Light and noise conditions of buildings for breeding dairy cows

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Abstract

Šístková M., Peterka A., Peterka B., 2010. **Light and noise conditions of buildings for breeding dairy cows**. Res. Agr. Eng., *56*: 92–98.

Check measurement of the illuminance, the uniformity ratio of illuminance and noise level was made in the selected stable building to prove quality of lightning both for service workers and the cattle. The measurement discovered that the noise level, the day lighting and artificial lighting do not satisfy valid health standards and can have harmful effect upon human and cattle organism. In the monitored stable building the permissible hygienic limit of noise was exceeded only during distribution of feed and bedding and it only for the short time.

Keywords: dairy cattle breeding; lighting; noise level; animal welfare; visual comfort people

Light and noise belong among the important factors affecting living standards and the environment. Many physiological and psychical reactions are caused by the radiation of light and noise. Numerous studies have documented the effects of light on the morphology, physiology, and behavior of various animals (Rendic 2002; Hayes 2007). Therefore the light microclimate is an integral part of the environment. Particular components of light radiation take effect in complexity (Petr et al. 1987). Favourable effects of UV and IR radiations are well known. They are used to prevent and to heal some diseases (Dobšinský et al. 1976; Prentice 2005; Polderman et al. 2006). When analyzing the effects of light upon physiological functions of human organism, the influences on blood system, balance, and brain action were proved, not only on eyesight. Psychological researches are focused particularly on the problems of the process of seeing and the orientation of visual field. The results of such researches are used for development of the light technology. The main task of the light technology is to create the best possible microclimate and to contribute to healthy conditions.

The process of creating of appropriate light conditions is called lighting.

A successful breeder has to observe zoo hygiene to ensure good conditions for the cattle. One of the main factors having an immediate influence on the cattle welfare is microclimate which includes noise and illumination (Hutla 1998; Šoch 2005). Illumination can be artificial or natural. The intensity and the length of illuminance have a significant influence on the health and utility of the cattle (Kosař, Chaloupková 2000; Doležal et al. 2002; Šoch 2005). The cattle prefer light places to dark ones. During the preference test up to 90% of the tested animals preferably stayed in the artificially illuminated part of the stall than in the naturally illuminated one. The test lasted from No-

Supported by the Ministry of Agriculture of the Czech Republic, Project No. QH72134.

vember to February, the tested stall was illuminated to 200–250 lx, from 4:30 a.m. to 9:00 p.m. (Doležal, Bílek 2001; Šoch 2005).

Good light conditions are necessary for technological operations and ensure hygiene and security of work. The light parameters, especially its intensity and wave length, are given by building, hygienic, and zoo technical regulations. Therefore the light parameters belong among the most important items when assessing buildings (ČSN 73 058 2007).

MATERIALS AND METHOD

Measurement techniques

Two luxmeters PU 150 (Metra Blansko, CR) were used. One belongs to the University of South Bohemia (Department of Agricultural Technique), the other was borrowed from the Regional Public Health Authority of the Southern Bohemia Region based in České Budějovice (CR) the devices were compared to each other as well as to newer types of luxmeters and the minimum deviation was found. The luxmeter consists of a receiver with a photocell and a measurement device. It has a selenium photocell which allows to measure light up to 5,000 lx, in the case of using a reduction filter up to 100,000 lx.

The measuring probe is equipped with a corrected photo resistor with an extender for light up to 10 lx, if need be, with a corrected stop up to 40 lx. The equipment mentioned above can be used only for orientation measurement of low levels of light.

The luxmeter PU 150 is of the 4^{th} grade of precision. The admissible error is circa 20%.

For measurement of the noise was used digital sound-level meter type Voltcraft Plus SL-300, accuracy class 2 according to IEC 61672-1, the sound calibrator, accuracy class 2 according to IEC 60942 and digital weather-station type Ws-1600 for measurement of the temperature, humidity, and barometer pressure.

The measuring check-points

As seen in the Fig. 1, the interior of the stable is symmetrical and the key lightning is located in a regular network with the same light source. Particular measuring check-points are not numbered because the measured values of light were almost the same at each point. At the time of testing the whole lighting system was fully working, so the measurement on the horizontal level was assessed only for one periodical part.

The edge measuring check-points on the horizontal level were located in accordance with the regulations ČSN 36 0011–1 (2006); ČSN 36 0011–2 (2006) and ČSN 73 058 (2007), 1 m from the enclosure wall and 0.85 m above the floor either for daylight or artificial light. To keep the same distance of check-points, the wooden scales were made.

The measurement of artificial lighting

It took place in the winter time, after dark, in compliance with regulation ČSN 36 0011–3 (2006). The whole illuminance over the working and dung corridors was assessed. Then the illuminance in the central part of the feeding corridors was measured and assessed, where there was not any straight lighting used and it was ensured by the luminaires from working and farm manure corridors. The illuminance was measured at every second fluorescent tube, straight at the tube level and in the half distance between them. The values of illuminance in each corridor were counted by arithmetic mean.

The measurement of daily illumination

In winter, the value of an outdoor plane was circa 5,000 lx, compared to summer, when it was 20,000 lx according to the regulation ČSN 36 0020 (2007), which applies to the day part of combined illumination. In the case of unsuitable values of the daylight, improving steps could be taken. The check-points were the same for both summer and winter measurements (Table 1). The daylight was measured in the axis of the central part of the windows, pillars and doors (Table 1); two luxmeters were used. One was used outside at the high place without shade near the building. The other one was used inside the building. The synchronization of the measurement was achieved by communication on mobile phones.

Assessment of lighting

The illuminance component in the interior of the building is the basic quantity for basic conditions of seeing and eyesight comfort. It was assessed according to:

Table 1. The level of daily illumination in winter and summer (by two different outdoor plane – 5,000 lx and 20,000 lx) in point of measurement the internal places a horizontal plane correlation (1.2 m above the floor)

Area	Measured place	Illuminance of plane in winter (lx)		Daylight factor in winter D (%)	Illuminance of plane in summer (lx)		Daylight factor in summer D (%)
		outdoor E_h	inside E		outdoor E_h	inside E	
Side working corridor and corridor for farm manure	1	5,300	140	2.64	19,700	450	2.28
	2	5,300	250	4.72	19,700	650	3.30
	3	5,350	80	1.50	19,900	900	4.52
	4	5,350	220	4.11	19,900	650	3.27
	5	5,350	60	1.12	19,950	700	3.50
Through feeding corridor	6	5,300	50	0.94	19,950	800	4.01
	7	5,250	70	1.33	19,950	350	1.75
	8	5,250	50	0.95	19,800	470	2.37
	9	5,200	70	1.35	19,850	450	2.27
	10	5,200	50	0.96	19,600	540	2.76
Central working corridor and corridor for farm manure	11	5,200	90	1.73	19,650	350	1.78
	12	5,100	80	1.57	19,500	420	2.15
	13	5,100	80	1.57	19,500	470	2.41
	14	5,100	90	1.76	19,550	550	2.81
	15	5,150	80	1.55	19,600	400	2.00

– the level of daily illumination, which was appointed by the daylight factor D in %,
– the daily illumination uniformity, ČSN 73 058 (2007),
– the level of artificial lighting in lx,
– the uniformity of artificial lighting, ČSN EN 12 464–1 (2004).

The noise level measurement

It took place in summer. The noise was measured at the measuring points (Fig. 1, height of microphone above the floor was 1.5 m) during these operations: milking, distribution of feed, distribution of litter, and during the removal of farm manure. The measurements of the background noise were carried out before each measurement (in our case, background noise is a noise of animals, so called biological noise).

The measurement and calculation were carried out according to the Act No. 148/2006 Coll. on Health protection from the adverse effects of noise and vibrations, valid from April 2006 and according to the Czech Technical Standard ČSN ISO 9612 (2000), valid from November 2000 (Anonymous 2006).

The relevant values – i.e. physical conditions of measurement (temperature, humidity and barometer pressure) were recorded before the measurement of noise and in the same place (Table 2).

RESULTS AND DISCUSSION

Characteristics of the K 174 stable building

The ground plan is rectangular with different height of the ceiling (sloping ceiling), stanchion housing in four rows.

The lighting is located over the three working corridors, 2.5 m over the floor in the side corridors and 3.7 m in the central corridor, Fig. 1. There are nine fluorescent luminaires with two narrow band tubes (diameter 26 mm) in each corridor. The supply of each tube is 36 W. The luminous flux is 3,450 lm and R_a = 80 (white fluor tubes). There are no light sources in the cross and feeding corridors. The daily illumination is ensured by simple windows along

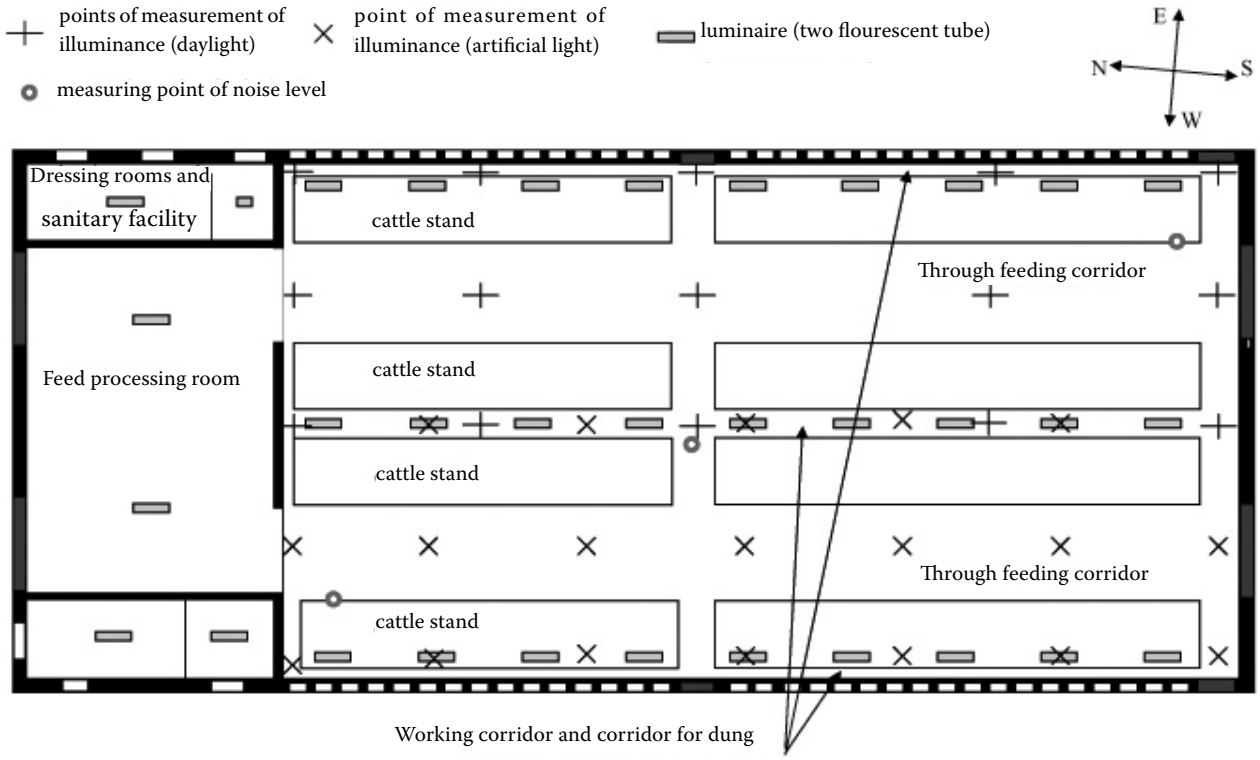

Fig. 1. Scheme of monitored object and points of measurement

the longer sides of the stable. There are side skylights in the east upper part. They serve for better illumination of the central corridors. The skylights have the same size as the windows (85 × 90 cm).

The assessment of the lighting

The constant stay of cattle service workman was taken based on the ČSN 73 058 (2007).

The assessed stable building has only side lighting premises, therefore the daylight factor was satisfied only minimally (D_{min}). The value of light balance was considered on the basis of D_{min}. It should not be less than 0.2 according to the grade of visual activity (IV).

The assessment of the intensity and uniformity of artificial lighting

The level of artificial lighting (E_m) is different in each corridor, (Fig. 2). The level of artificial lighting (E_m) should be 200 lx. That value of E_m was only at the level of fluorescent tubes in the side corridors, but between the luminaires the value of E_m was only 30 lx. In the central corridors it was 100 lx under the luminaires and less than 50 lx between them. The lowest values were measured at the edge check points. By far the smallest value of E_m was measured in the feeding corridors and central working corridor, where there are no luminaires E_m = 10 lx.

There should be technological lighting in the visual field of animals 60 lx, independent of working lighting. It should work 14 h a day (Habel 1991). The value of illuminance in the animal stables is 50 lx according to the ČSN EN 12 464–1 (2004). Considering the uniformity of lighting, the minimum border of 0.7 (ČSN EN 12 464–1 2004) is not observed in any corridor (the values of the balance were 0.15–0.29), Fig. 3. It proves the inequality of the lighting which can have a harmful effect on human and animal organism.

To improve the situation, the covering of the fluorescent luminaires should be cleaned. Another fluorescent luminaires with the same parameters should be installed in the edge parts of the corridors (gaps of 6 m). The intensity and uniformity of the lighting would be upgraded. In the central working and feeding corridors the current light source (Philips, 36 W, 3,450 lm) would be replaced by the light source with higher lm (Philips, 58 W, 5,400 lm). The height of location would be 3.7 m, to ensure good distribution of incident light. The lighting would probably rise

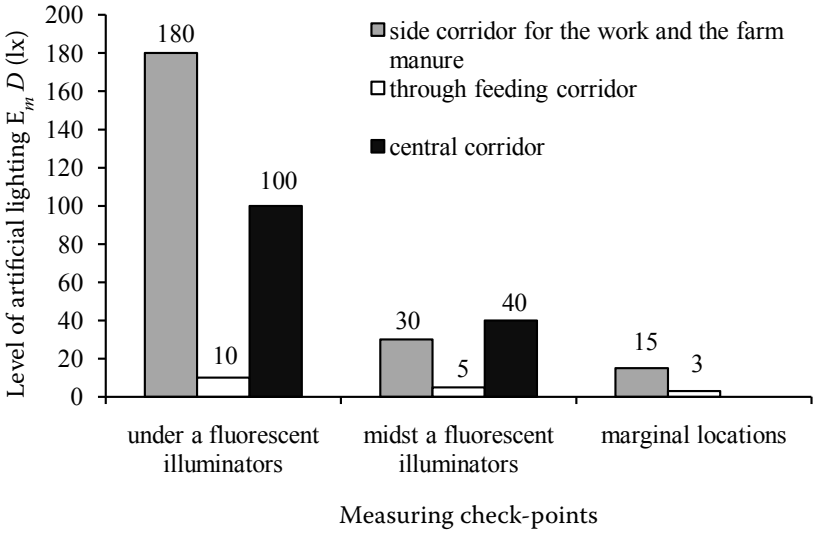

Fig. 2. Artificial lighting in particular points (corridors) of the monitored animal building

twice and the problem of low intensity of artificial lighting of feeding corridors would be partly solved. In each corridor there would be white tubes with good colour rendition (R_a = 80).

The number of luminaires would increase by ten in each corridor and the luminaires in the central corridor would be replaced. However, that would be financially more demanding.

Assessing of intensity and evenness of day light

The value of day illuminance factor should be 1.5%, ČSN 73 058 (2007). Unsuitable values of that factor were discovered in the feeding corridors. In the central corridor the factor was around the allowed value (winter time) as shown in Table 1. To improve the light condition the windows have to be kept clean.

Fig. 3 shows total average daily and artificial illuminances in the particular points (corridor) of the monitored animal building K 174. Fig. 4 compares daylight factors D of the monitored animal building K 174 and factors of different styles of the stanchion housings (K 144, K 120, K 96) which Šístková and Peterka (2008) mention.

The assessment of the noise

The mean values of the equivalent sound pressure level A $L_{Aeq, 8h}$ were obtained in three measurements during following operations: milking, distribution of feed, distribution of litter, and the

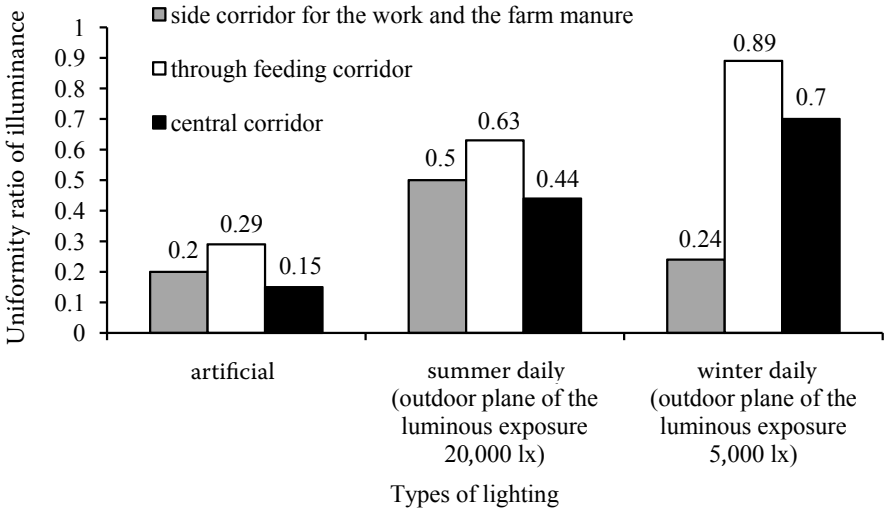

Fig. 3. Uniformity ratio of illuminance in particular points (corridors) of the monitored animal building

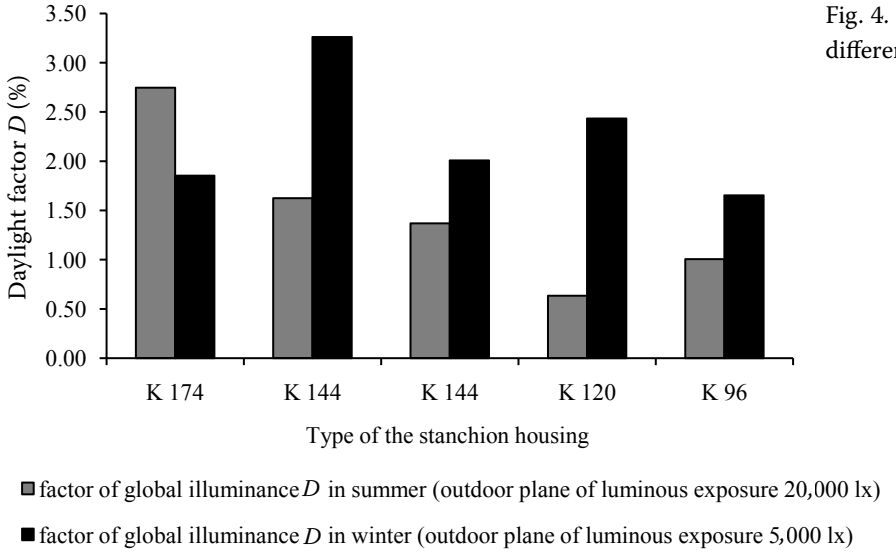

Fig. 4. Level of daily illumination for the different types of stanchion housing

removal of farm manure are shown in Fig. 5, for measuring conditions, Table 2.

The hygienic limit in the stable and flexible noise exposure of 85 dB was set for the eight-hour working time expressed by the equivalent sound pressure level A $L_{Aeq, 8h}$ according to the Act No. 148/2006 Coll.

The measured sound pressure levels for each working activity and the evaluation of the noise load; it can be claimed that the values of noise in the animal building are higher than the acceptable hygienic limit (distribution of feed and distribution of litter), but this noise takes effect for a short time (one passage of the tractor through the animal building lasts circa 3 min, 6 transits mean 18 min as a whole). The strongest noise was measured during the distribution of litter 106.8 dB (21.8 dB over the limit). The lower noise load than that allowed by hygienic limits is the cause of other work activities such as milking and removal of farm manure.

Table 2. Measuring conditions

Working	Temperature (°C)	Humidity (%)	Barometer pressure (hPa)
Milking	23	70	1,015
Distribution of feed	22.4	68	1,014
Distribution of litter	23.2	68	1,014
Removal of farm manure	22	68	1,014

The background noise level (biological noise) emerging from the biological manifestations of dairycows ranged from 72.7 to 83.8 dB (Fig. 5).

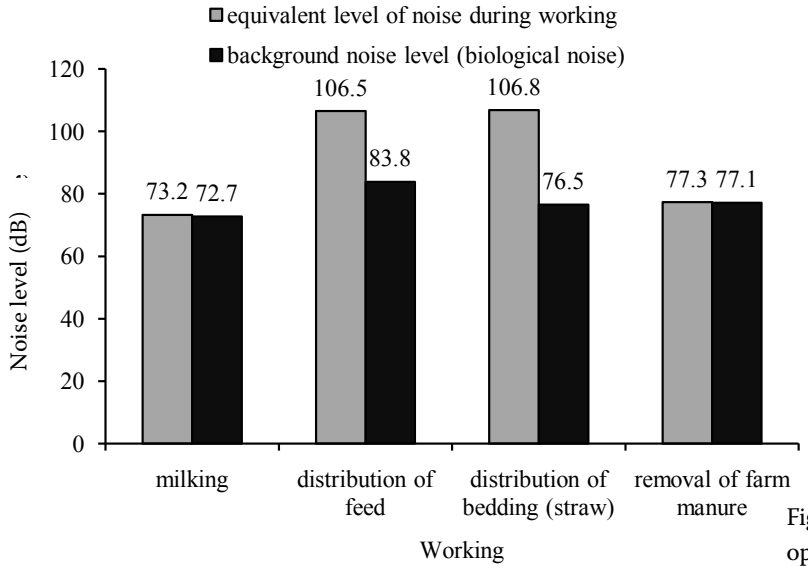

Fig. 5. Equivalent noise level during different operations in the monitored animal building

CONCLUSION

Unsuitable conditions of illumination were discovered in the evaluated stable building especially in the winter time. A suitable solution would be adding a light sensor device to the lighting system which would switch on the system automatically if the lighting levels get worse. Concerning the artificial lighting, it was completely unsatisfactory. Suggested measures would be financially more demanding (the annual expenses on electricity would increase by 250%).

Suggested lighting system was assessed only according to the data given by the producer. Consultation with a light technician would be recommended when replacing the unsuitable light sources. The light specialist would design the sufficient lighting system. The system has to be kept clean to improve lighting level.

In the monitored stable building the permissible hygienic limit of noise was exceeded only during distribution of feed and bedding and it only for the short time.

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Received for publication November 23, 2009
Accepted after corrections March 8, 2010

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