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Light and lighting — Lighting of work places

Part 1: Indoor

Lumière et éclairage — Éclairage des lieux de travail —

Partie 1: Intérieur

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Contents

iTeh Standards (https://standards.iteh.ai) Document Preview
ISO/CIE FDIS 8995-1
https://standards.iteh.ai/catalog/standards/iso/14a913c1-90e1-4806-9e27-3d5c0ab79e65/iso-cie-fdis-8995-1

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Field Code Changed

This document was prepared by Technical Committee ISO/TC 274, *Light and lighting*, in cooperation with the International Commission on Illumination (CIE).

This ~~second~~first edition of ISO/CIE 8995-1 cancels and replaces ~~the first edition (~~ISO 8995-1:2002~~),~~ which has been technically revised.

The main changes are as follows:

— ~~—~~scope revised;

~~Annex A, Annex B, Annex C and Annex D added;~~

— ~~—~~Annex A, Annex B, Annex C and Annex D added;

— editorially updated.

A list of all parts in the ISO/CIE 8995 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at ~~www.iso.org/members.html.~~www.iso.org/members.html.

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Introduction

Good lighting will create a visual environment that enables people to see, to move about safely and to perform visual tasks efficiently, accurately, and safely without causing undue visual fatigue and discomfort. The illumination can be provided by daylight, electric light sources, or a combination of both.

Good lighting requires equal attention to the quantity and quality of the lighting. While the provision of sufficient illuminance on the task is necessary, in many instances the visibility depends on the way in which the light is delivered, the colour characteristics of the light source and surfaces together with the level of glare from the system. In this document, opportunity was taken to specify for various work places and task types, not just the illuminance, but also the limiting of discomfort glare and minimum colour rendering index of the source. Parameters to create comfortable visual conditions are proposed in the body of this document. The recommended values are considered to represent a reasonable balance, having regard to the requirements for safe, healthy, and efficient work performance. The values can be achieved with practical energy efficient solutions.

There are also visual ergonomic parameters such as perceptual ability and the characteristics and attributes of the task, which determine the quality of the operator's visual skills, and hence performance levels. In some cases, enhancement of these influencing factors can improve performance without the need to raise illuminance. This can be achieved, for example by improving the contrast of the task attributes, enlarging the task by the use of up to date visual aids (e.g. glasses) and by the provision of special lighting systems with local directional lighting capability.

Adequate and appropriate lighting enables people to perform visual tasks efficiently and accurately including tasks performed over a prolonged time period or of a repetitive nature. The degree of visibility and comfort required in a wide range of work places is governed by the type and duration of the activity. The lighting also affects circadian rhythms and mood as well as improving performance and well-being.

The final designed, installed and operated lighting system should provide efficient and effective good quality lighting for the user needs tailored to their visual capacity, e.g. visual capacity of elderly users in workplaces.

It is important that all clauses of this document are followed although the target values for lighting criteria and specific requirements, depending of each type of task/activity, are tabulated in the schedule of lighting requirements (see ~~Clause 7).~~Clause 7).

This document reflects the generally recognized best practice at the time of publication.

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Light and lighting - — Lighting of work places - —

Part 1: Indoor

1 Scope

This document specifies lighting requirements for humans in indoor work places, which meet the needs for visual comfort, performance and safety of people having normal, or corrected to normal visual capacity and response to light.

This document specifies requirements for lighting solutions for typical indoor work places and their associated areas in terms of quantity and quality of illumination. The illumination can be provided by daylight, electric light sources, or a combination of both.

~~Recommendations are given~~This document gives recommendations for good lighting to fulfil the needs of integrative lighting.

This document neither provides specific solutions nor recommendations for atmosphere or aesthetics created by lighting. It does not restrict the designers' freedom from exploring new techniques nor restrict the use of innovative equipment.

This document is not applicable for emergency lighting. For emergency lighting, see ISO 30061.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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ISO 3864-1, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 9680, *Dentistry — Operating lights*

ISO/CIE TS 22012, *Light and lighting — Maintenance factor determination — Way of working*

CIE S 017, *ILV: International lighting vocabulary*

CIE S 026, *CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light*

CIE 58, *Lighting for sports halls*

CIE 62, *Lighting for swimming pools*

IEC 60601-2-41, *Medical electrical equipment - Part 2-41: Particular requirements for the basic safety and essential performance of surgical luminaires and luminaires for diagnosis*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE S 017 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ~~—~~ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp

— ~~—~~IEC Electropedia: available at ~~https://www.electropedia.org/~~https://www.electropedia.org/

CIE maintains a terminology database for use in standardization at the following address:

— ~~—~~e-ILV: available at ~~https://cie.co.at/e-ilv~~https://cie.co.at/e-ilv

3.1 ~~**3.1**~~
activity area
partial area in the work place in which more than one visual task is carried out

Note 1 to entry: Visual tasks can be different in type and/or position.

Note 2 to entry: A room can contain one or more activity areas.

Note 3 to entry: The spatial orientation needs to be specified by the designer.

Note 4 to entry: An activity area is not to be considered as aggregation of a number of distinct task areas across a larger area.

3.2 ~~**3.2**~~
immediate surrounding area
zone of at least 0,5 m width surrounding the task area within the field of vision

3.3 ~~**3.3**~~
background area
horizontal area at floor level adjacent to the *immediate surrounding area* ~~(3.2)~~(3.2) within the limits of space

3.4 ~~**3.4**~~
workplace
designated area in which ~~the~~ work activities are carried out

4 Symbols and abbreviations

$\bar{E}_{m,wall}$	maintained average illuminance on walls[1]
$\bar{E}_{m,ceiling}$	maintained average illuminance on ceiling[1]
U_o	illuminance uniformity
$\bar{E}_m$	maintained average illuminance~~1)~~
α	shielding angle
C-plane angle	elevation angle
γ	vertical photometric angle

~~1 According to CIE S 017, $\bar{E}_m$ is the value below which the average illuminance on a specified area shall not fall.~~
1) According to CIE S 017, $\bar{E}_m$ is the value below which the average illuminance on a specified area shall not fall.

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DGP	Daylight Glare Probability
L	luminance
R_{UG}	CIE Unified Glare Rating (UGR)
R_{UGL}	R_{UG} limit value
$\bar{E}_c$	average cylindrical illuminance~~[2]~~[2)]
$\bar{E}_{m,c}$	maintained average cylindrical illuminance[1]
T_{cp}	correlated colour temperature
R_a	general colour rendering index
R_i	special colour rendering index
TLM	temporal light modulation
$P_{st,LM}$	IEC short-term light modulation/ temporal light modulation indicator
SVM	Stroboscopic Visibility Measure
DSE	display screen equipment
f_m	maintenance factor
$\bar{E}_i$	initial illuminance
~~$\bar{L}_{m,wall}$~~ $\bar{L}_{m,wall}$	maintained average luminance of the walls
~~$\bar{L}_{m,ceiling}$~~ $\bar{L}_{m,ceiling}$	maintained average luminance of the ceiling
ρ_{wall}	luminous reflectance of the wall
$\rho_{ceiling}$	luminous reflectance of the ceiling

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5 Lighting design criteria

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5.1 General

For good lighting practice, it is essential that, ~~as well as~~along with the required illuminances, additional qualitative and quantitative needs are satisfied.

Lighting requirements are determined by the satisfaction of three basic human needs:

— ~~—~~visual performance, in which the workers are able to perform their visual tasks, even under difficult circumstances and during longer periods;

— ~~—~~visual comfort, in which the workers experience physical and mental comfort; evidence shows that this state contributes to improved work motivation, work quality, and reduced absenteeism;

— ~~—~~safety.

The principal parameters that describe the luminous environment with respect to daylighting and electric lighting are:

~~[2] Approximated by the average of the four main directions~~
[2)] Approximated by the average of the four main directions

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— luminance distribution;

— illuminance and illuminance uniformity;

— glare;

— directionality of light;

— lighting in the interior space;

— colour rendering and colour appearance of the light;

— temporal light modulation.

These criteria are further detailed in ~~Clause 5~~Clause 5 and ~~Clause 6,~~Clause 6, requirements and recommendations are given in ~~Clause 7.~~Clause 7.

NOTE In addition to the lighting, there are other visual ergonomic parameters which influence visual performance, such as:

— the intrinsic task properties (size, shape, position, colour and reflectance properties of detail and background);

— normal visual capacity and response to light of the person (visual acuity, depth perception, colour perception) (see CIE 227);

— for the visually impaired, for example those who are sensitive to glare or have visual field defects, adaptation and decreased contrast and colour vision where dimming, protection against glare and colour rendering are especially important factors to consider, see CIE 227.

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5.2 Luminance distribution

5.2.1 General

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The luminance distribution is a crucial factor to determine a proper luminous environment. It affects task visibility and shall be properly controlled.

An appropriate adaptation luminance is needed to optimize:

— visual acuity (sharpness of vision);

— contrast sensitivity (discrimination of small relative luminance differences);

— efficiency of the ocular functions (such as accommodation, convergence, pupillary contraction, eye movements, etc.).

The luminance distribution in the visual field also affects visual comfort. The following shall be avoided for the reasons given:

— excessive luminances and luminance contrasts which can cause discomfort glare and reduced task visibility;

— excessive luminance variation which can cause fatigue because of constant re-adaptation of the eyes.

Attention shall also be given to adaptation in moving from zone to zone within a building.

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To create a well-balanced luminance distribution, the luminance values of all surfaces shall be taken into consideration. They are determined by the reflectance and the illuminance on the surfaces. To avoid gloom and to raise adaptation levels and comfort of people in buildings, it is highly desirable to have bright interior surfaces. Room brightness is considered by specifying average illuminance values on walls and ceiling (see ~~Clause 7)~~Clause 7) and by recommending typical reflectance values ~~(5.2.3).~~(5.2.3).

The lighting designer shall consider and select the appropriate illuminance/luminance values for the interior surfaces based on the guidance in ~~5.2.2, 5.2.3 and 5.2.4.~~5.2.2, 5.2.3 and 5.2.4.

NOTE To simplify ~~the~~ calculation procedures, this document does not consider the spectral reflectance values but only the average reflectances of the surfaces themselves and considers these perfectly Lambertian surfaces, except for the cases that deal with the surfaces with non-isotropic diffuse reflections.

5.2.2 Average luminance of surfaces

When isotropic diffuse reflection can be assumed, the luminance of a certain point on the surface is proportional to the product of the illuminance on that point multiplied by the reflectance of the surface. That means that the reflectance of and the illuminance on the surfaces is a simplified substitution of luminance requirement.

NOTE 1 ~~It is noted that, when~~When the surfaces do not have isotropic diffuse reflection, the same luminous environment is not necessarily assured from the different points of view even if it meets the illuminance requirements.

When calculating the luminance distribution by using lighting simulation programs, the lighting designer shall consider and select the appropriate minimum requirements of the average luminance of the interior surfaces based as below.

a) ~~a)~~ When isotropic diffuse reflection can be assumed~~:~~.

   — The lighting designer can set view positions for calculating luminance distribution anywhere.

b) ~~b)~~ When isotropic diffuse reflection cannot be assumed~~:~~.

   — The lighting designer shall choose several representative view positions in the space depending on the tasks and/or activities being performed and calculate the average luminance values of walls and ceiling from these positions. It is desirable to meet the minimum requirements for the average luminance of walls and ceiling from all these positions.

The average luminance of walls and ceiling from all these positions depending on the tasks and/or activities being performed in the space shall meet the minimum requirements. The minimum requirements for the average luminance can be calculated from the recommended minimum illuminance ~~(Clause 7)~~(Clause 7) multiplied by the recommended value of the reflectance in the wavelength between 380~~-~~ nm to 780~~-~~ nm for the calculation purpose (see ~~5.2.3).~~5.2.3).

The average maintained luminance on the walls is calculated using ~~the following formula:~~Formula (1):

$$\bar{L}_{\mathrm{m,wall}} = \frac{\bar{E}_{\mathrm{m,wall}} \cdot \rho_{\mathrm{wall}}}{\pi} \quad \text{~~(1)~~}$$

$$\bar{L}_{\mathrm{m,wall}} = \frac{\bar{E}_{\mathrm{m,wall}} \cdot \rho_{\mathrm{wall}}}{\pi} \quad (1)$$

where

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$\bar{E}_{m,wall}$ is the average maintained illuminance on the walls given in ~~Table 9~~Table 9 to ~~Table 62,~~Table 62,

ρ_{wall} is the reflectance of the walls (see ~~5.2.3~~5.2.3 for recommended reflectances in the wavelength between 380- nm to 780- nm for the calculation purpose).

The average maintained luminance of the ceilings is calculated using ~~the following formula:~~Formula (2):

~~$$\bar{L}_{m,ceiling} = \frac{\bar{E}_{m,ceiling} \cdot \rho_{ceiling}}{\pi} \quad (2)$$~~

$$\bar{L}_{m,ceiling} = \frac{\bar{E}_{m,ceiling} \cdot \rho_{ceiling}}{\pi} \quad (2)$$

where

$\bar{E}_{m,ceiling}$ is the average maintained illuminance on the ceilings given in ~~Table 9~~Table 9 to ~~Table 62,~~Table 62,

$\rho_{ceiling}$ is the reflectance of the ceilings (see ~~5.2.3~~5.2.3 for recommended reflectances in the wavelength between 380- nm to 780- nm for the calculation purpose)

NOTE 2 The choice of view positions is at the discretion of the lighting designer, therefore, this method can be considered as an auxiliary one in the lighting design process.

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5.2.3 Reflectance of surfaces

For choice of materials and coatings, recommended diffuse reflectances in the wavelength between 380 nm to 780 nm for the calculation purpose are:

— ~~—~~ceiling: 0,7 to 0,9;

— ~~—~~walls: 0,5 to 0,8;

— ~~—~~floor: 0,2 to 0,6.

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The diffuse reflectance in the wavelength between 380- nm to 780- nm of major objects (such as furniture and machinery) are normally in the range of 0,2 to 0,7.

NOTE Clear interior glass has a typical reflectance of 0,1.

5.2.4 Illuminance on surfaces

Illuminances on walls and ceiling together with surface reflectances (see ~~5.2.3)~~5.2.3) contribute to luminances and are indicators for perceived room brightness.

~~Clause 7~~Clause 7 provides minimum requirements for the maintained illuminance on walls ($\bar{E}_{m,wall}$) and ceiling ($\bar{E}_{m,ceiling}$) depending on the tasks and/or activities being performed in the space.

NOTE Additional guidance can be found in ~~Clause 6.~~Clause 6.

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