Die Elektroindustrie

Guide to

Reliable Planning with LED Lighting

Terminology, Definitions and Measurement Methods: Bases for Comparison

Lighting Division

Reliable Planning with LED Lighting

Published by:
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Elektronikindustrie e. V.
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November 2013

Introduction

As someone in a position of responsibility, either in a ZVEI member company or an interested professional group, you will know from your own daily work that the lighting industry is currently experiencing what is probably the most fundamental technological change since the invention of electric lighting. That change presents companies – and also increasingly their customers –with a whole range of new technological and economic challenges and opportunities.

The standards by which light sources are measured used to be uniform; norms and a nomenclature developed over many years ensured that lighting manufacturers' communications to the market were clear and comprehensible.

The switch to generating light using exclusively electronics-based semiconductor light sources – with the resulting new scope for control and regulation – is proceeding at an unprecedented speed. The development of new electrical and lighting norms and standards can barely keep pace with it; nor can the process of communicating them to the market.

This development has the potential for confusing or distracting the industry's most important partner: the consumer. If this state of affairs continues for much longer, the quality of lighting solutions will ultimately suffer and consumer confidence in the new technology will disappear.

The ZVEI has thus taken the initiative and published this guide in an attempt to help create a new, uniform language for manufacturers and those who use their products.

In the preparation of this brochure, account was taken of the latest technological standards.

The success of the guide hinges crucially on widespread use.On behalf of the management of the ZVEI Lighting Division, I ask you to support the valuable work done and take account of the nomenclature in product quality assurance and documentation as well as in your communications.

Manfred Diez
Lighting Division Chairman

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I LED Lighting – Revolution in the World of Lighting

LED technology is a major driver of change in the global lighting industry. For applications such as design, scenography and ambient lighting, LEDs make it possible to create millions of colours and dynamic effects that cannot be realised with conventional light sources. Diminutive dimensions and low heat radiation are further characteristics promoting their widespread use. Easy to control with analogue or digital signals, LEDs are often programmable light sources and thus offer endless scope for creative solutions. Last but not least, they have a long service life, they are energy-efficient and they assure lower maintenance costs.

The LED applications market is growing fast. Today, a large number of new market participants with no background in lighting technology are marketing products that fail to live up to their technical specifications and thus cause uncertainty. To promote the continued growth and acceptance of LED technology, standard definitions and rating procedures are therefore needed so that specifications can be seen in a relative fashion and application-based comparisons made.

All those involved – manufacturers, lighting planners and designers, procurement agents and users – need to know what is meant by different specifications and what can be expected for a particular application.

By formulating key terms and describing methods of measurement, this guide sets out to provide market partners with a standard vocabulary and guidance on the parameters used. It is absolutely essential to use a uniform set of standardised – and thus comparable – quality criteria when assessing technical specifications.

II EU Regulations

It is a general rule in the EU that electrical equipment may only be placed on the market if the basic requirements of the relevant European directives (transposed into national law) are observed.

Light sources (lamps, modules) and luminaires for lighting purposes are thus governed by the EU Low Voltage Directive, the EMC Directive and the ErP Directive (possibly others as well). Accordingly, the products need to satisfy and document the safety, EMC, EMF, ecodesign and other requirements contained therein (see, for example, current EU Regulation 1194/2012). This guide does not look at those requirements.

The regulations cited above refer to the 'state of the art', which is essentially defined by the relevant standards listed in the Official Journal of the EU.

III LED Luminaire Performance Standards – Status Quo

The International Electrotechnical Commission (IEC) is currently working on performance standards for LED luminaires created on the basis of PAS (Publicly Available Specifications). The IEC and EN norms are expected to be published in 2014. The IEC/PAS documents on LED product performance define quality criteria and agree general conditions for measurement.

In this way, all those who are active in this field have a basis for comparative assessment, which is vital for fair competition. This guide is based on the following standards for LED luminaires and LED modules reflecting the current advanced state of design.

LED luminaire performance standards (under preparation):

- IEC 62722-1; Luminaire performance – Part 1: General requirements
- Luminaire performance – Part 2-1: Particular requirements for LED luminaires

LED module performance standards (under preparation):

- IEC 62717; LED modules for general lighting – Performance requirements

LED luminaire performance requirements are directly connected with the stipulations contained in the standard for LED modules; the latter norm must thus also be considered when assessing LED lighting systems.

The ZVEI Lighting Division has set up a working group to create and document a standard nomenclature. Its mission is to identify and define key parameters for describing LED luminaires in the context of LED lighting. This guide has been prepared by the working group and approved by the management and advisory committee of the ZVEI Lighting Division. The information contained in this guide could be considered when the selected LED luminaire data is used and published.

A data resource based on standard parameters is absolutely essential for manufacturers to be able to generate confidence and guarantee reliability in an environment of fair competition – especially in the fast-growing LED market segment. It helps give all market partners security for realising LED lighting systems.

The following have been identified as major parameters:

1 rated input power
2 rated luminous flux
3 luminaire efficacy
4 luminous intensity distribution
5 colour quality
  5a correlated colour temperature
  5b colour rendering index
  5c colour tolerance
6 rated ambient temperature
7 longevity criteria (rated life in h of the LED luminaire and the associated rated lumen maintenance)

As well as other individual product details, the working group recommends that photometric data should be included in the technical information provided about a luminaire (see also documentation obligations under current EU Regulation 1194/2012). At the same time, care needs to be taken to ensure that underlying data (e.g. temperature, lumenloss …) is comparable.

To be able to perform a technical comparison between 'conventional' and 'LED' luminaires, it is also advisable to look at the lighting design results for the same application.

The individual technical parameters are described in detail below.

IV Rated Values and their Use

Definitions of thermal, electrical and photometric characteristics have been set out in international standards to characterise light sources and luminaires.

Certain thermal, electrical and photometric data are published with a rated value – a quantitative value for a given light source or luminaire characteristic under specified operating conditions. The relevant values and conditions are set out in standards or defined by manufacturers or responsible vendors. This is vital if rated values are to be comparable. Many manufacturers' documents contain nominal values, which are approximations of (more precise) rated values.

To take account of possible differences in manufacturers' product designs or differences in components and tolerances in manufacturing processes, the rated value should be published with upper and lower thresholds. This should help to ensure reliable operating conditions and optimal information about the relevant characteristics of light sources and luminaires.

Typical examples of rated values are lamp voltage and lamp current. A typical example of a nominal value is the wattage on the packaging of conventional lamps.

The connection between the different values can be explained by taking a conventional high-pressure discharge lamp HCI-T 35 W (IEC nomenclature: MT-35) as an example:

- **The nominal input power of the lamp is 35 W** – practically the name of the lamp.
- **The rated input power of the lamp, however, is 39 W** – the power for which the lamp was designed.
- **The measured input power of the lamp may be 38 W** – actual tolerances are shown in the lamp specification sheets.

1 Rated Luminaire Input Power P (in W)

Rated input power is the effective power of the luminaire in terms of rated voltage. It is used for planning the energy consumption of the luminaire and includes the power consumed by all components (including control gear) incorporated in the luminaire and required for its operation.

Input power is measured at the rated ambient temperature t_q after thermal stabilisation.

Effective power is measured at 100% of the light output (defined operating point). In the case of dimmable luminaires, dimmed settings are not taken into account at present.

The electrical input power of the LED luminaire as a whole is declared in Watts (W).

For luminaires with constant luminous flux technology, effective power at rated life L_x (see 7a) needs to be additionally declared.

2 Rated Luminaire Luminous Flux Φ_v (in lm)

The rated luminous flux of a luminaire is the total power radiated in all directions within the visible spectrum; it always refers to the initial luminous flux emitted by the semiconductor light sources in the luminaire under defined operating conditions.

The initial luminous flux values measured for luminaires must be no more than ten percent lower than the rated luminous flux of the reference luminaire for which the data is published.

Unless stated otherwise, the luminous flux value given for the luminaire as a whole is based on an ambient temperature of 25 °C.

It is not customary for luminaire luminous flux to be measured and published for luminaires with traditional light sources (non-LED). In such cases, the lamp luminous flux (of the lamps used) is normally multiplied by the luminaire light output ratio (LOR). In LED technology, the separate declaration of luminaire light output ratios is less common.

3 LED Luminaire Efficacy η_v (in lm/W)

Luminaire efficacy is the quotient of radiant luminous flux and electrical power consumed.

The measured initial luminous flux is divided by the measured initial input power of the same LED luminaire. Luminaire efficacy is expressed as lumens per Watt (lm/W).

Note: Luminaire efficacy is occasionally used to rate energy efficiency. For an assessment of energy efficiency, it is generally not enough to consider this parameter alone because it also includes stray light that does not help illuminated the target area. This applies particularly in the case of narrow beam luminaires and streetlights.

4 Luminous Intensity Distribution of Luminaires

The spatial distribution of the luminous intensity of a light source is indicated by intensity distribution curves. Fig. 1 shows the luminous intensity distribution of an interior luminaire and Fig. 2 that of a streetlight.

Fig. 1: Example of the luminous intensity distribution of an interior luminaire

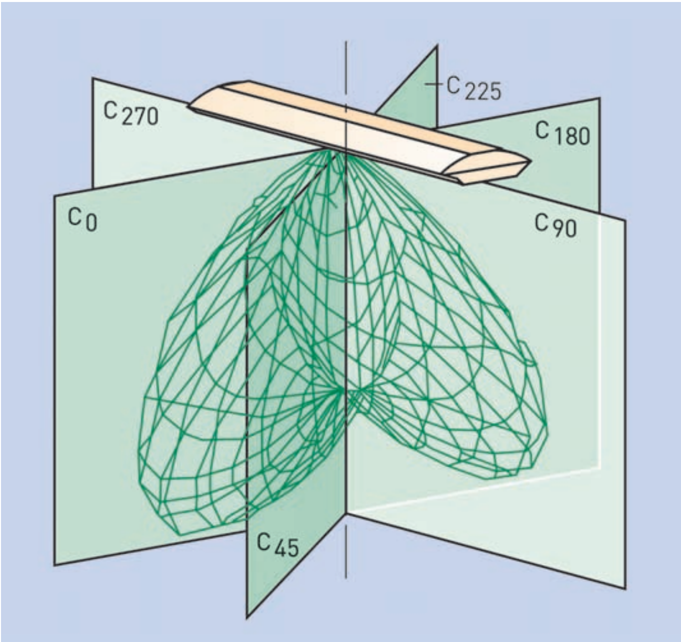
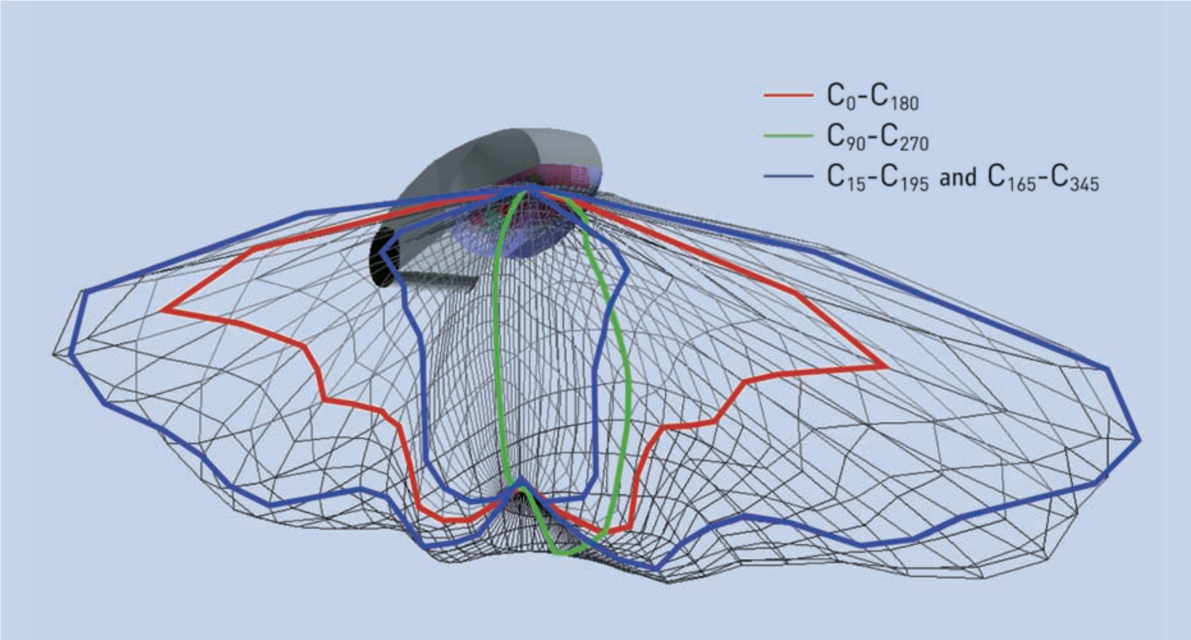


Fig. 2: Example of the luminous intensity distribution of a streetlight



Sections through the vertical axis are represented by **i**ntensity **d**istribution **c**urves (IDCs) for C planes plotted on polar coordinates. They are based on luminous intensity values in standard luminaire operating conditions (e.g. normal position of use, ambient temperature 25 °C). The values are expressed as cd (candela).

Depending on the shape and symmetry of the luminous intensity distributed by a luminaire, a distinction is made between narrow angle, wide angle, symmetrical and asymmetrical intensity distribution. In the case of luminaires, a distinction is also made between direct and indirect radiation. Intensity distribution curves are created using a goniophotometer and disclosed in lighting design documents.

5 Colour Quality

The colour quality of white light is defined by the following characteristics:

- **a** light colour, expressed as a correlated colour temperature
- **b** colour rendering, expressed as a colour rendering index
- **c** colour tolerance, expressed in MacAdam ellipses

5a Correlated Colour Temperature CCT (in K)

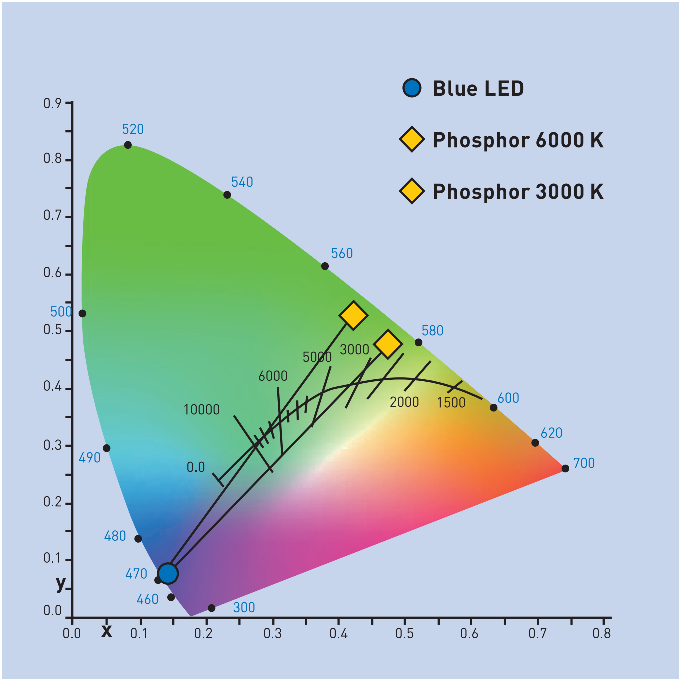
The light colour of white light is defined by correlated colour temperature T_{cp} expressed in K (Kelvin). Temperatures are described as warm white up to 3,300 K, neutralwhite from 3,300 K to 5,300 K and daylight white over 5,300 K (Fig. 3). Correlated colour temperatures should be declared rounded to 100 K (recommendation). In a typical design assignment, care should be taken to ensure that only light sources with similar colour temperatures (100 K tolerance) are used.

5b Colour Rendering Index CRI

Despite identical light colour, light sources can have different colour rendering characteristics because of the different spectral composition of their beam. The general colour rendering index, Ra, was introduced to provide a benchmark for identifying the colour rendering characteristics of a light source objectively. It indicates how closely the perceived colour of an object matches its appearance under a particular reference light source.

According to EN 12464-1, sources with a colour rendering index below 80 should not be used for work areas in which people spend a significant length of time.

Fig. 3: CIE chromaticity diagram



To identify the light colour and colour rendering characteristics of light sources clearly in addition to manufacturers' descriptions, a manufacturer-neutral three-digit colour code has been introduced internationally (see Table 1). The code number 840, for instance, denotes a colour rendering index of 80 to 89 and a colour temperature of 4,000 K, which is within the neutral-white light colour range.

Fig. 4: Example of good colour rendering

Fig. 5: Example of poor colour rendering

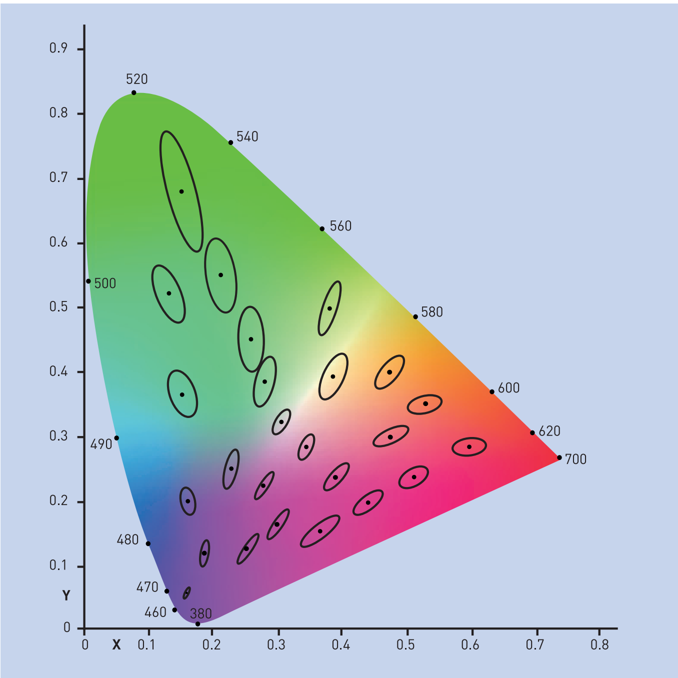
Tab. 1: Identification of LED light sources in terms of colour rendering index and colour temperature

1st numeral indicates colour rendering		2nd and 3rd numerals indicate light colour	
1st digit	R_a-range	2nd and 3rd numeral	Colour temperature
9	90 – 100	27	2,700 K
8	80 – 89	30	3,000 K
7	70 – 79	40	4,000 K
6	60 – 69	50	5,000 K
5	50 – 59	60	6,000 K
4	40 – 49	65	6,500 K

5c Colour Tolerance

The chromatic coordinates of a particular colour can be defined precisely by x and y coordinates in the CIE Chromaticity Diagram (according to the 1931 CIE Colour Space; DIN 5033). The coordinates of the achromatic locus (white), for example, are x = 0.3333 and y = 0.3333.

Fig. 6: MacAdam ellipses in the CIE chromaticity diagram



MacAdam ellipses refer to a region on the CIE Chromaticity Diagram that contains all the colours that the human eye cannot distinguish from the colour at the centre of the ellipse. The contour of the ellipse indicates the colours that can just be distinguished.

MacAdam ellipses are often extended, e.g. to three, five or seven times their original diameter. These 3, 5 or 7-step MacAdam ellipses are used to differentiate between two light sources, the steps representing the range of colour difference. Light sources with a 3-step-MacAdam ellipse colour difference will show less marked differences than light sources with a colour difference spanning a 5-step MacAdam ellipse.

Care should be taken to ensure small colour differences – especially for lighting applications where individual light sources are not far apart and can be seen simultaneously.

6 Rated Ambient Temperature for Luminaires

Luminaire performance is influenced by ambient temperature.

The rated ambient temperature t_a is the highest sustained temperature in which the luminaire may be operated under normal operating conditions (the value may be briefly exceeded in operation by 10 K). Where t_a = 25 °C, no declaration is required on the luminaire; any other rated ambient temperature value needs to be declared (same rule applies to t_q).

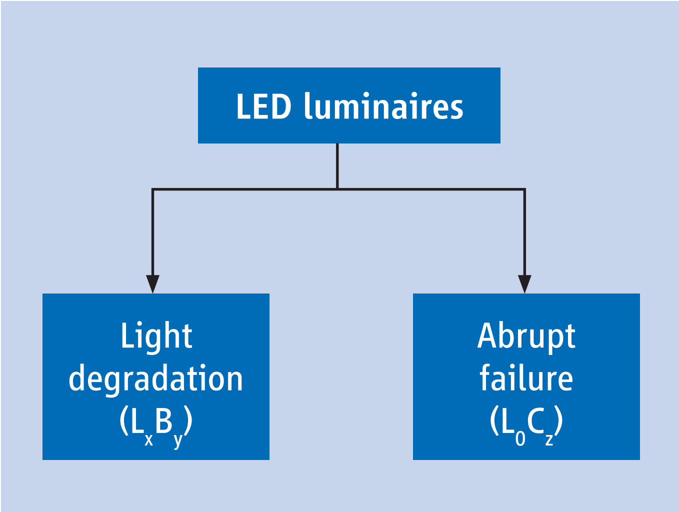
Temperature t_q (quality) is a new parameter indicating the highest rated ambient temperature permitted for a defined performance (incl. life expectancy, lighting characteristics). More than one t_q value can be declared for different performance characteristics.

7 Longevity Criteria for LED Lighting Products

LED lifespans are not measured only to the point of abrupt failure: up to a certain point, the majority of LEDs do not actually fail at all; their luminosity decreases over time (light degradation). The lifespan of LEDs, modules and luminaires is thus limited by the failure of the relevant electronics or by the luminous flux falling below a predefined minimum level. Fig. 7 shows the two longevity criteria, abrupt failure and light degradation, as defined in current IEC draft standards:

In the case of **LEDs**, the two parameters essentially depend on the permissible current and the temperature inside the LED. LED manufacturers need to declare the relevant information so that module or luminaire manufacturers can determine the life expectancy of their products.

Fig. 7: LED luminaire longevity criteria



In the case of **LED modules**, light degradation and abrupt failure are also influenced by the electrical interconnection of the LEDs, the temperature at the t_c or t_p point and other characteristics of the module. Temperature at the t_c point (marking on housing or PCB) is the maximum temperature permitted for safety under normal operating conditions. The t_p point temperature is the temperature at which the performance parameters are estimated. The temperatures at t_c and t_p points can differ. Module manufacturers must therefore make this information available to luminaire manufacturers so that the latter may determine the life expectancy of their products.

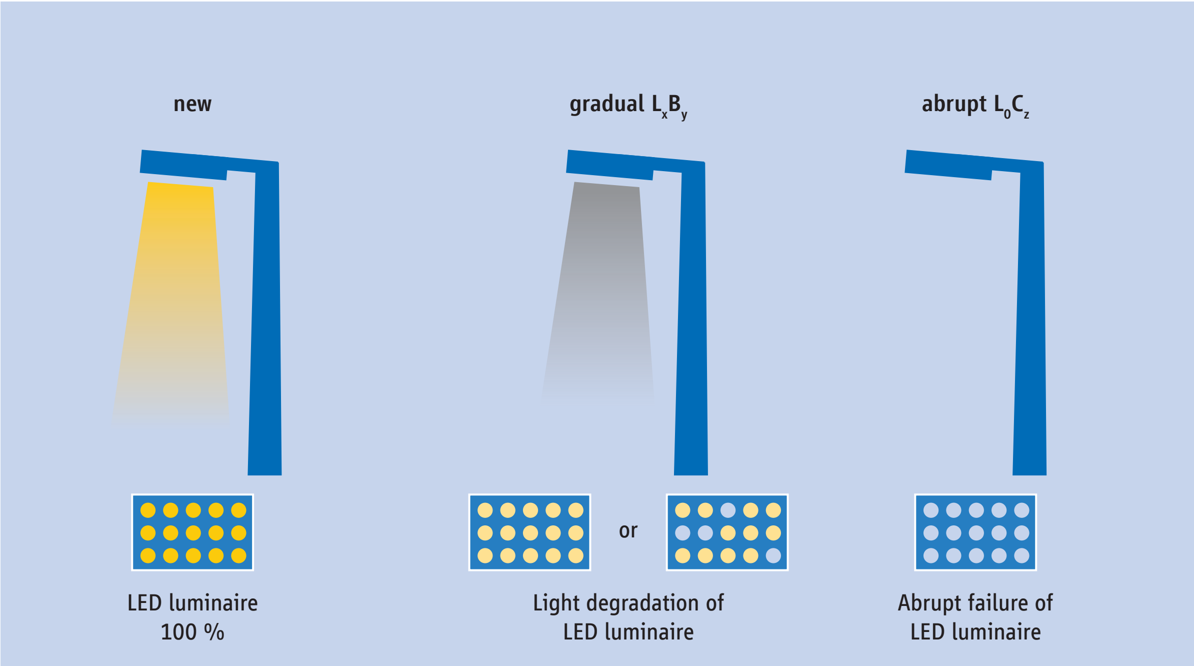
This guide presents comparable quality criteria that facilitate the assessment of technical claims for LED luminaires. LED modules and individual LEDs are not considered in greater depth below.

7.1 Longevity Criteria for LED Luminaires

In the case of LED luminaires, degradation and abrupt failure depend additionally on the electrical operating data of the LEDs or modules in the luminaires, the ambient temperature for the application and other characteristics of the LED luminaires. Luminaire manufacturers must declare the relevant information so that the user or designer of a lighting installation can determine when the installation requires maintenance.

Fig. 8 shows the original state, degradation and abrupt failure of a luminaire (terminology from current draft standard):

Fig. 8: Failure state of a luminaire (original state, degradation and abrupt failure)

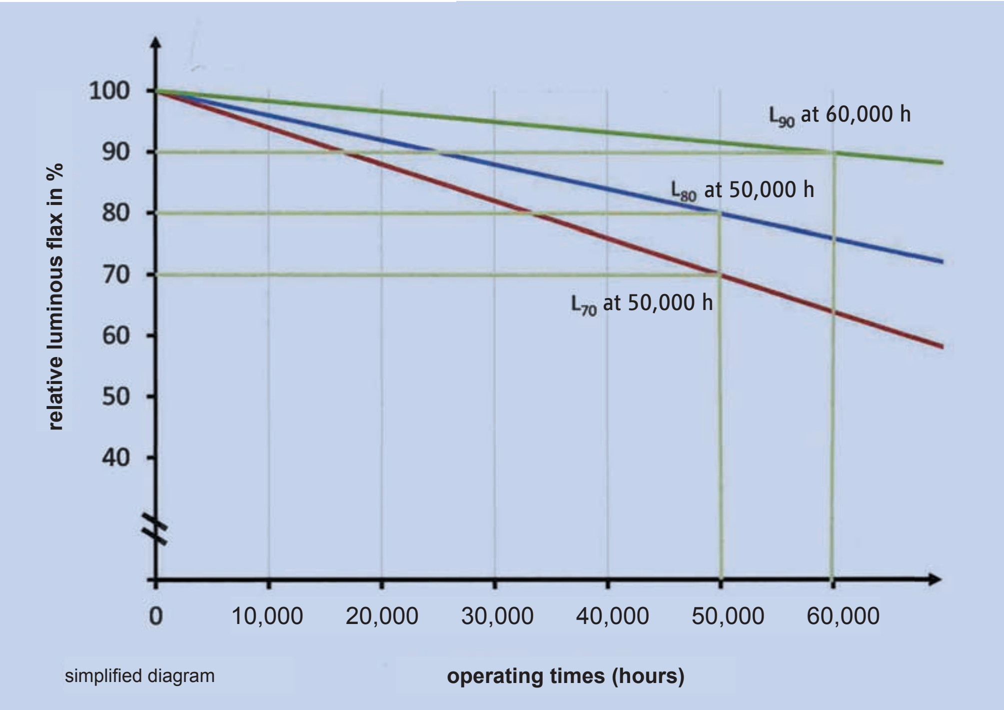


7a Rated Life (L_x) (useful life)

The light degradation of LED luminaires is indicated by rated or useful life L_x, where luminous flux declines to a percentage x of initial luminous flux.

Typical values of 'x'are 70 (L_{70}) or 80 percent (L_{80}) for a given rated or useful life.

Fig. 9: **Schematic representation of the change in luminous flux over operating time**



7b Taking Account of Lumen Loss (B_y)

The percentage of LED luminaires that fall below the target luminous flux of x percent (see x of L_x) at the end of their designated life is expressed by the 'gradual failure fraction' (B_y, see Fig. 8) (percentage of failures as a result of gradual loss of luminous flux). Gradual lumen loss refers to the product considered – LED luminaire or LED module – and can occur as a result of a gradual decline in luminous flux or the abrupt failure of individual LEDs on the module (see Fig. 8).

The value B_{50} thus means that 50 percent of a number of LEDs of the same type fail to deliver the declared percentage 'x' of luminous flux at the end of rated life 'L'. Occasionally, for certain applications, B_{10} may be of interest, i.e. the point in time when only ten percent of the LED luminaires fail to deliver the declared percentage 'x' of their initial luminous flux.

The B_{50} criterion (median value) is used to indicate the average luminous flux of LED luminaires functioning at the end of the rated median useful life L_x (x = percentage of initial value).

The B_y criterion says nothing, however, about the luminous flux of the individual LED luminaires or their precise distribution.

7c Taking Account of Abrupt Failures (C_z)

The percentage of LED luminaires that have failed completely by the end of rated life 'L_x'is expressed by 'C_z' (abrupt failure fraction, also known as 'catastrophic failure rate', see Fig. 8). LED luminaires with only isolated LED failures and LED luminaires where only individual LED modules fail among several do not fall into the category of abrupt failure. The value C_3, for example, means that three percent of a number of LED luminaires of the same type failed abruptly within the rated life and thus no longer deliver any light.

The failure of control gear or other luminaire components is not considered by this criterion. Studies and standardisation work have been initiated to develop an approach that includes such components.

8 ZVEI Recommendations

The ZVEI recommends that the parameters described in this guide should be adopted and declared as indicated.

There are two approaches to declaring the lifespan of LED luminaires, both of which are legitimate.

1 Based on IEC lifetime metrics:
- Declaration of useful life in hours to the limit L_x B_y and, irrespective of that, declaration of a second lifespan L_0C_z for defined z values (e.g. 5 or 10 percent) identifying the point by which 'z' percent of the luminaires have failed abruptly.
- Useful life 'Lx'where x = 80 percent (L_{80}) and an ambient temperature of 25 °C should be declared as typical variables.
- For the variable B_y, y = 50 percent (B_{50}) is assumed unless otherwise stated.

2 From the viewpoint of lighting designers:
Declaration of a single defined useful life in hours L_x B_y C_z (e.g. 50,000 hours) with the declared luminous flux percentage 'x', the gradual lumen loss 'y' (in percent – declaration can be omitted where B_y = B50) and the percentage 'z' of luminaires that have failed abruptly (C_z) by the end of their rated life 'L_x'.

V Notes on Lighting Planning

Maintenance factors are an important consideration in the planning of lighting installations. For compliance with the DIN EN 12464 series of standards, for example, the planner needs to establish and document how much the luminous flux of a lighting installation will decrease by a certain point in time and recommend appropriate maintenance action.

The following maintenance factors are defined by CIE in the publications CIE 97 (Indoor lighting) and CIE 154 (Outdoor lighting):

- **MF:** Maintenance Factor
- **LLMF:** Lamp Lumen Maintenance Factor
- **LSF:** Lamp Survival Factor
- **LMF:** Luminaire Maintenance Factor
- **RMF:** Room Maintenance Factor
- **SMF:** Surface Maintenance Factor

The maintenance factor MF of the lighting installation is the product of the individual maintenance factors.

Indoor lighting:
MF = (LLMF × LSF) × LMF × RMF

Outdoor lighting:
*MF = (LLMF × LSF) × LMF (× SMF)**

LLMF is obtained from manufacturers' light degradation curves for the relevant observation period.

LSF is obtained from the number of LED light sources that have failed abruptly over the time (in hours) up to the observation point.

Lamp survival factor:

$$LSF_{(ih)} = 1 - \frac{Z(c_{z\,(ih)})}{100}$$

For lighting designs incorporating LED luminaires, LLMF and LSF form a basis for rating LED sources and can be determined for different luminous flux classes on the basis of operating times (in hours). This method aligns to the declaration of LLMF and LSF for conventional lamps.

The relevant luminous flux class of an LED luminaire is indicated by its useful life L_x assuming a given 'reduction in luminous flux'.

'L_x'is expressed as follows: L_x–nn,nnn hours.

Examples:
L_{70}–50,000 hours; L_{80}–50,000 hours.

The following example shows how a manufacturer could present maintenance factors in tabular form (lamp lumen maintenance factor (LLWF) and lamp survival factor (LSF)):

* SMF is used where appropriate, e.g. as surface maintenance factor of an illuminated surface or for pedestrian subways.

Tab. 2: Maintenance factors of LED light sources and LED modules: LLMF and LSF

Rated life			Operating time in 1,000 h																					
Parameters			1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	...
L_{90}	ii.iii h	LLMF																						
		LSF																						
L_{80}	ii.iii h	LLMF																						
		LSF																						
L_{70}	ii.iii h	LLMF																						
		LSF																						
L_{60}	ii.iii h	LLMF																						
		LSF																						
L_{50}	ii.iii h	LLMF																						
		LSF																						

In this example of tabular representation of maintenance factors LLMF and LSF, the first column shows the rated life of the LEDs (L_x – ii,iii h). As a general rule, rated life is among the specifications found in manufacturers' product data sheets (examples: L_{90} – 25,000 h; L_{80} – 50,000 h; L_{70} – 50,000 h).

Lamp lumen maintenance factors (LLMF) and lamp survival factors (LSF) for the relevant rated lifespans of LED luminaires are also declared by luminaire manufacturers. Unless otherwise stated, the values are specified for an ambient temperature of 25 °C.

If this table is designed for B_{50} lumen loss, the lamp lumen maintenance factor (LLMF) after a rated life of ii,iii h reaches x/100, where x is taken directly from the declared value L_x. For other B_y rates of lumen loss, lamp lumen maintenance factors (LLMF) differ.

The lamp survival factor (LSF), which expresses the abrupt failure of an LED luminaire (excluding control gear), may be negligible for planning in many cases. Where a large number (> 100) of luminaires is considered, individual failures are statistically insignificant although this may affect the appearance of the installation. However, even where LSF = 1, individual LED luminaires may have failed. This approach is not appropriate for luminaires with LED replacement lamps.

The advantage of tabular or graphic representation is that the planner can easily identify the lumen loss at any specified point in time. The method cannot be used for warranty statements.

VI Appendix: Definitions of Quality Criteria Performance Requirements

<table>
<tr><th>Term</th><th>Definition</th><th>Standard</th><th>Remarks</th></tr>
<tr><td>Rated input power
(in W)</td><td>input power
P
electrical power from the mains supply consumed by the luminaire including the operation of all electrical components necessary for its intended functioning

Unit: W

rated value
quantity value for a characteristic of a product for specified operating conditions. The value and the conditions are specified in the relevant standard, or assigned by the manufacturer or responsible vendor</td><td>34D/1080/CDV > IEC 62722-1;
34D/1093/CDV > IEC 62722-2-1:
The provisions of Clause 7 of IEC 62717 apply to the LED luminaire.
IEC 62717 – Performance standard for LED modules:
The draft 34A/1659/CDV text:
The initial power consumed by each individual LED module in the measured sample shall not exceed the rated power by more than 10 %. The sample mean of the initial consumed power shall not be greater than xx[1] % of the rated power.

[1] Exact value of xx is under consideration.
Note 1: Note 2 of 1.1 should be regarded.</td><td>Definition in 34D/1080/CDV for IEC 62722-1.

Emergency lighting charging power should be deleted – Ad-hoc remarks (see also item 3).</td></tr>
<tr><td>Rated luminous flux
(in lm)</td><td>luminous flux
ϕ_v, ϕ

quantity derived from radiant flux, Φe, by evaluating the radiation according to its action upon the CIE standard photometric observer

Unit: lm
Note: For photopic vision
$$\Phi_v = K_m \int_0^{\infty} \frac{d\,\Phi_e(\lambda)}{d\,\lambda} V(\lambda) d\,\lambda$$
where
$$\frac{d\,\Phi_e(\lambda)}{d\,\lambda}$$
is the spectral distribution of the radiant flux and V(λ) is the spectral luminous efficiency.
Note 2: For the values of Km (photopic vision) and K'm (scotopic vision), see IEC 60050-845, 845-01-56.
Note 3: The luminous flux of LED dies is usually expressed in groups into which they are sorted.</td><td>1080/CDV > IEC 62722-1;
34D/1093/CDV > IEC 62722-2-1:

The provisions of Clause 8.1 of IEC 62717 apply to the LED luminaire. In addition the provisions in Annex A.1, Paragraph 2 of IEC 61722-2-1 apply where a declared ambient air temperature other than 25 °C is advised by the manufacturer.
IEC 62717 – Performance standard for LED modules:
The draft 34A/1659/CDV text:
The initial luminous flux of each individual LED module in the measured sample shall not be less than the rated luminous flux by more than 10%.The sample mean of the initial luminous flux shall not be less than xx[1] % of the rated luminous flux.

[1] Exact value of xx is under consideration.</td><td></td></tr>
<tr><td>LED luminaire efficacy
(in lm/W)</td><td>Luminaire efficacy (of a source)
η_v, η

ratio of the luminaires total luminous flux versus its rated input power, excluding any emergency lighting charging power, expressed as lumens per watt

Unit: lm .W^{-1}

Note:For LED applications, the source may be a LED package, module, lamp, luminaire etc.
[IEC 60050-845, 845-01-55, modified] and [CIE S 017/E:2011 ILV, 17-730]</td><td>34D/1080/CDV > IEC 62722-1;
34D/1093/CDV > IEC 62722-2-1:

The provisions of Clause 8.1 of IEC 62717 apply to the LED luminaire.
IEC 62717 – Performance standard for LED modules:
The draft 34A/1659/CDV text:
The luminaire efficacy shall be calculated from the measured initial luminous flux divided by the measured input power. For measurement of luminous flux see Annex A.3.2.</td><td></td></tr>
<tr><td>Luminous intensity distribution</td><td>luminous intensity (of a source, in a given direction)
I_v; I

quotient of the luminous flux dΦV leaving the source and propagated in the element of solid angle dΩ containing the given direction, by the element of solid angle
IV = dΦV/dΩ

Unit: cd = lm. sr^{-1}

Note 1: The definition holds strictly only a point of source.
Note 2: The luminous intensity of LED is expressed according to CIE 127:2007 measurement procedure.
[IEC 60050-845:1987, 845-01-31] and [CIE S 017/E:2011 ILV, 17-739 modified]</td><td>34D/1080/CDV > IEC 62722-1;
34D/1093/CDV > IEC 62722-2-1:

The provisions of Clause 8.2.3 of IEC 62717 apply to the LED luminaire.
IEC 62717 – Performance standard for LED modules:
The draft 34A/1659/CDV text:
The distribution of luminous intensity shall be in accordance with that declared by the manufacturer.</td><td></td></tr>
</table>

Term	Definition	Standard	Remarks
Correlated Colour Temperature (CCT in K)	**correlated colour temperature** T_{cp} temperature of the Planckian radiator having the chromaticity nearest the chromaticity associated with the given spectral distribution on a diagram where the (CIE 1931 standard observer based) $u', \frac{2}{3}v'$ coordinates of the Planckian locus and the test stimulus are depicted **Unit:** K **Note 1:** The concept of correlated colour temperature should not be used if the chromaticity of the test source differs more than $\Delta C = \left[(u'_t - u'_p)^2 + \frac{4}{9}(v'_t - v'_p)^2\right]^{1/2} =$ from the Planckian radiator, where (u'_t, v'_t) refer to the test source, (u'_p, v'_p) to the Planckian radiator. **Note 2:** Correlated colour temperature can be calculated by a simple minimum search computer program that searches for that Planckian temperature that provides the smallest chromaticity difference between the test chromaticity and the Planckian locus, or e.g. by a method recommended by Robertson, A. R. ‚Computation of correlated colour temperature and distribution temperature', J. Opt. Soc. Am. **58**, 1528-1535, 1968. (Note that the values in some of the tables in this reference are not up-to-date). Abbreviation: ‚**CRI**'	**34D/1080/CDV > IEC 62722-1;** **34D/1093/CDV > IEC 62722-2-1:** The provisions of Clause 8.2.3 of IEC 62717 apply to the LED luminaire. **IEC 62717 – Performance standard for LED modules:** **The draft 34A/1659/CDV text:** The distribution of luminous intensity shall be in accordance with that declared by the manufacturer.	
Rated Colour Rendering Index (CRI)	**colour rendering index** ***R*** measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation See also CIE 13 Method of Measuring and Specifying Colour Rendering of Light Sources Abbreviation: ‚**CRI**'	**34D/1080/CDV > IEC 62722-1;** **34D/1093/CDV > IEC 62722-2-1:** The provisions of Clause 9.3. of IEC 62717 apply to the LED luminaire. Where suitable component reliability data is available the test duration may be reduced from 6,000 h to 2,000 h. **IEC 62717 – Performance standard for LED modules:** **The draft 34A/1659/CDV text:** The initial Colour Rendering Index (CRI) of a LED module is measured. A second measurement is made at an operational time as stated in 6.1. (= 6,000 h / 25 % rated life) Compliance: For all tested items in a sample the measured CRI values shall not have decreased by more than • 3 points from the rated CRI value (see Table 1) for initial CRI values and • 5 points from the rated CRI value (see Table 1) for maintained CRI values.	
Rated chromaticity co-ordinate values (initial and maintained)	**chromaticity coordinates** ratio of each of a set of 3 tristimulus values to their sum **Unit:** 1 **Note 1:** As the sum of the 3 chromaticity coordinates is equal to 1, 2 of them are sufficient to define a chromaticity. **Note 2:** In the CIE standard colorimetric systems, the chromaticity coordinates are represented by the symbols x, y, z and x_{10}, y_{10}, z_{10}.	**34D/1080/CDV > IEC 62722-1;** **34D/1093/CDV > IEC 62722-2-1:** The provisions of Clause 9.1 of IEC 62717 apply to he LED luminaire. Where suitable component reliability data is available the test duration may be reduced from 6,000 h to 2,000 h and the measured chromaticity value co-codinate value for initial and 2,000 h shall not exceed the rated colour variation category for initial and 6,000 h respectively. **IEC 62717 – Performance standard for LED modules:** **The draft 34A/1659/CDV text:** The initial chromaticity coordinates are measured. A second measurement of maintained chromaticity coor-dinates is made at an operational time as stated in 6.1 (= 6,000 h / 25 % rated life). The measured actual chromaticity coordinate values (both initial and maintained) shall fit within one of 4 categories (see Table 5), which correspond to a particular MacAdams ellipse around the rated chromaticity coordinate value, whereby the size of the ellipse (expressed in n-steps) is a measure for the tolerance or deviation of an individual LED module.	

Term	Definition	Standard	Remarks
Maintained luminous flux	**luminous flux maintenance factor** **lumen maintenance factor** f_{LLM} ratio of the luminous flux emitted by the light source at a given time in its life to its initial luminous flux emitted, the light source being operated under specified conditions **Unit:** This ratio generally expressed in percent. [IEC 60050-845, 845-07-65, modified]ratio of luminous flux of lamp at a given time in the life to the initial luminous flux **Note:** Initial luminous flux of lamps is usually declared at 1 h for incandescent and 100 h for discharge lamps. Abbreviation: ‚**LLMF**'	**34D/1080/CDV > IEC 62722-1;** **34D/1093/CDV > IEC 62722-2-1:** The provisions of Clause 10.2 of IEC 62717 apply to the LED luminaire. Where suitable component reliability data is available the test duration may be reduced from 6,000 h to 2,000 h • the measured flux value at 2 000 h shall not be less than the rated maximum lumen maintenance value related to the rated life the measured lumen maintenance shall correspond with the 2,000 h lumen maintenance rated codes. For all of the tested items in a sample, the measured values shall be of the same maintenance code as the provided value. All the LED modules in a sample shall pass the test. **IEC 62717 – Performance standard for LED modules:** **The draft 34A/1659/CDV text:** See subclause 10.2.	f_{LLM} is not used in IEC standards (at least LED module) as the shape of the lumen depreciation curve as function of time between LED modules varies among manufacturers and is depending on the specific LED technology used. Specified in IEC is 'life', which is the length of time during which a LED module provides more than claimed percentage x of the initial luminous flux, under standard conditions. This definition relates to a lamp: 34/175/CDV
Ambienttemperature (t_q) for a luminaire	**temperature, rated ambient performance** (rated ambient performance temperature) ***tq*** highest ambient temperature around the luminaire related to a rated performance of the luminaire under normal operating conditions, both as declared by the manufacturer or responsible vendor **Unit:** °C **Note 1:** $t_q \leq t_a$ For ta, see 1.2.25 of IEC 60598-1. **Note 2:** For a given life time, the t_q temperature is a fixed value, not a variable. **Note 3** There can be more than one t_q temperature, depending on the life time claim.ambient temperature around the luminaire related to the performance of the luminaire	34D/1080/CDV > IEC 62722-1; 34D/1093/CDV > IEC 62722-2-1: **General** The provisions of Subclause A.1 of IEC 62717 apply to the LED luminaire. Where a rated ambient performance temperature tq other than 25 °C is advised by the manufacturer a correction factor will need to be established to correct the measured luminous flux value at 25 °C to the luminous flux value at the declared ambient. This shall be done using relative photometry in a temperature controlled cabinet.	Definition from 34/175/CDV.
Failure fraction (F_y), corresponding to the rated life of the LED module in the luminaire	**failure fraction at rated life** F_y percentage y of a number of LED products of the same **type** that at their rated life designates the percentage (fraction) of failures **Note 1:** This failure fraction expresses the combined effect of all components of a module including mechanical, as far as the light output is concerned. The effect of the LED could either be less light than claimed or no light at all. **Note 2:** For LED modules normally a failure fraction of 10 % or/and 50 % are being applied, indicated as F_{10} and/or F_{50}.	**34D/1080/CDV > IEC 62722-1;** **34D/1093/CDV > IEC 62722-2-1:** **Gradual failure fraction (B_y)** Percentage y of a number of LED modules of the same type that at their rated live designates the percentage (fraction) of failures. This failure fraction expresses only the gradual light output degradation. **Abrupt failure fraction (C_y)** Percentage y of a number of LED modules of the same type that at their rated live designates the percentage (fraction) of failures. This failure fraction expresses only the abrupt light output degradation. The recommended metrics for specifying LED luminaire life time is explained in Annex C of IEC 62717 and differs from the pass/fail criterion of the life time test as in 10.2.	

VII References

The appendix is taken from the following IEC draft standards:

34D/1080/CDV

34D/1093/CDV

34A/1659/CDV

Notes

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Acknowledgements for photographs Cover: Kostia Lomzov, Fotolia