Choosing the right Condenser

In the following we have put together some important criteria for the choice and use of condensers.

Our condensing optics vary in material and number of lenses, in their spherical aberration and radiant flux present at the output. Light gathering capability is described by the F-number. The F-number of a lens is as a first approximation given by the ratio of focal length to diameter. In principle one can say: the smaller the F-number, the more light can be collected and collimated by a condenser.

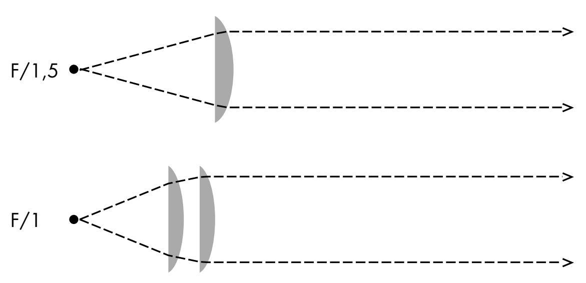

Fig. 1 Condensers with different F-number

F-Number and Beam Quality

The reduction of the F-number unfortunately leads to an increase of aberration of the optics. Though a lens with lower F-number collects much more light, the parallelism of the collimated beam is of poorer quality. Even with a point source the collimated beam has diverging rays far from the collimated ideal. No optical system can focus a poor quality beam to a good image of the source. I.e.: although the beam of a condenser with lower F-number collects more intensity than one with higher F-number, it is not possible to focus the highly intensive beam on a small spot! So for all applications where image quality or spot size are important, a condenser with higher F-number will give better results.

The practical limit for the F-number for spherical lenses depends on the application. For high performance imaging the limit is about F/4. In practice F-number of F/2 – F/1,5 have proved to be a good compromise for arc lamps. The lens must have an adequate radius of curvature and the correct side (plane) has to be turned to the light source. Plano-convex condensers have much poorer aberration performance, if the are not mounted correctly.

Spectral Transmittance

The spectral transmittance of arc and halogen lamps is limited by the quartz material of the envelope. The substrate material of a condenser also has a limited spectral transmittance. The UV transmittance of condensers especially is important, if you don't want to further reduce the limited transmission of the lamp due to the envelope material. The UV transmittance of quartz depends very much on the quality of the material and on cumulative exposure to short wavelength radiation (solarization < 260 nm). Our condensers are made from selected synthetic silica for best ultraviolet transmittance. For typical transmittance curves go to the chapter „Transmittance, reflectance and refractive index of optical materials" on www.lot-oriel.com/lightsources („Basics"). Depending on the application it may also be preferable to limit the emission of the light source by using a particular substrate material. It is for example possible to block UV transmittance with a glass condenser.

Thermal Stress

The refractive index and therefore the focal length depends on temperature. But for high power light sources the more relevant problem is the danger of lens breakage through thermal stress. The inner lens of a condenser always is situated very close to the lamp and absorbs the infrared and ultraviolet radiation. The resulting thermal stress and the thermal shock on start-up can lead to a breakage of the lens. Therefore the optics of our high power lamp housing's condensers which are closest to the source are always made of quartz. Quartz has a much higher thermal resistance than glass.

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Divergence and Spot size

All real sources resp. radiant sources are no (infinite) point sources, but have finite extent. Fig. 2 shows the geometry of collecting and imaging a source.

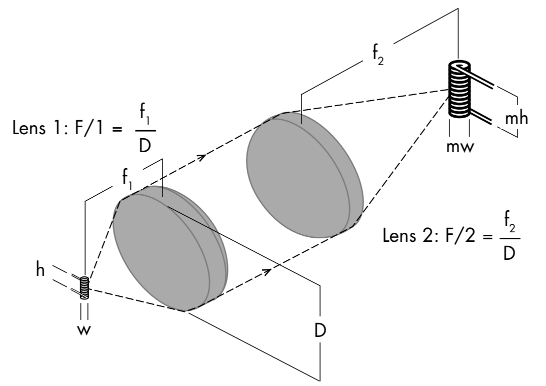

Fig. 2 Image of a Source

The „collimated" beam is divergent. The arc and filament sizes given in the specifications and the focal length of the optics are a good guideline for the divergence. Our 1 kW halogen lamp for example has a 16 mm long cylindric filament with 6 mm diameter. With the filament in the focus of an ideal 50 mm focal length condenser, the collimated beam in the worst case shows a divergence of 0 to ±9° to the optical axis.

Spherical Aberration

Due to manufacturing most lenses have spherical surfaces. A spherical surface does not make an ideal lens. The focal length of a spherical lens is shorter for marginal rays than for paraxial rays. The marginal rays of a single element condenser are diverging, whereas only the paraxial rays are collimated (see fig. 3). This effect is called spherical aberration.

The aberration of a condenser increases with widening collimation angle, eg. the wider the collimation angle, the more difficult a good quality image can be achieved. Especially (in cases) where a second lens should be used for imaging, eg. a monochromator slit or fiber optic, even little spherical aberration can lead to great losses in performance. Focussing collimated light through an optics with spherical aberration always leads to a magnified, diffuse image of the source. You will reach better results, when placing the lens closer to the lamp.

The best position depends on the lens, source size and your application. Our condensers have focus adjust (independent from lamp adjustment), which allows you to find the best position by trial and error.

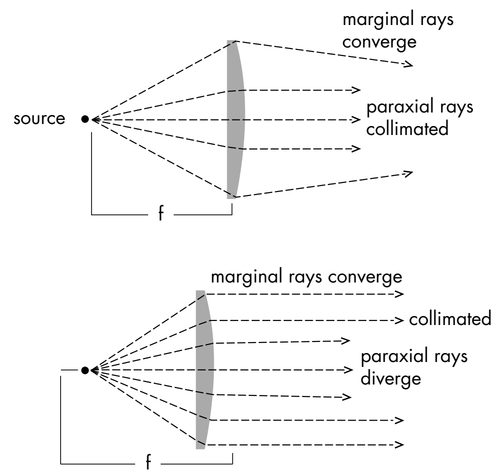

Fig. 3 Spherical Aberration

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