

## Lighting Assessment in Livestock Housing

Yu.V. Sizova\*, D.S. Toshin\*\*, L.A. Vasilieva\*, D.A. Tarakanov\*, M.V. Shuvarin\*

\*Nizhny Novgorod State University of Engineering and Economics, 606340, Russia,  
Knyaginino, Oktyabrskaya Street, 22a

\*\*Togliatti State University, Russia, 445020, Samara region, Tolyatti, st. Belarusian, house 14

### *Abstract.*

Lighting is one of the important parameters of the microclimate of livestock housing, ensuring the normal growth and development of animals, including dairy cows. Light, especially natural, provides positive influence on physiological processes in dairy cows, improves their health and fertility, as well as milk production. During the autumn-winter period, when the daytime is short, it is advisable to use artificial electric lighting to compensate the lack of natural illumination in premises, where dairy cattle are kept. In this regard, studies were conducted to evaluate the parameters of natural and artificial illumination in cowsheds of various designs. The measurements were carried out on a cattle farm with 200 dairy cows of Brown Swiss breed, kept in conditions of loose housing. The farm is a property of LLC “Solovyevskoye” located in the Knyagininsky district of the Nizhny Novgorod region. The natural and artificial illuminance of the premises was determined with the help of the measuring instrument “Percent Flicker meter + Luxmeter + Luminance meter TKA-PKM (09)”. The measurements were carried out on the farm three times a day for two adjacent days once a month. Illuminance was measured along each row of stalls in the all zone of accommodation of animals. The natural illumination near the yard was measured at the same time. The conducted studies revealed that the distribution of lighting over the housing was uneven. In the outer parts of the courtyard, compared to the center, the illuminance was lower (95 lx vs 305 lx). The total power of illumination in the room was  $(4.5 \text{ W/m}^2 \times 1400 \text{ m}^2) 6300 \text{ W}$ . In designing and building livestock premises, the main criterion for regulation and evaluation of natural light is the window-to-floor area ratio. The natural illuminance inside the building is 20 lx (on average) and outside is 3000 lx; therefore, the daylight factor (DF) is 0.7%, which corresponds to the norm. In the premises designed for animal housing, DF should be at least 0.8%.

## **Introduction.**

The rational housing of animals in conditions of optimum microclimate directly affects the economic efficiency of intensive cattle breeding on industrial basis. Illumination of livestock premises is regulated by Building Codes and Standards (SNiP 23-05-95) and Industry Building Codes of Agricultural-Industrial Complex (IBC-AIC 2.10.24.001-04) [1, 6, 16, 17, 23, 24].

The studies of N.M. Komarova, G.V. Burkser, A.K. Danilova, A.P. Onegov, I.M. Golosov, V.F. Matusevich, N.D. Krakosevich, and others show that microclimate of many livestock facilities built in past and even recent years does not meet zoo-hygienic requirements, especially for temperature-humidity conditions and illumination [4, 5, 7, 8].

The noncompliance of the microclimate to regulatory requirements leads to large economy losses during the autumn, winter, and early spring. In the southern regions, it affects summer season. These losses are caused by decrease in the reproductive capacity of the breeding stock and the productivity of animals, by rising incidence and mortality of young breed, by increase of forage required for producing a unit of production, and by decrease in production quality. In addition, the lifetime of premises is directly dependent on the temperature and humidity regime.

Illumination is one of the most important parameters of the microclimate, ensuring the normal growth and development of animals kept indoors [15, 19].

Studies show that keeping dairy cattle in unlit premises leads to reduction of average daily milk yield and of fat content in milk [4, 5, 13, 19]. Implementation of technological processes in cattle-breeding premises requires both artificial and natural lighting. The daylight provides only 70% of the required illumination in the spring-summer period and only 20% in the autumn-winter period. Artificial illumination of cattle-breeding premises has two different regimes: technological (working) and duty lighting [6, 8, 12].

Duty lighting uses 10-15% of the working lights and serves to monitor animals at night. The main characteristics of artificial lighting is power density expressed in watts per square meter. In order to calculate the power density of artificial lighting in the livestock housing area, one should count the number of electric bulbs in the cowshed, summarize their power, and divide it by the area of the floor [7, 9, 10, 21, 22].

The natural illumination depends on the height of the sun, time of year, cloudiness, location of the building in relation to the cardinal directions, shape and size of windows, their placement, properties of internal equipment, etc. (Figure 1). Dirt covering window glass can reduce natural illumination up to 58%. Drizzle provides almost the same effect. The influence of

interior decoration of the premises on natural illumination is also notable. The white or whitewashed wall reflects 85% of the daylight. Fresh wood and brick reflect only 40%.

In order to ensure sufficient degree of illumination, it is necessary to strive to use natural light in full. Designing of new facilities takes this trend into account. However, outdated premises have small windows that should be expanded during the reconstruction. Daylight should reach all parts of the cowshed, including the areas allocated for calving.

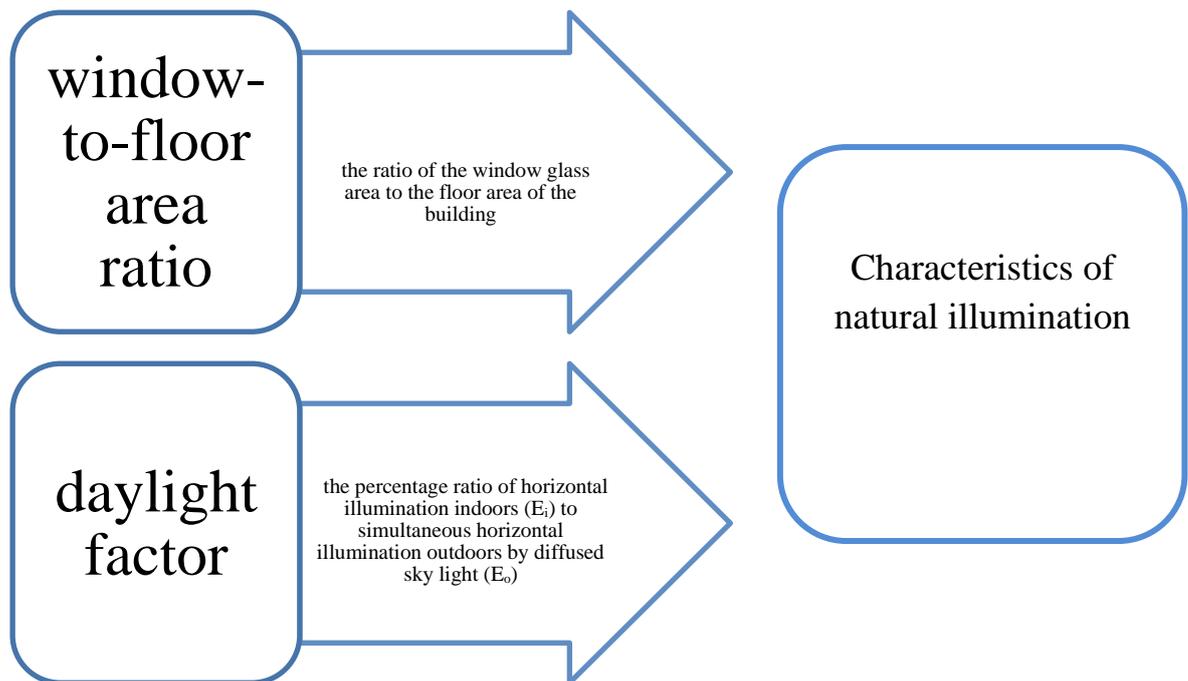


Figure 1. Regulation of natural illumination

The level of illumination and duration of daytime influence the life cycles of dairy cows. For this reason, it is necessary to pay sufficient attention to the arrangement of lighting in the construction of the barn. Neglecting this factor will result in decrease in weight gain of meat breeds and decrease of milk yield of dairy cows. One should not ignore it. For example, a competent organization of illumination with other things being equal increases the milk yield up to 10%, which is a significant result that can be achieved by minor increase in costs [2, 3, 10].

Studies show that a sufficient amount of light (at least 100-200 lx) contributes to increase in milk yield by 6-8%. Practice proves that cows are sensitive to the change in the rhythm of day and night. The level of illuminance in the resting boxes for lactating cows should be about 200 lx near the cow head, and it should be 200-300 lx near the water bowl and feeding table [9, 10, 20].

The small length of daytime in winter affects the productivity of cows. The functioning of mammary gland drops significantly compared with the summer period, when there is plenty of natural light in cowshed. The increase in the intensity of light to 100-300 lx contributes to increase of milk yield by 10-20% in the winter months.

In order to optimize the life cycle of cows, it is necessary to provide a 16-hour long light day, giving 8 hours for nighttime. This regime helps to rise the efficiency of the dairy farm and milk production to their maximum. In summer period, artificial lighting is not necessary except for cloudy days. However, optimization of life cycles in autumn, winter, and spring is impossible without artificial change of level and duration of illumination [11, 14, 20, 24].

The daytime should begin at 4:00 am and continue to 20:00 pm. The intensity of lighting should change gradually, as it happens in nature.

The measurement of illuminance level (expressed in lux) is carried out by a special instrument, a lux meter. Each device is supplied with operation manual. The daylight factor in cattle-breeding premises should be no less than the following numbers (in percent).

**Material and methods of research.** Guided by the material above, the authors conducted a work aimed at studying the parameters of natural and artificial illumination in cowsheds of various designs. The measurements were carried out on a cattle farm with 200 dairy cows of Brown Swiss breed, kept in conditions of loose housing. The farm is a property of LLC “Solovyevskoye” located in the Knyagininsky district of the Nizhny Novgorod region. The natural and artificial illuminance of the premises was determined with the help of the measuring device “Percent Flicker meter + Luxmeter + Luminance meter TKA-PKM (09)” (Figure 2).



Figure 2. A measuring instrument used in the study to determine level of natural and artificial illuminance

The measurements were carried out on the farm three times a day for two adjacent days once a month. Illuminance was measured along each row of stalls in the all zone of accommodation of animals. The natural illumination near the yard was measured at the same time.

**Results and discussion.** The design of the lighting system should provide evenly disturbed illumination without bright sports or dark niches. The illumination parameters of the studied cattle-breeding premises in the winter period were significantly lower than the norms.

The conducted studies revealed that the distribution of lighting over the housing was uneven. In the outer parts of the courtyard compared to the center, the illuminance was lower (95 lx vs 305 lx). Presumably, the reason is low light power density (expressed in watts per square meter). The required minimum of illuminance is 160 lx.

The total illumination power is  $(4.5 \text{ W/m}^2 \times 1400 \text{ m}^2)$  6300 W. It means that the cowshed needs 63 100-watt incandescent lamps. It is advisable to arrange them in four rows of 15-16 lamps. Eight or nine 100-watt lamps is enough to provide duty lighting, which corresponds to required percentage of the working illumination (10-15%). The height of the installation of lamps depends on their power (in watts). The greater the lamp power, the higher they can be mounted.

The level of illumination and spectral composition of light affect the growth and development, health and dairy productivity of animals, as well as their feed consumption and the quality of the products. The impact of light increases oxidative processes and metabolism, stimulates the functions of the endocrine glands, improves the immunity.

Precise evaluation of degree of natural light in the premises involves calculation of so-called daylight factor. The daylight factor is a percentage ratio of horizontal illumination indoors  $E_i$  to simultaneous outdoor illumination  $E_o$  on a horizontal plane. The formula is  $DF = E_i/E_o$  or  $DF = E_i \times 100/E_o$ .

The natural illuminance inside the building is 20 lx (on average) and outside is 3000 lx; therefore, the daylight factor is 0.7%, which corresponds to the norm. In the premises designed for animal housing, DF should be at least 0.8%.

In designing and building livestock premises, the main criterion for regulation and evaluation of natural light is the window-to-floor area ratio. It expresses the ratio of total area of window glass to the floor area of the building and shows the value of floor area per one  $\text{m}^2$  of glazing. The standard value of the ratio for the cowshed should be 1:10-1:15.

**Conclusions.** The relevance of the study is conditioned by the fact that lighting is one of the important parameters of the microclimate. Appropriate illumination ensures normal growth and development of animals contained in cattle-breeding premises, including dairy cows. Under the influence of light, especially natural, the physiological state of animals improves, their disease resistance, reproductive capacity, and dairy productivity increase. Taking into account these facts, the aim of the article is to study the parameters of natural and artificial illumination in livestock housing. The leading approach to the study of this problem is the visual assessment with the help of the advanced instruments, such as “Percent Flicker meter + Luxmeter + Luminance meter TKA-PKM (09)”. The measurements were carried out on the farm three times a day for two adjacent days once a month. Illuminance was measured along each row of stalls in the all zone of accommodation of animals. The natural illumination near the yard was measured at the same time. The article presents and reveals the microclimate parameters. The materials of the article are of practical value for the rational management of animal husbandry, as well as for the economic efficiency of intensive cattle breeding on industrial basis.

**Keywords:** microclimate, illuminance, livestock housing.

### References

1. Balanin V.I. Microclimate of livestock buildings [Mikroklimat zhivotnovodcheskikh zdaniy] /V.I. Balanin. Saint Petersburg.: ProfiKC, 2003. 136 p.
2. Berdova A.K. Productivity of animals [Produktivnost' zhivotnykh]. In collection of articles: Agrarian science, education, production: topical issues. Proceedings of the All-Russian scientific-practical conference with international participation. 2014. pp. 15-17.
3. Volkova S.V., Meleshkina S.R. Illuminance of cattle-breeding premises and its influence on the productivity of cows [Osveshchennost' zhivotnovodcheskikh pomeshcheniy i eye vliyanie na produktivnost' korov]. In collection of articles: Actual questions of veterinary medicine and technology of animal husbandry. Proceedings of the scientific and educational-methodical conference of teaching and research staff and post-graduate students of the faculty of veterinary medicine and livestock technology. 2017. pp. 16-18.
4. Volkov G.K. Zootechnical standards for livestock facilities: handbook [Zootekhnicheskie normativy dlya zhivotnovodcheskikh ob"ektov: spravochnik] / G.K. Volkov, V.M. Repin, V.I. Bolshakov et al. Moscow, Agropromizdat, 1986. 303 p.

5. Vtorykh S.V. Pilot testing of the device for monitoring microclimate parameters in the technological module for piglets feeding [Opytno-proizvodstvennaya proverka ustanovki monitoringa v tekhnologicheskom module dlya otkorma porosyat] / S.V. Vtorykh, I.E. Plaksin, E.O. Lantsova // Innovations in Agriculture, No. 4(14), 2015. pp. 218-222.
6. GOST 24940-96. Buildings and constructions. Methods for measuring illuminance [GOST 24940-96. Zdaniya i sooruzheniya. Metody izmereniya osveshchennosti]. Moscow: SE CPP, 1996.
7. Gordeev V.V. Influence of design decisions for cowsheds on the amount of manure-containing sinks [Vliyanie planirovochnykh resheniy korovnikov na kolichestvo navozosoderzhshchikh stokov] / V.V. Gordeev, T.Yu. Mironova, T.I. Gordeeva, V.N. Mironov // Dairy Bulletin, No. 4(24), 2016. pp. 92-98.
8. Gordeev V.V. Assessment of illuminance in cowsheds for farm with 1.200 dairy cows [Otsenka osveshchennosti v korovnikakh dlya fermy na 1200 doynykh korov] / V.V. Gordeev, V.E. Khazanov, A.F. Erk, V.A. Razmuk // Technologies and Technical Means of Mechanized Production of Crop and Livestock Products. No. 92, 2017. pp. 153-158.
9. Zabudskii Yu.I., Kamalov R.A., Kochish I.I., Naydenskiy M.S., Totoeva M.E., Tadzhieva A.V., Filina N.N., Gureev A.E., Sizov D.A., Levin M.V., Zakabunin S.V. Zoohygiene with the basics of designing livestock facilities [Zoogigiyena s osnovami proyektirovaniya zhivotnovodcheskikh ob'yektov]. Moscow: Agropromizdat, 2008. 432 p.
10. Zavodov A.V. Favorable microclimate is a guarantee of successful breeding of young domestic animals [Blagopriyatnyy mikroklimat – garantiya uspeshnogo vyrashchivaniya molodnyaka domashnikh zhivotnykh] / A.V. Zavodov, S.V. Zavodov, N.A. Laretin // Glavnyi Zootekhnik, No. 7, 2008. pp. 8-10.
11. Ilyin R.M. Justification of parameters of microclimate monitoring system in livestock premises [Obosnovaniye parametrov sistemy monitoringa mikroklimata v zhivotnovodcheskikh pomeshcheniyakh] / R.M. Ilyin, S.V. Vtorykh // Technologies and Technical Means of Mechanized Production of Crop and Livestock Products, No. 92, 2017. pp. 212-217.
12. Konaev N.V., Nazarenko Yu.V., Zhdanov S.I. Optimal lighting system [Optimal'naya sistema osveshcheniya]. In collection of articles: Integration of science and agricultural

- production. Proceedings of the international scientific-practical conference, 2017, Pt. 2. pp. 28-33.
13. Kuznetsov A.F., Nashenskiy N.S., Shukanov A.A., Belkin B.P. Animal hygiene [Gigiyena zivotnykh]. Moscow: Kolos, 2001. 368 p.
  14. Martynova E.N., Mel. I.V. Analysis of the effect of changes in outdoor air temperature on the microclimate in livestock buildings [Analiz vliyaniya izmeneniya naruzhnoy temperatury vozdukha na mikroklimat v zivotnovodcheskikh pomeshcheniyakh]. In collection of articles: The effectiveness of adaptive technologies in animal husbandry. Proceedings of the All-Russian scientific-practical conference dedicated to the 50th anniversary of agrarian education in the Udmurt Republic. Izhevsk State Agricultural Academy, 2004. pp. 236-240.
  15. Martynova E.N., Yastrebova E.A. Physiological state of cows depending on the microclimate of the premises [Fiziologicheskoye sostoyaniye korov v zavisimosti ot mikroklimata pomeshcheniy] / Achievements of Science and Technology of AIC, No. 8, 2013. pp. 53-56.
  16. IBC-AIC 2.10.24.001-04. Lighting standards for agricultural enterprises, buildings and structures [OSN-APK 2.10.24.001-04. Normy osveshcheniya sel'skokhozyaystvennykh predpriyatiy, zdaniy i sooruzheniy]. Moscow: SE CPP, 2004.
  17. SNiP 23-05-95. Natural and artificial lighting [SNiP 23-05-95. Yestestvennoye i iskusstvennoye osveshcheniye]. Moscow: SE CPP, 1995.
  18. Sytnik D.A. Sanitary-hygienic condition of livestock premises and its impact on the immunity of calves [Sanitarno-gigiyenicheskoye sostoyaniye zivotnovodcheskogo pomeshcheniya i yego vliyaniye na rezistentnost' telyat] // Effective Animal Husbandry, No. 3, 2014. pp. 24–25.
  19. Timoshenko V. Comfort of cows is the key to high productivity [Komfort korov – zalog vysokoy produktivnost] / V. Timoshenko, A. Musyka, A. Moskalev, N. Shmatko // Animal Husbandry of Russia, No. 8, 2014. pp. 39-41.
  20. Timoshenko V. Lighting in cowshed [Osveshcheniye v korovnike] / V. Timoshenko, A. Musyka, A. Moskalev // Animal Husbandry of Russia, No. 3, 2014. pp. 39-40.
  21. Fomin A.D. Manual on labor protection [Rukovodstvo po okhrane truda]. Moscow: Publishing Group “ENAS”, 2005. 232 p.
  22. Erk A.F. The use of energy saving lamps in lighting systems of premises of cattle-breeding complex [Ispol'zovaniye energosberegayushchikh lamp v sistemakh

- osveshcheniya pomeshcheniy zhivotnovodcheskogo kompleksa] / A.F. Erk, V.A. Razmuk, A.N. Efimova // International Agroindustrial Exhibition-Fair “Agrorus” Saint Peterburg, 2014. pp. 182-184.
23. Hartung J. Livestock farming and the environment / J. Hartung, C.M. Wathes. Braunschweig, 2001. 56 p.
24. Phillips C.J.C., Snofield S.A. The effect of supplementary light on the production and behaviour of dairy cows // Anim. Product. 1989. 48, 2: pp. 293–303.