ISA Recommendation

LED Lighting System for Classrooms - Product Requirements and Testing Methods

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International Solid State Lighting Alliance

Technical Committee on Standardization

This ISA Recommendation was prepared by ISA Technical Committee on Standardization, Working Group 15: "LED Lighting System for Classrooms - Product Requirements and Testing Methods"

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Foreword

International Solid State Alliance (ISA) is an international, not-for-profit organization aiming to promote the sustainable development and application of Solid State Lighting (SSL) worldwide, consisting of numerous cooperate members in the SSL industry as well as research organizations worldwide.

ISA Recommendations provide useful methods in lighting practice or technical specifications of products recommended by the ISA, for standardization purposes especially for areas not covered by the current international standards, and thus are proposed for consideration for use in future international standards or regional standards.

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LED Lighting System for Classrooms - Product Requirements and Testing Methods

1 Introduction

The standard specifies product requirements and testing requirements for classroom LED lighting system, including terms and definitions, basic requirements, product visual comfort index (VICO) testing requirements, photobiological safety requirements, maintenance and test methods of equipments.

2 Scope

The standard applies to LED lighting lamp and lighting systems in indoor education place.

3 Normative References

The terms in the following documents are referred to be part of this standard. For dated references, their subsequent revisions are all inapplicable to this standard. For undated references, their latest editions apply to this standard.

ANSI/IES RP-3 American national standard practice on lighting for education facilities

CISPR 15:2015 Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

IEC 60050-845-1987 International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting

IEC 60598-1-2014 Luminaires – Part 1: General requirements and tests

IEC 60598-2-1:1979 Luminaires – Part 2-1: Particular requirements – Fixed general purpose luminaires

IEC 60598-2-2:1997 Luminaires – Part 2-2: Particular requirements – Recessed luminaires

IEC 61000-3-2:2001 Limits for harmonic current emission (equipment input current≦16A per phase)

IEC 61547:1995 Equipment for general lighting purposes - EMC immunity requirements

IEC 62471-2006 Photobiological safety of lamps and lamp systems

IEC/TR 62778:2014 Application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires

IEEE Std 1789-2015 IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers

ISA-S-0006-2016 Human Factor Testing on the Index of Healthy and Comfortable Lighting: Terms and Definitions

ISA-S-0011-2019 Human Factor Testing on the Index of Healthy and Comfortable Lighting - Test Method and Technical Requirements Based on Physiological Function of Human Eyes

ISO 8995-1-2002 Lighting of work places - Part 1: Indoor

ISO 8995-3-2006 Lighting of work places - Part 3: Lighting requirements for safety and security of outdoor work places

4 Terms and Definitions

The terms, definitions and abbreviations specified in IEC 60050-845-1987 are applicable to this standard.

4.1 illuminance (at a point of a surface)

E

quotient of the luminous flux dΦv incident on an element of the surface containing the point, by the area dA of that element

Equivalent definition. Integral, taken over the hemisphere visible from the given point, of the expression Lv • cos θ • dΩ where Lv is the luminance at the given point in the various directions of the incident elementary beams of solid angle dΩ, and θ is the angle between any of these beams and the normal to the surface at the given point

$$E_{\mathrm{v}} = \frac{\mathrm{d}\Phi_{\mathrm{v}}}{\mathrm{d}A} = \int_{2\pi \mathrm{sr}} L_{\mathrm{v}} \cdot \cos\theta \cdot \mathrm{d}\Omega$$

unit: $\mathrm{lx} = \mathrm{lm} \cdot \mathrm{m}^{-2}$

4.2 luminance (in a given direction, at a given point of a real or imaginary surface)

L

quantity defined by the formula

$$L_{\mathrm{v}} = \frac{\mathrm{d}\Phi_{\mathrm{v}}}{\mathrm{d}A \cdot \cos\theta \cdot \mathrm{d}\Omega}$$

where

dΦv is the luminous flux transmitted by an elementary beam passing through the given point and propagating in the solid angle dΩ containing the given direction;

dA is the area of a section of that beam containing the given point;

θ is the angle between the normal to that section and the direction of the beam

unit: $\mathrm{cd} \cdot \mathrm{m}^{-2} = \mathrm{lm} \cdot \mathrm{m}^{-2} \cdot \mathrm{sr}^{-1}$

4.3 modulation depth

PFD

The modulation depth is the ratio of the difference between the maximum and minimum of the optical output to the sum of the maximum and minimum of the optical output, expressed as a percentage.

4.4 visual comfort index; VICO

Visual Comfort Index (VICO) is an index to evaluate the effects of lighting products on the physiological function changes of human vision and visual fatigue based on visual optometry. Moreover, VICO Index is independent of the physical indexes of lighting products (color temperature, color rendering index, illuminance, luminance, stroboflash, etc.), and it reflects an objective and quantitative evaluation on the effects of lighting products to the physiological function of human vision completely from the perspective of visual function of human eyes. And it is mainly applied to evaluate the effects of lighting products on the visual fatigue of human eyes in visual optometry - axial length and corneal diopter.

4.5 axial length; AL

The length of a hypothetical line - the axis of the eye - from the median cornea to the optic nerve and the macular fovea of the retina.

Note: Generally, the length is 22-27 mm, with an average of 24 mm. Along this axis, the eyeball can rotate inward and outward.

4.6 keratometric diopter; KR

The radius of curvature of the anterior corneal surface.

4.7 ciliary's accommodation; ACC

That is to say, the refractive power of the eyes changes when they change their gaze at distant and near objects.

4.8 higher order aberrations; HOAs

A dot-like target does not form an ideal image through an optical system, but occurs an optical defect and forms a blurred diffuse spot. At this moment, the shape of the image is very similar to the object, but not exactly the same, and the difference between them is called aberration. If the order expansion of aberration is greater than or equal to 3, it is called high order aberration.

4.9 modulation transfer function; MTF

Modulation transfer function (MTF) is an optical function that evaluates the imaging quality of an optical system. And it reflects the attenuation degree of the amplitude of the sinusoidal intensity distribution function after passing through an optical system. That is, the change of image over modulation degree. When the modulation degree varies with the spatial frequency, it is called the modulation transfer function.

5 Lighting system classification

5.1 Classification

Lighting systems are classified relative to the way they emit light, such as an uplight (indirect) or a downlight (direct). Lighting systems can be indirect, semi-indirect, direct-indirect, general diffuse, semidirect and direct (see Figure 1). The light distribution curves may take many forms within the limits of the upward and downward distribution, depending on the light source and the luminaire design.

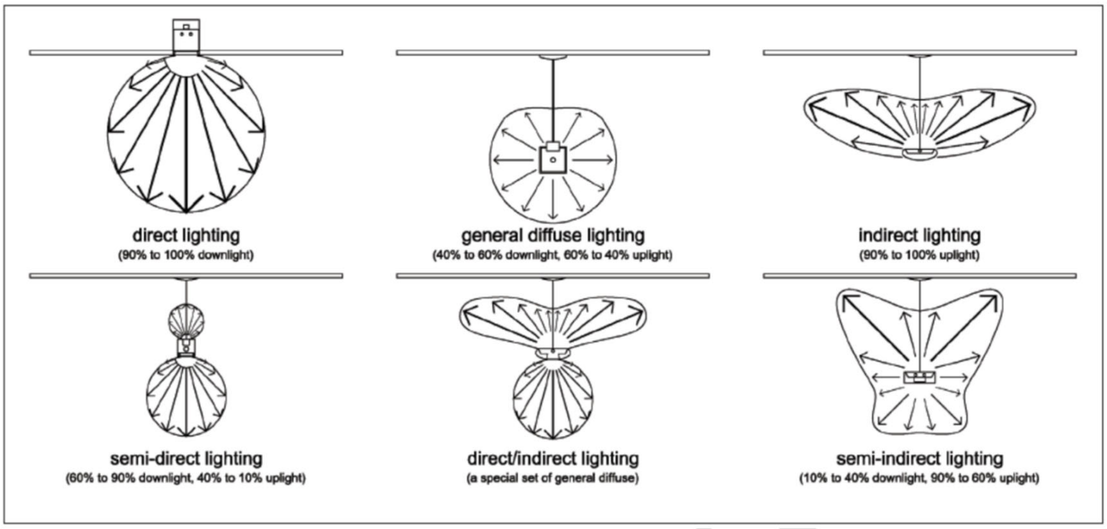


Fig. 1 Luminaires for general lighting are classified by the International Commission on Illumination inaccordance with the percentages of total luminaire output emitted above and below horizontal.

5.2 Light distribution of different types of Luminaires

5.2.1

Indirect: With an indirect system, 90- to 100-percent of the light from the luminaires is directed to the ceiling and upper walls, where it is reflected to all parts of the room.

5.2.2

Semi-Indirect: With a semi-indirect system, 60-90 percent of the light from the luminaire is directed upward while the rest is directed downward. This system uses the ceiling as the main source of illumination, and so the same considerations noted for indirect lighting should be observed regarding ceiling reflectance, surface finishes, and good maintenance.

5.2.3

Direct-Indirect: With a direct-indirect system, the light directed upward is about equal to the light directed downward (each is 40 to 60 percent of the total luminaire output - see Figure 1). The larger part of the task illumination will come from the downward directed light. Direct-indirect luminaires produce little light in directions near the horizontal to minimize direct glare. However, compared with indirect or semi-indirect lighting, reflected glare and veiling reflections are more
likely to occur and shadows may be more noticeable.

5.2.4

General Diffuse: With a general diffuse system, the upward/downward light distributions are the same as for the direct-indirect system, but light output near horizontal directions is unrestricted. Such luminaires may be used where illuminance requirements are moderate and a light, bright appearance is desired. They should not be used where high illuminances are required or when control of glare or veiling reflections
is needed

5.2.5

Semi-Direct: With a semi-direct system, 60 to 90 percent of the light is directed downward toward the horizontal work plane for more efficient utilization, while 10 to 40 percent, directed upward, illuminates the ceiling, increasing diffusion and reducing the luminance ratio between the luminaire and the ceiling.

5.2.6

Direct: With a direct system, almost all of the light is directed downward (for flush-mounted recessed luminaires, the downward proportion is 100 percent). With efficient optical and/or reflector design, these luminaires can achieve maximum performance. The luminous intensity distribution may be widespread or highly concentrated, depending on the reflector material, its finish and contour and the shielding or optical control media.

6 Basic requirement

6.1 Safety and EMC

The products applicable to this standard shall meet the requirements of IEC 60598-1-2014, IEC 60598-2-1:1979 or IEC 60598-2-2:1997, and their electromagnetic compatibility shall meet the requirements of IEC 61000-3-2:2001, IEC 61547:1995 and CISPR 15:2015.

6.2 Desktop horizontal-illumination

According to the 8.1 test method, the average illumination on horizontal desktop in the classroom should be 500lx – 750lx the horizontal reference height of the desk is 0.75m (the same below).

6.3 Desktop horizontal illumination uniformity

According to the 8.1.2 test method, the uniformity of illumination on the horizontal desktop in the classroom should be no less than 0.7.

6.4 Brightness in eye direction

According to the 8.1.3 9 point test method, the average luminance value of the 9 points class desktop center area should be no less than 80 cd/m^2, and the test height is 1.2m.

6.5 Uniformity of brightness in eye direction

According to the 8.1.3 9 point test method, the brightness uniformity of 9 points in the classroom should not be less than 0.7.

6.6 Blackboard illuminance and uniformity

The average illuminance on blackboard is between 500lx-1000lx, the uniformity should be no less than 0.7.

6.7 Color temperature

According to the 8.1.2 test method, 4000K -5300K color temperature light source should be used in the classroom. The color tolerance is less than 5.

Note: Non-cultural classrooms can adjust their color temperature requirements according to their visual work characteristics.

6.8 CRI

According to the 8.1.2 test method, the CRI of light source in classroom should be no less than 80.

6.9 Flicker

Refer to IEEE 1789-2015 8.1.1.

6.10 Glare

For direct lighting classroom, the glare value should be less than or equal to 16, the calculation method is based on ISO 8995-1-2002.
Non direct lighting classrooms do not adopt this indicator.

6.11 Initial luminous flux

The initial luminous flux of LED lamps should not be less than 90% of the rated value.

6.12 Efficiency of LED Lamps

The efficiency of blackboard lamp should not be lower than 70 lm/W, classroom lamp should not be lower than 80 lm/W, and should not be lower than the nominal value.

6.13 Input Power

When working under rated voltage and frequency, the deviation between measured input power and rated input power should not exceed 10%.

6.14 Power Factor

The nominal power factor of lamps and lanterns should not be less than 0.70. If the lamps and lanterns declare high power factor, it should be no less than 0.90. The measured power factor should not be 0.05 lower than the nominal power factor.

7 Product VICO test requirement

The Visual Comfort Index (VICO) should be tested according to ISA TCS-S-0006-2016 and ISA-S-0011-2019. The score should be less than 2.

8 Photo biosafety requirements

The assessment shall be conducted according to IEC 62471 and IEC / TR 62778. The danger group of the blue light of the general lighting lamps in the classroom is RG0.

9 Test Method

9.1 Testing of basic requirements

9.1.1 When testing the LED lighting system in classroom, the reflection ratio of each surface in classroom should conform to Table 1, and the reflection ratio of desktop should conform to Table 1. The influence of natural light should be eliminated by shading.

Table 1 Reflectance ratio of classroom surfaces.

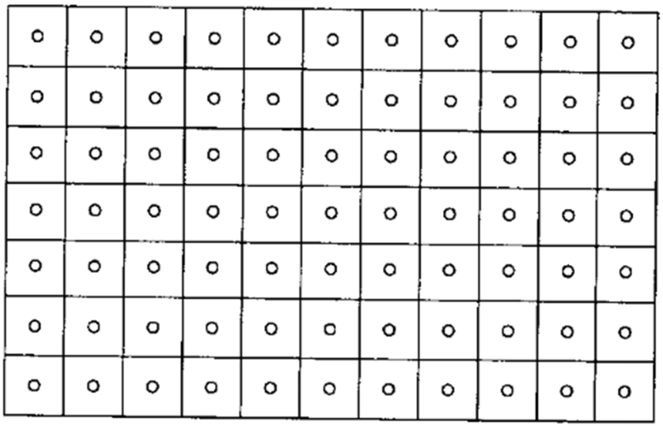
Surface name	Reflectance ratio	Surface name	Reflectance ratio
Ceiling	0.70～0.80	Side & back wall	0.70～0.80

Front wall	0.50～0.60	Desktop	0.25～0.45
Floor	0.20～0.40	Blackboard	0.15～0.20

9.1.2 Test of desktop horizontal illumination, desktop horizontal illumination uniformity, color temperature and color rendering index

9.1.2.1 Desktop horizontal illumination, desktop horizontal illumination uniformity should be tested according to Central point method.

In the area of illuminance measurement, the measurement area is generally divided into rectangular grids, and the grid should be square. The illuminance should be measured at the center of the rectangular grid, as shown in Figure 2.



o--- Test point

Fig. 2 Schematic diagram of point arrangement in the center of grid

The average illuminance of the central point arrangement method is calculated according to the formula (1)

$$E_{av} = \frac{1}{M \times N} \sum E_i \quad \cdots\cdots (1)$$

In this formula

E_{av} ———— is the average illuminance,unit: lx;

E_i ———— is the illuminance at test point i, unit: lx

M ————is the longitudinal measuring points

N ———— is the horizontal measuring points

Illuminance uniformity is calculated according to formula (2):

$$U_2 = \frac{E_{min}}{E_{av}} \quad \cdots\cdots (2)$$

In this formula

U_2 ————Illuminance uniformity (Mean deviation)

E_{min} ————Minimum illumination

E_{av} ————Average illumination

9.1.2.2 Spectral radiometer shall be used for the measurement of color temperature and color rendering index on site. The number of measurement points on each site shall not be less than 9, and then the arithmetic mean value shall be calculated as the color temperature and color rendering index of the tested lighting site.

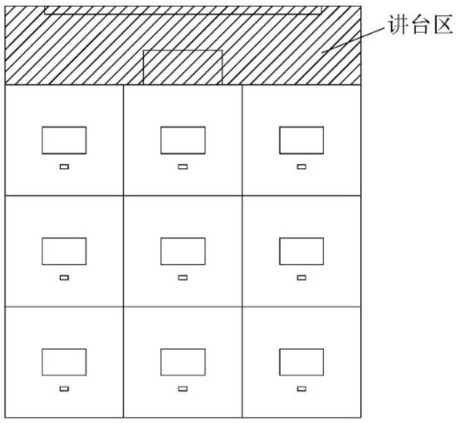
9.1.3 Test of brightness in eye direction and uniformity

Divide the classroom space except the platform into 9 equal parts. Place the desk at the center of each area. The height of the desk is generally 0.75m, as shown in Figure 2.

Place a luminance meter 0.05m away from the edge of the desk and 1.2m high to test the brightness of the center point of the desk, as shown in Figure 3.

Brightness tests were carried out in 9 regions to calculate brightness uniformity L_u.

$$L_u = \frac{L_{min}}{L_{average}} \quad \cdots\cdots (3)$$



Platform area

Fig. 2 Sketch map of classroom space partition

Luminance meter

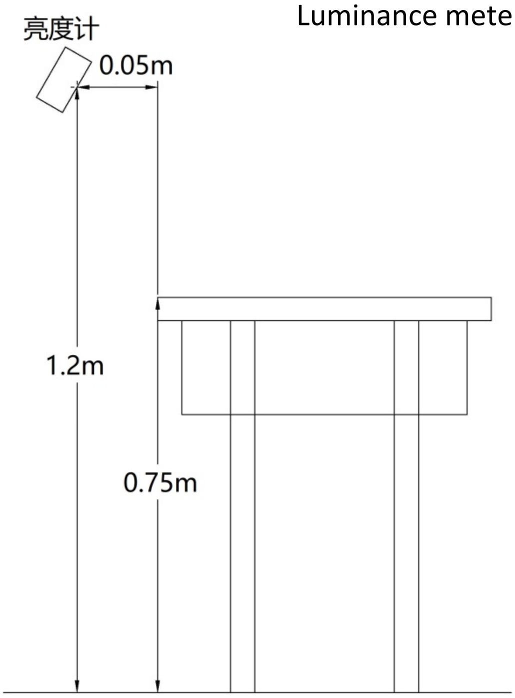


Fig. 3 position of luminance meter

9.2 Light biosafety test method

9.2.1 Blue light hazard

The blue light hazard should be tested according to the regulations of IEC/TR 62778.

9.3 Visual Comfort Index (VICO) test

The Visual Comfort Index (VICO) should be tested according to ISA TCS-S-0006-2016 and ISA-S-0011-2019.

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