

English Version

## Light and lighting - Lighting of work places - Part 1: Indoor work places

Lumière et éclairage - Éclairage des lieux de travail -  
Partie 1: Lieux de travail intérieurs

Licht und Beleuchtung - Beleuchtung von  
Arbeitsstätten - Teil 1: Arbeitsstätten in Innenräumen

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

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## **European foreword**

This document (prEN 12464-1:2019) has been prepared by Technical Committee CEN/TC 169 “Light and lighting”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 12464-1:2011.

The original standard EN 12464-1:2002 was already further developed in its first revision EN 12464-1:2011. It specifies the requirements for good lighting solutions rather than giving design guidelines. With the experience of applying the standard next steps are taken in the development of this new edition and human and user needs are given broader acknowledgement. Lighting requirements for task areas to fulfil visual tasks are given a close relation to the space in which they are carried out. Technologically LED has taking over as the light source from conventional lamps. The main changes with respect to the previous edition are:

- User needs are better reflected by adding an additional level of recommendations in the tables in Clause 6 next to the minimum requirements. This gives more emphasis to already existing requirements in 4.3.3.
- The impact of visual and non-image forming effects of light are elaborated in the new Annex C.
- Requirements for walls, ceilings and cylindrical illuminances are moved from the main text to the tables in Clause 6 for increased visibility and usability.
- A new chapter on design considerations (Clause 5) gives advice on how to apply the requirements when designing lighting for visual tasks and activities within a space.
- Relation between task area and its immediate surround and the background area is more detailed (4.3.3, 4.3.4, 4.3.5).
- Glare requirements have been clarified for improved usability including clarification for shielding in 4.5 and recommended practices for UGR in non-standard situations has been added in a new Annex B.
- Flicker and stroboscopic effect is updated (4.8).
- A new Annex D is introduced including examples on how to derive the requirements in different applications (office/industry) for designing lighting.

## Introduction

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 our 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. elderly users in workplaces.

It is important that all clauses of this document are followed although the specific requirements are tabulated in the schedule of lighting requirements (see Clause 6).

## 1 Scope

This document specifies lighting requirements for humans in indoor work places, which meet the needs for visual comfort and performance of people having normal, or corrected to normal ophthalmic (visual) capacity. All usual visual tasks are considered, including Display Screen Equipment (DSE).

This document specifies requirements for lighting solutions for most indoor work places and their associated areas in terms of quantity and quality of illumination. In addition, recommendations are given for good lighting practice including visual and non-visual (non-image forming) lighting needs. This document does not specify lighting requirements with respect to the safety and health of people at work and has not been prepared in the field of application of Article 169 of Treaty on the Functioning of the European Union although the lighting requirements, as specified in this document, usually fulfil safety needs.

**NOTE** Lighting requirements with respect to the safety and health of workers at work can be contained in Directives based on Article 169 of Treaty on the Functioning of the European Union, in national legislation of member states implementing these directives or in other national legislation of member states.

This document neither provides specific solutions, nor restricts the designers' freedom from exploring new techniques nor restricts the use of innovative equipment. The illumination can be provided by daylight, artificial lighting or a combination of both.

This document is not applicable for the lighting of outdoor work places and underground mining or emergency lighting. For outdoor work places, see EN 12464-2 and for emergency lighting, see EN 1838 and EN 13032-3.

## 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.

EN 12193, *Light and lighting — Sports lighting*

EN 12464-2, *Light and lighting — Lighting of work places — Part 2: Outdoor work places*

EN 12665, *Light and lighting — Basic terms and criteria for specifying lighting requirements*

EN 13032-1, *Light and lighting — Measurement and presentation of photometric data of lamps and luminaires — Part 1: Measurement and file format*

EN 13032-2, *Light and lighting — Measurement and presentation of photometric data of lamps and luminaires — Part 2: Presentation of data for indoor and outdoor work places*

EN 15193-1, *Energy performance of buildings - Energy requirements for lighting - Part 1: Specifications, Module M9*

EN 17037, *Daylight in buildings*

EN ISO 9241-307, *Ergonomics of human-system interaction — Part 307: Analysis and compliance test methods for electronic visual displays (ISO 9241-307)*

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

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

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12665, EN 17037 and the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### 3.1

##### **activity area**

area which contains one or more visual tasks

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

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

Note 3 to entry: An activity area is usually a horizontal area. Otherwise the orientation needs to be specified by the designer.

### 4 Lighting design criteria

#### 4.1 Luminous environment

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

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

- visual comfort, where the workers have a feeling of well-being; in an indirect way this also contributes to a higher productivity level and a higher quality of work;
- visual performance, where the workers are able to perform their visual tasks, even under difficult circumstances and during longer periods;
- safety.

The main parameters determining the luminous environment with respect to artificial light and daylight are:

- luminance distribution;
- illuminance;
- directionality of light, lighting in the interior space;
- variability of light (levels and colour of light);
- colour rendering and colour appearance of the light;
- glare;
- flicker.

Values for illuminance and its uniformity on task or activity areas, illuminances in the space, discomfort glare and colour rendering index are given in Clause 6; other parameters are described in Clause 4.

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),
- ophthalmic capacity of the person (visual acuity, depth perception, colour perception),
- intentionally improved and designed luminous environment, glare-free illumination, good colour rendering, high contrast markings and optical and tactile guiding systems can improve visibility and sense of direction and locality. (See CIE 227 *Lighting for Older People and People with Visual Impairment in Buildings*.)

## **4.2 Luminance distribution**

### **4.2.1 General**

The luminance distribution in the visual field 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 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 should be avoided for the reasons given:

- too high luminances and luminance contrasts which can give rise to glare;
- too high luminance variation which will cause fatigue because of constant re-adaptation of the eyes;
- too low luminances and too low luminance contrasts which result in a dull and non-stimulating working environment.

To create a well-balanced luminance distribution the luminances of all surfaces shall be taken into consideration and will be determined by the reflectance of 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 illuminances on walls and ceiling (see clause 6). Annex C provides further details of possible measures.

Although luminance requirements would be more accurate, this standard lists illuminance requirements as luminance requirements are not practical due to their dependence on exact material characteristics and viewing positions.

The lighting designer shall consider and select the appropriate reflectance and illuminance values for the interior surfaces based on the guidance below.

### **4.2.2 Reflectance of surfaces**

High surface reflectances contribute to energy savings and may lead to better visual comfort. For choice of materials, recommended reflectances are:

- ceiling: 0,7 to 0,9;
- walls: 0,5 to 0,8;
- floor: 0,2 to 0,6.

The reflectance of major objects (like furniture, machinery, etc.) should be in the range of 0,2 to 0,7.

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

In design calculations, surface reflectance values should be defined as close to the real surfaces as possible taking into account the variation in reflectance across the surface.

#### 4.2.3 Illuminance on surfaces

Clause 6 provides minimum requirements for the 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. Uniformity for walls and ceiling shall be  $U_0 \geq 0,10$  (see 4.3.6).

Illuminances on walls and ceilings together with surface reflectances (see 4.2.2) are indicators for perceived room brightness.

NOTE Additional guidance can be found in Clause 5.

### 4.3 Illuminance

#### 4.3.1 General

Areas to be lit are task and activity areas, the immediate surrounding and background area, walls, ceiling and objects in the space.

The illuminance and its distribution on the task area and on its immediate surrounding area have a great impact on how quickly, safely and comfortably a person perceives and carries out the visual task.

All values of illuminances specified in this European Standard are maintained illuminances and fulfil visual comfort and performance needs.

For calculation and measurement of illuminance averages and uniformities the grid specification in 4.4 shall be used.

#### 4.3.2 Scale of illuminance

To give a perceptual difference the recommended steps of illuminance (in lx) are according to EN 12665:

20 - 30 - 50 - 75 - 100 - 150 - 200 - 300 - 500 - 750 - 1 000 - 1 500 - 2 000 - 3 000 - 5 000

#### 4.3.3 Illuminances on the task or activity area

The values given in Clause 6 are maintained illuminances over the task or activity area on the reference surface which can be horizontal, vertical or inclined.

The values for  $\bar{E}_{m,r}$  and  $\bar{E}_{m,u}$  in Clause 6 give an indication of a suitable band of maintained illuminance values for the task or activity area. The average illuminance for each task shall not fall below the chosen value, regardless of the age and condition of the installation (see 5.3).

The values are valid for normal visual conditions and take into account the following factors:

- psycho-physiological aspects such as visual comfort and well-being;
- requirements for visual tasks;
- visual ergonomics;
- practical experience;
- contribution to functional safety;
- economy.

The value of maintained illuminance may be adjusted by at least one step in the scale of illuminances (see 4.3.2), if the visual conditions differ from the normal assumptions.

The required maintained illuminance should be increased when:

- visual work is critical;
- errors are costly to rectify;
- accuracy, higher productivity or increased concentration is of great importance;
- task details are of unusually small size or low contrast;
- the task is undertaken for an unusually long time;
- the task or activity area has a low daylight provision.
- the visual capacity of the worker is below normal

**NOTE 1** Retinal illuminance declines with age due to reduced pupil size and increased spectral absorption of the crystalline lens. It is reasonable for lighting practitioners to increase task illuminance to help older people compensate for the age-related losses in retinal illuminance. More information can be found in CIE 227:2017, *Lighting for Older People and People with Visual Impairment in Buildings*.

The required maintained illuminance may be decreased when:

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

**NOTE 2** For visually impaired people special requirements can be necessary with regard to illuminances and contrasts.

The size and position of the task or the activity area should be stated and documented, see Figure 1.

For work stations where the size and/or location of the task or activity area(s) is/are unknown, either:

- the whole area is treated as the task area, or
- the whole area is uniformly ( $U_o \geq 0,40$ ) lit to an illuminance level specified by the designer; if the task area becomes known, the lighting scheme shall be re-designed to provide the required illuminances.

If the type of the task is not known the designer has to make assumptions about the likely tasks and state task requirements.

When multiple tasks take place in the area, requirements for all these tasks shall be complied with.

This applies also to an activity area.

#### **4.3.4 Illuminance on the immediate surrounding area**

Large spatial variations in illuminance around the task or activity area can lead to visual stress and discomfort.

The illuminance of the immediate surrounding area shall be related to the illuminance of the task or activity area and should provide a well-balanced luminance distribution in the visual field. The immediate surrounding area should be a band with a width of at least 0,5 m around the task area within the visual field.

The illuminance of the immediate surrounding area may be lower than the illuminance on the task area but shall be not less than the values given in Table 1.

In addition to the illuminance on the task and activity area the lighting shall provide adequate adaptation luminance in accordance with 4.2.

The size and position of the immediate surrounding area should be stated and documented.

**Table 1 — Relationship of illuminances on immediate surrounding to the illuminance on the task or activity area**

<b>Illuminance on the task or activity area</b> $E_{\text{task}}$ lx	<b>Illuminance on immediate surrounding areas</b> lx
$\geq 750$	500
500	300
300	200
200	150
$\leq 150$	$E_{\text{task}}$

Figure 1 illustrates the minimum dimension of immediate surrounding area in relation to task area.

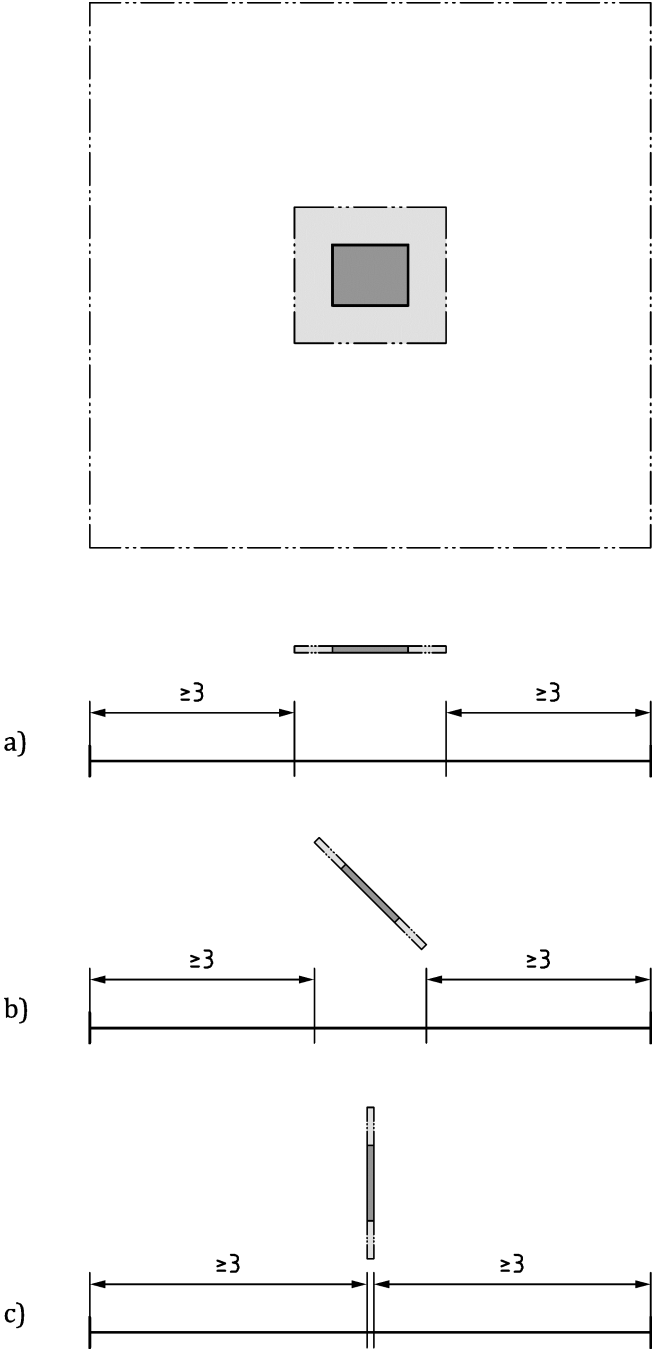
#### 4.3.5 Illuminance on the background area

In indoor work places, particularly those devoid of daylight, a large area outside the immediate surrounding area needs to be illuminated. The area known as the “background area” should be a band adjacent to the immediate surrounding area within the limits of the space and shall be illuminated with a maintained illuminance of 1/3 of the value of the immediate surrounding area. For larger rooms the band should be at least 3 m wide. The background area is a horizontal area on floor level.

The size and position of the background area should be stated and documented.

Figure 1 illustrates the minimum dimension of background area in relation to task and immediate surrounding area.

Dimensions in *m*



- Key**
- task or activity area (not true to scale) in a specified size and position (see 4.3.3)
  - immediate surrounding (band with a width of at least 0,5 m around the task or activity area within the visual field)
  - background (adjacent to the immediate surrounding area up to the limits of the space, for larger rooms at least 3 m wide) horizontal on floor level
- a) horizontal task or activity area                      b) inclined task or activity area
- c) vertical task or activity area

**Figure 1 — Minimum dimensions of immediate surrounding and background area in relation to task and activity area (figure is not true to scale)**

### 4.3.6 Illuminance uniformity

In the task or activity area, the illuminance uniformity ( $U_o$ ) shall be not less than the minimum uniformity values given in the tables in 6.3.

For light from artificial lighting or Daylight opening in the ceiling the illuminance uniformity:

- in the immediate surrounding area shall be  $U_o \geq 0,40$ ;
- on the background area shall be  $U_o \geq 0,10$ .

For light from vertical daylight openings:

- in larger areas, activity areas and background areas the available daylight decreases rapidly with the distance from the window; the additional benefits of daylight can compensate for the lack of uniformity. More information on the benefits of daylight can be found in 5.4 and Annex C.

Uniformity for walls and ceiling shall be  $U_o \geq 0,10$ .

### 4.4 Illuminance grid

Grid systems shall be created to indicate the points at which the illuminance values are calculated and verified for the task and activity area(s), immediate surrounding area(s) and background area(s).

Grid cells approximating to a square are preferred, the ratio of length to width of a grid cell shall be kept between 0,5 and 2 (see also EN 12193 and EN 12464-2). The maximum grid size shall be:

$$p = 0,2 \times 5^{\log_{10}(d)} \quad (1)$$

where

$$p \leq 10 \text{ m}$$

$d$  is the longer dimension of the calculation area (m), however if the ratio of the longer to the shorter side is 2 or more then  $d$  becomes the shorter dimension of the area, and

$p$  is the maximum grid cell size (m).

The number of points in the relevant dimension is given by the nearest whole number of  $d/p$ .

The resulting spacing between the grid points is used to calculate the nearest whole number of grid points in the other dimension. This will give a ratio of length to width of a grid cell close to 1.

A band of 0,5 m from the walls is excluded from the calculation area except when the task or activity area is in or extends into this border area. For narrow spaces (width < 2 m) the excluded band may not be wider than 10 % of the floor width. An appropriate grid size shall be applied to walls and ceiling and a band of 0,5 m may be applied also.

The grid point spacing should not coincide with the luminaire spacing.

NOTE 1 Formula (1) (coming from CIE x005-1992) has been derived under the assumption that  $p$  is proportional to  $\log(d)$ , where:

$$p = 0,2 \text{ m for } d = 1 \text{ m};$$

$$p = 1 \text{ m for } d = 10 \text{ m};$$

$$p = 5 \text{ m for } d = 100 \text{ m}.$$

NOTE 2 Typical values of grid point spacing are given in Annex A, Table A.1.

## 4.5 Glare

### 4.5.1 General

Glare is the sensation produced by bright areas within the visual field, such as lit surfaces, parts of the luminaires, windows and/or roof lights. Glare shall be limited to avoid errors, fatigue and accidents. Glare can be experienced either as discomfort glare or as disability glare. In interior work places disability glare is not usually a major problem if discomfort glare limits are met.

Glare caused by reflections in specular surfaces is usually known as veiling reflections or reflected glare.

NOTE Special care is needed to avoid glare when the direction of view is above horizontal.

### 4.5.2 Discomfort glare

To assess the occurrence of discomfort glare from windows prEN 14501 and EN 17037 provide recommendations of glare control classification and the daylight glare probability (DGP).

To select a luminaire suitable for a given space the rating of discomfort glare caused directly from the luminaires shall be determined using the CIE Unified Glare Rating (UGR) tabular method. The UGR value of the lighting installation shall not exceed the  $R_{UGL}$  value given in Clause 6.

All assumptions made concerning luminaire, room dimensions, room surface reflectance's and spacing to height ratio in the determination of the  $R_{UGL}$  (formerly: *UGR*) shall be stated in the scheme documentation. The  $R_{UGL}$  value as determined by the tabular method shall not exceed the value given in Clause 6.

The recommended limiting values of the  $R_{UG}$  form a series whose steps indicate noticeable changes in glare.

NOTE 1 Glare caused by daylight differs from glare caused by artificial light sources regarding size of the glare sources, complex luminance distributions and users acceptance.

NOTE 2 The series of  $R_{UGL}$  is: 16, 19, 22, 25, 28 where a low value means "little likelihood of discomfort glare" and a high value means "significant possibility of discomfort glare".

NOTE 3 The variations of  $R_{UGL}$  within the room can be determined using the comprehensive tables for different observer positions, as detailed in CIE 117-1995 and CIE 190.

A recommended practice regarding implementation of  $R_{UGL}$  for "non-standard" situations is given in Annex B.

### 4.5.3 Shielding against glare

Bright sources of light can cause glare and can impair the vision of objects. It shall be avoided for example by suitable shielding of light sources and roof lights, or suitable shading from bright daylight through windows.

For luminaires where the light source is directly visible, the minimum shielding angles (see Figure 2) in the visual field given in Table 2 shall be applied for the specified light source luminance.

For luminaires where a direct view of the light source is obscured via optics, the maximum average luminaire luminance for the values of gamma angle given in Table 3 shall be applied (see Figure 2).

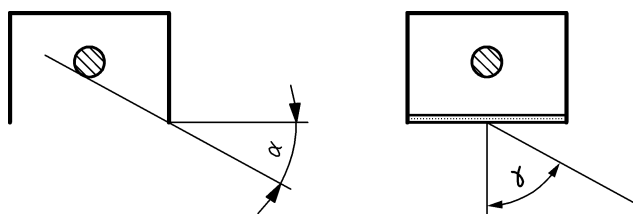
NOTE The values given in Tables 2 and 3 do not apply to up-lighters or to luminaires with a downward component only mounted below normal eye level.

**Table 2— Minimum shielding angles at specified light source luminance**

Light source luminance kcd m <sup>-2</sup>	Minimum shielding angle $\alpha$
20 to <50	15°
50 to < 500	20°
$\geq 500$	30°

**Table 3 — Maximum average luminaire luminance at specified gamma angles**

Gamma angle $\gamma$	Maximum Average Luminaire Luminance kcd m <sup>-2</sup>
$75^\circ \leq \gamma < 90^\circ$	$\leq 20$
$70^\circ \leq \gamma < 75^\circ$	$\leq 50$
$60^\circ \leq \gamma < 70^\circ$	$\leq 500$

**Key**

- $\alpha$  minimum shielding angle  
 $\gamma$  gamma angle

**Figure 2 — Shielding angle  $\alpha$  and Gamma angle  $\gamma$** **4.5.4 Veiling reflections and reflected glare**

High brightness reflections in the visual task can alter task visibility, usually detrimentally. Veiling reflections and reflected glare can be prevented or minimised by the following measures:

- arrangement of work stations with respect to luminaires, windows and roof lights;
- surface finish (matt surfaces);
- luminance restriction of luminaires, windows and roof lights;
- bright ceiling and bright walls.

**4.6 Lighting in the interior space****4.6.1 General**

In addition to lighting of the task and the activity areas the volume of space occupied by people should be lit. This light is required to highlight objects, reveal texture and improve the appearance of people within the space. The terms “mean cylindrical illuminance”, “modelling” and “directional lighting” describe the lighting conditions.

#### 4.6.2 Mean cylindrical illuminance requirement in the activity space

Good visual communication and recognition of objects within a space require that the volume of space in which people move or work shall be illuminated. This is satisfied by providing adequate mean cylindrical illuminance,  $\bar{E}_z$ , in the space.

The required maintained mean cylindrical illuminance to be determined on a horizontal plane in the interior space is given in Clause 6 for each type of task or activity. The uniformity of the mean cylindrical illuminance shall be  $U_0 \geq 0,10$ . The height of the horizontal plane shall be 1,2 m for seated people and 1,6 m for standing people above the floor.

Special attention is given to those spaces where visual recognition and communication is of higher importance.

When the complete space is treated as the task or activity area and is used for the calculation of the required horizontal mean illuminance,  $\bar{E}_m$ , the maintained mean cylindrical illuminance,  $\bar{E}_z$ , shall be calculated for the same area size and position. When the task area / immediate surrounding area / background area are defined separately, the cylindrical illuminance requirement given in the tables in 6.3 shall be calculated and fulfilled for the space including task area and the immediate surrounding area.

#### 4.6.3 Modelling

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.

The lighting should not be too directional or it will produce harsh shadows, neither should it be too diffuse or the modelling effect will be lost entirely, resulting in a very dull luminous environment. Multiple shadows caused by directional lighting from more than one position should be avoided as this can result in a confused visual effect.

Modelling describes the balance between diffuse and directed light and should be considered.

The ratio of cylindrical to horizontal illuminance at a point is an indicator of modelling. The grid points for cylindrical and horizontal illuminances shall coincide.

NOTE 1 For uniform arrangement of luminaires or roof lights a value between 0,30 and 0,60 is an indicator of good modelling.

NOTE 2 Daylight is distributed predominantly horizontally from windows. The additional benefits of daylight (see 5.5) can compensate for its effect on modelling values, and modelling values from daylight can be extended from the range indicated.

#### 4.6.4 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. Unintended veiling reflections and reflected glare should be avoided, see 4.5.4.

Harsh shadows that interfere with the visual task should be avoided. But some shadows help to increase the visibility of the task.

### 4.7 Colour aspects

#### 4.7.1 General

The colour qualities of a near-white light source or transmitted daylight are characterised by two attributes:

- the colour appearance of the light;

— its colour rendering capabilities, which affect the colour appearance of objects and persons.

These two attributes shall be considered separately.

#### 4.7.2 Colour appearance

The colour appearance of a light source refers to the apparent colour (chromaticity) of the light emitted. It is quantified by its correlated colour temperature ( $T_{CP}$ ).

Colour appearance of daylight varies throughout the day.

Colour appearance of artificial light can also be described as in Table 4.

**Table 4 — Light source colour appearance groups**

Colour appearance	Correlated colour temperature $T_{CP}$
warm	below 3 300 K
intermediate	3 300 to 5 300 K
cool	above 5 300 K

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

For the physiological impact of spectral distribution and colour temperature change see Annex C. Careful consideration is necessary, especially in the case of night shift work.

In Clause 6, for specific applications a restricted band of suitable colour temperatures is given. These are applicable for daylighting as well as artificial lighting.

#### 4.7.3 Colour rendering

For visual performance and the feeling of comfort and well-being colours in the environment, of objects and of human skin, shall be rendered with sufficient accuracy according to the task requirements given in clause 6.

To provide an objective indication of the colour rendering properties of a light source the general colour rendering index  $R_a$  is used. The maximum value of  $R_a$  is 100.

The minimum value of colour rendering index for distinct types of task and activity areas within a space are given in clause 6.

Safety colours according to ISO 3864-1 shall always be recognizable as such.

NOTE Colour rendering properties of light from a light source can be influenced by optics, glazing and coloured surfaces.

For accurate rendition of colours of objects and human skin the appropriate individual special colour rendering index ( $R_i$ ) should be considered.

### 4.8 Flicker and stroboscopic effects

#### 4.8.1 General

Flicker and stroboscopic effect (also called temporal lighting artefacts - TLA) can lead to undesired effects such as reducing visual comfort and reducing task performance and can lead to physiological effects such as fatigue or headaches.

Stroboscopic effects can also lead to dangerous situations by changing the perceived motion of rotating or reciprocating machinery. This is, however, outside of the scope of this standard.

Lighting systems should be designed to avoid the negative effects of flicker and stroboscopic effect. Background information and methods to objectively quantify these effects can be found in CIE TN 006:2016.

#### **4.8.2 Flicker**

Flicker is specified by using the IEC short-term flicker indicator ( $P_{st}$ ) and test method as described in IEC TR 61547-1:2015.

To prevent adverse direct perception of flicker, recommend limits can be found in, e.g. IEC TR 61547-1 and EN 61000-3-3.

#### **4.8.3 Stroboscopic effect**

Stroboscopic effect perceived by individuals in indoor work places executing typical tasks, can be objectively quantified using the Stroboscopic Effect Visibility Measure (SVM). The SVM can be used to quantify the visibility of this effect for applications where human motion is dominant and  $\bar{E} > 100$  lx. Limits for this measure are application dependent and currently under consideration.

NOTE SVM is not suitable to quantify the effects of lighting on rotating or reciprocating machinery as described in 4.8.1.

### **4.9 Lighting of work stations with Display Screen Equipment (DSE)**

#### **4.9.1 General**

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

For these areas the lighting criteria and system shall be chosen in accordance with type of task or activity area, from the schedule in Clause 6.

Reflections in DSE and, in some circumstances, reflections from the keyboard can cause disability and discomfort glare. It is therefore necessary to select, locate and arrange the luminaires to avoid high brightness reflections.

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

#### **4.9.2 Luminaire luminance limits with downward flux**

Light can lower the contrast of the presentation on DSE by:

- veiling reflection caused by the illuminance on the display surface and
- luminances from luminaires and bright surfaces reflecting in the display.

EN ISO 9241-307 gives requirements for the visual qualities of displays concerning unwanted reflections.

This subclause describes luminance limits for luminaires which can be reflected in DSE for normal viewing directions.

Table 5 gives the limits of the average luminaire luminance at elevation angles of 65° and above from the downward vertical, radially around the luminaires, for work stations where display screens which are vertical or inclined up to 15° tilt angle are used.

**Table 5 — Average luminance limits of luminaires, which can be reflected in flat screens**

Screen high state luminance	High luminance screen $L > 200 \text{ cd}\cdot\text{m}^{-2}$	Medium luminance screen $L \leq 200 \text{ cd}\cdot\text{m}^{-2}$
Case A (positive polarity and normal requirements concerning colour and details of the shown information, as used in office, education, etc.)	$\leq 3\,000 \text{ cd}\cdot\text{m}^{-2}$	$\leq 1\,500 \text{ cd}\cdot\text{m}^{-2}$
Case B (negative polarity and/or higher requirements concerning colour and details of the shown information, as used for CAD colour inspection, etc.)	$\leq 1\,500 \text{ cd}\cdot\text{m}^{-2}$	$\leq 1\,000 \text{ cd}\cdot\text{m}^{-2}$
NOTE Screen high state luminance (see EN ISO 9241-302) describes the maximum luminance of the white part of the screen and this value is available from the manufacturer of the screen.		

If a high luminance screen is intended to be operated at luminances below  $200 \text{ cd}\cdot\text{m}^{-2}$  the conditions specified for a medium luminance screen shall be considered.

Some tasks, activities or display screen technologies, particularly high gloss screens, require different lighting treatment (e.g. lower luminance limits, special shading, individual dimming, etc.).

In areas of industrial activities and crafts screens are sometimes protected by additional front glasses. The unwanted reflections on these protection glasses have to be reduced by suitable methods (such as anti-reflection treatment, tilting of the protection glass or by shutters).

## 5 Lighting design considerations

### 5.1 General

In addition to the base requirements as found in Clause 4, the following additional aspects should be taken into account for the lighting design:

- Recommended illuminance requirements
- Operation of the lighting system
- Energy efficiency requirements
- Variability of light

Examples for the application of the processes described in 5.2 are given in Annex D.

### 5.2 Illuminance requirements and recommendations

#### 5.2.1 General

To allow for a larger variety in application requirements, Clause 6 provides both the required illuminance values which shall be met at all times ( $\bar{E}_{m,r}$ ) but also a recommended value providing a more adequate lighting level for more strenuous working conditions.

### 5.2.2 Lighting of the task or activity area and its immediate surrounding area (see 4.3.1)

The following steps shall be followed in selecting the appropriate lighting criteria for the task or activity area and immediate surrounding area:

1. Determine the appropriate task or activity which is executed in the area. Note that the task or activity area may be horizontal, vertical or inclined, and multiple tasks or activities may take place in the same area (consult 4.3.3 for guidance).
2. Select the "task or activity related requirements" from the tables in 6.3 ( $\bar{E}_{m,r}$ ,  $U_o$ ,  $R_a$ ,  $R_{UGL}$ ). For areas with multiple tasks the most onerous requirements shall be used for design (see 4.3.3).
3. Based on the range of illuminances between  $E_{m,r}$  and  $E_{m,u}$  select the appropriate task or activity requirement ( $\bar{E}_m$ ) e.g. the specific context modifiers as specified in 4.3.3 or 5.6.

It is recommended to design higher illuminances by up to two steps than the minimum maintained value on the task area ( $\bar{E}_{m,r}$ ) to allow adjustment of the illuminance on the task to cater for higher visual performance and user satisfaction during different times of operation. Dimmable lighting provides flexibility. When the task or activity is not being performed, or an activity of less visual difficulty is being performed, lower light levels can be employed using dimming or switching if appropriate. Further information is contained in CIE 222 and CIE 227.

4. Select the appropriate illuminance requirements for the immediate surrounding area and background area based upon the  $\bar{E}_m$  selection in step 3 and Table 1 (see 4.3.4 and 4.3.5)

### 5.2.3 Lighting of the space

To enhance the visual appearance and brightness impression of the room and space and good visual communication and recognition of objects, the following steps shall be followed:

1. Determine the relevant room surfaces around the workplaces (the walls and ceiling).
2. Select the requirements for "objects and people" and for "room brightness" from the tables in 6.3 ( $\bar{E}_z$ ,  $\bar{E}_{m,wall}$ ,  $\bar{E}_{m,ceiling}$ ) based on all selected tasks and activities in 5.2.2 steps 1 and 2. If different requirements apply select the highest requirements to respect all specified tasks and activities.

The  $R_{UGL}$  determined by the task or activity requirements needs to be fulfilled by luminaires in the field of view within the space.

If in step 3 of 5.2.2 higher values have been selected for  $\bar{E}_m$  on the task or activity area, the wall, ceiling and cylindrical illuminance values shall also be increased by up to the same ratio (see 4.3.2. for step sizes).

### 5.2.4 Operation of the lighting system

Lighting should be adjustable to the actual user needs (see also 5.6). The system should ensure that illuminances can be achieved that meet or exceed the recommended upper maintained illuminance level using only the artificial lighting (assuming a worst case scenario without daylight contribution). Illuminance can be achieved by both daylight and artificial lighting or any combination of the two.

An adjustable system ensures that:

- The benefit of available daylight is maximized
- Occupancy of the space can be taken into account
- Changes of visual tasks can be catered for
- Changes of occupants, occupant preferences or needs can be catered for

This standard recommends the use of the upper design values to give the user the full use of the lit environment. Designing a basic lighting installation only fulfilling the minimum criteria limits the possible benefits of good lighting quality.

### 5.3 Maintenance factor

The lighting scheme shall be designed taking into account an overall maintenance factor ( $f_m$ ) calculated for the selected lighting equipment, environment and specified maintenance schedule according to ISO/CIE TS 22012.

The illuminance requirements for each task as specified in Clause 6 are given as maintained illuminance ( $E_m$ ) values. The initial illuminance  $E_{in}$  may be calculated from  $E_m$  as follows:

$$E_{in} = \frac{E_m}{f_m} \quad (2)$$

where

$E_m$  is maintained illuminance

$E_{in}$  is initial illuminance

$f_m$  is maintenance factor

The designer shall:

- state the  $f_m$  and list all assumptions made in the derivation of the value,
- specify lighting equipment suitable for the application environment and
- prepare a maintenance schedule to include e.g. frequency of light source replacement, luminaire and room cleaning intervals.

The  $f_m$  has a large impact on energy efficiency. The assumptions made in the derivation of the  $f_m$  shall be both realistically achievable and optimized in a way that leads to a high value.

**Note 1** Guidance on the determination of the maintenance factor can be found in ISO/CIE TS 22012 and further information on the derivation of  $f_m$  for artificial indoor lighting systems can be found in CIE 97.

**Note 2** For daylight calculations, reduction of transmittance of daylight openings due to dirt deposition should be taken into account.

### 5.4 Energy efficiency requirements

Lighting should be designed to meet the lighting requirements of a particular task, activity or space in an energy efficient manner. It is important not to compromise the visual aspects of a lighting installation simply to reduce energy consumption. Least maintained illuminance levels as set in this European Standard are minimum values and need to be maintained.

Energy savings can be made by harvesting daylight, responding to occupancy patterns, improving maintenance characteristics of the installation, and making full use of controls.

Daylight can supply all or part of the light needed for visual tasks or activities, and therefore offers potential energy savings. The amount of daylight indoors depends firstly on the availability of daylight outside (i.e. the prevailing climate at the site) and, thereafter, the environment surrounding the building, the components immediately around the daylight opening and the configuration of the interior spaces. With a near vertical daylight opening in the façade, the daylight availability decreases rapidly with the distance from the façade. Supplementary lighting (e.g. electric light or additional daylight

openings) may be needed to ensure the required illuminance levels at the work station are achieved and to balance the luminance distribution within the room. Automatic or manual switching and/or dimming can be used to ensure appropriate integration between artificial lighting and daylight.

A procedure for the estimation of the energy requirements of a lighting installation is given in EN 15193-1. It gives a methodology for the calculation of a lighting energy numeric indicator (LENI), representing the energy performance of lighting within buildings. This indicator may be used for single rooms on a comparative basis only, as the benchmark values given in the CEN/TR 15193-2 are drawn up for some types of room or application areas. EN 15193-1 provides a simplified method for calculating the potential energy savings of daylight. For a more comprehensive method EN 17037 defines metrics, gives principles of calculation and verification, with respect to using daylight to provide lighting within interiors.

## **5.5 Additional benefits of daylight**

Daylight can provide significant quantities of light indoors, with high colour rendering and variability in level, direction and spectral composition throughout the day and season. Daylight openings in a vertical, inclined or horizontal surface are strongly favoured in work places for the light they deliver, and for the visual contact they provide with the outside environment. Additionally, daylight provides variable modelling and luminance patterns, which is also perceived as being beneficial for people in indoor working environments. For any space with daylight openings, it is recommended to use shading devices to reduce risk of glare or thermal discomfort, and direct view to the sun or a reflection of it should be avoided. Note that glare caused by daylight differs from glare caused by artificial light sources regarding size of the glare sources, complexity of luminance distribution and acceptance of the users.

## **5.6 Variability of light**

Light is important to people's health and wellbeing. Light affects the mood, emotion and mental alertness of people. It can also support and adjust the circadian rhythms and influence people's physiological and psychological state. Varying illuminances in time and season (with values higher or temporarily lower than specified in this standard) and varying in colour temperature can enhance people's wellbeing. Up to date research indicates that these phenomena, in addition to the lighting design criteria defined in EN 12464-1, can be provided by the so-called "non-image forming" illuminances and colour appearance of light, as described in CEN/TR 16791:2017. The non-image-forming effects will depend on quantity and time of light exposure, spectral power distribution, duration of exposure, and individual parameters like circadian phase, light history, and others. These objectives can be achieved with daylight and electric lighting solutions.

More information about non-image forming aspects can be found in Annex C.

When varying lighting (e.g. using personal control) it is possible that lighting requirements (as stated in the tables in 6.3) are no longer met. However, the values from the tables in 6.3 shall always be achievable.

**NOTE** Variability of light is important in spaces that are occupied for extended periods. Examples are classrooms, offices and productions spaces.

## **5.7 Room brightness**

An indication of perceived room brightness in spaces where visual tasks or activities are carried out is given by illuminances on walls and the ceiling. Values are given in the tables in 6.3. In situations where the consideration of  $\bar{E}_{m,wall}$  and  $\bar{E}_{m,ceiling}$  is not appropriate, no values are given.

Additional indications of perceived room brightness are explained in Annex C.

## 6 Schedule of lighting requirements

### 6.1 Composition of the tables

**For the application of the tables in 6.3, see Clause 5: Design considerations**

**Column 1** lists the **reference** number for each task or activity area.

**Column 2** lists those **tasks or activities areas**, for which specific requirements are given. If the particular task or activity is not listed, the values given for a similar, comparable situation should be adopted. Task or activity areas can also be a room, e.g. a corridor or resting room.

**Column 3** gives the **minimum maintained illuminance**  $\bar{E}_{m,r}$  on the reference surface (see 4.3) for the interior (area) in which the task or activity from Column 2 is performed.

**Column 4** gives the **upper maintained illuminance**  $\bar{E}_{m,u}$  on the reference surface (see 4.3) for the interior (area) in which the task or activity from Column 2 is performed.

NOTE 1 The maintained illuminance  $\bar{E}_m$  is chosen in the limits of  $\bar{E}_{m,r}$  and  $\bar{E}_{m,u}$  as described in Clause 5.

NOTE 2 Lighting control can be required to achieve adequate flexibility for the variety of tasks performed.

**Column 5** gives the **minimum illuminance uniformity**  $U_o$  on the reference surface for the maintained illuminance  $\bar{E}_m$  chosen according to Note 1.

**Column 6** gives the **minimum colour rendering indices** ( $R_a$ ) (see 4.7.3) for the situation listed in Column 2.

**Column 7** gives the **maximum UGR limits** (Unified Glare Rating limit,  $R_{UGL}$ ) that are applicable to the situation listed in Column 2.

**Column 8** gives the **minimum cylindrical illuminance**  $\bar{E}_Z$  for the recognition of objects and people as described in clause 5

**Column 9** gives the **minimum average illuminance on walls**  $\bar{E}_{m,wall}$  as described in Clause 5

**Column 10** gives the **minimum average illuminance on ceilings**  $\bar{E}_{m,ceiling}$  as described in Clause 5

**Column 11** gives **specific requirements** for the situations listed in Column 2.

## **6.2 Schedule of task and activity areas**

Table 6.1 — Traffic zones inside buildings

Table 6.2 — General areas inside buildings – Rest, sanitation and first aid rooms

Table 6.3 — General areas inside buildings – Control rooms

Table 6.4 — General areas inside buildings – Store rooms, cold stores

Table 6.5 — General areas inside buildings – Storage rack areas

Table 6.6 — Industrial activities and crafts – Agriculture

Table 6.7 — Industrial activities and crafts – Bakeries

Table 6.8 — Industrial activities and crafts – Cement, cement goods, concrete, bricks

Table 6.9 — Industrial activities and crafts – Ceramics, tiles, glass, glassware

Table 6.10 — Industrial activities and crafts – Chemical, plastics and rubber industry

Table 6.11 — Industrial activities and crafts – Electrical and electronic industry

Table 6.12 — Industrial activities and crafts – Food stuffs and luxury food industry

Table 6.13 — Industrial activities and crafts – Foundries and metal casting

Table 6.14 — Industrial activities and crafts – Hairdressers

Table 6.15 — Industrial activities and crafts – Jewellery manufacturing

Table 6.16 — Industrial activities and crafts – Laundries and dry cleaning

Table 6.17 — Industrial activities and crafts – Leather and leather goods

Table 6.18 — Industrial activities and crafts – Metal working and processing

Table 6.19 — Industrial activities and crafts – Paper and paper goods

Table 6.20 — Industrial activities and crafts – Power stations

Table 6.21 — Industrial activities and crafts – Printers

Table 6.22 — Industrial activities and crafts – Rolling mills, iron and steel works

Table 6.23 — Industrial activities and crafts – Textile manufacture and processing

Table 6.24 — Industrial activities and crafts – Vehicle construction and repair

Table 6.25 — Industrial activities and crafts – Wood working and processing

Table 6.26 — Offices

Table 6.27 — Retail premises

Table 6.28 — Places of public assembly – General areas

Table 6.29 — Places of public assembly – Restaurants and hotels

Table 6.30 — Places of public assembly – Theatres, concert halls, cinemas, places for entertainment

Table 6.31 — Places of public assembly – Trade fairs, exhibition halls

Table 6.32 — Places of public assembly – Museums

Table 6.33 — Places of public assembly – Libraries

Table 6.34 — Places of public assembly – Public car parks (indoor)

Table 6.35 — Educational premises – Nursery school, play school

Table 6.36 — Educational premises – Educational buildings

Table 6.37 — Health care premises – Rooms for general use

Table 6.38 — Health care premises – Staff rooms

Table 6.39 — Health care premises – Wards, maternity wards

Table 6.40 — Health care premises – Examination rooms (general)

Table 6.41 — Health care premises – Eye Examination rooms

Table 6.42 — Health care premises – Ear Examination rooms

Table 6.43 — Health care premises – Scanner rooms

Table 6.44 — Health care premises – Delivery rooms

Table 6.45 — Health care premises – Treatment rooms (general)

Table 6.46 — Health care premises – Operating areas

Table 6.47 — Health care premises – Intensive care unit

Table 6.48 — Health care premises – Dentists

Table 6.49 — Health care premises – Laboratories and pharmacies

Table 6.50 — Health care premises – Decontamination rooms

Table 6.51 — Health care premises – Autopsy rooms and mortuaries

Table 6.52 — Transportation areas – Airports

Table 6.53 — Transportation areas – Railway installations

Table 6.54 — Logistics and warehouses

### 6.3 Lighting requirements for task and activity areas

The requirements for task and activity areas are given in Tables 6.1 to 6.54. The columns are understood as shown in Table 6.0.

The requirements for the specific tasks and activities are given by  $\bar{E}_{m,r}$ ,  $\bar{E}_{m,u}$ ,  $U_o$ ,  $R_a$  and  $R_{UGL}$ . The requirements for the space in which the task(s) or activities are carried out are given by  $\bar{E}_z$  for the perception of objects and people within this space and  $\bar{E}_{m,wall}$  and  $\bar{E}_{m,ceiling}$  for room brightness. The latter are used for designing the room and the space including  $R_{UGL}$ . Glare (by  $R_{UGL}$ ) is dedicated to the space in which a task is carried out. The first four columns are used for task or activity area design and more than one of these areas may occur within one space.

This applies to column 3 to column 10 in all tables in 6.3.

**Table 6.0 — Assignment of columns to requirements**

Task or activity area design					Room or space design		
Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)	
$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx

Table 6.1 — Traffic zones inside buildings

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.1.1	Corridors and circulation areas	100	150	0,40	40	28	50	50	30	<p>Illuminance at floor level.</p> <p><math>R_a</math> and <math>R_{UGL}</math> similar to adjacent areas.</p> <p>150 lx if there are vehicles on the route.</p> <p>The lighting of exits and entrances shall provide a transition zone to avoid sudden changes in illuminance between inside and outside by day or night.</p> <p>Care should be taken to avoid glare to drivers and pedestrians</p>
6.1.2	Stairs, escalators, travolators	100	150	0,40	40	25	50	50	30	<p>Illuminance at floor level.</p> <p>Requires enhanced contrast on leading edge of the steps.</p>
6.1.3	Elevators, lifts	100	150	0,40	40	25	50	50	30	<p>Illuminance at floor level.-</p> <p>light in front of elevator, see ref.no. 6.1.3.1</p>
6.1.3.1	Area in front of lifts, elevators and escalators	200	300	0,40	40	25	75	75	50	<p>Area up to 1 m in front of lift, elevators and escalators.</p> <p>Illuminance at floor level.</p>
6.1.4	Loading ramps/bays	150	200	0,40	40	25	50	50	-	
6.1.5	Building entrance with canopy	30	50	0,40	-	-	-	-	-	

**Table 6.2 — General areas inside buildings – Rest, sanitation and first aid rooms**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.2.1	Canteens and break areas	200	500	0,40	80	22	75	75	50	
6.2.2	Resting rooms	100	200	0,40	80	22	50	50	30	
6.2.3	Rooms for physical exercise	300	500	0,40	80	22	100	100	75	
6.2.4	Cloakroom (area), washrooms, bathrooms, dressing-, lockers-, shower-, sink- and toilet areas	200	300	0,40	80	25	75	75	50	In each individual toilet if these are fully enclosed.
6.2.4.1	Facial lighting in front of mirrors	300	500	0,40	80	-	-	-	-	Vertical illuminance, 0,5 m in front of mirror at head height.
6.2.5	Sick bay	500	750	0,60	80	19	150	150	100	
6.2.6	Rooms for medical attention	500	1000	0,60	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 5\,000\text{ K}$
6.2.7	General cleaning	100	150	0,40	-	-	50	50	30	Applicable where regular cleaning is necessary.

**Table 6.3 — General areas inside buildings – Control rooms**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.3.1	Plant rooms, switch gear rooms	200	300	0,40	80	25	75	75	30	
6.3.2	Post sorting, switchboard	500	750	0,60	80	19	150	150	100	
6.3.3	Surveillance station	300	500	0,60	80	19	100	100	75	

**Table 6.4 — General areas inside buildings – Store rooms, cold stores**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.3.1	Plant rooms, switch gear rooms	200	300	0,40	80	25	75	75	30	
6.3.2	Post sorting, switchboard	500	750	0,60	80	19	150	150	100	
6.3.3	Surveillance station	300	500	0,60	80	19	100	100	75	

**Table 6.5 — General areas inside buildings – Storage rack areas**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.5.1	Gangways: unmanned	20	-	0,40	40	-	-	-	-	Illuminance at floor level.
6.5.2	Gangways: manned	150	200	0,40	60	22	50	50	30	Illuminance at floor level.
6.5.3	Control stations	150	300	0,60	80	22	75	75	50	
6.5.4	Storage rack face	200	-	0,40	60	-	-	-	-	Vertical illuminance, additional portable lighting may be used.

**Table 6.6 — Industrial activities and crafts – Agriculture**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.6.1	Loading and operating of goods, handling equipment and machinery	200	300	0,40	80	25	50	50	-	
6.6.2	Buildings for livestock	50	75	0,40	40	-	-	-	-	
6.6.3	Sick animal pens; calving stalls	200	-	0,60	80	25	50	50	-	
6.6.4	Feed preparation; dairy; utensil washing	200	-	0,60	80	25	50	50	-	

**Table 6.7 — Industrial activities and crafts – Bakeries**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.7.1	Preparation and baking	300	500	0,60	80	22	100	100	50	
6.7.2	Finishing, glazing, decorating	500	750	0,70	80	22	150	150	75	

**Table 6.8 — Industrial activities and crafts – Cement, cement goods, concrete, bricks**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.8.1	Drying	50	-	0,40	20	28	-	-	-	Safety colours shall be recognisable.
6.8.2	Preparation of materials; work on kilns and mixers	200	300	0,40	40	28	75	75	-	
6.8.3	General machine work	300	500	0,60	80	25	100	100	-	
6.8.4	Rough forms	300	500	0,60	80	25	100	100	-	

Table 6.9 — Industrial activities and crafts – Ceramics, tiles, glass, glassware

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.9.1	Drying	50	-	0,40	20	28	-	-	-	Safety colours shall be recognizable.
6.9.2	Preparation, general machine work	300	500	0,60	80	25	100	100	-	
6.9.3	Enamelling, rolling, pressing, shaping simple parts, glazing, glass blowing	300	500	0,60	80	25	100	100	-	
6.9.4	Grinding, engraving, glass polishing, shaping precision parts, manufacture of glass instruments	750	1 000	0,70	80	19	150	150	100	
6.9.5	Grinding of optical glass, crystal, hand grinding and engraving	750	1 000	0,70	80	16	150	150	100	
6.9.6	Precision work e.g. decorative grinding, hand painting	1 000	1 500	0,70	90	16	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.9.7	Manufacture of synthetic precious stones	1 500	2 000	0,70	90	16	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$

Table 6.10 — Industrial activities and crafts – Chemical, plastics and rubber industry

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.10.1	Remote-operated processing installations	50	-	0,40	20	-	-	-	-	Safety colours shall be recognisable.
6.10.2	Processing installations with limited manual intervention	150	200	0,40	40	28	50	50	30	
6.10.3	Constantly manned work stations in processing installations	300	750	0,60	80	25	100	100	50	
6.10.4	Precision measuring rooms, laboratories	500	750	0,60	80	19	150	150	75	
6.10.5	Pharmaceutical production	500	750	0,60	80	22	150	150	75	
6.10.6	Tyre production	500	750	0,60	80	22	150	150	75	
6.10.7	Colour inspection	1 000	1 500	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.10.8	Cutting, finishing, inspection	750	1 000	0,70	80	19	150	150	100	

**Table 6.11 — Industrial activities and crafts – Electrical and electronic industry**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.11.1	Cable and wire manufacture	300	500	0,60	80	25	100	100	50	
6.11.2.0	Winding:									
6.11.2.1	Winding:- large coils	300	500	0,60	80	25	100	100	50	
6.11.2.2	Winding:- medium-sized coils	500	750	0,60	80	22	150	150	75	
6.11.2.3	Winding:- small coils	750	1000	0,70	80	19	150	150	100	
6.11.3	Coil impregnating	300	500	0,60	80	25	100	100	50	
6.11.4	Galvanising	300	500	0,60	80	25	100	100	50	
6.11.5.0	Assembly work:									
6.11.5.1	- rough, e.g. large transformers	300	500	0,60	80	25	100	100	50	
6.11.5.2	- medium, e.g. switchboards	500	750	0,60	80	22	150	150	100	
6.11.5.3	- fine, e.g. telephones, radios, IT equipment (computers)	750	1 000	0,70	80	19	150	150	100	
6.11.5.4	- precision, e.g. measuring equipment, printed circuit boards	1 000	1 500	0,70	80	16	150	150	100	
6.11.6	Electronic workshops, testing, adjusting	1 500	2 000	0,70	80	16	150	150	100	

Table 6.12 — Industrial activities and crafts – Food stuffs and luxury food industry

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.12.1	Work stations and zones in: - breweries, malting floor, - for washing, barrel filling, cleaning, sieving, peeling, - cooking in preserve and chocolate factories, - work stations and zones in sugar factories, - for drying and fermenting raw tobacco, fermentation cellar	200	300	0,40	80	25	50	75	30	
6.12.2	Sorting and washing of products, milling, mixing, packing	300	500	0,60	80	25	100	100	50	
6.12.3	Work stations and critical zones in slaughter houses, butchers, dairies mills, on filtering floor in sugar refineries	500	750	0,60	80	25	150	150	75	
6.12.4	Cutting and sorting of fruit and vegetables	300	500	0,60	80	25	100	100	50	
6.12.5	Manufacture of delicatessen foods, kitchen work, manufacture of cigars and cigarettes	500	750	0,60	80	22	150	150	75	
6.12.6	Inspection of glasses and bottles, product control, trimming, sorting, decoration	500	750	0,60	80	22	150	150	100	
6.12.7	Laboratories	500	750	0,60	80	19	150	150	100	
6.12.8	Colour inspection	1 000	1 500	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$

**Table 6.13 — Industrial activities and crafts – Foundries and metal casting**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.13.1	Man-size underfloor tunnels, cellars, etc.	50	-	0,40	20	-	-	-	-	Safety colours shall be recognisable.
6.13.2	Platforms	100	-	0,40	40	25	50	50	30	
6.13.3	Sand preparation	200	300	0,40	80	25	75	75	30	
6.13.4	Dressing	200	300	0,40	80	25	75	75	30	
6.13.5	Work stations at cupola and mixer	200	300	0,40	80	25	75	75	30	
6.13.6	Casting bay	200	300	0,40	80	25	75	75	30	
6.13.7	Shake out areas	200	300	0,40	80	25	75	75	30	
6.13.8	Machine moulding	200	300	0,40	80	25	75	75	30	
6.13.9	Hand and core moulding	300	500	0,60	80	25	100	100	50	
6.13.10	Die casting	300	500	0,60	80	25	100	100	50	
6.13.11	Model building	500	750	0,60	80	22	150	150	75	

**Table 6.14 — Industrial activities and crafts – Hairdressers**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.14.1	Hairdressing	500	750	0,60	90	19	150	150	100	

**Table 6.15 — Industrial activities and crafts – Jewellery manufacturing**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.15.1	Working with precious stones	1 500	2 000	0,70	90	16	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.15.2	Manufacture of jewellery	1 000	1 500	0,70	90	16	150	150	100	
6.15.3	Watch making (manual)	1 500	2 000	0,70	80	16	150	150	100	
6.15.4	Watch making (automatic)	500	750	0,60	80	19	150	150	100	

**Table 6.16 — Industrial activities and crafts – Laundries and dry cleaning**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.16.1	Goods in, marking and sorting	300	500	0,60	80	25	100	100	50	
6.16.2	Washing and dry cleaning	300	500	0,60	80	25	100	100	50	
6.16.3	Ironing, pressing	300	500	0,60	80	25	100	100	50	
6.16.4	Inspection and repairs	750	1 000	0,70	80	19	150	150	100	

**Table 6.17 — Industrial activities and crafts – Leather and leather goods**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.17.1	Work on vats, barrels, pits	200	300	0,40	80	25	75	75	30	
6.17.2	Fleshing, skiving, rubbing, tumbling of skins	300	500	0,40	80	25	100	100	50	
6.17.3	Saddlery work, shoe manufacture: stitching, sewing, polishing, shaping, cutting, punching	500	750	0,60	80	22	150	150	100	
6.17.4	Sorting	500	750	0,60	90	22	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.17.5	Leather dyeing (machine)	500	750	0,60	80	22	150	150	100	
6.17.6	Quality control	1 000	1 500	0,70	80	19	150	150	100	
6.17.7	Colour inspection	1 000	1 500	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.17.8	Shoe making	500	750	0,60	80	22	150	150	100	
6.17.9	Glove making	500	750	0,60	80	22	150	150	100	

Table 6.18 — Industrial activities and crafts – Metal working and processing

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.18.1	Open die forging	200	300	0,60	80	25	50	50	30	
6.18.2	Drop forging	300	500	0,60	80	25	100	100	50	
6.18.3	Welding	300	500	0,60	80	25	100	100	50	
6.18.4	Rough and average machining: tolerances $\geq 0,1$ mm	300	500	0,60	80	22	100	100	50	
6.18.5	Precision machining; grinding: tolerances $< 0,1$ mm	500	750	0,70	80	19	150	150	75	
6.18.6	Scribing; inspection	750	1000	0,70	80	19	150	150	100	
6.18.7	Wire and pipe drawing shops; cold forming	300	500	0,60	80	25	100	100	50	
6.18.8	Plate machining: thickness $\geq 5$ mm	200	300	0,60	80	25	50	50	30	
6.18.9	Sheet metalwork: thickness $< 5$ mm	300	500	0,60	20	22	100	100	50	
6.18.10	Tool making; cutting equipment manufacture	750	1 000	0,70	80	19	150	150	75	
6.18.11.0	Assembly:									
6.18.11.1	- rough	200	300	0,60	60	25	50	50	30	
6.18.11.2	- medium	300	500	0,60	80	25	100	100	50	
6.18.11.3	- fine	500	750	0,60	80	22	150	150	75	
6.18.11.4	- precision	750	1 000	0,70	80	19	150	150	100	
6.18.12	Galvanizing	300	500	0,60	80	25	100	100	50	
6.18.13	Surface preparation and painting	750	1 000	0,70	80	25	150	150	100	
6.18.14	Tool, template and jig making, precision mechanics, micro-mechanics	1 000	1 500	0,70	80	19	150	150	100	

**Table 6.19 — Industrial activities and crafts – Paper and paper goods**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.19.1	Edge runners, pulp mills	200	300	0,40	80	25	75	75	30	
6.19.2	Paper manufacture and processing, paper and corrugating machines, cardboard manufacture	300	500	0,60	80	25	100	100	50	
6.19.3	Standard bookbinding work, e.g. folding, sorting, gluing, cutting, embossing, sewing	500	750	0,60	80	22	150	150	100	

**Table 6.20 — Industrial activities and crafts – Power stations**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.20.1	Fuel supply plant	50	-	0,40	20	-	-	-	-	Safety colours shall be recognizable.
6.20.2	Boiler house	100	150	0,40	40	28	50	50	30	
6.20.3	Machine halls	200	300	0,40	80	25	50	50	30	
6.20.4	Side rooms, e.g. pump rooms, condenser rooms, etc.; switchboards (inside buildings)	200	300	0,40	80	25	50	50	30	
6.20.5	Control rooms	500	1 000	0,70	80	19	150	150	100	1. Control panels are often vertical. 2. Dimming may be required. 3. DSE-work, see 4.9.

**Table 6.21 — Industrial activities and crafts – Printers**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.21.1	Cutting, gilding, embossing, block engraving, work on stones and platens, printing machines, matrix making	500	750	0,60	80	19	150	150	75	
6.21.2	Paper sorting and hand printing	500	750	0,60	80	19	150	150	75	
6.21.3	Type setting, retouching, lithography	1 000	1 500	0,70	80	19	150	150	100	
6.21.4	Colour inspection in multicoloured printing	1 500	2 000	0,70	90	16	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.21.5	Steel and copper engraving	2 000	3 000	0,70	80	16	150	150	100	For directionality, see 4.6.4.

**Table 6.22 — Industrial activities and crafts – Rolling mills, iron and steel works**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.22.1	Production plants without manual operation	50	-	0,40	20	-	-	-	-	Safety colours shall be recognisable.
6.22.2	Production plants with occasional manual operation	150	200	0,40	40	28	50	50	30	
6.22.3	Production plants with continuous manual operation	200	300	0,60	80	25	75	75	30	
6.22.4	Slab Store	50	-	0,40	20	-	-	-	-	Safety colours shall be recognizable.
6.22.5	Furnaces	200	300	0,40	20	25	75	75	30	Safety colours shall be recognizable.
6.22.6	Mill train; coiler; shear line	300	500	0,60	40	25	100	100	50	
6.22.7	Control platforms; control panels	300	500	0,60	80	22	100	100	50	
6.22.8	Test, measurement and inspection	500	750	0,60	80	22	150	150	100	
6.22.9	Underfloor man-sized tunnels; belt sections, cellars, etc.	50	-	0,40	20	-	-	-	-	Safety colours shall be recognisable.

Table 6.23 — Industrial activities and crafts – Textile manufacture and processing

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.23.1	Work stations and zones in baths, bale opening	200	300	0,60	60	25	50	50	30	
6.23.2	Carding, washing, ironing, devilling machine work, drawing, combing, sizing, card cutting, pre-spinning, jute and hemp spinning	300	500	0,60	40	22	100	100	50	
6.23.3	Spinning, plying, reeling, winding	500	750	0,60	40	22	150	150	75	Prevent stroboscopic effects.
6.23.4	Warping, weaving, braiding, knitting	500	750	0,60	60	22	150	150	75	Prevent stroboscopic effects.
6.23.5	Sewing, fine knitting, taking up stitches	750	1 500	0,70	80	22	150	150	100	
6.23.6	Manual design, drawing patterns	750	1 500	0,70	90	22	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.23.7	Finishing, dyeing	500	1 000	0,60	80	22	150	150	100	
6.23.8	Drying room	100	-	0,40	60	28	50	50	30	
6.23.9	Automatic fabric printing	500	-	0,60	90	25	100	100	50	
6.23.10	Burling, picking, trimming	1 000	1 500	0,70	80	19	150	150	100	
6.23.11	Colour inspection; fabric control	1 000	1 500	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.23.12	Invisible mending	1 500	2 000	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.23.13	Hat manufacturing	500	750	0,60	80	22	150	150	75	

Table 6.24 — Industrial activities and crafts – Vehicle construction and repair

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.24.1	Press shop - large parts	300	500	0,60	80	25	100	100	30	
6.24.2	Press shop - visual inspection	500	750	0,60	80	22	150	150	30	
6.24.3	Body work and assembly - automatic line	300	500	0,60	80	25	100	100	30	
6.24.4	Body work and assembly - manual welding	500	750	0,60	80	22	150	150	30	
6.24.5	Painting, spraying chamber, polishing chamber	750	1 000	0,70	80	22	150	150	30	
6.24.6	Painting, inspection, touch-up and polishing	1 000	1 500	0,70	90	19	150	150	30	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.24.7	Upholstery manufacture (manual)	1 000	1 500	0,70	80	19	150	150	100	
6.24.8	Detailing: - Subparts assembly (doors, dashboard, upholstery) - Underchassis assembly - Motor and mechanical assembly - Final assembly conveyor line	750	1 000	0,70	80	19	150	150	30	
6.24.9	Detailing: - work with electronics	750	1 000	0,60	90	22	150	150	30	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$ for recognition of colours
6.24.10	Final inspection	1 000	1 500	0,70	90	19	150	150	30	
6.24.11	General vehicle services, repair and testing	300	750	0,60	80	22	100	100	30	Consider local lighting.

**Table 6.25 — Industrial activities and crafts – Wood working and processing**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.25.1	Automatic processing e.g. drying, plywood manufacturing	50	-	0,40	40	28	-	-	-	
6.25.2	Steam pits	150	200	0,40	40	28	50	50	30	
6.25.3	Saw frame	300	500	0,60	60	25	100	100	50	Prevent stroboscopic effects.
6.25.4	Work at joiner's bench, gluing, assembly	300	500	0,60	80	25	100	100	50	
6.25.5	Polishing, painting, fancy joinery	750	1 000	0,70	80	22	150	150	100	
6.25.6	Work on wood working machines, e.g. turning, fluting, dressing, rebating, grooving, cutting, sawing, sinking	500	750	0,60	80	19	150	150	75	Prevent stroboscopic effects.
6.25.7	Selection of veneer woods	750	1 000	0,70	90	22	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.25.8	Marquetry, inlay work	750	1 000	0,70	90	22	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.25.9	Quality control, inspection	1 000	1 500	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$

**Table 6.26 — Offices**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.26.1	Filing, copying, etc.	300	500	0,40	80	19	100	100	75	
6.26.2	Writing, typing, reading, data processing	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.3	Technical drawing	750	1 500	0,70	80	16	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.4	CAD work stations	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9.
6.26.5.1	Conference and meeting rooms	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.5.2	Conference table	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.6	Reception desk	300	750	0,60	80	22	100	100	75	
6.26.7	Archiving	200	300	0,40	80	25	75	75	50	

**Table 6.27 — Retail premises**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.27.1	General sales area	300	750	0,40	80	22	75	75	30	Ensure sufficient vertical illuminance on shelves.
6.27.2	Till area	500	1 000	0,60	80	19	100	75	30	
6.27.3	Wrapper table	500	1 000	0,60	80	19	100	100	50	
6.27.4	Storage area	300	500	0,40	80	25	50	-	-	

**Table 6.28 — Places of public assembly – General areas**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.28.1	Entrance halls	100	200	0,40	80	22	50	50	30	$R_{UGL}$ only if applicable
6.28.2	Cloakrooms	200	300	0,40	80	25	75	75	50	
6.28.3	Lounges	200	300	0,40	80	22	75	75	50	
6.28.4	Ticket offices	300	500	0,60	80	22	75	75	50	

**Table 6.29 — Places of public assembly – Restaurants and hotels**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.29.1	Reception/cashier desk, porters desk	300	500	0,60	80	22	100	100	75	
6.29.2	Kitchen	500	1 000	0,60	80	22	100	100	75	There should be a transition zone between kitchen and restaurant.
6.29.3	Restaurant, dining room, function room	-		-	80	-	-	-	-	The lighting should be designed to create the appropriate atmosphere.
6.29.4	Self-service restaurant	200	300	0,40	80	22	75	75	50	
6.29.5	Buffet	300	500	0,60	80	22	75	75	50	
6.29.6	Conference rooms	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable. Room brightness see 5.7.
6.29.7	Corridors	100	200	0,40	80	25	50	50	30	During night-time lower levels are acceptable. Illuminance on floor level

**Table 6.30 — Places of public assembly – Theatres, concert halls, cinemas, places for entertainment**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.30.1	Practice rooms	300	500	0,60	80	22	100	100	75	
6.30.2	Dressing rooms	300	500	0,60	90	22	100	100	75	Lighting at mirrors for make-up shall be “glare-free”. Disability glare should be avoided at mirrors for make-up.
6.30.3	Seating areas – maintenance, cleaning	200	500	0,50	80	22	75	75	30	Illuminance at floor level.
6.30.4	Stage area rigging	300	500	0,40	80	25	75	75	30	Illuminance at floor level.

**Table 6.31 — Places of public assembly – Trade fairs, exhibition halls**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.31.1	General lighting	300	500	0,40	80	22	50	50	30	

**Table 6.32 — Places of public assembly – Museums**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.32.1	Exhibits, insensitive to light	-	-		80		-	-	-	Lighting is determined by the display requirements.
6.32.2	Exhibits sensitive to light				80					1. Lighting is determined by the display requirements. 2. Protection against damaging radiation is paramount.

**Table 6.33 — Places of public assembly – Libraries**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.33.1	Bookshelves	200	300	0,40	80	19	-	-	-	Vertical illuminance on shelves. For dedicated bookshelf lighting the $R_{UGL}$ value does not apply.
6.33.2	Reading area	500	750	0,60	80	19	100	100	50	Pleasant atmosphere should be achieved
6.33.3	Counters	500	750	0,60	80	19	150	150	50	
6.33.4	General lighting	300	500	0,40	80	22	75	75	50	

**Table 6.34 — Places of public assembly – Public car parks (indoor)**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.34.1	Entry/exit ramps (during daylight hours)	300	500	0,40	40	25	75	75	50	1. Illuminance level to extend 5 m into parking floor 2. Illuminances at floor level.
6.34.2	Entry/exit ramps (at night)	75	100	0,40	40	25	50	50	30	1. Illuminances at floor level.
6.34.3	Traffic lanes, internal ramps and pedestrian paths	75	100	0,40	40	25	50	50	30	1. Illuminances at floor level. 2. A high vertical illuminance increases recognition of people's faces and therefore the feeling of safety.
6.34.4	Parking areas	75	100	0,40	40	-	50	30	15	1. Illuminances at floor level. 2. A high vertical illuminance increases recognition of people's faces and therefore the feeling of safety.
6.34.5	Ticket office	300	500	0,60	80	19	75	75	50	1. Reflections in the windows shall be avoided. 2. Glare from outside shall be prevented.

Table 6.35 — Educational premises – Nursery school, play school

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.35.1	Play room	300	500	0,40	80	22	100	100	75	High luminances should be avoided in viewing directions from below by use of diffuse covers.
6.35.2	Nursery	300	500	0,40	80	22	100	100	75	High luminances should be avoided in viewing directions from below by use of diffuse covers.
6.35.3	Handicraft room	300	500	0,60	80	19	100	100	75	

**Table 6.36 — Educational premises – Educational buildings**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.36.1	Classroom - General activities in primary schools	300	750	0,60	80	19	100	100	75	If activities in a class room are not completely clear in the design phase these general activities shall be taken. Lighting should be controllable. Room brightness see 5.7
6.36.2	Classroom - General activities in secondary schools and higher	500	1 000	0,60	80	19	150	150	100	If activities in a class room are not completely clear in the design phase these general activities shall be taken. Lighting should be controllable, Room brightness see 5.7
6.36.3.1	Auditorium, lecture halls	500	750	0,60	80	19	150	150	50	Lighting should be controllable to accomodate various A/V needs, Room brightness see 5.7
6.36.3.2	Attending lecture in seating areas in auditoriums and lecture halls	200	300	0,60	80	19	75	75	50	Reduction by dimming. DSE-work, see 4.9.
6.36.4.1	Black, green and white boards	500	750	0,70	80	19	150	150	100	Vertical illuminances. Specular reflections shall be prevented. Presenter/teacher shall be illuminated with suitable vertical illuminance.

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.36.4.2	Black, green and white boards in auditorium and lecture halls	500	750	0,60	80	19	150	150	50	Specular reflections shall be prevented
6.36.4.3	Projector and smartboard presentation	-		-	-	-				1. Lighting should be controllable. 2. Specular reflections shall be prevented. 3. 200 lx vertically behind (around) screen. 4. Direct lighting on screen when displaying content shall be avoided
6.36.4.4	Display board	200	300	0,60	80	19	150	150	100	Vertical illuminances
6.36.5.1	Demonstration table in classrooms	500	750	0,70	80	19	100	100	75	
6.36.5.2	Demonstration table in auditoriums and lecture halls	750	1 000	0,70	80	19	150	150	75	
6.36.5.3	Light on teacher / presenter				80		150			At 1,6 m above the floor. Suitable vertical illuminance.
6.36.5.4	Light on podium area	300	500	0,70	80		-	-	-	Illuminance should be vertical in direction of audience, Lighting should be controllable to accommodate various A/V needs.
6.36.5.5	Computer work only	300	500	0,60	80	19	100	100	75	DSE-work, see 4.9. Lighting should be controllable. Room brightness, see 5.7

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.36.6	Art rooms	500	750	0,60	80	19	150	150	100	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7.
6.36.7	Art rooms in art schools	750	1 000	0,70	90	19	150	150	100	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7. $4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$
6.36.8	Technical drawing rooms	750	1 000	0,60	80	19	150	150	100	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7.
6.36.9	Practical rooms and laboratories	500	750	0,60	80	19	150	150	100	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7.
6.36.10	Handcraft rooms	500	750	0,60	80	19	150	100	100	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7.

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.36.11	Teaching workshop	500	750	0,60	80	19	150	150	100	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7.
6.36.12	Music practice rooms	300	500	0,60	80	19	100	100	50	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7.
6.36.13	Computer practice rooms (menu driven)	300	500	0,60	80	19	100	100	75	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7. DSE-work, see 4.9.
6.36.14	Language laboratory	300	500	0,60	80	19	100	100	50	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7.
6.36.15	Preparation rooms and workshops	500	750	0,60	80	22	150	150	100	Lighting should be controllable. Ambient light should be considered, see Annex C, room brightness see 5.7..
6.36.16	Entrance halls	200	300	0,40	80	22	75	75	50	
6.36.17	Circulation areas, corridors	100	150	0,40	80	25	50	50	30	Horizontal illuminance floor level.

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.36.18	Stairs	150	200	0,40	80	25	50	50	30	Horizontal illuminance at floor level.
6.36.19	Student common rooms and assembly halls	200	300	0,40	80	22	75	75	50	
6.36.20	Teachers rooms	300	500	0,60	80	19	100	100	50	For office work see 5.26.
6.36.21	Library: bookshelves	200	300	0,60	80	19	-	-	-	Vertical illuminance on shelves. For dedicated bookshelves lighting the $R_{UGL}$ value does not apply.
6.36.22	Library: reading areas	500	750	0,60	80	19	100	100	50	See library 5.33
6.36.23	Stock rooms for teaching materials	100	150	0,40	80	25	50	50	30	
6.36.24	Sports halls, gymnasiums, swimming pools	300	500	0,60	80	22	100	75	30	See EN 12193 for training conditions.
6.36.25	School canteens	200	300	0,40	80	22	75	75	50	
6.36.26	Kitchen	500	750	0,60	80	22	100	100	75	

Table 6.37 — Health care premises – Rooms for general use

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
										Too high luminances in the patients' visual field shall be prevented.
6.37.1	Waiting rooms	200	300	0,40	80	22	75	75	30	
6.37.2	Corridors: during the day	100	200	0,40	80	22	50	50	30	Illuminance at floor level.
6.37.3	Corridors: cleaning	100	200	0,40	80	22	50	50	30	Illuminance at floor level.
6.37.4	Corridors: during the night	50	-	0,40	80	22	-	-	-	Illuminance at floor level.
6.37.5	Corridors with multi-purpose use (e.g. preexamination of patients)	200	300	0,60	80	22	75	75	50	Illuminance at task/activity level.
6.37.6	Day rooms	200	500	0,60	80	22	75	75	50	
6.37.7	Elevators, lifts for persons and visitors	100	200	0,60	80	22	50	50	30	Illuminance at floor level.
6.37.8	Service lifts	200	300	0,60	80	22	75	75	50	Illuminance at floor level.

Table 6.38 — Health care premises – Staff rooms

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.38.1	Staff office	500	1 000	0,60	80	19	150	150	100	
6.38.2	Staff rooms	300	750	0,60	80	19	100	100	50	

Table 6.39 — Health care premises – Wards, maternity wards

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.39.0										Too high luminances in the patients' visual field shall be prevented.
6.39.1	General lighting	100	200	0,40	80	19	50	50	30	Illuminance at floor level. Lighting for the walls should be controllable. Room brightness, see 5.7.
6.39.2	Reading lighting	300	750	0,70	80	19	100	100	75	lighting should be controllable and limited to each bed
6.39.3	Wards - Simple examinations	300	500	0,60	80	19	100	100	75	For normal examination and special treatment see also tables 5.40-5.51.
6.39.4	Examination and treatment	1 000	1 500	0,70	90	19	150	150	100	Room brightness, see 5.7, should be considered. Lighting should be controllable.
6.39.5	Night lighting, observation lighting	5		-	80	-				$2\,200\text{ K} \leq T_{CP} \leq 3\,000\text{ K}$ Illuminance at floor level.
6.39.6	Bathrooms and toilets for patients	200	300	0,40	90	22	75	75	50	Lower colour temperature for night lighting should be considered.

**Table 6.40 — Health care premises – Examination rooms (general)**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.40.1	General lighting	500	750	0,60	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 5\,000\text{ K}$
6.40.2	Examination and treatment	1 000	1 500	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 5\,000\text{ K}$

**Table 6.41 — Health care premises – Eye Examination rooms**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.41.1	General lighting	500	750	0,60	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 5\,000\text{ K}$
6.41.2	Examination of the outer eye	1 000	1 500	-	90	-	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 5\,000\text{ K}$
6.41.3	Reading and colour vision tests with vision charts	500	750	0,70	90	16	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$

**Table 6.42 — Health care premises – Ear Examination rooms**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.42.1	General lighting	500	750	0,60	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 5\,000\text{ K}$
6.42.2	Ear examination	1 000	1 500	-	90	-	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 5\,000\text{ K}$

**Table 6.43 — Health care premises – Scanner rooms**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.43.1	General lighting	300	500	0,60	80	19	100	100	75	
6.43.2	Scanners with image enhancers and television systems	50	-	-	80	19	-	-	-	DSE-work, see 4.9.

**Table 6.44 — Health care premises – Delivery rooms**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.44.1	General lighting	300	500	0,60	90	19	100	100	75	
6.44.2	Examination and treatment	1 000	1 500	0,70	90	19	150	150	100	

**Table 6.45 — Health care premises – Treatment rooms (general)**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.45.1	Dialysis	500	750	0,60	80	19	150	150	100	Lighting should be controllable.
6.45.2	Dermatology	500	750	0,60	90	19	150	150	100	
6.45.3	Endoscopy	300	500	0,60	80	19	100	100	75	
6.45.4	Plastering	500	750	0,60	80	19	150	150	100	
6.45.5	Medical baths	300	500	0,60	80	19	100	100	75	
6.45.6	Massage and radiotherapy	300	500	0,60	80	19	100	100	75	

**Table 6.46 — Health care premises – Operating areas**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.46.1	Pre-op and recovery rooms	500	750	0,60	90	19	150	150	100	
6.46.2	Operating cavity surround	1 000	1 500	0,60	90	19	150	150	100	
6.46.2	Operating theatre	1 000	1 500	0,60	90	19				
6.46.3	Operating cavity			-	90					Specific requirements are given in EN 60601-2-41:2009/A11:2011

**Table 6.47 — Health care premises – Intensive care unit**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.47.1	General lighting	100	150	0,60	90	19	50	50	30	Illuminance at floor level.
6.47.2	Simple examinations	300	500	0,60	90	19	100	100	75	Illuminance at bed level.
6.47.2	Examination and treatment	1000	1500	0,70	90	19	150	150	100	Illuminance at bed level.
6.47.3	Night watch	20	-	-	90	19	-	-	-	Color temperature should be considered.

**Table 6.48 — Health care premises – Dentists**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.48.1	General lighting	500	750	0,60	90	19	150	150	100	Lighting should be glare-free for the patient.
6.48.2	At the patient	1 000	1 500	0,70	90	-	150	150	100	
6.48.3	Operating cavity	-	-	-	-	-				Specific requirements are given in EN ISO 9680.
6.48.4	White teeth matching	-	-	-	-	-				Specific requirements are given in EN ISO 9680.

**Table 6.49 — Health care premises – Laboratories and pharmacies**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.49.1	General lighting	500	750	0,60	80	19	150	150	100	
6.49.2	Colour inspection	1 000	1 500	0,70	90	19	150	150	100	$4\,000\text{ K} \leq T_{CP} \leq 6\,500\text{ K}$

**Table 6.50 — Health care premises – Decontamination rooms**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.50.1	Sterilisation	300	500	0,60	80	22	100	100	75	
6.50.2	Disinfection	300	500	0,60	80	22	100	100	75	

**Table 6.51 — Health care premises – Autopsy rooms and mortuaries**

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.51.1	General lighting	500	750	0,60	90	19	150	150	100	
6.51.2	Autopsy table and dissecting table	5 000	7 500	0,70	90	-	150	150	100	Values higher than 5 000 lx may be required.

Table 6.52 — Transportation areas – Airports

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.52.1	Arrival and departure halls, baggage claim areas	200	300	0,40	80	22	75	75	30	
6.52.2	Connecting areas	150	200	0,40	80	22	50	50	30	
6.52.3	Information desks, check-in desks	500	750	0,70	80	19	150	150	100	DSE-work, see 4.9.
6.52.4	Customs and passport control desks	500	750	0,70	80	19	150	150	100	Facial recognition has to be provided.
6.52.5	Waiting areas	200	300	0,40	80	22	50	50	30	
6.52.6	Luggage storage rooms	200	300	0,40	80	25	50	50	30	
6.52.7	Security check areas	300	500	0,60	80	19	100	100	75	DSE-work, see 4.9.
6.52.8	Air traffic control tower	500	750	0,60	80	16	50	-	-	1. Lighting should be dimmable. 2. DSE-work, see 4.9. 3. Glare from daylight shall be avoided. 4. Reflections in windows, especially at night shall be avoided.
6.52.9	Tasks in hangars: - Testing and repair areas - Engine test areas - Measuring areas	500	750	0,60	80	22	50	50	30	

Table 6.53 — Transportation areas – Railway installations

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.53.1.1	Fully enclosed platforms, small number of passengers	50	-	0,30	80	-	-	-	-	1. Special attention to the edge of the platform <sup>a</sup> . 2. Avoid glare for vehicle drivers <sup>b</sup> and passengers <sup>c</sup> . 3. Illuminance at floor level in reference area.
6.53.1.2	Fully enclosed platforms, medium number of passengers	100	-	0,40	80	-	-	-	-	1. Special attention to the edge of the platform <sup>a</sup> . 2. Avoid glare for vehicle drivers <sup>b</sup> and passengers <sup>c</sup> . 3. Illuminance at floor level in reference area.
6.53.1.3	Fully enclosed platforms, large number of passengers	200	-	0,50	80	-	-	-	-	1. Special attention to the edge of the platform <sup>a</sup> . 2. Avoid glare for vehicle drivers <sup>b</sup> and passengers <sup>c</sup> . 3. Illuminance at floor level in reference area.
6.53.2.1	Fully enclosed passenger subways (underpasses), small number of passengers	50	-	0,30	80	-	<sup>4)</sup>	-	-	1. Avoid glare for passengers <sup>c</sup> . 2. Illuminance at floor level in reference area. 3. In case of high reflecting enclosure surfaces the average illuminance level can be reduced by 50 %. 4. $E_v / E_h = 0,2$ .

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_0$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.53.2.2	Fully enclosed passenger subways (underpasses), medium number of passengers	100	-	0,40	80	-	4)	-	-	1. Avoid glare for passengers <sup>c</sup> . 2. Illuminance at floor level in reference area. 3. In case of high reflecting enclosure surfaces the average illuminance level can be reduced by 50 %. 4. $E_v / E_h = 0,2$ .
6.53.2.3	Fully enclosed passenger subways (underpasses), large number of passengers	200	-	0,50	80	-	4)	-	-	1. Avoid glare for passengers <sup>c</sup> . 2. Illuminance at floor level in reference area. 3. In case of high reflecting enclosure surfaces the average illuminance level can be reduced by 50 %. 4. $E_v / E_h = 0,2$ .
6.53.3.1	Stairs, escalators, small number of passengers	50	-	0,30	80	-	-	-	-	1. Avoid glare for passengers <sup>c</sup> . 2. Special attention to landings.
6.53.3.2	Stairs, escalators, medium number of passengers	100	-	0,40	80	-	-	-	-	1. Avoid glare for passengers <sup>c</sup> . 2. Special attention to landings.
6.53.3.3	Stairs, escalators, large number of passengers	200	-	0,50	80	-	-	-	-	1. Avoid glare for passengers <sup>c</sup> . 2. Special attention to landings.

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.53.4	Ticket hall and concourse	200	300	0,50	80	-	75	75	50	Illuminance at floor level in reference area
6.53.5	Ticket counters and luggage offices	300	500	0,50	80	19	100	100	75	Illuminance in task areas
6.53.6	Waiting rooms	200	300	0,40	80	22	75	75	30	
6.53.7	Entrance halls, station halls	200	300	0,40	80	-	75	75	30	
6.53.8	Switch and plant rooms	200	300	0,50	80	16	75	75	30	Illuminance in task areas (horizontal, vertical, inclined), individually dimmable in task areas.
6.53.9	Access tunnels	50	75	0,40	20	-	-	-	-	Illuminance at floor level.
6.53.10.1	Assembly work in maintenance sheds - rough	200	-	0,40	80	-	-	-	-	Avoid glare for personnel <sup>c</sup> .
6.53.10.2	Assembly work in maintenance sheds - medium	300	-	0,50	80	-	-	-	-	Avoid glare for personnel <sup>c</sup> .
6.53.10.3	Assembly work in maintenance sheds - fine	500	-	0,60	80	-	-	-	-	Avoid glare for personnel <sup>c</sup> .
6.53.10.4	Assembly work in maintenance sheds - precision	750	-	0,70	80	-	-	-	-	Avoid glare for personnel <sup>c</sup> .

<sup>a</sup> Average illuminance in a strip of 1 m width along platform edge shall be a minimum of 50 % of the average platform illuminance.

<sup>b</sup> TI < 15% for relevant positions and viewing directions of vehicle drivers based on an adaption luminance of 10% of the average platform luminance (see EN 13201-2).

<sup>c</sup> Limitation of the luminous flux density of the luminaire luminous areas: 1 000 lm / 300 cm<sup>2</sup>.

<sup>d</sup> Ratio  $E_v/E_h$  shall be > 0,20.

Table 6.54 — Logistics and warehouses

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.54.1	Unloading / loading area	200	300	0,40	80	25	50	50	30	
6.54.2	Grouping / packing area	300	500	0,50	80	22	100	100	30	
6.54.3	Added value area (mezzanine)	750	1000	0,60	80	19	150	150	30	
6.54.4	Open goods storage	200	300	0,40	80	25	50	50	30	
6.54.5	Rack storage - floor	150	200	0,50	80	22	30	-	30	illuminance at floor level
6.54.6	Rack storage - rack face	75	100	0,40	80	--	-	-	30	On aisle rack face. Band of 1,0 m may be excluded from the perimeter (see 4.4).
6.54.7	Central logistics corridor (heavy traffic)	300	500	0,60	80	22	100	100	30	
6.54.8	Manual sorting station	300	500	0,60	80	22	100	100	30	

## **7 Verification procedures**

### **7.1 General**

Specified design criteria which are listed in this document shall be verified by the following procedures.

In lighting design, calculations and measurements, certain assumptions including degree of accuracy have been made. These shall be declared.

The installation and the environment shall be checked against the design assumptions.

### **7.2 Illuminances**

When verifying conformity to the illuminance requirements the measurement points shall coincide with any design points or grids used. Verification shall be made to the criteria of the relevant surfaces.

For subsequent measurements, the same measurement points shall be used.

Verification of illuminances that relate to specific tasks shall be measured in the plane of the task.

When verifying illuminances, account should be taken of the calibration of the light meters used, the conformity of the light source and luminaires to the published photometric data, and of the design assumptions made about surface reflectance, etc., compared with the real values.

The average illuminance and uniformity shall be calculated and shall be not less than the values specified.

### **7.3 Unified Glare Rating**

Authenticated UGR data produced by the tabular method shall be provided for the luminaire scheme by the manufacturer of the luminaire. The spacing shall be declared for the UGR-tables provided.

### **7.4 Colour rendering and colour appearance**

Authenticated colour rendering index  $R_a$  and correlated colour temperatures  $T_{cp}$  data shall be provided for the light source in the scheme by the manufacturer of the light source. The light sources shall be checked against the design specifications.

### **7.5 Luminaire luminance**

The average luminance of the luminous parts of the luminaire shall be measured and/or calculated in the C-plane (azimuth) at intervals of 15° starting at 0° and the  $\gamma$ -plane (elevation) for angles of 65°, 70°, 75°, 80° and 85°. Normally the manufacturer of the luminaire shall provide these data based on maximum (light source/luminaire) output (see also EN 13032-1 and EN 13032-2).

The values shall not exceed the limits specified in Table 4.

### **7.6 Maintenance schedule**

The maintenance schedule shall be provided and should be according to 5.3.

## Annex A (informative)

### Typical values of grid point spacing

Typical values of grid point spacing are given in Table A.1 based on Formula (1) in 4.4.

**Table A.1 — Recommended number of grid points**

Length of the area	Maximum distance between grid points	Minimum number of grid points
m	m	
0,40	0,15	3
0,60	0,20	3
1,00	0,20	5
2,00	0,30	6
5,00	0,60	8
10,00	1,00	10
25,00	2,00	12
50,00	3,00	17
100,00	5,00	20

## **Annex B** (informative)

### **Recommended practice regarding implementation of UGR for ‘non-standard’ situations**

#### **B.1 General**

The boundary conditions for the determination of the UGR include having a rectangular space, a regular luminaire grid and only one type of luminaire. This limits the application of the methodology to some extent, but does not exclude its use. However, as the limiting values (in the tables in Clause 6) have been determined based on the UGR tabular method, the limiting values cannot be applied to other uses of the UGR formula (such as individual point calculations) without further scientific validation. To maximize the applicability of the tabular method, B.2 covers recommended practices when specific boundary conditions are not met.

NOTE 1 The UGR methodology is intended to support the selection of luminaires which are appropriate for the given application. It is not intended as an exact prediction of glare in the given space.

NOTE 2 The highest UGR value will generally occur in the largest room with the lowest reflectance values. When using the recommended practices below it is advisable to keep this in mind when determining the worst-case scenarios.

#### **B.2 Recommended Practices**

##### **B.2.1 Deviating Luminaire sizes**

The UGR methodology can be applied to luminaires from 0,005 m<sup>2</sup> to 1,5 m<sup>2</sup>. For luminaires outside this range some advice is given in CIE147.

##### **B.2.2 Irregular area shapes**

The UGR methodology is based upon rectangular rooms. For a non-rectangular room, the room dimensions can be approximated by fitting it with a rectangle. The used dimensions of the approximated rectangle should be documented in the lighting design.

##### **B.2.3 Irregular luminaire placement patterns**

As the UGR-tabular method uses a ‘virtual’ luminaire placement to determine the UGR value, the exact luminaire placement pattern can be disregarded. However, in extreme cases such as clusters of luminaires tightly grouped together, the UGR should not be used.

##### **B.2.4 Deviating room reflectance values**

If the exact reflectance values needed are not given in the standard UGR table, the set of reflectance values closest to the required reflectance values should be used as a best approximation. Keep in mind that the lower the reflectance values, the higher the UGR. As such, for the worst-case scenario it is preferable to select a set of values lower than the requested values. Alternatively, a set of transfer values can be calculated allowing the calculation of standard UGR values for the required reflectances.

### **B.2.5 Multiple luminaire types**

When multiple luminaire types are used, the UGR should be determined for each individual luminaire type. For the worst-case scenario, the luminaire type with the highest UGR value should be referenced against the set limiting value.

### **B.2.6 Luminaires with (only) up-lighting or luminous ceilings**

The UGR methodology does not apply to up-lighters (i.e. luminaires with only up-light or luminaires in which the downward component only has an aesthetic function and does not contribute to achieving the lighting requirements specified within this standard). Additionally, the UGR methodology does not apply to luminous ceilings (see size limits above).

### **B.2.7 Room dimensions smaller or larger than the tabular values**

For room dimensions smaller than 2H (the minimum dimension ratio in the tabular method), 2H can be taken as a representative value. For room dimensions larger than 12H (the maximum dimension ratio in the tabular method), 12H can be taken as a representative value. In both cases, the used dimensions should be reported.

## **Annex C**

### **(informative)**

## **Additional information on visual and non-visual (non-image forming) effects of light**

### **C.1 General**

#### **C.1.1 General**

There is strong scientific evidence that light is not only essential for vision but also elicits important biological, non-image-forming effects, and emotional effects that are highly relevant for human performance and well-being.

Current lighting practice and the demand for energy saving tends to reduce indoor illumination levels. This can create lighting conditions that are sub-optimal for human well-being and functioning.

The emotional and biological effects of light have a direct impact on human performance and well-being with large implications for architecture, interior design, and lighting as well as for social and work-schedules. The integration of these effects in lighting applications and designs will require design practices and methods different to those currently in use.

#### **C.1.2 Perceived room brightness**

The perceived brightness of a space is important for the occupants' wellbeing and alertness. In the field of vision, the perceived brightness (luminance pattern) is a result of the interaction between illumination and the reflectance properties of objects and room surfaces. However, illuminances are more practical to evaluate than luminance, since no detailed information is usually available on interior decor or occupant seating and primary viewing directions in the design stage.

To ensure proper perceived room brightness and illumination of people and objects,  $\bar{E}_{m,wall}$  and  $\bar{E}_{m,ceiling}$  as well as  $\bar{E}_z$  are specified in the tables in 6.3. The exact values are application specific and as such need to reflect the activity and/or task characteristics. These include visual communication (e.g. in classrooms, meeting rooms and offices) and visual comfort for areas where the specified task or activity is performed for extended periods of time.

#### **C.1.3 Alternative parameters**

##### **C.1.3.1 General**

As stated above, the wall, ceiling and cylindrical illuminances are employed by this standard as indicators of room brightness and the recognition of objects and people. Due to their practical and intuitive nature, alternative methods have been proposed and three of these are briefly described below.

##### **C.1.3.2 Mean ambient illuminance, $\bar{E}_{amb}$ (Govén et al)**

This calculates an approximation of the apparent brightness within a space by evaluating the total amount of light reaching the walls and ceiling of the space. The average illuminances on these surfaces are calculated and these values are then averaged to calculate the mean ambient illuminance for the room.

$$\bar{E}_{amb} = (\bar{E}_{v,wall1} + \bar{E}_{v,wall2} + \bar{E}_{v,wall3} + \bar{E}_{v,wall4} + \bar{E}_{v,ceiling}) / 5$$

For workplaces where ambient light is considered (for example offices, class rooms, hospital wards), the mean ambient illuminance is recommended to be within a band of  $200 \text{ lx} < \bar{E}_{\text{amb}} < 500 \text{ lx}$  and the ratio between the mean ambient illuminance and the maintained task illuminance,  $\bar{E}_{\text{amb}} / \bar{E}_{\text{task}}$ , should not be lower than 1:2 (i.e.  $\geq 50\%$ ).

Note that the above formula for  $\bar{E}_{\text{amb}}$  is applicable for mid and large size rooms. For small rooms (such as cellular offices) the wall illuminance within the normal field of view should be used as the value for  $\bar{E}_{\text{amb}}$ .

### C.1.3.3 Mean room surface exitance, $M_{\text{rs}}$ (Cuttle)

This considers that the visual appearance of a space is based upon the brightness of the room surfaces, that is the amount of light leaving a surface as opposed to the light falling onto the surface. It proposes the use of mean room surface exitance, which is the measure of average illuminance at all points within the space due to reflected light from the room surfaces, (direct light from either luminaires or windows is excluded) and is expressed in  $\text{lm m}^{-2}$ . It is calculated as the first reflected flux (FRF) for the room divided by the room absorption ( $A\alpha$ ). The FRF is the sum of the direct flux reflected from each surface in the room. The room absorption is the sum of the surface area multiplied by the absorption value for the individual room surfaces.

$$M_{\text{rs}} = \text{FRF} / A\alpha \text{ (lm m}^{-2}\text{);} \quad \text{FRF} = \sum F_{\text{s(d)}} \rho_{\text{s}} \text{ (lm);} \quad A\alpha = \sum A_{\text{s}}(1-\rho_{\text{s}}) \text{ (m}^2\text{);}$$

where

$F_{\text{s(d)}}$  is the direct flux onto surface  $s$ ,  $\rho_{\text{s}}$  is the reflectance of surface  $s$  and  $A_{\text{s}}$  is the area of surface  $s$ .

Tentative values of mean room surface exitance give  $10 \text{ lm m}^{-2}$  as the lowest level for reasonable colour discrimination,  $30 \text{ lm m}^{-2}$  as having a dim appearance,  $100 \text{ lm m}^{-2}$  as the lowest level for an acceptably bright appearance,  $300 \text{ lm m}^{-2}$  for a bright appearance and  $1000 \text{ lm m}^{-2}$  for a distinctly bright appearance.

### C.1.3.4 Visual lightness and interest - 40 degree band luminance (Loe et al)

This considers that the key factors in the perception of a space are the two subjective parameters of 'visual lightness' and 'visual interest' related to the brightness of a horizontal band,  $40^\circ$  wide and centered at normal eye height. In relatively small rooms this  $40^\circ$  band relates closely to the area of the walls, but in larger rooms it includes the ceiling and the floor (see also C.1.3).

On the basis of the results of experiments it was proposed that for a commercial interior to have a measure of visual lightness the average luminance of the horizontal  $40^\circ$  band should not be less than  $30 \text{ cd m}^{-2}$ . For a possible maximum value it was noted that beyond  $100 \text{ cd m}^{-2}$  there was little change in subjective assessment.

Regarding visual interest it was suggested that the range of the ratio of maximum to minimum luminance within the  $40^\circ$  band should be between 10 % and 50 % which can be achieved either by a variation in illuminance or reflectance or both.

## C.1.4 Adaptation luminance within the normal field of view

The adaptation luminance describes the level of brightness to which the eye is adapted. The viewing direction and spatial luminance distribution have an impact on adaptation level within the field of view.

Within the field of view space dimensions and the position of the observer determine which parts of the space are the dominant aspects, e.g. walls, ceilings, furniture and partition walls.

The main surfaces determining the adaptation brightness are highly dependent on the space dimensions. In smaller spaces, the walls will be major determining factor, whereas in larger spaces the ceiling, floor and furniture will start to play a more prominent role.

### **C.1.5 The influence of spectral power distribution on non-image forming effects.**

The spectral power distribution of a light source plays a large role in the stimulation of the different receptors in the eye. The receptors for vision, the rods and cones, are relatively well understood and characterised by standards such as CIE S 017. Although melanopsin containing retinal ganglion cells (intrinsically photosensitive Retinal Ganglion Cells, ipRGCs,), which are most sensitive to short wave length parts of the spectral power distribution (between 460 nm and 500nm), play an important role in the non-image-forming effects of light, this photoreceptor was not yet included in existing lighting standards and recommendations. Therefore, a description of optical radiation solely according to the photopic action spectrum is not sufficient. The actual biological effect of ocular exposure to light will depend on the relative response of all photoreceptors and there is good evidence for synergistic responses between the receptors. For a deeper understanding of how a stimulation of the photoreceptors leads to a desirable or undesirable biological effect, light must be characterized in a way to quantify the input to each of the five known photoreceptors. CEN/TR 16791, has defined a method to characterize illuminants according to their potential in eliciting biological stimulation and sensation.

It is also important to recognise the importance of darkness, and the daily pattern of light and dark, particularly around and during periods of sleep. Additionally, certain changes to the balance of the spectrum of light at different times of day might be helpful in promoting circadian rhythms, but further evidence would be needed to support this as a general principle. Analysing the involvement of different photoreceptors would be crucial to understand how such outcomes with impact on human health are provoked.

The biological non-visual effects of light have a direct impact on human performance and well-being with large implications for architecture, interior design, and lighting as well as for social and work-schedules. The integration of these non-image forming effects in lighting applications and designs requires new metrics to quantify light.

**NOTE 1** The spectral power distribution has an impact on human circadian rhythm. This impact can be described approximately by means of the Correlated Colour Temperature (CCT) or, more accurately, by means of evaluation of the spectral power distribution of the light source.

**NOTE 2** The colour temperature perception of light in a space is related to the light intensity of artificial light sources, the the color of the decor of the room, and the amount of daylight penetration. High CCT is often linked to high impact on non-image forming effect but also affects many other factors.

**NOTE 3** The variability of the CCT over the day is one factor that can also influence the circadian rhythm. Individual preferences arising from, e.g. gender and culture can be considered.

### **C.1.6 Varying lighting conditions**

Varying lighting conditions in time by higher illuminance, luminance distribution and wider range of colour temperature with daylight and/or artificial lighting solutions can enhance people's wellbeing. Variation in illuminance levels can also make a space appear less monotonous. However, the perceived difference between bright and dark surfaces should be moderate to fit the adaptation level of the eye.

Occupants also tend to value occasional personal influence on light settings, e.g. with the use of adjustable task lighting (direction of light, illuminance level and possibly colour temperature).

Artificial light can be used to support space functions. Pre-programmed light scenarios may improve occupants wellbeing through variation and personal interaction, while enabling energy savings.

The recommended variations are shown in schedules in Clause 6 under 6.3.

### **C.1.7 Daylight penetration**

Daylight is the essential illumination source for human well-being. Daylighting is dynamic and it varies in magnitude, direction and spectral composition with time and season. It provides variable modelling

and luminance patterns, which is perceived as being beneficial for people in indoor environments. Daylight needs to be assessed in terms of daylight quantity, view, sunlight and glare.

The interplay between daylight and artificial lighting is of utmost importance. There must be possibilities to adjust the artificial lighting to the daylight conditions over time.

Low levels of daylight can have a negative impact on the alertness and well-being of humans. Increased ambient illuminance and task area illuminance provided by artificial lighting with an appropriate spectral power distribution may compensate for the lack of sufficient daylight or in areas with no daylight.

## Annex D (informative)

### Lighting design considerations - Examples

#### Example 1: Office

A large open plan office has a number of activities including data processing, CAD and printing/copying. The computer based tasks are flexible and may be performed in a number of positions, whilst the printing/copying is fixed in a number of positions throughout the office.

The staff ages within the space range from mid-20's to early 60's with a mid-range in their early 50's. No current staff members are visually impaired.

The office is to be lit to preserve the flexibility of the space whilst ensuring all tasks may be performed optimally.

The requirements from the schedule for the tasks listed are:

**Table D.1**

Task	$\bar{E}_{m,r}$	$\bar{E}_{m,u}$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Data processing – open plan office	500	1000	0,60	80	19	150	150	100
CAD	500	1000	0,60	80	19	150	150	100
Printing/copying	300	500	0,40	80	19	100	100	75

Due to the flexible nature of the office space the most onerous requirements must be met throughout the space, which means the requirements for the office are:

**Table D.2**

Task	$\bar{E}_{m,r}$	$\bar{E}_{m,u}$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Office requirements	500	1000	0,60	80	19	150	150	100

As there is a high percentage of older staff within the space the lowest illuminance,  $\bar{E}_{m,r}$ , of 500 lx would be inappropriate. Using the scale of illuminance given in section 4.3.2 the design team decided that this should be raised by at least one step

20 - 30 - 50 - 75 - 100 - 150 - 200 - 300 - **500 → 750** - 1 000 - 1 500 - 2 000 - 3 000 - 5 000

Therefore the requirements become:

**Table D.3**

Task	$\bar{E}_m$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Office requirements	750	0,60	80	19	150	150	100

However as the task illuminance has been raised by one step the cylindrical illuminance  $\bar{E}_z$ , wall illuminance  $\bar{E}_{wall}$  and ceiling illuminance  $\bar{E}_{ceiling}$  should also be raised by one step on the scale of illuminance, resulting in the requirements:

**Table D.4**

Task	$\bar{E}_m$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Office requirements	750	0,60	80	19	200	200	150

From Table 1 of the standard (4.3.4) this would require an illuminance on the immediate surround of 500 lx and a background illuminance of  $500 \text{ lx}/3 = 167 \text{ lx}$ .

Obviously for maximum flexibility the value for  $\bar{E}_{m,u}$  of 1 000 lx (see Table 2), could be used with suitable lighting controls to achieve the base requirements but allow for variability in the visual environment throughout the day.

### **Example 2: Industry machine workshop**

An industrial machine shop is to be lit. It is used for rough machining of large metal components. The space is dusty and noisy and protective equipment such as eye and ear protection is needed when operating machinery.

Gangways for fork lift trucks are placed between machinery to deliver raw materials and remove finished goods.

The requirements from the schedule for the tasks listed are:

**Table D.5**

Task	$\bar{E}_{m,r}$	$\bar{E}_{m,u}$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Rough machining	300	500	0,60	80	22	100	100	50
Circulation areas	100	150	0,40	40	28	50	50	30

As the spaces overlap to an extent the most onerous requirements must be met throughout the space, which means the requirements for the workshop are:

**Table D.6**

Task	$\bar{E}_{m,r}$	$\bar{E}_{m,u}$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Workshop requirements	300	500	0,60	80	22	100	100	50

Due to the distraction caused by the noise within the workshop and lower visibility due to dust on eye protection and surfaces within the workshop, the design team decided that the lowest illuminance,  $\bar{E}_{m,r}$ , of 300 lx would be inappropriate. Using the scale of illuminance given in section 4.3.2 this should be raised by at least one step

20 - 30 - 50 - 75 - 100 - 150 - 200 - **300** → **500** - 750 - 1 000 - 1 500 - 2 000 - 3 000 - 5 000

Therefore the requirements become:

**Table D.7**

Task	$\bar{E}_{m,r}$	$\bar{E}_{m,u}$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Workshop requirements	500	500	0,60	80	22	100	100	50

As the task illuminance has been raised by one step the cylindrical illuminance  $\bar{E}_z$ , wall illuminance  $\bar{E}_{wall}$  and ceiling illuminance  $\bar{E}_{ceiling}$  should also be raised by one step on the scale of illuminance. However as

the components are of a large size which reduces the visual difficulty of the task, the design team decided it would be acceptable to reduce the required illuminance by one step, resulting in the original requirements of:

**Table D.8**

Task	$\bar{E}_m$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Workshop requirements	300	0,60	80	22	100	100	50

From Table 1 of the standard (4.3.4) this would require an illuminance on the immediate surround of 200 lx and a background illuminance of  $200 \text{ lx}/3 = 67 \text{ lx}$ .

However this would limit the flexibility of the lighting in the event more detailed work was required within the space and the higher level given for  $\bar{E}_{m,u}$  of 500 lx or more could be used with suitable lighting controls to achieve the base requirements but allow for flexibility in the manufacturing processes.

#### Example 3: Industry machine workshop with inspection area

Within the industrial machine shop in Example 2 above a significant area for inspection is to be lit. The position of this area is defined and fixed. The requirements from the schedule for this task are:

**Table D.9**

Task	$\bar{E}_m$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Inspection area	750	0.70	80	19	-	-	-

The requirements for the machine shop determined within industry example 1 are:

**Table D.10**

Task	$\bar{E}_m$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Rough machining	300	0.60	80	22	100	100	50

As the requirements for the inspection task are more onerous than those for the main machining area the requirements for the entire machine shop should be raised to achieve the inspection area criteria.

However since the inspection area is only a section within the larger space, albeit without separate walls and ceiling, the design team decided that the task illuminance and uniformity needs to be considered separately for the inspection area and the main machine shop while  $R_{UGL}$  should be designed for the entire space.

A luminaire that fulfil  $R_{UGL}$  19 has to be chosen for the machining hall. The cylindrical illuminance  $\bar{E}_z$ , wall illuminance  $\bar{E}_{wall}$  and ceiling illuminance  $\bar{E}_{ceiling}$  for the rough machine task should be used throughout the machining hall.

Therefore the requirements become:

**Table D.11**

Task	$\bar{E}_m$	$U_o$	$R_a$	$R_{UGL}$	$\bar{E}_z$	$\bar{E}_{wall}$	$\bar{E}_{ceiling}$
Inspection area	750	0.70	80	19	-	-	-
Machining area	300	0.60	80	22	100	100	50

From Table 1 of the standard (see 4.3.4) this would require an illuminance on the immediate surround of 500 lx next to the inspection area and of 200 lx in the machining area. However, a background illuminance of  $200 \text{ lx}/3 = 67 \text{ lx}$  for the main machine hall and an illuminance on the immediate surround of 500 lx and a background illuminance of  $500 \text{ lx}/3 = 167 \text{ lx}$  for the inspection area. The final lighting design shall comply with the illuminances in all these areas.

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Retouching (printing)	6.21.3	Sports halls (education)	6.36.24
Rolling (ceramics etc.)	6.9.3	Staff office (health care)	6.38.1
Rolling mills	6.22	Staff rooms (health care)	6.38.2
Rooms for Medical attention (rest rooms etc.)	6.2.6	Stage area rigging (theatres etc.)	6.30.4
		Stairs (education)	6.36.18

Stairs, escalators, travolators (traffic zones)	6.1.2	Traffic lanes, internal ramps and pedestrian paths (car parks)	6.34.3
Stairs, large number of passengers (railway)	6.53.3.3	Traffic zones	6.1
Stairs, medium number of passengers (railway)	6.53.3.2	Treatment (health care)	6.39.4
Stairs, small number of passengers (railway)	6.53.3.1	Treatment (ICUs)	6.47.3
Standard bookbinding work	6.19.3	Treatment rooms, general (health care)	6.40.2
Station halls (railway)	6.53.7	Trimming (food industry)	6.12.6
Steam pits (wood processing)	6.25.2	Trimming (textile industry)	6.23.10
Steel engraving (printing)	6.21.5	Tumbling of skins (leather)	6.17.2
Steel works	6.22	Type setting (printing)	6.21.3
Sterilisation (health care)	6.50.1	Typing (offices)	6.26.2
Stock rooms for teaching materials (education)	6.36.23	Tyre production (chemical industry)	6.10.6
Storage area (retail)	6.27.4	Underfloor man-sized tunnels (rolling mills etc.)	6.22.9
Storage rack face (storage rack areas)	6.5.4	Unloading / loading area (logistics)	6.54.1
Store and stockrooms (Storing)	6.4.1	Upholstery manufacture (manual) (vehicles)	6.24.7
Student common rooms (education)	6.36.19	Utensil washing (agriculture)	6.6.4
Surface preparation and painting (metal industry)	6.18.13	vegetables and fruit, cutting and sorting (food industry)	6.12.4
Surveillance station (control rooms)	6.3.3	Vehicle construction	6.24
Swimming pools (education)	6.36.24	Vehicle repair	6.24
Switch rooms (railway)	6.53.8	Vehicle repair (general)	6.24.11
Switch gear rooms (control rooms)	6.3.1	Vehicle services (general)	6.24.11
Switchboard (control rooms)	6.3.2	Vehicle testing (general)	6.24.11
Switchboards (power stations)	6.20.4	Waiting areas (airports)	6.52.5
Taking up stitches (textile industry)	6.23.5	Waiting rooms (health care)	6.37.1
Teachers rooms (education)	6.36.20	Waiting rooms (railway)	6.53.6
Teaching workshop (education)	6.36.11	Wards (health care)	6.39
Technical drawing (offices)	6.26.3	Warehouses	6.54
Technical drawing rooms (education)	6.36.8	Warping (textile industry)	6.23.4
Test, measurement and inspection (rolling mills etc.)	6.22.8	Washing (textile industry)	6.23.2
Testing and repair areas in hangers (airports)	6.52.9	Washing and dry cleaning (laundries)	6.16.2
Textile industry	6.23	Washrooms (rest rooms etc)	6.2.4
Theatres	6.30	Watch making (automatic) (jewellery)	6.15.4
Ticket counters (railway)	6.53.5	Watch making (manual) (jewellery)	6.15.3
Ticket hall (railway)	6.53.4	Weaving (textile industry)	6.23.4
Ticket office (car parks)	6.34.5	Welding (metal industry)	6.18.3
Ticket offices	6.28.4	White boards (education)	6.36.4.1
Till area (retail)	6.27.2	White boards in auditorium and lecture halls (education)	6.36.4.2
Toilet area (rest rooms etc)	6.2.4	White teeth matching (Dentistry)	6.48.4
Toilets for patients (health care)	6.39.6	Winding (textile industry)	6.23.3
Tool making; cutting equipment manufacture (metal industry)	6.18.10	Winding: (electronics)	6.11.2.0
Tool, template and jig making (metal industry)	6.18.14	Winding: - large coils (electronics)	6.11.2.1
Trade fairs	6.31	Winding: - medium-sized coils (electronics)	6.11.2.2
		Winding: - small coils (electronics)	6.11.2.3
		Wire and pipe drawing shops; cold forming (metal industry)	6.18.7

Wood processing	6.25	Work stations and critical zones	
Wood working machines (wood processing)	6.25.6	(dairies mills)	6.12.3
Work at joiner's bench (wood processing)	6.25.4	Work stations and critical zones	
Work on stones and platens (printing)	6.21.1	(filtering floor in sugar refineries)	6.12.3
Work on vats, barrels, pits (leather)	6.17.1	Work stations and critical zones	
Work stations (breweries, malting floor)	6.12.1	(slaughter houses)	6.12.3
Work stations (cooking in preserve and chocolate factories)	6.12.1	Work stations and zones in baths, bale opening (textile industry)	6.23.1
Work stations (drying and fermenting raw tobacco, fermentation cellar)	6.12.1	Work stations at cupola and mixer (foundries etc)	6.13.5
Work stations (sugar factories)	6.12.1	Working with precious stones (jewellery)	6.15.1
Work stations (washing, barrel filling, cleaning, sieving, peeling)	6.12.1	Workshops (education)	6.36.15
Work stations and critical zones (butchers)	6.12.3	Wrapper table (retail)	6.27.3
		Writing (offices)	6.26.2