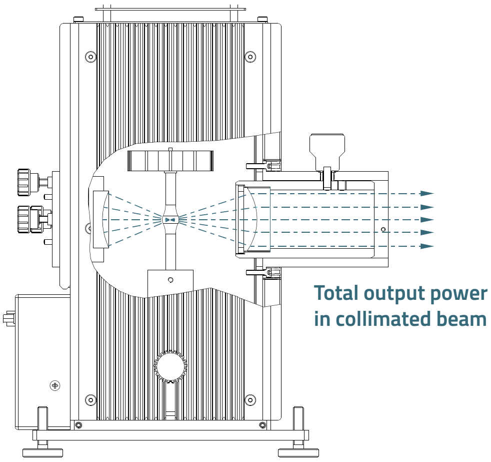
Estimating source output



A word on the data
The following output spectra data of different lamps are based on comparison with calibrated spectral irradiance and thermopile standards. Rather than providing absolute irradiance data the goal is to provide typical output data as a basis for the choice of a lamp. Accordingly, these data should be regarded as typical and they are subject to variation from lamp to lamp. There is a variation up to ±20 - 30% in output and even more in the UV (< 280 nm) depending on the lamp type and other factors.

Envelope materials may change in composition and the envelope thickness is not subject to tight tolerancing. Electrode materials and geometric size are constantly under development (and therefore changing) and accordingly have an impact on the output. Arc lamp aging causes a reduction in output of 20% due to bulb blackening.

The measurements are of lamps operated in the open. Thermal conditions are different for lamps operated in lamp housings. Nevertheless we believe this data to be very useful for choosing the right or best source.

Don't get misled by the total power! The total power increases with lamp power. But more irradiance is not necessarily better, lower power lamps have advantages.

Typical output of your source
The typical output power per nm in the collimated beam of the light source can be estimated by using the irradiance values with the following conversion factors:

F/number	Conversion factor*
150 to 500 W housing	
1.3	0.05 · x
1.0	0.065 · x
1000 W housing	
1.0	0.12 · x

* lamp-dependent:
150 W housing 150 W Xe
1 kW housing 1000 W Xe

The procedure is as follows: Read the value of irradiance from the curves in chapter "Lamp spectra and irradiance data". The value is in $mWm^{-2}nm^{-1}$ for a distance of 0.5 m. By multiplying this value with the conversion/ factor you get the total output in the collimated beam directly in $mWnm^{-1}$.

The conversion factor was measured empirically (as real light sources are neither point sources nor truly isotropic). The output intensity was measured with a lamp housing with specific optics and lamp and the conversion factor then was determined with the values of irradiance at 500 nm. The values for other wavelengths within this transmission range of the condenser are similar.

X gives effect to the lens's focal length shortening at shorter wavelengths (dispersion of refractive index). This can be taken as 1.0 above 500 nm. Below 500 nm it varies as follows:

$$x = \left(\frac{N_\lambda - 1}{N_{500\,nm} - 1}\right)^2$$

with N = wavelength in nm.

The data does not include power recovered by the spherical reflector which will adds 20 – 50%, depending on the lamp type and wavelength.

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Estimating source output

Example 1
Find for the output from 400 - 600 nm in the collimated beam of a 150 W Xe-lamp with F/1.5 condensing optics.

The curve for the 150 W Xe lamp shows a value of approx. 15 mWm-2nm-1 for the range of 400 - 600 nm. The F/1.5 condenser has a conversion factor of 0.05.

The spectral bandwidth is 200 nm. Multiplication of 15 with 0.05 gives a result of 0.75 mW/nm^{-1} for the average output in the collimated beam (under consideration of the changed units). The rear reflector in the lamp housing increases the output by approx. 50%.
So the final output is:

0.75 x 200 x 1.5 = 225 mW

Example 2
Find the output of a Hg line (365 nm) with 5 nm bandwidth in a collimated beam of a 1 kW Hg(Xe) lamp in a lamp housing with F/1 condensing optics.

The curve shows a value of approx. 3 x 10^3mWm^{-2}nm^{-1} resp. a value of approx. 1 x 10^3 mWm^{-2}nm^{-1} for 365 ± 2.5 nm. The calculation of the area (triangle) with a 5 nm bandwidth gives a value of 5.000 mWm^{-2}.

The conversion factor of the F/1 condenser is 0.12. Therefore the output will be 5.000 x 0.12 = 600 mW. The rear reflector adds 50%, so the total output is:

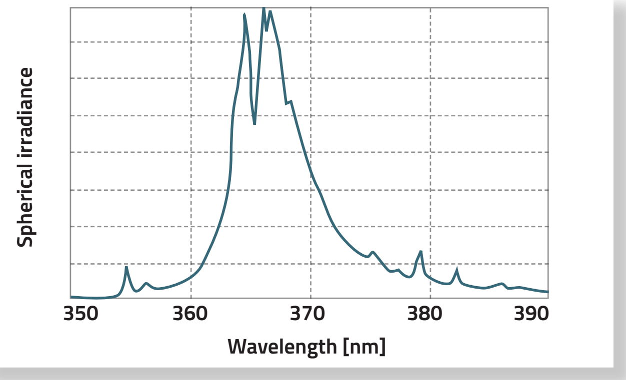
0.6 x 1.5 = 0.9 W

Approximation only
Please keep in mind that this is always just an approximation. The conversion factor depends on the lamp and does not consider the additional gain by the rear reflector in the lamp housing. Furthermore, all of the above refers to data of a condenser adjusted in a way that a collimated beam in the visible is produced. The total intensity may be increased by producing a diverging beam and by moving the condenser closer to the lamp and vice versa.

With a rear reflector you get up to 50% more output for arc lamps. Under 350 nm it reflects less (approx. 20% at 250 nm). For halogen lamps the reflector also provides more output. But for lamps with close-packed planar filaments the image of the filament produced by the reflector has to be placed next to the direct image. This can reduce the usefulness of the reflector. When the image of the reflector is directly placed on the filament, it will be overstrained. The power balance of the light source changes which leads to an intensity drift.

Hg lines
The Hg lines of high-pressure arc lamps are substantially broadened and show line shifting from the tabulated line values. The light emitted from the inner part of the plasma arc is absorbed in the cold outer part of the arc which leads to self-absorption of the Hg lines. The figure below shows the 365 Hg line.

This is important for selecting an interference filter peaking at Hg lines.



Self adsorption of 365 nm Hg line

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