
LED in Interior Lighting

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CEN TC 169, Convenor WG 2
President CIE Austria

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Your lecturer:



Peter Dehoff

- Graduated from Technical University Karlsruhe
- Zumtobel Lighting (Dornbirn AT) since 1987
- Senior expert in Lighting Application Management
- Director Professional Associations and Standards

- President **CIE** Austria
- Austrian representative in CIE Div. 3 „Interior Lighting“
- Chair CIE TC 3-49 „Lighting Controls“
- Austrian representative in **CEN TC 169 „Light and Lighting“**
- Convenor CEN TC 169 WG 2 „Lighting for Workplaces“
- Austrian representative in **ISO TC 274 „Light and Lighting“**
- Chair **ON-K 047** „Licht und Optik“
- Chair **LightingEurope** WG Smart Lighting
- Chair of **ZVEI AK licht.de** (Branch marketing www.licht.de)

- Zumtobel Research Conductor on Applied Lighting
- Lecturer in Zumtobel Lighting Solution Consultant education program
- Lecturer at Universities Graz (AT), Darmstadt (DE) and Liechtenstein: Lighting for Architects

- Trends
- Quality criteria
- Life time criteria
- Maintenance of LED
- LED luminaire data sheet
- ZVEI Guide

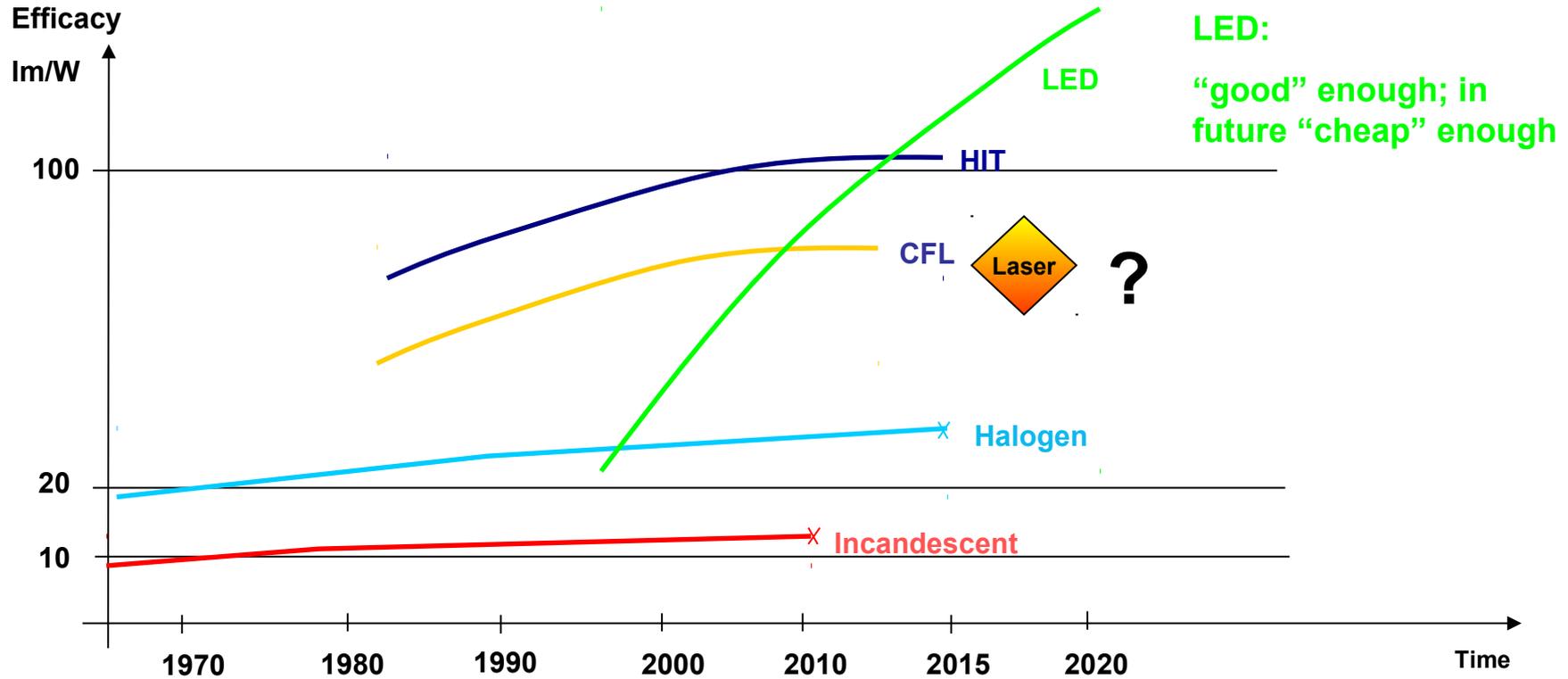




T-MOBILE SHOP Vienna |



Efficacy of LED is increasing leaving conventional light sources behind



Investigation of specific features of LED lighting solutions

Comparison with conventional lighting solutions

CIE 205:2013 Review of lighting quality measures for interior lighting with LED lighting systems

Further workplan for CEN TC 169 WG 2 “Lighting of workplaces”

i.e. EN 12464-1 “Lighting of interior workplaces” - 2011



The following quality measures were considered for relevance to indoor functional lighting with LED lighting systems (1)

Task visibility:	uniformity of horizontal illumination reflected glare veiling reflections shadows	Conclusion: New glare evaluation system needed for discomfort and overhead glare arriving from LED features
Visual comfort:	discomfort glare overhead glare luminance ratios visual fatigue eyestrain,	Conclusion: New metric for flicker and stroboscopic effects is required
Flicker and strobe		
Modelling	of faces and objects	Conclusion: Metric for modelling should be further developed

The following quality measures were considered for relevance to indoor functional lighting with LED lighting systems (2)

Colour appearance: colour rendering
light colour preference
object colour appearance

Conclusion:
A new metric for colour rendering is required

Consistency of colour and luminous flux over time and space

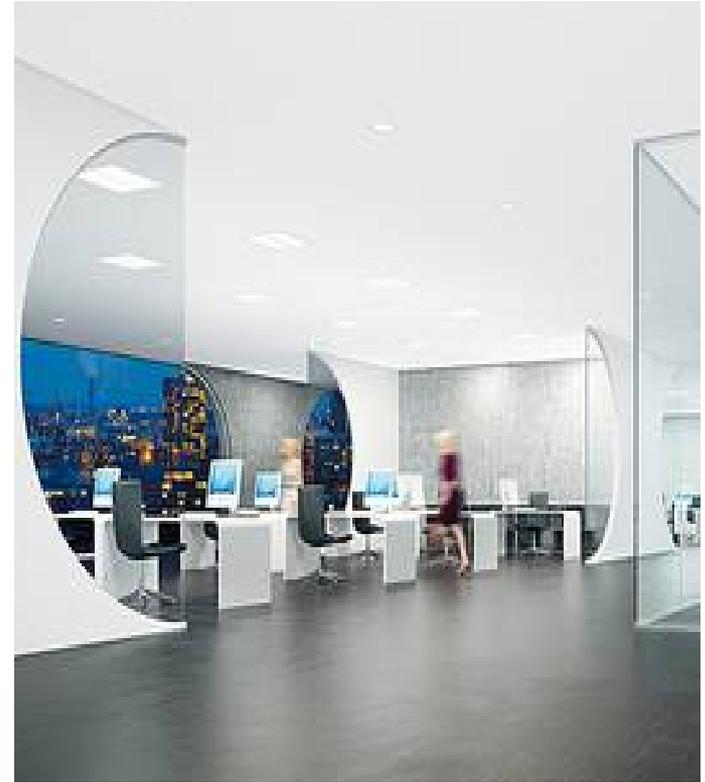
Conclusion:
Consistency measurements to be standardised.

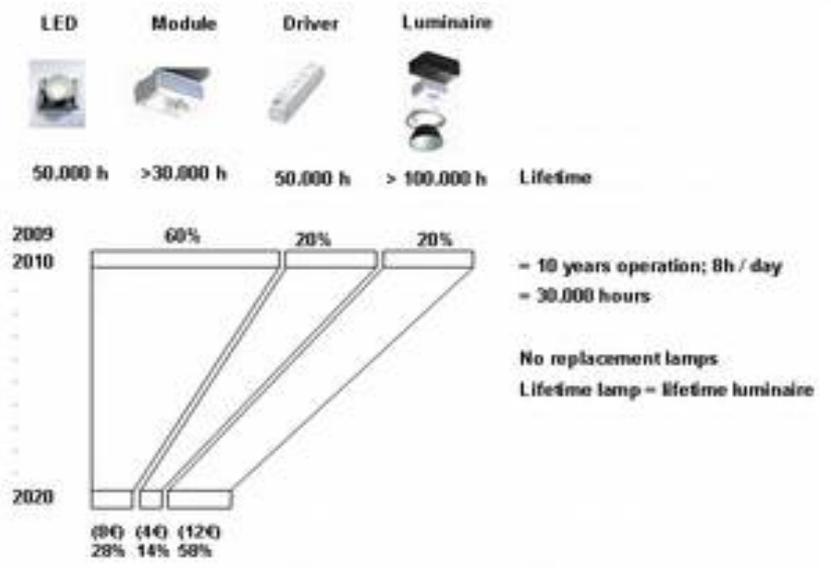
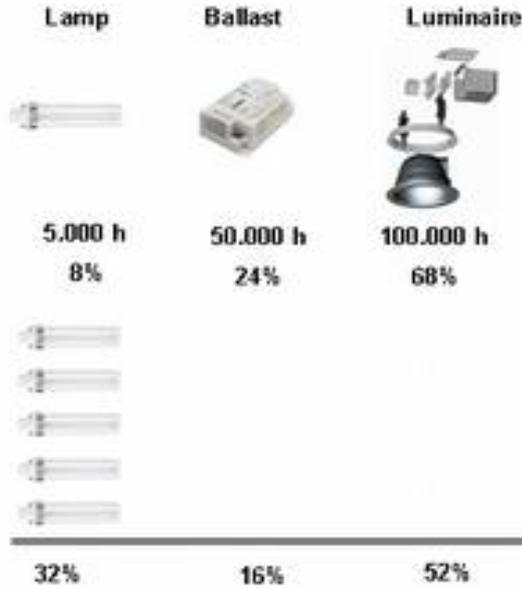
Appearance of spaces: room surface brightness
distribution of light on surfaces

Appearance of the light source and luminaire
style
integration into architecture
appropriateness of appearance
size, etc.

100.000 h
75.000 h
50.000 h
25.000 h

?





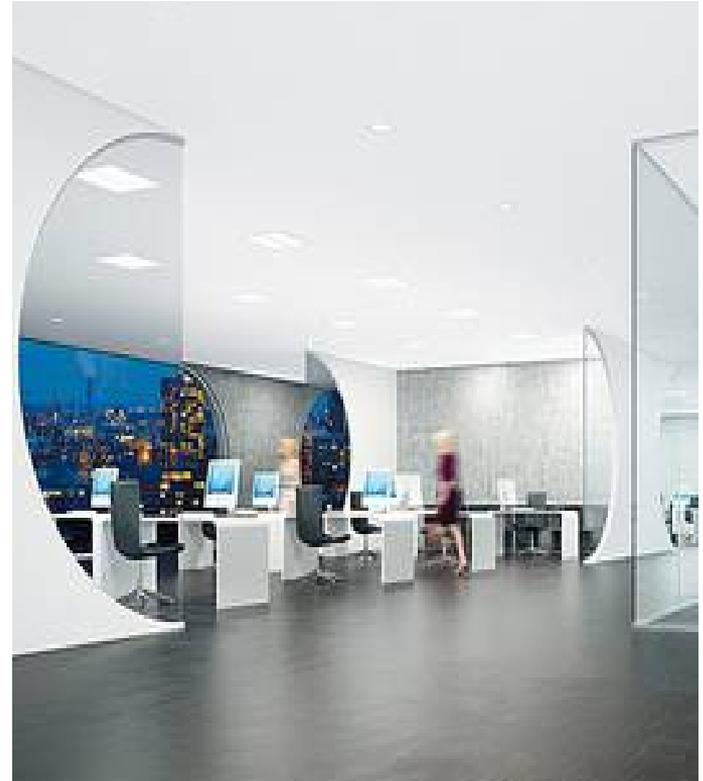
*Improvements and cost downs based on Moore's law and Hartz's law

100.000 h
75.000 h
50.000 h
25.000 h

Rated Median Useful Life (of LED modules) (L_x)

length of time during which 50 % (B_{50}) of a population of operating LED modules of the same type have parametrically failed, under standard test conditions as declared by the manufacturer or responsible vendor

Source: IEC 62717 LED modules for general lighting - Performance requirements



Many manufactureres

Many products

Many data

Many informations



ZVEI Leitfaden: to help designers, manufacturers and specifiers

Who is ZVEI – FV Licht?

- Association of lighting industry in Germany

Leitfaden = Guide

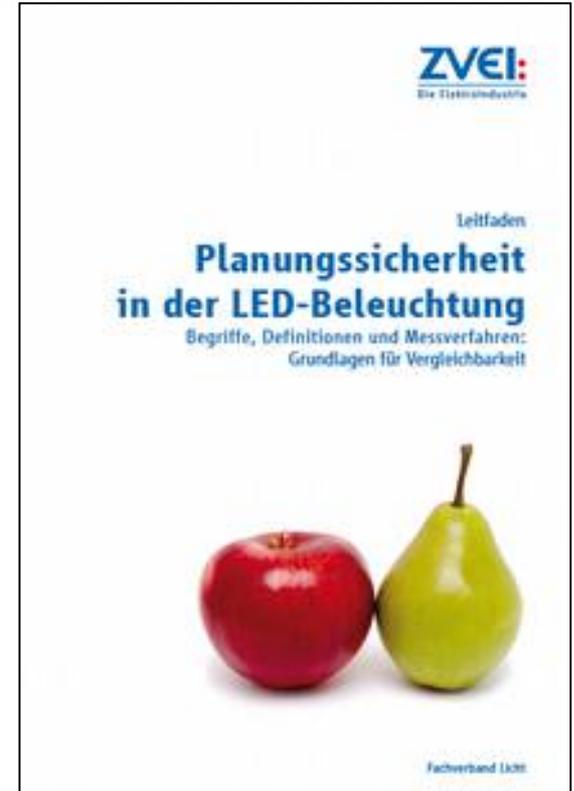
„Safety in designing LED-lighting“

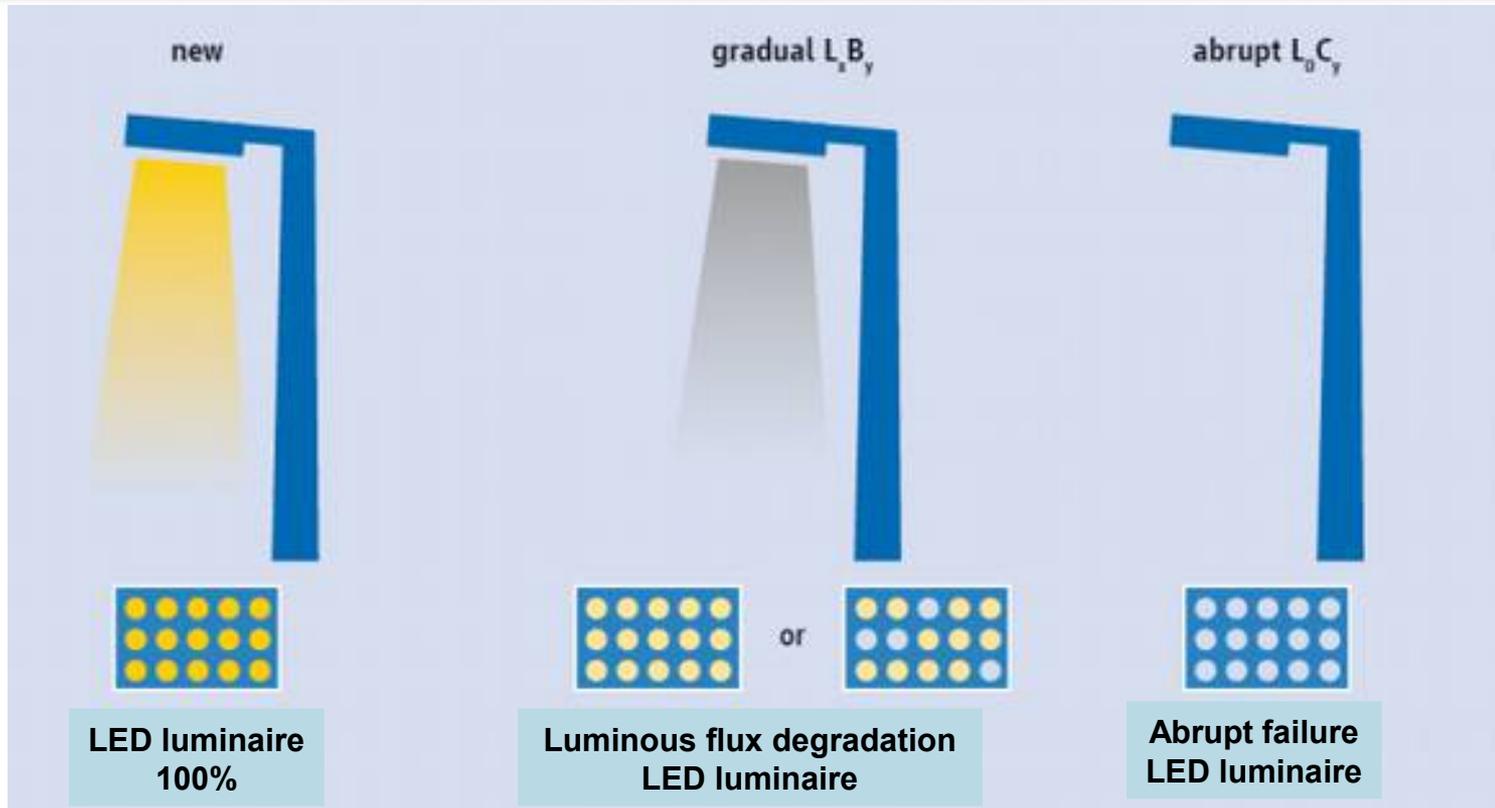
Time in LED lighting:

Life time: to describe a LED type

Usage time: to design maintenance

Time to failure: to define guarantee

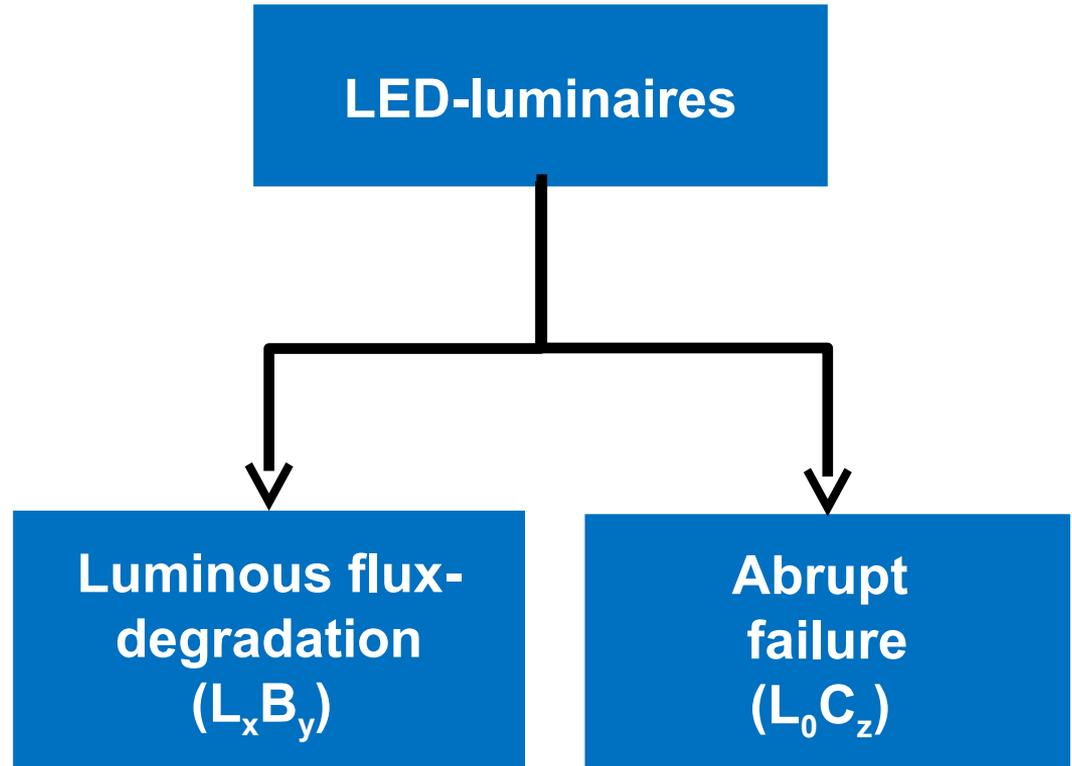




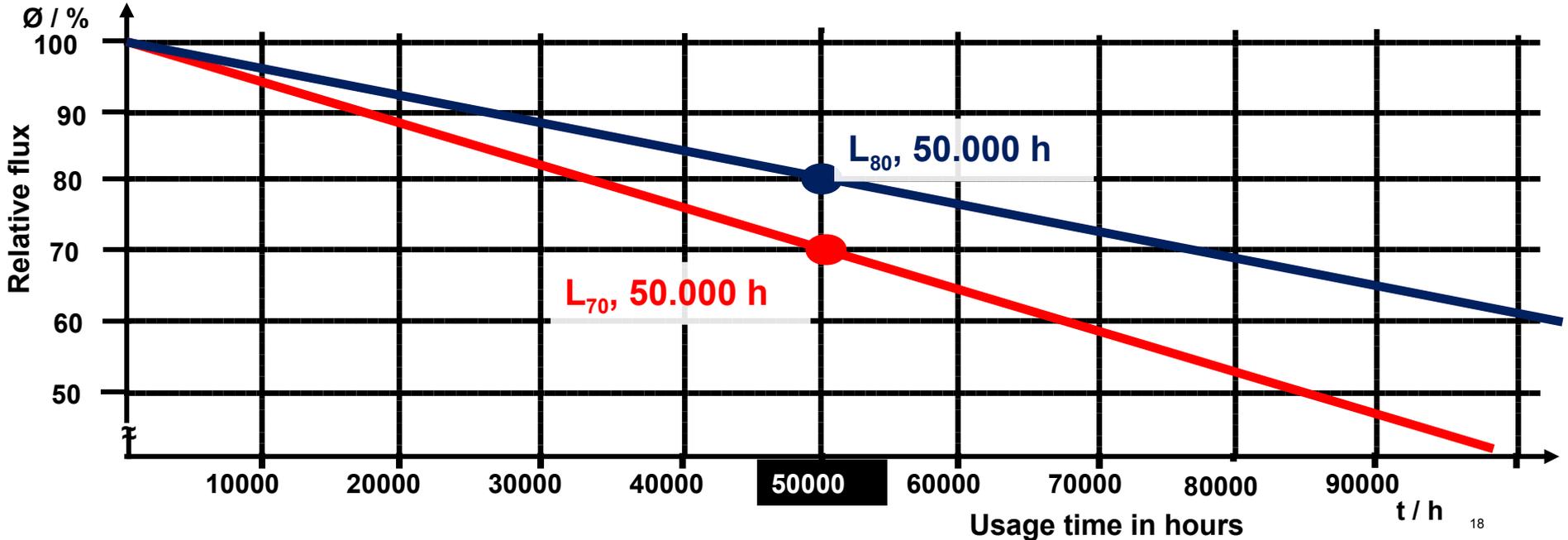


Life time descriptions

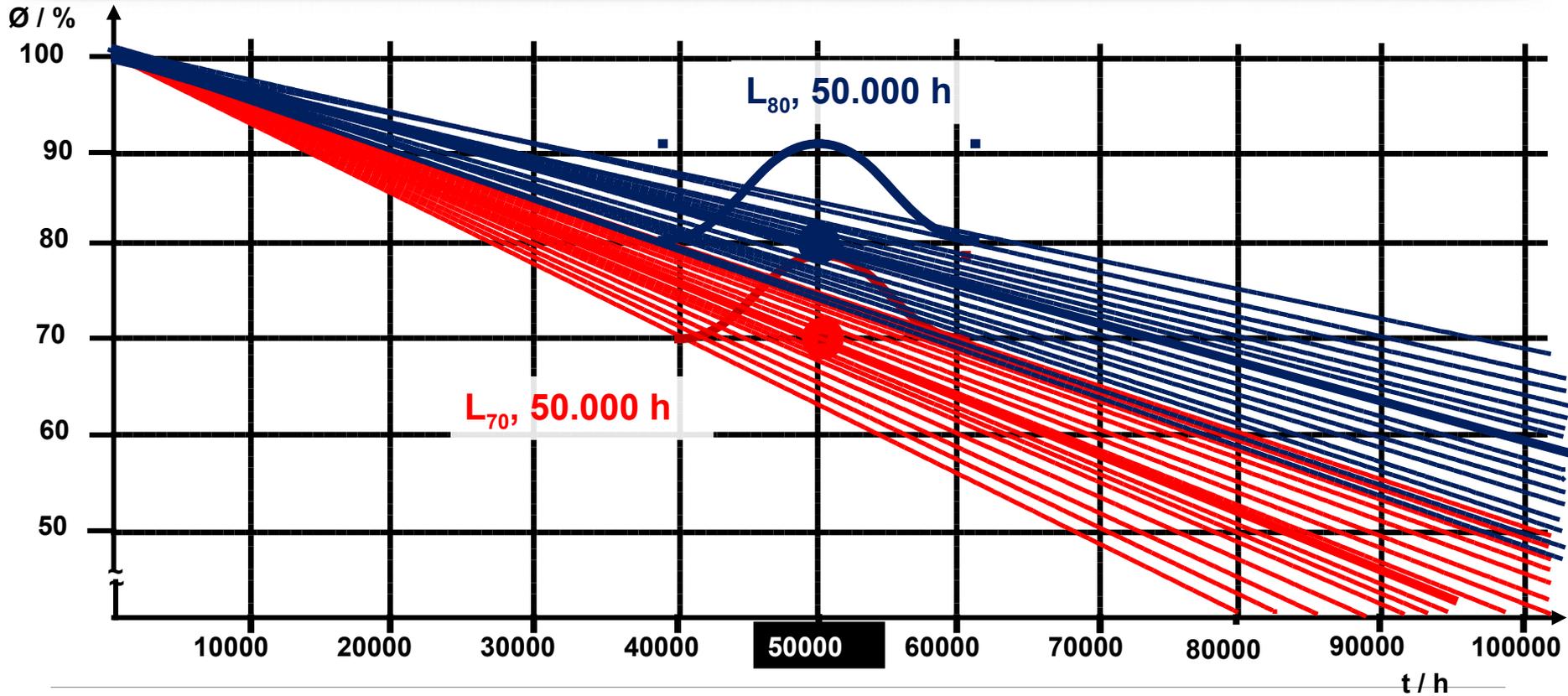
- L_x : rated median useful life
- B_y : percentage
- L_0 : life when flux = 0
- C_z : percentage of abrupt failure



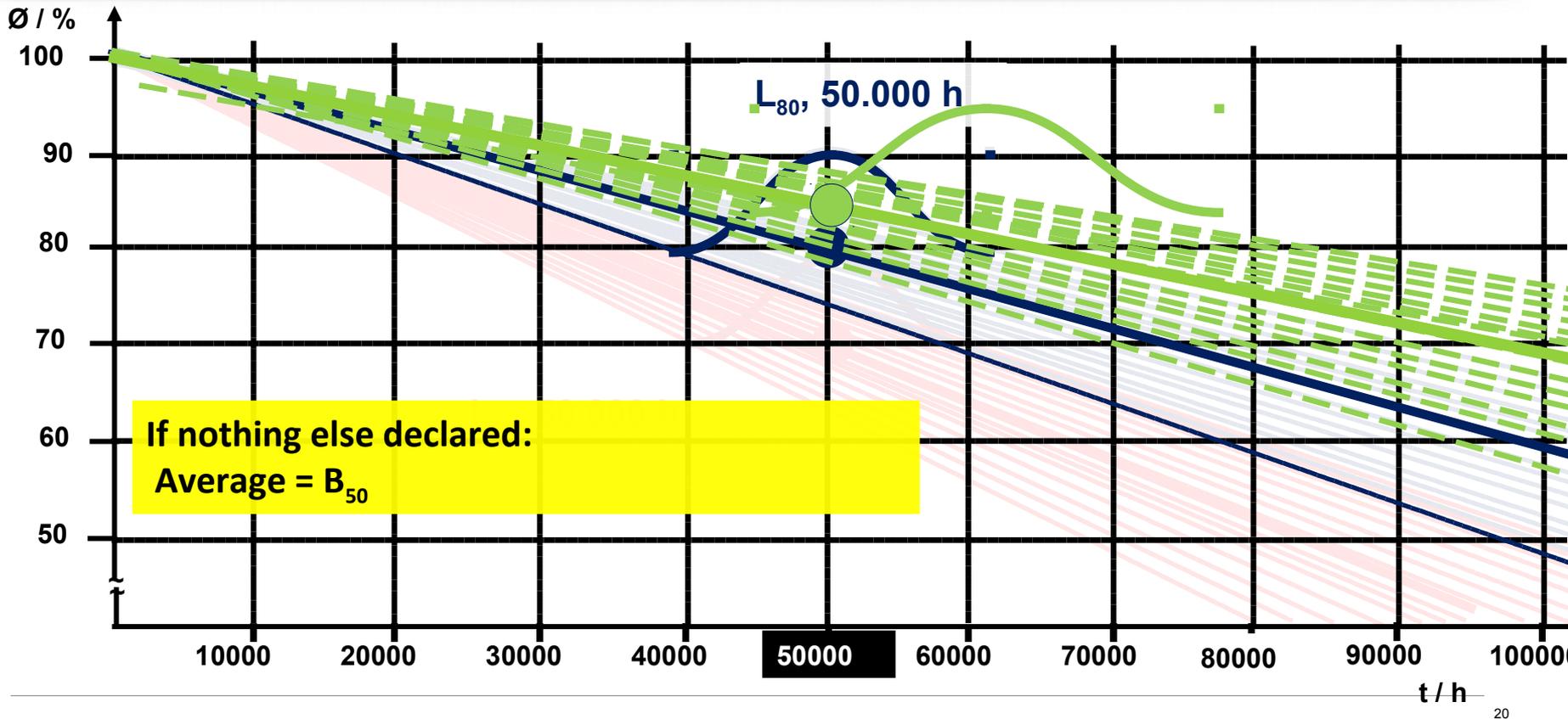
- Rated median useful life L_x : time when certain percentage reaches luminous flux of x %
- Example: L_{70} , 50.000h or L_{80} , 50.000h



- Example: $L_{70} B_{50}, 50.000 \text{ h}$: 50 % < 70 % flux \rightarrow LLMF ≈ 0.70
- Example : $L_{80} B_{50}, 50.000 \text{ h}$: 50 % < 80 % flux \rightarrow LLMF ≈ 0.80



• Example: $L_{80} B_{10}$, 50.000 h: 10 % < 80 % Lichtstrom \rightarrow LLMF \approx 0.85



1. IEC- life time metrics:

a) rate life L_x and B_y

b) rated life $L_0 C_z$ (flux = 0) for defined percentage of z: f.e. 5 % or 10 %,

f.e.: $L_{80}, B_{50} - 50.000$ h and $L_0 C_{10} - 97.000$ h

2. Lighting design:

Rated life L_x, B_y and abrupt failure at same time C_z

f.e. $L_{80}, B_{50}, C_3 - 50.000$ h or $L_{70}, B_{50}, C_2 - 50.000$ h or

$L_{80}, B_{10}, C_1 - 50.000$ h

Maintenance factor

Standard in lighting design with conventional light sources

EN 12464: The designer shall ... *state the MF and list all assumptions made in the derivation of the value ...*

To be applied to LED lighting



$$MF = (LLMF \times LSF) \times LMF \times RMF$$

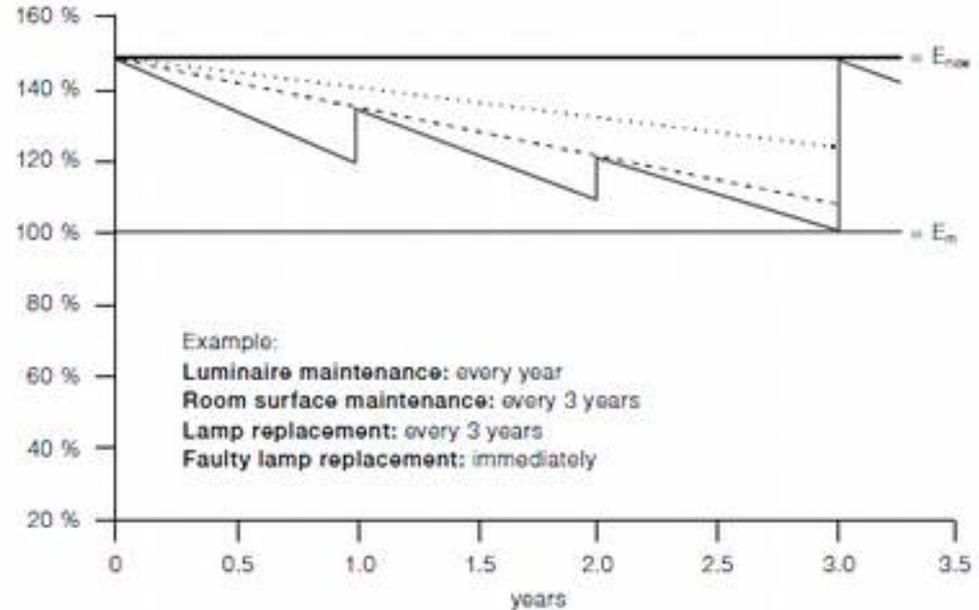
MF: Maintenance Factor

LLMF: Lamp Luminous Flux
Maintenance Factor

LSF: Lamp Survival Factor

LMF: Luminaire Maintenance
Factor

RMF: Room Maintenance Factor



Source: CIE 97:1992 : Maintenance of indoor electric lighting systems

Lamp maintenance factor for conventional lamps ...

Lamp luminous flux maintenance factor (LLMF)
and lamp survival factor (LSF)

Lamps	Service life given in hours																				
	100	500	1000	1500	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000	22000	24000	30000	35000	40000	45000	
Kalogen incandescent lamp OS/2005	1.1M	1.00	0.90	0.87		0.86															
T8 (low-loss ballast) triple-band Fluor. lamp ZVI 2005	1.1M	1.00	0.90	0.86	0.87	0.86	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71
T8 (electronic ballast) triple-band Fluor. lamp ZVI 3000/VDI 2005	1.1M	1.00	0.90	0.88	0.87	0.86	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71
T8 (ul. ballast) triple-band Fluor. lamp, long-life Philips MASTER TL-C triextra (long life)	1.1M	1.00	0.90	0.88	0.87	0.86	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71
T8 (ul. ballast) triple-band Fluor. lamp, long-life ALFA Ultimate II (long life)	1.1M	1.00	0.90	0.88	0.87	0.86	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71
T8 (electronic ballast) triple-band ZVI 3000	1.1M	1.00	0.90	0.88	0.87	0.86	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71
T8 (ul. ballast) triple-band Fluor. lamp, long-life ALFA SURVIVE TL-HD II (long life)	1.1M	1.00	0.90	0.88	0.87	0.86	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71
Compact fluorescent lamp OS/2005	1.1M	1.00	0.88	0.87		0.84	0.81	0.80	0.80	0.80											
TC-S, TC-D, TC-T 5-20 W (low-loss ballast) Compact fluorescent lamp ZVI 2005	1.1M	1.00	0.88	0.87	0.86	0.85	0.83	0.83	0.81	0.80											
TC-SL, TC-TSL 5-40 W (electronic ballast) Compact fluorescent lamp ZVI 2005	1.1M	1.00	0.88	0.86	0.84	0.83	0.82	0.81	0.80	0.79											
TC-SD, TC-SD W (electronic ballast) Compact fluorescent lamp ZVI 2005	1.1M	1.00	0.88	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78										
TC-L 18-24 W (low-loss ballast) Compact fluorescent lamp ZVI 2005	1.1M	1.00	0.88	0.86	0.87	0.86	0.83	0.83	0.80	0.80	0.80										
TC-L 18-24 W (electronic ballast) Compact fluorescent lamp ZVI 2005	1.1M	1.00	0.88	0.86	0.87	0.87	0.84	0.83	0.81	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Values are, to specifications by lamp manufacturers, January 2008, see: os/2007/2005
Technical report "Guide to the Maintenance of Indoor Electric Lighting Systems" 2nd edition, and ZVI publication
"Service life behaviour of discharge lamps for lighting" of November 2005.
For data of lamps by other manufacturers of other lamp types, please contact the respective manufacturer directly.
The use of state of the art ballast technology is a prerequisite.
The switching frequency has a major influence on lamp survival.
Most data are based on the standardized 2 hour switching rhythm see: IEC 60525-1-04, 5.25.1.011.



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Lamp maintenance factor to be applied for LED light sources

Lamp luminous flux maintenance factor (LLMF) and lamp survival factor (LSF)

LED luminous flux classes* with the following specific values

		Service life given in hours																				
		1000	5000	10000	15000	20000	25000	30000	35000**	40000	45000	50000	55000	60000	65000	70000	75000**	80000	85000	90000	95000	100000
130 @ 10,000 h	LLMF	1.00	1.00	0.90	0.80	0.68	0.56	0.47	0.37	0.30	0.26	0.22	0.20	0.18	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
130 @ 15,000 h	LLMF	1.00	0.94	0.88	0.82	0.76	0.70	0.64	0.58	0.53	0.49	0.45	0.42	0.39	0.37	0.35	0.33	0.32	0.31	0.30	0.29	0.28
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
135 @ 10,000 h	LLMF	1.00	0.94	0.87	0.80	0.74	0.68	0.62	0.56	0.51	0.47	0.44	0.41	0.38	0.36	0.34	0.33	0.32	0.31	0.30	0.29	0.28
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
130 @ 15,000 h	LLMF	1.00	0.90	0.84	0.78	0.72	0.66	0.60	0.54	0.49	0.45	0.42	0.39	0.37	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.27
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
175 @ 10,000 h	LLMF	1.00	0.96	0.91	0.86	0.81	0.76	0.71	0.66	0.61	0.57	0.54	0.51	0.48	0.46	0.44	0.42	0.41	0.40	0.39	0.38	0.37
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
170 @ 10,000 h	LLMF	0.96	0.91	0.86	0.81	0.76	0.71	0.66	0.61	0.57	0.54	0.51	0.48	0.46	0.44	0.42	0.41	0.40	0.39	0.38	0.37	0.36
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
105 @ 10,000 h	LLMF	0.88	0.87	0.82	0.76	0.70	0.64	0.58	0.53	0.49	0.45	0.42	0.39	0.37	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.27
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100 @ 10,000 h	LLMF	0.90	0.86	0.80	0.74	0.68	0.62	0.56	0.51	0.47	0.44	0.41	0.38	0.36	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115 @ 10,000 h	LLMF	0.90	0.86	0.81	0.76	0.71	0.66	0.61	0.57	0.54	0.51	0.48	0.46	0.44	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100 @ 15,000 h	LLMF	0.86	0.86	0.80	0.74	0.68	0.62	0.56	0.51	0.47	0.44	0.41	0.38	0.36	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.27
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* An LED luminous flux class is characterized by the useful service life (L80 as defined: 50,000 h) at a step in luminous flux to a % (initial level = 100 %) and an ambient temperature of 25 °C.
 Example: the LED luminous flux class of "130 @ 10,000 h" describes a step in luminous flux to 80 % (LLMF = 0.80) at a useful service life of 10,000 h.

The maintenance factor values specified for an LED luminous flux class are intended to facilitate planning. They indicate the prospective luminous flux changes over the course of time.

The maintenance factors for an assumed service life are available for planning purposes.

Please note the known lamp maintenance factors (L80 and L70) and apply to LED modules, although these are not lamps in the proper meaning of the term. L70 is assumed to be 5, so a total breakdown of the complete LED module can be neglected for planning purposes.

The levels specified are in line with the data for S-C 02117 that have not yet been completed at the time of going to press.

LED luminaires can be compared by finding the matching "L70" and service life" pair of values for the "Lx @ (50,000) h" class in the same line, with L80 = 100 corresponding to the Luminous flux component (in %).

Example: ** 130 @ 10,000 h corresponds to L70 @ 75,000 h
 ** 130 @ 20,000 h corresponds to L80 @ 10,000 h

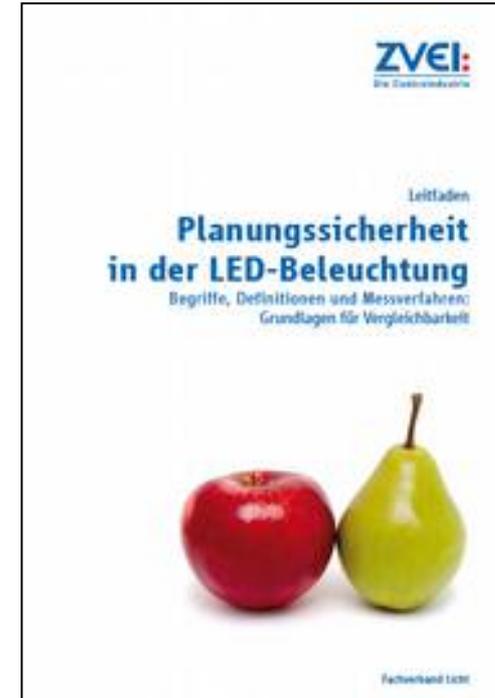
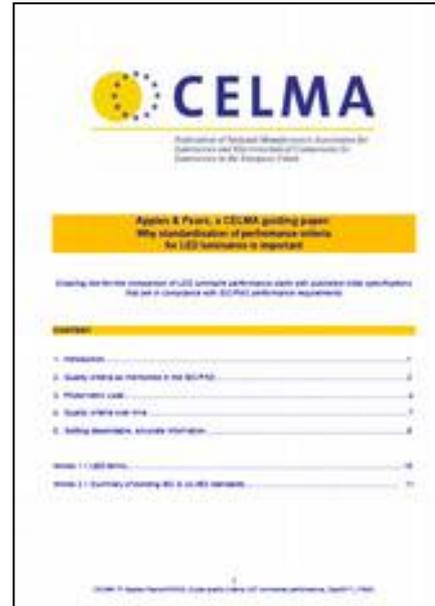


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Maintenance factor in lighting



LED-Lichtstromklassen		Kennwerte	Betriebsdauer in 1000 h																				
			1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
L90	50.000 h	LLMF	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80
		LSF	1	1	1	1	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
L90	100.000 h	LLMF	1,00	1,00	0,99	0,99	0,98	0,98	0,97	0,97	0,96	0,96	0,95	0,95	0,94	0,94	0,93	0,93	0,92	0,92	0,91	0,91	0,90
		LSF	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99
L80	50.000 h	LLMF	1,00	0,98	0,96	0,94	0,92	0,90	0,88	0,86	0,84	0,82	0,80	0,78	0,76	0,74	0,72	0,70	0,68	0,66	0,64	0,62	0,60
		LSF	1	1	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,98	0,98
L80	100.000 h	LLMF	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80
		LSF	1	1	1	1	1	1	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
L70	50.000 h	LLMF	0,99	0,97	0,94	0,91	0,88	0,85	0,82	0,79	0,76	0,73	0,70	0,67	0,64	0,61	0,58	0,55	0,52	0,49	0,46	0,43	0,40
		LSF	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,98	0,98	0,98	0,98
L70	100.000 h	LLMF	1,00	0,99	0,97	0,96	0,94	0,93	0,91	0,90	0,88	0,87	0,85	0,84	0,82	0,81	0,79	0,78	0,76	0,75	0,73	0,72	0,70
		LSF	1	1	1	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99
L60	50.000 h	LLMF	0,99	0,96	0,92	0,88	0,84	0,80	0,76	0,72	0,68	0,64	0,60	0,56	0,52	0,48	0,44	0,40	0,36	0,32	0,28	0,24	0,20
		LSF	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,98	0,96	0,94	0,92	0,88
L60	100.000 h	LLMF	1,00	0,98	0,96	0,94	0,92	0,90	0,88	0,86	0,84	0,82	0,80	0,78	0,76	0,74	0,72	0,70	0,68	0,66	0,64	0,62	0,60
		LSF	1	1	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,99	0,98	0,98
L50	50.000 h	LLMF	0,99	0,95	0,90	0,85	0,80	0,75	0,70	0,65	0,60	0,55	0,50	0,45	0,40	0,35	0,30	0,25	0,20	0,15	0,10	0,05	0,00
		LSF	1	1	1	0,99	0,99	0,99	0,99	0,99	0,98	0,98	0,98	0,98	0,98	0,98	0,97	0,95	0,90	0,80	0,60	0,40	0,20
L50	100.000 h	LLMF	1,00	0,98	0,95	0,93	0,90	0,88	0,85	0,83	0,80	0,78	0,75	0,73	0,70	0,68	0,65	0,63	0,60	0,58	0,55	0,53	0,50
		LSF	1	1	1	1	1	1	1	0,99	0,99	0,99	0,99	0,99	0,98	0,98	0,98	0,98	0,98	0,98	0,97	0,97	0,97



Data sheet: agreed major parameters



Lighting parameters:

Light source:

Luminaire luminous flux*:

Luminaire efficacy:

Colour rendering index CRI (R_a)

Correlated colour temperature:

Colour consistency (initial MacAdam):

Rated life time:

Rated ambient temperature :

NAME

lm

lm/W

min. or ≥

K

(number)

f.e. L70 at 50.000 h

°C (optional when different from 25°C)

Electrical parameters:

Ballast:

Luminaire connected load* :

NAME

W

* Rated values

LIGHT FIELDS LED
HL-FIELDS A 44W LED940 Q LDE
 Surface-mount luminaire, with microprismatic optic

ZUMTOBEL
 42180003

Surface-mounted ceiling luminaire 44W (L70), Total luminous flux of luminaire 3880 lm, luminaire efficacy 88 lm/W, colour temperature 4000K, colour rendering Ra 90, L70 service life 50,000 h at 70% luminous flux, special luminaire for (day-) control using highly efficient electronic LED components, light guided via double multiple MPO microprismatic optic with micro-lens and defined light emission for precise light distribution with LGZ = 13 and LGZ = 1500° up to 30° (LM84: 2017), reduced luminous flux at steep angles specifically designed to cut glare on floor, effective and glare-free operation, flexibility in positioning of luminaire, energy efficient, L70 50,000 hours, efficient, remote of high grade PMMA for an exceptional look of quality, low-ohm aluminium and easy easy to clean, sophisticated optical system (controlled) by luminaire housing without frame, advanced control system includes protection cover for LED modules to prevent damage from electrostatic discharge (ESD) and anti-condensation (see separate separate), high-quality, low-voltage luminaire housing made of ultra-thin aluminium, can be installed as a single luminaire or in a cluster (luminaire-sets with 100mm-flare depth, grooveless rear 50x70), dimensions: 104 x 104 x 60 mm, weight: 4.9 kg.

Light Distribution **STD - standard**

- Lamp: T4 x 2400270 14400
- Total Luminous Flux of Luminaire 3880 lm
- Luminaire efficacy 88 lm/W
- Rated life: 50000 h L70 at 25°C
- Colour Rendering Index min. 90
- Colour temperature: 4000 K (warm)
- Normalized luminance (initial MacAdam) 4
- Rated T4 x 2400270 14400-1700000 21000000
- Controlled: anti-ESD and anti-condensation
- Identity: Power: 11 W
- Drawing: L200 (drawn to 1/16)
- max. cable: 100 mm and maximum
- GC level: emergency lighting is adjustable
- Maintenance category: 0 - Outdoor 100%

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LED quality essential for lighting quality

Life time metrics to be applied to

Type (Life time)

Maintenance Factor (Usage time for design)

Trustful data to compare apples with apples



Thank you for your kind attention



Dipl.-Ing. Peter Dehoff

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CEN TC 169, Convenor WG 2
President CIE Austria

