COLIPA

GUIDELINES

FOR

MONITORING UV RADIATION SOURCES

as proposed by

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2007

Guidelines
for
Monitoring UV Radiation Sources

Foreword

This guideline is established in order to maintain an equal quality of UV sources that are employed for Sun Protection Factor (SPF) testing, as recommended in the International SPF test method issued in May 2006, or for UVA-PF determination, according to the corresponding document issued in 2007.

This guideline addresses the certification and monitoring of the irradiance received on the test area from UV source(s). It comprises specifications and guidance for both the monitoring of UV sources by qualified spectroradiometry experts and the internal monitoring by the SPF testing laboratory. In particular, it addresses necessary actions to be taken in case a UV source is not complying with the reference method. This procedure also specifies how to report on all these events.

The personal and technical requirements to produce reliable, precise and reproducible spectral data are difficult to reach. Therefore, a differentiation is done between the high-grade equipment employed in the external certification process and the conventional equipment usually employed for the internal control monitoring by the testing laboratory.

A lexicon is available in the Appendix, page 25.

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External UV source monitoring and certification

1.1 Frequency of UV-source certification

It is recommended to have the spectral irradiance of the UV source controlled by a qualified expert and certified for compliance with the given acceptance limits specified in the International SPF test method whenever:

- An optically significant part of the source has been modified. The optically important parts are the dichroic mirrors and filters; their transmission definitively influences the spectrum;
- The source has been run during 3000 hours. Given an estimated run time of 9 hours every work day, the corresponding certification is required approximately every 1.5 years;
- The latest certification was achieved 18 months ago.

1.2 Qualified Experts for UV-source monitoring and certification

External testing laboratories/experts capable to perform the UV-source measurement and provide a certificate should be accredited by an accreditation institution that is a member of a supervising organisation. Most of the National Standard institutions are members of these organisations. The accreditation institutions are recommended by the regional cosmetic industry associations; the list of accredited European National Bureaus of Standards (issued in 1999) about spectroradiometric irradiance measurements can be accessed here:
http://www.npl.co.uk/optical_radiation/publications/orcs/spectroradiometry.pdf. As an alternative, qualified external testing laboratories / experts can directly be recommended by the regional cosmetic industry associations (e.g. COLIPA). For instance, a list of qualified experts is available from the Colipa bureau.

1.3 Instrumental requirements for the external certification

The external certification of an UV source is based on spectroradiometric measurements and on spatial uniformity measurements. For the spectroradiometric measurements, a double-monochromator spectroradiometer must be employed. Corresponding technical specifications are gathered in Table 1.

Table 1: Instrumental specifications of a double-monochromator spectroradiometer

Double monochromator spectroradiometer	
Minimal spectral range	250 - 780 nm
f-number [i]	About 4.
Bandwidth (FWHM) [ii] (6)	1.0 – 1.2 nm in the UV range, maximum 5 nm in the visible and IR-A ranges
Slit function	< 10^{-3} of maximum at 2.5 * bandwidth away from the centre (e.g. Hg spectral calibration lamp at 253.65 nm or a laser line, such as the 325 nm line of a He-Cd laser)
Stray radiation [iii]	< 10^{-6} (see Appendix, Stray radiation section) (This criterion applies to sources used for SPF testing)
Wavelength repeatability	Better than ± 0.05 nm, in the UV range
Wavelength accuracy	Better than ± 0.1 nm in the dUVB and ± 0.2 nm for dUVA No specifications for the visible or IR-A ranges
Calibration in wavelength	A pen-type mercury lamp should be used to check accurate wavelength calibration and linearity before each use. Examples of usable wavelengths given for Hg, in air at 15°C/760mm Hg: 253.652, 275.278, 289.360, 296.728, 334.148, 404.656, 407.784, 435.833, 546.075, 576.961, and 579.067 nm; + possibly using the second order of diffraction: 507.304, 593.456 and 668.296 nm.
Input optics: integrating sphere or diffuser, fitted for UV Spatial angular sensitivity	The area of the entrance port must be less than half of the exposed area where the irradiance at sample / skin level is measured [iv]. In addition, a centring mechanical adapter should enable the correct repositioning of the probe at the same exposed site: for further details, see section 0 of the Appendix. Should be close to a cosine response (i.e. cosine error smaller than ± 10% for incident angles < 60°)
Maximal spectral irradiance	> 30 $W.m^{-2}.nm^{-1}$ at the maximum of the spectrum Attenuating filters / so-called neutral densities can be used,

[i] The f-number of a focusing system is the focal distance divided by the limiting aperture.

[ii] FWHM = Full Width at Half Maximum (6,9)

[iii] Stray radiation rejection: The UV source signal (= NEI, noise equivalent irradiance composed of electronic noise and stray radiation) is recorded from 250 up to 280 nm, where the irradiance is expected to be zero. The signal within this wavelength range is due to:

- the electronic noise ('dark' noise, easy to measure with no radiation entering the instrument)
- and the stray radiation, due to internal multiple reflection and radiation leakage.

Further explanation about stray radiation can be found in the book "Reliable Spectroradiometry" written by Henry J. Kostkowski (8), especially in figure 4.2.

The UV-to-UVC-stray radiation value is obtained from the full signal between 250 nm and 280 nm minus the electronic noise. This stray radiation is regarded in relation to the complete UV spectrum from 290 nm to 400 nm. For the final stray radiation criterion the UV-to-UVC-stray radiation value is compared with the UV irradiance value as calculated from 290 to 400 nm (see calculation in Appendix, Stray radiation section).

[iv] The area of the probe is a more important parameter than its diameter, since irradiances (unit: W.m-2) are measured and irradiated spots may not be round-shaped. For instance, when using a Solar-Light Multiport solar UV simulator, equipped with light guides with a 10 mm diameter, the irradiated spot has a typical diameter of 8 mm; hence the diameter of the probe should be no more than $\sqrt{50\%} \cdot 8 = 5.6$ mm.

	once their spectral transmission at the operating temperatures has been characterized.
Determination threshold (minimal irradiance to be measured)	< 10^{-4} W.m^{-2} .nm^{-1} at 290 nm
Detection threshold (9)	< 5.10^{-5} W.m^{-2} .nm^{-1} (for SNR = 1 at 1 nm FWHM)
Integrating time	Should be adjustable in a 10-fold range of pulse length, i.e. at least 100 ms for each wavelength when measuring a flash-lamp operating at 50 Hz
Calibration in absolute irradiance	A certified calibration bulb is used (e.g. QTH, DXW, XTH types) for the instrument calibration. The spectral irradiance certificate of calibration bulb must be traceable to a national standard for spectral irradiance and be less than 1 year old or less than 50 hours used. The ASTM G138 document can be used as a basis (1).
Step width in UV range	1 nm
Step width in VIS and IR-A ranges	5 nm maximum; interpolation to 1 nm authorized
Scan speed	< 3 minutes for the UV range
Samples per reading of the Analogous to Digital Converter	At least 5
Stability	Whenever the environment changes (temperature difference higher than 3 K, switch on or off of devices including magnetic parts electrically activated, air Relative Humidity change > 10%), at least the wavelength calibration and preferably the absolute irradiance calibration too should be checked on site. Temperature stabilization of the spectroradiometer and automatic, periodic (at least hourly) zeroing of the dark current are recommended.

Some commercially available instruments may fulfil most of these specifications, provided that some adapters and additional checks are done, according to the requirements of Table 1. The list of the corresponding companies is available in the Appendix, section 7.2.
In addition, a useful device for "field calibrations" is a portable field calibrator, which prevent from looking for a dark room on site to perform calibrations with regular (cumbersome) devices. Such devices are commercially available from Optronic Laboratories (Orlando, Florida) or from CMS Schreder (Austria).

For the spatial uniformity measurements, Gafchromic dosimeters can be exposed during relevant durations and then scanned using a standard flat office scanner. An image analysis of the grey levels is linked to the spatial uniformity of UV irradiance. For local distributors of Gafchromic film, please visit:
http://www.ispcorp.com/products/dosimetry/content/gafchromic/index.html.

2 <u>Internal UV source monitoring in the testing laboratory</u>

2.1 Frequency of UV-source routine monitoring

The irradiance will be routinely controlled by the laboratory that is conducting SPF tests using a broadband UV-meter. This control monitoring should be repeated before UV exposure of each test site. The broadband UV-meter should also be cross-calibrated with the spectroradiometric measurement that is performed during every expert evaluation of the lamp (4).

In addition to daily radiometric measurements, when a calibrated spectroradiometer is available for internal purposes, it is encouraged that a spectroradiometric measurement be performed regularly (for instance twice a year). However, it must be emphasized that these checks cannot replace the external checks that are mandatory, e.g. when an optical component is changed (see § 1.1 above).

2.2 Instrumental requirements for the internal routine monitoring

The internal routine monitoring of an UV source is based on spectroradiometric and/or radiometric measurements. The employed instruments are regularly calibrated over the full-intensity range of operation according to the supplier's recommendations and/or the ASTM G138 method (1). An additional calibration should be conducted against the double-monochromator spectroradiometer of the certifying testing laboratories (see § 3.2.1 below).

Apart from external spectroradiometric measurements, the spectra quality can be monitored internally using spectroradiometers, either with the instrumental high-grade characteristics listed in § 1.3 above (Instrumental requirements for the external certification), or with other types of instruments (list available at the regional cosmetics industry associations).

Generally speaking, diode and CCD array spectroradiometers do not allow the high-quality results required for SPF testing, as compared to the double-monochromator systems with photomultiplier detectors. Impairments in using diode or CCD array instruments include:

- Low sensitivity compared to photomultipliers, especially in the dUVB range
- Poor stray light rejection and consequently small dynamic range
- Limited linearity of the dynamic
- Cross-talk between sensing elements

Diode and CCD array spectroradiometers could be used to perform relevant measurements, but many clever corrections involving additional laboratory materials are necessary (10). As a consequence, to date no expert proposes to use such devices for in situ measurements. Therefore, if such instruments are used for internal spectroradiometry, the results should be compared carefully to the results of the expert instrument at the times of the certification.

3 Measurement processes

3.1 Preparation of the measurement and materials

Before the measurements are started, the instruments must have adapted to room temperature. The prevailing temperature will be recorded and reported, at least once before the measurements and at the end of the measurements. The instruments sensing aperture has to lie exactly in the same plane as the irradiated skin surface and at the same distance from the source.

The manufacturer’s instructions for warm-up times of the lamps, pre-cooling times for certain photo-detectors etc. should be observed before beginning the measurements. The lamps must be warmed up with the radiation going through the optical filters, namely WG-320, UG-11 etc., i.e. with the shutters in the open position. This is because the cut-off wavelength of these filters depends on their temperature, so measurements must be conducted at the operating temperature. The same remark applies when the lamps are operated during the tests. During the warming-up time, the flux must be directed to a matt black absorbing material, to prevent any unwanted and harmful exposure of the operators. The spectroradiometer should be set up on a vibration-free place with constant room temperature and as far as possible away from powerful sources of magnetic fields (e.g. loud speakers, computer screens and voltage transformers…) and be warmed up for at least 30 minutes.

No radiation except the radiation from the source to be checked should reach the entrance optics of the spectroradiometer. When it is not possible to exclude all the other radiation except the radiation from the source to be checked from the entrance optics of the spectroradiometer, a measurement of the background radiation is recommended, to be compared with the measures.

3.2 Measurement conduction

3.2.1 Spectral irradiance measurement

The lamp irradiance received at skin level is recorded at constant rated lamp intensity. This UV irradiance can be controlled by using a UV meter. The rated lamp intensity can be specified by the manufacturer as typically 15 A for 300 W xenon lamp, 7.5 A for a 150 W, 45 A for a 1 kW xenon lamp etc., or 150, 300, 1000 W.

The settings for step width (1 nm), scale, wavelength range, irradiance range, number of repetitions, dark current assessment etc. are chosen following these guidelines and the manual of the spectroradiometer.

Some sources are equipped with several light guides or spots, each one has its own optical characteristics; thus, each light-guide / spot has to be measured individually. At least three measurements for each light-guide / spot are recommended to compensate for the xenon lamp scintillation during spectral recording, particularly when the source is not provided with a photo-feedback stabiliser. In case of light-guide monitoring, the measure must be conducted in the same bending position as it is used in the SPF test. In broad-beam UV-sources, spectra from different locations under the beam should be recorded in order to account for non-uniformity.

3.2.2 Total irradiance measurement

Beside UV radiation, the total irradiance of an UV source may include visible light (VIS, 400–800 nm) and infrared light (IR-A, 780-1400 nm). The total irradiance can be measured with a spectroradiometer or a thermopile. A spectroradiometer with an additional detector for the infrared rays allows measuring the total irradiance with detailed information on UV, VIS and IR by a single instrument. Without an IR-detector, only the UV and VIS parts can be measured. When a thermopile is used for the total irradiance measurement, it is recommended to specifically design and calibrate the thermopile for each UV source (5).

For the sources used in SPF determination, the maximum total irradiance should be limited to 1600 $W.m^{-2}$, e.g. using apertures. The routinely used maximal irradiance should comply this requirement. For this purpose, the UV irradiance should be set to the highest irradiance which is used during the tests (e.g. 2.5 “standard” $MED.min^{-1}$) on all ports. The irradiance settings used during SPF testing should be reported in the certificate of the expert.

For the sources used in UVA in vitro tests, it should be possible to limit the maximum total irradiance allowed to 1400 $W.m^{-2}$, as specified in the Colipa UVA-PF determination document issued in 2007.

In addition, the visible irradiance should be less than 5% of the UV irradiance.

3.2.3 Broadband radiometer calibration (principle and application)

Anytime a dose is specified in absolute values, the calibration of the broadband radiometer is mandatory. However, when a test measures only the ratio of two doses, absolute radiometer calibration may not be used (e.g. SPF expression as MED ratio between treated and untreated test sites).

Should a comparison between different UV meters and UV sources be needed, the absolute radiometer calibration has to be used, provided it was performed during the visit of the external expert with the high-grade spectroradiometer.

The calibration supplied by the manufacturer of the radiometers used for routine UV-source monitoring was originally performed under a particular standard UV source, the emission spectrum of which is likely not identical to that of the UV source to be monitored. There are significant variations in the shape of the spectral sensitivity curves from one sensor to another, even in the same sensor category.

As a consequence, one spectral correction factor SCF is to be established for each sensor and each source spectrum. The SCF is the number by which the irradiance read on the radiometer display must be multiplied to obtain the corrected value with the same irradiance unit as given by the spectroradiometer (SCF = spectroradiometric integral irradiance / radiometric irradiance) (7). An example on how to report the radiometer and spectroradiometer data including SCF values is given in the templates included in the CD-Rom.

3.3 Data processing

After the measurements, the raw data are saved in secured files, which should never be altered (clearly identified with laboratory, source and optical filters, port, number of measurement, instrument and probe, date…). Raw data are then copied to a spreadsheet for processing.

The data processing for the calculation of %RCEE values is described in detail in the appendix of the International SPF Test Method. A template spreadsheet for %RCEE and other results calculation is included in these guidelines (CD-Rom).

4 Incidental causes that can lead to extra checking (internal and/or external)

Apart from the routine periodic checking, additional spectroradiometric monitoring must be done if one of the following causes occurs:

- Abnormal change of the irradiance, as recorded with the routine broadband radiometer.
- Change of significant optical parts, which leads to a possible alteration of the spectrum or of the total irradiance: filters, (dichroic) mirror, light guide, kind of bulb.
- Abnormal deviation from expected effects (e.g. skin response).

5 Actions to be taken if the UV-source does not comply with the specifications

For SPF testing, it is advisable to check the compliance of the UV source with the %RCEE limits immediately after the spectroradiometric measurement has been completed. If the spectral irradiance of a solar simulator does not comply with the %RCEE values of the International SPF test method, then the testing laboratory should have at its disposal a stock of Schott UG11 and WG 320 filters of different thicknesses. This is to allow changing optical filters and repeat the measurement while the measurement session is still in course.

For spatial uniformity, the main solutions are to check and adjust the position of the bulb, to clean the optics (filters, mirrors), with the cleaning material recommended by the lamp supplier and, if there are any bubbles in liquid light guides (when applicable), to replace the liquid light guides.

6 Reporting Data

The appendix (7.4) includes templates for reporting data to the customer that can generally be used for the monitoring of any UV source. The templates are available in the included CD-Rom and experts are strongly encouraged to use them. These templates may be updated and the latest versions are available from the Colipa.

The testing laboratories should be prepared to supply *at least* the following information to the sponsor (routinely or on request):

- General data:
  lamp type (brand, model, serial number, power) with optical filters and their thicknesses; name of the person internally responsible for lamp checks; date of the latest spectroradiometric check; name of the person or external expert who conducted the check; spectroradiometer type (brand model) used for the latest check.

- Raw data on CD-Rom and/or by e-mail:
  tables of measured spectral irradiances nanometer-wise (from 250 up to 780 nm, 1 nm step); calculated erythemal effectiveness and calculated %RCEE values; tabulated integral energetic irradiances for dUVB, dUVA, UV, VIS, and UV+VIS irradiance from spectroradiometric measures.

- For SPF-test reports, table of %RCEE values.

- Plots of emission spectrum both in linear and logarithmic Y scales.

- Total UV+VIS+IR irradiance (specifying wavebands).
- Irradiance values as measured with the internal radiometer(s), equipped with the same sensor that is used in the cosmetic study (brand, model, type of sensors, energetic and/or erythemal irradiance, data units).

7 Appendix

7.1 Specific recommendations for spectroradiometric measurements with liquid light guides of Solar-Light Co. solar simulators Multiport 600-150W, Multiport 601-150W and Multiport 601-300W.

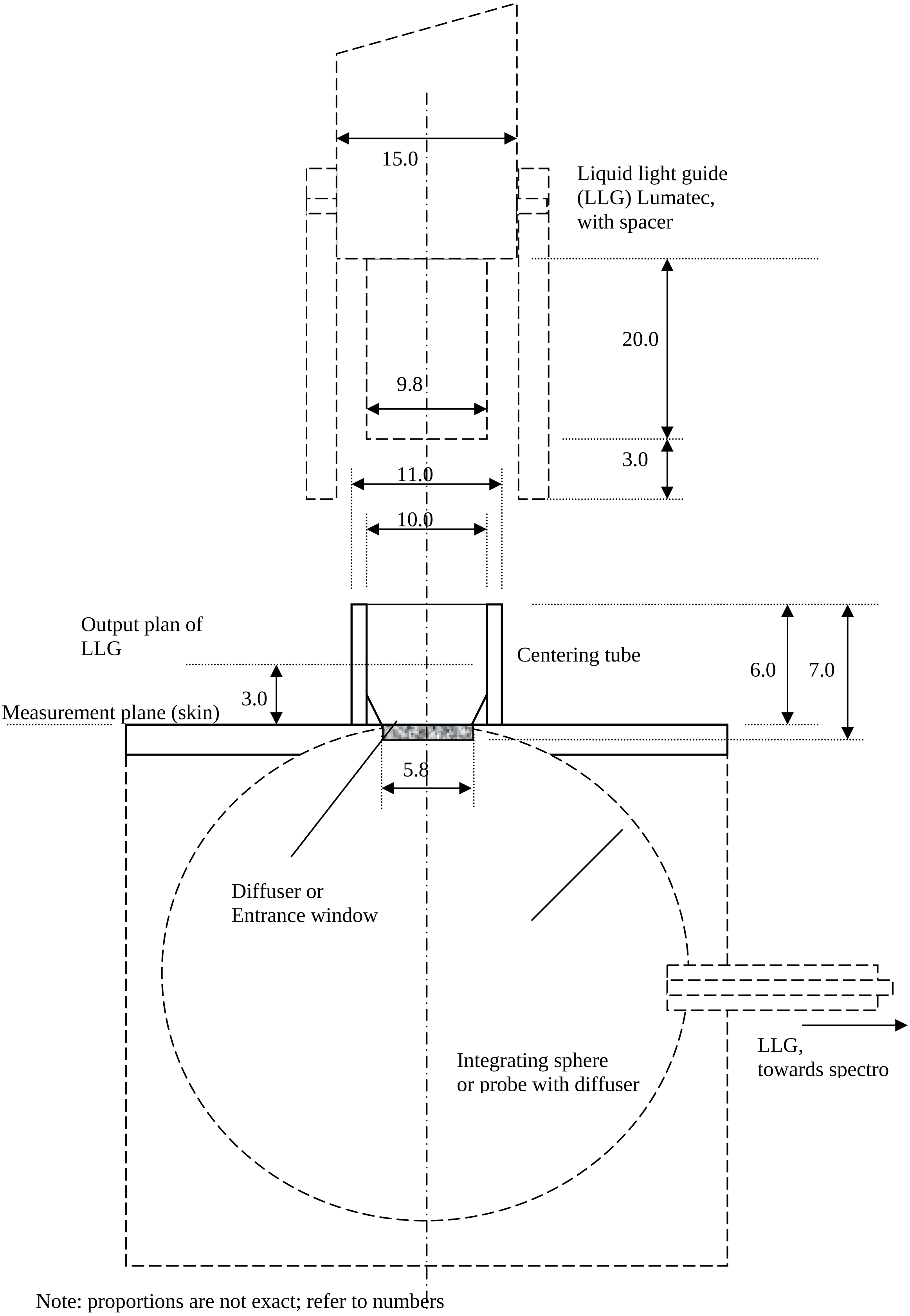
Solar-Light Co Multiport simulators are equipped with 6 liquid light guides (LLG) LUMATEC. Each LLG ends by a spacer that keeps a fixed distance (~3 mm) between the end window of the LLG and the skin. On the skin, exposed areas have an approximate diameter of 6 to 8 mm. This space between LLG and skin is needed to prevent the window of the LLG to be polluted by sunscreens applied on the skin. The diverging beam has a half angle of about 28°. The irradiance depends heavily on the distance between the probe and the LLG. Therefore, radiometric and spectroradiometric measures must be performed exactly at the skin level; thus, such measures are relevant, can be compared and the calculation of correction factors for radiometric probes from spectroradiometric measures is correct.

- The probe of the spectroradiometer should be made of either an integrating sphere or a (PTFE or equivalent, adapted to UV) diffuser with a 90° side-view mirror.
- In either case, the entrance port must have a diameter as close as possible to that of the Solar-Light PMA detector fitted for LLG measures (i.e. 5.8 mm). The diameter of the entrance port must be inferior or equal to the diameter of the irradiated area.
- The probe must have an angular response as close as possible to the cosine response (error < ±10% for incident angles < 60°)
- The probe should be connected to the spectroradiometer with a fiber optic, so that the setup is easy. A mechanical part, similar to the PMA detectors one (tube with a 10 mm inner diameter, 6 mm long, the inside being painted with a mate black paint, which can be adjusted to the detector entrance in a reproducible way, see scheme below), should enable a rigid link between integrating sphere or diffuser and LLGs and thus guarantee a high level of reproducibility of spectral measurements. Please note that the surface of the adaptor, defining the measure plane (skin level), must include no unevenness (such as screw heads) that would alter the planarity of the reference surface. Spacers must exactly slide (such as a runner) with this surface.
- LLGs must stay in the same position as during UV exposure, with no particular curvature. The spectroradiometer and the probe with the adaptor must adapt to the source, not the opposite.

Given a spatial instability of the xenon arc (flickering), which is not compensated by the regulated power supply, the intensity may vary during recording, making artifact peaks in the recorded spectra. Such instabilities may be smoothed: at least three measures should be recorded and the average calculated.

Solar-Light PMA detector and other systems

Scheme of the centering device of the probe,
for liquid light guides "Lumatec"
from solar simulators Multiport Solar-Light Co.



Note: proportions are not exact; refer to numbers

7.2 Spectroradiometers and equipment relevant for UV-sources monitoring

Alphabetically sorted list, according to the company name

Company	**Address**	**Spectroradiometer model**
Bentham	2 Boulton Road Reading Berks RG2 0NH Great Britain Tel: +44 (0) 118 975 1355 Fax: +44 (0) 118 931 2971 M25Clark@bentham.co.uk http://www.bentham.co.uk/spf.htm	DM300 DM150
Instruments Systems GmbH	Neumarkter Str 83 81673 Munich (Germany) Tel: 49.89.45.49.43.26 Fax 49-89.45.49.43.11 justin.blake@instrumentsystems.de http://www.instrumentsystems.de/products/prodmain.htm#spectro320	IS SPECTRO 320 D
Macam Photometrics Ltd	10, Kelvin Square Livingstone EH54 5PF (Scotland) Tel: +44.506.4373.91 Fax: +44.506.43.85.43 rmorley@macam.com http://www.macam.com/spect.htm#sr9910	Macam 9910 V7 with modified slits (1 nm)
Optronic Laboratories Inc.	4632 36th Street Orlando (USA) Tel: 1.407.433.3171 1.407.422.3171 http://www.olinet.com/products-ol-series-756.php3	OL756

7.3 Monitoring questionnaire for UV sources and radiometry

7.3.1 General information

Characterization of a UV-radiation source system

Date:

Testing laboratory

Name:
Service:
Full address:
Street 1
Street 2
ZIP
City
Country

Person in charge of the monitoring of the UV sources:

Name:
Tel n°:
Fax n°:
E-mail:

External expert / Institute monitoring the UV-source

Institute Name:
Full address:
Street 1
Street 2
ZIP
City
Country
Expert:
Name:
Tel n°:
Fax n°:
E-mail:

Do you dispose of a regular maintenance service:

☐ Internal ☐ External

Do you dispose of a text which includes the specifications of the solar simulator irradiance, to check the compliance of the UV source irradiance spectrum for SPF testing?

☐ the International SPF test method (2006)
☐ European COLIPA SPF test method (1994)
☐ DIN67501
☐ Önorm-S1130

Additional technical documents enclosed:

☐ Photos
☐ Manufacturer(s) leaflets and notices
☐ Standard Operating Procedures
☐ Other

If other, please specify:

Signature of the Technical Manager

7.3.2 *UV source information*

Characterization of a UV-radiation source system

Note: if you use several sources, please make one copy of this sheet per source and complete each copy

UV source designation

Brand:

Model

Serial number:

Internal ID N°:

Date of purchase:

Supplier:

Local address:

Street 1

Street 2

ZIP

City

Country

Contact name:

Tel n°:

Fax n°:

E-mail:

Was your UV source: Manufacturers of the UV source

○ supplied by a unique manufacturer

○ an integrated system, made of several components from different suppliers

Supplier(s) :

Other useful comments or information :

Please describe your own internal equipments, as fully as possible:

For which 'cosmetic' applications do you use this UV-source?

☐ SPF

☐ PF-UVA (PPD)

☐ Photostability

☐ Phototoxicity

☐ Other(s)

Give reference(s) of test standards:

Characterization of a UV-radiation source system

Note: if you use several ***sources,*** *please make one copy of this sheet per source and complete each copy*

Bulb / Electronics

Kind of bulb(s)

- ○ Xenon
- ○ Metal halide
- ○ Xenon + metal halide
- ○ Mercury (Hg)
- ○ Fluorescent UV tubes

Type / model: ______

If Xenon bulb, shape of the arc:

- ○ Short
- ○ Long

Rated electrical power of the bulb:

Bulb power

○ 20 W	○ 30 W	○ 40 W	○ 50 W
○ 75 W	○ 150 W	○ 175 W	○ 300 W
○ 1000 W	○ 1600 W	○ 2000 W	○ 3000 W
○ 6500 W	○ 7000 W	○ Other	

If other or multiple bulbs, please specify: ______

Is the bulb run at its rated power?

- ○ Yes
- ○ No t, at which power / intensity / percentage of full power? ______

During use, is the bulb supply monitored by (excluding radiometers):

☐ Current	Amps:	
☐ Voltage	Volts:	
☐ Power	Watts:	
☐ Temperature	°C / °F:	
☐ Other		

Stabilization

Is the source/power supply equipped with a current stabiliser?

- ○ Yes
- ○ No

Is the source/power supply equipped with a radiation stabiliser (photo-feedback)?

- ○ Yes
- ○ No

Filters and optics

Shape / size of the output window / lens: ______ mm

Is the output window / lens / light guide:

Contact

- ○ in direct contact with the skin/sample
- ○ Protected (spacing ring,...)

Protection: ______

Low cut-off filters (list all filters and thicknesses installed or available) (in case of several filters of the same kind, separate thicknesses with a "/")

Schott:

☐ WG295	Thickness / mm:	
☐ WG305	Thickness / mm:	
☐ WG320	Thickness / mm:	
☐ WG335	Thickness / mm:	
☐ WG345	Thickness / mm:	
☐ WG360	Thickness / mm:	

(Report actual measured -calliper- thickness in mm at 0.05)

Other brands, references & thicknesses: ______

High cut-off filters (list all visible & infrared reducers):

Schott:

- ☐ UG5 — Thickness / mm:
- ☐ UG11 — Thickness / mm:

(Report actual measured -calliper- thickness in mm at 0.05)

Other brands, references & thicknesses:

Are the filters easily removable and interchangeable?
Ease of use: ○ Yes ○ No

Number of filters which can simultaneously be mounted in the source beam:

- ☐ Water filter — Path length / mm
- ☐ Dichroic mirror — Number of dichroic mirrors:

	Brand	Model
Pass band at 1% of the max. reflexion	from / nm	to / nm
Pass band at 10% of the max. reflexion	from / nm	to / nm

(or better enclose the reflection spectrum)

Incidence angle of the incoming beam: ○ 45° ○ Other:

Light guides:

UVR guides: ○ Fused silica fibers ○ Liquid light guide(s)

Number:		
Diameter:		mm
Length:		mm
Brand		
Model:		

Other filters available

Brand	Type	Thickness / mm

Geometric and optical characteristics

Incidence angle of the incoming beam

Irradiated area (at ± 7% uniformity):		cm x cm
...at a distance from the source:		cm
Diameter of individual spots at skin level:		mm

Beam expansion — Divergence: ○ Collimated ○ Convergent ○ Divergent

Half angle (°)

Does the source allow: ☐ Horizonal exposure prone position)? ☐ Vertical exposure (sit position)?

Fractional exposure? ○ continuous ○ logged (intermittent)

Duration (open / close) sequence: seconds / seconds

7.3.3 UVmetry

Characterization of a UV-radiation source system
Devices for monitoring irradiance and doses

*Note: if you use several **radiometers,** please make one copy of this sheet per source and complete each copy*

Radiometer(s) / UVmeter(s) for daily monitoring (broadband)

Brand:
Model:
Date of purchase:
Supplier:
Local address:
Street 1
Street 2
ZIP
City
Country
Contact name:
Tel n°:
Fax n°:
E-mail:

Sensor(s): ☐ UV ☐ Erythemal UV ☐ UVB ☐ UVA ☐ Other

(Enclose response spectra of sensors whenever available)

Irradiance units displayed by the radiometer / UVmeter:

☐ mW.cm-2 ☐ W.m-2 ☐ µW.cm-2 ☐ J.cm-2.min-1
☐ MED.min-1 ☐ MED.hour-1 ☐ SED.min-1 ☐ SED.hour-1
☐ Other:

Calibration by the manufacturer / the supplier:

Units
Calibration source:
Date of the certificate:
If available, f1(Z)

Date of latest calibration of the radiometer versus a high-grade spectroradiometer:
UV source and spectra used for this radiometer calibration:

Thermopile

Do you dispose of a thermopile?
○ Yes ○ No

Brand:
Model:
Date of purchase:
Supplier:
Local address:
Street 1
Street 2
ZIP
City
Country
Contact name:
Tel n°:
Fax n°:
E-mail:

Aperture / sensor diameter: mm
Entrance filter / window (reference, material):

	from / nm	to / nm
Wavelength range:		

	Min / W.m-2	Max / W.m-2
Sensitivity range:		

Your spectroradiometer for internal routine monitoring of UV-source spectra

Brand:	
Model:	
Date of purchase:	
Supplier:	
Local address:	
Street 1	
Street 2	
ZIP	
City	
Country	
Contact name:	
Tel n°:	
Fax n°:	
E-mail:	

Number of monochromator(s)

Monochromator:	◯ Single	◯ Double	
Grating(s) λ blaze(s)		nm (/ nm)	
Bandwidth		nm	
Shape of the slit function:			
Wavelength precision: ±		nm	
Wavelength accuracy: ±		nm	
	from / nm	to / nm	
Measuring wavelength range:			

Probe:

Kind	☐ Integrating sphere	☐ Diffuser	☐ Includes fiber optic	☐ Other
Brand / model of the probe:				
Probe diameter:		mm		
Exposure time:		ms		
Accumulation number (number of scans):				
Stray-light level:		$W.m^{-2}.nm^{-1}$		
Maximal irradiance:		$W.m^{-2}.nm^{-1}$		
Detection threshold (for signal / noise ratio = 1):		$W.m^{-2}.nm^{-1}$		

Your calibration sources for your spectroradiometers

Wavelength

Kind of lamp

Kind	☐ Hg	☐ Ar	☐ Ne	☐ Other
Brand / Model:				
Power:		W		

Amplitude

	☐ Deuterium	☐ QTH	☐ XTH	☐ Other
Brand / Model:				
Power:		W		
Calibration certificate for calibration source(s)				
Date(s)				
Issued by				

7.4 Reporting data

Table 2: Irradiance integrals for the wavelength ranges [v]

Energetic Irradiance (W.m^{-2})						
< 290 nm						
dUVB (290-320 nm)						
dUVA (320-400 nm)						
UVA-2 (320-340 nm)						
UVA-1 (340-400 nm)						
UV (290-400 nm)						
Visible (400-780 nm)						
IR-A (780-1400 nm)						
UV+Visible (290-780nm)						
Total (UV+VIS+IR-A)						
Total (thermopile)						
Ratio dUVA / dUVB						
Ratio UVA2 / UVA1						
Ratio (VIS+IR-A) / UV						

Table 3: Spatial uniformity checks

UV irradiance	
Maximum	
Minimum	
Mean (over at least 5 different locations)	
Contrast: (Max – Min) / Mean	
Criterion: maximum contrast	10%
Pass / Fail test	

[v] Use one or several columns according to the number of ports/channels available on the UV source. Integrals are calculated using trapezium approximation, not rough summation (3)

Table 4: Relative cumulative erythemal effectiveness (%RCEE) of the UV source [vi]

Wavelength range	Accept. limits		
	Lower	Upper	
< 290 nm		< 0.1%	
290-300 nm	1.0%	8.0%	
290-310 nm	49.0%	65.0%	
290-320 nm	**85.0%**	**90.0%**	
290-330 nm	91.5%	95.5%	
290-340 nm	94.0%	97.0%	
Pass / fail test (SPF source)			

Table 5: UV source specifications for in vitro determination of UVA protection

	Accept. limits		
	Lower	Upper	
Total UV irradiance / W.m-2	50	140	
Ratio of dUVA / dUVB irradiances	8	22	

[vi] Use one or several columns according to the number of ports/channels available on the UV source.
Integrals are calculated using trapezium approximation, not rough summation (3)

7.5 Stray radiation

The stray radiation criterion is calculated as the unitless ratio of the UVC virtual irradiance measured from 250 nm to 280 nm, to the irradiance measured from 290 nm to 400 nm, and should be less or equal to 3 x 10^{-6}.

Stray radiation criterion:

$$\frac{\int_{250}^{280}[I(\lambda) - B(\lambda)].\, d\lambda}{\int_{290}^{400}[I(\lambda) - B(\lambda)].\, d\lambda} \leq 3 \cdot 10^{-6}$$

Exemplary value:

$$\frac{1.382}{2372963} = 5.82 \cdot 10^{-7}$$

where:

- I(λ) is the raw spectral irradiance measured,
- B(λ) is the spectral dark signal (electronic noise), without radiation entering the instrument, generally automatically subtracted by the instrument software,
- dλ as 1 nm step.

Note: Since the step width is set at 1 nm, a number of 30 signal intervals are measured between 250 nm and 280 nm. As a result the stray radiation criterion of “better than 3x10^{-6} " corresponds, when divided by 30 (steps), to “better than 10^{-7} nm^{-1}" (= 3x10^{-6} / 30 nm).

7.6 Lexicon

Short definition of some technical terms and acronyms used in this document:

Term	**Definition**
Bandwidth	Interval of adjacent wavelengths (in spectral unit, nm, Å)
Broadband	Series of several adjacent wavelengths (in opposition to spectral). Characterises radiometers (vs. spectroradiometers).
CCD	Coupled Capacity Detector, type of light (photo) sensor
Cosine response	Angular sensitivity of a radiation sensor, which should be as proportional as possible to the cosine value of the incidence angle of the incoming beam onto the sensor entrance plane (1 for normal incidence, 0 for tangent / lateral incidence).
dUVA	Waveband 320 - 400 nm
dUVB	Waveband 290-320 nm
FWHM	Full Width Half Maximum, bandwidth of a 'bell' or peak distribution at half of the maximal height
Hg	Mercury (in low-pressure mercury arc lamp)
IR-A	InfraRed spectral band (770 - 1400 nm)
Irradiance	Intensity of radiation per unit surface falling (from a source) onto a test surface ($W.m^{-2}$, $mW.cm^{-2}$); note that it actually characterises the radiation intensity at the test surface (ground, skin, orientation, distance from the source), not the UV source emission (lamp, sun).
m, cm	unit of length (m^2, cm^2, units of area)
NEI	Noise equivalent irradiance (virtual irradiance composed of electronic noise and stray radiation)
nm	10^{-9} meter, unit of (wave)length
Radiance	Intensity of radiation per unit of emitting surface of a radiation source.
Radiometer	Instrument devoted to measuring the broadband irradiance. Equipped with one or several specific sensing head(s) (the sensors) and the AD converter and display unit (in single or separate parts).
Slit function	Spatial radiation intensity distribution across the picture of the entrance slit at the output slit of a monochromator. May be used to find the FWHM or the bandpass.
SNR	Signal (significant information) to noise (error/background signal) ratio
Spectral	Relative to each wavelength unit (nm, Å)
Spectral irradiance	Irradiance per wavelength unit ($W.m^{-2}.nm^{-1}$)
Spectroradiometer	Instrument analysing the spectral radiance or irradiance, in terms of absolute or relative units (depending on the quality of its calibration).
Spectrum	Description (generally graphical) of a spectral irradiance or of the spectral radiance of a source.
SPF	Sun Protection Factor
Stray radiation	Radiation transferred from a wavelength to another due to multiple reflections, scattering and leakage in the spectroradiometer.
UV	Waveband 290-400 nm (solar UV)
UV solar simulator	UV source emitting UV radiation similar to solar UV radiation. Generally based on a xenon emitter (bulb).

Term	Definition
UV source	Laboratory lamp emitting mainly UV radiation for specific applications
UVery	Erythemal effective UV irradiance (weighed with the CIE-1987 erythema action spectrum)
VIS	Visible spectral band (380 - 780 nm)
W, mW	Watt, milliWatt, units of power (correspond respectively to 1 Joule per second and 1 mJ per second)

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