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# INFLUENCE OF DIFFERENT WAYS OF KEEPING COWS ON THE ENERGY EFFICIENCY OF THE MICROCLIMATE

## ВПЛИВ РІЗНИХ СПОСОБІВ УТРИМАННЯ КОРІВ НА ЕНЕРГОЕФЕКТИВНІСТЬ МІКРОКЛІМАТУ *(оглядова)*

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***Abstract.*** *The formation of a comfortable microclimate depends on providing animals with a microclimate in accordance with the zone of thermal neutrality of animals, which is provided by energy-saving enclosing structures of livestock premises, thermal protection of enclosing structures and equipment with energy-saving air ducts, microclimate control systems, the use of automatic control, the use of air conditioning and recirculation, the provision of microclimate parameters for animals and the automation of agricultural enterprises.*

***Key words:*** *energy efficiency, microclimate, housing, cows, cattle breeding*

During the stall period, the ventilation system is used without additional heat carriers, so in such energy-saving conditions, due to measures to maintain the enclosing structures, heat is kept in the livestock premises.

During steady-state operation, the ventilation system operates without the use of additional heat transfer fluids. This contributes to the preservation of heat in livestock buildings through energy-saving measures, which include heat retention with the help of enclosing structures.

The air temperature in animal housing is the main factor that determines the microclimate and provides comfortable conditions for animals. Depending on the level of minimum and maximum air temperatures in the room, the metabolism of animal tissues may increase or decrease. For example, increased heat loss or overheating of the body leads to a deterioration in the preparation of cows for calving and subsequent lactation.

During the stall period of cow housing, a decrease in indoor air temperature mostly occurs when the conditions of animal housing are unsatisfactory.

One of the most effective ways to control indoor air temperature is to study the minimum and maximum temperatures. These indicators are very important in the reconstruction of livestock facilities, especially when assessing the impact of the temperature factor on the physiological functions of cows, primarily on their behavior, feed and water consumption, and clinical condition.

The determination of the indoor air temperature showed that only cows that were kept tethered in stalls with dairy cows during the dry period were exposed to elevated temperatures. Thus, the minimum indoor air temperature for them exceeded the permissible norm by 1.7 times. The highest values of the minimum indoor air temperature for cows were recorded from 24 to 6 hours, which was 1.7 and 0.8° C higher than the average for the day. Subsequently, the minimum temperature from 6 to 12 hours in this room decreased by 1.6° C.

The minimum room air temperature in the room where dry cows were tethered in an isolated section in stalls was 16.3° C, which is 2.6° C higher than in similar studies conducted to determine the minimum room air temperature when dry cows were kept together with lactating cows. When dry cows were kept in a free-stall manner in a separate section with combine cubicles, the minimum indoor air temperature was on average 2.2° C higher than when they were kept in stalls with lactating cows.

During the day, the minimum air temperature in the room for keeping cows during the dry period in separate sections in combine barns, as well as in a separate section in tethered stalls, changed to a much lesser extent than when dry cows were kept in tethered stalls together with lactating cows.

Studies have shown that the minimum indoor air temperature when dry cows are kept in stalls together with lactating cows, as well as tethered in a separate section and untethered in a separate section with combine boxes, was the highest at 24 hours a day, which corresponds to the generally accepted values of this indicator for cattle.

In the morning, the minimum air temperature in all three rooms where the research was conducted slightly decreased by an average of 0.1-0.9° C compared to the values of this indicator at night. However, when dry cows were kept untethered in a separate section equipped with combine cubicles, the fluctuation in the minimum indoor air temperature was much lower than when animals were tethered.

Studies have also shown that from 18 to 24 hours of the day, the minimum air temperature where dry cows were kept together with lactating cows increased by 3.4 ° C, tied in a separate section by 1.2° C and untied in a separate section with combine cows by 1.0 ° C. That is, the smaller the technological groups of cows in the premises, the lower the air temperature fluctuations, which has a positive effect on the processes of thermoregulation of the animal body and provides better indicators of the heat balance of the premises.

This is also evidenced by the data on average daily minimum indoor air temperatures for different methods of keeping dry cows. Moreover, these indicators for untethered dry cows in a separate section equipped with combiboxes during the stall period were 2.2 ° C higher than for tethered cows in stalls in a separate section, and 2.6 ° C higher than for tethered cows in stalls with dairy cows, which indicates more optimal comfortable conditions for keeping animals in the first case compared to others.

Thus, the reconstruction of cowsheds, which involves the arrangement of a separate section in the end part of the room without combine boxes (tethered) or with combine boxes (untethered) for keeping dry cows, helps to optimize the minimum indoor air temperatures during the stall period of animal husbandry. However, it was also important to study the dynamics of maximum indoor air temperatures during the day in different ways of keeping dry cows.

Studies have shown that at certain hours of the day, the maximum air temperature rose to 19° C in the dry cow room when cows were kept untethered in a separate section with combine cows. However, the average daily fluctuations in the maximum air temperature in this room did not exceed 1.1° C.

This indicates that fluctuations in maximum air temperatures in a separate section of the building equipped with combine cubicles with untethered dry cows were less significant than when animals were kept together with lactating cows and in a separate isolated section, but tethered.

The average daily fluctuations in maximum air temperatures in different rooms with different methods of keeping dry cows were insignificant, within 0.3-0.8 ° C, were at the level of the established values and met the requirements of the Departmental norms for technological design of cattle breeding enterprises.

Determination of the difference between the maximum and minimum air temperatures at different times of the day showed that the greatest changes in this indicator (from 3.4 to 3.9° C) were found in the premises where dry cows were kept in stalls tied together with dairy cows. When dry cows were kept in a separate section tied, this indicator was significantly lower - from 1.5 to 1.7° C, and when untethered in an isolated section with combine boxes - from 2.0 to 2.4° C.

Based on the studies of minimum and maximum temperatures, in order to ensure a stable air temperature regime throughout the day during the reconstruction of existing livestock facilities, it is proposed to keep cows during the dry period untethered in a separate section equipped with combine boxes.

The obtained experimental data on the values of maximum and minimum indoor air temperatures for dry cows are consistent with the results of studies by other authors.

In addition to temperature, humidity and air velocity are important factors in the formation of the microclimate in livestock buildings.

According to calculations, a cow in the dry period, depending on body weight and productivity, releases 350-520 g/h of moisture. In addition, about 25% of the total amount of water vapor in the room is released from the floor, feeders and drinkers. Almost 15% of water vapor enters the room with atmospheric air. There are many ways to reduce the humidity of indoor air evaporating from the floor surface, but the main ones are the design of enclosing structures, floors and equipment of sewage and ventilation systems.

Scientific research conducted in this area by many scientists has shown that the relative humidity in barns should be within 50-75%. There is no information in the literature on the relative humidity of barns when dry cows are kept in isolated sections, tied or untied in a separate section with combine boxes. Therefore, in order to determine this important indicator of the microclimate of the room, taking into account its values during the reconstruction of barns, it was necessary to conduct appropriate research.

It was shown that when cows were kept in a tethered housing during the dry period together with dairy cows in the stall period, the relative humidity of the room during the day changed slightly, and its values were slightly higher than the established normative indicators.

It was found that during the day (from 6 to 12 hours), indoor air humidity in the room during the tethered keeping of dry cows increased significantly, remaining almost at this level until 18 hours, and then gradually decreased by 3.6%. This can be explained by the fact that during this period the main technological operations are carried out indoors, as well as the main physiological processes such as defecation, urination, and respiration, which are the main source of water vapor in the room.

At the same time, up to 20 liters of water are consumed for technological operations related to washing dairy equipment, dishes, animal care, etc. In the cold season, outside air saturated with water vapor enters the barn, which condenses on the building envelope and equipment and then evaporates again. This is primarily due to the unorganized entry of a large amount of air into the building as a result of technological operations through the doors of the building: entry and exit of feeders, work of service personnel, manure removal, milking, bedding change, etc.

At night, the barn receives much less moisture from the outside, but more is released as a result of evaporation of water vapor from the manure channels and floor. This is primarily due to the lack of technological operations for milk production, feeding, and manure removal, which leads to a decrease in the flow of unorganized air into the premises.

Excessive humidity in the room is also due to its incomplete removal at night through exhaust ventilation ducts. However, despite this, at 6 am the air humidity decreased by 3.6% (the room where dry cows were kept together with milk cows), but its value was 13.1% higher than the permissible norm. Keeping cows in a separate section during the dry period in a tethered manner was more comfortable, as the average air humidity during the day and at night was 15.5-16.0% lower than when keeping animals in the same technological group with lactating cows.

In the room where dry cows were kept untethered in a separate section with combine cubicles, the relative humidity during the day compared to their tethered housing with dairy cows was also on average 18.2-18.6% lower. Moreover, the air humidity in this way of keeping dry cows was significantly lower during the entire experimental period and provided much better hygienic conditions for their maintenance. The latter was achieved by applying an appropriate design solution during the reconstruction of the barn, namely the equipment of a separate isolated section with combine boxes.

Thus, it was found that only in the room where dry cows were kept tethered together with dairy cows, the air humidity of the premises during the day did not meet the established standards for this sex and age group of animals. This requires taking the necessary measures to improve the conditions for keeping dry cows and to comply with sanitary and hygienic standards. The use of energy-saving measures such as isolation of cows in a separate section, arrangement of cows' rest on wooden bedding in cubicles led to an improvement in the microclimate for animals.

Significantly lower relative humidity in the barn when cows are kept untethered in a separate section with combine barns during the dry period was achieved not only by separating the animals into a separate technological group, but also by installing a wooden checkerboard floor.

The obtained research results complement the data obtained by other authors and indicate that during the stall period, keeping dry cows in isolated sections is the most optimal and provides an acceptable level of relative humidity. Tethered housing of dry cows together with dairy cows is inexpedient from a hygienic point of view, since it does not ensure compliance with the relative humidity of the room within the permissible norm. Therefore, when choosing a method of keeping dry cows during the stall period, preference should be given to untethered housing in isolated sections equipped with combine boxes, as it is more energy-efficient and more efficient than tethered housing.

An important factor in the energy efficiency of building envelopes with natural ventilation is the determination of air composition.

The chemical composition of the air in livestock buildings differs significantly from that in the atmosphere. Thus, the amount of carbon dioxide, ammonia, and hydrogen sulfide in the air of livestock buildings increases as a result of animal activity, which cause various respiratory disorders accompanied by hypoxia and reduce animal productivity. All of this reduces the efficiency of livestock production without the installation of appropriate technological measures that reduce the concentration of harmful gases in the premises.

Ammonia is constantly released from urine, manure and litter indoors. It quickly dissolves in water, enters the lungs and blood, and leads to inflammation of the mucous membranes of the nose, larynx, and eyes. The maximum permissible concentration of ammonia in the air of cow quarters is up to 20 $mg/m^3$ .

The concentration of carbon dioxide in the air of the premises for cows kept in tether was on average 0.26%, which corresponds to its permissible level. At the same time, it was found that the highest level of carbon dioxide in the air of the room where the cows were kept tethered was observed at 6 o'clock, then it decreased by an average of 0.13% and increased again at 24 o'clock. A significant increase in the content of carbon dioxide in the air of livestock premises during this period can be explained by a decrease in air exchange and insufficient ventilation efficiency in this way of keeping cows. To improve the hygienic condition in the cow housing, it is advisable to provide energy-saving measures.

For example, the arrangement of a separate section for tethered housing of dry cows during the stall period and their separation from lactating cows contributed to a 0.08% reduction in carbon dioxide content.

It has been established that tethered housing of dry cows in a separate section can reduce the level of carbon dioxide in the air of the room to 0.18% compared to their housing together with dairy cows. This is one of the elements of an energy-saving approach to creating comfortable conditions for livestock.

The next energy-saving factor is the untethered housing of cows. Untethered cow housing during the dry period in a separate section with specially equipped cubicles also contributed to a significant reduction in the concentration of carbon dioxide in the air. Thus, compared to the tethered keeping of dry cows together with dairy cows, the carbon dioxide content in the air of a separate section of the room where animals were kept untethered with rest in combine cubicles was 0.10% lower in the morning, 0.05% lower at lunch, 0.04% lower in the evening and 0.06% lower at night, and met the established hygiene requirements.

Thus, the studies have shown that one of the energy-saving ways to reduce the content of carbon dioxide in the air of the premises when keeping dry cows is tethered or untethered in isolated sections using combiboxes, which do not involve additional costs for improving the ventilation system. Thus, improving the microclimate through organizational measures allows for an increase in the efficiency of the livestock enterprise in production conditions.

This conclusion is confirmed by the average value of carbon dioxide in the air of dry cow barns during the day and their comparison with the permissible value of this indicator according to sanitary and hygienic requirements, as well as energy-saving measures.

It was found that at the 6th and 24th hour of the day, the content of carbon dioxide in the room air during the tethered keeping of dry cows together with dairy cows exceeded the permissible level by an average of 0.05-0.09%. With the developed and applied methods of keeping dry cows, the content of carbon dioxide in the air of the premises during the day was significantly lower than the permissible norm.

An important indicator of the energy-saving sanitary condition of the air and the efficiency of the natural ventilation system of a livestock building is the content of such harmful gas as ammonia. It was found that the concentration of ammonia in the air of the premises for dry cattle significantly depended on the method of their maintenance. When cows were kept in stalls together with milk cows, the ammonia content in the air during the day fluctuated within the permissible level, but at night the concentration of this gas in the air was 16% higher than the permissible level.

When dry cows were kept in a separate section, the ammonia content in the air did not exceed the maximum permissible concentration, except at night.

The concentration of ammonia in the air during the untethered housing of dry cows in a separate section with combine barns was the lowest compared to the same air in the control room. This is due to the fact that the floor surface area from which ammonia is released in a separate section after the reconstruction of the premises decreased. and the installation of combine cows and the use of untethered dry cows contributed to the improvement of hygienic conditions in this part of the room, and improved energy efficiency of natural ventilation.

The increase in the level of ammonia in the indoor air at night, which in some cases exceeded the maximum permissible concentration, is likely due to a decrease in the intensity of air exchange in the room during this period of the day when cattle are kept in stalls. Conducting technological operations during the day and removing manure leads to a decrease in the release of this gas and the removal of contaminated air from the premises. This conclusion is also indicated by the data on the comparative analysis of the ammonia content in the air of the premises in different ways of keeping dry cows.

It was found that the ammonia content in the indoor air depends less on the way dry cows are kept and more on the efficiency of manure removal and ventilation systems, and the energy efficiency of the building envelope, heat generation by animals, etc.

The data obtained can also be used to improve ventilation at night during the reconstruction of barns. Finding different ways to improve the performance of the ventilation system at night can also be an important element of new engineering solutions. It is possible to supplement natural ventilation with mechanical ventilation during critical periods of operation.

Thus, it has been shown that the most optimal gas composition of indoor air can be achieved only when dry cows are kept in isolated sections, especially when using the tetherless method and combiboxes.

Increasing the level of general microbial contamination of the air in livestock buildings worsens the conditions for keeping livestock. The growth of microbial contamination of livestock facilities causes a decrease in animal productivity by 10-20%, increases the number of animal diseases, and contributes to a deterioration in their adaptive capacity. Therefore, reducing the number of microorganisms in the indoor air is an important factor in optimizing the sanitary, hygienic and energy-saving conditions for keeping cows and improving the sanitary quality of milk, which is an economic measure for livestock production.

However, microbial contamination of premises in different ways of keeping dry cows has not been studied sufficiently. In this regard, it is important to study the impact of the main technological processes, namely feed distribution and watering, ventilation, milking, and the role of different building materials for floors in stalls or cubicles on the formation of the overall microbial contamination of dry cow premises. These data indicate a significant difficulty in maintaining an energy-saving regime for keeping animals indoors.

However, the search for improving the performance of the natural ventilation system showed that the total microbial contamination of livestock premises under different methods of keeping cows during the day ranged from 34.2 to 79.5 thousand microbial bodies/$m^3$ The lowest microbial contamination of the air was found in the room for dry cows, which were kept untethered in a separate section equipped with combine boxes.

On average, this figure for tethered dry cows together with dairy cows was 45.3 thousand/$m^3$, or 43.0% higher than the same figure for untethered animals in a separate section with combine cows.

Separating dry cows from dairy cows into a separate section helped to reduce overall microbial air pollution. Thus, when cows are kept in a separate section, microbial air pollution decreased by an average of 40.7 thousand microbial bodies/$m^3$ compared to similar air indicators when dry cows are kept together with dairy cows. This is due to the fact that in a separate section of the premises where dry cows were kept untethered, the dust load was significantly lower, the number of animals was lower, and a number of technological operations for animal maintenance were excluded. Reducing technological operations for animal care is not only an economical, energy-saving measure, but also a preventive measure against the spread of pathogens that can be carried along with dust particles in the air.

When comparing the total microbial contamination of indoor air, with tethered dry cows in an isolated section and untethered, it was found that in the latter method the number of microorganisms in the air was 13.4% less than in the first variant. It was found that in the air of the room where dry cows were kept together with lactating cows, the highest microbial contamination was observed at 18 hours (83.4 thousand microbial bodies/$m^3$ ), decreasing slightly at 12 hours and 24 hours, reaching the lowest level in the morning at 6 hours.

Thus, during the day, microbial contamination of the air in different ways of keeping dry cows varied significantly. This is due to the fact that the main elements of the technological process of milk production, which lead to an increase in the number of microorganisms in the air of the premises, have the greatest impact on this indicator during the day, and the least - at night.

Similar changes in the nature of microbial air pollution were obtained in the premises for dry cows when they were kept in a separate section or untethered in a separate section with combine boxes.

Comparing the data obtained on microbial air pollution of premises without and after reconstruction in different ways of keeping animals with the permissible value of this indicator, it should be noted that when dry cows were kept tethered together with dairy cows during the day, the number of microorganisms exceeded the permissible level by 4.9-13.4 thousand microbial bodies/$m^3$ ). When dry cows were kept in separate sections with or without tethering, which was achieved by reconstructing the premises, the level of microbial air pollution was significantly lower than the permissible level.

Such technological methods as changing bedding, cleaning animals, and removing manure make a significant contribution to reducing the number of microorganisms in the air of the premises in different ways of keeping dry cows. Therefore, it is advisable to carry out such technological methods in the absence of animals.

It was found that the total microbial contamination of the air in the feeding aisles of the premises when dry cows were kept together with dairy cows and feed was distributed in the feeders using a feeder of the KTU-10 type was 2.1 times higher than the same indicators when cows were kept in a separate section.

Such a sharp decrease in the number of microorganisms in the air of the feed aisles when keeping dry cows in separate sections equipped after the reconstruction of the premises is primarily due to the use of different methods of feed distribution. In the isolated section, feed was distributed to the animals of the experimental groups using special handcarts.

When feed was distributed to animals using the mobile feed dispenser KTU-10, the number of microorganisms in the air of the room increased. Moreover, at 12 and 18 hours the highest number of them was observed in the air. When the feed was distributed to the cows manually using carts, microorganisms accumulated in the air of the feed aisles to a much lesser extent during the day. Thus, at 12 and 18 hours in the feeding aisle when cows were kept in an isolated section, almost 2 times fewer microorganisms were found tied, and when cows were kept untied in an isolated section - 2.5 times compared to similar data in the air when dry cows were kept together with milk cows.

Under different methods of keeping cows during the dry period compared to the permissible level, it was shown that in the premises where animals were kept tethered together with lactating cows from 12 to 18 hours, the number of microorganisms in the air exceeded the permissible norm by 5-7%.

When dry cows were kept in a separate section, tethered or untethered, the total microbial contamination of the air in the feed aisles, depending on the time of day, was significantly lower than the permissible level.

The total microbial contamination of the air in the stalls when dry cows were housed together with dairy cows exceeded the permissible level by 17.7 thousand/m$^3$ or 25.3%, and in some periods (at 12 and 18) - by 30%.

At different times of the day, this indicator in the air of the premises for dry cows kept in separate sections was on average 1.8-2.2 times lower than the same indicator when dry cows were kept together with dairy cows.

Another factor in the energy-saving technological solution that affects the overall microbial air pollution in different ways of keeping dry cows is the design of the stall and its size, as well as the material of the floor. The accumulation of urine and feces in the back of the stall leads to intensive development of microorganisms, and when the contaminated bedding and manure dry, they are released into the room air with dust.

Making the floor of the dry cow barns from wooden end caps helped to reduce the number of microorganisms in the air in the cow housing areas.

The tethered keeping of dry cows in a separate section on floors made of wooden end caps helped to reduce the number of microorganisms in the room air on average per day to 43.2 thousand, which is 49.2% less than in rooms on the floor made of boards, where cows were kept together with dairy cows during the dry period. A significant difference in the number of microorganisms in the air of the premises was also found when dry cows were kept in a separate section with combine boxes and together with lactating cows.

The fact that the number of microorganisms in the indoor air is reduced when dry cows are kept in a separate section using stalls or combine cows indicates that there are significant opportunities to find energy-saving technological solutions in the production of livestock products. The installation of floors made of materials that meet hygiene requirements, have low thermal conductivity, do not accumulate moisture and do not create conditions for the intensive development of microorganisms also leads to a decrease in their number in the air. In the experimental version, a wooden checkerboard floor, which is also an energy-saving material, meets these requirements.

Comparison of the total level of microbial contamination of the air in different ways of keeping cows using different floors with the permissible level showed that when dry cows were kept in stalls with lactating cows in stalls with a floor made of boards, the number of microorganisms in the air during the day exceeded the permissible level by 19-31%.

Tethered or untethered keeping of dry cows in a separate section in stalls or using combine boxes on floors made of end caps, compared to similar indicators when keeping dry cows in stalls together with dairy cows, reduces the total microbial air pollution by 50 - 65%, depending on the time of the study.

The obtained results of studies of the general microbial contamination of indoor air in different ways of keeping dry cows indicate fundamental differences in these indicators and are consistent with the data of studies by other authors.

Thus, one of the most effective ways to reduce microbial contamination of indoor air when keeping dry cows is to arrange separate sections with combine boxes, end checkerboard floors, and the use of small mechanization - feed trolleys.

In livestock buildings equipped with an energy-saving natural ventilation system, the direction of air flows is regulated to ensure hygienic requirements for animal husbandry. The temperature of the outside and inside air and its humidity must be taken into account, since an increase in the speed of air flow in the room leads to an increase in its cooling capacity.

It has been established that for full-grown cattle during the stall period, the air velocity in the room should not exceed 0.2 m/s.

During the reconstruction of livestock buildings for keeping different sex and age groups of cattle, including dry cows, the movement of air flows in different parts of the building changes, which requires additional research to assess it and develop effective ways to regulate this important indicator.

The air velocity in the sections of the room without reconstruction and with the equipment of a separate isolated section for keeping dry cows was determined at different times of the day (at 6, 12, 18, 24 hours). In three sections of the room where the experimental cows were kept, at a height of 1 m in the feed passage and stalls (combiboxes), in the middle of the room (section), at a distance of 1-2 m from the end walls.

It was shown that in the sections of the room where dry cows were kept together with dairy cows, the air velocity was the lowest at 6 hours, gradually increasing 2.2 times at 12 and 18 hours. At this time of day, the air velocity did not change and only at 24 hours it decreased again to its values in the morning.

The average value of air velocity per day in this room was slightly higher than the established standard.

The transfer of dry cows to a separate section with tethered housing provided a more stable value of air velocity during the day and night, although at night this indicator was slightly higher than the same value when dry cows were kept together with dairy cows.

This is probably due to the fact that air flows in a confined space move more intensively, removing more air from a separate section of the room, which is replaced by air from the outside. Changing the air velocity during the day, both indoors and outdoors, had a positive effect on the content of carbon dioxide and ammonia in the air of a separate section, which provided significantly better sanitary and hygienic microclimate indicators.

The untethered keeping of dry cows in a separate section after the reconstruction of the premises using combiboxes also provided comfortable conditions for the animals and contributed to more stable values of air velocity in this part of the building.

Comparison of the air velocity in the premises under different methods of keeping dry cows with the normative indicators according to hygienic requirements showed that only during the day, when animals with different physiological conditions were kept together on a tether, the air velocity in the room was 20.0% higher at 12 o'clock and 16.7% at 18 o'clock.

The speed of air movement in the room when keeping dry cows together with dairy cows changed most during the day compared to the average value of this indicator and increased by 38.5% at 12 hours and by 34.6% at 18 hours. When dry cows were kept in isolated sections on a tether or untethered in combine barns, the air velocity in the premises changed to a much lesser extent.

Thus, from the point of view of assessing the microclimate in individual sections of livestock buildings for keeping dry cows, it can be stated that in terms of air velocity, these structural parts of the building created by reconstruction are more comfortable for animals.

It is important for the hygienic assessment of the livestock building during its operation to determine the technological noise generated by various mechanisms involved in the technological process of milk production, namely: feed distribution, manure removal, milking, etc.), but they must be reliable, not create additional stress for animals and be energy efficient.

Operating mechanisms affect not only animals but also the staff through noise. Therefore, compliance with the established standards for noise levels in animal premises is a prerequisite for the effective work of the staff. Compliance with sanitary and hygienic requirements and prevention of exposure to stress factors, including industrial noise in the premises, is an important condition for keeping dry cows, maintaining animal health and avoiding additional costs for their treatment or replacement.

Technological noise is one of the insufficiently studied stressors that many researchers pay special attention to.

As our previous observations have shown, most of the production noise is generated by manure removal by conveyors, feed distribution, milking machines, etc. In the building where dry cows were kept together with dairy cows, where feed was distributed using the KTU-10, the noise level was the highest and slightly exceeded the permissible standards for cattle.

This figure was 3.6% higher than the average and 17.8% higher than the maximum permissible technological level. Therefore, in our opinion, it is advisable to distribute feed by mobile transport KTU-10 when there are no animals in the premises and they are on the walking grounds. Under such conditions, the negative impact of industrial noise can be prevented.

Determination of the noise level in the premises during the tethered keeping of cows during the dry period in an isolated section, where feed was distributed using hand carts, showed that this method was 69 dB less than the control.

Similar results were obtained when dry cows were kept untethered in a separate section with combine barns, where feed was distributed using hand carts.

Given that the number of dry cows is about 10-12% of the total number of breeding cows, it is not advisable to distribute feed to them with the KTU-10 feeder. For a small number of animals in a separate section of the premises that require a small amount of feed, it is advisable to use handcarts, which significantly reduces the level of production noise in the room. And the diet for cows during the dry period is significantly different from the diet of dairy cows, which is dominated by such feed as hay, which is also the reason for distributing feed using hand carts, not the KTU-10 feeder.

Technological noise in animal premises is also generated by the operation of milking machines during milking, which negatively affects the behavior of dry cows when they are kept together.

For example, studies have shown that during the operation of the Volga milking machine, the level of industrial noise generated by it in the room ranged on average from 43.4 to 47.3 dB. The lowest noise level from its operation was 41.5 dB (evening milking of the cow Raketa 0528) and the highest was 50.4 dB (evening milking of the cow Ripka 0324).

Some discrepancies in the production noise indicators during the operation of the Volga milking machine when milking different cows can be explained by the fact that the noise background in the room is constantly changing, which arises as a result of communication between the operating personnel, changes in the vacuum level, external noise, etc. Therefore, when milking cows with even one milking machine at different times, a difference between noise levels was found, albeit a slight one.

It is noted that the operation of the milking machine has a positive effect on dairy cows, stimulating milk production, and on dry cows it acts as a negative irritant.

During milking, dry cows, when kept together with other cows, are restless, often changing their body position and behavior. Reducing the noise load on the body of dry cows by isolating them and keeping them in separate sections in compliance with sanitary and hygienic standards is a prerequisite for ensuring the physiological course of pregnancy, especially in the last two months before calving.

Studies of the level of production noise arising from the operation of TSG-160 type conveyors when removing manure from the premises under different methods of keeping dry cows showed that their value in the room where cows were kept together with milk cows during the dry period was slightly higher than in the case of untethered animals in an isolated section.

It has been established that when dry cows are kept tethered or untethered in isolated sections with combine barns, the noise level during manure removal is somewhat lower than when dry and lactating cows are kept together in a tethered manner. This difference in performance can be explained by the fact that when dry cows are kept in a separate section, additional noise is much less than when they are kept together in a room with dairy cows.

Studies have confirmed the conclusion that when dry cows are kept in the stall period together with the milking cows, industrial noise, especially the operation of milking machines and mobile feed dispensers such as KTU-10, create additional stress on the animals. Therefore, in order to reduce the impact of production noise on dry cows, it is advisable to keep them in separate sections of the premises to prevent the effects of external stimuli and create the most favorable conditions for their maintenance. These requirements can be achieved through the reconstruction of production facilities for keeping cows.

The studied microclimate indicators made it possible to conduct a sanitary and hygienic assessment of livestock premises and conclude that they can be used for keeping dry cows in the stall period after their reconstruction. The need for such studies is also confirmed by existing regulatory documents.

Significant changes in the microclimate parameters of the premises have been shown to cause negative stress reactions in animals. Given that dry cows in the stall period are in the last months of pregnancy, such a stressor as industrial noise can significantly change their health status, thereby reducing the efficiency of animal husbandry. Today, the existing regulatory documents do not contain data on the permissible level of industrial noise and its impact on the health of dry cows during the stall period. Therefore, a point-based assessment of industrial noise was proposed, which was reflected in the previously developed scale for assessing the microclimate of the premises. It was decided to evaluate the level of industrial noise up to 16 dB as 5 points, and over 67 dB as 2 points.

Thus, the level of industrial noise in the premises was assessed in different ways of keeping dry cows: during feed distribution, manure removal, and milking machines operation.

Evaluation of the microclimate of the reconstructed premises under different methods of keeping dry cows during the stall period, namely tethered with lactating cows, untethered in a separate section and untethered in a separate section with combiboxes, by nine indicators showed that the last option is the most optimal in terms of design and technological regime for keeping dry cows.

A somewhat lower design and technological regime is established for premises where dry cows are kept in a separate section.

The lowest design and technological regime was registered for premises for keeping dry cows together with lactating cows.

The analysis of microclimate parameters and design and technological solutions for the feasibility of reconstructing livestock facilities showed that the most optimal is the untethered keeping of dry cows in a separate section with combiboxes. The tethered method of keeping dry cows in a separate section of the premises is less effective according to the scoring of microclimate parameters. It has been established that it is inappropriate to use tethered housing for dry cows together with lactating cows. Our data on the scoring of the microclimate parameters of the reconstructed premises are close to the hygienic requirements adopted in EU livestock production. Evaluating the compliance of the microclimate parameters of the premises with sanitary and hygienic standards for keeping dry cows in the stall period together with dairy cows, it was found that low scores were obtained in the assessment of the microclimate in relation to the level of relative humidity, carbon dioxide concentration and the level of industrial noise when distributing feed by mobile transport of the KTU-10 type. The minimum temperature and air velocity, as well as the level of industrial noise during manure removal by TSG-160 conveyors, were rated at five points. On average, the assessment of the microclimate of the premises for this method of keeping dry cows was 3.4 points, which corresponds to the maximum permissible operational level of sanitary and hygienic standards of the microclimate of the premises. However, given that only one of the 10 microclimate indicators was rated at one point and two at two points, the microclimate of the room where the cows of the first group were kept was assessed at the level of maximum daily fluctuations (MPCF). This indicates an appropriate impact on the body of cows during the dry period of unfavorable stress factors. Such factors, according to some researchers, cause a decrease in milk production of animals after calving by 22-31% compared to the optimal design and technological parameters of the microclimate in animal housing.

The cows in the dry period in a separate section were assessed by microclimate indicators at 4.33 points, which corresponds to the permissible design and technological regime.

The analysis of the data showed that with different methods of keeping dry cows in separate sections, there were no significant differences in the assessment of the microclimate by nine indicators. The largest deviations in the overall microclimate assessment were observed in the ammonia content in the air, its relative humidity, and the level of industrial noise during feed distribution. It should be emphasized that the level of industrial noise, excluding the operation of milking machines and mobile feed dispensers, was rated at five points. It can be predicted that reducing the impact of external stimuli on animals will have a positive effect on dry cows, their preparation for calving and future lactation.

The untethered keeping of dry cows in a separate section with combiboxes was rated the highest in terms of microclimate indicators compared to other methods used in the experiment. About 67% of the microclimate indicators in this method of keeping dry cows were rated at 5 points. However, it would be desirable to reduce the level of ammonia in the room air with this method of keeping dry cows, since its permissible content should not exceed 20 $mg/m^3$ . That is, the untethered keeping of dry cows in a separate section with combine barns corresponds to the optimal design and technological regime, which indicates better preparation of animals for calving and lactation. Under different methods of keeping dry cows, microclimate indicators and its scoring based on them had significant deviations from the average score.

Thus, the research has established that, in accordance with sanitary and hygienic requirements, the condition of the premises and methods of keeping dry cows during the stall period should be assessed by the following parameters: production noise, minimum and maximum temperature, relative humidity, speed, total microbial air pollution, concentration of carbon dioxide and ammonia in the air. We also conduct research on the energy-saving and cost-effectiveness of such technological solutions.

In the maternity ward and calf barn of a dairy farm, overhead air ducts are installed with air coming in from the outside and going down, ending above the machines with animals with a funnel for air supply from above.

The upper main duct of the air inlet duct, installed 3 m above the floor, is a cylindrical pipe that gradually tapers toward the end, with smaller diameter branches extending perpendicularly to the sides. The ends of the branches are curved downward and end with a distribution end in the form of an air shower head. Each shower is located above a group of machines. The air outflow rate from the nozzles is variable and is regulated by a common damper installed at the beginning of the duct.

The microclimate in the calf house during the transitional (spring) period of 1973 was maintained at 14-17°C, relative humidity - 78-84%, ammonia concentration - 0.007-0.012 milligrams/l, air velocity in the area where the animals were kept was 0.26-0.33 m/s. In the summer, when the outside temperature rises, the air velocity supplied to the animals from above should be increased.

For a long time, some agricultural enterprises have not been able to achieve a normal microclimate in the calf dispensary. In order to prevent the spread of diseases, the dispensary was divided into separate sections with individual cages for calves. However, these cages make it difficult for the animals to get even airflow. The air temperature in the area where the calves were kept was 4-5°C C, and 6-7°C C below normal under the cages. Relative humidity reached 95% at a normal rate of 75%, ammonia content was 0.02 milligrams and above, and air movement was virtually absent.

In this regard, the issue of improving the microclimate in the sections of the preventive period arose. Therefore, a combined ventilation system was proposed.

Conventional air supply systems require a high air outlet velocity from the openings to maintain the required air velocity in the animal area, especially during warm periods of the year, as well as the required amount of heat (in winter) or cold (in summer). Therefore, in addition to the usually used central system for supplying fresh air to all sections, we proposed additional circulation of fresh air in each section of the dispensary through the use of ceiling fans with adjustable speed and capacity. These fans make it possible to evenly distribute fresh air vertically, sending it inside each cell without an additional network of overhead ducts and increasing the power of the outdoor air intake fan.

Ceiling fans can be used to control the speed and direction of air flow in the animal area depending on the season, age and condition of the animals, eliminate stagnant "dead zones" in certain parts of the building and pens, improve heat transfer in calves, reduce the amount of heat consumed by electric heaters, and this is an energy-saving measure to improve the efficiency of animal husbandry.

The preventive clinic is adjacent to the maternity ward and consists of three isolated sections measuring 6x12 meters each. Each section contains 20-30 calf cages.

The air duct system consists of a supply air ventilation and heating unit (fan motor power - 2.2 kW, total power of the electric heater sections - 40 kW; the supply of outside air is evenly distributed through the air duct; under-ceiling circulation fans, two in each room (electric motor power of one fan is 75 W); centrifugal fan with a 2.2 kW electric motor, which works for removal with lower channels; installations of ICUF with infrared and ultraviolet irradiators.

The top-down ventilation of the rooms using circulation fans is carried out as follows. Fresh air is sucked in by a single centrifugal supply fan for all rooms and evenly distributed through air ducts (air distributors) to the rooms. Ceiling fans located under the outlets of the main air ducts capture this air and, distributing it throughout the room, thereby creating the necessary air flow in all its parts. The exhaust air is removed through the lower ducts.

In the cold season, the supply air is heated by an electric heater, and the indoor air is additionally heated by the heat generated by the infrared lamps of the ICUF unit and water heating radiators. The air supply and exhaust ventilation performance is regulated by throttle flats.

The amount of heat generated by the electric heater is regulated by changing the number of switched-on sections in stages (manually or automatically). When the internal temperature is automatically regulated, signals are received from sensors installed in the preventorium.

The performance of the under-ceiling circulation fans, and therefore their rotation speed and the speed of the air flow from top to bottom, is regulated by changing the voltage supplied to their electric motors. Changing the supplied voltage is achieved with the help of a rheostat-type speed controller RS-5 supplied with the ceiling fan, which provides five speed levels. By using semiconductor voltage thyristor regulators, the fan speed can be changed smoothly.

The lamps of the ICUF unit for additional infrared heating and ultraviolet irradiation of calves are automatically turned on and off periodically at a set time.

Based on the research, it can be concluded that the use of the proposed ventilation system has significantly improved the microclimate in the dispensary of the milk production enterprise. Thus, the ammonia content in the air of the dispensary decreased by 2 times, and the relative humidity decreased by 20-25%. The air temperature in the area where the animals are kept was 17°C, and under the cage was not lower than 16°C. The temperature difference between the floor and the ceiling did not exceed 1 -1.5°C.

The use of ceiling fans reduced the power of the electric heater by 20-30% compared to a conventional centralized system of uniform air supply due to the vertical alignment of temperature fields. There is a uniform air movement in the cages with a speed of up to 0.1 m/sec. when supply and exhaust ventilation is turned on, and up to 0.3 m/sec. when using additional ceiling fans at low speeds. If necessary, the air speed can be increased by adjusting the speed of the ceiling fans.

Thus, the measures presented to create a microclimate in calf dispensaries indicate an energy-saving approach to calf rearing.

Scientists have long proved that if the indoor temperature is low and the air humidity is high, cows' milk production decreases by 10-15%, and average daily weight gain during fattening by 7-12%. Conversely, keeping fattening cattle at an optimum temperature of 16-20°C and relative humidity of 60-75% allows for 13-22% higher weight gain and 18-20% lower feed costs per 1 kg of live weight gain. At this temperature and humidity, animals get less sick.

The better the microclimate in the premises, the higher the production performance. This can be seen on the example of a pig farm where electric heaters are installed in the premises, and the premises are clean and dry. And where manure is removed using an energy-saving method and a self-compacting system, microclimate indicators are monitored twice or thrice a week: temperature, humidity, and gas composition of the air. In case of deviations from the optimal parameters, urgent measures are taken to eliminate them. For example, to reduce air humidity in the aisles of the livestock building, it is sprinkled with a mixture of quicklime and sawdust (1:3) at night. All this is energy-saving in creating an energy-saving microclimate for animals.

This is due to the good microclimate in the premises, scientifically based feeding, and animal husbandry. The average daily weight gain of young animals under four months of age exceeds 800 grams.

To maintain an optimal microclimate, livestock enterprises successfully use forced electric air ventilation and automatic temperature control according to a set mode. Steam or water heaters, heat generators, and electric heaters are used to heat the supply air.

The use of heating units of the Klimat series (Klimat 44, 45, 47), as well as supply and exhaust units PVU-4, which allow air heating by supplying and using part of the biological heat released by the animals themselves.

To ensure the optimal temperature and humidity conditions in the premises, it is advisable to use infrared radiation lamps such as IKZ-220-500, IKZK-220-250, IKO-2, KI-1000, as well as "dark" infrared emitters of the OKB-1376A brand. Ultraviolet irradiation gives good results.

For example, when using mercury-quartz lamps in the air, the number of microorganisms decreases by 5.7 times, and relative humidity - by 7.1%. The use of ultraviolet rays in calf houses has reduced the waste of young animals by 8%. The general condition of animals improves, and their resistance to various diseases increases.

Ultraviolet irradiation is one of the most effective ways to prevent rickets, osteomalacia and other animal diseases associated with impaired calcium and phosphorus metabolism in the body, which allows normalizing the microclimate in livestock facilities.

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***Анотація*** *Формування комфортного мікроклімату залежить від забезпечення тварин мікрокліматом у відповідності зони термічної нейтральності тварин, що забезпечується енергоощадними огороджуючими конструкціями тваринницьких приміщень, теплозахистом огороджуючих конструкцій та обладнанням енергоощадних повітропроводами, системи* *регулювання мікроклімату, використання автоматичного керування, використанням кондиціонування та рециркулювання повітря, забезпеченням параметрів мікроклімату для тварин та автоматизацією управління сільськогосподарських підприємств.*

***Ключові слова:*** *енергоефективність, мікроклімат, утримання, корови, скотарство*