Whitecroft lighting

LED & Maintenance Factors

Revision 1, 2017

LED & Maintenance Factors

Section 1 – The Maintenance Factor Calculation – **MF**

A maintenance factor (MF) is applied to a lighting design to take into account a reduction in the output of the luminaires used within any lighting installation and ensure the correct level of light is delivered at the 'end of life'. The MF calculation takes into account lamp depreciation and the impact the environment will have on the installation. LED is no exception.

With conventional source technology the methodology for calculating a maintenance factor for a luminaire was clearly laid out in the *CIE 97:2005 document* and The *SLL Code for Lighting.*

MF = LLMF (Lamp Lumen Maintenance Factor)
x LMF (Luminaire Maintenance Factor)
x RSMF (Room Surface Maintenance Factor)
x LSF (Lamp Survival Factor)

Due to the construction and access to performance data for an LED luminaire, how the elements included in a maintenance factor calculation are used for LED luminaires is different from a conventional source luminaire.

This document has been produced to aid the lighting designer in applying sensible MF values to maximise the opportunity of an LED luminaire in the lighting design process. This will ensure the solution provided is delivering the right lighting level at end of life. It will demonstrate how MF values used by some manufacturers of ≥0.9 should be treated with caution and how these values can be challenged.

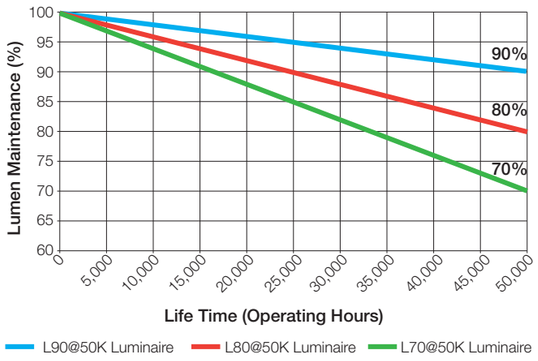
Lamp Lumen Maintenance Factor – **LLMF**

As with conventional source lamps LED output will depreciate over time. The rate of depreciation depends on 3 key features; the quality of LEDs, luminaire construction and thermal management. We define this figure as $L_xB_{50}@_yHRS$. Further information on this definition can be found in section 2 of this document.

Calculating the L Value

LED manufacturers test the rate of depreciation of their LEDs over a minimum period of 6,000 hours. Measurements are taken every 1,000 hours and from these a rate of depreciation is established. From this an extrapolation can be made as to the likely output over longer periods. The most common rate for comparison is at 50,000 hours.

As indicated in the graph and table below, a luminaire with an L_{90} value will be producing significantly more light than one with an L_{70} value at the end of its rated life.



LED performance	LLMF@50k	Initial Lumens	Actual lumens at 50k
L_{70}@50k Hrs	0.7	5,000 lumens	3,500 lumens
L_{90}@50k Hrs	0.9		4,500 lumens

Converting L values to LLMF values

The LLMF value is used in a calculation to factor in the depreciation of a lamp at a point of time. For an LED luminaire the L value can be used. For example, if the specified luminaire has a stated life of L_{90}@50,000 hours then this will equate to an LLMF of 0.9 at 50,000 hours.

Please see section 3 of this document for a summary of the L values for several Whitecroft luminaires. Please contact technical for other luminaires.

Defining the life of an installation

The LLMF value will change if the life of the project differs. For example, there is little point using the L value at 50,000 hours if the luminaires are expected to be replaced after 30,000 hours. The table below indicates the average number of years these burning hours equate to in different applications.

Application	Typical annual operational hours	30,000 hour replacement	50,000 hour replacement
Education	1,500	20 years	33 years
Offices	3,000	10 years	16.5 years
Healthcare	4,000	7.5 years	12.5 years

If actual project operational hours and life of an installation can be sought then the actual life metric value for a specific luminaire as outlined in Section 3 of this document can be used. For example, a Cascade LED luminaire with a life metric of L_{92}@50,000 hours, used in a classroom with an expected 30,000 hour or 20 year life, will equate to an LLMF value of 0.94.

If the life of installation is not advised it is recommended an LLMF of 0.9 is used. This would equate to a minimum operational period of 30,000 hours on all Whitecroft luminaires, and in many instances in excess of 50,000 hours.

Luminaire Maintenance Factor – **LMF**

To make the most of any installation (LED or fluorescent) we recommend an annual luminaire cleaning regime.

The construction of an LED luminaire and make-up of an LED differ from standard luminaires. The impact of dirt deposits are not as significant as conventional source luminaires. For example there is a reduction in the surface area for dirt deposit on the LEDs as they typically have no upward facing surface and are often enclosed. In addition, the impact of insects due to heat and UV radiation reduction is less.

From our experience and the reasons highlighted above the value within the SLL Code for lighting for a dustproof type fitting are more appropriate for an LED luminaire. Below are the figures for a 6 month and annual luminaire clean:

	LMF	
	6 Month Clean	1 Year Clean
Very Clean	0.94	0.96
Clean	0.96	0.94
Normal	0.93	0.90
Dirty	0.91	0.86

To maximise the efficiency of a luminaire we recommend an annual cleaning regime

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Room Surface Maintenance Factor (Annual Clean) – **RSMF**

To ensure the most efficient lighting installation regardless of the application, we recommend an annual room cleaning regime. Below are industry standard RSMF values for an annual and 3 Year Room clean based on 70/50/20 reflectances:

	1 Year Room Clean		3 Year Room Clean	
	Direct Luminaires	Direct/ Indirect Luminaires	Direct Luminaires	Direct/ Indirect Luminaires
Very Clean	0.97	0.96	0.97	0.95
Clean	0.95	0.91	0.94	0.91
Normal	0.91	0.84	0.90	0.83
Dirty	0.86	0.75	0.86	0.75

Note: This value is unaffected by the type of lamp or luminaire being used.

To maximise the efficiency of a lighting scheme we recommend an annual room cleaning regime

Lamp Survival Factor – **LSF**

Catastrophic failure (C value) is very rare with LED luminaires. In the unlikely event of a failure as with a conventional source lamp, it would be expected a spot replacement would be made.

Note: in most instances driver failure may be the cause of failure and not the LED module.

As LED failure is extremely rare we recommend using an LSF of 1 for all calculations

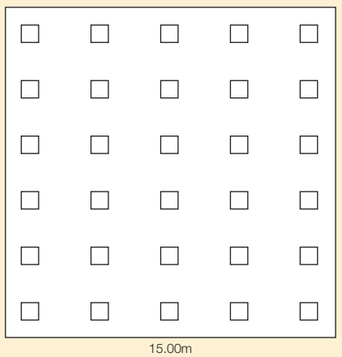
Using Maintenance Factors to optimise lighting design

Below are illustrated two lighting schemes for an identical open plan office environment using recessed modular luminaires. Both are using luminaires with the same initial lumen output, but with different L values. The calculations show how using higher rated luminaires results in fewer installed points, which in turn will reduce energy loading and installed cost.

MF, standard L_{70}@50,000 hrs rated luminaire:

LLMF L_{70} = **0.7**
LSF = 1
LMF clean environment = 0.94
RSMF clean environment = 0.95
MF = **0.7** x 1 x 0.94 x 0.95 = **0.63**

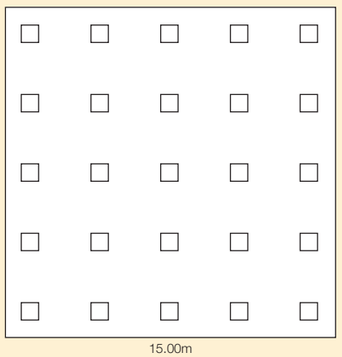
30 luminaires needed, average 315 Lux



MF, standard L_{90}@50,000 hrs rated luminaire:

LLMF L_{90} = **0.9**
LSF = 1
LMF clean environment = 0.94
RSMF clean environment = 0.95
MF = **0.9** x 1 x 0.94 x 0.95 = **0.80**

Only **25** luminaires needed, average 331 Lux



Section 2 – LED Life Metrics

With the advent of LED luminaires, different standards and terminology from conventional source lamps are being used to define life. Below is a summary of these applicable standards and their relevance to lighting design. On the previous pages is a breakdown of our recommendations and explanation for calculating the Maintenance Factor for an LED light source, as well as recommendations for the best maintenance regimes.

Published Standards

IEC 62717 LED modules for general lighting – Performance Requirements

IEC 62722-2-1 Particular requirements for LED luminaires

LM80-08 Measuring lumen maintenance of LED Light Sources

TM21 Lumen degradation lifetime estimation method for LED light sources

All Whitecroft LED luminaire life time metric performance data is calculated from LM80 data via a TM21 methodology. LM80 is the approved standard for measuring lumen maintenance of an LED package, based on a test period of at least 6,000 hours. The TM21 tool takes this data and is used to apply a lifetime projection for an LED luminaire.

Section 3 of this document advises the LED performance data for several Whitecroft luminaires. Other luminaire data is available on request. Whitecroft are also able to issue full TM21 life data for all LED luminaires through our technical helpdesk.

It is recommended that compliance against these standards should be sought from the LED luminaire manufacturer to ensure the integrity of published data.

L value – Life-time

As with other light source technology LED output depreciates over life. The L value states the percentage of initial lumens that will be delivered by an LED luminaire at a point in time. For example, an LED luminaire that is stated as having a lifetime metric of L_{90}@50,000 hours will be delivering 90% of the initial lumen output at 50,000 hours. The L value is only relevant when stated with a defined operation time.

Due to the importance of thermal management within LED life, the rate of depreciation will vary from manufacturer to manufacturer and output to output. This data should be sought from the specific manufacturer and is an important value to consider when benchmarking luminaire quality.

B Value – Luminous Flux Deviation

The lumen output of LED chips will depreciate at slightly different rates. The B value defines the % of LED chips that will fall below the L value threshold. The remaining chips will be at or above the threshold value. A B50 value stated provides the median performance of a light fixture with 50% of the chips being below the lumen output (L value) and the remaining being at or above.

Whitecroft recommend for all applications a lumen performance of Lxx B50 is appropriate to provide consistency with established MF principles, whilst maximising the life of an installation.

Other B values are available on request. However, the B value has no influence within established lighting design maintenance factor calculations.

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C Value – Abrupt Failures

The standards define catastrophic failure (C value) being when an LED module emits no light. This is extremely uncommon for well-engineered LED luminaires incorporating LEDs with certified LM80 data. Due to the catastrophic failure rate being negligible at a chip level, this value is not stated by Whitecroft.

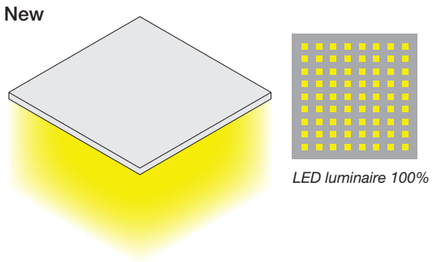
F Value – Overall Failures

The F value is the sum of the B & C values. As the C value is negligible it is the same as the B value.

LED Drivers

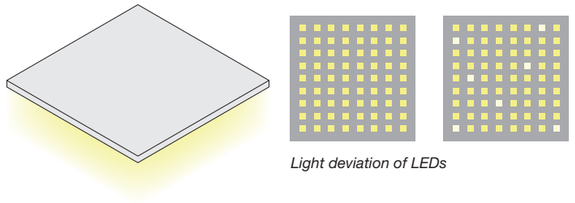
Driver failure is **not** considered within the maintenance factor calculation. However, performance and quality of driver supplied should be considered to ensure a reliable maintenance regime. Whitecroft will only use drivers from quality suppliers that are rated for a minimum of 50,000 hours and 4K marked. Where LED life is stated on our data sheets as 100,000 hours this is supported by a driver with a 100,000 hour rated life. Driver life is typically defined as a 10% drop out of rated life.

New



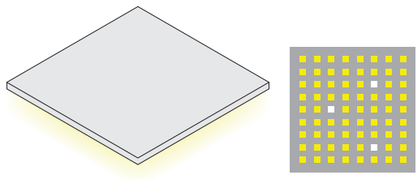
LED luminaire 100%

Gradual L_x, B_y

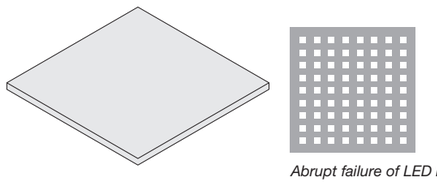


Light deviation of LEDs

Abrupt L_0 C_x



Abrupt failure of individual LEDs



Abrupt failure of LED luminaire

Whitecroft define catastrophic failure as being that where LED failure negatively affects the appearance of the luminaire. For this reason module and chip failure are both seen as a catastrophic failure.

Section 3 – Life Data

To aid the designer in calculating an accurate MF value, the table below provides information that can be used to ensure the correct LLMF value is used. These values are based on data generated from Samsung laboratory test data and through specific Whitecroft laboratory testing of junction temperatures and driver current operation. Whitecroft are able to provide certified LM80 & TM21 test data for all of our luminaires, giving confidence to the designer.

The table below shows the projected operational hours of various Whitecroft LED luminaires. The operational hours to an L70, L80 and L90 output are shown, alongside the projected L value at an operational period of 50,000 hours.

		B50			LxB50@ 50k hours
	Part Nos	Operational hours to an L70 output	Operational hours to an L80 output	Operational hours to an L90 output	
RECESSED					
AVENUE	All Low Output	>100k	>100k	74k	93
	All High Output		90k	42k	88
CASCADE LED	CMH14KXT	>100k	>100k	63k	92
	CMH24KXT		98k	45k	89
	CMH34KXT		>100k	55k	90
	CAH14KXT		66k	32k	84
	CAH34KXT		80k	38k	87
	CAH44KXT		>100k	47k	89
CITYLINE	CLCY1/SRF1	>100k	>100k	64k	92
	CLCY2/SRF1			55k	90
	CLCY3/SRF2			53k	90
	CLCY4/SRF2		98k	45k	89
	CLCY5/SRF3		79k	37k	86
	CLFY1/SRF1	>100k	>100k	>100k	95
	CLFY2/SRF1			95k	94
	CLFY3/SRF2			76k	93
	CLFY4/SRF2			75k	93
	CLFY5/SRF3			65k	92
DTFA/N	DLAAGH14K	>100k	>100k	65k	92
	DLAAGH24K		84k	39k	89
	DLAAGH34K		>100k	65k	92
	DLAAGH44K		84k	39k	89
	DLAAGH54K		>100k	65k	92
	DLAAGH64K			46k	89
	DLAAGH74K		84k	39k	87
DUO 3 OFFICE	D3MAY1XT	>100k	>100k	>100k	95
	D3MAY2XT			89k	94
	D3MAY3XT			64k	92
HELM	HEAH14K	>100k	>100k	50k	90
	HEAH24K			50k	90
	HEH14K			50k	90
	HEH24K			50k	90
LISTER 2 LED	L2LH14K	>100k	>100k	65k	92
	L2LH24K		84k	39k	87
	L2LH34K		>100k	65k	92
	L2LH44K		84k	39k	87
	L2LH54K		>100k	65k	92
	L2LH74K		100k	46k	89
TEGAN	TEHDH14K	>100k	>100k	90k	94
	TEHDH24K			76k	93
	TESDH24K			76k	93
	TEPDH14K			92k	94
	TEPDH24K			89k	94
	TEPDH34K			63k	92
TEGAN SLIM	TMELH24KXT	>100k	97k	44k	88
	TMELH34KXT		91k	45k	89
	TAELH24KXT		97k	44k	88
	TAELH34KXT		68k	33k	85

This figure shows the L value at 50,000 hours. This period of time is most often used in generic calculations.

This figures can be used to aid the designer in being able to anticipate the life of an installation (in hours) for when the LED luminaire will be at 90% of the initial output

This figures can be used to aid the designer in being able to anticipate the life of an installation (in hours) for when the LED luminaire will be at 80% of the initial output

This figures can be used to aid the designer in being able to anticipate the life of an installation (in hours) for when the LED luminaire will be at 70% of the initial output.

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	Part Nos	B50 Operational hours to an L70 output	B50 Operational hours to an L80 output	B50 Operational hours to an L90 output	LxB50@ 50k hours
DOWNLIGHTS					
ESPRIT LED 3K & 4K	ESLH14K	>100k	>100k	74k	93
	ESLH24K		77k	36k	86
MIRAGE LED 3K & 4K	MB11204KCF	80k	55k	30k	82
	MB11204KCM	80k	55k	30k	82
SUSPENDED					
AERIAL LED FAMILY	AELMY44K	97k	61k	30k	83
	AESLY14K	>100k	>100k	60k	91
	AELBH14K		75k	36k	86
	ATMY1		96k	44k	88
	ATMY2		96k	44k	88
	ATMY3		96k	44k	88
	ATBMY3		87k	41k	88
	ATBAY3		>100k	46k	89
	AET6WY14K		68k	32k	85
	AET6MY14K		68k	32k	85
	AET6NY14K		68k	32k	85
AVENUE	All Low Output	>100k	>100k	74k	93
	All High Output		90k	42k	88
BAYON	All Low Output	>100k	>100k	62k	91
	All High Output		72k	34k	85
BROADSWORD	BSSTH14KW	>100k	>100k	75k	93
	BSSTH24KW			58k	91
	BQSTH14KW			75k	93
	BQSTH24KW			63k	92
	BQSTH34KW			63k	92
FOIL SINGLE OPTIC LED	FSAH73014KS	>100k	>100k	65k	92
	FSAH73024KS		100k	46k	89
	FSAH73034KS		100k	46k	89
	FSAH73044KS		100k	46k	89
FOIL SRD	FREH4S	>100k	>100k	66k	92
	FREH6S			66k	92
	FREH7S			66k	92
FOIL XS-LINE	FSEH1S	>100k	>100k	>100k	95
	FSEH2S				95
	FSEH3S				95
	FXINFUPH18S				95
LANCE	LN12Y71W	>100k	>100k	86k	94
	LN12Y72W			86k	94
	LN15Y71W			86k	94
	LN15Y72W			86k	94
	LN18Y71W			86k	94
	LN18Y72W			86k	94
	LN12Y91W			82k	93
	LN12Y92W			82k	93
	LN15Y91W			82k	93
	LN15Y92W			82k	93
	LN18Y91W			82k	93
	LN18Y92W			82k	93
OCULUS 3K & 4K	OMSY14KW	>100k	>100k	>100k	95
	OMMY54KW				95
	OMLY74KW				95
	OMSY24KW				95
	OMMY64KW				95
	OMLY84KW				95
	OPSY34KW			60k	91
	OPSY44KW			60k	91

	Part Nos	B50 Operational hours to an L70 output	B50 Operational hours to an L80 output	B50 Operational hours to an L90 output	LxB50@ 50k hours
SURFACE					
ACL INDUSTRY	ACH24K	>100k	>100k	84k	94
	ACH34K			84k	94
	ACH44K			84k	94
	ACH54K			46k	88
	ACH64K			46k	88
	ACH74K			46k	88
STILETTO LED	STLEH14K	>100k	>100k	76k	93
	STLEH24K			64k	92
	STLEH34K			53k	90
	STLEH44K			65k	92
	STLEH54K			55k	90
	STLEH64K		99k	45k	89
STYLUS AREA	STSH1	>100k	97k	44k	88
	STSH2		97k	44k	88
	STSH3		97k	44k	88
STYLUS COMFORT	SUSH1	>100k	>100k	>93k	94
	SUSH2				94
	SUSH3				94
BULKHEAD					
HORIZON 360 3k & 4K	HZH14K	>100k	>100k	54k	90
	HZH24K			54k	90
	HZH34K			54k	90
KOLO	K4H3124KS	>100k		92k	94
	K4H364KS	>100k	>100k	100k	95
	K4H4154KS			95k	94
	K4H4204KS			87k	94
	K4H4274KS			75k	93
	KOLO HOOD			>100k	95
PORTAL	PTH14K	>100k	>100k	62k	91
	PTH24K			62k	91
	PTH34K			62k	91

Note: Due to all data being extrapolated from lab test, Whitecroft do not feel it is credible to state lifetime figures in excess of 100,000 hours.

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