



Proceeding Paper

Work Comfort in a Home Office with Mechanical Ventilation—A Case Study[†]

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Abstract: The paper presents an analysis of the work comfort in a home office located in a single-family building with supply and exhaust ventilation with heat recovery. The noise level was measured, and the subjective feelings of the working person were analysed. The analysis covered five fan efficiency settings: fan off, low, normal, high and maximum. The highest sound level (31–32 dB(A)) was observed for the maximum and high power of the fan. Normal and low fan levels resulted in a similar noise level of 20–21 dB(A). The sound level influenced the feeling of work comfort of the person. At the highest and maximum level of fan operation, the person complained about noise and draft. The low level did not adversely affect the comfort of work. The normal level, most often set by household members, resulted in the absence of draught or the sensation of a slight draught, and the ventilation operation was described as not onerous or slightly onerous. Workplace comfort depends on the operating conditions of the ventilation system (noise level, air velocity and temperature) and on the subjective feelings of the person working. In order to improve comfort, it is recommended that one locate the workplace away from the ventilation elements.

Keywords: comfort; home office; mechanical ventilation; noise level; temperature



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1. Introduction

Noise is an environmental pollutant, and its excessive levels negatively affect human health and life [1]. In modern buildings, in order to ensure a low energy consumption and comfort, the use of high-efficient heating, ventilation and air conditioning (HVAC) systems is required [2]. An example of this is mechanical supply and exhaust ventilation with heat recovery.

The use of mechanical ventilation in a building adds another source of noise [3]. The main source of noise in the ventilation system is the turbulent air flow in ducts. The higher the air flow velocity, the greater the noise [4]. An important source of noise is the fan and its motor [5]. Correctly selected devices, taking into account the ventilation air flow rate, compression and the maximum permissible air flow velocity, should not generate large noise. However, it happens that an incorrect installation design and natural usage of the fan components cause noise generation. Noise generated by ventilation may be perceived as tonal, disturbing and uncomfortable. It can negatively affect human well-being, productivity [6], the quality of sleep [7,8] and even self-esteem [9].

In the last three years, due to the COVID-19 pandemic, the number of people working remotely in domestic spaces has increased. Consequently, the working conditions have changed. Among the main circumstances negatively affecting work at home, there are other family members' presence and the lack of a separate room for work. The quality of the indoor environment, consisting of temperature, humidity, airspeed and noise level, also has a significant impact.

2. Methods

The room under analysis is located in a single-story building located in a quiet area away from traffic. The examined room has a surface area of 14.2 m² and is 2.74 m high (Figure 1).

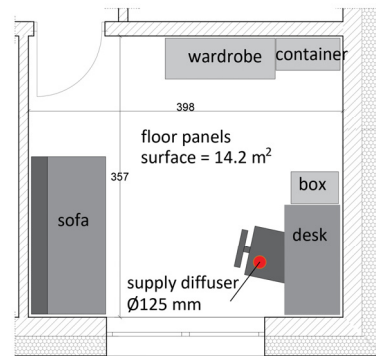


Figure 1. Scheme of the test room.

The building is equipped with an air handling unit with a capacity of 387 m³/h with a rotary heat recovery exchanger. The ventilation is made in a distributor system. In the analysed room, there is one supply air diffuser with a diameter of 125 mm, connected to an expansion box, lined with 3 mm thick sound-absorbing material. Two 75 mm flexible corrugated ducts, 12 m long, are connected to the plenum box to supply air from the supply air distributor and the air handling unit. The ducts are laid in the thermal insulation layer—styrofoam. The calculated airflow rate in the room is 40 m³/h. The supply air diffuser is not equipped with a throttle, and the airflow is regulated by the degree of opening of the anemostat.

The sound level emitted by the air handling unit is 42 dB(A). Central can operate on 5 levels:

- OFF level—unit switched off—fan speed 0 rpm,
- LOW level—fan speed 1020 rpm,
- NORMAL level—fan speed 1320 rpm,
- HIGH level—fan speed 3000 rpm,
- MAXIMUM level—fan speed 3120 rpm.

The office is used by one person at a time. The work is carried out in the absence of other family members, so during work, there are no sources of noise associated with the normal use of the house: talking, cooking, watching TV or playing. The only sources of noise are the air handling unit and mechanical appliances in the house, such as the refrigerator. Since the tested room is not adjacent to the kitchen, the impact of noise from the kitchen equipment is negligible.

The equivalent sound level A L_{Aeq} was measured with meter DSA-50 SONOPAN (accuracy class 1). The total measurement range for this meter of sound level (L_A) and equivalent sound level (L_{Aeq}) is 18–135 dB(A). The accuracy is 0.1 dB. The sound level measurements were taken at the desk, where the working person was sitting, at a height of 1.2 m from the floor (Figure 1). The outflow of air from the anemostat was measured using a TESTO 435 meter and a TESTO 417 wing anemometer with a measuring range of 0.3–20 m/s and accuracy of 0.01 m/s.

3. Results

Five L_{Aeq} measurements, each 10 min long, were taken at each fan speed setting, both with measurements of the speed of the air flowing out of the diffuser. The averaged results are presented in Table 1.

A questionnaire was carried out among the occupants of the room for variable settings of the ventilator. The persons did not know which fan operating level was set during the

survey. The questions related to subjective perceptions of the operating ventilation system: noise nuisance, description of loudness and draught sensation (Table 1). A 5-grade scale was used to assess noise nuisance: not onerous, slightly onerous, moderately onerous, very onerous, extremely onerous. For the evaluation of noise loudness, the following description was used: very quiet, quiet, neutral, loud, very loud. For the assessment of draught, a three-stage scale was used: no draught, weak draught, strong draught.

Table 1. Noise level L_{Aeq} and its assessment with the speed of the air flowing out of the diffuser v .

Parameter	L_{Aeq}	v	Noise Nuisance		Noise Loudness		Draught	
Fan Set	[dB(A)]	[m/s]	Person 1	Person 2	Person 1	Person 2	Person 1	Person 2
OFF	19.1	0.00	not onerous	not onerous	very quiet	very quiet	no draught	no draught
LOW	19.8	0.66	not onerous	not onerous	quiet	quiet	no draught	no draught
NORMAL	20.4	1.05	slightly onerous	not onerous	neutral	quiet	weak draught	no draught
HIGH	31.4	2.28	very onerous	very inconvenient	very loud	loud	strong draught	weak draught
MAX	32.0	2.48	very onerous	very onerous	very loud	loud	strong draught	weak draught

4. Discussion

The maximum permissible sound levels in Poland are specified in the PN-87/B-02156 standard [10]. In residential buildings, during the daytime, the permissible equivalent sound level from technical equipment of the building is 35 dB(A). The second standard, which is binding but not obligatory for use in Poland, is PN-B-02151-2 [11], in which the highest permissible equivalent sound level during the day is 25 dB(A).

The equivalent sound level with the ventilation off was about 19.1 dB(A). Operating the fan at a low and normal level resulted in a non-significant, from the noise measurement point of view, increase in the sound level by 0.7 dB(A) for the LOW fan setting and by 1.3 dB (A) for the NORMAL setting. At the LOW setting, the noise was described as not onerous and as quiet. The air discharge at the LOW setting did not cause any draught. At the NORMAL level, where the speed of air discharged from the diffuser oscillated around 1 m/s, the noise was assessed as slightly onerous and not onerous as well as neutral and quiet. One person felt a weak draught. The sound level increased significantly at fan operation levels HIGH and MAX to a value of 31.4 dB(A) at HIGH and 32.0 dB(A) at MAX. The difference in the sound level at the HIGH and MAX levels is negligible (0.6 dB(A)). Noise at the HIGH and MAX levels was rated as very onerous and as loud and very loud. A weak and strong draught was felt, with air discharge velocities from the anemostat ranging from 2.28–2.48 m/s.

The noise level for LOW and NORMAL settings, which are most often set by the residents, does not exceed the permissible values specified in the PN-87/B-02156 (35 dB(A)) [10] and PN-B-02151-2 (25 dB(A)) [11]. The fan operation at the HIGH and MAX levels caused the permissible sound level set by the PN-B-02151-2 standard to be exceeded.

5. Conclusions

The requirements in terms of an acceptable sound level were met for the fan setting, most often set by users, that represents about 33% of the maximum fan setting. Despite this, one person felt a slight annoyance with the operating ventilation, related to the noise level and speed of the supplied air.

In addition to the normative requirements, the subjective feelings of people working in a room with mechanical ventilation are important. They depend on many factors: gender, age, health condition and the type of work performed. The feeling of comfort among people during work requiring concentration is different than in the case of people performing everyday activities at home such as cooking and cleaning.

The perception of noise is also influenced by the level of the acoustic background, i.e., the noise level when the noise source is switched off. In this case, the background noise was low, so even a slight increase of 1–2 dB(A) caused negative feelings among the users of the room.

To reduce the negative impact of mechanical ventilation on a person performing mental work, it is recommended that one locate ventilation diffusers away from the workplace.

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Informed Consent Statement: The survey participant's consent was waived due to non-collection of data which include personal or sensitive information.

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Conflicts of Interest: The author declares no conflict of interest.

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