

Lighting Dairy Facilities

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Introduction

Light is an important environmental characteristic in dairy facilities. Proper lighting can improve cow performance and provide a safer and more pleasant work environment. Dairy cows given 16 hours of light continuously each day (16L) will increase milk production from 5 to 16% (8% being typical), increase feed intake about 6%, and maintain reproductive performance, compared to cows receiving 13.5 hours or less of light (Peters et al., 1978, 1981; Piva et al., 1992). This cow response to 16L is not immediate. A response can take two to four weeks or longer to develop (Tucker, 1992; Dahl et al., 1997) assuming that nutrition and other management conditions are acceptable.

Enhanced lighting for the milking herd is profitable (Dahl et al., 1997; Chastain and Hiatt, 1998). The increased milk production generates a payback of less than one year considering initial, installation, operating, and replacement costs of the lights, and the increased feed intake (Chastain and Hiatt, 1998).

In addition, many producers report that increased and better quality light improves cow movement, observation, and care. Cows move more easily through uniformly lit entrances and exits. Herdsmen, veterinarians, and other animal care workers often report easier and better cow observation and care. This means that sick cows can be more quickly spotted and treated. Workers also report that a well-lit area is a more pleasant work environment. Increased cow performance and well being and better working conditions make lighting an important environmental characteristic in a dairy facility.

The purpose of this article is to describe current lighting recommendations for dairy facilities. This article focuses on freestall barns and cow-occupied areas in milking centers.

Lighting System Performance

Key lighting-system performance characteristics for dairy facilities are: light intensity or illumination level, photoperiod or duration, color characteristics, and uniformity. The lighting equipment installed should be selected and installed to meet the performance recommendations described.

Illumination Levels

Illumination levels are measured using a light meter. Light intensity is expressed in foot-candles (fc), which have units of lumens per square foot. Lumens are the amount of light put out by a light source. In the metric system, illumination level is expressed in terms of lux, where 1 fc equals 10.76 lux. The relation between lumen output from a single light

or bank of lights and the illumination level below depends on many factors, but distance between the light and the illuminated area is one of the most important.

Table 1 lists recommended illumination levels for different areas in a dairy facility. Excessive lighting is uneconomical and wastes energy. No minimum effective illumination level has been determined for cows, but responses have been observed at levels as low as 10 to 12 fc (Tucker, 1992).

Table 1. Recommended illumination levels (ASAE, 1997).

Work Area or Task	Illumination Level (foot-candles)																
Freestall feeding area	20																
Housing and resting area	10																
Holding area	10																
Treatment and maternity areas																	
General lighting	20																
Surgery	100																
Milking parlor																	
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	General lighting																
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	Loading platform																
	20																
	50																
	100																
	20																
Utility or equipment room	20																
Storage room	10																
Office	50																

Photoperiod

Sixteen to 18 hours of continuous light (16L to 18L) followed by six to eight hours of darkness (6D to 8D) each day is recommended for dairy cows. Twenty-four hours of continuous light each day does not provide additional milk yield response compared to 16L:8D (Dahl et al., 1998). It is a challenge to provide a six to eight hour period of continuous darkness in operations that milk three times a day (3X). Darkness is not defined, but levels around 2 to 3 fc are expected to suffice.

The extended light period can be controlled with a timer and a photocell in series or a timer alone (Chastain and Hiatt, 1998). The timer and photocell in series is the most energy efficient. The timer turns the lights on and off at set times, while the photocell overrides the timer (turns the lights off) when there is sufficient natural sunlight. Chastain and Hiatt (1998) recommend that the photocell be located under the eave on the northwest corner of the freestall barn. The photocell needs to be shielded from both interior and exterior lighting to work properly. Two-phase timers allow for a manual

override. A timer alone can be used to turn the lights on and off to provide 16 to 18 hours of light. In this case the lights are on even if there is plenty of sunshine.

In work areas, light switches can be used to manually turn lights on and off as needed. Motion detectors can be used to automatically turn lights off when no one is working in an area (i.e., office, and equipment room) to save energy.

Color Characteristics

Sunlight is made up of light at different wavelengths that produce different colors (i.e., rainbows). The color characteristic temperature (CCT) and color rendition index (CRI) are used to describe color characteristics of artificial lights. The CCT describes the color of the light using a Kelvin temperature scale that ranges from 1,500 to 6,500 degrees K. Lights with CCT values closer to 6,500 K produce a whiter light that more closely approximates sunshine.

The CRI indicates a light’s ability to render the true color of an object. CRI values range from 0 to 100. Lights with higher CRI values produce light that renders a truer color. Lights with lower CRI values produce some color distortion.

Table 2. Color characteristic temperature and color rendition index values for common lights.

Lamp Type	Color Characteristic Temperature (deg K)	Color Rendition Index
Incandescent	2,500-3,000	100
Halogen	3,000-3,500	100
Fluorescent	3,500-5,000	70-95
High Intensity Discharge		
Mercury Vapor	n/a	20-60
Metal Halide	3,700-5,000	60-80
High Pressure Sodium	2,000-2,700	n/a

Uniformity

Required illumination uniformity in dairy facilities is not well established. Uniformity is more critical for visually difficult tasks or intense work areas. ASAE (1997) defines uniformity as the ratio of the maximum illumination level (fc) to the minimum fc value. Satisfactory uniformity ratios range from 1.5:1 for visually difficult tasks to 5:1 for less difficult tasks (ASAE, 1997). Professionals in the field suggest that cow movement and performance is better if light illumination levels along the feed bunk or manger area and cow walkways are closer to the 1.5:1 ratio. Illumination uniformity generally increases by installing more lights and decreasing the separation distance between lights. Some non-

uniformity is acceptable because installing an excessive number of lights is too expensive.

Uniform light levels along the feed bunk in a freestall barn are more important than uniform levels from the feed bunk to the freestalls. Twenty fc of light along the feed bunk and lower levels, down to 6 or 7 fc along the outside walls at night, are acceptable light levels in naturally ventilated freestall barns. Twenty fc of light is not needed in the outside alleys or freestalls. The feed bunk and freestall areas serve different functions and can have different light levels.

Common Light Characteristics

Table 3 lists general characteristics of common light sources used in dairy facilities. New dairy facilities are typically using fluorescent and either metal halide or high-pressure sodium lights to provide most of the general-purpose lighting. Halogen lamps are used for spot lighting.

Table 3. General characteristics of common light sources.

Lamp Type	Lamp Sizes (watt)	Efficiency (lumens/watt)	Typical Lamp Life (hours)
Incandescent	60-200	15-20	750-1,000
Halogen	50-150	18-25	2,000-3,000
Fluorescent (ballast)			
T-12 (electromagnetic)	34	66	20,000
T-8 (electronic)	32	98	20,000
T-8 HLO (electronic)	32	92	24,000
High Intensity Discharge			
Mercury Vapor	50-250	40-50	16,000-24,000
Metal Halide	75-400	80-92	15,000-20,000
High Pressure Sodium	100-400	90-110	15,000-24,000

Fluorescent Lights

Standard 32-watt T-8 fluorescent lights are generally used when they can be placed seven to eight feet above the lighted area. High-light-output (HLO) 32-watt T-8 fluorescent lights are used if the lights must be placed higher, up to 14 feet above the lighted area. Compact fluorescent lights can be used to replace incandescent lights when the existing fixture meets the National Electric Code safety requirements for livestock buildings, but

tube fluorescent lights provide the best life cycle cost option for new construction (Chastain and Hiatt, 1998).

Fluorescent bulbs come in different diameters. T-8 bulbs are 1 inch in diameter while T-12 bulbs are 1.5 inches in diameter. T-8 lamps are recommended over the older T-12 lamps because T-8s are more energy efficient.

The color characteristic temperature of fluorescent lights depends on the bulb installed in the light. The last two digits in the bulb number indicate the CCT of a fluorescent bulb. For example, a fluorescent bulb with the number F32 T8 SP41 means that it is a 32-watt fluorescent T-8 (1-inch diameter) bulb with a CCT of 4,100 K.

Fluorescent lights have ballasts that start and keep the bulbs lit. Electronic ballasts are recommended because they are more energy efficient, generate less heat, have a longer life expectancy, and operate and start at colder temperatures (0° F) than other ballasts. Fluorescent bulbs also last longer when electronic ballasts are used. Magnetic and electromagnetic ballasts are not recommended. They generate more waste heat, can hum or click, and cause light flickering at cold temperatures. Magnetic ballasts have operating and starting problems at temperatures of 50°F and below. They can also produce harmonic distortions, which can affect electronic equipment (i.e., computers). Electromagnetic ballasts have operating and starting problems at temperatures of 40°F and below.

High light output (HLO) fluorescent fixtures are available with electronic ballasts. HLO lights generally put out 33% more light with only an 8% increase in energy usage. They are more expensive, approximately 20%, and are generally used only when either extra lumens are needed or the fluorescent lamps need to be mounted 8 to 14 ft above the lighted area.

High Intensity Discharge Lights

Metal halide, high pressure sodium, and mercury vapor lights are part of a group of long lasting high intensity discharge lights that put out large amounts of lumens. They are used to light large areas.

Metal halide lights put out a fairly white light with a CCT value up to 5,000 K and CRI values up to 80%. Their use in dairy facilities is growing.

High-pressure sodium lights put out a gold or yellowish light with a CCT value up to 2,700 K and CRI values up to 60%. Professionals in the field report that red is not clearly distinguishable from brown under high-pressure sodium lights. This means that bloody discharges may not be recognizable under high-pressure sodium lights. Other than the problem with distinguishing red, the color rendition index of high-pressure sodium lights is acceptable for use in dairy facilities.

Mercury vapor lights give off a bluish light and have been commonly used as yard lights. They are not recommended for use in dairy facilities because the mercury in burned-out lights can be an environmental hazard and the CRI values are lower than other options.

Mounting Height and Separation Distances

Distance is the enemy of light. Illumination levels decrease rapidly with increasing distance from the light source. Both the mounting height and separation distance between evenly distributed lights affect the average illumination level (i.e., fc). Excessively high mounting heights waste light by dispersing it over too large of an area. Excessive separation distances decrease illumination uniformity. Table 4 lists some typical mounting heights for select lights that produce an average illumination level of 20 fc. The values for the 250-W and 400-W metal halide lamps work well in typical four-row and six-row barns (96 to 1120-ft wide) with 12-ft sidewalls and 4:12 roof slopes. A rule-of-thumb is to have separation distances between 1.2 and 1.7 times the mounting height.

Table 4. Typical mounting heights and horizontal separation distances to produce illumination level of 20 fc.

Lamp Type	Mounting Heights (ft)	Separation Distances (ft)
Standard Fluorescent (32 W, T-8)	7-8	10-16
HLO Fluorescent (32 W, T-8)	9-12	12-20
Metal Halide		
175 W	11-14	24-28
250 W*	14-24	24-30
400 W*	20-35	25-40

* Typical for 96-112 ft wide freestall barns with 12 ft sidewalls and 4:12 roof slope

Locate and mount lights to minimize shadows. Cows often stop to investigate shadows and dark areas around corners and exits and entrances before proceeding, which slows cow flow. In freestall barns with trusses, mount lights at or below the bottom chord so that the trusses do not block light from reaching the feed bunk and freestall areas. In milking parlors and stall barns, mount fluorescent lights below structural members and other equipment to minimize shadows.

Consider installing extra light fixtures, protected compact fluorescent lights, at waterers and leaving these lights on continuously (24 hours/day) to encourage drinking during both light and dark periods.

Some of the factors generally not considered in lighting system design include building surface reflectivity, light loss due to dust and dirt accumulation, and decreased light output with increasing usage. Prompt light replacement and periodic cleaning will minimize light loss over time.

Additional lighting design information for dairy facilities is available on the World Wide Web at www.bae.umn.edu/extens/. Two publications by Chastain and Nicolai (1996a, 1996b) are available on the web site. The Electric Power Research Institute (EPRI) also has a publication (Chastain and Hiatt, 1998) on lighting. Very detailed lighting design information is available in an Illuminating Engineering Society (IES) handbook (Kaufman and Christensen, 1984).

Safety and Electrical Codes

Lights installed in dairy barns should meet National Electric Code (NEC) requirements (NFPA 70, 1996) for use in agricultural buildings. Be sure to follow all applicable state electrical codes, too. Use UL-approved fixtures, not UL-listed fixtures. Dairy barns are damp and dusty, so lights should be watertight and constructed of corrosion resistant materials (Article 547). Wiring in dairy facilities should also meet NEC requirements for agricultural buildings (Article 547). To minimize the potential for fire and stray voltage, a knowledgeable and qualified electrician should do all wiring.

Conclusion

Many factors affect lighting-system performance. This article discussed some of the key factors for planning a lighting system for dairy facilities. An experienced lighting professional can help design a safe, economical, and effective lighting system.

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References

- ASAE. 1997. Lighting for dairy farms and the poultry industry. EP344.2. *ASAE Standards*. ASAE, St. Joseph, MI 49085-9659. Pp. 636-639.
- Chastain, J. P. and R. S. Hiatt. 1998. Supplemental lighting for dairy milk production. National Food and Energy Council, Columbia, MO 65203. Pp. 20.
- Chastain, J. P. and R. Nicolai. 1996a. Dairy lighting system for tie stall barns. AEU-13, Department of Biosystems and Agricultural Engineering, University of Minnesota, St. Paul, MN 55108.
- Chastain, J. P. and R. Nicolai. 1996b. Dairy lighting system for free stall barns and milking centers. AEU-12. Department of Biosystems and Agricultural Engineering, University of Minnesota, St. Paul, MN 55108.
- Dahl, G. E., J. P. Chastain, and R. R. Peters. 1998. Manipulation of photoperiod to increase milk production in cattle: biological, economical and practical considerations.

In: *Proc. Fourth Int. Dairy Housing Conf.*, ASAE, St. Joseph, MI 49085-9659. Pp. 259-265.

Dahl, G. E., T. H. Elsasser, A. V. Capuco, R. A. Erdman, and R. R. Peters. 1997 Effects of long day photoperiod on milk yield and circulating insulin-like growth factor-I. *J. Dairy Sci.* 80:2784-2789.

Kaufman, J. E. and J. F. Christensen. 1984. *IES Lighting Handbook*. Illuminating Engineering Society of North America, New York.

NFPA 70. 1996. National Electric Code. National Fire Protection Assoc. Batterymarch Park, Quincy, MA 02269.

Peters, R. R., L. T. Chapin, K. B. Leining, and H.A. Tucker. 1978. Supplemental lighting stimulates growth and lactation in cattle. *Science* 199:911-912.

Peters, R. R., L. T. Chapin, R. S. Emery, and H.A. Tucker. 1981. Milk yield, feed intake, prolactin, growth hormone, and glucocorticoid response of cows to supplemental light. *J. Dairy Sci.* 64:1671-1678.

Piva, G., P. Navarotto, G. Fusconi, and S. Repetti. 1992. Effect of photoperiod on milk production and composition of dairy cows. *J. Animal Sci.* (Suppl. 1): 165.

Tucker, H. A. 1992. Manipulation of photoperiod to improve lactation, growth, and reproduction. IN: *Large Dairy Herd Management*, H. H. Van Horn and C. J. Wilcox, ed. Amer. Dairy Sci. Assoc., Champaign, IL. Pp. 146-152.

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