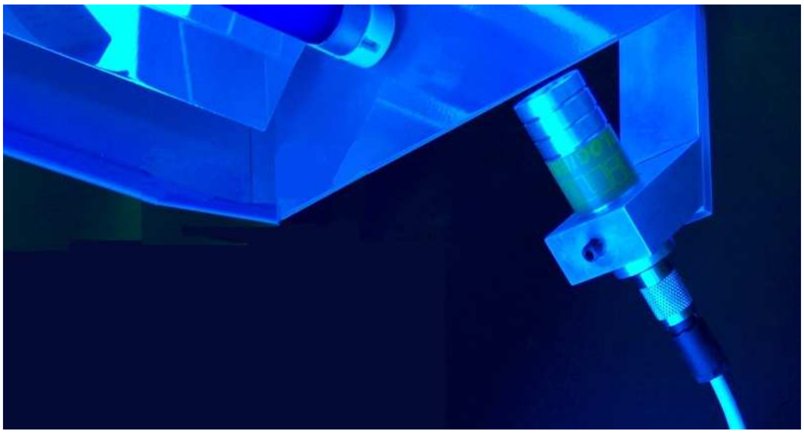
Exposure limit to UV radiation between 180 and 400 nm



Information regulotary

Directive 2006/25/CE from April 5th 2006 regarding the evolution of risks linked artificial optic radiations has been transposed in the French law by decree 2010-750 from July 2nd 2010.

It is the end user's responsibility to ensure the ligthing respect the directive (according to the production restrictions). Norm AFNOR NF EN 14255-1 specifies how to measure and evaluate the exposure of people to UV radiations from artificial sources. The required material to do measures (spectroradiometer) is very expensive so it is usually necessary to hire specialized contractor.

Evaluation and exposure limit

The limits stated by directive 2006/25/CE have been established on the basis of recommendations formulated in 2004 by the ICNIRP [International Commission on Non-Ionizing Radiation Protection (ndlr : Commission internationale pour la protection contre les rayonnements non ionisants)], an organization globally rekognized as the authority in the field of the evaluation of the effects of this kind of radiation on health.

http://www.who.int/uv/publications/Protecting_Workers_UV_pub.pdf (March 2007)

http://www.icnirp.org/cms/upload/publications/ICNIRPUV2004.pdf (August 2004)

An exposure to UV radiation can be quantified in energetic lighting E (W/m² or W/cm²) for a continuous exposure with a steady level or in energetic exposure *H* (J/m² or J/cm²) for a time limited exposure.

$$H(J/m^2) = \int_{durée\_exposition} E(W/m^2).dt$$

For an exposure to a monochromatic source, we can use the maximum value of exposure of board 1 on page 2. In most cases the light sources give a large spectral beam. It is then necessary to make calculation by taking into account normalisation coefficients S(λ) in order to determin the energetic lighting. It will give the relative spectral efficiency in comparison to maximum efficiency situated at 270 nm (see board 1).

$$Eeff = \sum E_{\lambda} S(\lambda) \Delta\lambda$$

Eeff = normalised actual energetic lighting (W/m²)
Eλ = spectral energetic lighting (W/m²/nm)
S(λ) = relative spectral efficiency (no unit of measure)
Δλ = interval of measure (nm)

The recommendations of the ICNIRP regarding the exposure of the eyes and the skin of people to UV radiations (180-400 nm) are a daily limit to a normalized energetic radiation of 30 J/m². Under these conditions, if the energetic lighting is steady, the maximum daily exposure duration is calculated :

$$t_{\max}(s) = (30 J/m^2) / Eeff\,(W/m^2)$$

1st recommendation
Physiological effects :
-Skin: *erythema, carcinogenic effects*
-Eye: *keratitis,conjunctivitis*

In addition to the first recommendation it is necessary to **limit the daily exposure of the eyes to UV light (315 – 400 nm) to an energetic exposure (not normalized this time) of 10 000 J/m².** Under these conditions, if the energetic lighting is steady, the maximum daily exposure duration is calculated :

$$t_{\max}(s) = (10000 J/m^2) / E_{uva}(W/m^2)$$

2nd recommendation
Physiological effect :
-Eye: *cataract*

avec $$E_{uva} = \sum_{315nm}^{400nm} E_{\lambda} \Delta\lambda$$

Board 1. Exposure limit to UV light according to spectral moderation

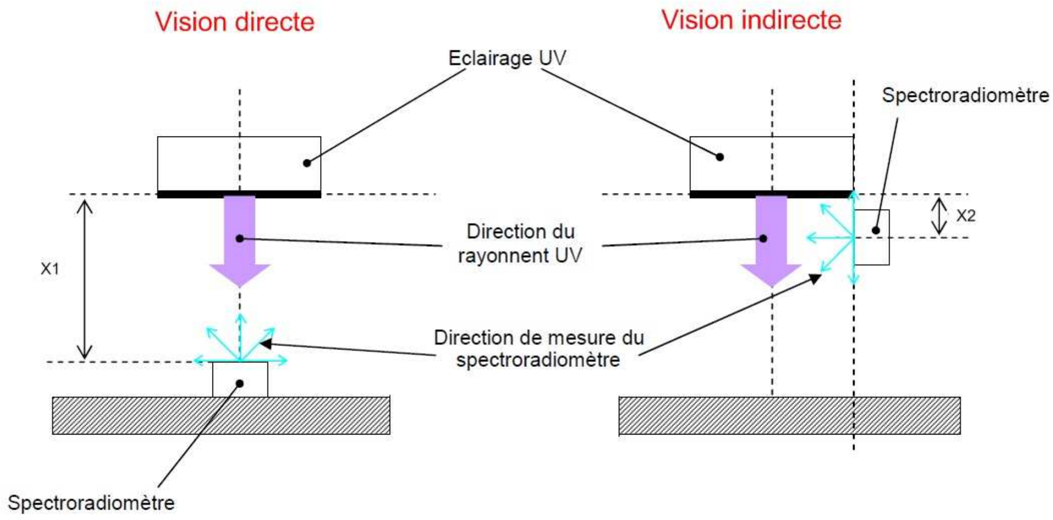
λ[a] (nm)	(J m⁻²)	(mJ cm⁻²)	S(λ)[b]	(nm)	(J m⁻²)	(mJ cm⁻²)	S(λ)[b]
180	2,500	250	0.012	310	2,000	200	0.015
190	1,600	160	0.019	313[c]	5,000	500	0.006
200	1,000	100	0.030	315	1.0×10^4	1.0×10^3	0.003
205	590	59	0.051	316	1.3×10^4	1.3×10^3	0.0024
210	400	40	0.075	317	1.5×10^4	1.5×10^3	0.0020
215	320	32	0.095	318	1.9×10^4	1.9×10^3	0.0016
220	250	25	0.120	319	2.5×10^4	2.5×10^3	0.0012
225	200	20	0.150	320	2.9×10^4	2.9×10^3	0.0010
230	160	16	0.190	322	4.5×10^4	4.5×10^3	0.00067
235	130	13	0.240	323	5.6×10^4	5.6×10^3	0.00054
240	100	10	0.300	325	6.0×10^4	6.0×10^3	0.00050
245	83	8.3	0.360	328	6.8×10^4	6.8×10^3	0.00044
250	70	7	0.430	330	7.3×10^4	7.3×10^3	0.00041
254[c]	60	6	0.500	333	8.1×10^4	8.1×10^3	0.00037
255	58	5.8	0.520	335	8.8×10^4	8.8×10^3	0.00034
260	46	4.6	0.650	340	1.1×10^5	1.1×10^4	0.00028
265	37	3.7	0.810	345	1.3×10^5	1.3×10^4	0.00024
270	30	3.0	1.000	350	1.5×10^5	1.5×10^4	0.00020
275	31	3.1	0.960	355	1.9×10^5	1.9×10^4	0.00016
280[c]	34	3.4	0.880	360	2.3×10^5	2.3×10^4	0.00013
285	39	3.9	0.770	365[c]	2.7×10^5	2.7×10^4	0.00011
290	47	4.7	0.640	370	3.2×10^5	3.2×10^4	0.000093
295	56	5.6	0.540	375	3.9×10^5	3.9×10^4	0.000077
297[c]	65	6.5	0.460	380	4.7×10^5	4.7×10^4	0.000064
300	100	10	0.300	385	5.7×10^5	5.7×10^4	0.000053
303[c]	250	25	0.120	390	6.8×10^5	6.8×10^4	0.000044
305	500	50	0.060	395	8.3×10^5	8.3×10^4	0.000036
308	1,200	120	0.026	400	1.0×10^6	1.0×10^5	0.000030

[a] The wavelengths chosen are representative, the other values must be calculated interpolation (see Équations 2a-c).
[b] Relative spectral efficiency
[c] Emission line from a mercury vapor bulb
[d] Emission line from a monochromatic source limited to an output of 10 kW m⁻² (1 W cm⁻²) for duration over 1 s so to exclude the thermal effects.

Evaluation of SREM lightings

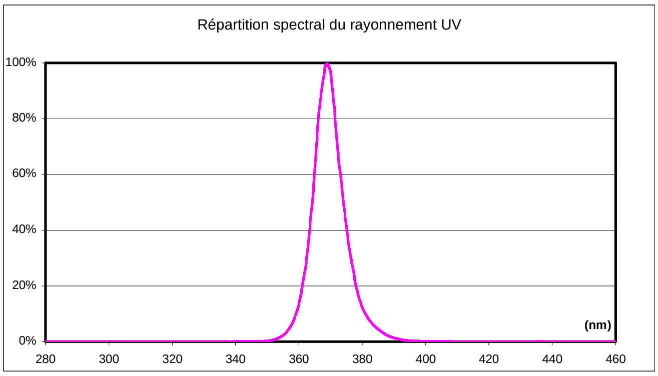
SREM characterized some of their lamps in standard conditions of use (direct vision, indirect vision), but it is not necessarily representative of real conditions of use. The values are given as a guide and if doubts arise, conducting a study in real conditions of use is advised.

Conditions of measure



Example of results for UV lamp PF310

Specter :



Energetical lighting and exposure duration

PF310LED	Indirect vision (X2=400 mm)		Direct vision (X1=100 mm)	
	Eeff (280-400 nm)	Euva (315-400 nm)	Eeff (280-400 nm)	Euva (315-400 nm)
Energetical lighting	45,28 $\mu W/m^2$	0,48 W/m^2	3,85 mW/m^2	40,52 W/m^2
Maximum daily exposure duration	> 24 h	5 h 47 mn	2 h 9 min	4 min 7 s

NB : The maximum daily exposure durations are given supposing no glass or specific clothes are worn. Direct vision (Euva) is not considered as standard conditions of use.

Conclusion

It is recommended to respect the following rules to respect the maximum values regarding the exposure to UV radiations MPI or fluorescent PT controls :

- Wear anti-UV glasses adapted to non-destructive testing by MPI or fluorescent PT ;
- Wear long clothes that cover the body entirely. They must not be fluorescent ;
- Avoid any direct vision with the light source in particular when using handy lamps.

UV radiations are up to the operating conditions, it is necessary to define clear operating conditions and do measures within.