TECHNICAL DIRECTORATE

TECHNICAL PAPER

Concourse Lighting Maintained Illuminance and Reflectances

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1 Abstract

Background: The purpose of this technical paper is to describe the method by which the cleaning and maintenance requirements for the C100 Concourse Tunnels lighting scheme have been determined for use in their lighting calculations, to demonstrate that compliant illuminance levels are achieved throughout the design life of the installation.

Results: In order to comply with LUL requirements the illuminance levels at floor level on the concourse must be such that the lighting scheme provides an average maintained illuminance of 100 lux on the floor at all times during the lifecycle of the installation (in accordance with LUL 1-066). Maintenance Factor (MF) is the industry standard means by which the various parameters that affect these maintained light levels are quantified. The MF has been calculated by C100 using four industry standard factors which describe the various parameters which contribute to the degradation in the light performance of the whole installation over time, in accordance with an established methodology based on CIE document No. CIE Publication 97: 2005: “Guide on the maintenance of indoor electric lighting systems” and published in the SLL Code for Lighting 2012.

Conclusions: The method used by C100 to determine the input maintenance parameters for their Concourse lighting calculations, is based on current industry guidance and best practice and aims to avoid imposing an excessive maintenance burden on the Station Infrastructure Manager so that a minimum of 100 lux on the floor is maintained at all times during the lifecycle of the installation.

Note that this Technical Paper does not intend to consider the actual light output peformance of the C100 proposed Totem uplighter luminaire. The Totem luminaire performance will be assessed by CRL when C100 have provided the measured photometric data and have tested the Totem luminaire installed in the C100 Concourse prototype.

2 Introduction

The performance of any lighting installation starts to deteriorate as soon as it is put into service. A suitable maintenance regime will ensure that the performance of the lighting scheme stays within design limits.

Maintenance activities include:

- the replacement of failed lamps and luminaires,
- cleaning of luminaires and
- cleaning of room surfaces.

The required frequency of these maintenance activities is summarised in the maintenance factor (MF). The method of calculating the MF and this MF is defined in the Society of Light and Lighting (SLL) “Code of Lighting” 2012 [1].

3 Definition of the Lighting Maintenance Factor

The maintenance factor (MF) is defined as the ratio of *maintained illuminance* to *initial illuminance*. Maintained illuminance is the minimum light level that the installation will produce on the task surface, just before maintenance of the system is carried out. The closer the MF is to one, the fewer luminaires that will be needed.

To achieve the required maintained illuminance, a suitable maintenance regime is required, which will include planned lamp/LED replacement, luminaire cleaning and room surface cleaning.

3.1 Determination of the Maintenance Factor (MF)

The Society of Light and Lighting (SLL) provides detailed guidance in it's Code of Lighting on how to calculate the MF and provides a series of tables that contain the necessary data to determine the MF.

The maintenance factor (MF) for an indoor lighting installation is a multiple of four factors, as follows:

Maintenance Factor MF = LLMF x LSF x LMF x RSMF

where: LLMF is the lamp lumen maintenance factor

LSF is the lamp survival factor

LMF is the luminaire maintenance factor

RSMF is the room surface maintenance factor

LLMF, the lamp lumen maintenance factor is required because the light output from any lamp decreases over time. This rate of fall-off of lumen output, the LLMF, varies for different types of lamp and the actual value is determined by the manufacturer. For LED installations in particular the operating temperature of the LEDS is critical to maintaining lumen output over time.

Lamp survival factor, LSF, is defined as the proportion of lamps, of a specific type, that will still be functioning normally after a set number of hours of operation. The value for LSF is set at one where spot replacement of failed lamps is implemented. A value of less than one, as defined by the manufacturer, is used when a group relacement strategy is implemented, without spot replacement of failed lamps. For LED lighting installations, it is assumed that all LED light sources will be functioning at the end of life, albeit at a reduced light output.

Luminaire maintenance factor, LMF, is used in the calculation of MF as the dirt deposited on, or in, the luminaire will cause a reduction in the light output. The LMF is obtained from two tables within the SLL Code of Lighting, the first which categorises the ingress protection (IP) level of the luminaire body, and the second which classifies the environment where the luminaire is to be located in terms of how clean it is. By cross-referencing the two classifications, against the planned luminaire cleaning frequency, an accurate value for LMF is obtained.

RSMF, room surface maintenance factor, quantifies the changes in the room surface reflectances, i.e., ceilings, walls and floors, caused by the build-up of dirt and the frequency of cleaning. These changes in reflectance values will cause changes in the illuminance produced

by the lighting installation. The SLL Code for Lighting contains tables that show typical changes in the illuminance that occur due to dirt deposition. These tables enable an accurate value for RSMF to be selected for the MF calculation.

3.2 The C100 Calculation of the MF for Concourse Tunnels

C100 have specified a bespoke luminaire, referenced SPL-501, as detailed in their *RIBA Stage E Lighting Design Guide,* document reference C100-ATK-A-TSY-CRG02-00005, Rev 1.0 [2], with the required performance characteristics for the Concourse Totem normal duty indirect uplighter.

Through consultation with lighting manufacturers C100 have determined that the appropriate value for LLMF for the Totem luminaire is 0.70, based on current industry standards.

LLMF = 0.70

In accordance with the guidance contained in the SLL Code for Lighting, C100 have set the LSF value at 1.0, as required when a spot replacement strategy is in place, as it will be for the Crossrail Stations.

LSF = 1.0

The LMF was then derived by first referring to the SLL Code for Lighting table 18.2 for the correct luminaire classification for an indirect uplighter, as used in their Totem design. The luminaire is defined as a Class F type. Then C100 referred to table 18.3 to define the cleanliness of the Concourse environment, which is Normal (N). Using both of these values for luminaire and environment type, and the proposed luminaire cleaning frequency of once every 2 years, the LMF value of 0.66 was obtained from table 18.4.

LMF = 0.66

Having defined the Totem normal service luminaire as an indirect uplighter and using values for the reflectances of the Concourse GRC cladding and floor finishes and being 0.50 and 0.20 respectively, C100 used table 18.8 to determine the value for RSMF was 0.73. This value is dependent on a GRC cladding and floor finishes maintenance strategy that requires these surfaces to be cleaned once every two years.

RSMF = 0.73

By substituting all these values into the Maintenance Factor equation, C100 obtained the following value for MF:

MF = 0.70 (LLMF) x 1.0 (LSF) x 0.66 (LMF) x 0.73 (RSMF) = 0.34

MF = 0.34

Having determined a Maintenance Factor (MF) of 0.34, C100 applied this MF value to their lighting calculations for the Concourse Totem generic Station lighting scheme. These calculations indicated that the maintained average illuminance levels of 100 lux could be achieved on the Concourse floor at all times in normal service mode, i.e. not in Emergency lighting mode, using the assumed Totem uplighter luminaire performance data.

The C100 Stage E Concourse lighting calcs values for the MF assumed that the GRC cladding would have a reflectance value of 0.60, when in fact the measured value of the selected GRC material, referenced “Wall GRC 328” has a reflectance value of 0.56.

Similarly, the Stage E calcs assumed a value for reflectance of 0.20 for the MF value of the floor finishes, but the preferred floor finish material, “Floor Tile Granite”, has an actual reflectance value of 0.30, as proven by C100 material testing. The C100 design team is recommending an increase in the cleaning intervals for the totem uplighters to ensure that the optimum light output for the system is maintained.

4 Conclusion

The C100 Concourse Totem lighting calculations, performed using only theoretical luminaire data, not measured photometric data, indicates that this lighting scheme can provide compliant lighting levels throughout the design life of the scheme with a low frequency maintenance regime.

Only when lighting calculations are carried out using actual photometric data measured from an actual Totem luminaire prototype can it be conclusively determined that the C100 Concourse Totem lighting scheme is feasible.

Note: C100 still recommend that the top of the totem safety glass is cleaned at 6 monthly intervals since this removes the build up of dirt and dust and significantly improves light output. It is estimated that an increase of approximately 15% in light output can be achieved as a result.

1 References

[1] Society of Light and Lighting Code for Lighting 2012

[2] C100 RIBA Stage E – Lighting Design Guide Rev 1.0