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The Noise Produced by the Air Handling Units Depending on the Type of Engine

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Abstract. The elaboration is the study is to examine the difference in the sound level in the air handling units made by the same producer. These units are of the same design parameters and components, and supply air and exhaust air. The only difference is mounted engines. Tested air handling units are equipped with an engine type EC, and traditional direct drive, controlled by an converter.

Sound level measurements were carried out in the ducts supply air ventilation system at a distance of 1 m from the air handling unit and for the unit at a distance of 2 m from the inspection door of the fan section of the supply, with 3 settings efficiency of units 30%, 60% and 90%. Tested headquarters are located inside the building.

Excessive noise has a negative effect on the human body, resulting in fatigue, difficulty in learning and concentration, impaired orientation, annoyance, increase in blood pressure, headaches, dizziness, and in the worst case of temporary or permanent hearing loss.

For this reason it is very important to protect against noise. Therefore, it was these studies.

Keywords: air handling units, sound, measurement of sound.

Conference topic: Environmental protection.

Introduction

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General requirements (main text)

The signals coming from the environment, recorded ear, called sounds.

Sound is called acoustic vibrations propagating in elastic medium capable of generating the impression of sound, which human contained in the band of frequencies between limit of approx. 20 Hz to 20,000 Hz. It depends to a large extent from the Age of the listener. With age range of ten is shrinking, especially from the High sounds *(Puria, Rosowski 2012; Wawrzynowicz* et al. *2014) [1].*

Occurring in the Environment Sounds undesirable or harmful to human health is referred to as noise. The most commonly used measure of noise is the sound level is expressed in dB.

Noise is the result of overlapping of different sounds that are mixed in a free land. Noise is called in common parlance each disturbing sound. The noise may cause adverse effects on human health, the world animal and vegetable (Ayr et al. 2001) [2].

Noise is undesirable, it causes irritability, fatigue and fatigue of the whole body, especially a hearing (Ayr et al. 2002) [3]. The noise has a negative action on health and the human condition. the effects on the body can be considered at three levels:

- direct action on the middle and inner ear,
- indirect action on the nervous system,
- action on other organs.

Excessive noise has a negative effect on the human body, associates revealed fatigue, difficulty in learning and concentration, impaired orientation, annoyance, increased blood pressure, headaches, dizziness, and in the worst case

of temporary or permanent hearing damage, noise causes anxiety, uncertainty, insecurity, crying (Ayr et al. 2002; Yong Jeon et al. 2011) [4], [5].

Sound intensity measurements generated by the air handling units are, one of the basic research performed in ventilation systems (Barrigón Morillas et al. 2016) [6].

When designing the installation of ventilation, both domestic as well as for public spaces, important to draw attention to issues of acoustics. Polish Standard PN-87/B-02151/02 Building acoustics. Noise protection facilities by weight of buildings. Allowable values sound level indoors [7] gives specific permissible sound level values at dedicated facilities do stay people. The sound level is that the value for the sound pressure level, adjusted tor. weighting curves A, B OR C Defines approximately level volume perceived by the human ear.

Acceptable levels of noise penetrating make the room from all sources of noise, including, in Various types of premises, included in the PN-B-02151-4:2015-06 (Kłosak, Jarosz 2016) [8], [9] is:

- For rooms in residential buildings and hotel – 40dB in the day and 30dB at night.
- For the kitchen and toilets in the apartments – 45 dB in the day and 40dB at night.
- For room patients in hospitals – 30–35dB in the day and 30dB at night.
- For classes in kindergartens and rooms for children in nurseries – 35dB.
- For lecture halls, conference rooms, classrooms, auditoriums – 40dB.
- For halls shops, cafes and restaurant – 50dB.

The exact division of the permissible levels of Sound, noise With fixed or not, is given in PN-87/B-02151/02 [7].

A significant effect on the sound level produced by the air handling systems of may which is the main source of sound (Shimizu, Koizumi 2015; Barclay et al. 2012) and [10], [11].

Measurements of sound in HVAC units have already been carried out by Crocker et al. (2004) [12], and also Hu and Ding (2006a, 2006b) [13], [14].

The aim of the study was to investigate the difference in the sound level produced by the air handling units are made by the same manufacturer. These devices are about the same structure and parameters of components and flow of supply and exhaust air. The only difference are mounted engines. Tested ventilation central are with engine type EC (Fig. 1) and traditional direct drive, controlled by an inverter.

Methodology

Were examined two AHU supply and exhaust with air flow up Vn = 10 650 m^3/h, Vw = 9700 m^3/h, will compress dispositions p = 350 Pa, AHU with water heaters and coolers and rotary heat exchanger, of similar size housings and flow velocities air. AHU vary the applied AC (Fig. 2) motors and EC (Fig. 1), while maintaining the same size Fans.

Asynchronous AC motor (induction) is the most popular engine, of the widest uses of all types of electric motors used in particular in industry, but also in household equipment (Fig. 3). It has very simple to maintain design. Asynchronous motor consists of two parts: a stationary stator formed of ferromagnetic sheets with grooves for the electrical windings of the coil, and a moving rotor is also made of a metal plate with grooves for winding. The alternating current in the symmetric multi-phase stator winding machine leads to the formation of variable magnetic field of each phase in such a way that the resultant field is called. rotating field, along the periphery of the rotating equipment, which is around the rotor. Control the amount of rotation of motors AC is done by a frequency converter.

Fig. 1. AHU with EC motors

Fig. 2. AHU with AC motors

Fig. 3. Asynchronous motor AC

EC motor (EC = electronically commutated) is a DC motor with an external rotor (Fig. 4). Using the charger and the electronic commutation alternating voltage is converted to DC voltage. Available power for operation of the engine depends on the setting of the frequency – the principle similar to the adjustments for frequency except in the case of EC motor electronic commutation is dependent on the state, the rotation direction and speed control and thus change the phase voltage of the stator of the motor (commutation). The motor rotor generated magnetic field is essential to create torque. This allows a high efficiency, low noise and variable speed.

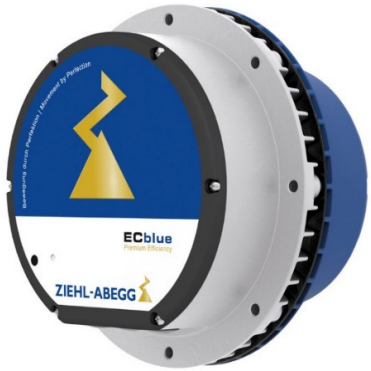

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Fig. 4. Motor EC

Results

For the measurement of sound (sound pressure) is used measuring instrument Testo 815 0563 8155 (Table 1). Measurements were carried out in October 2016, with the following parameters of external air temperature 9.2°C, 81% relative humidity, atmospheric pressure 1008 hPa using a measuring instrument Testo 435-4 and probe air quality (Table 1).

Table 1. Description of measuring equipment

Measuring items	Measuring range	Resolution	Accuracy
Testo 435-4 and probe air quality			
Temperature	–20°C to +50°C	0.1°C	±0.3°C
Humidity	+2 to +98% RH	0.1% RH	±2 %RH
Atmospheric pressure	+600 to +1150 hPa	0.5 hPa	±5 hPa
Testo 815 0563 8155			
Sound	+32 to +130 dB	0.1 dB	±1.0 dB

Table 2. The sound pressure values of the cards selection of supply and exhaust with AC motor

Supply Fan									
Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	Sum
IN (dB)	42	62	72	74	76	75	72	69	81
OUT (dB)	49	66	76	83	86	81	77	71	89
Exhaust Fan									
Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	Sum
IN (dB)	40	64	70	71	74	72	69	65	79
OUT (dB)	46	69	74	81	83	78	74	68	87

Table 3. The measured sound pressure fan supply air and exhaust air from the AC motor

Supply Fan			
Efficiency	30%	60%	90%
IN	54 dB	66.4 dB	77.1 dB
OUT	53.3 dB	60.7 dB	68 dB
Exhaust Fan			
Efficiency	30%	60%	90%
IN	53 dB	65.9 dB	79 dB
OUT	59.6 dB	73.4 dB	83.3 dB
Sound pressure level measured at a distance of 1 m from the housing	37.6 dB	45.4 dB	54.3 dB

Table 2 shows the average values of the cards selection of sound pressure air unit installed AC motor on the fan supply air and exhaust air. Table 3 shows the measured sound pressure fan supply air and exhaust air from the AC motor. Table 4 shows the sound pressure of the card selection supply and exhaust with EC motor, and Table 5 values measured sound pressure fan supply and exhaust with EC motor.

Table 4. The sound pressure values of the cards selection of supply and exhaust with EC motor

Supply Fan								
Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
IN (dB)	69	69	79	75	74	76	73	75
OUT (dB)	71	73	80	83	83	81	75	76
Exhaust Fan								
Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
IN (dB)	69	69	79	74	73	74	71	72
OUT (dB)	70	74	80	82	82	80	74	73

Table 5. The measured sound pressure fan supply air and exhaust air from the EC motor

Supply Fan			
Efficiency	30%	60%	90%
IN	70.5 dB	73 dB	74.5 dB
OUT	70.1 dB	71.4 dB	72.8 dB
Exhaust Fan			
Efficiency	30%	60%	90%
IN	69 dB	70.3 dB	71.5 dB
OUT	70 dB	70.7 dB	72.1 dB
Sound pressure level measured at a distance of 1 m from the housing	33.1 dB	41.6 dB	48.7 dB

Analyzing the Cards selection of AHU with AC motors and EC (Table 2 and Table 4) can be seen that the control of EC motor for the supply air fan in the lower frequency range is louder by 17%, in the medium and upper range of volume both fans joke on the same level.

Fans for the extraction can be seen that in the lower frequency range is louder by 18%, mid-range volume both Fans joke at the same level for frequencies in the upper range of the fan motor is EC louder by 4%.

On the basis of the volume Measurements AHU (Table 3 and Table 5) can say that the control of EC motor in the diffuser are louder by 17% compared to do with AHU AC motor, for return section with EC motor is quieter by about 4% compared with control AC.

Units with EC motors emit through the housing by 10% compared with the sound air handling units with AC motor.

Conclusions

1. According to the manufacturer's card selection acoustic pressure appearance frequency is lower for AC fans in the whole frequency range, especially at lower values.

2. The measured values of the sound pressure supply and exhaust fans are lower at the expense of 30% and 60% for AC fan, and at a flow rate of 90%, these values are lower for EC fans, which correlates with the card selection of sound pressure against frequency, in which the pressure the sound at low frequencies vary greatly, and at higher values converge.

3. The sound emitted by the air handling units measured at a distance of 1 m the device is smaller for the panel is equipped with an engine EC average of 11%.

4. The sound of the air handling units at a load of 90% for both types of engines used in the range of 68–83.3 dB, which is obviously too burdensome for the human ear, as long stay in the environment with such a high acoustic pressure is negative impact on the nervous system entails fatigue and loss of productivity, it can also reduce the intelligibility of speech and impede the filling and rest, which is why at such a high sound pressure level to be used silencers on supply and launch the ventilation system. The sound emitted by the housing central vent at the level of 48.7–54.3 dB which corresponds to the volume of a normal conversation.

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References

Barclay, M.; Kang, J.; Sharples, S. 2012. Combining noise mapping and ventilation performance for non-domestic buildings in an urban area, *Building and Environment* 52: 68–76. https://doi.org/10.1016/j.buildenv.2011.12.015

Ayr, U.; Cirillo, E.; Martellotta, F. 2001. An experimental study on noise indices in air-conditioned offices, *Applied Acoustics* 62(6): 633–643. https://doi.org/10.1016/S0003-682X(00)00072-4

Ayr, U.; Cirillo, E.; Martellotta, F. 2002. Further investigations of a new parameter to assess noise annoyance in air-conditioned buildings, *Energy and Buildings* 34: 765–774. https://doi.org/10.1016/S0378-7788(02)00095-6

Yong Jeon, J.; You, J.; Il Jeong, C.; Yeon Kim, S.; Jae Jho, M. 2011. Varying the spectral envelope of air-conditioning sounds to enhance indoor acoustic comfort, *Building and Environment* 46(3): 739–746. https://doi.org/10.1016/j.buildenv.2010.10.005

Barrigón Morillas, J. M.; Montes González, D.; Gozalo, G. R. 2016. A review of the measurement procedure of the ISO 1996 standard. Relationship with the European Noise Directive, *Science of The Total Environment* 565: 595–606. https://doi.org/10.1016/j.scitotenv.2016.04.207

PN-87/B-02151/02 Building acoustics. Noise protection facilities by weight of buildings. Allowable values sound level indoors (In Polish).

PN-B-02151-4:2015-06 Building acoustics. Protection against noise in buildings. Part 4: Requirements concerning the conditions of reverberation and speech intelligibility in spaces and research guidelines (In Polish)

Kłosak, A. K.; Jarosz, M. 2016. New acoustic requirements for auditoriums and conference rooms, and for reverberation noise protection in buildings according to PN-B 02151-4:2015-06, *IZOLACJE* 7/8: 78–81.

Shimizu, T.; Koizumi, S. 2015. Study of the compatibility between sound insulation performance and ventilation performance in gaps by installing nonwoven fabrics, *Building and Environment* 94: 335–343. https://doi.org/10.1016/j.buildenv.2015.08.020

Crocker, M. J.; Arenas, J. P.; Dyamannavar, R. E. 2004. Identification of noise sources on a residential split-system air-conditioner using sound intensity measurements, *Applied Acoustics* 65: 545–558. https://doi.org/10.1016/j.apacoust.2003.10.008

Hu, J.; Ding, G. 2006a. Effect of the air outlet louver on the noise generated by the outdoor set of a split-unit air conditioner, *Applied Thermal Engineering* 26: 1737–1745. https://doi.org/10.1016/j.applthermaleng.2005.10.032

Hu, J.; Ding, G. 2006b. Effect of deflecting ring on noise generated by outdoor set of a split-unit air conditioner, *International Journal of Refrigeration* 29: 505–513. https://doi.org/10.1016/j.ijrefrig.2005.07.002

Puria, S.; Rosowski, J. J. 2012. Békésy's contributions to our present understanding of sound conduction to the inner ear, *Hearing Research* 293(1–2): 21–30. https://doi.org/10.1016/j.heares.2012.05.004

Wawrzynowicz, A.; Krzaczek, M.; Tejchman, J. 2014. Experiments and FE analyses on airborne sound properties of composite structural insulated panels, *Archives of Acoustics* 39(3): 351–364.