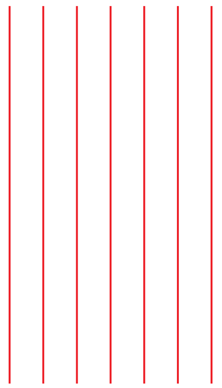
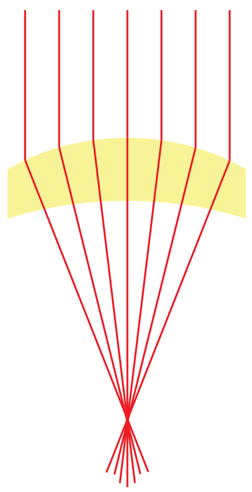
Perfect Laser Technologies

TECHNICAL BULLETIN # 32

Focus on your lens and you will get good cuts



Beam direct from tube without focus lens showing the light path. Note lack of convergence and focus point.



Beam through standard lens showing the light path. Note convergence and focus point.

Laser Lens Focus

Lasers, in general, require focusing the beam. The reason is that what actually does the cutting is not the raw power in the beam, but the power density, or how many Watts per unit area.

A 50 Watt unfocused laser beam measured at about one metre away from the laser output end, has a beam diameter of about 6mm (more or less). The area of a 6mm circle is around 28.27 square mm. So the beam (at maximum theoretical power) at that position has a power density of 50/28.27 = 1.77 Watts per square mm (or an intensity of 177 Watts per square cm).

If there was something you could cut with this intensity (say some thin plastic), then the width of the cut would be 6mm (one diameter) wide, which would not be a precision cut, and would have to be extremely slow, which would then allow heat of the beam to propagate and set things on fire.

Try cutting a piece of steak with a 6mm wide, dull knife.

Let's say you could increase the power of your laser to 500 Watts. Now you would have the same 6mm cut, but an intensity of 1768 Watts per square cm. All you would do is set everything on fire.

If, however, we reduce the area of the 50 Watt beam by using a lens, things start to happen! Let's say you use a lens that can reduce the beam diameter from 6mm to 0.6mm (10 times smaller), the area would become 100 times smaller and therefore the power density (intensity) would be 100 times larger or 17700 Watts per square cm or 177 Watts per square mm.

With an intensity of 177 Watts per square mm and a 0.6mm beam diameter, you can cut a lot of stuff - and fast.

So what would happen if you get a lens to reduce the beam diameter 100 times and increase its intensity 10000 times? Well, you can't, because there are fundamental laws of physics that limit the size of a beam of light (a laser is light, remember?).

Even if the laser and lens were perfect, you can't focus a beam to a size smaller than its wavelength. The wavelength of a CO^2 laser is 10.6 micrometers (µm) or 0,0106 mm. This is the smallest diameter it can be focused to under perfect conditions.

In the real world however, you have to compromise, and you would be doing really well to get a spot size of 200 or even 300 µm. The cost of a lens that will provide a 0,0106mm spot could be 20 or more times the cost of the one that gives you a 0.2mm spot. Most clients would not even notice this difference because of the materials used.

More important, from a practical point of view, you need to have some working distance from the output of the lens to the surface you are working on. A very short focal length lens does not have much depth of focus. That means you would be unable to cut anything thicker than say, 1mm.

Again we have to compromise. If you have a working distance of say 101.6mm, then you have automatically chosen to live with a bigger spot than you would have at 50.8mm. Bottom line is : with an ordinary (affordable) ZnSe lens, you should be happy to get a spot size anywhere from 200 to 500 micrometers (0.2 to 0.5mm).

From the spot diameter you can calculate the spot area and from there you can calculate the beam intensity at any power setting.

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