Article 13

Practical guide

In order to facilitate application of this Directive the Commission shall draw up a practical guide to the provisions of Articles 4 and 5 and Annexes I and II.

Article 14

Transposition

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by … (*). They shall forthwith inform the Commission thereof.

When Member States adopt these measures, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. The methods of making such reference shall be laid down by Member States.

2. Member States shall communicate to the Commission the text of the provisions of national law which they adopt or have already adopted in the field covered by this Directive.

Article 15

Entry into force

This Directive shall enter into force on the day of its publication in the Official Journal of the European Union.

Article 16

Addressees

This Directive is addressed to the Member States.

Done at …, on …

For the European Parliament	For the Council
The President	*The President*

(*) Four years after the *date of* entry into force of this Directive.

ANNEX I

NON-COHERENT OPTICAL RADIATION

The biophysically relevant exposure values to optical radiation can be determined with the formulae below. The formulae to be used depend on the range of radiation emitted by the source and the results should be compared with the corresponding exposure limit values indicated in Table 1.1. More than one exposure value and corresponding exposure limit can be relevant for a given source of optical radiation.

Numbering (a) to (o) refers to corresponding rows of Table 1.1.

(a)	$H_{eff} = \int_{0}^{t} \int_{\lambda = 180\,nm}^{\lambda = 400\,nm} E_{\lambda}(\lambda, t) \cdot S(\lambda) \cdot d\lambda \cdot dt$	(H_{eff} is only relevant in the range 180 to 400 nm)
(b)	$H_{UVA} = \int_{0}^{t} \int_{\lambda = 315\,nm}^{\lambda = 400\,nm} E_{\lambda}(\lambda, t) \cdot d\lambda \cdot dt$	(H_{UVA} is only relevant in the range 315 to 400 nm)
(c), (d)	$L_B = \int_{\lambda = 300\,nm}^{\lambda = 700\,nm} L_{\lambda}(\lambda) \cdot B(\lambda) \cdot d\lambda$	(L_B is only relevant in the range 300 to 700 nm)
(e), (f)	$E_B = \int_{\lambda = 300\,nm}^{\lambda = 700\,nm} E_{\lambda}(\lambda) \cdot B(\lambda) \cdot d\lambda$	(E_B is only relevant in the range 300 to 700 nm)
(g) to (l)	$L_R = \int_{\lambda_1}^{\lambda_2} L_{\lambda}(\lambda) \cdot R(\lambda) \cdot d\lambda$	(See Table 1.1 for appropriate values of λ1 and λ2)
(m), (n)	$E_{IR} = \int_{\lambda = 780\,nm}^{\lambda = 3\,000\,nm} E_{\lambda}(\lambda) \cdot d\lambda$	(E_{IR} is only relevant in the range 780 to 3 000 nm)
(o)	$H_{skin} = \int_{0}^{t} \int_{\lambda = 380\,nm}^{\lambda = 3000\,nm} E_{\lambda}(\lambda, t) \cdot d\lambda \cdot dt$	(H_{skin} is only relevant in the range 380 to 3 000 nm)

For the purposes of this Directive, the formulae above can be replaced by the following expressions and the use of discrete values as set out in the following tables:

(a)	$E_{eff} = \sum_{\lambda = 180\,nm}^{\lambda = 400\,nm} E_{\lambda} \cdot S(\lambda) \cdot \Delta\lambda$	and $H_{eff} = E_{eff} \cdot \Delta t$
(b)	$E_{UVA} = \sum_{\lambda = 315\,nm}^{\lambda = 400\,nm} E_{\lambda} \cdot \Delta\lambda$	and $H_{UVA} = E_{UVA} \cdot \Delta t$
(c), (d)	$L_B = \sum_{\lambda = 300\,nm}^{\lambda = 700\,nm} L_{\lambda} \cdot B(\lambda) \cdot \Delta\lambda$	
(e), (f)	$E_B = \sum_{\lambda = 300\,nm}^{\lambda = 700\,nm} E_{\lambda} \cdot B(\lambda) \cdot \Delta\lambda$	
(g) to (l)	$L_R = \sum_{\lambda_1}^{\lambda_2} L_{\lambda} \cdot R(\lambda) \cdot \Delta\lambda$	(See Table 1.1 for appropriate values of λ_1 and λ_2)
(m), (n)	$E_{IR} = \sum_{\lambda = 780\,nm}^{\lambda = 3000\,nm} E_{\lambda} \cdot \Delta\lambda$	
(o)	$E_{skin} = \sum_{\lambda = 380\,nm}^{\lambda = 3000\,nm} E_{\lambda} \cdot \Delta\lambda$	and $H_{skin} = E_{skin} \cdot \Delta t$

Notes:

$E_{\lambda}(\lambda,t)$, E_{λ}	spectral irradiance or spectral power density: the radiant power incident per unit area upon a surface, expressed in watts per square metre per nanometre [W m^{-2} nm^{-1}]; values of $E_{\lambda}(\lambda,t)$ and Eλ come from measurements or may be provided by the manufacturer of the equipment;
E_{eff}	effective irradiance (UV range): calculated irradiance within the UV wavelength range 180 to 400 nm spectrally weighted by S(λ), expressed in watts per square metre [W m^{-2}];
H	radiant exposure: the time integral of the irradiance, expressed in joules per square metre [J m^{-2}];

H_{eff}	effective radiant exposure: radiant exposure spectrally weighted by S (λ), expressed in joules per square metre [J m^{-2}];
E_{UVA}	total irradiance (UVA): calculated irradiance within the UVA wavelength range 315 to 400 nm, expressed in watts per square metre [W m^{-2}];
H_{UVA}	radiant exposure, the time and wavelength integral or sum of the irradiance within the UVA wavelength range 315 to 400 nm, expressed in joules per square metre [J m^{-2}];
S(λ)	spectral weighting taking into account the wavelength dependence of the health effects of UV radiation on eye and skin (Table 1.2) [dimensionless];
t,Δt	time, duration of the exposure, expressed in seconds [s];
λ	wavelength, expressed in nanometres [nm];
Δλ	bandwidth, expressed in nanometres [nm], of the calculation or measurement intervals;
Lλ(λ),Lλ	spectral radiance of the source expressed in watts per square metre per steradian per nanometre [W m^{-2} sr^{-1} nm^{-1}];
R(λ)	spectral weighting taking into account the wavelength dependence of the thermal injury caused to the eye by visible and IRA radiation (Table 1.3) [dimensionless];
L_R	effective radiance (thermal injury): calculated radiance spectrally weighted by R (λ) expressed in watts per square metre per steradian [W m^{-2} sr^{-1}];
B(λ)	spectral weighting taking into account the wavelength dependence of the photochemical injury caused to the eye by blue light radiation (Table 1.3) [dimensionless];
L_B	effective radiance (blue light): calculated radiance spectrally weighted by B (λ), expressed in watts per square metre per steradian [W m^{-2} sr^{-1}];
E_B	effective irradiance (blue light): calculated irradiance spectrally weighted by B (λ) expressed in watts per square metre [W m^{-2}];
E_{IR}	total irradiance (thermal injury): calculated irradiance within the infrared wavelength range 780 nm to 3 000 nm expressed in watts per square metre [W m^{-2}];
E_{skin}	total irradiance (visible, IRA and IRB): calculated irradiance within the visible and infrared wavelength range 380 nm to 3 000 nm, expressed in watts per square metre [W m^{-2}];
H_{skin}	radiant exposure, the time and wavelength integral or sum of the irradiance within the visible and infrared wavelength range 380 to 3 000 nm, expressed in joules per square metre (J m^{-2});
α	angular subtense: the angle subtended by an apparent source, as viewed at a point in space, expressed in milliradians (mrad). Apparent source is the real or virtual object that forms the smallest possible retinal image.

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Table 1.1: Exposure limit values for non-coherent optical radiation

Index	Wavelength nm	Exposure limit value	Units	Comment	Part of the body	Hazard
a.	180-400 (UVA, UVB and UVC)	$H_{eff} = 30$ Daily value 8 hours	$[J\ m^{-2}]$		eye (cornea, conjunctiva, lens) skin	photokeratitis, conjunctivitis, cataractogenesis, erythema, elastosis, skin cancer
b.	315-400 (UVA)	$H_{UVA} = 10^4$ Daily value 8 hours	$[J\ m^{-2}]$		eye lens	cataractogenesis
c.	300-700 (Blue light) (1)	$L_B = \frac{10^6}{t}$ for $t \leq 10\,000$ s	L_B: $[W\ m^{-2}\ sr^{-1}]$ t: [seconds]	for $\alpha \geq 11$ mrad	eye retina	photoretinitis
d.	300-700 (Blue light) (1)	$L_B = 100$ for $t > 10\,000$ s	$[W\ m^{-2}\ sr^{-1}]$			
e.	300-700 (Blue light) (1)	$E_B = \frac{100}{t}$ for $t \leq 10\,000$ s	E_B: $[W\ m^{-2}]$ t: [seconds]	for $\alpha < 11$ mrad (2)		
f.	300-700 (Blue light) (1)	$E_B = 0{,}01$ $t > 10\,000$ s	$[W\ m^{-2}]$			
g.	380-1 400 (Visible and IRA)	$L_R = \frac{2{,}8\ 10^7}{C_\alpha}$ for $t > 10$ s	$[W\ m^{-2}\ sr^{-1}]$	$C_\alpha = 1{,}7$ for $\alpha \leq 1{,}7$ mrad $C_\alpha = \alpha$ for $1{,}7 \leq \alpha \leq 100$ mrad $C_\alpha = 100$ for $\alpha > 100$ mrad $\lambda_1 = 380$; $\lambda_2 = 1\,400$	eye retina	retinal burn
h.	380-1 400 (Visible and IRA)	$L_R = \frac{5\ 10^7}{C_\alpha * t^{0.25}}$ for $10\ \mu s \leq t \leq 10$ s	L_R: $[W\ m^{-2}\ sr^{-1}]$ t: [seconds]			
i.	380-1 400 (Visible and IRA)	$L_R = \frac{8{,}89\ 10^8}{C_\alpha}$ for $t < 10\ \mu s$	$[W\ m^{-2}\ sr^{-1}]$			
j.	780-1 400 (IRA)	$L_R = \frac{6\ 10^6}{C_\alpha}$ for $t > 10$ s	$[W\ m^{-2}\ sr^{-1}]$	$C_\alpha = 11$ for $\alpha \leq 11$ mrad $C_\alpha = \alpha$ for $11 \leq \alpha \leq 100$ mrad $C_\alpha = 100$ for $\alpha > 100$ mrad (measurement field-of-view: 11 mrad) $\lambda_1 = 780$; $\lambda_2 = 1\,400$	eye retina	retinal burn
k.	780-1 400 (IRA)	$L_R = \frac{5\ 10^7}{C_\alpha\ t^{0.25}}$ for $10\ \mu s \leq t \leq 10$ s	L_R: $[W\ m^{-2}\ sr^{-1}]$ t: [seconds]			
l.	780-1 400 (IRA)	$L_R = \frac{8{,}89\ 10^8}{C_\alpha}$ for $t < 10\ \mu s$	$[W\ m^{-2}\ sr^{-1}]$			
m.	780-3 000 (IRA and IRB)	$E_{IR} = 18\,000\ t^{-0{,}75}$ for $t \leq 1\,000$ s	E: $[W\ m^{-2}]$ t: [seconds]		eye (cornea, lens)	corneal burn, cataractogenesis
n.	780-3 000 (IRA and IRB)	$E_{IR} = 100$ for $t > 1\,000$ s	$[W\ m^{-2}]$			
o.	380-3 000 (Visible, IRA and IRB)	$H_{skin} = 20\,000\ t^{0{,}25}$ for $t < 10$ s	H: $[J\ m^{-2}]$ t: [seconds]		skin	burn

(1) The range of 300 to 700 nm covers parts of UVB, all UVA and most of visible radiation; however, the associated hazard is commonly referred to as 'blue light' hazard. Blue light strictly speaking covers only the range of approximately 400 to 490 nm.

(2) For steady fixation of very small sources with an angular subtense < 11 mrad, L_B can be converted to E_B. This normally applies only for ophthalmic instruments or a stabilized eye during anaesthesia. The maximum 'stare time' is found by: $t_{max} = 100 / E_B$ with E_B expressed in $W\ m^{-2}$. Due to eye movements during normal visual tasks this does not exceed 100s.

Table 1.2: S(λ) [dimensionless], 180 nm to 400 nm

λ in nm	S(λ)	λ in nm	S(λ)	λ in nm	S(λ)	λ in nm	S(λ)	λ in nm	S(λ)
180	0,0120	228	0,1737	276	0,9434	324	0,000520	372	0,000086
181	0,0126	229	0,1819	277	0,9272	325	0,000500	373	0,000083
182	0,0132	230	0,1900	278	0,9112	326	0,000479	374	0,000080
183	0,0138	231	0,1995	279	0,8954	327	0,000459	375	0,000077
184	0,0144	232	0,2089	280	0,8800	328	0,000440	376	0,000074
185	0,0151	233	0,2188	281	0,8568	329	0,000425	377	0,000072
186	0,0158	234	0,2292	282	0,8342	330	0,000410	378	0,000069
187	0,0166	235	0,2400	283	0,8122	331	0,000396	379	0,000066
188	0,0173	236	0,2510	284	0,7908	332	0,000383	380	0,000064
189	0,0181	237	0,2624	285	0,7700	333	0,000370	381	0,000062
190	0,0190	238	0,2744	286	0,7420	334	0,000355	382	0,000059
191	0,0199	239	0,2869	287	0,7151	335	0,000340	383	0,000057
192	0,0208	240	0,3000	288	0,6891	336	0,000327	384	0,000055
193	0,0218	241	0,3111	289	0,6641	337	0,000315	385	0,000053
194	0,0228	242	0,3227	290	0,6400	338	0,000303	386	0,000051
195	0,0239	243	0,3347	291	0,6186	339	0,000291	387	0,000049
196	0,0250	244	0,3471	292	0,5980	340	0,000280	388	0,000047
197	0,0262	245	0,3600	293	0,5780	341	0,000271	389	0,000046
198	0,0274	246	0,3730	294	0,5587	342	0,000263	390	0,000044
199	0,0287	247	0,3865	295	0,5400	343	0,000255	391	0,000042
200	0,0300	248	0,4005	296	0,4984	344	0,000248	392	0,000041
201	0,0334	249	0,4150	297	0,4600	345	0,000240	393	0,000039
202	0,0371	250	0,4300	298	0,3989	346	0,000231	394	0,000037
203	0,0412	251	0,4465	299	0,3459	347	0,000223	395	0,000036
204	0,0459	252	0,4637	300	0,3000	348	0,000215	396	0,000035
205	0,0510	253	0,4815	301	0,2210	349	0,000207	397	0,000033
206	0,0551	254	0,5000	302	0,1629	350	0,000200	398	0,000032
207	0,0595	255	0,5200	303	0,1200	351	0,000191	399	0,000031
208	0,0643	256	0,5437	304	0,0849	352	0,000183	400	0,000030
209	0,0694	257	0,5685	305	0,0600	353	0,000175		
210	0,0750	258	0,5945	306	0,0454	354	0,000167		
211	0,0786	259	0,6216	307	0,0344	355	0,000160		
212	0,0824	260	0,6500	308	0,0260	356	0,000153		
213	0,0864	261	0,6792	309	0,0197	357	0,000147		
214	0,0906	262	0,7098	310	0,0150	358	0,000141		
215	0,0950	263	0,7417	311	0,0111	359	0,000136		
216	0,0995	264	0,7751	312	0,0081	360	0,000130		
217	0,1043	265	0,8100	313	0,0060	361	0,000126		
218	0,1093	266	0,8449	314	0,0042	362	0,000122		
219	0,1145	267	0,8812	315	0,0030	363	0,000118		
220	0,1200	268	0,9192	316	0,0024	364	0,000114		
221	0,1257	269	0,9587	317	0,0020	365	0,000110		
222	0,1316	270	1,0000	318	0,0016	366	0,000106		
223	0,1378	271	0,9919	319	0,0012	367	0,000103		
224	0,1444	272	0,9838	320	0,0010	368	0,000099		
225	0,1500	273	0,9758	321	0,000819	369	0,000096		
226	0,1583	274	0,9679	322	0,000670	370	0,000093		
227	0,1658	275	0,9600	323	0,000540	371	0,000090		

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Table 1.3: B(λ), R(λ) [dimensionless], 380 nm to 1 400 nm

λ in nm	B(λ)	R(λ)
$300 \le \lambda < 380$	0,01	-
380	0,01	0,1
385	0,013	0,13
390	0,025	0,25
395	0,05	0,5
400	0,1	1
405	0,2	2
410	0,4	4
415	0,8	8
420	0,9	9
425	0,95	9,5
430	0,98	9,8
435	1	10
440	1	10
445	0,97	9,7
450	0,94	9,4
455	0,9	9
460	0,8	8
465	0,7	7
470	0,62	6,2
475	0,55	5,5
480	0,45	4,5
485	0,32	3,2
490	0,22	2,2
495	0,16	1,6
500	0,1	1
$500 < \lambda \le 600$	$10^{0,02\cdot(450-\lambda)}$	1
$600 < \lambda \le 700$	0,001	1
$700 < \lambda \le 1\,050$	-	$10^{0,002\cdot(700-\lambda)}$
$1\,050 < \lambda \le 1\,150$	-	0,2
$1\,150 < \lambda \le 1\,200$	-	$0,2\cdot10^{0,02\cdot(1150-\lambda)}$
$1\,200 < \lambda \le 1\,400$	-	0,02