Measurement of time variant sound pressure levels at low frequencies in buildings - verification of sound class using EN ISO 10052 and 16032

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Summary

Swedish building regulations set limits on the A-weighted equivalent and maximum sound pressure levels from service equipments in dwellings, schools, offices and hospitals. In bedrooms, a special limit is given as a C-weighted equivalent level. Furthermore, Swedish environmental regulations introduced other limits in 1996, on the room average sound pressure levels in third octave bands 31,5-200 Hz. Until recently, measurements have been conducted according to national standards or guidelines, but there has been a request to refer to international standards rather than national. For this purpose, a new guideline has been developed. Measurement procedures have been described, one for the standard EN ISO 10052 and one for the EN ISO 16032. Several changes as well as some new instructions had to be included to make measurement results compatible with the national requirements, e.g. using third octave bands rather than octave bands. The standards focus on sound from one type of source at the time, whereas in our regulations, sound in rooms may stem from multiple sources. Hence, the guidelines had to describe measurement conditions as well as define handling of background noise in some detail.

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1. Introduction

Swedish building regulations set limits on the A-weighted equivalent and maximum sound pressure levels from service equipments in dwellings, schools, offices and hospitals. In bedrooms, a special limit is given as a C-weighted equivalent level[1]. Furthermore, Swedish environmental regulations introduced other limits in 1996, on the room average sound pressure levels in third octave bands 31,5-200 Hz[2]. These regulations followed after an increased number of complaints on disturbance caused by heat pumps, that had become common by then. Annoyance from low frequency sound is also frequently reported by occupants living close to discoteques, pubs and similar. The limits have been updated to include 5 dB stricter limits on A-weighted music sound pressure levels, other time variant sounds as well as sounds with tonal components. Modern equipments typically include frequency controlled power supplies used to vary the speed of a compressor, fan or water pump, which makes many sources time variant.

Until recently, measurements have been conducted according to national standards or guidelines[3], but there has been a request to refer to international standards rather than national.

For this purpose, a new guideline has been developed[4]. Measurement procedures have been described, one for the standard EN ISO 10052 and one for the EN ISO 16032. Several changes as well as some new instructions had to be included to make measurement results compatible with the national requirements, e.g. using third octave bands rather than octave bands. The standards focus on sound from one type of source at the time, whereas in our regulations, sound in rooms may stem from multiple sources. Hence, the guidelines had to describe measurement conditions as well as define background noise in some detail.

In this paper, the use of "standards" refer to EN ISO 10052 and/or EN ISO 16032.

This paper only describes some instructions of the guidelines. Unfortunately, there are no measurement results available, but we hope to be able to present comparisons at a later occasion. However, some previous studies have been considered in this work[5, 6].

2. Preparation of a field measurement

The purpose of a measurement according to the guidelines is to verify whether Swedish guidelines and building regulations are fulfilled, with respect to sounds from elevators, building service equipment or noisy activities in adjoining spaces or outdoors. That is, sources may be inside or outside of the space where the requirement applies.

The operator may choose to follow the survey method in SS-EN ISO 10052 or the engineering method in SS-EN ISO 16032. The guidelines contain additional instructions in order to reduce uncertainty with respect to the spatial sampling of the sound field in a room as well as uncertainty caused by temporal variations in the sound source.

As a rule, all sources of noise that pertain to the same owner, operator or activity shall be in service at the time measurements are carried on. Operating conditions should be typical for the most noisy hour, as documented by the occupants or the owner. The measurement time is normally much shorter. Other sources, e.g. coolers, ventilation and traffic should be turned off or their influence minimized by other means. Correction for background noise may only be applied with ISO 16032 and only if the noise is steady during the full measurement period. For sources that may be controlled by the owner or the measurement operator, the instructions of the standards are followed in detail.

Measurement positions are in a corner and in the room, according to the standards except when the sound occurs so irregularly that the corner selection procedure cannot be completed. Then the corner with the apparently most reflecting surfaces may be selected also with EN ISO 16032.

The measurement times are typically 30 seconds per position, but in some cases they are longer. Several cases with time variant sources are described.

3. Survey method – EN ISO 10052

To handle time varying sources and to reduce uncertainties a selection procedure for the number of positions and measurement is introduced.

The principal method to determine the number of measurements in each position is to start by one measurement in the corner position and two measurements in one position in the reverberant field. Then, the 3 registred sound pressure levels are compared. In case the A-weighted level is the target, the operator checks whether their A-weighted differences are less than 3 dB. If so, the energetic average of the 3 levels is the final result.

If not, new positions are chosen and further measurements are conducted. If the difference between the six measurements is less than 6 dB, these levels are averaged and the measurement session is completed. If not, a third set of measurements has to be conducted.

If the difference is still not acceptable (less than 9 dB) the variation is too large to enable a relevant measurement and a new session has to be initiated at another occasion. This scheme is illustrated in Figure 1.

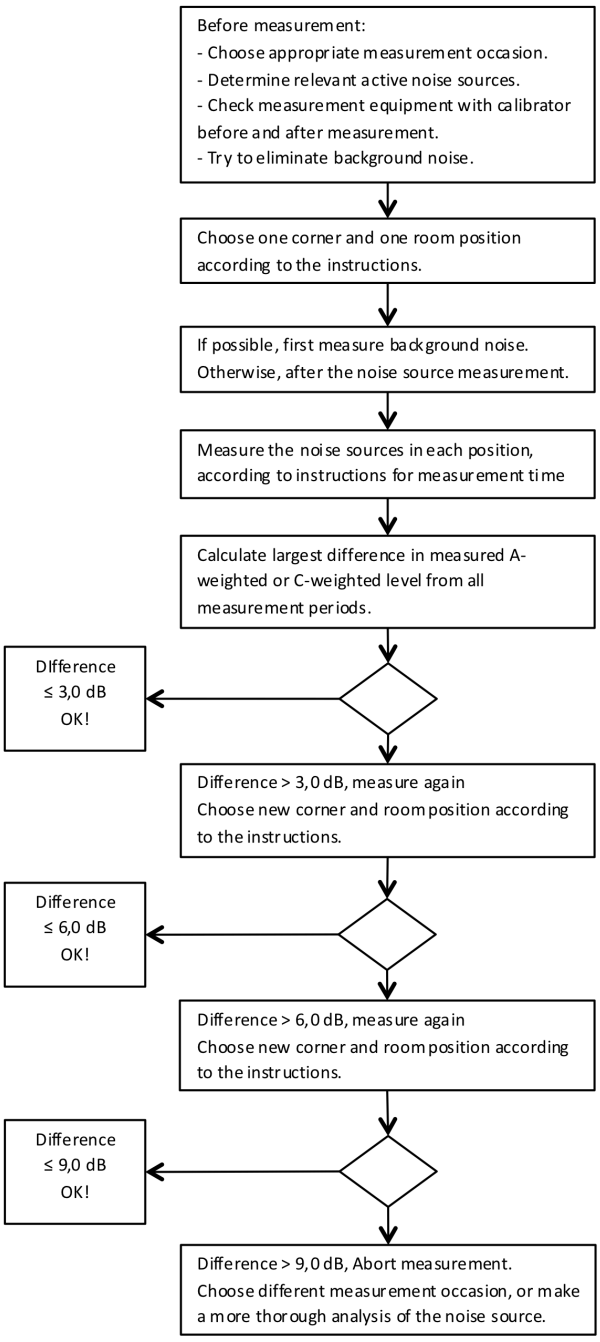

Figure 1. Flow chart for determination of number of measurements and positions – EN ISO 10052.

This procedure is stricter than in EN ISO 10052 and closer to the EN ISO 16032, see section 4. The reason is that comparisons have indicated that the choice of corner is very important and the instruction in the standard is not unambiguous.

Time variations may be one reason for large variations between individual measurements. Such variations can be handled by extension of the averaging time, but the measurement time should always be twice as long in the room position(s) as in the corner.

Another reason for large variations may be interference, i.e. standing waves. The dedicated corner position of the standard intends to partly compensate for this. This procedure has been found to correlate reasonably with an average taken with the microphone positions distributed evenly in the room (but not closer to the boundaries than 0,5 m) [5].

No correction for background sound is allowed when the survey method is used.

Correction for the influence of furniture etcetera is made in a simplified way compared to the standard: if measurements are made in an empty room that is intended to be furnished, e.g. in dwellings, a -3 dB correction is applied to the A-weighted level but not to the C-weighted level, nor to the third octave band levels 31-200 Hz.

Maximum sound pressure levels are handled in the same was as for equivalent sound pressure levels.

4. Engineering method – EN ISO 16032

This method is similar to the survey method, but there are some important differences, e.g. in how many measurements need to be taken in each position.

First of all, the corner position is determined by measuring the C-weighted levels in all corners and choosing the corner with the highest level. Two separate room positions are chosen (instead of one). The flow chart in Figure 2 illustrates how the number of measurements is determined in course of the measurement session. Some instructions are given on how background sound should be measured for correction after the measurements have been completed.

Recording of the sounds and editing is allowed, provided all chains of the equipment fulfils the requirements on linearity. A number of known issues are pointed out in the guidelines, e.g. that mp3 recordings are not applicable.

The A- or C-weighted levels are calculated from the averaged levels in third octave bands 31-10000

Hz which is a change compared to ISO 16032 where the A-weighted level is calculated from the octave bands 63-8000 Hz. However, standardization of the sound levels to 0,5 seconds of reverberation time is only made in the third octave bands 100-5000 Hz, all other frequency band values are applied without correction. This is also a change compared to ISO 16032. Both changes were necessary in order to comply with the national requirements.

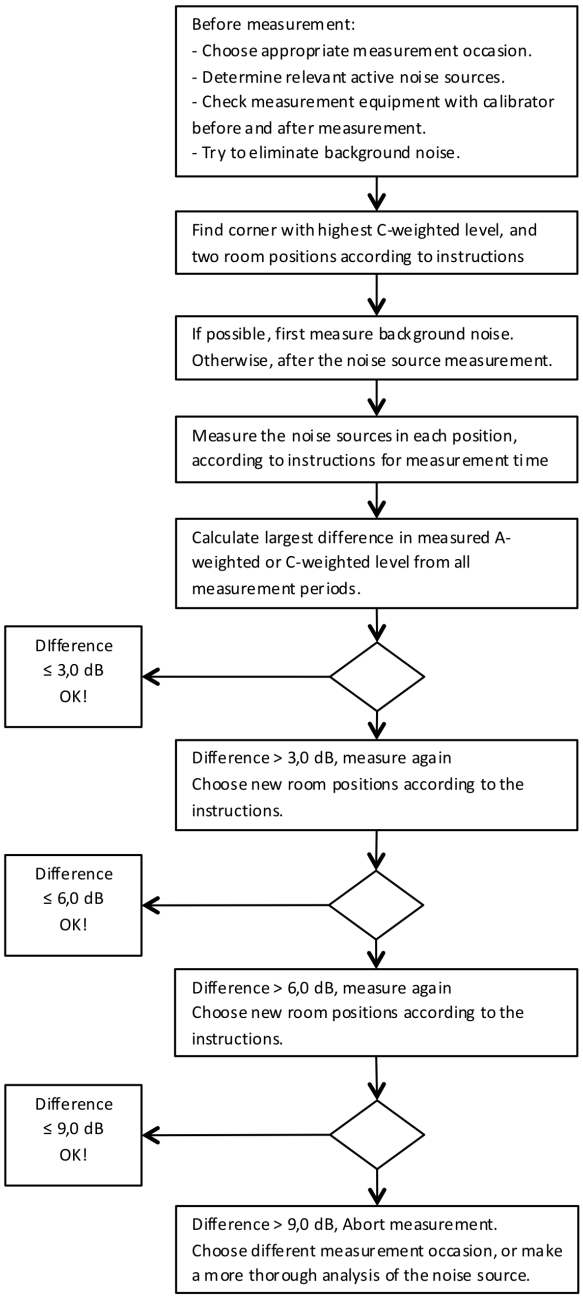

Figure 2. Flow chart for determination of number of measurements and positions – EN ISO 16032.

Further descriptions of the averaging is given in section 5.

For the purpose of identification and ranking of sources that may explain excessive sound levels in a room nearby, some examples are given in the guidelines, however outside of the scope of the standards. For example, running sources one by one, using FFT or other coherent analyses, vibration measurement on the source and in the room in parallel are mentioned as possible techniques, to be conducted by an acoustic expert.

5. Averaging of sound pressure levels

The averaging equations are detailed to facilitate the application also for users who do not have access to the standards. They follow from equations 1, 2 and 3.

When the difference ≤ 3,0 dB: Calculate the average sound pressure level according to eq (1):

$$L_{Xeq} = 10lg\left(\frac{10^{\frac{L_{Xeq,H}}{10}}+10^{\frac{L_{Xeq,R1}}{10}}+10^{\frac{L_{Xeq,R2}}{10}}}{3}\right) \quad (1)$$

where

X denotes the actual third octave band
$L_{Xeq,H}$ denotes the measurement in the corner
$L_{Xeq,R1}$ and $L_{Xeq,R2}$ denote the two measurements in the single room position in the reverberant field

When the difference ≤ 6,0 dB, use eq (2):

$$L_{Xeq} = 10lg\left(\frac{\sum_{i=1}^{2}10^{\frac{L_{Xeq,Hi}}{10}}+\sum_{j=1}^{4}10^{\frac{L_{Xeq,Rj}}{10}}}{6}\right) \quad (2)$$

where

X denotes the actual third octave band
Hi is the measurement *i* in the selected corner
Rj is the measurement in the room position j

When the difference ≤ 9,0 dB, use eq (3):

$$L_{Xeq} = 10lg\left(\frac{\sum_{i=1}^{3}10^{\frac{L_{Xeq,Hi}}{10}}+\sum_{j=1}^{6}10^{\frac{L_{Xeq,Rj}}{10}}}{9}\right) \quad (3)$$

If the difference > 9,0 dB, the measurement session is discontinued.

Maximum levels are calculated in the same way as for equivalent sound levels, which implies the final result is not the real maximum level but a time and spatially averaged level. This was considered necessary to reach an acceptable

reproducibility. The procedure in the guidelines adds a stricter definition of a maximum level than is given in the regulations. Since the averaging is made of the squared sound pressures, it follows that the loudest events will determine the final result and this argument was accepted by the authorities.

6. Conclusions

A guideline has been developed, to adapt the measurement methods in EN ISO 10052 and EN ISO 16032 to the national regulations in Sweden. Additional instructions address handling of time variant sources, a problem that has become more common in recent years.

Acknowledgement

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