Noise Emissions During Mixing of Feed by Mixer Feeder Wagon

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Abstract: *Nowadays, when it is quite difficult to find adequate skilled labor to work on the farm, management of farms is focusing on an issue of attractiveness of workplace for a potential employee. And this factor is closely linked to workplace hygiene and thus the noise emissions. Employees working in conditions of farms are exposed to different unnatural influences, such as noise. In terms of cattle farms, we can found different sources of noise. Farm machinery, and especially tractors are important sources of noise emissions. The aim of this article was to analyze the noise levels in the work environment of operators of tractors, when feeding cattle. We have measured noise pressure values on three farms with different types of mixer feeder wagons and tractors. Values were processed in noise maps and compared with values under the Directive of the European Parliament and the Council Nr. 2003/10/EC, which gives the exposure limit values* $L_{AEX,\ 8h}$ *(noise exposure with weighting filter "A". The values were also compared between each farm. Values of sound pressure levels measured in tractor cabin were processed in graph for better comparison.*

Keywords: *working environment, noise, mixer feeder wagon*

INTRODUCTION

Nutrition has the greatest impact on the usefulness of cattle. It is factor that is directly influenced by the farmer. Feeding rations are formed by computer programs, which vary according to different requirements for nutrients, but also based on the categories of cattle for which the rations are made (Bouška et al., 2006).

To achieve a homogenous mass is important to mix the feeding ration in mixer feeder wagon. Mixing normally takes up to 10 minutes. It may be provided by vertical or horizontal augers, vanes, or combination of both mechanisms (Gálik et al., 2008).

Gradually, with the development of mixer feeder wagons, the loading systems have evolved. For horizontal mixer feeder wagons were used only cutters. In many cases, they lead to shortening an already short sliced fodder (Stehno, 2015). To avoid shortening of chop can be used as a loading device a loading shield or loader of feed blocks.

According to the type of chassis, mixer feeder wagons are divided into towed and self-propelled. As first, towed mixer feeder wagons were used, and their advantage is acquisition price. Self-propelled mixer feeder wagons are constructed as a four-wheel of three-wheel with drive on one or both axes. They offer good maneuverability (Stehno, 2015).

Operator of mixer feeder wagon is working in specific working environment. During preparation of feed and during feeding is located in the cabin, or in outside of vehicle.

The working environment is the sum of natural and artificial conditions in which the worker performs operations of employment. Working environment is based on various indicators, such as organization of work and workplace, level of technological development, physical workplace factors and also standard of hygiene of work (Daniel, Pikala et al., 1976).

A significant factor that affects the quality of operating the MFW is exposure to noise.

Not only farmed animals are exposed to noise on farms. Short-lived but intense noise can have a detrimental impact not only on farmed animals, but also on operators (Venglovský et al., 2007).

Human ears are more sensitive to perception of noise in the range from 500 Hz to 4 kHz, which is the range of normal ordinary human speech (within this range, we can hear quiet sounds) (Castelhano-Carlos, Baumans, 2009).

If the sound pressure level exceeds a certain limit, and in long-term effects, it will have stressful noise reflect, followed by eventual damage to the health of workers (Havránek 1990), and also animals. (Hauptman, 1972). A great deal of research has been done on the effects of noise on performance (Kjellberg, Landström, 1994) and (Smith, Jones, 1992) and

some recent field studies give evidence that noise may add to the development of fatigue (Kjellberg et al., 1998).

Although the majority of the literature suggests that farming animals and wildlife species exhibit adaptation after repeated exposure to noise, careful planning should be made before construction of the animal building, in order to avoid stressful environmental sounds both for the animal and personnel (Brouček, 2014).

Sound is defined as a change in pressure over 20 times per second in an environment, that is recognizable to human sense – hearing. Human ear can detect a change of acoustic pressure at value of 3 dB (Peťková, 2010).

Noise can have different effects on humans:

- - specific- arise when noise acts directly on the organ of hearing,
- - nonspecific – noise effects are felt in mental damage, or other organs of human body (Hudecová, Beňová, Pšenáková, 2013).

Agricultural production generates high level of noise. Tractors, harvesters, plows, loaders are one of the most typical noise sources on farms. Studies suggest that prolonged exposure to noise levels has resulted in noise-inducted hearing damage to workers of all ages.

Gradual hearing loss does not so dramatically as when the suddenly overturned tractor and associated injuries, but it is permanent (Murphy et al., 2007)

The table below (Tab. 1) shows maximum noise levels which should not be exceeded by work activities of employees.

Table 1 Action levels of normalized sound pressure level $L_{aex,8h}$ for various work groups (Flimel, 2013)

Work group	Activity	Noise at workplace, dB
1.	The need for high concentration, creative activities	40
2.	Activity where communication is important, with high requirements for precision, speed	50
3.	Routine activities, communication as part of performed work	65
4.	Activity with use of noisy machinery and tools	80

MATERIALS AND METHODS

Research place

The experiment was conducted on three farms for cattle in the Slovak Republic. On every farm in our experiment, the animals are fed by mixer feeder wagons.

The aim of the experiment was to research the environment of tractor operators during operations, related to feeding of cattle in terms of noise exposure. To obtain adequate values, measurements were made on several farms. These measured values were then processed and compared to values on each mentioned farm.

First measurement was carried out on farm with Tractor 1, year of manufacture 2009, with a cylinder capacity 4,500 m^3, with highest performance 71 kW and 2,300 rpm. To this tractor, it was attached mixer feeder wagon MFW 1 with horizontal auger and loading cutter, with parameters showed in table (Tab. 2).

Table 2 Technical parameters of mixer feeder wagon MFW 1

Parameter	MFW 1
Volume, m^3	9
Needed power, kW	45
PTO revolutions, min^{-1}	540
Cutter revolutions, min^{-1}	450
Maximum height of cutter, mm	4 800

The second measurement was carried out on a farm with Tractor 2, with year of manufacture 2004, with a cylinder capacity 4,987 m^3, the highest performance 74 kW and with a pump power 66 RPM. It was used mixer feeder wagon MFW 2 with the specifications listed in the table (Tab. 3)

Table 3 Technical parameters of mixer feeder wagon MFW 2

Parameter	MFW 2
Volume, m^3	15
Needed power, kW	64
Number of knives, ks	5/2
Width by unloading, mm	920
Height by unloading, mm	820

Third measurement was carried out on a farm with a Tractor 3, with year of manufacture 1975, with a cylinder capacity 4,560 m^3, highest power 65 kW, maximum tractive force 3,800 kp and lifting force of 33.35 kN. It was used mixer feeder wagon MFW 3, with technical specifications described in the table (Tab. 4)

Table 4 Technical parameters of mixer feeder wagon MFW 3

Parameter	MFW 3
Volume, m^3	7,5
Needed power, kW	41
Weight, kg	3 050
Carrying capacity, kg	3 000

Measuring device

Sound level meter Testo 816 (**Error! Reference source not found.**) was used for measuring of noise. It allows to measure sound levels in a standard way and carrying out evaluation of living and working environment. Sound level meter has an overall measuring range of 30 to 130 dB, frequency range 31.5 Hz – 8 kHz. It includes sensor Elekret – measuring condenser microphone.
It allows to select frequency filter A/C and accuracy of the device is +- 0.1 dB.

This device was used for measuring of noise during activities associated to feeding of cattle.

Laser distance measuring device Bosch DLE 70 was used to measure distances. These dimensions were used to create noise maps.

Software NoiseAtWork was used for creating of noise maps.

Fig. 1 Sound level meter Testo 816

Data acquisition

Measurements were performed during preparing of feed with mixer feeder wagon. Measuring device was placed in 7 locations (7 measuring places), on each farm. Measurement points were chosen in distance 1 meter, 5 meters and 10 meters from tractor, and we have also measured sound pressure level in cabin of tractor.

The microphone was placed at a distance of 1.5 meters above the floor) and set in the toward the noise source. It was made 10 repeated measurements on each measurement place, the duration of the time interval of individual measurements was chosen to 60 seconds (to record any significant changes in the noise levels).

With sound level meter was recorded equivalent sound pressure level LAFekv, which reflects the equivalent value of sonic energy for a given measured period, weighted with filter "A".

Data analysis

One of the most important evaluation descriptors of working environment, according to ISO 9612:2009, is the equivalent sound pressure level A LA eq, T [dB]. It is calculated steady sound pressure level A. It applies always to a particular time interval T. Directive of the European Parliament and the Council Nr. 2003/10/EC indicates the exposure limit values LAEX, 8h (noise exposure during weighting filter "A" for 8 hour shift) and upper and lower exposure action value LAEX, 8h.

Determining the daily noise exposure at working place with a shorter or longer time of duration Te to the nominal duration of the working day 8 hours T0 can be with normalizing of equivalent sound pressure level A at nominal time of working day according to relationship [1].

$$L_{AEX,8h} = L_{Aeq,T_e} + 10lg\frac{T_e}{T_0} \quad dB, \qquad [1]$$

Where is: $L_{Aeq,Te}$ - equivalent sound pressure level durint the period of T_e

T_0 - nominal duration of working day – 8 hours

According to Directive of the European Parliament and the Council Nr. 2003/10/EC, exposure limit value $L_{AEX, 8h}$ has a value L = 87 dB and with this value, the worker can´t be exposed under any circumstances, therefore after use of methods for reducing noise. The upper exposure action value $L_{AEX, 8h}$ has a value a = 85 dB, and the lower exposure action value $L_{AEX, 8h}$ has a value a = 80 dB. These action values are noise values in working place, beyond which is the employer obliged to carry out actions (shares) to reduce noise.

RESULTS AND DISCUSSION

The measurements were conducted under the climatic conditions specified in the table Tab.5.

Table 5 Climatic conditions during measurement

Location of farm machinery	Air temperature [°C]	Relative humidity of air [%]	Atmospheric pressure [hPa]
Tractor 1 + MFW 1	15.2	46	983
Tractor 2 + MFW 2	16.7	44	975
Tractor 3 + MFW 3	13.8	57	951

First measurement we have concluded on farm with Tractor 1 and MFW 1 during mixing of feeding ration when the engine speed of tractor was 1,150 rpm. The measuring device was distant 1 meter, 5 meters and 10 meters. It was also measured noise directly inside tractor cabin. Based on these values and drawing of tractor when wieved from above and an indication of measurement points distance, we have generated noise map (Fig. 2).

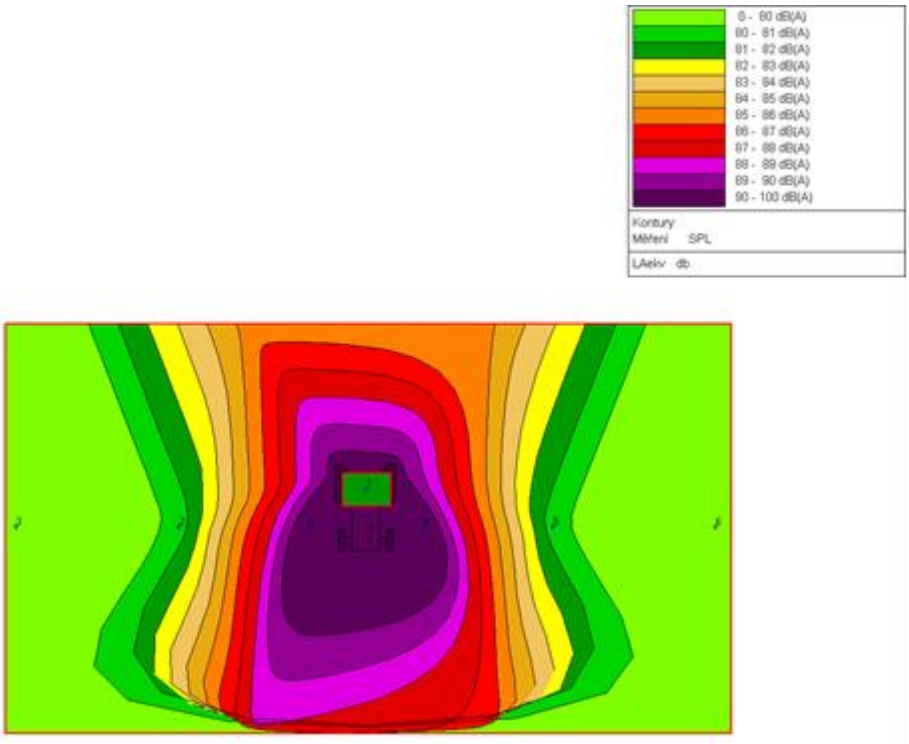

Fig. 2 Measured values of noise during mixing of feeding ration with Tractor 1 and MFW 1 in outdoor showed on the noise map

From the noise map (Fig. 2) it can be seen that at a distance of 1 meter from the machine was sound pressure level of 100 dB. At a distance of 5 meters from the machine the noise pressure level was in the range of 80 dB to 81 dB and at a distance of 10 meters from the machine it ranged from 0 to 80 dB. It follows that an employee situated a distance of 1 meter from the macine was exposed to relative higher sound pressure level, even that it would be only for a short time. Measured values during the same operation in the tractor cabin are representing a value of 80 to 81 dB.

Second measurement we have conducted on farm with Tractor 2 and MFW 2 during mixing of feeding ration when the engine speed of tractor was 1,150 rpm. The measuring device was distant 1 meter, 5 meters and 10 meters. It was also measured noise directly inside tractor cabin. Based on these values and drawing of tractor when viewed from above and an indication of measurement points distance, we have generated noise map (Fig. 3).

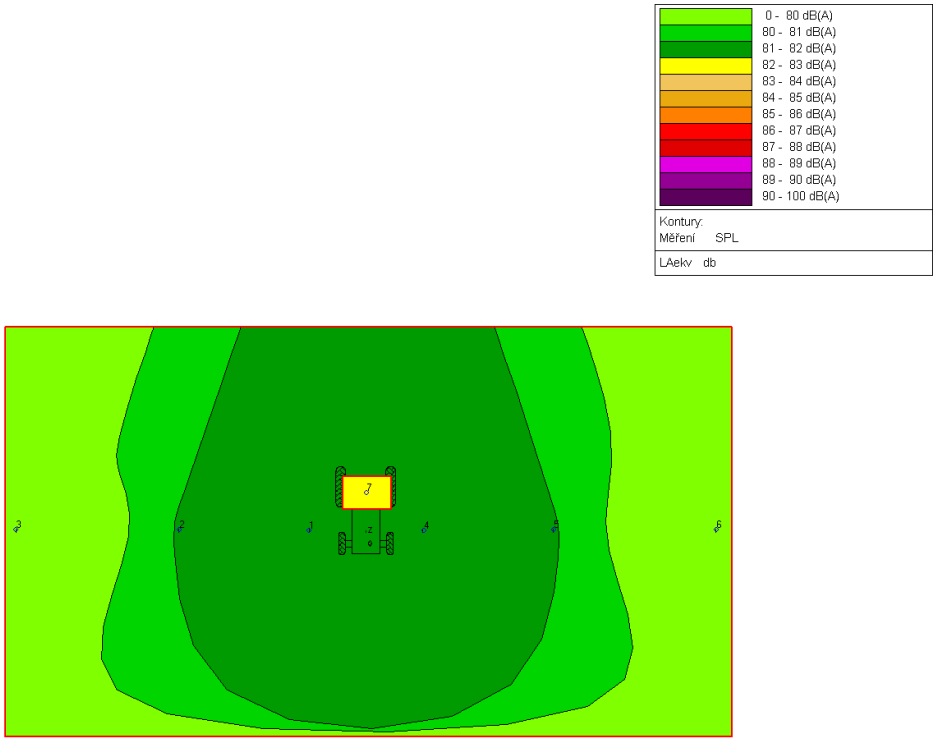

Fig. 3 Measured values of noise during mixing of feeding ration with Tractor 2 and MFW 2 in outdoor showed on the noise map

When analyzing the noise map (Fig. 3) it was clear that in all measured distances did not exceed 87 dB. When measuring sound pressure levels in the tractor cabin with the same conditions, it can be seen that in the area of cabin is the value of sound pressure level of 82 to 83 dB. This value was higher than the values measured outside the tractor cabin. The reason may be inadequate soundproofing of the cabin and sound reflection.

Third measurement we have concluded on farm with Tractor 3 and MFW 3 during mixing of feeding ration when the engine speed of tractor was 1,100 rpm. The measuring device was distant 1 meter, 5 meters and 10 meters. It was also measured noise directly inside tractor cabin. Based on these values and drawing of tractor when viewed from above and an indication of measurement points distance, we have generated noise map (Fig. 4).

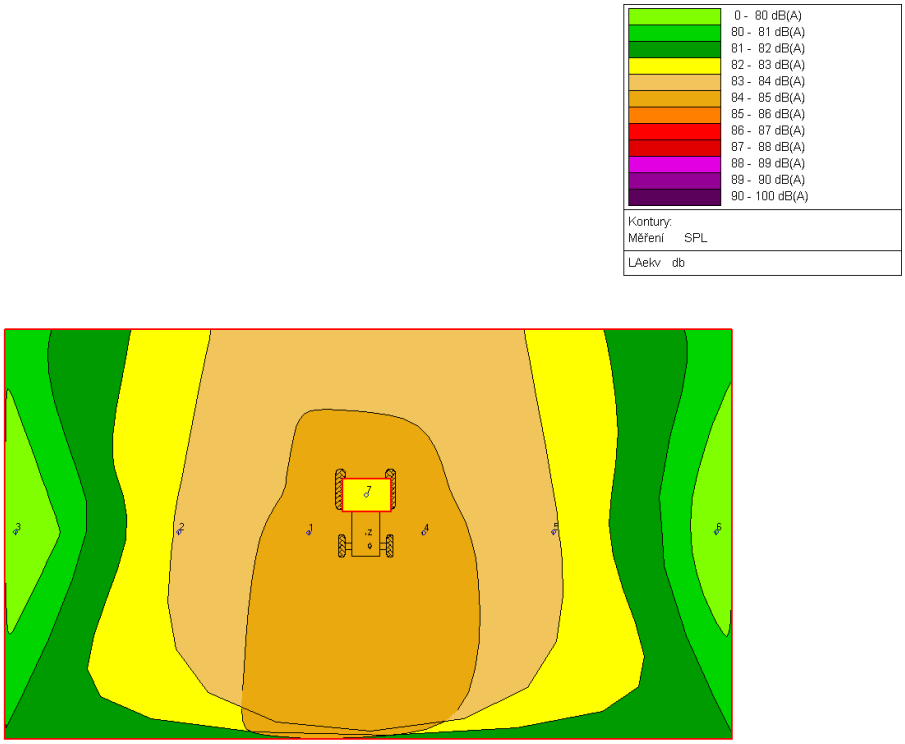

Fig. 4 Measured values of noise during mixing of feeding ration with Tractor 3 and MFW 3 in outdoor showed on the noise map

Distribution of sound pressure levels in noise map on Fig. 4 shows, that at distance of 1 meter from machine were sound pressure levels about 84 to 85 dB. At a distance of 5 meters from the machine were values of sound pressure levels under 84 dB and at a distance of 1 meters were values under 80 dB. Measurement of sound pressure levels in the cabin of the tractor during same operation is shown on the map in the area of cabin and it is representing a value of 82 to 83 dB.

When comparing the noise emissions of individual tractor during mixing of feeding ration, measured in the tractor cabin (Fig. 5), it was obvious that all the tractors, that are subjected to measurements, meet the limit values specified in the standards (indicated by the red line in the graph). While mixing, the engine speed was by Tractor 1 and Tractor 2 around 1,150 rpm and by Tractor 3 1,100 rpm. By Tractor 2 measured values have upward trend, by Tractor 1 these values decreased slightly. Different values of sound pressure level can be attributed to differences in age of tractors and their technical settings.

The values obtained in the measurement of noise emissions from individual tractors at a distance of 1 meter from the machine when the engine speed by Tractor 1 and Tractor 2 was 1,150 rpm and by Tractor 3 1,100 rpm, were also compared. The sound pressure level of Tractor 2 and Tractor 3 did not reach 87 dB. However Tractor 3 showed values in excess of 92 dB.

Measured values at a distance of 5 meters from the machine when mixing the feeding ration, whit engine speed 1,150 rpm by Tractor 1 and Tractor 2 and 1,100 rpm by Tractor 3 were also compared between each other. Based on the results it was evident, that noise emission from Tractor 2 and Tractor 33 did not exceed the sound pressure level of 85 dB. Tractor 1 even at this distance showed higher levels of noise relative emissions.

As a last were compared measured values at a distance of 10 meters from the machine during mixing. Engine speed was 1,150 rpm by Tractor 1 and Tractor 2 and 1,100 rpm by

Tractor 3. Based on the comparison of values it could be established that the three tractors at distance of 10 meters from the machine did not exceed the sound pressure level value of 80 dB.

Fig. 5 Measured values of noise during mixing of feeding ration in tractor cabin

Several authors deal with the problem of noise in agriculture. They have studied noise emissions produced by different types of tractors according to age and performance in the implementation of various agricultural operations. According to Likař (2014), tractors similar to Tractor 3 are meeting the limit values set by legislation, even after 30 years of age. This type of tractor was measured at sowing and reached mean value of sound pressure level about 83 dB. Furthermore, this author evaluate new tractor Zetor Fortera 135, and his measurement showed, that average sound pressure level was about 81 dB. But that was according to Líkaře (2014) high value, compared to other tractors in the same power class from other producers. For example, by tractor New Holland T 6070, the noise emissions did not exceeded 72 dB and by Deutz-Fahr M620 did not exceeded 74 dB. These results were obtained by various conditions, so it is necessary to take them as indicative processing of current state by tractors.

Opekar (2015) examined the amount of generated noise emissions directly in the tractor cabin. He compared to each 11 different brands of tractors with power between 70-90 kW. The result of the measurement was detection, that the lowest noise exposure showed a tractor Steyr, with the lowest sound pressure level around 69 dB. Noise emissions from tractors Claas and Fendt were around 70 dB. According to Opekar (2015), the highest value showed tractor Zetor, it was about 81 dB.

Opekar (2015) has focused its research on the way, how the manufacturers of agricultural machinery improve design of tractor cabins due to limit the transmission of noise emissions to the operator of the tractor sitting in the cabin. He found that the greatest improvement achieved manufacturer Fendt, which reduces the transmission of noise emissions by up to 12 dB. Very good results have company Lamborghini, which it succeeded by 11 dB. He recorded the least progress in reduction of noise passing into the tractor cab (only 4 dB) by tractors Zetor.

CONCLUSION

The main reason to make measurements of noise emissions of machinery and equipment, not only in agriculture, is need for improvement of working environment for employees. Authors of publications and research activities on issue of noise, referred to the legislative rules that are setting limits of sound levels.

Through our measurements, we found that in some cases, the sound pressure levels are exceeding maximum values set by legislation. Even in case of Tractor 3, with year of manufacture 1975, we have recorded lower values of sound pressure levels, than in case of newer and more modern type Tractor 1, with year of manufacture 2009. Noise emissions of Tractor 1 have remained above 92 dB, when measured 1 meter from the machine, while in case of Tractor 3 under the same conditions it was onli 85 dB.

It must be noted, that in our experiment, operators have not been subjected to the measured noise for 8 hours (whole shift), because in their daily routine they are dealing with other activities. Every preparing of feed and feeding takes maximally 3 hours.

Noise exposure levels didn´t exceed the values given in The Directive of the European Parliament and the Council Nr. 2003/10/EC. In any of cases, the noise level didn´t exceed even the value of the lower exposure (for 8 hour shift) action value of 80 dB.

In terms of noise, most favorable working environment was in case of Tractor 2 and Tractor 3.

As the primary measure against noise, hence reducing the emission of noise source, is not feasible for various reasons (mainly technical capabilities), a possible solution may be a tertiary measures against noise. It means to equip operators with protective means, or another solution, secondary measures against noise by improving the technical equipment of operator´s environment (soundproofing of tractor cab).

Despite the fact, that the employee is not exposed the whole time of shift to noise values, that are exceeding values set in legislation, it would be appropriate to introduce measures to protect hearing. The most appropriate and simplest solution would be to use hearing protection.

REFERENCES

[1] Bouška, J. A Kol. 2006. Chov dojeného skotu. 1. Issue. Praha 2006. ISBN 80 – 86726 – 16-9.
[2] Brouček, J. 2014. Effects of noise on performance, stress, and behavior of animals: a review. Slovak Journal of Animal Science, vol. 47 (2), 2014. p. 151-160.
[3] Castelhano-Carlos, M. J. – Baumans, V. 2009. The impact of light, noise, cage cleaning and in-house transport on welfare and stress of laboratory rats. Laboratory Animals, vol. 43, 2009, p. 311-327.
[4] Daniel, J., Pikala, I. et al. 1976. Psychológia práce. Bratislava 1976. 1. vyd. 222 s.
[5] Flimel, M. 2013. Manažment hluku v pracovnom prostredí. Košice : TU. 1. vydanie. 2013. ISBN 978 -80-8086-230-5.
[6] Gálik, R. a kol. 2008. Mechanizácia živočíšnej výroby. Nitra : SPU. 2008. 181 s. ISBN 978-80-552-0111-5.
[7] Hauptman, J. et. al.: Etologie hospodářských zvířat. Praha: SZN. 1972. s. 294.
[8] Havránek, J. a kol.: Hluk a zdraví. Praha: Avicenum 1990. 280 s.

[9] Hudecová, J., Beňová, M., Pšenáková, Z. Životné a pracovné prostredie človeka. Pdf.[cit. dňa 2016-03-25] Available online on: <http://158.193.212.66/ivana/biomedici/site/materialy/Posledny-10_semester/ZE/07.pdf>.
[10] Kjellberg, A. - Landström U. 1994. Noise in the office: Part II—the scientific basis (knowledge base) for the guide. International Journal of Industrial Ergonomics, vol. 14 (1994), p. 93–118.
[11] Kjellberg A. - Muhr, P. – Sköldström, B. 1998. Fatigue after work in noise—an epidemiological survey study and three quasi-experimental field studies. Noise and Health, vol. 1 (1998), p. 47–55.
[12] Líkař, O. 2014. Pracovní prostředí obsluhy v kabině traktoru. Bakalárska práca. Str. 65. [cit. dňa 2016-05-05] Available online on: <https://theses.cz/id/t1frxu/Bakalarska_prace_Likar_Ondrej_2_ZT.pdf>.
[13] Murphy, D. – Harshman,W. 2016. Noise induced hearing loss in agriculture. Internetový článok. [cit. dňa 2016-05-05] Available online on: <http://extension.psu.edu/business/ag-safety/health/e48>.
[14] Opekar, J. 2014. Porovnání hlučnosti traktorů uvnitř kabiny a v okolním prostředí. Bakalárska práca. Str. 49. [cit. dňa 2016-05-05] Available online on: <http://docplayer.cz/3913115-Jihoceska-univerzita-v-ceskych-budejovicich-zemedelska-fakulta.html>
[15] Peťková, V. 2010. Teória a aplikácia vybraných metód technickej diagnostiky. Košice : TU. 234 s. 1. vydanie. 2010. ISBN 978–80–533–0483–0.
[16] Smith, A.P. - Jones D.M. 1992. Noise and performance. Handbook of Human Performance. The Physical Environment, vol. 1 Academic Press, London (1992), p. 1–28.
[17] Stehno, L. 2015. Univerzální krmné vozy. In: Mechanizace zemědělství. Ročník – LXV. Číslo 10/2015.Str 68-68. ISSN 0373 – 6776.
[18] Turčeková, P. 2016. Pracovné prostredie obsluhy traktora pri kŕmení hovädzieho dobytka. Nitra : SPU. 2016. 81 s.
[19] Venglovský, J. – Sasáková, N. – Vargová, M. – Ondrašovičová, O. – Onrašovičová, S. – Hromada, R. – Vučemilo, M. – Tofant, A. 2007. Noise in the animal housing environment. ISAH-2007 Tartu, Estonia, 2007, p. 995-999.
[20] Directive of the European Parliament and the Council Nr. 2003/10/EC from 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (Seventeenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)
[21] ISO 9612:1997 Acoustics – Guidelines for the measurement and assessment of exposure to noise in a working environment

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