Noise from Service Equipment in Residential Buildings and Hospitals

– Regulations in selected countries in Europe

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Abstract: Noise from service equipment can cause disturbances for both occupants and nearby residents. This paper describes the regulatory limits set by various European countries regarding noise from HVAC systems and other installations in residential buildings and hospital bedrooms. It is observed that the descriptors used are, in some cases, different from each other and therefore not always directly comparable. Very often the main differences are found in the verification procedures and descriptors rather than in the limit values. The regulations in each country define the necessary requirements and provide reference values for the design phase, while standards specify the measurement methods to be applied for field tests to ensure compliance with the requirements.

Keywords: Service equipment noise, HVAC systems, Acoustic comfort, Sound pressure level, Dwellings, Hospitals.

Introduction

Noise from building services can lead to annoyance and discomfort for the occupants and people in the surroundings and this is the reason why regulations in several European countries set noise limits for service equipment. Complying with regulations often involves a solid understanding of how noise from building services is generated and transmitted, enabling effective design choices that minimize noise. In an HVAC system, potential noise sources are fans, compressors, ducts, airflow noise, grilles, and terminal equipment.

Figure 1 shows an example of the layout of a typical mechanical ventilation with heat recovery (MVHR) installation in a dwelling and its potential sources of noise. Due to energy efficiency requirements, this type of units is becoming more common in dwellings around Europe and they work continuously, circulating air and affecting noise sensitive spaces such as bedrooms and living rooms. While the duct system consisting of ducts, branches, bends and grilles, provides some attenuation, it can also provide some flow generated noise.

In addition, noise may break out from the heat recovery unit enclosure to the room where it is located, and also through the duct walls. Structure-borne transmission from the fans can also be transmitted to the floors and walls if anti-vibration mounts are not used.

This paper reports and compares the regulatory limits and verification procedures in some European countries with a specific focus on residential buildings and hospitals. Regarding other buildings, very often the verification procedures are similar while the reference values change.

Understanding acoustic descriptors for service and equipment

Concerning service equipment noise, acoustic regulations distinguish between continuously and discontinuously operating systems.

Continuously operating systems are characterised by sound emission with an essentially stationary character, i.e. when the Sound Pressure Level, SPL, measured with Fast time weighting (F) fluctuates by no more than 5 dB throughout the entire operating time. For example, continuously operating systems are heating, cooling, air-conditioning, mechanical ventilation and central vacuum systems.

On the other hand, discontinuous operation systems are characterised by sound emissions with fluctuating or intermittent variations and short periods of operation; in these systems, the fast SPL varies randomly with oscillations greater than 5 dB. Therefore, sanitary installations, exhaust systems, lifts and automatic shutoffs are to be classified as discontinuous systems.

The main difference in the required limits for the two types of equipment concerns the measured quantity. For continuously operating systems, the limit refers to the equivalent SPL, $L_{Aeq,}$, which provides a representative noise value for a certain period of time, whereas for discontinuous operating installations, the limit refers to the maximum SPL, $L_{Amax.,}$ which provides a representative value of the maximum noise level.

For both descriptors, $L_{Aeq,}$ and $L_{Amax.,}$ it is necessary to measure the background noise, i.e. the average ambient SPL when the equipment is switched off.

Measurement methods

When checking compliance with regulations or investigating noise complaints, measurements are usually performed. References to measurement methods are found in the building regulations or in the guidelines referred to in the regulations or in other national guidelines. The ISO standards for measuring noise from building services are typically ISO 10052 [1] and/or ISO 16032 [2]. As SPL can vary significantly from point to point in a room, these two standards include important aspects to ensure repeatable and accurate results, such as microphone positions, the number of measurements, the correction for background noise and the duration of each measurement.

The SPL of HVAC equipment will also vary with the operating conditions of the equipment, for example, for partial load or full load operation. Thus, the operating conditions must be specified in the reports. ISO 10052 [1] and ISO 16032 [2] provide a common framework defining some operating conditions for each kind of building services including ventilation, heating and cooling services, but in some countries, other conditions may apply in their own guidelines. However, for automatically controlled equipment, such as ventilation systems in dwellings, field tests require the adjustment

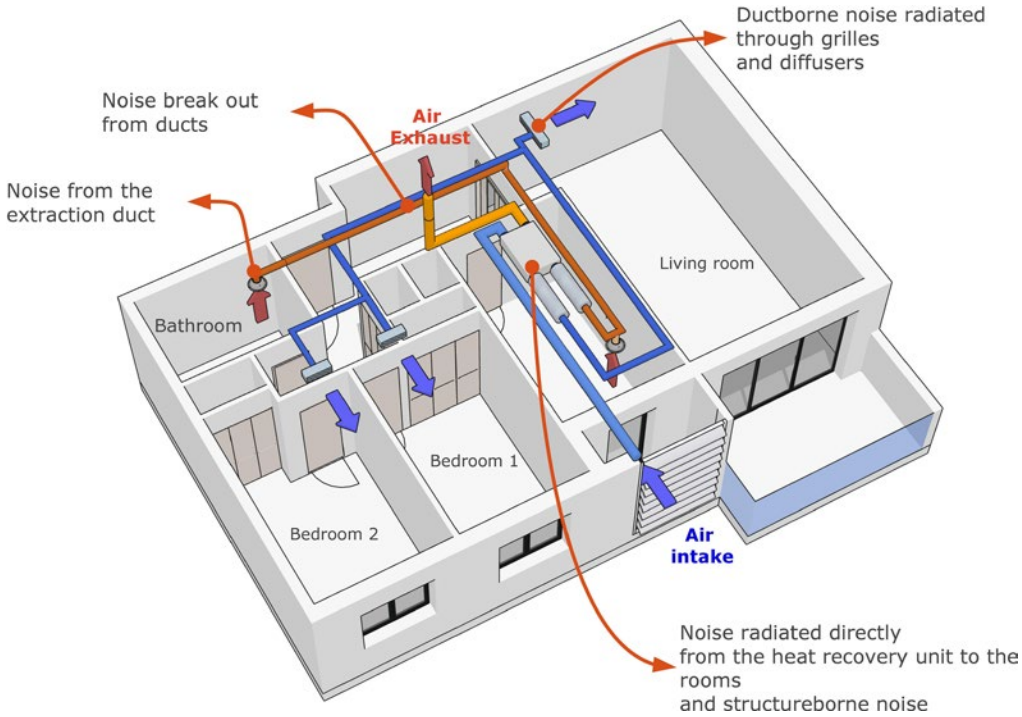

Figure 1. Typical layout of a MVHR system in a dwelling and its potential noise sources.

of the operating conditions to comply with the building code requirements on air quality [3].

Moreover, in several countries additional methods apply for low-frequency noise, pure tones, impulses and intermittent noise. It should be noted that usually (Vienna agreement) the ISO standards are implemented as EN standards and subsequently as national standards in CEN member countries.

The following issues are relevant to ensure the quality of measurements of service and equipment noise:

- The confirmation that the instrumentation complies with IEC standards.
- The calibration of test instruments.
- The Instrumentation details, which must be capable of measuring low sound pressure levels at relevant frequency bands with sufficient accuracy.
- The operator expertise in both the test method and systems.
- The quality of tests reports according to the test standard including the test conditions.

Limit values in some European countries

In this paragraph, the regulatory limits for equipment noise in dwellings and in hospitals in selected European countries, are reported together with the reference standard for the verification and other specific information. For a better understanding, the limit values, the reference standards and detailed comments have been collected in table format. More information can be found in some previous studies by the authors [4, 5].

The selected countries and related regulations are Denmark, England, France, Italy, Norway, Portugal, Spain and Turkey.

Limit values for service equipment noise in dwellings are found in **Table 1** [5] and in **Table 2** for hospitals bedrooms [4].

The data are generally divided into those for continuously operating equipment whose descriptor is generally L_{Aeq} and discontinuously operating equipment with the descriptor L_{ASmax} or L_{AFmax}. In almost all cases, there is either a correction for reverberation time or a correction depending on the presence or absence of furniture.

Please note that all data presented in **tables 1 and 2** have been extracted from regulations and laws which were in force in November 2022. Links to the regulations of each of the selected countries can be consulted in the reference section.

It should also be noted that the limit values included in this paper should not be applied directly as legislation, but the original documents or updates consulted, as they include more details and conditions than in the present paper.

The values given are mandatory or recommended according to the requirements of the various countries. It can be seen that the requirements for continuously operating systems generally vary between 25 and 30 dB(A), while for discontinuous noise, they vary between 30 and 35 dB(A).

To get an idea of the extent of these requirements, a comparison can be made with the limit values defined by the ISO/TS 19488 [26] for the acoustic classification of dwellings. The scope of this standard is to specify a classified level of acoustic quality for a dwelling and help users and builders to be informed about the acoustic conditions and define increased acoustic quality. It does not have a legal status in a country, unless decided by its own authorities. At present, none of the countries surveyed refer to ISO/TS 19488 for the acoustic performances of buildings.

ISO/TS 19488 provides six classes from A to F. For service equipment producing continuous noise, the values range from a value of less than 22 dB(A) for Class A to a value of less than 42 dB(A) for Class F. For service equipment producing intermittent or irregular sound, from neighbouring spaces, the values range from a value below 26 dB(A) for Class A to a value below 46 dB(A) for Class F. Therefore, the limit values are approximately Class C for both types of noise.

As a reference, EN 16798-1 [27] specifies levels for the characteristic parameters of indoor environmental quality to be used in building system design for the purpose of calculating energy performance. Regarding the noise from installations and HVAC systems, the standard considers three levels of expectation for the equivalent noise level normalized to reverberation time, $L_{Aeq,nT}$, according to the building's intended use and the type of environment considered. These reference values are suggested for design purposes, but only in few cases become part of the requirements for the enforced legislation in European countries studied in this paper.

Conclusion

In the paper, the regulatory limits and related test methods were described. An initial analysis of the requirements showed that the descriptors applied seemed different among the various European countries. However, from a detailed analysis, it was seen that the meaning is essentially equivalent. In fact, for verification of noise emitted by continuously operating

Table 1. *Service equipment noise limits for dwellings (habitable rooms) (1). November 2022.*

Country	BR	Test method	Requirement [dB] (*)	Furnished	Comments
Denmark	[6]	ISO 10052 and DK guideline [7]	$L_{A,eq} \leq 30$	–	If measured in a furnished room, +3 dB is added to the measured value. BR [6] refers to Class C in ACS [8] as the requirement for habitable rooms.
England	[9] [10]	National procedure and Guideline [11]	$(L_{Aeq,T} \leq 30)$ $(L_{Aeq,T} \leq 45)$	Not specified	Levels for living rooms and bedrooms, for ventilation systems. Levels for kitchens and bathrooms for ventilation systems. Recommended limits for noise from other building services in dwellings are found in [12].
France	[13]	ISO 10052 and FR guideline [14]	$L_{nAT} \leq 35$ $L_{nAT} \leq 30$ $L_{nAT} \leq 30$ $L_{nAT} \leq 30$	Not specified	Noise produced by individual heating or cooling systems. Noise produced by mechanical ventilation systems. Noise produced by other equipment belonging to another dwelling. Noise produced by collective building equipment, such as lifts, water pumps, boilers, etc. $L_{nAT} = L_{ASmax,nT}$. standardized to the reference reverberation time (average of the RT values for 500 Hz, 1000 Hz et 2000 Hz). Note: Noise limits for living rooms and bedrooms. Limit for kitchens specified in [13].
Italy (public)	[15] [16]	ISO 10052 or ISO 16032 and national procedure	$L_{ic} \leq 28$ $L_{id} \leq 33$	+	Equivalent SPL from service equipment with continuous operation. Maximum SPL from service equipment with discontinuous operation. Note: Descriptors are explained in [17].
Italy (private)	[15]	ISO 10052 or ISO 16032	$L_{Aeq} \leq 25$ $L_{ASmax} \leq 35$	Not specified	Equivalent SPL from service equipment with continuous operation. Maximum SPL from service equipment with discontinuous operation.
Norway	[18]	ISO 16032	$L_{p,A,T} \leq 30$ $L_{p,AF,max} \leq 32$	+	The Building regulations [18] refers to Class C in ACS [19] 5 dB higher sound levels are ok in kitchens, WC, bathrooms, entrances etc. In addition to the limits indicated, there are also low frequency limits for octaves 31,5-125 Hz.
Portugal	[20]	National procedure[21]	$L_{Ar,nT} \leq 27$ $L_{Ar,nT} \leq 32$ $L_{Ar,nT} \leq 40$	Not specified	For building services producing a continuous noise. For building services that works intermittently For an emergency power unit. $L_{Ar,nT} = L_{A,eq}$ (standardized to the reference reverberation time) corrections for background noise and tonal noise.
Spain	[22] [23]	National procedure[23]	$L_{k,n} \leq 25$ $L_{k,n} \leq 30$	Not specified	For bedrooms in dwellings. Limits for the night period, 23:00 – 7:00h. For the day and evening periods, limits are: $L_{k,d;}\ L_{k,e} \leq 35$ For living rooms in dwellings. Limits for the night period, 23:00 – 7:00h. For the day and evening periods, limits are: $L_{k,d;}\ L_{k,e} \leq 40$ Limit value $L_k = L_{A,eq,T}$ + corrections for background noise, tonal, impulsive and low frequency noise.
Turkey	[24]	ISO 10052 or ISO 16032	$L_{A,eq,nT} \leq 30$ $L_{A,eq,nT} \leq 35$	+	Limit for continuous noise in bedrooms during night-time, 23:00 – 07:00. Limit for continuous noise in living areas, kitchen - during 24 hours.

(1) Overview information only. Detailed criteria and conditions are found in references.
(*) Limits in (brackets) = Recommendation.

equipment L_{Aeq} is generally used and L_{Amax} with slow or fast time constant is used for discontinuously operating equipment. In both cases, a correction for reverberation time is generally applied. A comparison of the limit values shows that for L_{Aeq} the limits vary between 25 and 30 dB(A) while for L_{Amax} values vary between 30 and 35 dB(A).

From a comparison with the values in ISO/TS 19488 Table 4, it is observed that the noise Class of the regulatory limits generally are approx. Class C for both types of noise on a range between A and F.

Concerning the three performance levels in EN 16798-1, where different values are suggested depending on the type of environment, it is vital to compare them with the requirements in the Building Codes before applying them, as the suggested values in EN 16798-1 for some environments are much noisier than the regulatory limits.

References

Please find the complete list of references in the html-version of this article at rehva.eu ■

Table 2. *Service equipment noise limits for hospital bedrooms[(1)]. November 2022.*

Country	BR	Test method	Requirement [dB] (*)	Furnished (**)	Comments
Denmark	[6]	ISO 10052 and DK guideline [7]	($L_{A,eq}$ ≤ 30)	+	
England	[25]	National procedure and Guideline [11] [25]	(NR ≤ 30)	+	
France	[13]	ISO 10052 and FR guideline [14]	L_{nAT} ≤ 30 L_{nAT} ≤ 35	Not specified	Noise produced by communal equipment or individual equipment inside the room. Noise produced by plumbing and drainage systems in adjacent rooms. $L_{nAT} = L_{ASmax,nT}$. standardized to the reference reverberation time (average of the RT values for 500 Hz, 1000 Hz & 2 000 Hz).
Italy (public)	[15] [16]	ISO 10052 or ISO 16032 and national procedure	L_{ic} ≤ 28 L_{id}≤ 34	Not specified	Equivalent SPL from service equipment with continuous operation. Maximum SPL from service equipment with discontinuous operation. **Note**: Descriptors are explained in [17]
Italy (private)	[15]	ISO 10052 or ISO 16032	L_{Aeq} ≤ 25 L_{Asmax} ≤ 35	Not specified	Equivalent SPL from service equipment with continuous operation. Maximum SPL from service equipment with discontinuous operation.
Norway	[18]	ISO 16032	$L_{p,A,T}$ ≤ 28 $L_{p,AF,max}$ ≤ 30	+	BR [18] refers to Class C in ACS [19].
Portugal	[20]	National procedure [21]	$L_{Ar,nT}$ ≤ 30 $L_{Ar,nT}$ ≤ 35	Not specified	For building services producing a continuous noise. For building services producing intermittent noises. $L_{Ar,nT} = L_{A,eq}$ (standardized to the reference reverberation time) corrections for background noise and tonal noise.
Spain	[22] [23]	National procedure [23]	$L_{k,d}$; $L_{k,e}$ ≤ 35 $L_{k,n}$ ≤ 25	Not specified	Limit value $L_k = L_{A,eq,T}$ + corrections for background noise, tonal, impulsive and low frequency noise.
Turkey	[24]	ISO 10052 or ISO 16032	$L_{A,eq}$ ≤ 30 $L_{AF,max,nT}$ ≤ 34	+	BR [24] refers to Class C in ACS [24]. The two limits are for continuous and intermittent noise, respectively.

(1) Overview information only. Detailed criteria and conditions are found in references.
(*) Limits in (brackets) = Recommendation. (**) +: Requirements apply to furnished rooms. Not specified: Regulations do not specify if requirements apply to furnished rooms.