

Table 1.2

S ( $\lambda$ ) [dimensionless], 180 nm to 400 nm

$\lambda$ in nm	S ( $\lambda$ )	$\lambda$ in nm	S ( $\lambda$ )	$\lambda$ in nm	S ( $\lambda$ )	$\lambda$ in nm	S ( $\lambda$ )	$\lambda$ in nm	S ( $\lambda$ )
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		

Table 1.3

**B ( $\lambda$ ), R ( $\lambda$ ) [dimensionless], 380 nm to 1 400 nm**

$\lambda$ in nm	B ( $\lambda$ )	R ( $\lambda$ )
$300 \leq \lambda < 380$	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
$500 < \lambda \leq 600$	$10^{0,02 \cdot (450 - \lambda)}$	1
$600 < \lambda \leq 700$	0,001	1
$700 < \lambda \leq 1\ 050$	—	$10^{0,002 \cdot (700 - \lambda)}$
$1\ 050 < \lambda \leq 1\ 150$	—	0,2
$1\ 150 < \lambda \leq 1\ 200$	—	$0,2 \cdot 10^{0,02 \cdot (1\ 150 - \lambda)}$
$1\ 200 < \lambda \leq 1\ 400$	—	0,02

**Laser 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 wavelength and duration of radiation emitted by the source and the results should be compared with the corresponding exposure limit values indicated in the Tables 2.2 to 2.4. More than one exposure value and corresponding exposure limit can be relevant for a given source of laser optical radiation.

Coefficients used as calculation tools within the Tables 2.2 to 2.4 are listed in Table 2.5 and corrections for repetitive exposure are listed in Table 2.6.

$$E = \frac{dP}{dA} \text{ [W m}^{-2}\text{]}$$

$$H = \int_0^t E(t) \cdot dt \text{ [J m}^{-2}\text{]}$$

Notes:

dP power expressed in watt [W];

dA surface expressed in square metres [m<sup>2</sup>];

E (t), E irradiance or power density: the radiant power incident per unit area upon a surface, generally expressed in watts per square metre [W m<sup>-2</sup>]. Values of E(t), E come from measurements or may be provided by the manufacturer of the equipment;

H radiant exposure: the time integral of the irradiance, expressed in joules per square metre [J m<sup>-2</sup>];

t time, duration of the exposure, expressed in seconds [s];

λ wavelength, expressed in nanometres [nm];

γ limiting cone angle of measurement field-of-view expressed in milliradians [mrad];

γ<sub>m</sub> measurement field of view expressed in milliradians [mrad];

α angular subtense of a source expressed in milliradians [mrad];

limiting aperture: the circular area over which irradiance and radiant exposure are averaged;

G integrated radiance: the integral of the radiance over a given exposure time expressed as radiant energy per unit area of a radiating surface per unit solid angle of emission, in joules per square metre per steradian [J m<sup>-2</sup> sr<sup>-1</sup>].

Table 2.1

**Radiation hazards**

Wavelength [nm] $\lambda$	Radiation range	Affected organ	Hazard	Exposure limit value table
180 to 400	UV	eye	photochemical damage and thermal damage	2.2, 2.3
180 to 400	UV	skin	erythema	2.4
400 to 700	visible	eye	retinal damage	2.2
400 to 600	visible	eye	photochemical damage	2.3
400 to 700	visible	skin	thermal damage	2.4
700 to 1 400	IRA	eye	thermal damage	2.2, 2.3
700 to 1 400	IRA	skin	thermal damage	2.4
1 400 to 2 600	IRB	eye	thermal damage	2.2
2 600 to $10^6$	IRC	eye	thermal damage	2.2
1 400 to $10^6$	IRB, IRC	eye	thermal damage	2.3
1 400 to $10^6$	IRB, IRC	skin	thermal damage	2.4