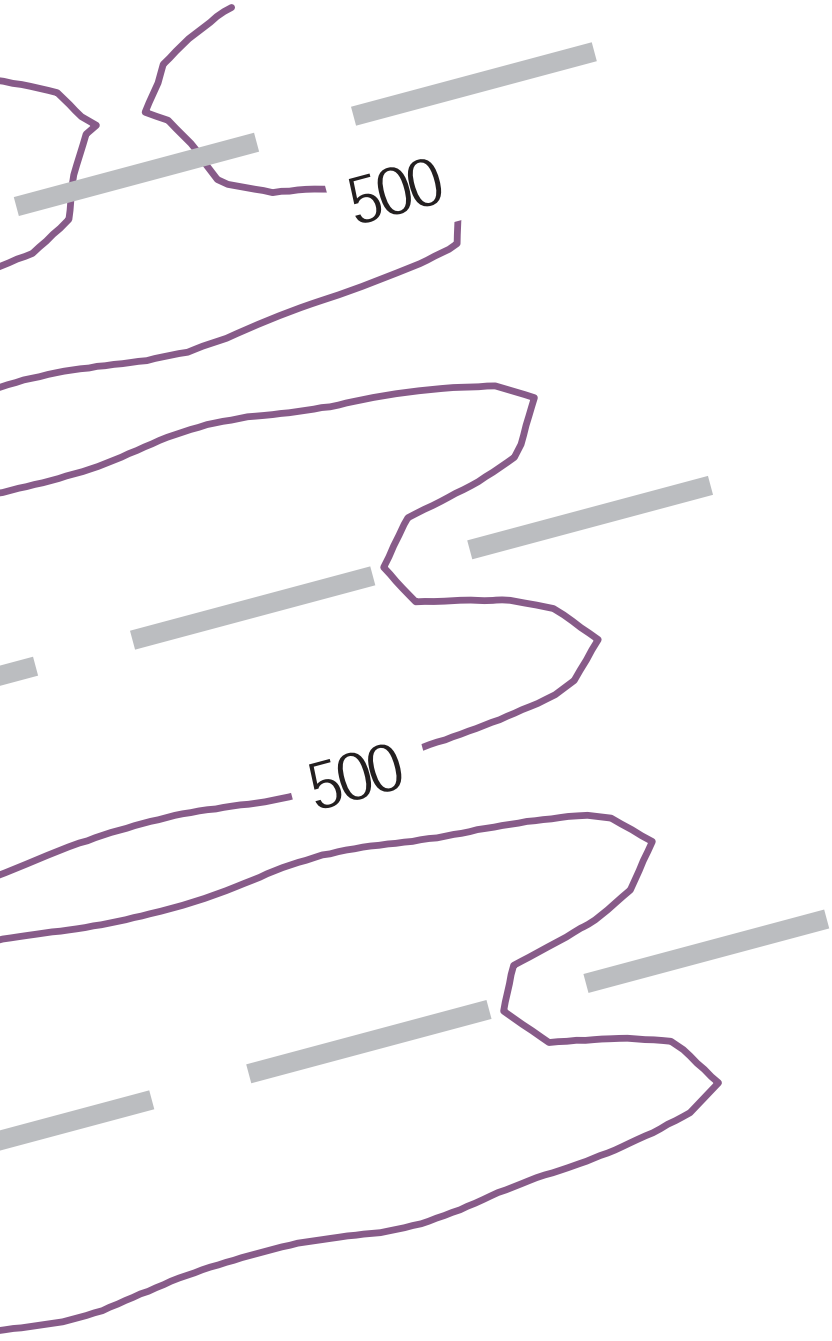
DOSSIER EN 12464-1



CONCISE DESCRIPTION OF THE STANDARD

2nd edition, june 2012

ETAP

EXCELLENT LIGHTING, SAVING ENERGY

Foreword

EN 12464-1 is an application standard for lighting. The original standard was written by Study group 2 of the TC 169 Technical Committee of the European Committee for Standardisation (CEN). It took thirteen years and almost thirty international meetings but in 2002 the EN 12464 standard came into force in Europe. One European standard which replaced the very diverse national standards required a considerable adjustment from all countries. Over the years, all the observations were collected and the standard was adjusted. It resulted in a renewed version that was approved in 2011 and has been in use since. Within two years all countries will ratify the renewed standard and the old standard version will be phased out.

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SCOPE OF THE STANDARD

The standard governs indoor workplace lighting. As with most standards, minimum requirements are laid down. In other words, it concerns a minimum that workplace lighting and the direct environment needs to meet. Standard compliant lighting is no guarantee in itself for good lighting. For this, application know-how, product know-how and an understanding of the customer's situation are required.

In this document the standard is described with a view to developing a lighting solution:

- Gathering the necessary project data and laying down the preconditions.
- Considering different alternatives (determining the most suitable lighting concept, choice of luminaire type, choice of lamp, ...).
- Calculating and documenting.

MAIN INNOVATIONS

- The luminance requirements of luminaires for computer screen work are less strict.
- The uniformity for the visual task can be lower, 0.1 lower on average compared to the old standard.
- The definitions of 'task', 'environment' and 'background' have been refined, new guidelines for background illuminance will be issued.
- Vertical illuminance is given more attention, particularly in the context of more qualitative lighting solutions. Not just walls and ceilings need to be sufficiently bright, the vertical lighting component is also a major factor in the work environment.
- Grid points for calculation : the renewed standard defines a system to determine the minimum number of calculation and measuring points.

EN 12464-1 is primarily about the quantitative aspects of light and lighting. Achieving these quantitative requirements using low-energy techniques is an important and difficult, but feasible, job. Normative preconditions for energy-aspects are treated in other standards. The use of daylight is promoted in the renewed EN12464-1.

LEDs are not specifically mentioned but the new standard also applies to lighting solutions with LEDs. The same quantitative criteria apply.

Gathering project data and laying down preconditions

DEFINING THE APPLICATION

In most projects, the application type for which the lighting needs to be defined is determined first. Obviously the needs of a school are not the same as the needs in an office or an industrial hall. The appendix of the standard includes a 25 page list with such applications. Four criteria are specified for each application:

- The minimum required average illuminance (i.e. maintained illuminance) per task ($\bar{E}_m$).
- The maximum UGR ('Unified Glare Rating'). The UGR is an approximate model that expresses the chance of direct glare by luminaires. The higher this figure, the greater the chance of glare. For each luminaire, a standardised table can be calculated with UGR values. The parameters are the size of the room, the reflection factors and the observer's orientation in the room. The appendices of the standard specify the UGR value that may not be exceeded for each application. Typical limits are applied in the standard. Luminaire manufacturers produce UGR data tables which express the UGR of a luminaire with reference to surface reflectances and room geometry. UGR values are usually expressed in steps of 3. For example a typical office environment requires a UGR of 19 or less.
- Minimum uniformity to be respected (U_o).
- The minimum required colour rendering. The choice of lamp is decisive for this. In rooms where people need to work or stay for longer periods, lamps with a Ra of at least 80 are required.

3	Offices				
Ref. no.	**Interior type, task or activity**	$\bar{E}_m$	UGR_L	U_o	R_a
3.1	Performance of work, copying, etc.	300	19	0,4	80
3.2	Writing, typing and reading, data processing on a PC	500	19	0,6	80
3.3	Technical drawing	750	16	0,7	80
3.4	CAD workstations	500	19	0,6	80
3.5	Conference and meeting rooms	500	19	0,6	80
3.6	Reception desks	300	22	0,6	80
3.7	Archives	200	25	0,4	80

Whether it concerns reflectors, diffusers or lenses; with LEDs or fluorescent lamps, ETAP possesses the photometric expertise to develop lighting solutions that meet all requirements of the standard.

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WORK ON DISPLAY SCREEN EQUIPMENT (DSE)

When Display Screen Equipment is used, the standard specifies luminance limits for luminaires, the value of which depends on the quality of the screen. A cut-off angle of 65° is usually applied.

Table 4 – Average luminance limits of luminaires, which can be reflected in flat screens

Screen high state luminance *		**High luminance screen** $L > 200$ cd/m²	**Medium luminance screen** $L \leq 200$ cd/m²
Case A	positive polarity and normal requirements concerning colour and details of the shown information, as used in office, education, etc.	≤ 3000 cd/m²	≤ 1500 cd/m²
Case B	negative polarity and/or higher requirements concerning colour and details of the shown information, as used for CAD colour inspection, etc.	≤ 1500 cd/m²	≤ 1000 cd/m²

** 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.*

Luminances of luminaires for computer screen work require an in-depth evaluation. For smaller cut-off angles it is recommended and more comfortable to limit the luminances or determine a lower maximum for a cut-off angle of 65°, depending on the screen quality, the clarity of the screen and the screen angle. In critical cases, a test rig can even be considered. Peak luminances as such are not specified in the standard. Naturally, good peak luminance control still has a positive effect on the average luminance and guarantees a uniform and comfortable reflector image.

TAKING INTO ACCOUNT SPECIFIC CONDITIONS

As specified in the introduction, the standard lays down minimum requirements. However, the standard also specifies that sometimes 'more' is required, depending on the situation. This is not always specified in detail, but the fact that it is mentioned is an invitation to everyone to do better than the minimum of the standard.

For example:

- The mentioned illuminance should be increased if the 'visual conditions differ from the normal assumptions', e.g.: if errors are costly to rectify; if accuracy or higher productivity is of great importance; if task details are of unusually small size or low contrast; if the visual capacity of the worker is below normal; ...
- A higher uniformity increases the comfort for the user. Less eye adaptation required.
- A lighting solution must enable the workers to perform their visual tasks, 'even under difficult circumstances and during longer periods'.
- Lighting from a specific direction may reveal details within a visual task, increasing their visibility and making the task easier to perform.
- For computer screen work, lower luminances may be recommended than prescribed in the standard, for comfort sake or to achieve a safe margin. Both the computer screens and the type of work that needs to be carried out may change at a later date.

LIGHTING EXPERIENCE: CHOICE OF LIGHTING CONCEPT

EN 12464-1 deals with a number of aspects concerning the lighting experience in a room. The main aspect remains the attention for visual comfort. This results in a better feeling and higher productivity. Achieving sufficient visual comfort remains a job for the lighting designer based on the customer's requirements. Both direct lighting and indirect lighting, reflector luminaires, softlight and lenses, general lighting and task lighting,... can be used to guarantee visual comfort provided they have been well thought out.

Although visual comfort is in part subjective, the standard specifies three objective criteria that need to be met:

- **MINIMUM ILLUMINANCE ON WALL AND CEILING**

  The standard recommends sufficient vertical illuminance. Not just making the room sufficiently bright increases the visual comfort, the presence of a vertical component in the illuminance also increases our visual performance and comfort: a lot of visual tasks are not entirely horizontally positioned. Moreover, communication in case of higher vertical illuminances (lighting faces,...) is more powerful and pleasant. The standard does not specify any criteria for wall and floor luminances, which is, however, just as important, or even more important, a factor in illuminating a room.

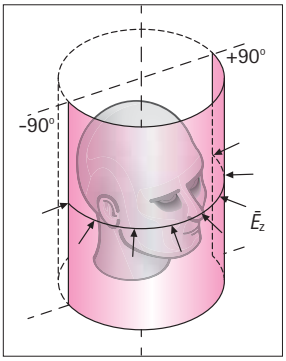
  Standard requirements:
  Walls: $\bar{E}_m$ (average illuminance) > 50 lx and $U_o \geq 0.1$
  Ceilings: $\bar{E}_m$ >30 lx and $U_o \geq 0.1$
  For certain enclosed rooms such as offices of classrooms, and for entrance rooms (corridors, stairways) more rigorous requirements apply: $\bar{E}_m$ >75 lx for walls and $\bar{E}_m$ >50 lx for ceilings.

Office with U7 luminaires. Walls: $\bar{E}_m$ = 241 lx and U_o = 0,38
Ceiling: $\bar{E}_m$ = 141 and U_o = 0,55

- **CYLINDRICAL ILLUMINANCE**

  The standard specifies the minimum vertical all-round (360°) luminance, which determines whether the faces of the people present in the work area are sufficiently illuminated. The height at which the illuminance is measured depends on the fact whether it concerns areas where people are standing up mostly (e.g. supermarkets) or sitting down (offices).

  Standard requirements:
  $\bar{E}_z$ > 50 lx and $U_o \geq 0.1$
  Height: 1.2 metre for desk jobs and 1. 6 meter for standing work.
  For classes, offices and conference rooms: $\bar{E}_z$ > 150 lx



- **MODELLING**

  The standard lays down the ratio between the horizontal and cylindrical illuminance. With a correct ratio, shapes and surface structures of three-dimensional objects come out clearly. This is achieved if the light comes chiefly from one direction (directional light). The light may not be too focused because this will result in exaggerated cast shadows. It should not be too weak either because the contrasts are reduced.

  Standard requirements:
  $\bar{E}_z / \bar{E}_h$ = 0.3 - 0.6

These three values which also determine the visual comfort can be derived from simplified data, or are calculated with specialised programmes such as DIALux.

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DEFINING THE TASK AREA AND THE ENVIRONMENT

Depending on the situation, the task area on the working plane can be defined as follows:

- An entire room can be considered as task area: this could be useful if the exact location of the task area is not yet known, or if flexibility is required to change the task area at a later stage.
- Task-oriented thinking is also possible: in this case, a distinction can be made between the areas where the task takes place and the surrounding area.

The required minimum illuminance on the task is specified in the standard. If not the entire room but individual tasks are lit, the illuminance in the immediate surrounding areas can be 1 step lower. These steps have been defined in the standard as follows:

20–30–50–75–100–150–200–300–500–750–1000–1500–2000–3000–5000 (values in lx):

The immediate surrounding area is often defined as 'the rest of the space' to avoid a restricted interpretation of the standard resulting in imperfect solutions (e.g. offices where large areas only have 200 lx). A peripheral zone is not explicitly specified in the standard, but it is alluded to. In the following example, we are assuming a peripheral zone of 0.6 m.

With regard to an office or a typical industrial application, this gives the following alternatives:

LOW-ENERGY LIGHTING

The standard specifies explicitly that when working out a lighting solution, the energy consumption is also important: the lighting requirements should be met without waste of energy. However, it is important not to compromise the visual aspects of a lighting installation simply to reduce energy consumption. In this respect, the use of control systems is an ideal way to reconcile visual comfort and low energy demands. And of course high luminaire LORs, the use of high efficiency lamps, etc. assist in providing lowenergy solutions. EN 12464-1 does not go into detail though: don't forget it is an application standard and not an energy performance standard.

The energy performance standard goes into more detail of the energy aspects of lighting. A European directive (Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings) has obliged every member state or region to draw up rules and regulations regarding the energy performance of buildings, for both residential and non-residential buildings. This standard has been introduced in various European countries.

The use of daylight is also recommended in the standard. This provides variability within an interior (thanks to the variation in level and spectral composition with time) and may contribute to a good 3D rendering of objects. In addition, visual contact with the outside world is preferred by most people. Of course, the use of daylight control systems will help to increase the energy efficiency of the lighting system.

ETAP pays a lot of attention to low-energy luminaires. Sophisticated lenses, reflectors and diffusers direct the light wherever necessary.

An ingenious lighting design determines the most low-energy lighting solution for every work environment.

With lighting control systems such as ELS, the artificial light is dimmed as a function of daylight. In this way energy is saved per individual luminaire.

Excellum manages the lighting on building level and optimises the global energy consumption.

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CHOICE OF LUMINAIRES AND COMPONENTS

Once a decision has been made regarding the lighting concept, the practical side follows: the choice of the eventual luminaires and details such as lamp position, ballast type , source of light (LED or fluorescence lamp).

The following needs to be taken into account according to the standard:

- The aforementioned preconditions: both the direct glare (via UGR) requirements and the luminance limits in case of display screen equipment need to be met.
- Choice of lamp type: colour rendering, colour temperature, dimmability, start up behaviour, lamp output, depreciation, ... are all factors that contribute to choosing the right lamp type. The standard is neutral in terms of LED: with good LED luminaires perfect standard compliant solutions are possible.
- For the colour rendering index, (Ra), the standard specifies a minimum requirement for practically all tasks. In rooms where people need to work or stay for longer periods, lamps with an Ra of at least 80 are required.
- The choice of a certain colour temperature of the light source is down to psychology, aesthetics and feeling. This choice depends on the colours in the room, the application, the climate, market practice,...
- The other aspects (dimmability, ...) depend on the application.
- Choice of possible light controls (see higher)
- Choice of ballast type.
- Minimum lamp shielding to prevent glare: bright light sources can cause glare. This is why the standard specifies a minimum shielding angle depending on the lamp luminance.

Lamp luminance (cd/m²)	Minimum shielding angle
20,000 till < 50,000	15°
50,000 till < 500,000	20°
≥ 500,000	30°

Examples:

- T8-ø26mm lamps have luminances from 10,000 to 15,000 cd/m².
- The T5-ø16mm HE lamps have luminances starting from approximately 17,000 cd/m².
- For the T5-ø16mm HO lamps this varies between 23,000 (for 49W) and 33,000 cd/m² (for 80W).
- For compact lamps, these values vary between 20,000 and 70,000 cd/m².
- For a low-voltage halogen spot this varies between 9,000 and 480,000 cd/m².
- CDM-T lamps always have values in excess of 500,000 cd/m², and therefore always require a minimum shielding of 30°.
- LED: in case of naked high-power LEDS, the luminance can increase to more than 30,000,000 cd/m². Extra light treatment is therefore necessary at all times.

UNIFORMITY TO BE EMPLOYED

Usually, a uniformity of 0.6 is specified, in the surrounding area 0.4 suffices.

THE MAINTENANCE FACTOR

The standard specifies the maintained illuminance ($\bar{E}_m$). The maintained illuminance is the value below which the average illuminance on the specified surface is not allowed to fall throughout the life of the installation. Age and dirt accumulation have a negative effect on the light yield and the lighting design needs to take this into account. In calculations, the maintenance factor compensates these negative effects. EN 12464-1 specifies that when determining the maintenance factor, the following factors need to be taken into account:

- A drop in light output of the lamps.
- Pollution of the room.
- How the luminaires are maintained or cleaned.
- How the room is maintained or cleaned.
- The accumulation of dirt on the luminaires.

- **FLUORESCENCE LUMINAIRES**

  The danger is that wrong comparisons are made in the calculations between manufacturers due to differences in assumptions concerning the maintenance factor. This is why ETAP, Philips, Zumtobel Staff and Osram have requested an independent scientific institute to draw up a report to determine the maintenance factor. This report specifies factors for certain types of dust pollution, luminaire types, ... This has resulted in the following table that applies to aluminium reflector luminaires with electronic ballasts in a room that is cleaned regularly. When all the lamps are replaced at the same time (group replacement), the assumption is that the room and the luminaires are thoroughly cleaned.

Protection against construction dust.

With the uplight grooves directional air circulation is created, which prevents disruptive dust deposits on the reflector.

Maintenance factor (MF) fluorescent lamps	Dust pollution levels			
	minimum [1]	low [2]	medium [3]	high [4]
Open luminaires for direct lighting (T5 - ø16 mm or T8 - ø26 mm: Ra > 85)				
group replacement	0,85	0,80	0,75	0,70
replace lamp + group replacement	0,90	0,85	0,80	0,70
correction factor for				
luminaires with cover for direct lighting	MF x 0,95			
luminaires with painted reflector	MF x 0,90			
Uplights (T5 - ø16 mm or T8 - ø26 mm: Ra > 85)				
group replacement	0,85	0,70	0,65	0,65
replace lamp + group replacement	0,90	0,75	0,70	0,65
correction factor for				
luminaires with painted reflector	MF x 0,90			
Luminaires with up- and downlight (T5 - ø16 mm or T8 - ø26 mm: Ra > 85)				
group replacement	0,85	0,75	0,70	0,65
replace lamp + group replacement	0,90	0,80	0,75	0,70
correction factor for				
luminaires with painted reflector	MF x 0,90			

[1] *A dust and smoke free room that is thoroughly cleaned every day. e.g. cleanrooms, operating rooms, ...*

[2] *A room where hardly any dust or smoke is produced. e.g. offices, hospital rooms, ...*

[3] *A room near an environment where dust or smoke is produced, where a limited amount of dust or smoke is produced. e.g. restaurants, bakeries, ...*

[4] *A room where more dust or smoke is produced. e.g. industry, ...*

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- **LED LUMINAIRES**
  Determining and supporting the maintenance factor of LED luminaires requires more attention. The manufacturer will – on top of taking in account luminaire and space pollution– have to make available well-argued data about the LEDs, with maintenance factors based on normalised tests, depending on the chosen burning hours. IES LM80 and TM-21 are the reference. ETAP always calculates the maintenance factor of the lamp on the basis of the manufacturer's data and our own LED temperature measurements, in accordance with TM-21.

	25,000 h	
	350mA	500mA
	MF (%)	MF (%)
D42/LEDN20S	88	
D42/LEDW20S	88	
D42/LEDN39S	88	
D42/LEDW39S	88	
FLARE-1x/LEDN10C (x=0/1/2)		86
FLARE-1x/LEDN6C (x=0/1/2)		88
FLARE-1x/LEDN5C (x=0/1/2)		88
FLARE-1x/LEDW10C (x=0/1/2)		86
FLARE-1x/LEDW6C (x=0/1/2)		88
FLARE-1x/LEDW5C (x=0/1/2)		88

Extract from table with luminous flux and maintenance factors for FLARE (status 2012).

DOCUMENTING THE MAINTENANCE FACTOR

EN 12464-1 specifies that the person who makes the lighting study needs to list the assumptions (concerning the drop in light output of the lamps, dust pollution of luminaires and room, the cleaning of the luminaires and the room) that were made to apply a certain maintenance factor. Therefore, these assumptions need to be included in the study.

GRID POINTS CALCULATION

The new EN 12464-1 defines a system to determine the minimum number of calculation and measuring points. Task area, immediate surroundings and background need to be determined
separately. The horizontal and cylindrical illuminance can be determined using this calculation grid. Attention: this is the minimum number of grid points. In practice the calculation is still based on a greater number of points, e.g. with DIALux.

The distances between the grid points should be the same in terms of lengths and width. In any case, the ratio between both should be between 0.50 and 2.00

Minimum number of grid points

Length of the space in metres	Maximum distance between grid points in metres	Minimum number of grid points
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

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