Luminous Range

The range at which a light can be seen by a normal observer with a direct line of sight depends on the light's intensity (brightness), the level of back-ground light and the atmospheric conditions at the time. For a light of a given intensity (expressed in candelas) the effective range under normal conditions, either at night or in daytime, can be read from the tables below. The tables give ranges for atmospheric transmissivity of 74% (0.74T) which corresponds to clear weather conditions and is customarily used for estimating ranges for the North Atlantic and similar areas. The night-time table also gives ranges for 85% (0.85T) which corresponds to very clear conditions and is used for tropical areas.

Day Range

Day-Time Range in Nautical Miles for 0.74T assuming background light intensity of 10,000 cd/m²

Nm	cds	Nm	cds	Nm	cds
0.1	35	2.1	28,500	4.1	198,000
0.2	146	2.2	32,200	4.2	215,000
0.3	338	2.3	36,300	4.3	232,000
0.4	620	2.4	40,700	4.4	250,000
0.5	998	2.5	45,600	4.5	270,000
0.6	1,480	2.6	50,800	4.6	290,000
0.7	2,080	2.7	56,400	4.7	312,000
0.8	2,800	2.8	62,600	4.8	336,000
0.9	3,650	2.9	69,200	4.9	361,000
1.0	4,640	3.0	76,300	5.0	387,000
1.1	5,790	3.1	83,900	5.1	415,000
1.2	7,100	3.2	92,200	5.2	444,000
1.3	8,580	3.3	101,000	5.3	476,000
1.4	10,300	3.4	111,000	5.4	509,000
1.5	12,100	3.5	121,000	5.5	544,000
1.6	14,200	3.6	132,000	5.6	581,000
1.7	16,600	3.7	143,000	5.7	621,000
1.8	19,100	3.8	156,000	5.8	662,000
1.9	22,000	3.9	169,000	5.9	706,000
2.0	25,100	4.0	183,000	6.0	753,000

Night Range

Night-Time Range in Nautical Miles assuming no background light **at 0.74T and** 0.85T

Nm	cd	cd	Nm	cd	cd	Nm	cd	cd
0.5	0.2	0.2	4.0	37	21	9.0	836	240
0.6	0.3	0.3	4.1	40	22	9.2	928	259
0.7	0.4	0.4	4.2	43	24	9.4	1,030	280
0.8	0.6	0.5	4.3	46	26	9.6	1,140	301
0.9	0.7	0.6	4.4	50	27	9.8	1,260	324
1.0	0.9	0.8	4.5	54	29	10.0	1,390	349
1.1	1.2	1.0	4.6	58	31	10.2	1,540	375
1.2	1.4	1.2	4.7	62	33	10.4	1,700	403
1.3	1.7	1.4	4.8	67	35	10.6	1,880	432
1.4	2.1	1.7	4.9	72	37	10.8	2,070	463
1.5	2.4	2.0	5.0	77	39	11.0	2,280	497
1.6	2.8	2.3	5.1	83	41	11.2	2,510	532
1.7	3.3	2.6	5.2	89	43	11.4	2,760	569
1.8	3.8	3.0	5.3	95	46	11.6	3,040	609
1.9	4.4	3.4	5.4	102	48	11.8	3,340	651
2.0	5.0	3.8	5.5	109	51	12.0	3,670	695
2.1	5.7	4.3	5.6	116	54	12.5	4,630	818
2.2	6.4	4.8	5.7	124	56	13.0	5,820	960
2.3	7.3	5.3	5.8	132	59	13.5	7,290	1,120
2.4	8.1	5.8	5.9	141	62	14.0	9,120	1,310
2.5	9.1	6.4	6.0	151	66	14.5	11,400	1,520
2.6	10.2	7.1	6.2	171	72	15.0	14,100	1,770
2.7	11.3	7.8	6.4	193	80	15.5	17,600	2,050
2.8	12.5	8.5	6.6	218	87	16.0	21,700	2,370
2.9	13.8	9.3	6.8	246	96	16.5	26,900	2,730
3.0	15.3	10.1	7.0	277	105	17.0	33,200	3,150
3.1	16.8	10.9	7.2	311	115	17.5	40,900	3,620
3.2	18.4	11.8	7.4	349	125	18.0	50,300	4,150
3.3	20.2	12.8	7.6	391	136	19.0	75,700	5,440
3.4	22.1	13.8	7.8	438	148	20.0	113,000	7,090
3.5	24.1	14.9	8.0	489	161	22.0	250,000	11,900
3.6	26.3	16.0	8.2	545	175	24.0	544,000	19,600
3.7	28.6	17.2	8.4	608	190	26.0	1,170,000	31,800
3.8	31.1	18.4	8.6	677	206	28.0	2,470,000	51,000
3.9	33.8	19.7	8.8	753	222	30.0	5,180,000	81,000

Effective Intensity of a Flashing Light

The effective intensity of a flashing light is always less than the peak intensity. The human eye does not have time to completely respond to a short flash in the same way as to a fixed light.

If the variation of intensity through the flash cycle can be measured then the effective intensity, Ie, can be calculated using the Schmidt-Clausen formulae published in the IALA Recommendation paper, published November 1980.

However, when that variation is not known and cannot be measured the following formula can be used to give a good approximation:

$$Ie = \text{Peak intensity} \times \frac{\text{duration of flash in seconds}}{\text{duration of flash} + A}$$

The value of A depends on how the flash is produced. If by blanking or switching, the value of A is 0.2 at night and 0.1 in the daytime. If it is by rotating the light then the value of A is 0.3 at night and 0.15 in the daytime.

This formula can be used for lights flashing up to 300 times per minute. When the light character includes flashes of different lengths (such as a Morse Code character) the shortest flash period should be used.

When using lamp manufacturers' figures for calculating effective intensity, if the light passes through a colour filter or any other form of glazing, there will be some loss of intensity for which due allowance should be made.

Effective Intensity of a Revolving Beam

A rotating beacon must have good photometric qualities. Uniformity of peak intensity from beam to beam, equal angular displacement between beams, and unvarying rotation speeds are essential. Vega's Zero Range photometry facility automatically collects photometric test data, computes key results, and prints a one-page graphical test report. Effective intensity is calculated for each beam as follows:

$$Ie = \frac{\mathbf{Io \ x\ (t2 - t1)}}{\frac{C}{F} + (t2 - t1)}$$

If a photometric data-logging facility is not available a crude estimation of the effective intensity can be obtained by estimating the shape of the intensity-time profile and measuring the effective duration of the flash. A selection of several possible intensity-time profiles is shown at right *(per IALA Dec 1977).*

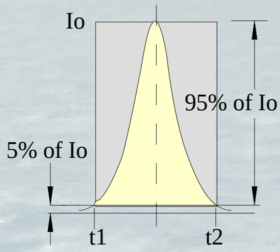
Underneath each profile is the basis for calculating the effective flash duration. For the Gaussian profile, the duration is taken as the time for which the instantaneous intensity exceeds 10% of peak intensity. For simple (single-lens) optical systems the Gaussian profile is the most common one.

Results obtained will only be accurate to the extent that the actual intensity-time profile follows the examples given. The Vega VRB-25 profile, for example, runs above the Gaussian profile because there is less wasted light on the edges of the beam, and the 10% cutoff point yields a relatively short flash duration. The flashed VLB-27 LED Beacon has a profile very close to rectangular.

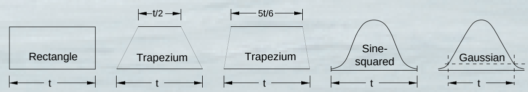
Calculation of Form Factor "F"

$$F = \frac{\text{Area under the curve}}{\text{95\% of Io x (t2 - t1)}}$$

Io = peak Intensity
t = time
t1 = start of flash
t2 = end of flash
C = 0.2 sec for night
C = 0.1 sec for day



Ratio of Effective to Peak Intensities for a Rotating or Flashing Beacon



Flash duration seconds t	Rectangle	Trapezium	Trapezium	Sine-squared	Gaussian
0.001	.004975	.003736	.004562	.002494	.002912
0.002	.009901	.007444	.009083	.004975	.005806
0.005	.02439	.01840	.00224	.01235	.01439
0.01	.04762	.03614	.04383	.02439	.02837
0.02	.09091	.06977	.08397	.04762	.05518
0.05	.2000	.1579	.1864	.1111	.1274
0.1	.3333	.2727	.3143	.2000	.2260
0.2	.5000	.4286	.4783	.3333	.3687
0.5	.7143	.6522	.6962	.5556	.5935
1.0	.8333	.7895	.8209	.7143	.7449
2.0	.9091	.8824	.9010	.8333	.8538
5.0	.9615	.9494	.9582	.9259	.9359
10.0	.9804	.9740	.9786	.9615	.9669

PEL Sector Light Intensity

The fixed intensity of a PEL Sector Light can be expressed by the following formula. The formula assumes that the objective is large enough to pass the magnified filament image.

$$Io = \left[\frac{\text{Sin C}}{\text{Sin O}}\right]^2 \text{ x } \frac{L}{4\pi} \text{ x (M) x (F) x } (U^a \text{ x } C^b)$$

C = 0.5*condenser pickup angle
O = 0.5*total subtense of light
L = lamp lumens output
M = mirror factor (extra light) = 1.7
F = lamp filament factor = 1.0 or 1.41 (M series)
U = uncoated surface transmission = 0.950
C = coated surface transmission = 0.988
a = no. of uncoated surfaces
b = no. of coated surfaces

Geographical Range

To be seen at a long range a light needs to be above the observer's horizon

Geographical Range in Nautical Miles

Ht of light above msl	Height of observer above mean sea level: 0m	5m	8m	11m	15m
3m	3.3	7.6	8.8	9.7	10.8
5m	4.3	8.6	9.8	10.7	11.8
7m	5.1	9.4	10.5	11.5	12.6
10m	6.1	10.4	11.5	12.5	13.6
15m	7.5	11.8	12.9	13.8	14.9
20m	8.6	12.9	14.1	15.0	16.1
30m	10.5	14.9	16.0	16.9	18.0
40m	12.2	16.5	17.6	18.6	19.6
50m	13.6	17.9	19.1	20.0	21.1
60m	14.9	19.2	20.4	21.3	22.4
70m	16.1	20.4	21.6	22.5	23.6
80m	17.2	21.5	22.7	23.6	24.7
90m	18.3	22.6	23.7	24.7	25.7

Atmospheric Transmissivity

Some light from a beacon is always absorbed or scattered by the air it passes through. The exact amount is dependent on the atmospheric conditions at the time. Atmospheric transmissivity is expressed as the proportion of light remaining after travelling one nautical mile. 0.74T corresponds to conditions in which a beam of light retains 74% of its intensity after one nautical mile.

Visibility also depends on contrast with background light. The table gives approximate visibility for a contrast ratio of 0.05.

T	Visibility	Weather	T	Visibility	Weather
0.10	1.3Nm	Haze	0.70	8.5Nm	Clear
0.20	1.8Nm	-	0.74	10.0Nm	Very clear
0.30	2.5Nm	Light haze	0.80	14.0Nm	-
0.40	3.2Nm	-	0.85	20.0Nm	-
0.50	4.3Nm	-	0.90	29.0Nm	Except clear
0.60	6.0Nm	Clear	1.00	Unlimited	-