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DEPARTMENT OF ELECTRICAL, ELECTRONIC & COMPUTER ENGINEERING

RADIOMETRY & PHOTOMETRY LABORATORIES

TEST REPORT

UVC RADIANT INTENSITY DISTRIBUTION:
POLAR DIAGRAM , ISO-IRRADIANCE DIAGRAM & TOTAL RADIANT FLUX OUTPUT

ASHUR: "UVGI LUMINAIRE WITH FAN"

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PrEng - DEng - SMIEEE

12 August 2008

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1. GENERAL

Testing the UVGI luminaire is done in the Gonioradiometer laboratory (dark room) of the Department of Electrical, Electronic and Computer Engineering. The luminaire is suspended in the centre of the frame and the double arm rotates around the luminaire with the UVC sensor mounted on one of the arms.

2. EQUIPMENT USED

The distance from luminaire (centre) to sensor	2.680m
Power supply to luminaire (regulated AC)	230 V 50Hz (± 1 V)
Lamps (supplied by client)	Aged for 100 hrs
UVC detector	IFW JIC169C

(Calibrated against Goldilux UVC meter – calibrated by the CSIR Dual arm Gonioradiometer in dark room.

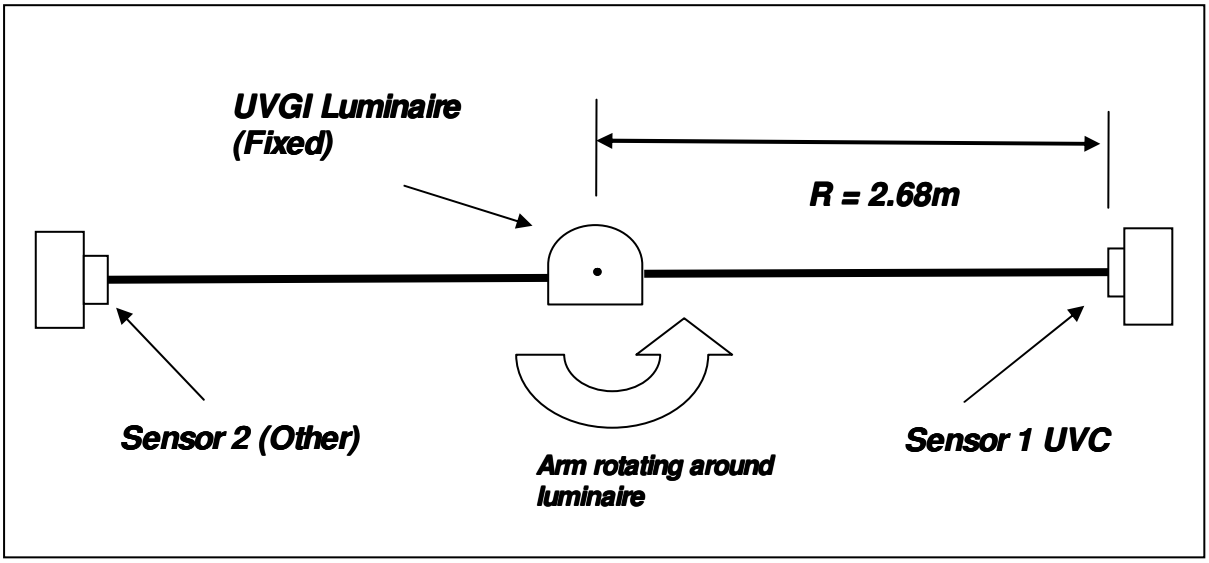


Figure 1: Dual arm Gonioradiometer.

3. PROCEDURE

3.1 Lamps, all equipment and instruments are stabilized for 60 minutes.
3.2 One set of background readings are taken with a screen between the source and the sensor (at all the positions where radiant intensity readings will be taken).
3.3 Measured values recorded on computer (Background)
3.4 One set of signal + background readings are taken with screen removed for the main axis (i.e. perpendicular to the lamps – plan AA).
3.5 Measured values are recorded on computer (Plane AA)
3.6 One set of signal + background readings are taken with screen removed for the auxiliary axis (i.e. 45 degrees from the main axis as described in 3.3 - plane BB).
3.7 Measured values are recorded on computer (Plane BB).
3.8 The radiant intensity is calculated by subtracting the background reading from the signal + background readings and multiplied by the calibration factor.
3.9 The calibration factor is determined on an optical bench at 2.680m and a calibrated UV-C meter (Goldilux UV-C).

3.10 From the radiant Intensity distribution the Polar Diagram is plotted.
3.11 The Iso-Irradiance diagram for a peak irradiance of 6 microwatt per square centimetre (6 μW / cm^2) is calculated and plotted.
3.12 The total UVC radiant flux leaving the luminaire (total in all directions) is calculated in milliwatt (mW).

4. MEASUREMENT POINTS (Direction)

4.1 As most of the radiation takes place between 70 and 90 degrees the following measuring points are programmed into the computer:

0 to 50 degrees	every 10 degrees
50 to 70 degrees	every 2 degrees
70 to 90 degrees	every 1 degree
90 to 120 degrees	every 2 degrees
120 to 180 degrees	every 10 degrees

It is assumed that the luminaire is symmetrical in each plane (i.e. AA or BB), i.e. readings from 0 to 180 degrees (anti-clockwise) will be the same as from 0 to -180 degrees (clockwise).

4.2 Once all the measurements are recorded, the recorded data is transferred to the computer programs for calculating all the diagrams and values as listed in paragraph 3.

5. ACCURACY

The shaft encoder and control system positions the goniometer arm to within 2 minutes of arc (0.02 degrees).

The detector readings and all calculations are accurate to within 5%.

6. MEASUREMENTS

Measuring Radiant Intensity distribution of UVC luminaire as a function of rotation angle in two planes AA and BB

Radiant Intensity distribution:
6.1 The measured values of Radiometric Intensity (recorded in Voltage readings as output of the UVC sensor) at a fixed distance of 2.680m from the centre of the luminaire, is converted to Intensity values by multiplication with the detector calibration constant k_1 = 0.1467 W/sr per volt.
6.2 The calibration constant allows for the conversion of the detector from Volts to W/m^2 and also using the Inverse Square and Cosine Law to change the Irradiance to Radiant intensity (i.e. $I = E \times R^2$ where R is the distance between the sensor and the luminaire; R = 2.65m).
6.3 All the readings are then converted to radiant Intensity as a function of direction θ i.e. $I_e(\theta)$

7. RESULTS

7.1 ASHUR UVGI LUMINAIRE

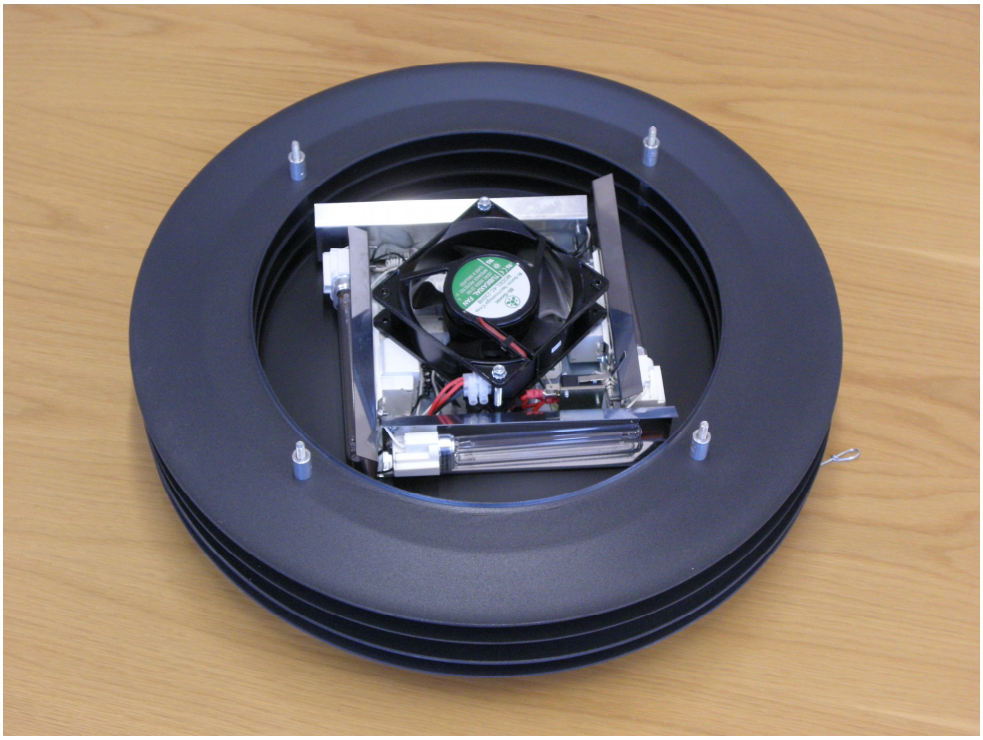
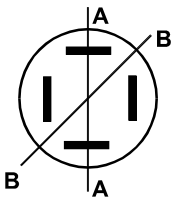


Figure 2: AHUR: UVGI Luminaire

7.2 RADIANT INTENSITY DISTRBUTION AS A FUNCTION OF DIRECTION

Table 1: Radiant Intensity as a function of direction for plane AA and plane BB

Angle θ	***Plane AA***	***Plane BB***	***AVERAGE***
Deg.	Ave. Intens.	Ave. Intens.	Ave. Intens.
On graph	mW / sr.	mW / sr.	mW / sr.
90	0	0	0
100	0	0	0
110	0	0	0
120	0	0	0
130	1	1	1
140	3	3	3
142	4	4	4
144	5	5	5
146	7	8	7
148	11	10	11
150	15	15	15
152	22	20	21
154	28	26	27
156	34	33	33



158	41	40	40
160	53	55	54
161	64	81	72
162	94	116	105
163	149	151	150
164	200	189	195
165	226	239	233
166	257	297	277
167	312	360	336
168	349	409	379
169	349	436	393
170	353	433	393
171	376	421	399
172	387	410	398
173	374	415	394
174	332	406	369
175	293	352	322
176	283	310	296
177	284	299	291
178	254	278	266
179	205	239	222
180	167	213	190
182	152	123	137
184	59	40	49
186	29	28	29
188	25	24	24
190	18	18	18
192	13	14	13
194	11	12	11
196	9	10	9
198	8	8	8
200	7	7	7
202	6	6	6
204	5	5	5
206	4	4	4
208	3	4	3
210	3	3	3
220	1	1	1
230	1	1	1
240	0	0	0
250	0	0	0
260	0	0	0
270	0	0	0

7.3 POLAR DIAGRAM

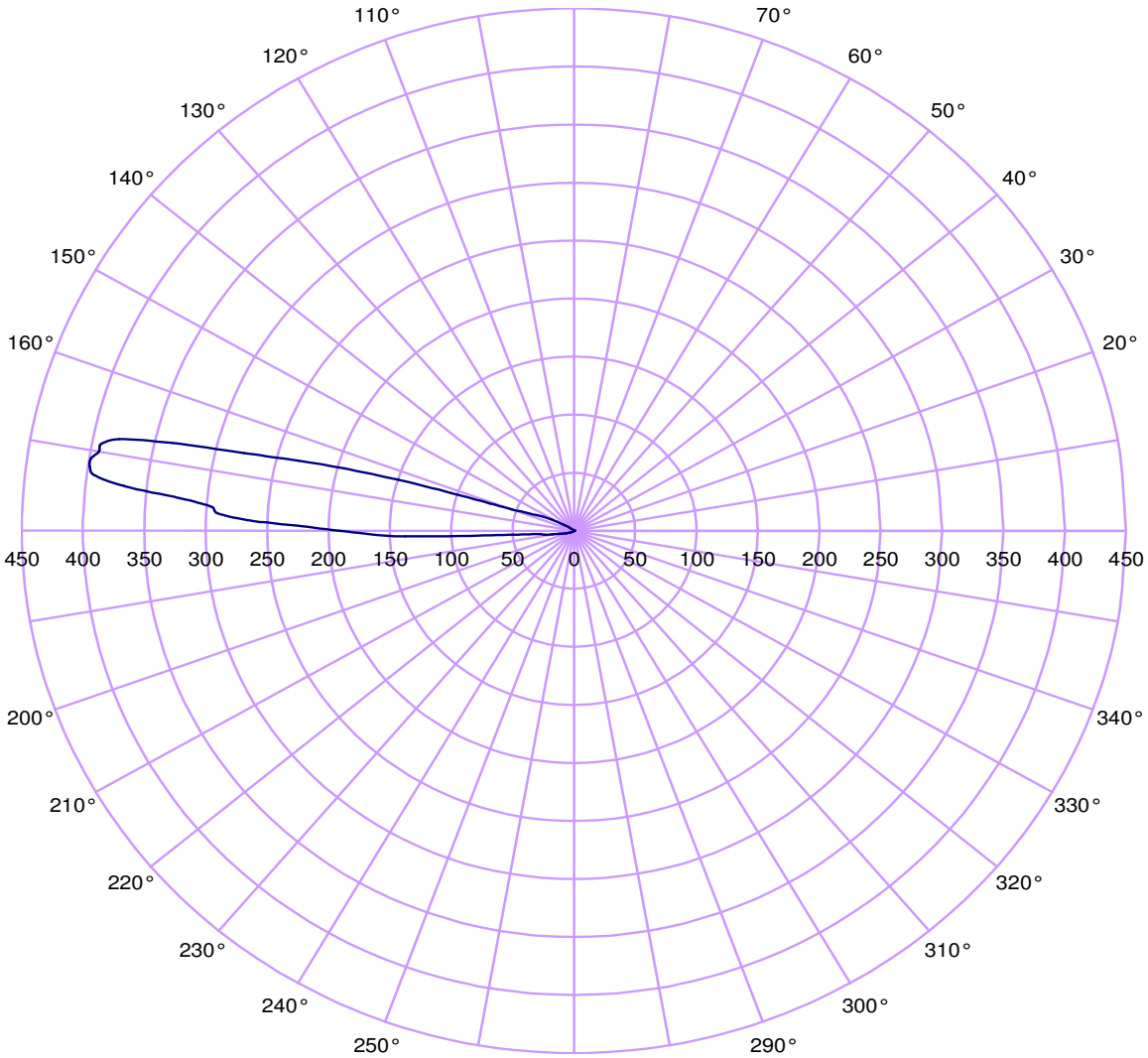


Figure 3: Polar diagram of Average Radiant Intensity of the UVGI luminaire tested - I(θ) in mW /sr

7.4 ISO-IRRADIANCE DIAGRAM

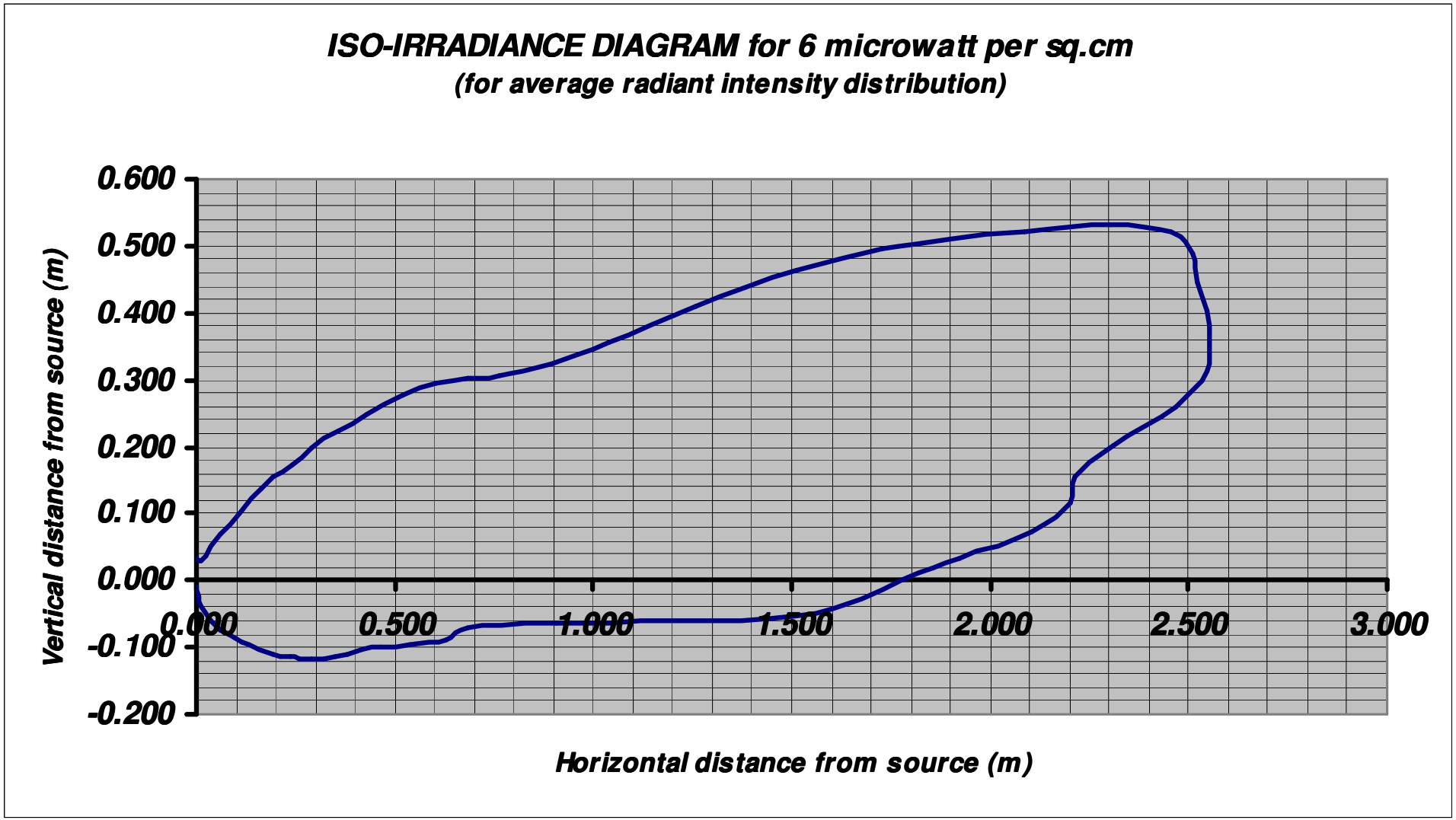


Figure 4: Iso-Irradiance diagram for a maximum Irradiance of 6 μW/m2

7.5 TOTAL UVC RADIANT FLUX

Total Radiant Flux leaving the UVGI luminaire = 841 mW

8. DISCUSSION OF RESULTS

8.1 Intensity distribution

Table 1:
The peak values are as follows: 387 mW/sr at 172 degrees for plane AA
415 mW/sr at 173 degrees for plane BB
This is just above the horizontal plane at 180 degrees.
It is interesting to note that plane BB gives higher readings than plan AA; even though plane AA is perpendicular to the UVC lamps (plane BB is at 45 degrees to the direction of the lamps – two lamps contribute to the radiant intensity)

From these values irradiance can be calculated at any point in a room where these luminaires are installed.

Figure 2: Polar diagram:
The polar diagram of the average radiant intensity for planes AA and BB are show. This indicates clearly the low radiation below the horizontal plane (which is important for eye safety).

8.2 Irradiance distribution

Figure 3: Iso-irradiance diagram:
This figure shows the range of distances from the luminaire within which the Irradiance will be above 6 microwatt per square centimetre (6 µW / cm^2).

It is clear that at no position of more than 100mm below the plane of the lamps (cente-line) will the irradiance be above 6 µW / cm^2 (except for a a position within approximately 300mm (horizontal) from the luminaire; i.e. one has to be within 300mm from the luminaire and at 100mm below the centre-line to get irradiance of more than 6 µW / cm^2 .

8.3 Radiant flux and radiant efficiency of the luminaire

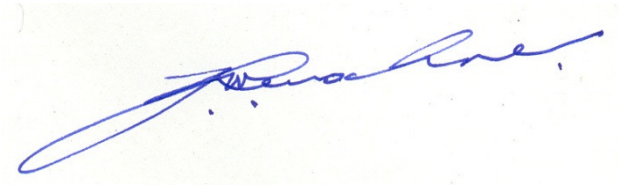
Through integration over the total sphere around the luminaire and assuming the average radiant intensity of planes AA and BB is a good representation of the true average radiant intensity, the total UVC radiant flux leaving the luminaire has been calculated as 841 mW.

From lamp data the total UVC radiant flux from the for lamps can be approximated by the following calculation:

Φ_{input} ≈ 4 lamps x 9 watt electrical per lamp x 0.28 UVC watts per electrical watt
= 10 Watt UVC

Φ_{output} ≈ 0.841 W UVC

Efficiency of the luminaire ≈ Φ_{output} / Φ_{input} = 0.841 / 10 = 0.08 or 8% ⇒



Prof FW Leuschner PrEng DEng SMIEEE

9. APPENDIX A: CALCULATION OF RADIANT FLUX LEAVING THE LUMINAIRE

Calculating Flux:

Angle θ	Angle θ	Solid angle Ω	Increase in Ω	Intens.	Flux
Degree	Radian	Steradian	Steradian	mWt/sr	mW
0	0.0000	0.0000	0		
10 (7.5)				0.1	0.0
15	0.2618	0.2141	0.2141		
20				0.1	0.0
25	0.4363	0.5887	0.3746		
30				0.1	0.1
35	0.6109	1.1363	0.5476		
40				0.5	0.4
45	0.7854	1.8403	0.7040		
50				2.7	1.3
51	0.8901	2.3290	0.4887		
52				2.7	0.5
53	0.9250	2.5019	0.1728		
54				3.7	0.7
55	0.9599	2.6793	0.1774		
56				5.3	1.0
57	0.9948	2.8611	0.1818		
58				7.5	1.4
59	1.0297	3.0471	0.1860		
60				10.6	2.0
61	1.0647	3.2370	0.1899		
62				15.0	2.9
63	1.0996	3.4307	0.1936		
64				20.8	4.1
65	1.1345	3.6278	0.1971		
66				27.2	5.5
67	1.1694	3.8281	0.2004		
68				33.4	6.8
69	1.2043	4.0315	0.2033		
70				40.5	6.2
70.5	1.2305	4.1858	0.1543		
71				54.2	5.6
71.5	1.2479	4.2895	0.1037		
72				54.0	5.6
72.5	1.2654	4.3938	0.1043		
73				72.4	7.6
73.5	1.2828	4.4987	0.1049		
74				105.2	11.1
74.5	1.3003	4.6041	0.1054		
75				149.8	15.9
75.5	1.3177	4.7100	0.1059		
76				194.8	20.7
76.5	1.3352	4.8164	0.1064		
77				232.7	24.9
77.5	1.3526	4.9233	0.1069		
78				277.4	29.8

78.5	1.3701	5.0305	0.1073		
79				335.8	36.1
79.5	1.3875	5.1382	0.1076		
80				379.0	40.9
80.5	1.4050	5.2462	0.1080		
81				392.6	42.5
81.5	1.4224	5.3545	0.1083		
82				392.9	42.7
82.5	1.4399	5.4631	0.1086		
83				398.6	43.4
83.5	1.4573	5.5719	0.1088		
84				398.4	43.4
84.5	1.4748	5.6810	0.1091		
85				394.2	43.1
85.5	1.4923	5.7902	0.1092		
86				369.1	40.4
86.5	1.5097	5.8996	0.1094		
87				322.4	35.3
87.5	1.5272	6.0091	0.1095		
88				296.2	32.5
88.5	1.5446	6.1187	0.1096		
89				291.1	31.9
89.5	1.5621	6.2284	0.1096		
90				266.3	43.8
91	1.5882	6.3928	0.1645		
92				221.8	48.6
93	1.6232	6.6120	0.2192		
94				190.1	41.6
95	1.6581	6.8308	0.2188		
96				189.4	41.3
97	1.6930	7.0489	0.2181		
98				137.5	29.9
99	1.7279	7.2661	0.2172		
100				49.5	10.7
101	1.7628	7.4821	0.2160		
102				28.5	6.1
103	1.7977	7.6966	0.2145		
104				24.3	5.2
105	1.8326	7.9094	0.2128		
106				18.0	3.8
107	1.8675	8.1202	0.2108		
108				13.5	2.8
109	1.9024	8.3288	0.2086		
110				11.2	2.3
111	1.9373	8.5349	0.2061		
112				9.5	1.9
113	1.9722	8.7382	0.2033		
114				8.1	1.6
115	2.0071	8.9386	0.2004		
116				6.9	1.4
117	2.0420	9.1357	0.1971		
118				5.9	1.7
120	2.0944	9.4248	0.2891		

125				4.9	4.4
130	2.2689	10.3219	0.8972		
135				4.2	3.2
140	2.4435	11.0964	0.7744		
145				3.5	2.2
150	2.6180	11.7246	0.6282		
155				2.9	1.4
160	2.7925	12.1874	0.4629		
165				2.9	0.8
170	2.9671	12.4709	0.2835		
175				1.3	0.1
180	3.1416	12.5664	0.0955		
TOTAL			***12.5664***		***840.9***
			sr		***mW***

10. APPENDIX B: LAMP DATA

广明源照明电器有限公司

产 品 规 格 书

Specification of product

Customer:

Product: H-Quartz UV lamp for disinfections

Type: GMYok9W-UVC

Date: Dec 10, 2007

Manufacturer: GMY Lighting and Electrical Co. Ltd

Address: West Industrial Zone, Gonghe Town,

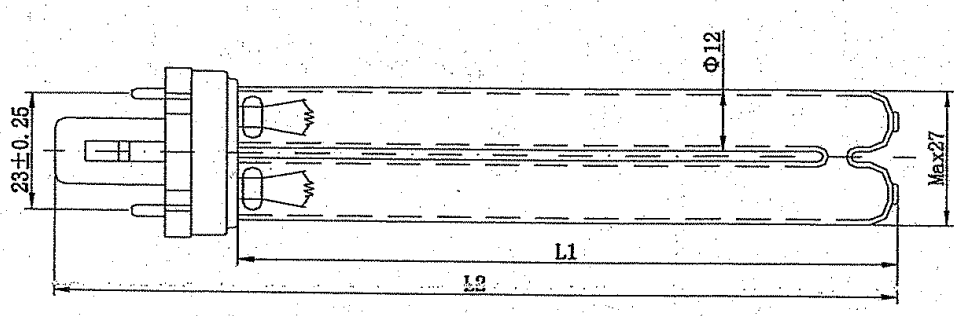
Heshan City, Guangdong Province, PR. China

Tel: 86-750-8309189 8309168 Fax: 86-750-8309198

Website: www.gmyok.com email: els.zgs@163.com

1. Lamp Type: GMYok9WUVC-H

2. Outer dimension



parameter	L1max. (mm)	L2min. (mm)	Bmax. (mm)	Dmax. (mm)	Base type
Dimensions	168+/-2	129+/-2		12.3	G23

产品规格书 1/3 1/23/2008

3. Materials :

Number	Description	Material	Remark
1	Glass tube	Without Ozone quartz	Highpurity OH<4ppm
2	Electrode	Copper pin	2 pins
3	Cathode	DC coiled-coil filament	Metal-oxide cathode
4	filling gas	Pure Ar, Pure Hg	Optical purity
5	Cathode resistance	tungsten	15Ω
6	Base	PBT plastics	

4. Initial characterization:

No.	Parameter	Symbol	Norm	Unit	range
1	Wattage	P_L	9	W	±8%
2	Lamp voltage	U_L	60	V	±8%
3	* Current	I_L	170	mA	
4	Radiation at 254nm (@ 1 meter)	UV值	>28	μW/cm²	
5	Stable time	$T_{差}$	5	min	
6	Average life	H	>8000	h	

广明源照明电器有限公司

test condition	1. Ballast: DYJ-FL-220V-50Hz standard ballast 2. Instrument: Everfine PF9800 intelligent electrical parameter tester 3. Environment: Temp: 26±2℃ Humidity: 50%-90% 4. UV Radiation test: UV2000Z everfine UV2000Z UV radiation tester

2. Operation mode

Hot-cathode , Low pressure mercury discharge, Requires electron ballast and inductance ballast to tuning.

3、Average service life: >8000h

4、UV depreciation: Reduction of UV strength is less than 20% after 3,000 hours normal working condition.

5. Note: ROHS Approved