The current version of ISO 3746 [8] is still that from 1979. It is a survey method for determining A-weighted sound power levels only, in similar environments to those of ISO 3744 but with a relaxed requirement on the environmental correction, K, such that values up to 7 dB are acceptable. This allows sources to be tested in situ, in workshops or other surroundings where little control is imposed upon the acoustic conditions. The reproducibility standard deviation achievable in this case for A-weighted levels is 4 dB for sources producing sounds that are uniformly distributed in frequency.

ISO 3747 [9] was the last of the original series to be published, in 1987. It is again a survey method for A-weighted sound power levels only, but in contrast to all the other standards in the series it imposes no requirements on the surroundings, and instead of giving an absolute method of sound power determination, it describes a comparison method involving a calibrated reference sound source. The reproducibility standard deviations are the same as for ISO 3746.

2.2 Revisions in progress

The ISO 3740 series of standards are produced by Sub-Committee 1 (Noise) of Technical Committee 43 (Acoustics) of ISO. Working Group 28 of ISO/TC 43/SC 1 has the task of re-drafting these standards; so far it has completed its work on ISO 3743-1 and ISO 3744 and the new versions have been published. When ISO 3743-1 was proposed as a replacement for the original ISO 3743, objections were raised by some industries which had accumulated large quantities of measurement data using the old standard; the fear was that the new standard would give a systematic difference in the results and all the old data would be void. In consequence ISO 3743 is to be re-issued as ISO 3743-2, with only editorial changes to accommodate the new regime. The voting process has been completed on this proposal and publication of the new version is awaited.

Drafting work has also been completed on a new edition of ISO 3746. A survey method will still be given for the A-weighted sound power level in situ, but greater reliance will be placed upon the use of a reference sound source for evaluation of the environmental correction. In consequence, the measurement uncertainties are reduced, and a reproducibility standard deviation of 3 dB will be quoted for the A-weighted sound power level of a source having a relatively flat spectrum. Again, publication of this standard is imminent, at which time the current version will be withdrawn.

The next standards to be re-drafted by WG 28 are ISO 3741, ISO 3742 and ISO 3747. The intention is to combine ISO 3741 and ISO 3742 into one standard under the former number. No changes of substance are expected in the main part of the new standard, except that considerable editing is required in order to coalesce the two present texts. However, in response to requests from some industries, the opportunity is being taken in advisory annexes to provide guidelines on test procedures at extreme frequencies, in the 32 Hz, 63 Hz and 16 kHz octaves. The main difficulty in this last respect is that insufficient data exist to yield measurement uncertainties at the frequencies concerned.

The aim with ISO 3747 is to up-grade the method from survey to engineering, but retain its applicability to sources installed in situ. Engineering or grade 2 measurement uncertainties are certainly achievable from a comparison method involving a reference sound source in reverberant surroundings, but not in a hemi-anechoic environment. The problem which arises in re-drafting the standard is how to give adequate guidance on the point of delineation of a semi-reverberant environment at which grade 2 uncertainties can no longer be achieved.

Drafts of new versions of the combined ISO 3741/3742 and ISO 3747 can be expected to be ready to begin the voting process during 1995, with publication at the earliest by 1996. It will then remain to revise ISO 3745 and to produce a new summary of all the sound power standards in ISO 3740.

3. STANDARDS USING SOUND INTENSITY LEVEL MEASUREMENTS

In the case of sound intensity, the standards are produced as parts of ISO 9614. The first, ISO 9614-1 [10], was published in 1993 and gives a method for measurements at discrete points around a source. Sound power levels can be determined in frequency bands within the range of the 63 Hz to 4000 Hz octaves, and also A-weighted within the confines of this same range. Methods are described in the one standard for precision, engineering and survey grades of accuracy. The reproducibility standard deviations quoted for the 1000-4000 Hz octaves are 1 dB at grade 1 and 1.5 dB at grade 2; that for the A-weighted level from grade 3 is tentatively 4 dB.

Within ISO/TC 43/SC 1, Working Group 25 is responsible for drafting these new standards. Voting has taken place on the draft for ISO 9614-2, giving a method for measurement by scanning the probe around a source. The same frequency range is covered as in part 1,and again different grades of accuracy are put forward for the one standard, but in this case they are restricted to grades 2 and 3. Where the conditions are sufficient for grade 2 to be achieved, the reproducibility standard deviation in the the 500-4000 Hz octaves is 1.5 dB; otherwise, for the A-weighted level at grade 3 it is 4 dB. WG 25 has recently begun work to produce ISO 9614-3, giving a grade 1 (precision) method; this level of accuracy is said to be achievable in ISO 9614-1, where the method is applied to a source in situ, but the expectation is that part 3 will be restricted to a controlled acoustic environment.

4. STATUS OF SOUND POWER STANDARDS

All the references made so far to standards have identified them with ISO. However, following agreement between ISO and the European standards organisation, CEN, the same standards are being adopted by the latter with EN numbering. The technical committee concerned in CEN is 211, Acoustics. Within the UK, BSI is bound to adopt European standards once voting is complete, and so the same documents are appearing with BS numbering also.

The standards have a formal status in relation to legislation to implement European directives on the safety of new types of machinery. In this connection, CEN has adopted a hierarchical designation for its standards, by which they are referred to as type A, type B or type C. Type A standards give basic concepts and principles for design, applicable to all machinery; type B cover one safety aspect only, such as noise, but apply to a wide range of machinery types; and type C give detailed requirements in relation to a specific safety hazard and a particular type of machinery. All of the standards described in this paper are type B. They are used as the basis for a number of type C standards, not referenced here, which apply the general methods for determining sound power levels to the particular circumstances of individual machinery types.

European Community directive 89/392 [11], often referred to as the Machinery directive, applies to a wide range of machinery, defined as an assembly of components, at least one of which moves, for the processing, treatment, moving or packaging of material. In addition to requiring machinery to be designed and constructed to minimise the risks resulting from the emission of airborne noise, the directive requires information on noise to be given in the instructions. Sound power levels are included in the information to be given, in those cases of machinery where the equivalent continuous A-weighted sound pressure level at workstations exceeds 85 dB(A). It is made clear in general references to the provision of information that where it is provided in conformance with a harmonised (European) standard, the requirement of the directive is satisfied; however, information may also be given by following some other means. In effect, reference to standards is deemed to satisfy the requirement, whereas reference to other means might or might not satisfy the requirement, depending on the interpretation of the enforcement authority. While standards thus do not have a mandatory status, they are recognised as providing a means by which compliance with the requirements can be demonstrated. In the case of a particular type of machinery, it would be preferable to refer to the relevant type C standard, but where this is lacking reference could be made directly to a type B, provided the machine mounting and operating conditions under which the results had been obtained were specified.

5. CONCLUDING REMARKS

There is a choice of standardised methods by which the sound power level of machinery can be determined, some employing measurements of sound pressure level and some of sound intensity level. In the context of European standards, these are designated type B and can be applied to many different kinds of machinery. The selection of methods for individual machinery types, including the grade of accuracy achievable, the acoustic environment requirements and the specification of the relevant machinery mounting and operating conditions, is made in an appropriate type C standard. Measurements made in conformity with these standards are deemed to satisfy the requirements of the European Machinery directive for information to be given in the machinery instructions.

6. REFERENCES

[1] ISO 3740, Acoustics - Determination of sound power levels of noise sources - Guidelines for the use of basic standards and for the preparation of noise test codes (1980).
[2] ISO 3741, Acoustics - Determination of sound power levels of noise sources - Precision methods for broad-band sources in reverberation rooms (1988).
[3] ISO 3742, Acoustics - Determination of sound power levels of noise sources - Precision methods for discrete-frequency and narrow-band sources in reverberation rooms (1988).
[4] ISO 3743, Acoustics - Determination of sound power levels of noise sources - Engineering methods for special reverberation test rooms (1988).
[5] ISO 3743-1, Acoustics - Determination of sound power levels of noise sources - Engineering methods for small, movable sources in reverberant fields - Part 1: Comparison method in hard-walled test rooms (1994).
[6] ISO 3744, Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane (1994).
[7] ISO 3745, Acoustics - Determination of sound power levels of noise sources - Precision methods for anechoic and semi-anechoic rooms (1977).
[8] ISO 3746, Acoustics - Determination of sound power levels of noise sources - Survey method (1979).

[9] ISO 3747, Acoustics - Determination of sound power levels of noise sources - Survey method using a reference sound source (1987).
[10] ISO 9614-1, Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 1: Measurement at discrete points (1993).
[11] Council Directive of 14 June 1989 on the approximation of the laws of the Member States relating to machinery, OJ No L 183, 29.6.1989, p. 9.