High pressure sodium lamp with twin arc tube – variation parameters of road lighting

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Abstract: Article presents changes of luminous intensity distribution of road lighting luminaire with twin arc tube high pressure sodium lamp. Slight shift of active arc tube's center causes significant variations of luminous intensity distributions. Tested road luminaire has polished reflector with many small surfaces directing light precisely on the road. This article presents research about changeable arc tubes influencing parameters of road lighting.

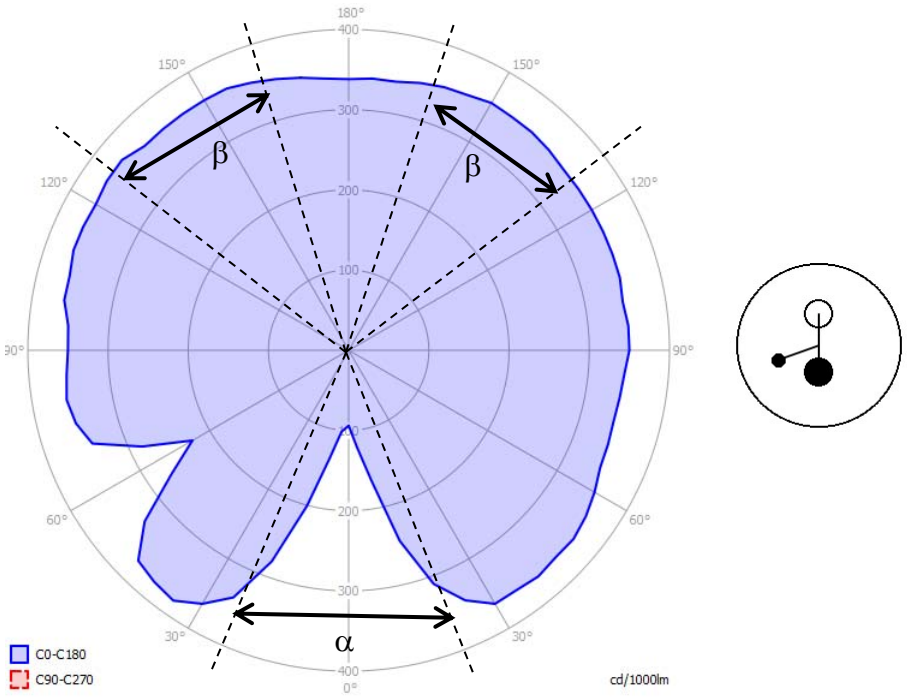
1. Introduction

The process of light designing bases on right selection of light luminaries location and appropriate choice of parameters. For proper design it is necessary to know the geometric dimensions of the object (i.e. room, road), localisation of the luminaries, method of assembling it, as well as height and photometric data. Companies producing luminaries use photometric files based on single arc tube. Nowadays the high competitiveness results in designing new products like twin arc tube e.g. Helios WLS DJ double arc, Sylvania Twin arc, Osram NAV-TT, Aura Sodinette Long Life [1, 2, 3, 4].

2. Description of the subject of research – twin arc tubes

First of all, twin arc tubes have longer life than single arc tubes, work time reaches even 55,000h [3, 5]. Secondly, twin arc tubes reduce decrease in luminous flux and enables fast re-ignition. The aim is to lower operating costs. However, the use of such lamps may have a negative impact on lighting performance. The disadvantage of this solution is non-uniformed luminous intensity distribution of lamps causing non-uniformed ratio of luminance, which has negative influence of light parameters on work surface. Finally, producers do not share photometric data of twin arc tube. Figure 1 presents luminous intensity distribution of twin arc high pressure sodium lamp in two planes.

a)



b)

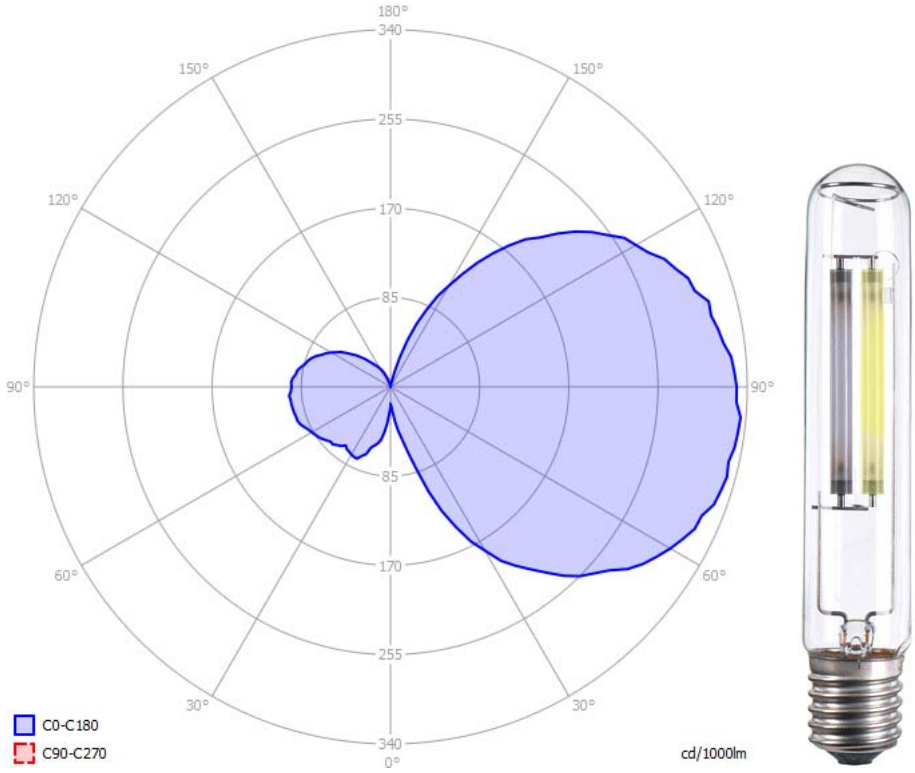


Fig. 1 Luminous intensity distribution twin arc high pressure sodium lamp for a) γ=90°, C between 0° and 345° by 5° b) C0-C180 for γ between 0° and 180° by 2.5°

During research twin arc tube Helios WLS DJ double arc 70W, screw cap E27 with external ignitor was used. Each arc tube has been aged for 100h [6] and directly before

measurements had steady-state lighting condition over 60 minutes [7]. Figure 2 and table 1 presents figure and dimension of high pressure sodium lamp 70W with clear bulb.

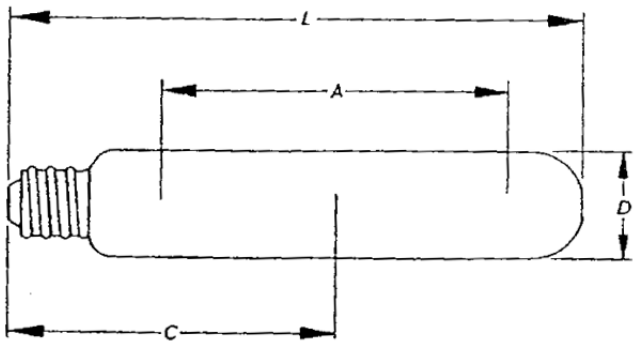


Fig. 2 Dimension of high pressure sodium lamp 70W with clear bulb [7]

Table 1 Dimension of high pressure sodium lamp 70W with clear bulb [7]

Lampholder	Diametre of bulb (max) D	Length sum (max) L	Height of photometric centre C	Lenght of arc tube(nominal) A	Any point variation of Arc tube to symmetry lamp axis	Work position
	mm	mm	mm	mm	-	According to the producer
E27	72	165	105±10	28-45		

All parameters of light source are listed in EN 60662:2012, except for horizontal lamp axis symmetry. This raise a problem in selling twin arc tubes – asymmetrical arc tube position. Research about alternating burning of arc tubes were conducted. After burning out arc tube 1, arc tube 2 ignited, it was because of lower starting voltage of a discharge lamp.

3. Description of reflectors

The most important element of luminaries is reflector. Reflector is responsible for forming luminary intensity distribution. Dependable of reflector shape and material different parameters of luminaries intensity distribution are obtained. In research the most popular raod and pavement luminaries were used: Elgo OUS, Philips SGP340, Siteco SQ100, Rosa ELBA. Reflectors of this luminaries differs in complexity of the light system, starting form the simplest construction of Elgo OUS characterized by of two polished flat reflecting surface, more complicated luminaire is Philips SGP340 consisting several flat polished surfaces, the most complex Siteco SQ100 with many small mirroring surfaces.

In addition Rosa ELBA luminaire optical system is constructed to prevent emission in upper sphere.

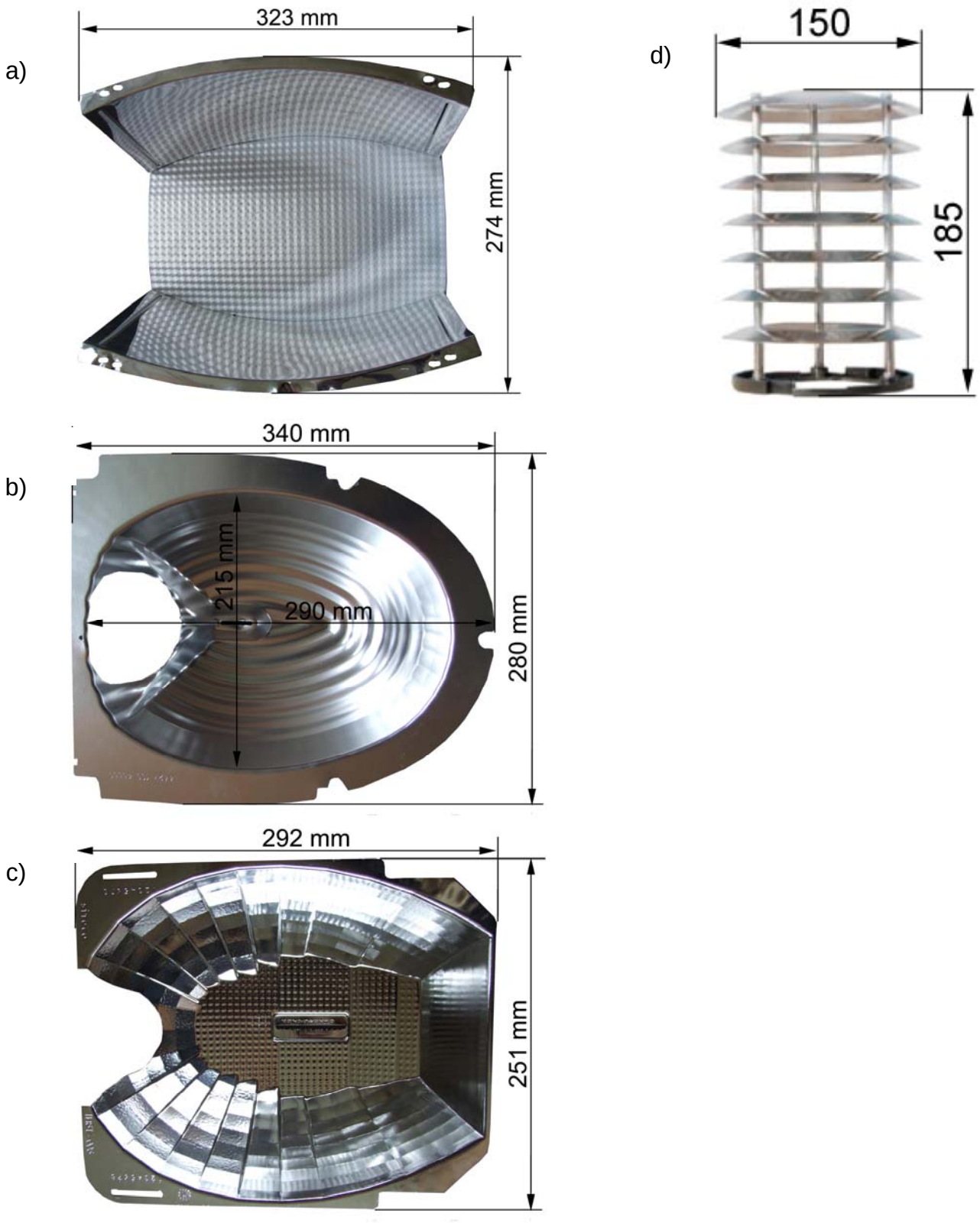


Fig. 3 Reflector of tested luminaires a) Elgo OUS, b) Philips SGP340, c) Siteco SQ100 d) Rosa ELBA

4. The Laboratory

Measurements were performed according to standard PN-EN 13032 for 12 C surfaces every 30° and for γ from 0° to 90° every 2,5° (figure 4)

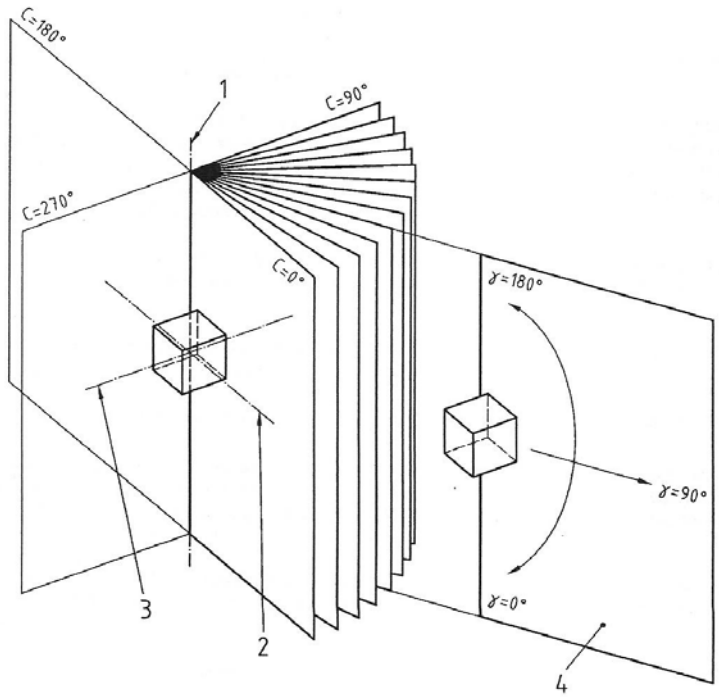


Fig. 4 Orientation of C, γ coordinate system in relation to longitudinal direction of carriageway
1 – first photometric axis, 2 – second photometric axis, 3 – third photometric axis, 4 – data sheet = C surface

Position of light centre for twin arc tube is luminaire photometric centre. Measuring results were converted to eulumdat (*.ldt) file and used to calculate of lighting parameters in Dialux 4.11 for single and twin arc tube for all working possibilities. Horizontal position of arc tubes are the same in all tested cases. Due to the fact, that changing its horizontal position causes the biggest variation of lighting results.

5. Results of luminaries intensity distribution

The following figures present luminaries intensity distribution for C surfaces 0°–180° and C surfaces 90°–270 for single and twin arc tubes.

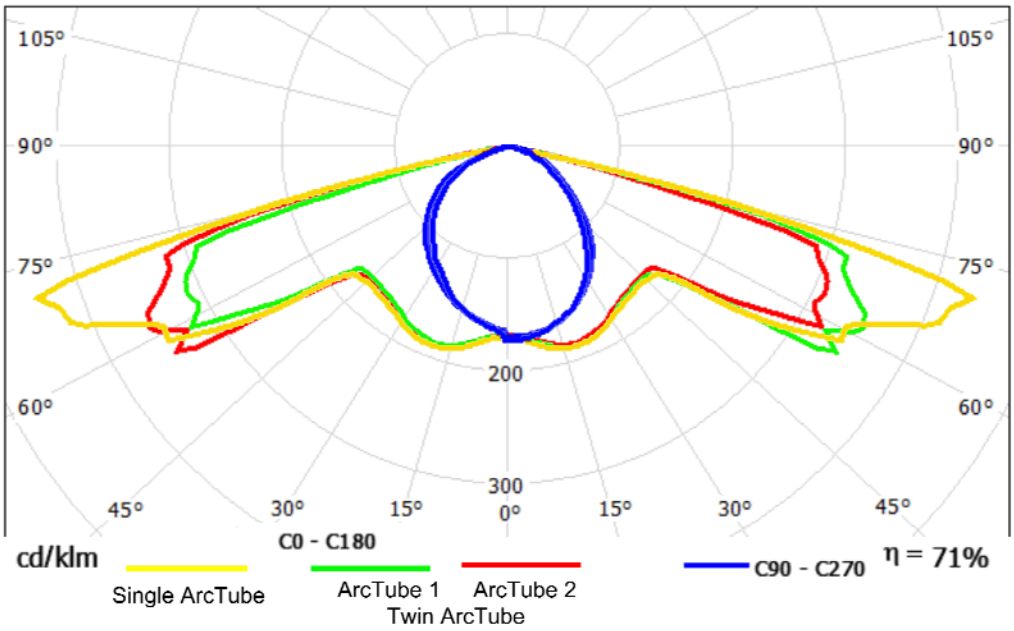


Fig. 5 Luminous intensity distribution for Single arc tube - yellow and Twin arc tube (arc tube 1- turned on 2- turned off - green; arc tube 1- turned off 2- turned on - red) installed on luminaire Elgo OUS

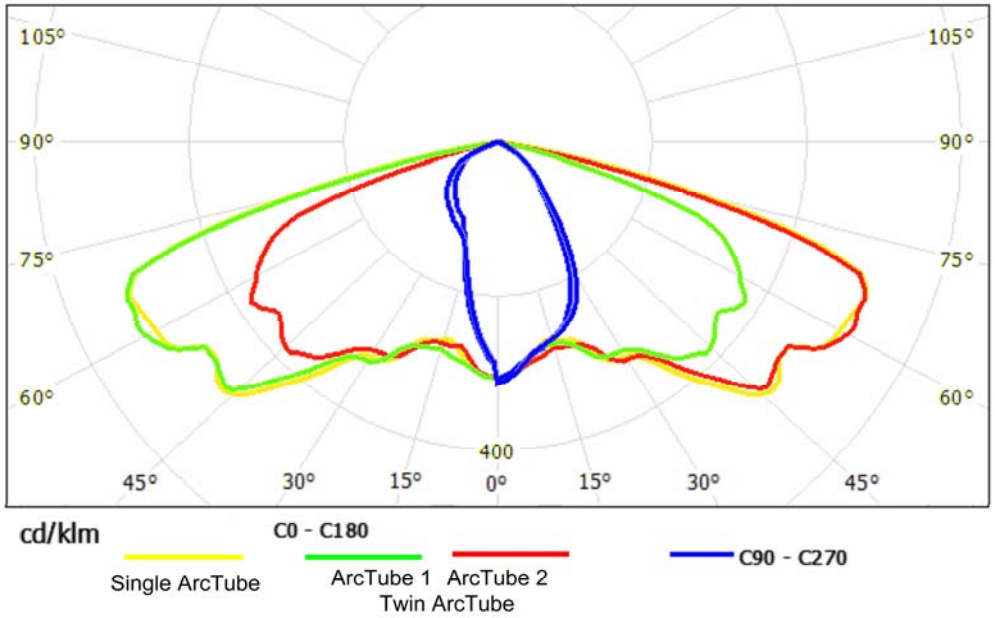


Fig. 6 Luminous intensity distribution for Single arc tube - yellow and Twin arc tube (arc tube 1- turned on 2- turned off - green; arc tube 1- turned off 2- turned on - red) installed on luminaire Philips SGP340

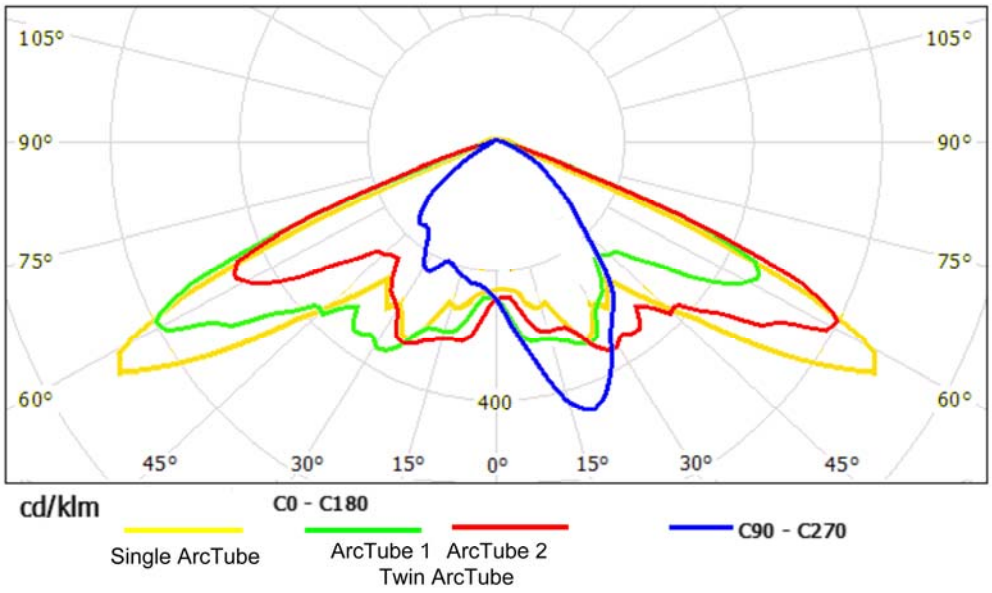


Fig. 7 Luminous intensity distribution for Single arc tube - yellow and Twin arc tube (arc tube 1- turned on 2- turned off - green; arc tube 1- turned off 2- turned on - red) installed on luminaire Siteco SQ100

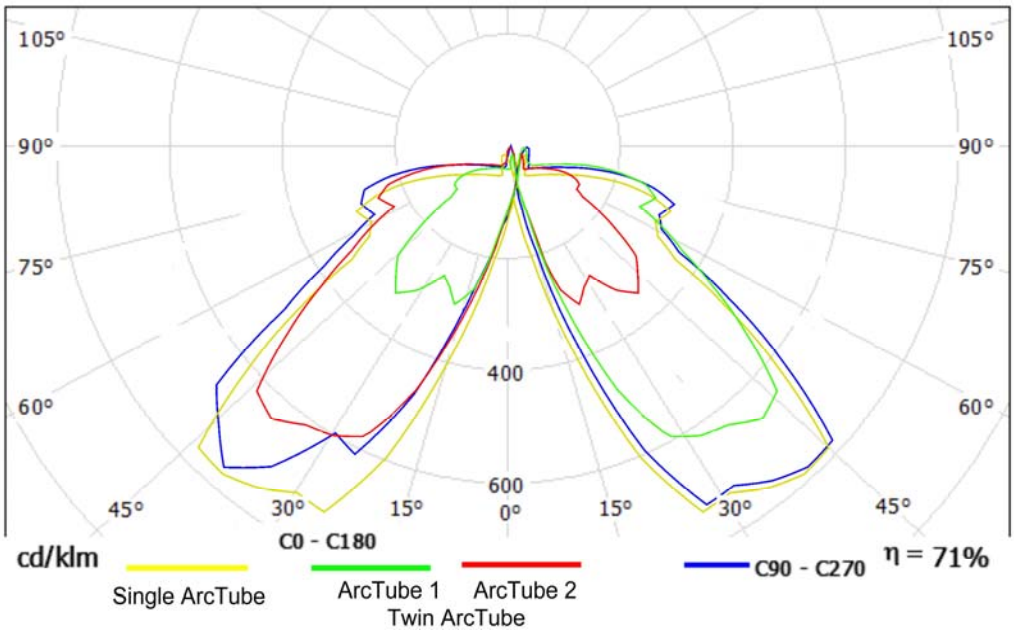


Fig. 8 Luminous intensity distribution for Single arc tube - yellow and Twin arc tube (arc tube 1- turned on 2- turned off - green; arc tube 1- turned off 2- turned on - red) installed on luminaire Rosa ELBA

6. Results of illuminance and luminance

In simulation created eulumdate files in Dialux software was used. To determine the influence of exchange the single arc tube onto twin arc tube causes variations of results in 4 situations:

situation a – used only single arc tube lamps

situation b – turned on left arc tube in double arc tube lamp

situation c - turned on right arc tube in double arc tube lamp

situation d - turned on alternate left and right arc tube in double arc tube lamp simultaneously

The object of research was used at two lane street (lane width 3,5 metre). Pole height of luminaire was 7 metre, distance between each poles: 25 metre (Elgo OUS), 34 metre (Philips SGP340), 33 metre (Siteco SQ100). Standard lighting class: S2. At the following figures iso-illumiance curves for the all lighting situation are presented.

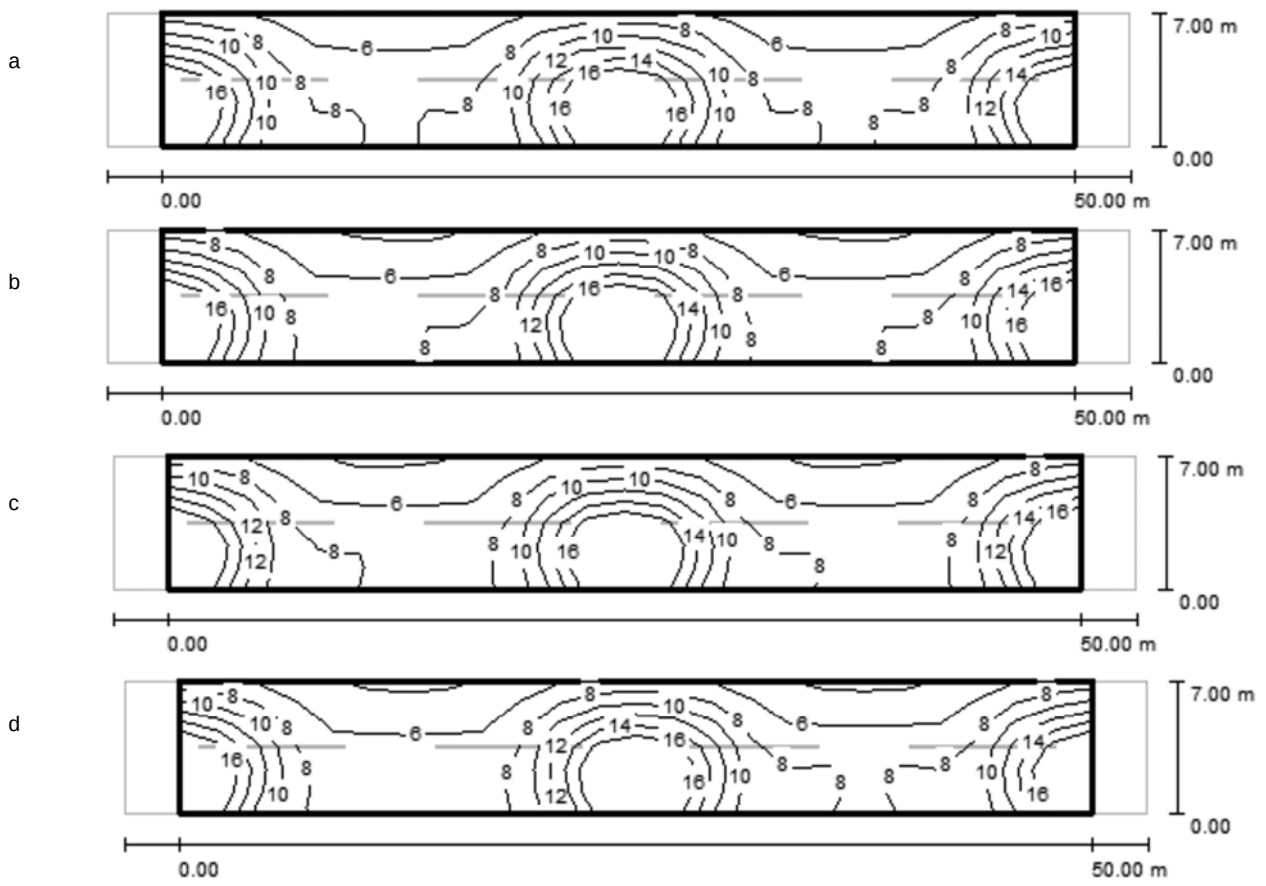


Fig. 9 Graphs of iso-illumiance curves E [lx] at the road for luminaire OUS

Table 2. Results of lighting parameters at the road for all situation with luminaire OUS

	Standard requirements EN 13201 (lighting classes S2)	E_m [lx]	E_{min} [lx]	E_{max} [lx]	E_{min}/E_m [-]	E_{min}/E_{max} [-]
		>10	>3	-	-	-
situation	a	**10,03**	**4,66**	22	0,465	0,213
	b	**9,69**	**4,00**	22	0,413	0,183
	c	**9,69**	**4,00**	22	0,413	0,183
	d	**9,69**	**4,01**	22	0,414	0,183

Green – accepted result **Red** – unaccepted result

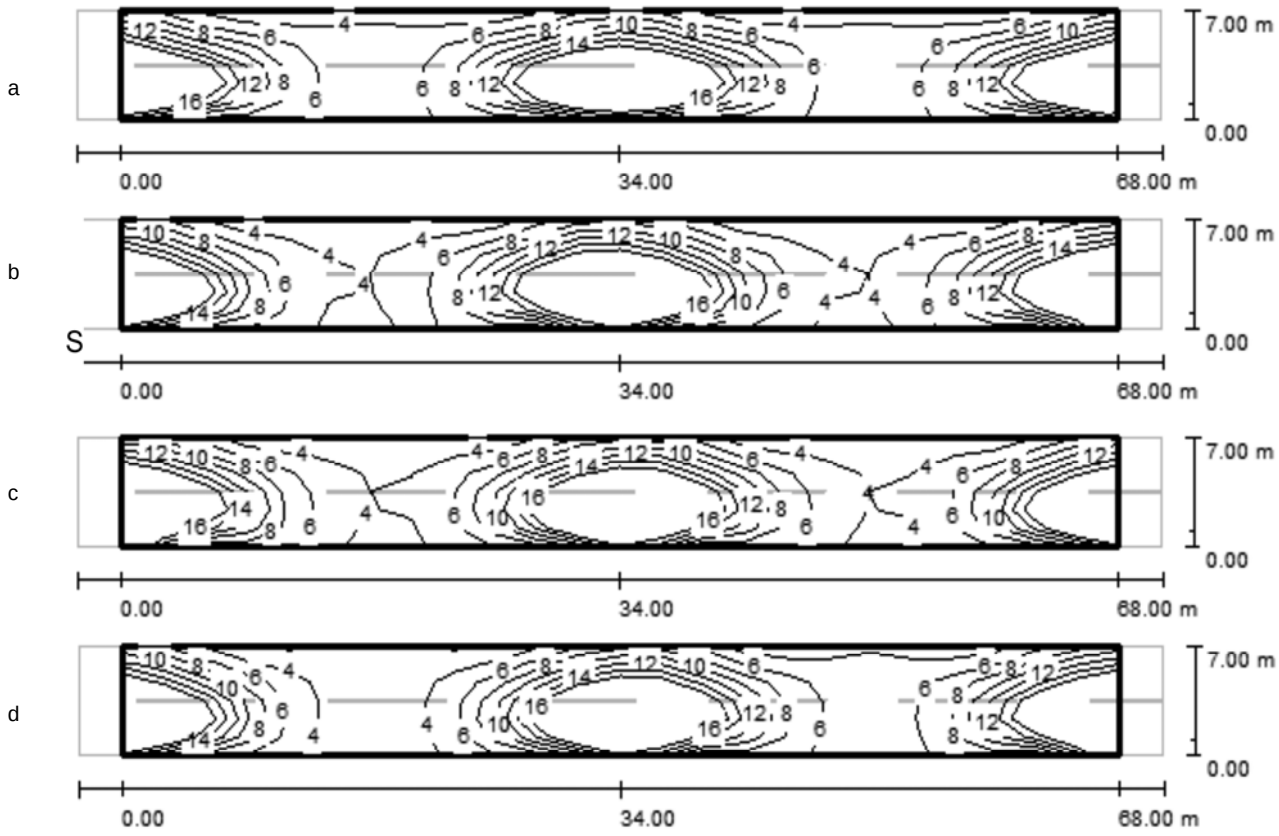


Fig. 10 Graphs of iso-illumiance curves E [lx] at the road for luminaire SGP340

Table 3. Results of lighting parameters at the road for all situation with luminaire SGP340

	Standard requirements EN 13201 (lighting classes S2)	E_m [lx]	E_{min} [lx]	E_{max} [lx]	E_{min}/E_m [-]	E_{min}/E_{max} [-]
		>10	>3	-	-	-
situation	a	**10,42**	**3,10**	28	0,297	0,111
	b	**10,27**	**2,77**	32	0,269	0,087
	c	**10,27**	**2,77**	32	0,269	0,087
	d	**10,26**	**2,23**	32	0,218	0,070

Green – accepted result **Red** – unaccepted result

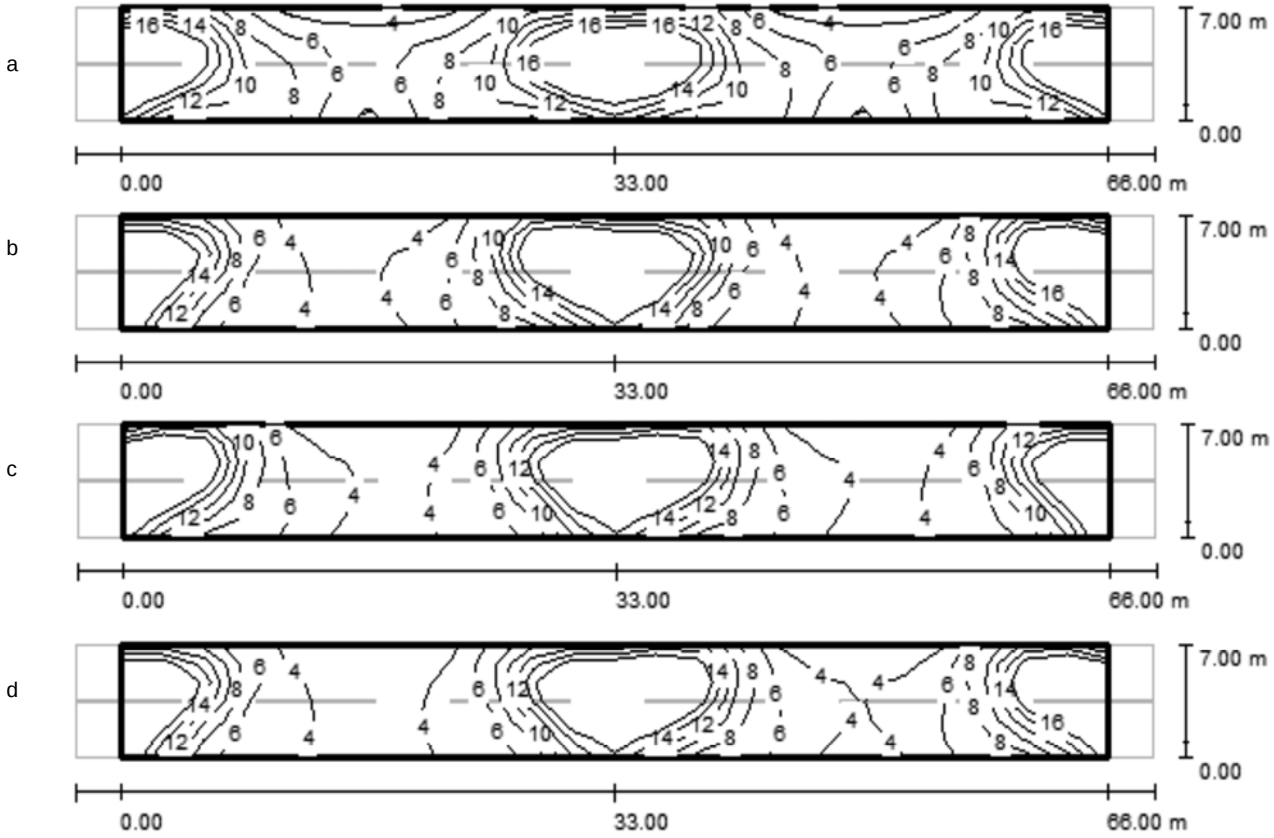


Fig. 11 Graphs of iso-illumiance curves E [lx] at the road for luminaire SQ100

Table 4. Results of lighting parameters at the road for all situation with luminaire SQ100

	Standard requirements EN 13201 (lighting classes S2)	E_m [lx]	E_{min} [lx]	E_{max} [lx]	E_{min}/E_m [-]	E_{min}/E_{max} [-]
		>10	>3	-	-	-
situation	a	**10,97**	**3,29**	25	0,300	0,130
	b	**10,00**	**2,42**	28	0,242	0,087
	c	**10,00**	**2,42**	28	0,242	0,087
	d	**10,00**	**2,40**	28	0,240	0,086

Green – accepted result **Red** – unaccepted result

Results for Rosa ELBA luminaire

Next measures were performed on park luminaire Rosa ELBA used for pavement and bicycle path. The following figures present iso-illuminance curves the best and the worst vertical rotation situations possible.

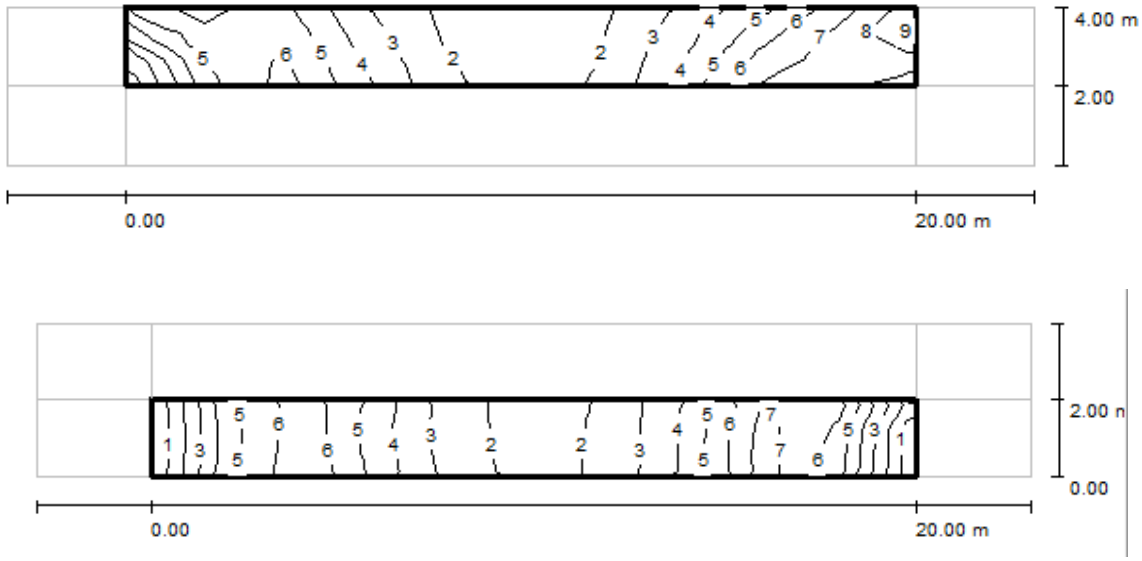


Fig. 12 Best situation for vertical rotation Z=90°

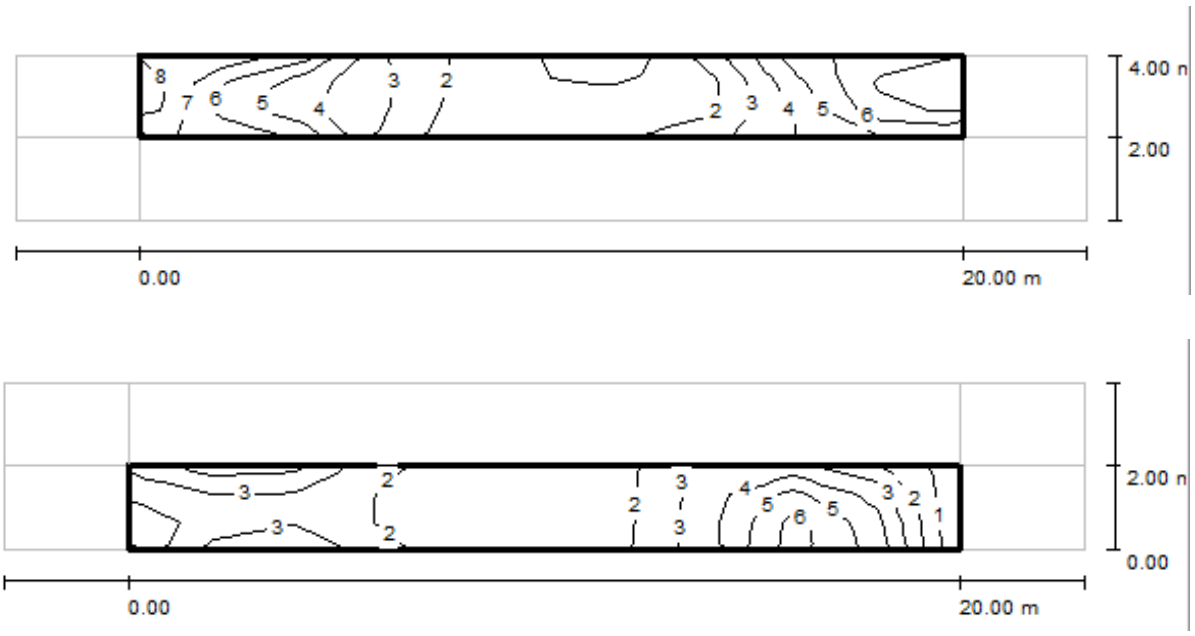


Fig. 13 Worst situation for vertical rotation Z=180°

Table 5. Results of lighting parameters for Rosa ELBA luminaire

		Pavement lighting classes S5		Bicycle path lighting classes S5	
	Needs by EN 13201	E_m [lx]	E_{min} [lx]	E_m [lx]	E_{min} [lx]
		>3	>0.6	>3	>0.6
Vertical rotaction of luminaire	Z=0°	**3,28**	**1,03**	**4,45**	**1,25**
	Z=45°	**3,58**	**0,74**	**4,10**	**0,69**
	Z=90°	**4,12**	**1,12**	**4,30**	**1,40**
	Z=135°	**3,87**	**1,13**	**4,18**	**1,42**
	Z=180°	**2,73**	**0,85**	**3,79**	**0,65**
	Z=225°	**4,16**	**1,10**	**4,12**	**1,41**
	Z=270°	**3,95**	**1,55**	**4,19**	**0,82**
	Z=315°	**3,68**	**0,97**	**3,91**	**1,28**

Green – accepted result **Red** – unaccepted result

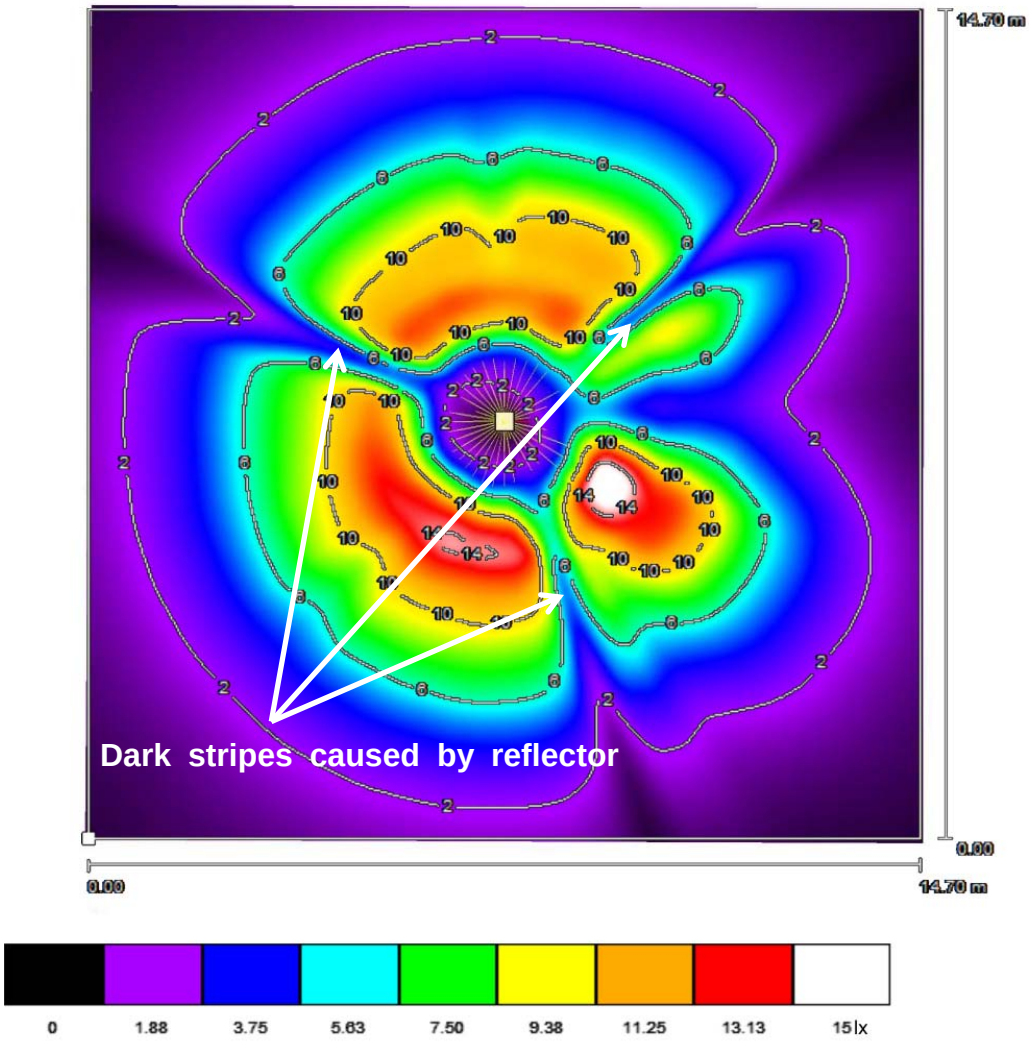


Fig. 14 Iso-illuminance curves and false colours for Rosa ELBA luminaire

7. Conclusion

- ✓ In comparison to the single arc tube the change of the arc tube in twin arc tube lamp causes the significant changes of luminous intensity distribution
- ✓ Unsymmetrical position of lamp causes unsymmetrical luminous intensity distribution.
- ✓ Slight change of centre in arc tube position has small influence on direct emission from arc tube without reflection reflector.
- ✓ Any change of centre in arc tube position in park luminaire has a small influence on luminous intensity distribution.
- ✓ Overriding of turned off arc tube in twin arc tube has significant impact on luminous intensity.
- ✓ Decreasing luminous intensity in angle α (fig. 1a), and increasing in angle β was noticed, caused with overriding and reflecting light by turned off arc tube.
- ✓ Location of arc tube has significant influence on illuminance at work surface.
- ✓ During light designing and exploitation alternate left and right arc tubes in twin arc tube lamp are not taken into account. This causes significant irregularity ratio of luminance.
- ✓ Correction of any point variation of arc tube of symmetry lamp axis in table 1, which is attached to standard PN-EN 60662 is recommended.

References

[1] http://www.helios.katowice.pl

[2] http://www.sylvania.pl/

[3] http://www.osram.com

[4] http://auralight.com

[5] Philips PIA SON features and benefits over Twin Arc Technology – A buyers Guide, October 2008

[6] PN-EN 13032-1+A1:2012E Light and lighting. Measurement and presentation of photometric data of lamps and luminaires. Measurement and file format

[7] PN-EN 60662:2012. High-pressure sodium vapor lamps. Performance specifications