BRITISH STANDARD

BS ISO 8995:2002
Incorporating Corrigendum No. 1

Lighting of indoor work places

ICS 13.180; 91.160.10

BSI British Standards

National foreword

This British Standard reproduces verbatim ISO 8995:2002 and implements it as the UK national standard. It supersedes BS 8206-1:1985 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PH/9, Applied Ergonomics, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, the ISO title page, pages ii to viii, pages 1 to 19 and a back cover.

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INTERNATIONAL STANDARD

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CIE S 008/E

Second edition
2002-05-15

Lighting of indoor work places

Éclairage intérieur pour des lieux de travail

Reference number
ISO 8995:2002(E)
CIE S 008/E-2001

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standard ISO 8995 was prepared as Standard CIE S 008/E by the International Commission on Illumination, which has been recognized by the ISO Council as an international standardizing body. It was adopted by ISO under a special procedure which requires approval by at least 75 % of the member bodies casting a vote, and is published as a joint ISO/CIE edition.

The International Commission on Illumination (abbreviated as CIE from its French title) is an organization devoted to international cooperation and exchange of information among its member countries on all matters relating to the science and art of lighting.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 8995 was prepared jointly by CIE TC 3-21 and ISO/TC 159, *Ergonomics*, Subcommittee SC 5, *Ergonomics of the physical environment*.

This second edition cancels and replaces the first edition (ISO 8995:1989), of which it constitutes a technical revision.

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ISO 8995:2002(E)
CIE S 008/E-2001

Standard

Lighting of Indoor Work Places

Eclairage intérieur pour des lieux de travail

Beleuchtung von Arbeitsplätzen in Innenräumen

CIE Central Bureau, Vienna
Kegelgasse 27, A-1030 Vienna, Austria

S 008/E

UDC: 628.972 Descriptor: Interior lighting

Foreword

Standards produced by the Commission Internationale de l'Éclairage (CIE) are a concise documentation of data defining aspects of light and lighting, for which international harmony requires such unique definition. CIE Standards are therefore a primary source of internationally accepted and agreed data, which can be taken, essentially unaltered, into universal standard systems.

This International Standard was prepared jointly by CIE-TC 3-21 and ISO/TC 159/SC 5. It replaces publication CIE 29.2-1986 and deals with Lighting Requirements for Indoor Work Places.

Table of contents

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LIGHTING OF INDOOR WORK PLACES

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 may be daylight, electric light or 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 standard opportunity was taken to specify for various work places and task types not just the illuminance but also the limiting discomfort glare and minimum colour rendering index of the source. Parameters to create comfortable visual conditions are proposed in the body of this standard. 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. For example by improving the contrast of the task attributes, enlarging the task by the use of up to date visual aids (glasses) and by the provision of special lighting systems with local directional lighting capability.

1. Scope

This standard specifies lighting requirements for indoor work places and for people to perform the visual tasks efficiently, in comfort and safety throughout the whole work period.

This standard does not explain how lighting systems or techniques should be designed to optimise solutions for specific work places. These may be found in the relevant CIE guides and reports.

2. Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying most recent editions of the standards indicated below. Members of CIE, the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) maintain registers of currently valid international standards.

ISO 3864	Safety colours and safety signs
ISO 6309	Fire protection - safety signs
ISO 6385	Ergonomic principles in the design of work systems
ISO 9241 Parts 6/7/8	Ergonomic requirements for office work with visual display terminals
CIE 13.3 - 1995	Method of measuring and specifying colour rendering of light sources
CIE 16 - 1970	Daylight
CIE 17.4 - 1987	International lighting vocabulary 4th ed. – equivalent to IEC 50(845)
CIE 19.2 - 1981	An analytic model for describing the influence of lighting parameters upon visual performance
CIE 40 - 1978	Calculations for interior lighting - basic method
CIE 58 - 1983	Lighting for sports halls

CIE 60 - 1984	Vision and the visual display unit work station
CIE 62 - 1984	Lighting for swimming pools
CIE 96 - 1992	Electric light sources. State of the art - 1991
CIE 97 - 1992	Maintenance of indoor electric lighting systems
CIE 103/5 - 1993	The economics of interior lighting maintenance
CIE 117 - 1995	Discomfort glare in interior lighting
CIE 129 - 1998	Guide for lighting of exterior work areas

3. Definitions

In general the terms used in this standard are defined in the CIE Lighting Vocabulary (CIE 17.4 – 1987), but there are few more terms that are defined below:

3.1 **visual task:** The visual elements of the task to be carried out.

3.2 **task area:** The partial area in the work place in which the visual task is located and carried out.

3.3 **immediate surrounding:** A zone of at least 0,5 m width surrounding the task area within the field of vision.

3.4 **maintained illuminance ($\overline{E_m}$):** Value below which the average illuminance on the specified surface should not fall.

3.5 **unified glare rating (*UGR*):** The CIE discomfort glare measure.

3.6 **limiting unified glare rating (UGR_L):** The maximum allowable design *UGR* value for the lighting installation.

3.7 **Shielding angle:** the angle measured from the horizontal, down to which the lamp(s) is screened by the luminaire from direct view by an observer.

3.8 **Working plane:** the reference surface defined as the plane at which work is usually done.

4. Lighting design criteria

4.1 Luminous environment

Good lighting practice for work places is more than just providing good task visibility. It is essential that tasks are performed easily and in comfort. Thus the lighting must satisfy the quantitative and qualitative aspects demanded by the environment. In general lighting is to ensure:

- visual comfort, where the workers have a feeling of well-being,
- visual performance, where the workers are able to perform their visual tasks, speedily and accurately even under difficult circumstances and during long periods,
- visual safety, to see one's way around and detect hazards.

To satisfy these, attention to all parameters contributing to the luminous environment is required.

The main parameters are:

- luminance distribution,
- illuminance,
- glare,
- directionality of light,
- colour aspect of the light and surfaces,
- flicker,
- daylight,
- maintenance.

Design values for the quantifiable parameters of illuminance, discomfort glare and colour rendering are given in clause 5 for the various activities.

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

a) the intrinsic task properties (size, shape, position, colour and reflectance of detail and background)
b) ophthalmic capacity of the operator (visual acuity, depth perception, colour perception).

Attention to these factors can enhance visual performance without the need for higher illuminance.

4.2 Luminance distribution

The luminance distribution in the field of view controls the adaptation level of the eyes, which affects task visibility.

A well balanced adaptation luminance is needed to increase:

- visual acuity (sharpness of vision),
- contrast sensitivity (discrimination of relatively small luminance differences),
- efficiency of the ocular functions (such as accommodation, convergence, pupillary contraction, eye movements, etc.).

Diverse luminance distribution in the field of view also affects visual comfort and should be avoided:

- too high luminances can give rise to glare.
- too high luminance contrasts will cause visual fatigue due to continuous readaptation of the eyes.
- too low luminances and too low luminance contrasts result in a dull and non-stimulating working environment.
- attention should be given to adaptation in moving from zone to zone within a building.

The luminances of all surfaces are important and will be determined by the reflectance of and the illuminance on the surfaces. The range of useful reflectances for the major interior surfaces are:

- ceiling: 0,6 - 0,9
- walls: 0,3 - 0,8
- working planes: 0,2 - 0,6
- floor: 0,1 - 0,5

4.3 Illuminance

The illuminance and its distribution on the task areas and the surrounding area have a major impact on how quickly, safely and comfortably a person perceives and carries out the visual task. For spaces where the specific area is unknown the area where the task may occur is taken as the task area.

All values of illuminances specified in this standard are maintained illuminances and will provide for visual safety at work and visual performance needs.

4.3.1 Recommended illuminances at the task area

The values given in clause 5 are the maintained illuminances over the task area on the reference surface which may be horizontal, vertical or inclined. The average illuminance for each task shall not fall below the values given in clause 5 regardless of the age and condition of the installation. The values are valid for normal visual conditions and take into account the following factors:

- requirements for visual tasks,

- safety,
- psycho-physiological aspects such as visual comfort and well-being,
- economy,
- practical experience.

The value of illuminance may be adjusted, by at least one step on the scale of illuminance, if the visual conditions differ from the normal assumptions. The illuminance should be increased when:

- unusually low contrasts are present in the task,
- visual work is critical,
- errors are costly to rectify,
- accuracy or higher productivity is of great importance,
- the visual capacity of the worker is below normal.

The required maintained illuminance may be decreased when:

- the details are of an unusually large size or high contrast,
- the task is undertaken for an unusually short time.

In areas where continuous work is carried out the maintained illuminance shall not be less than 200 lux.

4.3.2 Scale of illuminance

A factor of approximately 1,5 represents the smallest significant difference in subjective effect of illuminance. In normal lighting conditions approximately 20 lux of horizontal illuminance is required to just discern features of the human face and is the lowest value taken for the scale of illuminances. The recommended scale of illuminance is:

20 - 30 - 50 - 75 - 100 - 150 - 200 - 300 - 500 - 750 - 1000 - 1500 - 2000 - 3000 - 5000 lux.

4.3.3 Illuminances of immediate surroundings

The illuminance of immediate surrounding areas shall be related to the illuminance of the task area and should provide a well-balanced luminance distribution in the field of view.

Rapid spatial changes in illuminances around the task area may lead to visual stress and discomfort.

The maintained illuminance of the immediate surrounding areas may be lower than the task illuminance but shall not be less than the values given in the table below.

Task illuminance lux	Illuminance of immediate surroundings lux
$\geq$ 750	500
500	300
300	200
$\leq$ 200	Same as task illuminance

In addition to the task illuminance the lighting shall provide adequate adaptation luminance in accordance with clause 4.2.

4.3.4 Uniformity

The uniformity of the illuminance is the ratio of the minimum to average value. The illuminance shall change gradually. The task area shall be illuminated as uniformly as possible. The uniformity of the task illuminance shall not be less than 0,7. The uniformity of the illuminance of the immediate surrounding areas shall be not less than 0,5**.**

4.4 Glare

Glare is the visual sensation produced by bright areas within the field of view and may be experienced either as discomfort glare or disability glare. Glare may also be caused by reflections in specular surfaces usually known as veiling reflections or reflected glare.

It is important to limit the glare to avoid errors, fatigue and accidents.

Disability glare is more common in exterior lighting but may also be experienced from spotlights or large bright sources such as a window in a relatively poorly lit space.

In interior workplaces discomfort glare usually arises directly from bright luminaires or windows. If the discomfort glare limits are met then disability glare is not usually a major problem.

4.4.1 Shielding against glare

Glare is caused by excessive luminances or contrasts in the field of view and can impair the vision of objects. It should be avoided for example by suitable shielding of lamps or shading of windows by blinds.

For electric lamps the minimum shielding angle for lamp luminances shall be not less than the values given in the table below:

Lamp luminance kcd/m^2	Minimum shielding angle
1 to 20	10°
20 to 50	15°
50 to 500	20°
≥ 500	30°

The above mentioned shielding angle should not be applied to luminaires which do not appear in the field of view of a worker during usual work and/or do not give the worker any noticeable disability glare.

4.4.2 Discomfort glare

The discomfort glare rating of the lighting installation shall be determined by the CIE Unified Glare Rating (UGR) tabular method, based on formula:

$$UGR = 8 \cdot \log\left(\frac{0{,}25}{L_b} \cdot \sum \frac{L^2 \cdot \omega}{p^2}\right)$$

where

- L_b is the background luminance (cd/m^2),
- L is the luminance of the luminous parts of each luminaire in the direction of the observer's eye (cd/m^2),
- ω is the solid angle of the luminous parts of each luminaire at the observer's eye (steradian),
- p is the Guth position index for each individual luminaire which relates to its displacement from the line of sight.

Details of the UGR method are given in CIE 117 - 1995.

In this standard all *UGR* values in clause 5 are based on the standard observer's position which have been validated by the UGR tabular method at a 1:1 spacing to height ratio. The *UGR* data shall be corrected for the initial luminous flux of the lamps used. If the

lighting installation is composed of different types of luminaires with different photometry and/or lamps, the determination of the *UGR* value shall be applied to every lamp/luminaire combination in the installation. The highest *UGR* value thus obtained shall be taken as typical value of the entire installation and shall conform to the *UGR* limit. All assumptions made in the determination of *UGR* shall be stated in the scheme documentation.

The *UGR* value of the lighting installation shall not exceed the value given in clause 5.

Note: The variations of *UGR* within the room may be determined using the tabular method or the formula for different observer positions.

The values of *UGR* limits in clause 5 were taken from the *UGR* scale - where each step in the scale represents one significant change in glare effect and 13 represents the least perceptible discomfort glare.

The *UGR* scale is: 13 - 16 - 19 - 22 - 25 - 28

4.4.3 Veiling reflections and reflected glare

Specular reflections in the visual task, often called veiling reflection or reflected glare, may alter task visibility, usually detrimentally. Veiling reflections and reflected glare may be prevented or reduced by the following measures:

- arrangement of luminaires and work places (avoid placing luminaires in the offending zone),
- surface finish (use low gloss surface materials),
- luminance of luminaires (limit),
- increased luminous area of luminaire (enlarge luminous area),
- ceiling and wall surfaces (lighten, avoid bright spots).

4.5 Directionality

Directional lighting may be used to highlight objects, to reveal texture and improve appearance of people within the space. This is described by the term “modelling”. Directional lighting of a visual task may also enhance its visibility.

4.5.1 Modelling

Modelling refers to the balance between diffuse and directional light. It is a valid criterion of lighting quality in virtually all types of interiors. The general appearance of an interior is enhanced when its structural features, the people and objects within it are lit so that form and texture are revealed clearly and pleasingly. This occurs when the light comes noticeably from one direction; the shadows formed are essential to good modelling and are formed without confusion.

The lighting should not be too directional as it can produce harsh shadows, neither should it be too diffuse or the modelling effect will be lost entirely, resulting in a very dull luminous environment.

4.5.2 Directional lighting of visual tasks

Lighting from a specific direction can reveal details within a visual task, increasing their visibility and making the task easier to perform. Particularly important for fine textured tasks and scribes/grooves.

4.6 Colour aspects

The colour qualities of a near-white lamp are characterised by two attributes:

- the colour appearance of the lamp itself,
- its colour rendering capabilities, which affect the colour appearance of objects and persons illuminated by the lamp.

These two attributes must be considered separately.

4.6.1 Colour appearance

The "colour appearance" of a lamp refers to the apparent colour (lamp chromaticity) of the light it emits. It may be described by its correlated colour temperature.

Lamps are usually divided into three groups according to their correlated colour temperature (T_{cp}).

Colour appearance	Correlated colour temperature
warm	below 3300 K
intermediate	3300 K to 5300 K
cool	above 5300 K

The choice of colour appearance is a matter of psychology, aesthetics and of what is considered to be natural. The choice depends on illuminance, colours of the room and furniture, surrounding climate and the application. In warm climates generally a cooler light colour appearance is preferred, and in cold climates a warmer light colour appearance is preferred.

4.6.2 Colour rendering

It is important for both visual performance and the feeling of comfort and well being that colours in the environment of objects and human skin are rendered naturally, correctly and in a way that makes people look attractive and healthy.

Safety colours according to ISO 3864 shall always be recognisable and clearly discriminated.

To provide an objective indication of the colour rendering properties of a light source the general colour rendering index R_a has been introduced. The maximum value of R_a is 100. This figure decreases with decreasing colour rendering quality.

Lamps with R_a less than 80 should not be used in interiors where people work or stay for long periods. Exceptions can be high-bay lighting and outdoor lighting. (Industrial downlights used at mounting height in excess of 6 m.) But even here suitable measure must be taken to ensure that higher colour rendering lamps are used in continually occupied work places and where safety colours have to be recognised.

The recommended minimum value of the general colour rendering index for different types of interiors, tasks or activities are given in clause 5.

4.7 Daylight

Daylight may provide all or part of the lighting for visual tasks.

Daylight varies in level and spectral composition with time and therefore provides variability within an interior. Daylight may create a specific modelling and luminance distribution due to its nearly horizontal flow from side windows. Daylight can also be provided by roof lights and other fenestration elements.

Windows can also provide a visual contact with the outside world, which is preferred by most people. Avoid excessive contrast and thermal discomfort caused by direct sunlight in work areas. Provide adequate sun control such as blinds or shades, so that direct sunlight does not hit workers and/or surfaces within their field of view.

In interiors with side windows the available daylight decreases rapidly with distance from the window. In these interiors the daylight factor should not fall below 1% on the working plane 3 m from window wall and 1 m from side walls. Supplementary lighting should be provided to ensure the required illuminance at the work place and to balance the luminance distribution within the room. Automatic or manual switching and/or dimming can be used to ensure appropriate integration between electric lighting and daylight.

To reduce glare from windows, screening shall be provided.

4.8 Maintenance

The recommended lighting levels for each task are provided as maintained illuminance. Maintained illuminance depends on the maintenance characteristic of the lamp, the luminaire, the environment and maintenance programme.

The lighting scheme should be designed with overall maintenance factor calculated for the selected lighting equipment, space environment and specified maintenance schedule. The calculated maintenance factor should not be less than 0,70.

4.9 Energy considerations

The lighting installation should meet the lighting requirements of a particular interior, task or activity without waste of energy. However, it is important not to compromise the visual aspects of a lighting installation simply to reduce energy consumption.

This requires the consideration of appropriate lighting systems, equipment, controls and the use of available daylight. In some countries there are limits on the available energy for lighting that should be observed. These limits may be achieved by prudent selection of the lighting system and the use of automatic or manual switching or dimming of the lamps.

4.10 Lighting of workstations with visual display terminals VDT (also known as visual display units VDU and display screen equipment DSE)

The lighting for the VDT work stations shall be appropriate for all tasks performed at the work station, e.g. reading from screen, printed text, writing on paper, keyboard work, etc.

For these areas therefore the lighting criteria and systems shall be chosen in accordance with activity area, task type and type of interior from the schedule in clause 5.

The VDT screens and in some circumstances the keyboard can suffer from reflections causing disability and discomfort glare. It is therefore necessary to select, locate and manage the luminaires to avoid disturbing high brightness reflections.

The designer shall determine the offending mounting zone and shall choose suitable luminance controlled equipment and plan mounting positions which will cause no disturbing reflections.

The luminance limits for downward flux of luminaires which maybe reflected in the VDT screens for normal viewing directions are shown in the table below. The limits of the average luminaire luminance are given at elevation angles of 65° and above from the downward vertical radially around the luminaires for work places where display screens which are vertical or inclined up to 15° tilt angle are used.

Screen classes see ISO 9241-7	I	II	III
Screen quality	good	medium	poor
Limit of average luminance of luminaires	≤ 1000 cd/m^2		≤ 200 cd/m^2

Note: For certain special places using for example sensitive screens or variable inclination the above luminance limits should be applied for lower elevation angles (e.g. 55°) of the luminaire.

4.11 Flicker and stroboscopic effect

Flicker causes distraction and may give rise to physiological effects such as headaches. The lighting system should be designed to avoid flicker and stroboscopic effects. Stroboscopic

effects can lead to dangerous situations by changing the perceived motion of rotating or reciprocating machinery.

Note: This can be achieved by use of DC electrical supply or by operating lamps at high frequency (around 30 kHz) or distribute the connection of the lighting over more than one phase of the supply.

4.12 Emergency lighting

Emergency lighting shall be installed, the details are to be found in a separate standard that is under preparation.

5. Schedule of lighting requirements

The lighting requirements recommended for various rooms and activities are given in the tables of this clause in the following manner.

Column 1: List of interior (areas) tasks or activities
Column 1 lists those interiors, tasks or activities for which specific requirements are given. If the particular interior, task or activity is not listed, the values given for a similar, comparable situation should be adopted.

Column 2: Maintained illuminance **(** $\overline{E_m}$ **,** lux**)**
Column 2 gives the maintained illuminance on the reference surface for interior, task or activity given in column 1 (see 4.3).

Column 3: Limiting unified glare rating (UGR_L)
Column 3 gives the *UGR* limits applicable to the situation listed in column 1, (see 4.4).

Column 4 : Minimum colour rendering index (R_a)
Column 4 gives the minimum colour rendering indices for the situation listed in column 1, (see 4.6.2).

Column 5: Remarks
Advice and footnotes are given for exceptions and special applications of the situations listed in column 1.

For VDT applications see 4.10.

THE SCHEDULE OF INTERIORS (AREAS) TASKS AND ACTIVITIES WITH SPECIFICATION OF ILLUMINANCE, GLARE LIMITATION AND COLOUR QUALITY

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
1. General building areas				
Entrance halls	100	22	60	
Lounges	200	22	80	
Circulation areas and corridors	100	28	40	At exits and entrances provide a transition zone and avoid sudden changes.
Stairs, escalators, travelators	150	25	40	
Loading ramps/bays	150	25	40	
Canteens	200	22	80	
Rest rooms	100	22	80	
Rooms for physical exercise	300	22	80	
Cloakrooms, washrooms, bathrooms, toilets	200	25	80	
Sick bay	500	19	80	
Rooms for medical attention	500	16	90	T_{cp} at least 4000 K
Plant rooms, switch gear rooms	200	25	60	

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
Post room, switchboard	500	19	80	
Store, stockrooms, cold store	100	25	60	200 lux if continuously occupied
Dispatch packing handling areas	300	25	60	
Control station	150	22	60	200 lux if continuously occupied
2. Agriculture building				
Loading and operating of goods handling equipment and machinery	200	25	80	
Building for livestock	50	28	40	
Sick animal pens, calving stalls	200	25	80	
Feed preparation, dairy, utensil washing	200	25	80	
3. Bakeries				
Preparation and baking	300	22	80	
Finishing, glazing, decorating	500	22	80	
4. Cement, concrete, & bricks industry				
Drying	50	28	20	Safety colours shall be recognisable.
Preparation of materials, work on kilns and mixers	200	28	40	
General machine work	300	25	80	For high-bay: see also clause 4.6.2.
Rough forms	300	25	80	For high-bay: see also clause 4.6.2.
5. Ceramics and glass industry				
Drying	50	28	20	
Preparation, general machine work	300	25	80	For high-bay: see also clause 4.6.2.
Enamelling, rolling, pressing, shaping simple parts, glazing, glass blowing	300	25	80	For high-bay: see also clause 4.6.2.
Grinding, engraving, glass polishing, shaping precision parts, manufacture of glass instruments	750	19	80	For high-bay: see also clause 4.6.2.
Decorative work	500	19	80	
Grinding of optical glass, crystal hand grinding and engraving, work on average goods	750	16	80	
Precision work e.g decorative grinding, hand painting	1000	16	90	T_{cp} at least 4000 K
Manufacture of synthetic precious stones	1500	16	90	T_{cp} at least 4000 K
6. Chemicals, plastics and rubber industry				
Remote operated processing installations	50		20	Safety colours shall be recognisable.
Processing installations with limited manual intervention	150	28	40	
Constantly manned work places in processing installations	300	25	80	
Precision measuring rooms, laboratories	500	19	80	
Pharmaceutical production	500	22	80	
Tyre production	500	22	80	
Colour inspection	1000	16	90	T_{cp} at least 6500 K
Cutting, finishing, inspection	750	19	80	

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
7. Electrical industry				
Cable and wire manufacture	300	25	80	For high-bay: see also clause 4.6.2.
Winding:				
- large coils	300	25	80	For high-bay: see also clause 4.6.2.
- medium-sized coils	500	22	80	For high-bay: see also clause 4.6.2.
- small coils	750	19	80	For high-bay: see also clause 4.6.2.
Coil impregnating	300	25	80	For high-bay: see also clause 4.6.2.
Galvanising	300	25	80	For high-bay: see also clause 4.6.2.
Assembly work:				
- rough e.g. large transformers	300	25	80	For high-bay: see also clause 4.6.2.
- medium e.g. switchboards	500	22	80	
- fine e.g telephones	750	19	80	
- precision e.g. measuring equipm.	1000	16	80	
Electronic workshops, testing, adjusting	1500	16	80	
8. Food industry				
Workplaces and zones in breweries, malting floor, for washing, barrel filling, cleaning, sieving, peeling, cooking in preserve and chocolate factories, work places and zones in sugar factories, for drying and fermenting raw tobacco, fermentation cellar	200	25	80	
Sorting and washing of products, milling, mixing, packing	300	25	80	
Work places and zones in slaughter houses, butchers, dairies mills, on filtering floor, in sugar refineries	500	25	80	
Cutting and sorting of fruit and vegetables	300	25	80	
Manufacture of delicatessen foods, kitchen	500	22	80	
Manufacture work of cigars and cigarettes	500	22	80	
Inspection of glasses and bottles, product control, trimming, sorting decoration	500	22	80	
Laboratories	500	19	80	
Colour inspection	1000	16	90	T_{cp} at least 4000 K
9. Foundries and metal casting plants				
Mansize underfloor tunnels, cellars etc.	50	28	20	Safety colours shall be recognisable.
Platforms	100	25	40	
Sand preparation	200	25	80	For high-bay: see also clause 4.6.2.
Dressing room	200	25	80	For high-bay: see also clause 4.6.2.
Workplaces at cupola and mixer	200	25	80	For high-bay: see also clause 4.6.2.
Casting bay	200	25	80	For high-bay: see also clause 4.6.2.
Shake out areas	200	25	80	For high-bay: see also clause 4.6.2.
Machine moulding	200	25	80	For high-bay: see also clause 4.6.2.
Hand and core moulding	300	25	80	For high-bay: see also clause 4.6.2.
Die casting	300	25	80	For high-bay: see also clause 4.6.2.
Model building	500	22	80	For high-bay: see also clause 4.6.2.

Type of interior, task or activity	$\overline{E}_m$ lux	UGR_L	R_a	Remarks
10. Hairdressers				
Hairdressing	500	19	90	
11. Jewellery manufacturing				
Working with precious stones	1500	16	90	T_{cp} at least 4000 K
Manufacture of jewellery	1000	16	90	
Watch making (manual)	1500	16	80	
Watch making (automatic)	500	19	80	
12. Laundries and dry cleaning				
Goods in, marking and sorting	300	25	80	
Washing and dry cleaning	300	25	80	
Ironing, pressing	300	25	80	
Inspection and repairs	750	19	80	
13. Leather industry				
Work on vats, barrels, pits	200	25	40	
Fleshing, skiving, rubbing, tumbling of skins	300	25	80	
Saddlery work, shoe manufacture stitching, sewing, polishing, shaping, cutting, punching	500	22	80	
Sorting	500	22	90	T_{cp} at least 4000 K
Leather dyeing (machine)	500	22	80	
Quality control	1000	19	80	
Colour inspection	1000	16	90	T_{cp} at least 4000 K
Shoe making	500	22	80	
Glove making	500	22	80	
14. Metal working and processing				
Open die forging	200	25	60	
Drop forging, welding, cold forming	300	25	60	
Rough and average machining: tolerances > 0,1 mm	300	22	60	
Precision machining: grinding: tolerances < 0,1 mm	500	19	60	
Scribing; inspection	750	19	60	
Wire & pipe drawing shapes	300	25	60	
Plate machining $\geq$5mm	200	25	60	
Sheet metalwork <5mm	300	22	60	
Tool making; cutting equipment manufacture	750	19	60	
Assembly:				
- rough	200	25	80	For high-bay: see also clause 4.6.2.
- medium	300	25	80	For high-bay: see also clause 4.6.2.
- fine	500	22	80	For high-bay: see also clause 4.6.2.
- precision	750	19	80	For high-bay: see also clause 4.6.2.
Galvanising	300	25	80	For high-bay: see also clause 4.6.2.
Surface preparation and painting	750	25	80	
Tool, template and jig making, precision mechanics, micro-mechanics	1000	19	80	
15. Paper industry				
Pulp mills, edge runners	200	25	80	For high-bay: see also clause 4.6.2.
Paper manufacture and processing, paper and corrugating machines, cardboard manufacture	300	25	80	For high-bay: see also clause 4.6.2.

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
Standard book binding work, e.g. folding, sorting, gluing, cutting, embossing, sewing	500	22	60	
16. Power stations				
Fuel supply plant	50	28	20	Safety colours shall be recognisable.
Boiler house	100	28	40	
Machine halls	200	25	80	For high-bay: see also clause 4.6.2.
Auxiliary rooms, e.g pump rooms, condenser rooms, switchboard, etc.	200	25	60	
Control rooms	500	16	80	1. Control panels are often vertical. 2. Dimming may be required. 3. For VDT work see clause 4.10.
17. Printers				
Cutting, gilding, embossing, block engraving, work on stones and platens, printing machines, matrix making	500	19	80	
Paper sorting and hand printing	500	19	80	
Type setting, retouching, lithography	1000	19	80	
Colour inspection in multi-coloured printing	1500	16	90	T_{cp} 5000 K
Steel and copper engraving	2000	16	80	For directional light see clause 4.5.2.
18. Iron and steel works				
Production plants without manual Intervention	50	28	20	Safety colours shall be recognisable.
Production plants with occasional manual operation	150	28	40	
Production plants with continuous manual operation	200	25	80	For high-bay: see also clause 4.6.2.
Slab store	50	28	20	Safety colours shall be recognisable.
Furnaces	200	25	20	Safety colours shall be recognisable.
Mill train, coiler, shear line	300	25	40	
Control platforms, control panels	300	22	80	
Test, measurement and inspection	500	22	80	
Underfloor man sized tunnels belt sections, cellars etc.	50	28	20	Safety colours shall be recognisable.
19. Textile industry				
Workplace and zones in baths, bale opening	200	25	60	
Carding, washing, ironing, drawing, combing, sizing, card cutting, pre-spinning, jute and hemp spinning	300	22	80	
Spinning, plying, reeling, winding warping, weaving, braiding, knitting	500	22	80	Prevent stroboscopic effects.
Sewing, fine knitting, taking up stitches	750	22	90	
Manual design, drawing patterns	750	22	90	T_{cp} at least 4000 K
Finishing, dyeing	500	22	80	
Drying room	100	28	60	
Automatic fabric printing	500	25	80	
Burling, picking, trimming	1000	19	80	
Colour inspection, fabric control	1000	16	90	T_{cp} at least 4000 K
Invisible mending	1500	19	90	T_{cp} at least 4000 K

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
Hat manufacturing	500	22	80	
20. Vehicle construction				
Body work and assembly	500	22	80	
Painting, spraying chamber, polishing chamber	750	22	80	
Painting: touch-up, inspection	1000	16	90	T_{cp} at least 4000 K
Upholstery manufacture (manned)	1000	19	80	
Final inspection	1000	19	80	
21. Wood working & furniture industry				
Automatic processing e.g. drying plywood manufacturing	50	28	40	
Steam pits	150	28	40	
Saw frame	300	25	60	Prevent stroboscopic effects.
Work at joiner's bench, gluing, assembly	300	25	80	
Polishing, painting, fancy joinery	750	22	80	
Work on wood working machines e.g. turning, fluting, dressing, rebating, grooving, cutting, sawing, sinking	500	19	80	Prevent stroboscopic effects.
Selection of veneer woods, maquetry, inlay work	750	22	90	T_{cp} at least 4000 K
Quality control	1000	19	90	T_{cp} at least 4000 K
22. Offices				
Filing, copying, circulation, etc.	300	19	80	
Writing, typing, reading, data processing	500	19	80	For VDT-work see clause 4.10.
Technical drawing	750	16	80	
CAD workstation	500	19	80	For VDT-work see clause 4.10.
Conference and meeting rooms	500	19	80	Lighting should be controllable.
Reception desk	300	22	80	
Archives	200	25	80	
23. Retailing				
Sales area small	300	22	80	
Sales area large	500	22	80	
Till area	500	19	80	
Wrapper table	500	19	80	
24. Restaurants and hotels				
Reception/cashier desk, porters desk	300	22	80	
Kitchen	500	22	80	
Restaurant, dining room, function room	200	22	80	The lighting should be designed to create intimate atmosphere.
Self-service restaurant	200	22	80	
Buffet	300	22	80	
Conference rooms	500	19	80	Lighting should be controllable.
Corridors	100	25	80	During night time lower levels are acceptable.
25. Places of entertainment				
Theatres & concert halls	200	22	80	
Multi purpose halls	300	22	80	

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
Practice rooms, dressing rooms	300	22	80	Glare free mirror lighting for make-up required.
Museums (general)	300	19	80	Lighting to suit the display requirements, protect against radiation effects. See Museum Lighting Guide.
26. Libraries				
Bookshelves	200	19	80	
Reading area	500	19	80	
Counters	500	19	80	
27. Public car parks (indoor)				
In/out ramps (during the day)	300	25	40	Safety colours shall be recognisable.
In/out ramps (at night)	75	25	40	Safety colours shall be recognisable.
Traffic lanes	75	25	40	Safety colours shall be recognisable.
Parking areas	75	28	40	A high vertical illuminance increases recognition of peoples faces and therefore the feeling of safety.
Ticket office	300	19	80	1. Avoid reflections in the windows. 2. Prevent glare from outside.
28. Educational buildings				
Play school room	300	19	80	
Nursery class	300	19	80	
Nursery craft room	300	19	80	
Classrooms, tutorial rooms	300	19	80	Lighting should be controllable.
Classroom for evening classes and adults education	500	19	80	
Lecture hall	500	19	80	Lighting should be controllable.
Black board	500	19	80	Prevent specular reflections.
Demonstration table	500	19	80	In lecture halls 750 lux
Art and craft rooms	500	19	80	
Art rooms in art schools	750	19	90	T_{cp} > 5000K
Technical drawing rooms	750	16	80	
Practical rooms and laboratories	500	19	80	
Teaching workshop	500	19	80	
Music practice rooms	300	19	80	
Computer practice rooms	500	19	80	For VDT-work see clause 4.10.
Language laboratory	300	19	80	
Preparation rooms and workshops	500	22	80	
Student common rooms and assembly halls	200	22	80	
Teachers rooms	300	22	80	
Sports halls, gymnasiums and swimming pools	300	22	80	For public access facilities see CIE 58 - 1983 and CIE 62 - 1984.
29. Health care premises				
Waiting rooms	200	22	80	Illuminance at floor level
Corridors: during the day	200	22	80	Illuminance at floor level
Corridors: during the night	50	22	80	Illuminance at floor level
Day rooms	200	22	80	Illuminance at floor level
Staff office	500	19	80	
Staff rooms	300	19	80	
Wards				
- General lighting	100	19	80	Illuminance at floor level
- Reading lighting	300	19	80	
- Simple examination	300	19	80	
Examination and treatment	1000	19	90	
Night lighting, observation lighting	5	19	80	

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
Bathrooms and toilets for patients	200	22	80	
Examination room general	500	19	90	
Ear and eye examination	1000		90	Local examination luminaire
Reading and colour vision test with vision charts	500	16	90	
Scanners with image enhancers and television systems	50	19	80	For VDT work see clause 4.10.
Dialysis rooms	500	19	80	
Dermatology rooms	500	19	90	
Endoscopy rooms	300	19	80	
Plaster rooms	500	19	80	
Medical baths	300	19	80	
Massage and radiotherapy	300	19	80	
Pre-op and recovery rooms	500	19	90	
Operating theatre	1000	19	90	
Operating cavity	Special			$\overline{E_m}$ =10000 lux – 100000 lux
Intensive care				
- General lighting	100	19	90	At floor level
- Simple examinations	300	19	90	At bed level
- Examination and treatment	1000	19	90	At bed level
- Night watch	20	19	90	
Dentists				
- General lighting	500	19	90	Lighting should be glare free for the patient.
- At the patient	1000		90	Local examination luminaire
- Operating cavity	5000		90	Values higher than 5000 lux may be required.
- White teeth matching	5000		90	$T_{cp} \geq$ 6000 K
Colour inspection (laboratories)	1000	19	90	$T_{cp} \geq$ 5000 K
Sterilisation rooms	300	22	80	
Disinfection rooms	300	22	80	
Autopsy rooms and mortuaries	500	19	90	
Autopsy table and dissecting table	5000		90	Values higher than 5000 lux may be required.
30. Airports				
Arrival and departure halls, baggage claim areas	200	22	80	For high-bay: see also clause 4.6.2.
Connecting areas, escalators, travelators	150	22	80	
Information desks, check-in desks	500	19	80	For VDT work see clause 4.10.
Customs and passport control desks	500	19	80	Vertical illuminance is important.
Waiting areas	200	22	80	
Luggage store rooms	200	28	60	
Security check areas	300	19	80	For VDT-work see clause 4.10.
Air traffic control tower	500	16	80	1. Lighting should be dimmable. 2. For VDT work see clause 4.10. 3. Glare from daylight should be avoided.
Air traffic rooms	500	16	80	1. Lighting should be dimmable. 2. For VDT work see clause 4.10.
Testing and repair hangars	500	22	80	For high-bay: see also clause 4.6.2.
Engine test areas	500	22	80	For high-bay: see also clause 4.6.2.
Measuring areas in hangars	500	22	80	For high-bay: see also clause 4.6.2.
Platforms and passenger subways (underpasses)	50	28	40	
Ticket hall and concourse	200	28	40	
Ticket and luggage offices and counters	300	19	80	

Type of interior, task or activity	$\overline{E_m}$ lux	UGR_L	R_a	Remarks
Waiting rooms	200	22	80	
31. Churches, mosques, synagogues and temples				
Body of church	100	25	80	
Chair, altar, pulpit	300	22	80	

6. Verification procedures

6.1 Illuminance

The illuminance shall be measured at specified points on the relevant areas. The readings shall not be less than that calculated for the point.

The maintained illuminance shall be calculated from measured values on the same grid points as used in the design calculation and the value shall be not less than that specified for the task.

For repeat measurements the same points shall be used.

6.2 Unified glare rating

Authenticated *UGR* data produced by the tabular method at 1:1 spacing to height ratio in accordance with Publication CIE 117 - 1995 shall be provided for the luminaire/scheme by the manufacturer of the luminaire. The installation layout and the surface finishes shall be checked against the design assumptions.

The installation shall be in accordance with the design assumptions.

6.3 Colour rendering index (R_a)

Authenticated R_a data shall be provided for the lamps used in the scheme by the manufacturer of the lamps. The lamps shall be checked against the design specifications and shall have an R_a not less than the value specified in the design.

The lamps shall be as specified in the design.

6.4 Colour appearance (T_{cp})

Authenticated T_{cp} value shall be provided for the lamps in the scheme by manufacturer of the lamps. The T_{cp} value of the lamps shall be not less than the value specified in the design.

6.5 Maintenance

The designer shall:

- state the maintenance factor and list all assumptions made in the derivation of the value,
- verify the lighting equipment suitable for the application environment. Prepare a comprehensive maintenance schedule to include frequency of lamp replacement, luminaire and room surface cleaning intervals and cleaning method.

6.6 Luminaire luminance

The average luminance of the luminous part of the luminaire shall be measured and/or calculated radially in the C-plane at intervals of 15ωstarting at 0ωand the elevation in γ- angles of 65ω 75ωand 85ω Normally the manufacturer of the luminaire shall provide these data based on maximum (lamp/luminaire) output. The values shall not exceed the limits specified in clause 4.10.

6.7 Tolerances in measurements

There can be many factors which can cause disparity between the calculated prediction and the measured performance of a lighting installation. The main reason for this is that, even if the calculation process is of the highest possible accuracy, it is assumed that all the individual lamps, circuits and luminaires provide an identical photometric performance. This is clearly impossible and some tolerance must be expected. The magnitude of the difference based on practical experience expected to be within 10% for illuminance and luminance measures.

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