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Revision of international standards on field measurements of airborne, impact and facade sound insulation to form the ISO 16283 series

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ABSTRACT

This paper gives the background to the main technical changes concerning the field measurement of sound insulation in the new ISO 16283 series of standards for airborne, impact, and façade sound insulation. These changes were: (1) inclusion of only one-third octave bands without an option for octave band measurements, (2) indication of a preference for standardised (rather than normalised) sound insulation descriptors, (3) introduction of spatial sampling using manual scanning with the operator inside the source and/or receiving room, (4) introduction of a low-frequency procedure for one-third octave bands below 100 Hz in room volumes below 25 m^3 using (a) corner measurements to determine the spatial average sound pressure level and (b) the 63 Hz octave band rather than one-third octave bands to measure the reverberation time, (5) alteration of the requirement on the source room spectrum for airborne sound insulation, (6) clarification of the loudspeaker directivity requirements and (7) introduction of the rubber ball as an option for impact sound insulation measurements.

1. Introduction

In 2009 a proposal was made to ISO TC43/SC2 by the United Kingdom to revise the series of international standards concerning field sound insulation, ISO 140 Parts 4, 5, 7 and 14 which concerned airborne, impact and facade sound insulation [1–4]. Revisions were necessary for both administrative and technical reasons. This proposal was approved by ISO TC43/SC2 in March 2010 and three ISO project groups were initiated under Working Group 18; namely Project Group 5 for airborne sound insulation, Project Group 6 for impact sound insulation and Project Group 7 for facade sound insulation. The author of this paper was the project leader of these three groups. Thirteen countries participated in the project groups that steered the changes, improvements and additions to create a new series of standards, ISO 16283 Parts 1, 2 and 3 for airborne, impact and façade sound insulation respectively. This new series of standards will replace ISO 140 Parts 4, 5, 7 and 14. ISO 16283 Part 1 was published in 2014 [5]. At the time of writing, the final vote on Part 2 was positive and it was being prepared for publication, and Part 3 was being prepared for the final vote.

Administrative reasons for the revision were due to the fact that the introduction of the ISO 10140 series for laboratory sound insulation testing had left the ISO 140 series with many gaps in the numbering system due to the deletion of several parts of the ISO 140 series. In addition, ISO 140 Parts 4, 7 and 14 were at their five year review point in 2009. This review highlighted a need to (a) improve the text and remove ambiguities in the English language versions, (b) make the text more consistent with the ISO 10140 series of standards, and (c) incorporate measurement guidance from ISO 140 Part 14 within informative annexes in the airborne and impact field sound insulation standards.

Technical reasons for the revision were primarily due to an increasing number of field tests that were being carried out for national building regulations. These require more repeatable and reproducible measurements to avoid legal issues when sound insulation measurements are close to the regulatory requirement or close to the boundaries between specified sound insulation classes. For the purposes of this discussion, repeatability is defined as the variation in the measured sound insulation when measured by the same operator within a short space of time, and reproducibility is defined as the variation when measured by a different operator or when measured on a different day. With increased levels of testing, acoustic consultants were keen to have test procedures that were adapted to allow measurements to take place in buildings on construction sites with intermittent, high noise levels whilst using minimal cabling. For this reason the revision introduced manual scanning using a hand-held microphone or sound

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level meter to sample the sound field using an engineering method, rather than the survey method described in ISO 10052 [6]. This allows operators to be inside the receiving room to monitor the background noise; hence it was logical to also allow manually-held sound level meters at a fixed point in the space. ISO 140 Parts 4, 5 and 7 did not specifically allow or forbid the presence of an operator in the source or receiving rooms; hence clarification was needed in ISO 16283.

A specific technical problem for airborne, impact and facade sound insulation concerned the fact that the ISO 140 measurement procedures were prone to poor repeatability and reproducibility at low frequencies [7]. The uncertainty was quantified in ISO 12999 Part 1 [8] and in more recent work [e.g. Refs. [9,10]]. In dwellings, many habitable rooms with volumes less than 25 m^3 have strong modal responses below 100 Hz where there are often less than five room modes. In ISO 140 Parts 4 and 7 for airborne and impact sound insulation respectively there were informative annexes giving guidance for measurements in low frequency bands below 400 Hz, but with emphasis on frequency bands below 100 Hz. Unfortunately the requirements in this guidance were sometimes impossible to satisfy in small room volumes. The annex was not included in ISO 140 Part 5 even though low-frequency sound insulation is important for many environmental noise sources. The need for improved accuracy for measurements of sound insulation at low-frequencies in lightweight framed-buildings was highlighted by the project under EU COST action FP0702 [11]. A more general need for the ability to carry out field sound insulation measurements below 100 Hz was identified by EU COST action TU0901 [12]. For airborne sound insulation, there is evidence showing that incorporating the 50, 63 and 80 Hz one-third octave bands in the determination of some single-number quantities for airborne sound insulation can improve the link to subjective impression [e.g. [13]] whilst other studies provide evidence that it does not [e.g. see Refs. [14,15]]. For impact sound insulation there have also been suggestions that frequencies down to 20 Hz should be considered in single-number quantities [13]. However, the need to improve the repeatability and reproducibility of field sound insulation measurements below 100 Hz in small rooms was a necessary step before considering what, if any, low-frequency bands should be considered in the calculation of single-number quantities.

For impact sound insulation, the ISO rubber ball had been included as a heavy/soft impact source in the laboratory standard ISO 10140 Part 5 [16] in 2010. Hence there were requests from Japan and South Korea to include the rubber ball as a technical addition to ISO 16283 Part 2 so that both laboratory and field tests were defined in ISO standards.

2. Scope of the ISO 16283 standards

The scope of ISO 140 Part 4 [1] stated "This part of ISO 140 specifies field methods for measuring the airborne sound insulation properties of interior walls, floors and doors between two rooms under diffuse sound field conditions in both rooms, and for determining the protection afforded to the occupants of the building.". This was not strictly correct because diffuse sound fields don't occur in real box-shaped rooms with stationary surfaces and absorbent boundaries. However, in the field situation there are some rooms in which there are close approximations to a diffuse sound field in the mid- and high-frequency ranges. In the revision it was deemed important to emphasize this fact and because of the introduction of a low-frequency measurement procedure into all three parts of ISO 16283 it was possible to state in the scope that the test results can be used to quantify, assess and compare the sound insulation of unfurnished or furnished rooms where the sound field may or may not approximate to a diffuse field. In addition, the opportunity was taken to state a limit of application of all three parts of ISO 16283 to room volumes in the range from 10 m^3 to 250 m^3, and to measurements in one-third octave bands between 50 Hz and 5 kHz.

3. Frequency bands and sound insulation descriptors

In the ISO 16283 standards, the scope was changed to specify only one-third octave bands. ISO 140 Parts 4 and 7 stated that (a) field measurements of airborne sound insulation shall be made in one-third octave bands unless octave band measurements have been agreed upon, and (b) when the results from octave band measurements are converted to single-number quantities, these results are not directly comparable with those from one-third octave band measurements. However ISO 140 Part 5 allowed measurements to be made in one-third octave bands and/or octave bands.

In the revision, a decision was made to tackle the issue of whether to continue to have the option of measuring in octave bands. The skirts of an octave band filter are not usually as steep as those of the lower and upper one-third octave bands that form part of that same octave band. An example is shown in Fig. 1 for a 1 kHz octave band with the three corresponding one-third octave bands for 6th order Butterworth filters that satisfy the attenuation limits for a Class 1 filter according to IEC 61260 [17]. Because octave bands have a wide skirt they produce a sound insulation curve that is 'smoother' and without the deep dips that often occur in one-third octave band measurements. Adverse dips in the sound insulation due to mass-spring resonances and critical frequencies are easily identifiable with one-third octave bands; whereas with octave bands the wider filter skirts mean that sound energy is 'smeared' between adjacent frequency bands. For this reason, one-third octave bands are particularly useful for noise control purposes as they can help the measurer identify dominant radiating surfaces when the mass-spring and critical frequencies for different walls/floors can be estimated [24]. In addition they ensure that deep dips in the sound insulation curve are accurately quantified for use in rating procedures. This becomes more important if the rating range is reduced from 100 Hz to 50 Hz (particularly with mass-spring resonances) and increased from 3.15 kHz to 5 kHz (particularly with critical frequencies from thin board materials such as plasterboard). Scholl and Wittstock [18] also noted that requiring all measurements to use one-third octave bands and no longer allowing octave band measurements would provide uniformity in the calculation of single-number quantities. In addition, requiring one-third octave band measurements in ISO 16283 clarifies that it is an engineering grade measurement; this allows a clear distinction between ISO 16283 and the survey method in ISO 10052 which is restricted to measurements in octave bands. However, ISO 16283 provides the equations needed for the user to calculate octave band values from the measured one-third octave bands if needed.

For airborne and impact sound insulation the ISO project group decided that the revision provided an opportunity to steer users of the standard away from the use of normalised descriptors towards the use of standardised descriptors (e.g. D_{nT} and L'_{nT}) which provide a more straightforward link to the subjective impression of sound insulation [19]. Hence normalised descriptors were not included in the parts of ISO 16283 concerning airborne and impact sound insulation.

4. Spatial sampling of sound pressure levels

To sample the sound field, ISO 16283 introduced the option to carry out manual scanning with a hand-held microphone or sound level meter using an engineering method as well as carrying out fixed positions with the operator inside the test rooms.