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METHODS FOR TESTING AND EVALUATING ARTIFICIAL LIGHTING PARAMETERS IN ROOMS

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Abstract. Proper lighting is an important environmental factor affecting human health, visual performance and safety. This article reviews artificial light sources and lighting systems, the main physical parameters of lighting (illuminance, luminous flux, luminance, color temperature and uniformity), instruments and procedures for measuring illuminance with a lux meter, the criteria of hygienic assessment, the effects of lighting on health and work capacity, requirements for different types of rooms, and common lighting deficiencies with ways of eliminating them. It is emphasized that the assessment cannot be based on lamp power alone: measured values at the working surface must be compared with the sanitary and building standards in force, and qualitative characteristics such as glare, flicker and color rendering must also be considered.

Keywords: artificial lighting, illuminance, lux meter, hygienic assessment, glare, flicker, color rendering, communal hygiene.

INTRODUCTION

Lighting is one of the important environmental factors affecting human life, health and activity. People receive most of the information about their surroundings through vision. Therefore, proper organization of lighting in dwellings, classrooms, laboratories, hospitals and industrial buildings is of great importance. When light is insufficient, distinguishing objects, reading text and performing fine work become difficult. Excessively bright or dazzling light, on the other hand, may increase visual discomfort.

Natural light is an important source during the day, but its amount varies with the weather, season, time of day, orientation of windows and the structure of the building. Therefore, artificial lighting, produced by lamps and luminaires powered by electricity, is used where natural light is insufficient. Its hygienically correct organization helps to reduce eye strain, to make educational and work activity more comfortable and to increase safety.

Hygienic assessment of the artificial lighting of rooms is the process of measuring the level and quality of lighting, comparing the results with the sanitary and building standards in force, and identifying existing deficiencies. It takes into account not only lamp power but also the amount of light reaching the working surface, uniformity of its distribution, glare, color rendering and flicker.

Hygienically, artificial lighting matters in several ways. It facilitates visual work and helps to distinguish the shape, color and details of objects; it makes it easier to concentrate and to perform tasks accurately; it improves the safety of movement on stairs, corridors and industrial areas; and in medical institutions it is necessary for patient examination, procedures and laboratory work. Insufficient lighting may lead to eye strain, reduced work speed and more errors, while excessive light, direct exposure of the eye to the source, or reflections from glossy surfaces also

cause discomfort. Therefore, in hygienic assessment, the quality of light is studied together with its quantity.

Aim of the study: to systematize the methods of testing and hygienic evaluation of artificial lighting parameters in rooms.

Objectives: (1) to describe artificial light sources and lighting systems; (2) to define the main physical parameters of lighting; (3) to present the instruments, procedure and calculations used in measuring illuminance; (4) to outline the criteria of hygienic assessment and the requirements for different rooms; (5) to describe typical lighting deficiencies and measures for their elimination.

MATERIALS AND METHODS

This work is a theoretical and analytical review based on educational literature on hygiene, medical ecology and communal hygiene, and on the analysis of sanitary rules and building standards concerning lighting. The data were processed by content analysis, comparison and systematization.

Instrument

Illuminance is measured directly with a lux meter. A lux meter usually consists of a light-sensitive sensor and a display. The sensor receives the light falling on a surface and shows the result in lux. Before use, the condition of the device and the manufacturer's instructions are checked.

Measurement procedure

The procedure consists of five stages:

1. The room and the working surface are identified. The type of room, the work performed, and the number and arrangement of luminaires are recorded.
2. The lighting system is switched on under normal working conditions. Where the light of a lamp needs to stabilize, the appropriate time is allowed to pass before measuring.
3. The lux meter sensor is placed on the surface being measured, for example, on a desk in a classroom or on the table where analyses are performed in a laboratory, and the reading is recorded.
4. The measurement is repeated at other designated points of the room: the center, the edges, the workplaces and, if necessary, the relatively dark points.
5. The results are analyzed and compared with the standard requirements.

Measurements must be taken not at a single point but in different parts of the room. The sensor must not be shadowed or covered by the hand, and the same conditions must be maintained during measurement. The results are entered in a table.

Calculations

Illuminance is the amount of luminous flux falling on a unit area and is measured in lux (lx):

$$E = \Phi / S,$$

where E is illuminance, Φ is luminous flux (lumen, lm) and S is the illuminated area (m^2).

From values obtained at several points, the average illuminance can be calculated as:

$$E_{avg} = (E_1 + E_2 + \ldots + E_n) / n,$$

where E1, E2, … En are the measurements at individual points and n is the number of measuring points.

Assessment criteria and documentation

The obtained illuminance values are compared with the sanitary rules, standards and building norms that correspond to the type of room and the nature of the work. It is not correct to set one common lux value for all rooms, because the needs of a corridor, a study desk, an operating room and a place where fine details are handled differ. The assessment takes into account illuminance at the working surface, uniformity, arrangement of luminaires, glare, shadows, flicker and color rendering. Measurements must be performed according to the established methodology, on the required plane and at the required points.

At the end of the inspection, the name of the room, the date of measurement, the instrument used, the measuring points and the illuminance value at each point are recorded. If necessary, the average is calculated, and the results are compared with the norms applicable to the room type and the work. In drawing conclusions, the measurement conditions, the technical condition of the luminaires and the uniformity of light are also considered.

RESULTS

Artificial light sources and lighting systems

Artificial light sources differ in construction, energy consumption, service life and light characteristics (Table 1).

Table 1

Main types of artificial light sources

Lamp type	Principle and features	Limitations
Incandescent	A tungsten filament heated by electric current emits light; warm-colored light, good color rendering	Converts most electrical energy into heat; low energy efficiency compared with many modern lamps
Fluorescent	Ultraviolet radiation from an electric discharge is converted into visible light by a special coating; long used for lighting large rooms	Flicker in some models; contains mercury, so broken lamps must be collected and disposed of properly
LED	Semiconductor-based; usually energy-efficient, long-lived, available in various color temperatures	Quality depends on the driver, optics and manufacturing; poor devices may flicker or cause glare

By purpose, lighting systems are divided into general, local and combined. General lighting distributes light throughout the room; local lighting illuminates a particular workplace; combined lighting uses both together. In addition, emergency lighting serves to maintain safety when the main lighting fails, and evacuation lighting directs people to safe exits.

Main physical parameters of lighting

Illuminance, expressed in lux, is the most important parameter. For example, if a luminous flux of 1000 lumens were ideally and uniformly distributed over an area of 10 m², the theoretical illuminance would be 100 lux. In practice, the result is affected by the decrease of light with distance, the direction of the lamp, the reflection of light from walls and ceilings, and the optical properties of the luminaire.

Luminous flux, measured in lumens (lm), expresses the amount of visible light emitted by a source. Luminance describes how bright a light source or illuminated surface appears in a given direction and is expressed in candelas per square meter (cd/m²); excessive luminance may cause glare.

Color temperature is measured in kelvins (K) and expresses the warm or cool tone of light. Approximately 2700–3000 K corresponds to warm white, 3500–4500 K to neutral white and 5000–6500 K to cooler white light. Color temperature is not the same as the amount of illuminance: lamps of different color temperatures can produce the same lux level.

Uniform distribution of light is also important. If one part of the room is very bright and another dark, the eye has to adapt frequently to different lighting conditions and discomfort may appear. In addition, the flicker of the source, its color rendering property and the degree of glare are evaluated.

Influence of lighting on health and work capacity

Lighting conditions affect the functioning of the visual system and everyday activity. Sufficient light makes it easier to distinguish details, creates comfort when reading and writing, and reduces the probability of some errors at work. This is especially important for students who read for long periods, employees who work with computers, laboratory specialists and medical staff.

Insufficient lighting may strain the eyes, make the working posture uncomfortable and make it harder to maintain attention. Dazzling light, reflections from glossy surfaces or sharp shadows also adversely affect work quality, and noticeable flicker of some lamps may cause discomfort. In medical institutions, lighting suited to the task is needed for examining patients, preparing medicines, completing documents and laboratory tests, while excessive brightness and uncomfortable reflections should be avoided in rooms where patients rest.

Requirements for different rooms

Classrooms. Light must fall on desks and writing surfaces sufficiently and uniformly. Luminaires are arranged so that students are not exposed to dazzling direct light or strong reflections when looking at the board or notebook. A desk lamp should be placed so that the shadow of the writing hand does not fall on the text.

Laboratories. Lighting must suit the type of analysis. Where sample color or fine marks must be seen, luminaires with correct color rendering and uniform light are important. Illuminance at the work surface is checked against the established requirements.

Hospitals. The purpose of each room is taken into account: procedure and examination rooms need sufficient lighting for work, while rooms where patients rest need comfort and absence of glare.

Industrial enterprises. The lighting level is determined according to the precision of the work, hazards and production conditions.

Corridors and stairs. Continuous and sufficient lighting is necessary for safe movement.

Typical deficiencies and their elimination

Several deficiencies may be encountered in practice (Table 2).

Table 2

Typical lighting deficiencies, causes and corrective measures

Deficiency	Possible causes	Corrective measures
Insufficient illuminance	Too few lamps, wrong choice of power or luminous flux, aged lamps, dusty luminaires	Review the lighting system; install additional luminaires; replace lamps; clean luminaires
Uneven light distribution	Incorrect spacing or placement of luminaires	Reposition luminaires; take measurements at several points
Glare and reflections	Lamp within the field of view; light reflected from glossy desks, screens or other surfaces	Relocate the luminaire; use a protective shade; change the position of the work surface
Flicker or faulty lamps	Defective lamp, control device or power supply	Check the lamp, control device and power supply; replace faulty lamps; clean luminaires regularly; carry out periodic instrumental checks

The measured values are also influenced by aging of lamps, dust on luminaires, the color of walls and ceilings, incorrect placement of lamps and changes in the power supply. Therefore, the real condition of the room is checked together with the measurement.

Example of calculation

Suppose illuminance in an auditorium is measured at three points as 300, 350 and 400 lux. The average illuminance is (300 + 350 + 400) / 3 = 350 lux.

DISCUSSION

The results show that the hygienic assessment of lighting cannot rely on a single number. First, the average value does not automatically mean that all points comply with the standard. In the example above, 350 lux is the mean, but if some workplaces have low illuminance, they must be assessed separately and the cause determined. Likewise, if in a classroom illuminance is sufficient on part of the desks and low on the others, the room cannot be assessed as fully compliant based on the average alone; problem areas should be identified and the placement or number of luminaires changed.

Second, conclusions cannot be drawn from lamp electrical power or the luminous flux printed on the package. The light that actually reaches the working surface depends on the placement of luminaires, reflection from room surfaces, dust and the technical state of the lighting system.

Third, although lux meter measurement is the main quantitative method, a full evaluation of qualitative characteristics such as glare, color rendering and flicker may require other methods or special instruments. Therefore, a quantitative result should be supplemented by an inspection of these qualitative parameters.

Finally, after any change in the lighting system, repeated measurement is advisable to confirm the effect of the corrective measures. Such an approach helps to assess lighting conditions objectively and on a sound basis. A limitation of this work is that it is a review and does not present independent measurement data; practical measurements in specific rooms would be a useful direction for future research.

CONCLUSION

Testing and hygienic assessment of the artificial lighting of rooms is one of the important areas of communal hygiene. Correctly organized lighting creates comfortable conditions for visual activity, supports reading and work productivity and helps prevent some hazards. The lux meter is the main instrument for measuring illuminance. Measurements are taken at several points of the room and on the relevant working surfaces, and the results are compared with the sanitary and building standards in force.

In hygienic assessment, together with the amount of illuminance, the uniformity of light, glare, flicker, color rendering and the technical condition of luminaires are also considered. When deficiencies are found, measures such as cleaning or replacing lamps, repositioning luminaires and organizing additional local lighting are taken. Thus, regular inspection and correct hygienic assessment contribute to a healthy, comfortable and safe environment in rooms.

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