LIGHT & VISION LABORATORY LVL - RSA

TEST REPORT

March 2017 (Revision 17.4)

UPPER ROOM GUV FIXTURE

(Rectangular – wall-mounted)

TESTS IN ACCORDANCE WITH South Africa Technical Specification SATS 1706:2016 (Approved)

for

UV Resources (Pty) Ltd

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The testing facility at the **Light & Vision Laboratory – RSA** has been established over a number of years and new and better instruments are constantly added. The instruments used in conducting tests are regularly calibrated by NIST traceable testing laboratories.

2. DISCUSSION ON SATS 1706- 2016

South African Bureau of Standards (SABS)
SABS STANDARDS DIVISION
Technical specification
SATS 1706-2016: UVGI luminaires —Safety and performance requirements

2.1 BACKGROUND TO SATS 1706 – 2016

The UVGI Working Group on UltraViolet Germicidal Irradiation (UVGI) developed the Technical Specification with the following main aims:

- Introduce the fundamentals of UVGI w.r.t. equipment and applications to achieve "Safe" and "Effective" UVGI installations.
- Introduce the main UVGI technologies w.r.t. luminaire types.
- Set some guidelines w.r.t. testing and characterisation of UVGI luminaires and UVGI installations.

Manufacturers wanting to manufacture and sell UVGI luminaires in South Africa, will have to get their luminaires tested in accordance with SATS 1706 – 2016.

Note: Like all SABS Technical Specifications, SATS1706 will be reviewed during the next year and only when all changes and upgrades have been included; will this specification become an SABS National Specification and get a SANS xxx number.

2.2 Types of UVGI luminaires

The following two categories of UVGI luminaires were identified:

- "Open" or "louvered" luminaires for mainly upper room UVGI applications
- "Closed" UVGI luminaires; sometimes referred to as "Air cleaners"

Both these types of luminaires are covered by SATS 1706.

2.3 UVGI Safety criteria

The internationally accepted UVC eye safety Fluence value of 30J/m^2 has been used to set certain Irradiance levels to determine whether a UVGI luminaire is "inherently safe or un-safe".

Even when a luminaire is inherently unsafe, the UVGI installation in any application can be designed to be safe for the occupants in the specific room.

By measuring UVC irradiance levels and determining the time exposure for occupants in the room; a calculation can be done to determine the daily Fluence level; which must be below 30J/m^2. ~~With~~

With upper room UVGI and closed UVGI luminaires ("air cleaners"), there should be little or no stray UVC radiation where the occupants in the UVGI room is situated. Reflected UVC radiation in a room from most surfaces can usually be ignored; but definitely measured and the respective Fluence values calculated.

The UVC radiation (Irradiance) from UVGI luminaires that can cause safety concerns, will be in the Near-Field of the luminaire. These Near-Field UVC Irradiance patterns can usually not be measured with Far-Field Gonioradiometry; as the signal levels are minute at those distances.

2.4 UVGI Effectiveness

In contrast to Safety requirements (where certain maximum levels of UVC radiation is specified); for effectiveness of UVGI requires fairly high levels of UVC Fluence Rate in UVGI applications'

Unfortunately, there is no linear relationship between UVC Fluence Rate and UVGI effectiveness:

- Saturations sets in at very high levels of Radiation.
- Zero effect can be expected at low levels of Radiation.
- Negative / inverse effects, such as photo-reactivation and photo-mutation may set in at very low levels of Radiation.

To obtain the correct (optimal) levels of UVGI Fluence Rate, the two approaches followed are as follows:

- Dosing of the upper room volume with UVC radiation from open / louvered UVGI luminaires and preventing stray UVC radiation to enter the lower room volume. Good air movement in the room, is required to circulate the infected air to the "Dosing volumes" (which is most effective near the UVGI luminaires) - i.e. move the UVC radiation from the UVGI luminaires to the infected air.
  In certain UVGI guidelines a volumetric UVC radiant flux density is used for UVGI design installations (e.g. 14 or 20mW/m^3). For these methods, the total maintained UVC radiant flux emitted from the UVGI luminaire has to be determined. This can be done in many ways; e.g. Gonioradiometry, Integrating Sphere, Near-Field fixed flat surface irradiance measurements or fixed distance angular Irradiance measurements in one plane (for linear light sources and luminaires). This last method is the most accurate, quick and in-expensive method that the author favours.

- Closed UVGI luminaires with very high levels of UVC Fluence Rates inside the luminaires and moving all the infected room air through the luminaire(s) – i.e. move the infected air to the UVC radiation in the UVGI luminaires.

  In the first case the direction of highest radiation and the Near-Field value of such UVC Irradiance is the most important value.

  In the second case the average or lowest value of UVC Fluence rate in the UVGI luminaire is important.

Note: For none of the above measurements is it necessary to do complete Far-Field Gonioradiometry.

2.5 SATS 1706 prescribed tests

As SATS1706 was intended for UVGI luminaire manufacturers, installation designers, users of UVGI systems, installation and maintenance contractors and people working in the field of infectious disease prevention; it covers the following topics of UVGI luminaires:

(i) Radiometric quantities (safety levels and effectiveness)
(ii) Electrical quantities (power and energy considerations)
(iii) Air movement quantities (air flow speed and volume)
(iv) Noise levels (fans and electronics - hospital applications)
(v) Overall inclusion of all relevant luminaire (visible light) specifications e.g. SANS, IEC, etc.

3. TESTS CONDUCTED BY THE LIGHT & VISION LABORATORY FOR UV Resources

3.1 TESTS CONDUCTED ON GUV FIXTURE

Electrical and Radiometric tests of GUV Fixture to determine UVC radiant power output in Watts, as well as all electrical and other important metrics as described below; in accordance with SATS1706 - 2016.

3.2 UV RESOURCES GUV FIXTURE TESTED

Wall-mounted louvered GUV fixture for upper room GUV:

(590mm wide x 165mm deep x 112mm high – weight 3.4kg).

A

B

Figure 1: Louvered GUV fixture as tested (475 x 250 x 103H mm)
A Front view & B Rear view

3.3 TESTING FACILITY

The testing facility at the **Light & Vision Laboratory – RSA** has been established over a number of years and new and better instruments are constantly added. The instruments used in conducting certified tests are regularly calibrated by SANAS accredited testing laboratories.

The **Light & Vision Laboratory – RSA** measurements are conducted in compliance with international standards and under controlled conditions. The **Light & Vision Laboratory – RSA** is however not yet a SANAS accredited Photometric & Radiometric testing laboratory.

3.4 DETAILS OF TESTS CONDUCTED

ALL THE RELEVANT METRICS FOR THE GUV FIXTURE HAVE BEEN TESTED AS PRESCRIBED IN SATS 1706:2016 (APPROVED)

NOTE: UVC RADIANT POWER EFFICACY (AS CALCULATED) FOR THE GUV FIXTURE IS DEFINED AS:

$$\text{Radiant Efficacy } \eta = \frac{\text{UVC Radiant flux output in Watt}}{\text{Input Electrical Apparent Power in Volt·Ampere}} \quad (\mathrm{W \cdot VA^{-1}})$$

This provides a metric to compare different GUV fixtures, with different ECG power factors; without having to consider the Power Factors separately.

4. INSTRUMENTATION & MEASURING TECHNIQUES

4.1 INSTRUMENTATION & EQUIPMENT

The following instruments were used:

(i) Adjustable regulated AC power supply (voltage source).

(ii) AC Power analysers (calibrated).

(iii) High Sensitivity calibrated UVC irradiance meter (Goldilux).

(iv) Digital temperature & humidity meters.

(v) Calibrated constant distance radial irradiance meter (CDRIM).

4.2 MEASUREMENT TECHNIQUES

The following test procedures were followed:

(i) Accurate mounting of the fixture at the correct height and in a horizontal position with a digital level. The fixture is positioned exactly 2m from the CDRIM, such the distance from the centre of the lamp and the face of the irradiance sensor is exactly 2000mm.

(ii) The fixture is powered from a regulated adjustable AC power supply.

(iii) The fixture is switched ON for 100 hours prior to any measuring.

(iv) Warm-up time of at least 8 hours is allowed for.

(v) Irradiance measurements are taken at intervals of one degree from the 90° above Nadir vertical direction (horizontal).

(vi) A dark reading is recoded for the Irradiance meter as well as a back-ground reading at the measuring points.

(vii) Date, time, room temperature and relative humidity is recorded.

4.3 MEASUREMENT ACCURACY

(i) Distance and positioning of the fixture can be done very accurately.

(ii) The irradiance meter is calibrated with and accuracy of about 5% at the ranges used in these measurements. Calibration is NIST traceable.

(iii) The UVC output of the 25W lamp in the fixture is however a function of many variables, including: Age of lamp, envelope temperature of lamp, quality of electronic control gear, humidity and more.

An overall accuracy of values obtained for total radiant flux and irradiance could be ±10% at best; which is good enough for GUV installations, with many dynamic variables.

5. TEST RESULTS: Table 5.1 Summary of test results

UV RESOURCES GUV Fixture GLO-1 TEST REPORT FOR TESTS DONE IN COMPLIANCE WITH SATS 1706: 2016

A	*FIXTURE DETAIL*					
Item #	Description					Comments
A1	Fixture Supplier / Manufacturer	UV Resources				
A2	Product catalog no.	GLO-1				
A3	UVC lamp manufacturer	Philips				
A4	Lamp catalogue no.	TUV 25W G25 T5				
A5	SABS or CE mark on lamps (state which)	CE				
A5	Number of lamps	1				
A6	Fixture rated input AC voltage range: From / To (V)	120 - 277 (50/60 Hz)				Electronic Control Gear specs
A7	Rated input electrical lamp power (each) (W)	23.0				Datasheet
A8	Rated UVC output per lamp (UVC W) - after 100hrs aging	8.0				Datasheet
A9	Lamp output UVC flux derating factor to be used over life expectancy	0.8				Assumed
B	*TESTING DETAIL*					
B1	Name of test laboratory	Light & Vision Laboratory - L&VL RSA				
B2	Initials and surname of person doing the tests	FW Leuschner (Director of L&VL - RSA)				
B3	Contact details: Tel. & e-mail	Cell 0836361384 fwleuschner@gmail.com				
B4	Date of tests	29 December 2016				
B5	Room temperature (°C) / Relative humidity in room (%)	24 °C		43%		
B6	Fixture: Wide x Deep x High (mm)	W = 590 D = 165 H = 112				
B7	Luminaire weight / Largest UVC radiating length of luminaire	3.4kg		500 mm		
		Acronym	Units / Measurement	Abbreviation	Measurement	Comments
B8	Regulated supply voltage: (1.06 x maximum rated input voltage) 254.4	V or U	Volt	V	255	SATS1706 requirement
B9	Supply frequency	f	hertz	Hz	50	
B10	Supply current	I	Amp	A	0.108	
B11	Apparent electrical power to luminaire	S	Volt×Amp	VA	27.7	
B12	Power factor	PF	p.u.		0.99	Excellent
B13	Total Harmonic Distortion of supply current	THD	Percentage	%	11.8	Excellent
B14	Total UVC Radiant Flux exiting luminaire (lamps aged for 100hrs)	Φ	UVC Watt	UVC W	0.55	± 10%
B15	Radiant Efficacy of luminaire	Φ / S	UVC Watt / VA	W/VA	0.020	Good
B16	Peak Irradiance at 200mm ($\mu W/cm^2$) / Vertical angle α	$E_{Max\alpha}(\alpha_{Vertical})$	952	Verical angle	90	± 2° because of Near field
B17	Peak Irradiance at 1000mm ($\mu W/cm^2$) / Vertical angle α	$E_{Max}(\alpha_{Vertical})$	241	Verical angle	90	± 2°
B18	Peak Irradiance at 2000mm (mW/cm^2) / Vertical angle α	$E_{Max}(\alpha_{Vertical})$	77.1	Verical angle	90	± 1°
	Signature of person responsible for tests:				Date: 2016-12-29	
	(Prof FW Leuschner)					

5.2 Spatial distribution of Irradiance at a fixed distance of 2.00m from the fixture in one plane

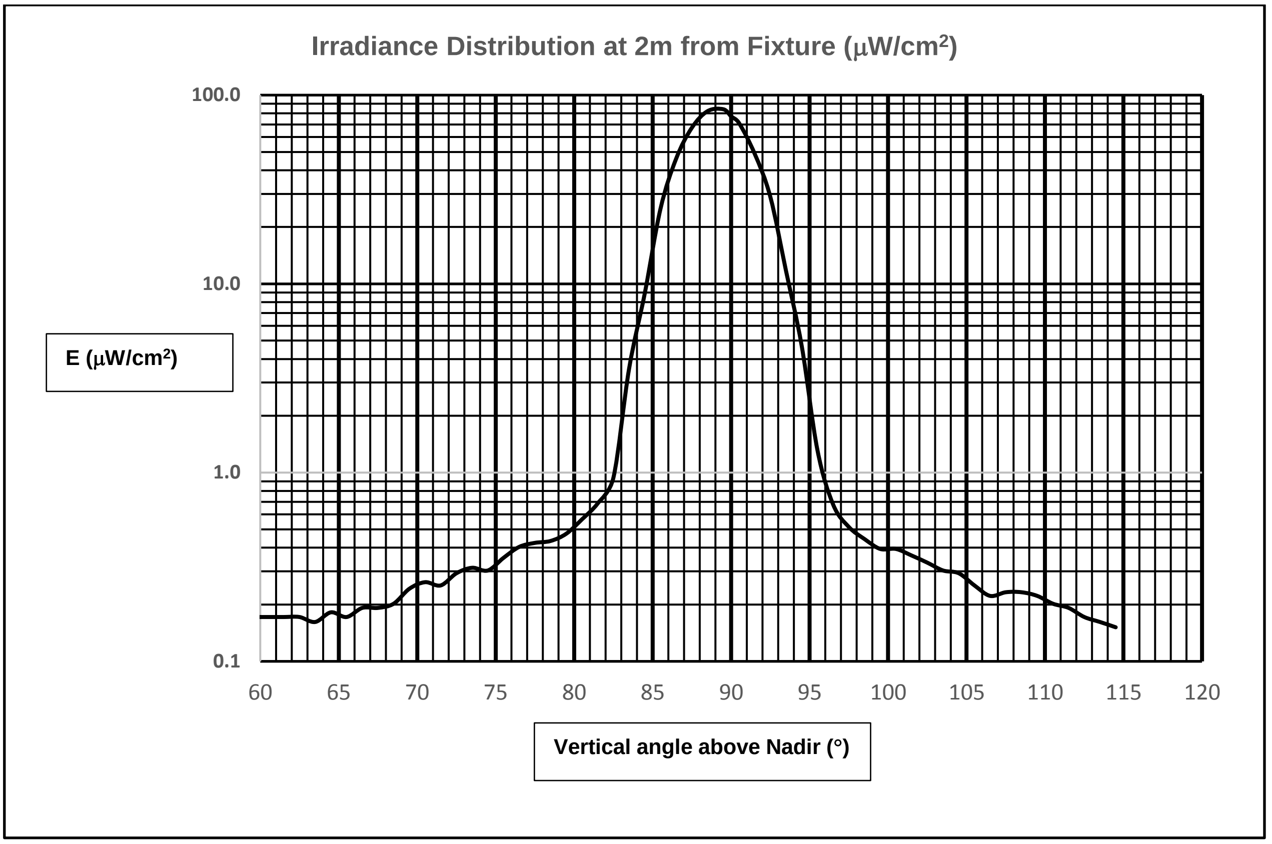

Figure 2: Logarithmic graph of vertical irradiance distribution at a fixed distance of 2.00m from the GUV fixture

From fig. 2 above it is clear that:

(i) The narrow beam of radiation is made possible by the use of a linear 25W UVC lamp. Beam Angle of about 5 degrees and a Field Angle of about 10 degrees.

(ii) The peak irradiance at 2.00m from the fixture is slightly below the 90° direction; i.e. slightly below the horizontal plane through the bottom of the fixture.
This can be compensated for by tilting the fixture upwards through 5 to 10 degrees.

(iii) An average circular irradiance value can be calculated at every angle.
From that value and the dimensions of the luminaire the total radiant flux of the fixture can be calculated using the Keitz equation.
This has been double checked with measurements in the spatial error corrected integrating sphere in the Light & Vision Laboratory at UP.

(iv) The radiation distribution is fairly symmetrical.

(v) The same method was used to determine the UVC radiant flux from the fixture, with the louvers removed and a value of Φ_{UVC} = 5.0 W was determined. This gives an improvement factor of 5.0/0.55 = 9 over the louvered fixture output.

6. DISCUSSION OF RESULTS

6.1 UVC RADIANT FLUX

Radiant flux from the GLO-1 GUV Fixture (590mm wide x 165mm deep x 112mm high – weight 3.4kg):

Φ_{UVC} = 0.55W

6.2 GUV FIXTURE RADIANT EFFICACY

UVC Fixture Radiant Efficacy is defined as:

$$\text{Radiant Efficacy } \eta = \frac{\text{UVC RADIANT FLUX OUTPUT IN WATT}}{\text{INPUT ELECTRICAL APPARENT POWER IN VOLT}\cdot\text{AMPERE}} \qquad (W\cdot VA^{-1})$$

Radiant Efficacy of GUV Fixture:

η_{UVC} = 0.020 W/VA

This metric is influenced by the UVC lamp efficacy, the luminaire efficiency and the Power Factor of the electronic control gear.

A value of 0.02 and above can be considered as good.

6.3 PEAK UVC IRRADIANCE AT 200mm IN ANY DIRECTION

The peak irradiance in any direction at 200mm form the GUV Fixture in any direction:

$E_{UVC-200mm}$ = 952 μW/cm^2

This value is above the prescribed threshold of 0.2μW/cm^2 and the fixture is therefore “Inherently Unsafe”. The GUV installation design must consider this fact and prevent possible over-exposure of more than 30J/m^2 per day, at any location in the room where this fixture will be used.

6.4 PEAK UVC IRRADIANCE AT 1000mm & 2000mm AND THE VERTICAL ANGLES AT WHICH IT OCCUR

6.4.1 Peak Irradiance at 1000mm from the luminaire and the vertical angle at which it occurs (degrees above Nadir):

$E_{UVC\ at\ 1000mm}$ = 241 μW/cm^2 at 90 degrees ($\pm$ 1°)

6.4.2 Peak Irradiance at 2000mm from the luminaire and the vertical angle at which it occurs (degrees above Nadir):

$E_{UVC\ at\ 2000mm}$ = 77.1 μW/cm^2 at 90 degrees ($\pm$ 1°)

6.4.2 The peak irradiance at 3000mm and the elevation angle at which it occurs has been measured. Although this is not required by SATS1706 – 2016; it gives a good Peak Radiant Intensity value for Far-Field calculations (i.e. sensor to source distance is 6 times the largest radiation length of 500mm:

Peak Irradiance at 3000mm from the luminaire and the vertical angle at which it occurs (degrees above Nadir):

$E_{UVC\ at\ 3000mm}$ = 34 μW/cm^2 at 90 degrees (± 0.5°)

Thus the Peak Far-Field Radiant Intensity and the direction in which it occurs is:

$I_{UVC\ peak\ at\ 3000mm}$ = 306 μW/sr at 90 degrees (± 0.5°) from Nadir and in a vertical plane through the centre of the fixture.

Note: Beyond 3 metres the inverse square law can be used to determine the Peak Irradiance (and Fluence Rate) at that point.

Whenever the vertical angle of radiation as measured, is more than 90 degrees from Nadir (i.e. radiation peak in a direction above the horizontal bottom plane of the luminaire; eye safety should be simple to achieve in an application.

Whenever the vertical angle of radiation as measured, is less than 90 degrees from Nadir (i.e. radiation peak in a direction below the horizontal bottom plane of the fixture); eye safety must be assured through special means.

It is clear that the GUV Fixture may create dangerous UV-p radiation below the horizontal plane of the bottom of the luminaire and must be installed with due regard to eye safety through special design features (fixture mounting height or other considerations).

7. CONCLUSION

The fixture as tested is of good quality, with excellent electronic control gear and fairly easy access to the lamp, for cleaning the parabolic reflector and lamp (or for lamp replacement).

The fixture is only 3.4kg and simple to install. To optimise the vertical angle of peak radiation for different mounting heights and variation in applications; the fixture can be mounted at a small upward vertical angle to reduce any possible eye safety hazards.

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