

## 5.7 Maintenance of street (road) lighting installations (Kostic and Djokic 2009)

The maintenance factor of a luminaire is defined as the ratio between its luminous flux emitted at the end of the maintenance period and its initial luminous flux. It depends on the light source lumen depreciation and the dirt accumulated on the optical parts of the luminaire.

Since there is a reduction in the luminaire luminous flux during the maintenance period, it is necessary to provide proper maintenance, which will ensure the periodic renewal of the initial street (road) luminance (illuminance) level. In addition, better maintenance ensures a higher maintenance factor, i.e. a lower difference between the initial and maintained values of the luminance (illuminance) level. As the number of luminaires (poles) is determined by the initial value of the light level, a higher maintenance factor, which corresponds to a smaller number of luminaires on the observed street (road) section, results in the reduction of both investment and electricity consumption costs.

Note that proper maintenance is not possible if luminaires of an inappropriate degree of mechanical protection are used. The following example (from research carried out by the Schröder Group) may serve as an illustration: in an environment characterised by the third category of air pollution (air with dirt particles), the maintenance factor (determined assuming the usual maintenance procedure) had the following values: for open luminaires with a degree of protection IP23 – 0.50, for closed luminaires with IP54 – 0.70, and for dust-tight luminaires (IP65) even 0.85 (all luminaires were with HPS lamps). It can, therefore, be concluded that the choice of adequate luminaires (regarding mechanical protection) represents a basic prerequisite for proper maintenance of street (road) lighting installations.

Studying available literature, the authors of this book have not been successful in finding an appropriate procedure for the determination of both the maintenance period and the luminaire maintenance factor. This is particularly true for the determination of the maintenance period, by which the luminaire maintenance factor can be evaluated using available documents related to both the lamp lumen depreciation factor and the luminaire dirt depreciation factor. Namely, the lamp manufacturers usually issue documents containing lamp lumen depreciation curves, and CIE published a technical report offering luminaire dirt depreciation factors (for example, for IP6X luminaires, generally recommended for road (street) lighting, the luminaire dirt depreciation factor amounts to 0.91–0.93 after one year, and 0.83–0.90 after three years (the lower values correspond to a high, and the higher ones to a low pollution category)) (CIE 2003b). Therefore, the authors conducted their own research intended to determine both the maintenance periods and maintenance factors in street (road) lighting.

The final results of the research are shown in **Table 5.5** (Kostic and Djokic 2009). It contains the recommended values for both the maintenance period and maintenance factor for luminaires with almost all conventional lamp types used in street (road) lighting. They are determined assuming group lamp replacement and simultaneous cleaning of the optical parts of luminaires. The maintenance periods (periods of group lamp replacement),  $T_{gr}$ , were determined analysing curves that show the percentage decline in the lamp luminous flux and the percentage of early failed lamps, provided by Philips Lighting and Osram. Based on the determined maintenance periods, it was possible to obtain the lamp lumen depreciation

factors, as well as the luminaire dirt depreciation factors (the latter, also depending on the IP of luminaires and the pollution category, were determined using BSI (1992)), and thus the maintenance factors.

**Table 5.5** Recommended maintenance periods ( $T_{gr}$ ) and maintenance factors of luminaires intended for street (road) lighting

Atmospheric pollution category	High		Medium		Low	
	Degree of mechanical protection					
Lamp type Maintenance period ( $T_{gr}$ )	IP 5X	IP 6X	IP 5X	IP 6X	IP 5X	IP 6X
Conventional HPS lamps: $T_{gr}$ =36 months	0.67	0.73	0.72	0.77	0.77	0.79
HPS lamps with improved properties: $T_{gr}$ =48 months	/	0.74	/	0.81	/	0.85
Conventional HPM lamps: $T_{gr}$ =24 months	0.67	0.71	0.69	0.71	0.72	0.72
HPM lamps with prolonged lifetime: $T_{gr}$ =48 months	0.72	0.75	0.73	0.76	0.76	0.76
Conventional MH lamps (250 W and 400W): $T_{gr}$ =24 months	0.71	0.74	0.72	0.75	0.75	0.76
MH lamps with a ceramic discharge tube: $T_{gr}$ =24 months	0.69	0.71	0.70	0.72	0.72	0.73
CFLs intended for outdoor lighting: $T_{gr}$ =42 months	/	0.72	/	0.77	/	0.80

Assuming that LED luminaires are cleaned every four years, the approximate values of their maintenance factors of 0.68 (L80) and 0.76 (L90) might be used (see subsection 3.4.7).

Applying new technologies, the Schröder Group designed a luminaire with self-cleaning properties. The Sun's ultraviolet radiation in combination with a special coating of the glass optical cover (a thin layer of  $TiO_2$ ) causes decomposition of dust layers. In addition, the  $TiO_2$  layer makes the glass surface hydrophilic, meaning that the rain spreads all over the surface (without forming rain droplets), thereby washing away the decomposed dust particles. In the described way, the luminaire dirt depreciation factor approaches the maximal possible (theoretical) value of one.

Note that adequate maintenance of road (street) lighting assumes quick replacement of early failed light sources.

The use of hot-dip galvanised steel poles is economically more advantageous than the use of painted steel poles, although the former are more expensive. This is a result of the fact that hot-dip galvanised steel poles do not require almost any maintenance, while painted steel poles must be periodically protected against corrosion and painted (usually every five years). In addition, hot-dip galvanised poles are aesthetically more pleasant, because they have almost constant appearance during the whole exploitation period.