Whitecroft lighting

LED & Maintenance Factors

Revision 3, 2021

Introduction

At a very basic level a lighting scheme should be one that provides the correct illumination throughout the life of an installation. Whilst the technology has changed, using LED luminaires hasn't changed this necessity.

Due to the variation in quality of LED luminaires in the market, and individual project requirements, the importance of applying an appropriate maintenance factor is as, if not more, important than ever. Simply applying the industry standard generic one fits all '0.8 maintenance factor' may not be appropriate. By using this value it could result in wasted energy, a failure to deliver the specified illumination level resulting in an impact on productivity, additional client cost and at worst case our safety.

This document has been put together to support the designer in how to implement maintenance factors using current best practice guidance.

At the end of this document you will find a summary of recommended maintenance factors based on Whitecroft Lighting luminaires.

The Maintenance Factor Calculation (MF)

'During the life of a lighting installation, the light available for the task progressively decreases due to accumulation of dirt on surfaces and again of equipment.' (SLL Code for Lighting).

To take account of this depreciation the following calculation should be applied to all lighting designs:

MF = LLMF (Lamp Lumen Maintenance Factor)

x LMF (Luminaire Maintenance Factor)

x RSMF (Room Surface Maintenance Factor)

x LSF (Lamp Survival Factor)

With conventional source light fixtures the designer would traditionally base their calculation metrics as follows

RSMF & LMF:

- *The Society of Light & Lighting: Code for Lighting, Chapter 18.*
- *CIE97:2005 Guide on the maintenance of indoor electric lighting systems, 2nd Ed*

LLMF & LSF: Lamp supplier datasheets

The details outlined below show how the existing metrics we have around us can be used effectively with LED technology. In addition, it highlights new questions, a change of responsibility for the supply of data and how to apply this data correctly.

Installation lifetime

In addition to the energy benefits that LED technology has provided, one of the key benefits of an LED luminaire is that if applied and designed correctly it can last for the lifetime of the project.

However, LED output reduces throughout its life.

If we don't specify or understand the anticipated lifetime in operational hours and number of years of the project then we cannot apply the appropriate maintenance factor and be confident we are delivering the specified light level.

The client may have this information, Where it is not available the below guide can be used by the designer and communicated to the client.

Where not advised, Whitecroft Lighting will use the below table.

Indoor Applications	Average annual operating hours	Average time to refurb (years)	Average installation life (total hours)
Commercial	2500	20	50,000
Education (Further)	2000	25	50,000
Education (Schools)	1500	20	30,000
Healthcare	5000	10	50,000
Industrial	4000	25	100,000

Source:
Education Schools (DfE Output Specification, Annexe 2E)
All other: Lighting Europe: Evaluating performance of LED based luminaires Guidance Paper

Lamp Lumen Maintenance Factor (LLMF)

The LLMF value applies to the % of reduction for the light source within the overall MF calculation. With conventional source lamps this data came from the lamp supplier. For an LED fitting the data must be supplied by the luminaire manufacturer and can vary significantly for what on the surface looks like the same product.

LED life is impacted by:

- Thermal management
- Luminaire design
- Quality of LED

By measuring the LED temperature within the luminaire the % reduction in output overtime can be calculated using IES LM80 data and IES TM21 calculator.
This is reported as the 'L' value at a point in time. For example a fitting reported as L90@50,000Hours means the fitting has 90% of the initial output at 50,000 hours.
To be relevant and meaningful, the luminaire manufacturer must report the 'L' value and point in time together.

For the maintenance factor calculation this 'L' value becomes the LLMF:

L90@50,000 hours = LLMF 0.9 @ 50,000 hours

To enable a more accurate comparison, test certificates should always be sought from the luminaire manufacturer to support reported life values.

The example below shows a comparison of 2 fittings that have the same initial lumens but different 'L' values at 50,000 hours. As can be seen this has a significant difference in the calculated MF value:

	Initial Lumens	Initial Wattage	L Value @50K hours	LLMF @50K hours	Calculated MF @50K hours*	End of Life Lumens	Qty to achieve 500 lux	Total Wattage
Product 1	4000	34	L70	0.7	0.625	2800	130	4,160
Product 2	4000	32	L90	0.9	0.80	3600	100	3,400

**Annual Clean, Clean Environment, Recessed Modular – see below for further details on RSMF & LMF*

Please see table on page 8 & 9 of this document for further details of Whitecroft products and MF values to use based on the operating hours highlighted in the 'Installation Lifetime' section above.

Lamp Survival Factor (LSF)

Within most MF calculations it is always assumed a spot replacement will take place.

LED has a low failure rate, with the driver often being the most likely component to fail.

Note: For LED luminaires there are several metrics that are often used or can cause confusion when reviewing LED life. 'L' value is the main metric of relevance in relation to the MF calculation.

For further details on the other terminology used in relation to LED performance please see Lighting Europe document:
Evaluating performance of LED based luminaires Guidance Paper.

The Luminaire Maintenance Factor (LMF) & Room Surface Maintenance Factor (RSMF)

To optimise any lighting scheme, a regular annual cleaning of luminaires and room is recommended.

The LMF & RSMF values are typically based on tables provided within the SLL & CIE documents highlighted above. However, are these values still appropriate? People no longer smoke indoors, air quality in many cities is better and the expectation of the individuals is for a cleaner space. Can we challenge these values to still apply an appropriate reduction factor but without wasting energy by 'over-engineering' a solution?

LMF

Traditionally, based on product construction and impact of dirt on the lamp itself the guidance documents gave different values to use. However, with LED fittings there is a chance to challenge whether these values are still appropriate. Some of the reasons include:

- no ‘backward’ facing surface for the lamp
- Reduced UV and degradation of optics
- Reduced dirt within the environment
- Light source often being ‘enclosed’

Through investigation, Whitecroft are able to provide evidence that the value provided within the SLL Code for a dust-proof fitting (Type E) provides the designer with a sufficient level of output depreciation for all LED fixtures:

LMF		
Cleaning Regime	**1 Year**	**3 Year**
Very Clean	0.96	0.92
Clean	0.94	0.90
Normal	0.90	0.85
Dirty	0.86	0.80

RSMF

Without access to further data it is recommended to use the values provided within the SLL Code for Lighting and CIE97:2005.

Reflectance	**70/50/20**				**50/30/20**			
Cleaning Regime	**1 Year Clean**		**3 Year Clean**		**1 Year Clean**		**3 Year Clean**	
Product Distribution	**Direct**	**Direct/Indirect**	**Direct**	**Direct/Indirect**	**Direct**	**Direct/Indirect**	**Direct**	**Direct/Indirect**
Very Clean	0.97	0.96	0.97	0.95	0.99	0.97	0.98	0.97
Clean	0.95	0.91	0.94	0.91	0.97	0.95	0.97	0.94
Normal	0.91	0.84	0.90	0.83	0.95	0.90	0.95	0.90
Dirty	0.86	0.75	0.86	0.75	0.92	0.84	0.92	0.84

Outdoor Applications

Whilst this document has focused on internal applications, applying the correct MF calculation for outdoor applications is of equal importance to balance effective task performance, safety and energy consumption. Again, understanding expectation/specifying design lifetime for installation is key to providing an accurate lighting design.

The same principles of understanding life expectation and onus on LED luminaire manufacturer to provide accurate reported life (LLMF & LSF) is the same as it is for internal applications. In an outdoor application the RSMF is not relevant and is removed from the calculation.

BS5489-1:2020, Annex C1 provides the following table advising recommended LMF values to use based on 3 criteria: Environmental Zone, IP rating & Mounting Height.

Environmental Zone	**Mounting Height**	**Maintenance Factor**					
		Cleaning Frequency					
		12 Months	**24 Months**	**36 Months**	**48 Months**	**60 Months**	**72 Months**
E1/E2	≤ 6m	0.96	0.96	0.95	0.94	0.93	0.92
E1/E2	> 6m	0.96	0.96	0.95	0.94	0.93	0.92
E3/E4	≤ 6m	0.94	0.92	0.90	0.88	0.86	0.84
E3/E4	> 6m	0.96	0.96	0.95	0.94	0.93	0.92

Note 1: This table is not valid if cleaning is not undertaken within the maximum 6 year scope of the table
Note 2: Each site experiences different levels of pollution, so it is advisable to assess local conditions through measurement in accordance with ILP document TR28
Note 3: The relevant value from this table is combined with the luminous flux factor to provide a combined maintenance factor.

Other considerations

The above gives details for the simple application of the maintenance factor. With technology innovation and changes in our working space there are other aspects that could affect the maintenance factor used, energy consumption and achieved lux levels through life. Below are some examples of aspects that go beyond the traditional maintenance factor calculation that may need to be considered into the future.

Circular Economy: Moving towards a Circular Economy means we will focus on replacement of components, including light sources, rather than entire luminaires. This has the potential for improved maintenance factor.

Driver Lifetime: The most likely 'failure' of an LED luminaire is the driver. However, whilst this is not part of the maintenance factor calculation understanding and specifying driver lifetime can help to manage luminaire failure rates.

Daylight linked and dimmable drivers: Whilst the dimming of fluorescent lamps had at best no impact on life, LED life would be extended due to reduced burning hours or reduced output and reduction in thermal temperatures.

Lighting Controls: We apply control factors to reduce operating hours for energy calculations. Why not for maintenance factor calculations to take the LED life back up the curve for output reduction?

The Environment: Whilst we typically design with 70/50/20 reflectance values, variations in surface finishes/reflectance's on day one or in the future can have a far greater impact on delivered light levels than a small variation in MF.

Constant Light Output (CLO) Drivers: When considering using CLO drivers it is important to make sure correct ldt files accounting for the 'end of life' output is used and that the impact of dirt on rooms and fittings is still considered.

Operation hours vary by space: Within this document we have discussed applying operating hours for a whole project. However, in reality within that project spaces will have varying operational hours. For example, the burning hours in a store room will be significantly lower than a classroom. With this in mind do we have to go beyond a 'generic' MF value for projects?

Typical maintenance factors for Whitecroft Lighting luminaires

This section provides a summary of maintenance factors that can be used for Whitecroft luminaires at various operational points in time.

For any additional fixtures or further information please contact us.

Application Operating Hours

Indoor Applications	Average annual operating hours	Average time to refurb (years)	Average installation life (total hours)
Commercial	2500	20	50,000
Education (Further)	2000	25	50,000
Education (Schools)	1500	20	30,000
Healthcare	5000	10	50,000
Industrial	4000	25	100,000

Source:
Education Schools (DfE Output Specification, Annexe 2E)
All other: Lighting Europe: Evaluating performance of LED based luminaires Guidance Paper

Example

The maintenance factors contained in this document are based on the design parameters shown below.

These factors can be re-calculated according to environmental considerations using the formula illustrated.

LMF (0.94) X
RSMF (0.94) X
LSF (1.0) X
LLMF (0.91) X
MF = 0.8

Family & Variant		LED Life - LxB50@			
		35k Hours	50k Hours	75K Hours	100K Hours
Cascade Flex	Pod LO	95	91	87	83
	Pod MO	95	91	86	82
	Pod HO	94	90	85	81
	Opal LO, MO1 & MO2	95	91	87	83
	Opal HO	94	90	85	81

Design Parameters:
Commercial Application - 70/50/20 reflectance - Clean Environment
Annual Luminaire Clean - 3 year room clean - Spot Replacement - Cascade Flex Pod Mid Output

Luminaire Maintenance Factor (LMF)

Cleaning Regime	1 Year	3 Year
Very Clean	0.96	0.92
Clean	0.94	0.90
Normal	0.90	0.85
Dirty	0.86	0.80

SLL Classification 'Type E'

Room Surface Maintenance Factor (RSMF)

Reflectance	70/50/20				50/30/20			
Cleaning Regime	1 Year Clean		3 Year Clean		1 Year Clean		3 Year Clean	
Product Distribution	Direct	Direct/Indirect	Direct	Direct/Indirect	Direct	Direct/Indirect	Direct	Direct/Indirect
Very Clean	0.97	0.96	0.97	0.95	0.99	0.97	0.98	0.97
Clean	0.95	0.91	0.94	0.91	0.97	0.95	0.97	0.94
Normal	0.91	0.84	0.90	0.83	0.95	0.90	0.95	0.90
Dirty	0.86	0.75	0.86	0.75	0.92	0.84	0.92	0.84

Figures taken from SLL Code for Lighting

Family & Variant		Environment Cleanliness	Reflectance's	MAINTENANCE FACTOR					LED Life - LxB50@			
				35k Hours	50k Hours	75K Hours	100K Hours		35k Hours	50k Hours	75K Hours	100K Hours
Downlights												
Mirage	All Variants	Clean	70/50/20	0.84	0.82	0.79	0.76		94	92	89	85
Mirage 3 C110	LO, MO			0.84	0.82	0.79	0.76		94	92	89	85
	HO			0.82	0.79	0.74	0.70		92	89	83	78
Mirage 3 C165 **Mirage 3 SQ165**	LO, MO1, MO2			0.84	0.82	0.79	0.76		94	92	89	85
	HO			0.82	0.79	0.74	0.70		92	89	83	78
Esprit LED	LO, MO			0.83	0.81	0.74	0.73		93	90	83	82
	HO			0.83	0.80	0.77	0.73		93	90	86	82
XR1	All Variants			0.82	0.80	0.76	0.72		92	89	85	80
Suspended												
Avenue Metro	Pod	Clean	70/50/20	0.80	0.77	0.74	0.71		93	91	87	83
	Prism & Opal			0.80	0.78	0.74	0.70		94	91	86	82
Foil XS	All Variants			0.80	0.78	0.75	0.71		94	91	87	83
Foil SRD	All Variants			0.80	0.78	0.75	0.71		94	91	87	83
Foil Radiant	All Variants			0.80	0.78	0.75	0.71		94	91	87	83
Oculus	All Variants			0.80	0.78	0.75	0.71		94	91	87	83
Selene	All Variants			0.80	0.78	0.75	0.71		94	91	87	83
Rink	All Variants			0.80	0.78	0.75	0.71		94	91	87	83
Inspiration	All Variants			0.80	0.78	0.75	0.71		94	91	87	83
Flight & Flight Vitalty	IP20		50/30/20	0.86	0.83	0.79	0.76		94	91	87	83
	IP65			0.86	0.82	0.78	0.76		94	90	86	83
	Sport		70/50/20	0.86	0.83	0.79	0.76		94	91	87	83
Recessed												
Cityline	Central Hex	Clean	70/50/20	0.83	0.81	0.77	0.74		93	91	87	83
	Full Hex & Quad			0.86	0.84	0.81	0.79		96	94	91	89
Cascade Flex	Pod LO			0.85	0.81	0.78	0.74		95	91	87	83
	Pod MO			0.85	0.81	0.77	0.73		95	91	86	82
	Pod HO			0.84	0.80	0.76	0.72		94	90	85	81
	Opal LO, MO1 & MO2			0.85	0.81	0.78	0.74		95	91	87	83
	Opal HO			0.84	0.80	0.76	0.72		94	90	85	81
Cascade Flex Vitality	All Variants			0.84	0.80	0.77	0.73		94	90	86	82
CityEdge	LO			0.84	0.81	0.78	0.74		94	91	87	83
	MO			0.83	0.81	0.77	0.73		94	91	86	82
Hygiene	All Variants			0.84	0.82	0.78	0.74		94	91	87	83
Rink	All Variants			0.85	0.81	0.78	0.74		95	91	87	83
Tegan 2	All Variants			0.83	0.80	0.77	0.73		93	90	86	82
Helm	All Variants			0.84	0.82	0.78	0.74		94	91	87	83

Family & Variant		Environment Cleanliness	Reflectance's	MAINTENANCE FACTOR					LED Life - LxB50@			
				35k Hours	50k Hours	75K Hours	100K Hours		35k Hours	50k Hours	75K Hours	100K Hours
Clean Area & Healthcare												
Lister/DTFU	600x600 & 1200x300	Very Clean	70/50/20	0.86	0.84	0.80	0.76		93	90	86	82
	1200x600			0.86	0.84	0.80	0.76		93	90	86	82
Florence+	At full output			0.86	0.84	0.80	0.76		92	90	86	81
N'gale LED	LO			0.88	0.86	0.82	0.79		94	92	89	85
Surface												
Kolo	All Variants	Clean	70/50/20	0.84	0.82	0.78	0.74		94	91	87	83
Horizon 360	All Variants			0.83	0.81	0.77	0.73		93	91	86	82
Vespere Wall	All Variants			0.83	0.81	0.77	0.73		93	90	86	81
Trimpak	14K & 24K			0.83	0.81	0.77	0.73		94	91	86	82
	34K & 44K			0.83	0.81	0.77	0.73		93	91	86	82
	54K			0.83	0.80	0.76	0.72		93	90	85	80
	64K			0.82	0.80	0.75	0.64		92	89	84	72
ACL	04K - 44K		50/30/20	0.85	0.82	0.78	0.74		95	91	87	83
	64K - 94K			0.83	0.81	0.77	0.73		93	90	86	81
	E-light			0.86	0.84	0.82	0.80		96	94	92	89

Note: LMF type is based on SLL Classification 'Type E' for reasons highlighted in this document.

LMF & RSMF based on annual clean regime and environment type outlined within the SLL Code for most common applications for product use.

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