Statens strålskyddsinstitut
Swedish Radiation Protection Institute

SSI FS 1990:1 **Unofficial translation**

The Swedish Radiation Protection Institute´s General Advice on Exposure Limits to Ultraviolet Radiation;

August 22nd 1990.

General

Ultraviolet (UV) radiation causes acute damage of unprotected skin and unprotected eyes after an overexposure. Prolonged exposure also imply a risk for late damages such as skin cancer. The cancer hazard has by animal experiments been proved to increase with the exposure in particular in the wavelength range 280 - 315 nanometres.*

Purpose

The purpose of exposure limits (ELs) and recommendations on ultraviolet radiation is preventive to avoid acute biological effects.

The ELs should not be regarded as sharp border-lines between harmful and safe exposures. They are laid down as exposure levels where, if not exceeded, no acute effects on skin or eyes occur. In most wavelength regions the hazard to the eye is the limiting factor. Such a damage (on the cornea) is of a temporary nature. No guarantee against late damages can be given even if the ELs are not exceeded.

Exposure to ultraviolet radiation should not exceed the ELs, in particular not if exposures occur frequently.

Field of use

These exposure limits are in the first place intended for use in risk assessment of man-made UV-sources but could also serve as guidelines for the risk of sunlight. It should be noticed that an individual may be exposed to UV-radiation in his job and during his time off in the same day.

The ELs could directly apply on UV-radiation from welding arcs, discharge lamps or fluorescent tubes provided that the devices emit UV-radiation for longer periods than 0.1 second.

The ELs should not be used for medical exposures in treatment of patients.

Specific rules apply on lasers emitting UV-radiation.

* 1 nm = 1/1000 000 000 m.

Exposure limits in the wavelength range 180 - 400 nm

1. The exposure to a monochromatic source should not exceed the EL-values, according to the table below, in a day (24-hours). Sλ are weighting factors to be explained in section 2.

λ	EL (J/m^2)	Sλ	λ	EL (J/m^2)	Sλ
180	2500	0,012	310	2000	0,015
190	1600	0,019	313*	5000	0,0060
200	1000	0,03	315	10000	0,0030
205	590	0,051	320	29000	0,0010
210	400	0,075	325	60000	0,00050
215	320	0,095	330	73000	0,00041
220	250	0,12	335	88000	0,00034
225	200	0,15	340	110000	0,00028
230	160	0,19	345	130000	0,00024
235	130	0,24	350	150000	0,00020
240	100	0,30	355	190000	0,00016
245	83	0,36	360	230000	0,00013
250	70	0,43	365*	270000	0,00011
254*	60	0,50	370	320000	0,000093
255	58	0,52	375	390000	0,000077
260	46	0,65	380	470000	0,000064
265	37	0,81	385	570000	0,000053
270	30	1,00	390	680000	0,000044
275	31	0,96	395	830000	0,000036
280*	34	0,88	400	1000000	0,000030
285	39	0,77			
290	47	0,64			
295	56	0,54			
297*	65	0,46			
300	100	0,30			
303*	250	0,12			
305	500	0,060			

* Wavelengths of a mercury lamp

Note: The limitation of the total exposure in a 24-hours period of time is due to the fact that biological tissue needs time to recover after an exposure near or above the EL. If an exposure according to the table has occurred within 8 hours, further exposure to UV-radiation is not to be advised in the following 16 hours.

2. The radiation from a source giving more than one spectral line or a continuos spectrum should be weighted with respect to the biological spectral efficiency of the radiation. The weighted exposure should not exceed 30 J/m^2, the value that apply to the most effective wavelength 270 nm according to the table. The weighted effective irradiance (E_{eff}) is calculated as shown below.

As the biological response differs for different wavelengths the contribution from each wavelength range should be multiplied by the applicable weighting factor $S\lambda$. The weighting procedure makes the different contributions comparable and thus they could be added:

$$E_{eff} = \sum_{\lambda} (E\lambda \cdot S\lambda \cdot \Delta\lambda)$$

where

$E\lambda$ = the spectral irradiance in W/m^2 nm,
$S\lambda$ = the relative biological efficiency and
$\Delta\lambda$ = the wavelength interval in nm.

Thus E_{eff} is the weighted irradiance with respect to a monochromatic source giving the wavelength 270 nm.

The weighted exposure is the weighted irradiance multiplied by the exposure time. The longest exposure time to be advised (t_{max}, seconds) is calculated from

$$E_{eff} \cdot t_{max} = 30\ J/m^2 \quad \text{and hence} \quad t_{max} = 30/E_{eff}$$

Comments

As reference and in order to easier comprehend the figures above a comparison to solar-radiation containing UV-radiation within the interval 290 - 400 nm could be done. In the middle of the day in the middle of the summer the solar radiation on the latitudes of the Canary Islands at sea level gives a weighted exposure of about 280 J/m^2 per hour. In Sweden, at 60^o north latitude, the corresponding value is, as maximum, measured to be 100 J/m^2 per hour.

The table below shows the approximate exposure times needed to produce a barely recognised erythema (reddening of the skin) at not sunburned skin.

Source	Exposure time
Solar radiation (Sweden)	30 minutes
Quarts lamp (old type)	1 - 3 minutes (distance 0.7 metres)
Electric welding arc	1- 10 seconds (distance 0.5 metres)

Exposure exceeding the above mentioned exposure times by a factor of about three gives obvious erythema. An exposure exceeding the exposure times in the table by a factor of five gives a painful sunburn. An exposure exceeding the exposure times in the table by a factor of ten gives blistering.

In order to simplify computer calculations the factors $S\lambda$ are given in analytic expressions that work in all practical applications with sufficient accuracy.

$220 < \lambda \leq 270$	$S\lambda = 0.959^{(270 - \lambda)}$
$270 < \lambda \leq 300$	$S\lambda = 1 - 0.36((\lambda - 270) / 20)^{1.64}$
$300 < \lambda \leq 400$	$S\lambda = 0.3 \cdot 0.736^{(\lambda - 300)} + 10^{(2 - 0.0163 \cdot \lambda)}$

λ shall be expressed in nm.

These general advice replace the general advice (SSI FS 1978:6) on ultraviolet radiation.

On behalf of the Board of the Swedish Radiation Protection Institute

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