REPORT

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Measurement of optical radiation from UV-dryer

(1 appendix)

SP Technical Research Institute of Sweden has performed measurements of optical radiation from an IRT UVA-1 PrepCure 3 Digital mobile UV-dryer, consisting of one 1000 W Hg-lamp mounted on a movable stand. The results are compared to requirements in AFS 2009:7 *Artificiell optisk strålning*, which in turn is based on the requirements in *Directive 2006/25/EC on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation).*

Summary of results

Depending on the distance from the UV-dryer, the limit value according to AFS 2009:7 index b. (UVA eye) for one working day (8 h) is reached after one or a few minutes at close distances (~0,5 m). At longer distances than about 3 m, the acceptable exposure time is an hour or more. The acceptable exposure times according to index a. in AFS 2009:7 (UVA, UVB and UVC, skin and eye) is more than 20 times longer than for index b. (UVA eye).

Test object

IRT UVA-1 PrepCure 3 Digital mobile UV-dryer, s/n 100123, consisting of one 1000 W Hg-lamp mounted on a movable stand. The unit was equipped with the following lamp:

Isolde CLEO HPA (1 kW Hg-lamp) with glass window in front.

Identification

Reference: Andreas Lundevall
Date: 2016-01-29
Type: UV-dryer IRT UVA-1 PrepCure 3 Digital for curing UV paint material

Date of measurement

January 2016

Test conditions

Measurements were carried out in a temperature-stabilized laboratory with the temperature 23 °C ±2 °C.

Measurements of irradiance were made at several distances between 0,2 m and 5 m from the lamp. Outside this range irradiance values for distances up to 10 m was extrapolated based on fitting a second-degree polynomial to the relation between 1/distance^2 and the measured irradiance, which yields almost a straight line (the inverse-square-law). The error in this extrapolation is negligible compared to the overall uncertainty.

Measurements were made in the wavelength range 250 nm to 800 nm. No significant radiation was detected outside this range.

Based on the measured irradiance values, the total exposure time per working day (8 h) before the relevant limit values in AFS 2009:7 (index a. and b.) are reached, was calculated. For the calculation according to index a., the spectral irradiance was weighted with the relevant action curve $S(\lambda)$. Relevant limits according to AFS 2009:7 are shown in table 1 below.

Table 1. Exposure limit values according to AFS 2009:7 for UV-radiation

Index AFS	Wavelength (nm)	Action curve	Exposure limit	Hazard
a.	180-400	$S(\lambda)$	30 J/m^2	UVA, UVB and UVC Eye and skin
b.	315-400	1	10^4 J/m^2	UVA eye

Instruments
Spectrometer Optronic 756, SP inv.no. 901723
Current amplifier Keithley 427, SP inv.no. 500066
Multimeter Keithley 2000, SP inv.no. 500768
Silicon diode ∅ 10 mm
Precision aperture ∅ 2 mm

Test method
Applicable parts of SP-Method 4432.

Test result
The spectral content from the lamp is shown in Figure 1 below.

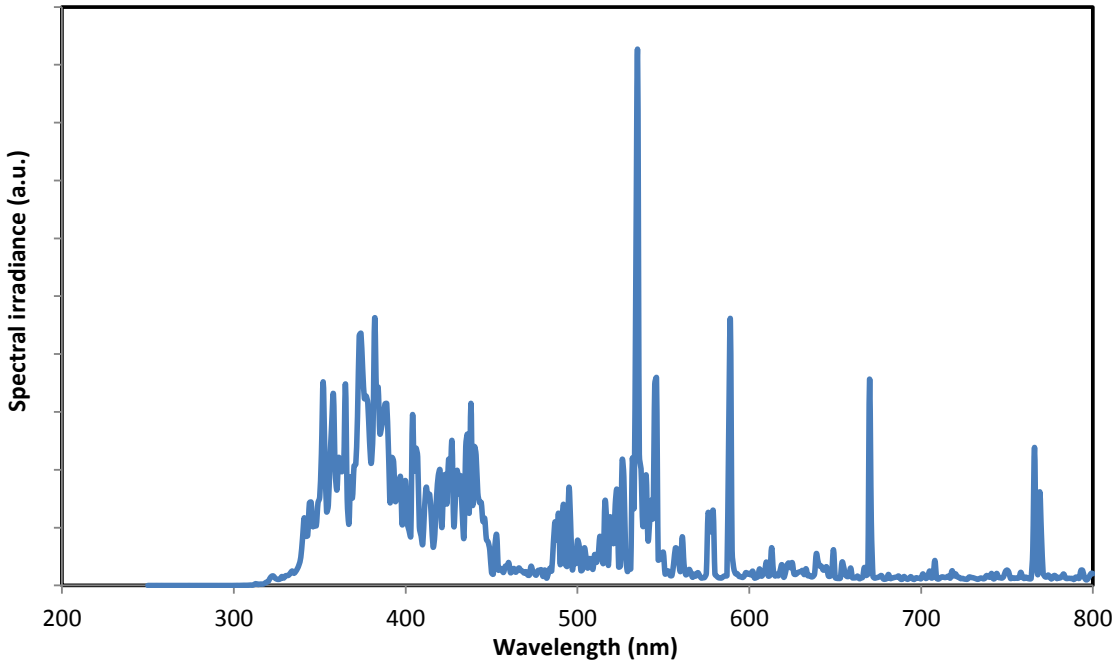

Figure 1. Spectral irradiance from the light source.

Table 2. UV-radiation and acceptable exposure times at various distances from the lamp.

Distance from lamp (m)	Index a. (UV 180 - 400 nm) Irradiance ($W \cdot m^{-2}$)	Exposure time (h)	Index b. (UVA 315 - 400 nm) Irradiance ($W \cdot m^{-2}$)	Exposure time (min)
0,2	$5{,}80 \times 10^{-2}$	0,14	422	0,4
0,5	$1{,}37 \times 10^{-2}$	0,61	99,7	1,7
1,0	$3{,}52 \times 10^{-3}$	2,4	25,6	6,5
1,5	$1{,}64 \times 10^{-3}$	5,1	11,9	14
2,0	$9{,}47 \times 10^{-4}$	>8	6,88	24
3,0	$4{,}21 \times 10^{-4}$	>8	3,06	55
4,0	$2{,}35 \times 10^{-4}$	>8	1,71	98
5,0	$1{,}46 \times 10^{-4}$	>8	1,06	157
6,0	$1{,}01 \times 10^{-4}$	>8	0,735	227
7,0	$7{,}26 \times 10^{-5}$	>8	0,528	316
8,0	$5{,}41 \times 10^{-5}$	>8	0,394	424
9,0	$4{,}14 \times 10^{-5}$	>8	0,301	553
10,0	$3{,}23 \times 10^{-5}$	>8	0,235	709

Comment on results: The results in table 2 has been taken perpendicular to the lamp's front surface (glass). Previous measurements on similar lamps indicate that the maximum irradiance may be reached with the lamp slightly tilted up or down. However, one should always have significant margins to the above reported exposure times. Also, for UV-dryers equipped with two similar 1 kW- lamps the irradiance, at least at some distance away from the lamps, will be approximately twice of that for a single lamp and the exposure times about half as long. This calculation is presented in table 3 below.

Table 3. Calculated UV-radiation and acceptable exposure times at various distances from an UV-dryer equipped with two 1 kW Hg-lamps.

Distance from lamp (m)	Index a. (UV 180 - 400 nm) Irradiance ($W \cdot m^{-2}$)	Exposure time (h)	Index b. (UVA 315 - 400 nm) Irradiance ($W \cdot m^{-2}$)	Exposure time (min)
0,2	$1{,}16 \times 10^{-1}$	0,07	844	0,2
0,5	$2{,}74 \times 10^{-2}$	0,30	199	0,8
1,0	$7{,}04 \times 10^{-3}$	1,2	51,2	3,3
1,5	$3{,}28 \times 10^{-3}$	2,5	23,9	7,0
2,0	$1{,}89 \times 10^{-3}$	4,4	13,8	12
3,0	$8{,}41 \times 10^{-4}$	>8	6,11	27
4,0	$4{,}70 \times 10^{-4}$	>8	3,41	49
5,0	$2{,}93 \times 10^{-4}$	>8	2,13	78
6,0	$2{,}02 \times 10^{-4}$	>8	1,47	113
7,0	$1{,}45 \times 10^{-4}$	>8	1,06	158
8,0	$1{,}08 \times 10^{-4}$	>8	0,787	212
9,0	$8{,}29 \times 10^{-5}$	>8	0,602	277
10,0	$6{,}47 \times 10^{-5}$	>8	0,470	354

Comment on Blue-light hazards: In addition to the UV-hazard reported in table 2 and 3, the lamps also emit intense light in the visual part of the spectrum that may propose a risk to the eye (so-called Blue-light hazards). For the lamp of interest the related exposure limits in AFS 2009:7 (index c. and d.) will depend on the actual (effective) angular subtense of the source and, depending on how the radiance of the lamp (including the reflector) is distributed one could achieve quite different acceptable exposure times. However, since this hazard is only valid for an eye viewing directly into the light source, the intensity of the lamp (very high brightness) will make it very unlikely that any person exposed to the radiation will look directly into the lamp for any extended time.

Measurement uncertainty
Irradiance: ±10 %

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k = 2$, which for a normal distribution corresponds to a coverage probability of approximately 95 %. The standard uncertainty of measurement has been determined in accordance with EA Publication EA-4/02.

Remark
The results in this report are only valid for the item tested.

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Performed by

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Appendix
Photos of test object.

Appendix 1

Photo of test object