Measurements and analysis of ventilation equipment noise according to the ISO 16032

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The analysis of noise measurements from ventilation system for more than 520 rooms is presented in this paper. The main goal of the measurements was to check if the noise levels in apartments fulfil the requirements regulated by Estonian Social ministry act #42 „Permitted noise levels in residential and recreational areas, residential and communal buildings and noise measurement method“ and improving the sound insulation of ventilation units or ducts in case the evaluated noise levels exceeded the limit values. Measurements were conducted for all types of apartments rooms: bedrooms, living rooms, kitchens, bathrooms, saunas etc. The main sources of noise were ventilation units that have been installed in each bathroom of the apartment. As a result of analysis, it can be stated that: measured reverberation time values in unfurnished rooms have the biggest impact on the final results of calculated noise levels according to ISO 16032 measurement standard, while the measured background noise results in most cases have the minimum influence on the calculated results.

1 Introduction. Measurements conditions

In the end of April 2020 series of technical noise measurements in new residential complex were started. The main aim of the measurements was to compare the noise levels in each apartment's room in the complex with permitted limits of the noise levels for the technical equipment according to the Estonian Social ministry act #42 „Permitted noise levels in residential and recreational areas, residential and communal buildings and noise measurement method“ [1]. Noise from the technical equipment, background noise levels as well as reverberation time values were measured in 1/1 octave bands in the range 31,5 – 8000 Hz. 3 measurement positions were taken in each room according to the measurement standard [2]. The limit values for each type of room are presented in Table 1 [1].

Table 1. Limits values for the technical noise in apartments

Parameter	Type of the room	
	Living rooms, bedrooms	Kitchens, bathrooms, saunas
L_{Aeq}, dB	30	35
L_{Ceq}, dB	50	55
L_{Amax}, dB	35	40

In case the calculated noise levels after the first measurements exceeded the permittable noise levels, additional measurements were conducted after implemented improvements until the final results would fulfil the noise requirements. Number of rooms by type and total amount of measurements are presented in Table 2.

Table 2. Number of rooms, measurements, and repeated measurements

Type	Number of rooms	Number of measurements	Number of repeated measurements
Kitchen-Living room	117	122	5
Bedroom	152	163	11
Bathroom/WC	124	234	110
WC	3	3	0
Sauna	2	2	0
Total amount	398	524	126

1.1 Noise sources

The main sources of noise were the ventilation units that have been installed in each bathroom of the apartment and ventilation outlets in other rooms. Noise measurements were performed at the first operating speed of the ventilation unit ("Home" mode). In some apartments additionally to the ventilation units, air cooling systems were installed and measured as well.

1.2 Reverberation time measurements

All rooms, except bathrooms were not furnished during the measurements, therefore reverberation time measurements were conducted in the rooms with original shapes and volumes. In total, reverberation time measurements were conducted in 47 rooms of different area, volume or shape. Averaged reverberation time is presented on Figure 1 for three types of the rooms: small rooms, where the floor area is less than 20 m^2; medium rooms, floor area 20-30 m^2; large rooms with the floor area more than 30 m^2.

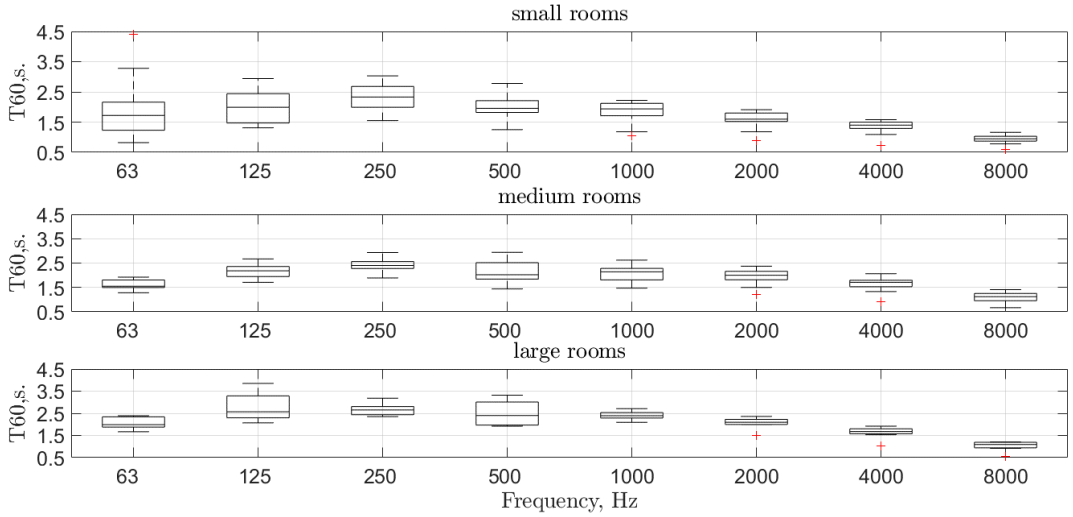


Figure 1. Average reverberation time in small (< 20 m^2), medium (20-30 m^2) and large rooms (>30 m^2)

2 Measurement processing

According to the measurement standard [2], measured noise levels in all types of rooms must be corrected by background noise and reverberation time (unfurnished rooms), except bathrooms. Correction by background noise depends on difference of averaged noise levels and averaged background noise levels for each 1/1 octave band. According to the measurement standard [2] formulas (5, 8) correction by background noise is limited in a range [0; 2.2] dB, while the correction by reverberation time can be in a range [-7; 9] dB for reverberation time [0;4] s. each octave band. Correction by background noise depends on difference between the measured noise and background noise levels, while the correction by reverberation time depends on measured reverberation time values. Corrections dependencies from measured noise, background noise and reverberation time corrections are shown on Figure 2.

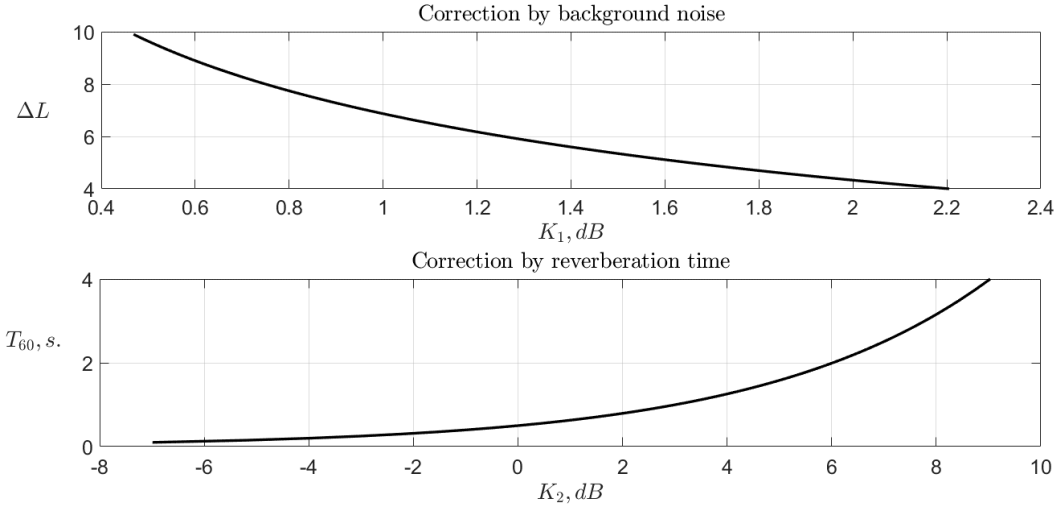


Figure 2. Background noise and reverberation time correction dependencies

3 Analysis of measured data

According to the standard [2] next data have to be measured in 1/1 octave bands in a frequency range 31.5 Hz – 8000 Hz:

- noise levels from the technical equipment;
- background noise levels (technical equipment is turned off);
- reverberation time in unfurnished rooms (except bathrooms).

Measured values have to be averaged in 1/1 octave bands for each measurement point, noise levels have to be corrected by background noise levels and reverberation time (if needed) and calculated noise levels have to be compared with limit values. Analysis of measured and calculated noise levels is presented below.

3.1 Measured noise levels in the rooms with installed ventilation units

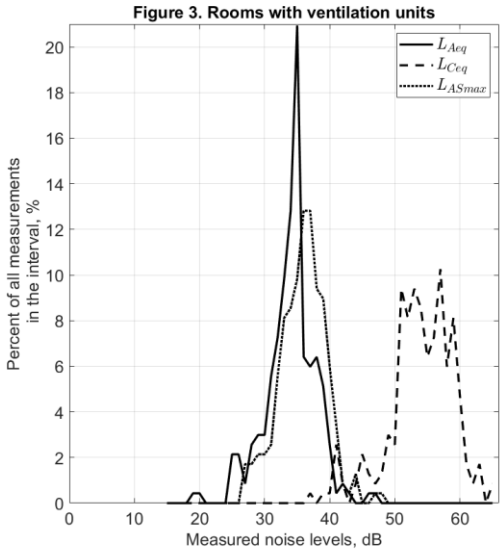
The distribution of measured levels L_{Aeq}, L_{Ceq} , L_{ASmax} in the rooms where ventilation units were installed (bathrooms), presented on Figure 3. According to the measurement results:

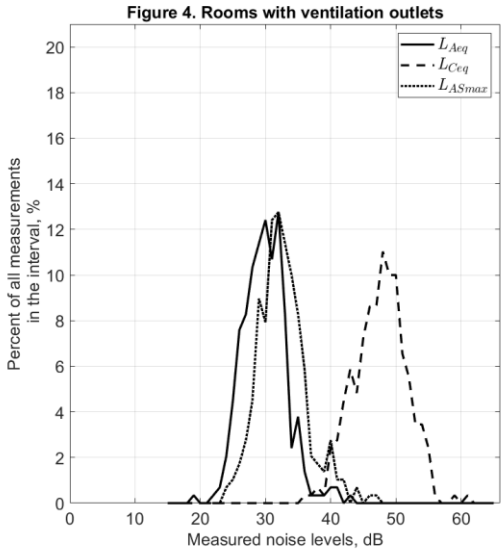
- for more than 98% of results, measured L_{Aeq} = [25; 44] dB;
- for more than 98% of results, measured L_{ASmax} = [25; 45] dB;
- for more than 92% of results, measured L_{Ceq} = [44; 65] dB;
- average difference between L_{Aeq} and L_{ASmax} equal to 1.8 dB.

3.2 Measured noise levels in the rooms with ventilation outlets

The distribution of measured L_{Aeq}, L_{Ceq} , L_{ASmax} levels in the rooms with ventilation outlets only (all types of rooms except bathrooms), presented on Figure 4. According to the measurement results :

- for more than 97% of results, measured L_{Aeq} = [23; 37] dB;
- for more than 98% of results, measured L_{ASmax} = [24; 43] dB;
- for more than 98% of results, measured L_{Ceq} = [38; 56] dB;
- average difference between L_{Aeq} and L_{ASmax} equal to 3.8 dB.

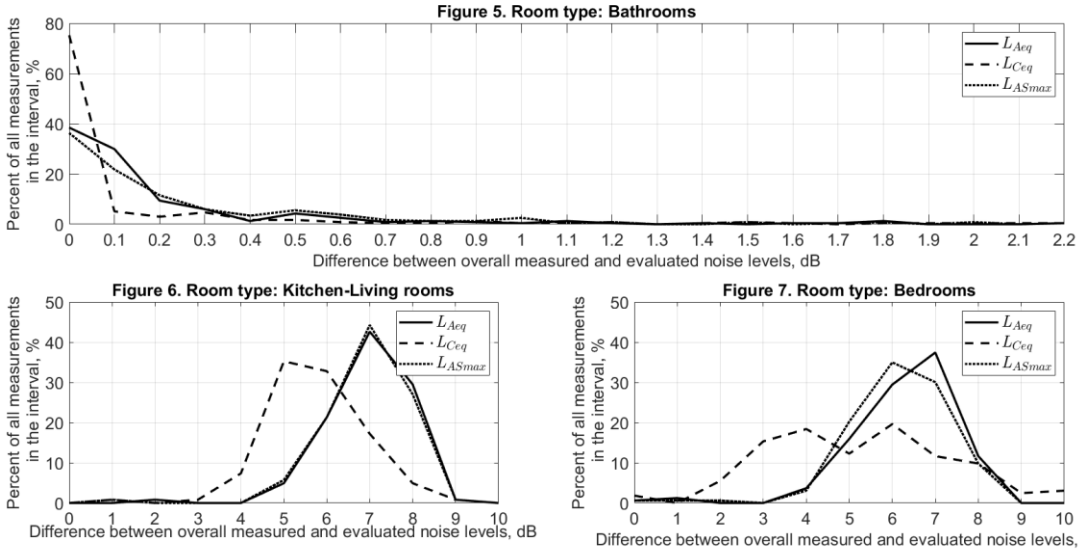




Figures 3 and 4. The distributions of measured levels L_{Aeq}, L_{Ceq} , L_{ASmax} in the rooms with ventilation unit and outlets only

3.3 Background noise and reverberation time influence on the calculated noise levels

As it was already mentioned above, correction from the background noise can be in a range of [0, 2.2] dB depending on the measured difference between the measured noise levels in 1/1 octave bands. To evaluate the overall correction, measured noise levels were subtracted from the calculated levels and the results are presented on Figures 5-7. All rooms were distributed on three types: bathrooms, bedrooms with the floor area up to 30 m^2, kitchen-living rooms with the floor area equal or over 30 m^2 .



Figures 5-7. Difference between overall measured and calculated noise levels in bathrooms, kitchen-living rooms and bedrooms

4 Conclusions

- The ventilation units are a noise sources with steady noise levels, where the average difference between L_{Aeq} and L_{ASmax} values in the rooms, where the ventilation units were installed, is equal to 1.8 dB. In other rooms with ventilation outlets only, the difference between L_{Aeq} and L_{ASmax} was equal 3.8 dB, due to bigger influence of background noise, such as outside sources of noise, traffic, weather conditions etc., as well as lower noise levels from the ventilation outlets;
- Correction by background noise in bathrooms were in a range of [0, 0.2] dB for more than 80% of the rooms. In case the measured noise levels in the bathrooms exceeded the permitted noise limits, only 14% of the calculated L_{Aeq} results, 2% of L_{Ceq} and 5% of L_{ASmax} values fulfilled the requirements after background correction has been applied to the measurement result;
- In unfurnished rooms with ventilation outlets average correction by background noise and reverberation time is in a range of 6-8 dB. Correction by background noise and reverberation time makes a sufficient impact on calculated noise level results. For more than 88% of the rooms, where measured noise levels exceeded the noise requirements for all L_{Aeq}, L_{Ceq} , L_{ASmax} values, the calculated noise levels fulfilled the requirements, after background noise and reverberation time corrections have been applied;
- The permitted noise level exceedance was mainly registered in the bathrooms with installed ventilation units. Only in 5 apartments out of 110 (251 rooms), the noise limit was also exceeded in other apartment rooms besides the bathroom. This result demonstrates properly designed and performed sound insulation works in the ventilation ducts of the system.
- It is highly recommended to perform the noise level measurements and calculation for all types of technical equipment according to ISO 16032 measurement standard in apartments or office rooms, if the rooms are unfurnished during the measurements, as measured noise levels can change dramatically after implementing the reverberation time correction.

References

[1] Sotsiaalministri määrus nr. #42 „Müra normtasemed elu- ja puhkealal, elamutes ning ühiskasutusega hoonetes ja mürataseme mõõtmise meetodid“

[2] ISO 16032 (2004) Measurement of sound pressure levels from service equipment in buildings - Engineering method