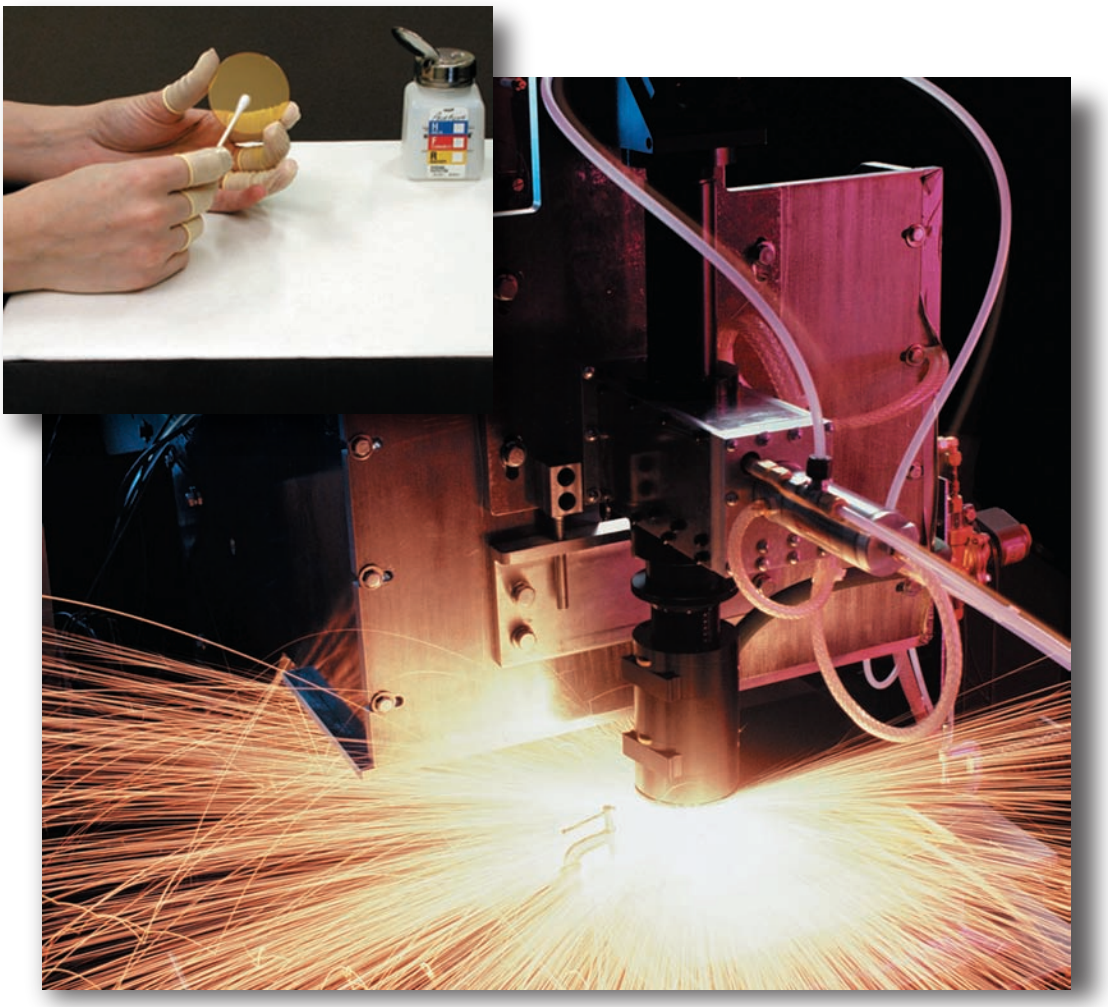
TECHNICAL DATA SHEET

CLEANING AND HANDLING LASER OPTICS

Practical maintenance tips to keep CO_2 lasers running smoothly

By Gary L. Herrit and Dave Scatena



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Introduction

Although optics are considered consumables in high-power CO_2 laser systems, the goal is to consume as few of them as possible. This helps to increase laser uptime and decrease costs.

During replacement, optics must be handled, inspected, and mounted in a way that does not damage or contaminate them. After their initial installation, as optics become contaminated during use, they must be removed and cleaned periodically.

These procedures are fairly simple, and when they are done properly, they will extend the life of the optic and reduce operating costs. Done improperly, however, they will shorten the optic's life.

During laser operation, it is impossible to provide an operating environment for the optics that is completely free of airborne contaminants. Cutting, welding, and heat treating materials with CO_2 lasers can release gases and particulate matter from the workpiece that are potentially harmful to the optics.

When contaminants are deposited on the optic's surface, they begin to absorb the laser beam, resulting in thermal lensing. If the optic has not been heat-stressed, it can be removed and cleaned by the operator. This should be done in a way that minimizes the risk of optic damage and further contamination.

General Handling Tips

During optics handling and cleaning, any contamination on an optic surface, even a fingerprint or oil droplet, can cause the optic to absorb more, shortening its life. Therefore, the following precautions should be taken:

1. Optics never should be handled with bare hands. Finger cots or rubber gloves always should be used.
2. Suction devices for loading or unloading during mounting should not be used because they leave scratches.
3. Optics never should be touched on their coated surfaces. They should be held only at the edge.
4. Optics should be placed on a clean, dry surface for inspection and cleaning. A good optic workstation surface is a few layers of clean paper towels or wipes, covered with a few sheets of clean lens tissue.
5. The user should avoid speaking over the optic and should keep food, beverages, and other potentially contaminating materials away from the work area.

Proper Cleaning Method

In any optics cleaning process, the goal is to remove contamination from the optic's surfaces without further contaminating or damaging them. To this end, the user always should begin with the least risky cleaning method and progress to more stringent methods only if necessary. The steps outlined here are in the order in which they should be taken by the optic user, beginning with the least risky method.

The first step in any optics cleaning process is to use an **air bulb** to remove loose contamination from the surface. For optics with minor particulate or lint on their surfaces, this step may be all that is necessary. Shop air lines should not be used for this step, because compressed air contains oil and water, which will further contaminate the optic.

The next step in the process is a light cleaning with reagent-grade (also known as spectroscopic or HPLC) **acetone** (see **Figure 1**). These finer grades of acetone are nearly water-free, which minimizes the possibility of streaking or contaminating the optic.

A cotton swab dampened with acetone should be used to clean the optic surfaces in a light-pressure, circular motion. The swab should be changed if it becomes contaminated. Cleaning is completed with slow, straight strokes to prevent streaks from forming.

If the optic has two coated surfaces (such as a lens does), both sides should be cleaned in this way. The first side needs to be placed on a clean layer of lens tissue to protect it during this step.

If the acetone cleaning fails to remove all contamination, the next step is to use **acetic acid** to clean the surface. Acetic acid cleans by dissolving certain contaminants, but it will not harm the optic's substrate or coatings. This acetic acid can be laboratory-grade (diluted to 50 percent strength) or even common household white vinegar, which is 6 percent acetic acid.

The cleaning procedure is the same as outlined for acetone, followed by a final acetone cleaning to remove the acid and dry the surface. During the final acetone cleaning, the cotton swabs should be changed frequently to allow the acid/water mixture to be absorbed completely from the optic surface.

If the surface still shows evidence of contamination after this cleaning, then the most stringent cleaning — **polish cleaning** — is performed using a fine-grade (0.1-µm particle size) alumina polishing compound.

This thick, white liquid is applied with a cotton ball. The polish cleans by mechanical abrasion, so it should be applied to the optic surface using slow, overlapping circular strokes without any pressure for no more than 30 seconds. It then is removed with a distilled water rinse or a cotton swab dampened with water.

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After most of the polish is removed, the surface should be cleaned with isopropyl alcohol.

After most of the polish is removed, the surface should be cleaned with isopropyl alcohol. The alcohol picks up the remaining polish and water on the surface and holds it in suspension. Then, the surface can be cleaned with acetone on a cotton swab to remove the alcohol. If the optic still appears to have polish or other residue on its surface after this cleaning, the alcohol and acetone cleaning steps can be repeated until the surface appears clean.

Of course, some contamination and optic damage simply cannot be removed by any cleaning method. This is especially true for metal splatter and for contamination that has been burned into the coating. In these cases, replacing the optic is the only way to restore proper functioning.

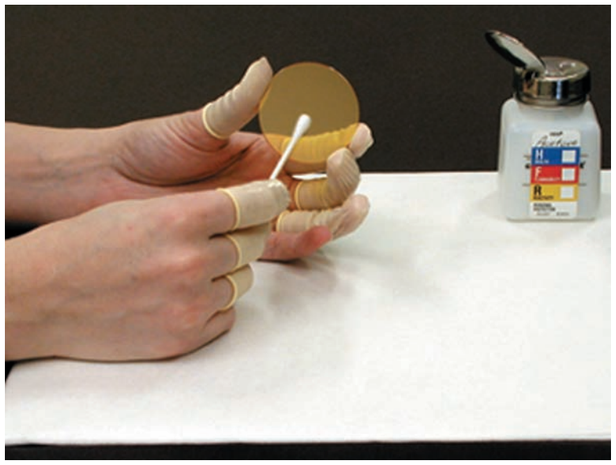

Figure 1

Proper Cleaning Method

During the installation process, optics can be contaminated if they are not handled properly, so the handling tips presented previously in the article should be followed. If a large number of optics must be mounted and dismounted, it is well worth the time and money to design a fixture that can assist in this task. Specialized mounting fixtures minimize the amount of contact with the optic, decreasing the risk of contamination and damage.

In addition, if the optics are installed improperly, the laser system may not function properly, or it could fail entirely. All CO_2 laser optics must be mounted in a particular direction, so the user must determine the optic's proper orientation.

For example, the high-reflection surface of an output coupler in the laser cavity must face the laser, and its antireflection coated surface must face the beam delivery system. If the output coupler is installed backwards, the laser will not lase, or it will lase at a reduced power level.

Final focusing lenses must be oriented with their convex surface facing the laser cavity. The second surface of a lens is either concave or plano, and this surface must face the workpiece. When lenses are installed backwards, the focused spot is larger, and the working distance will change. For cutting applications, this usually results in a larger kerf and slower cutting speeds.

Mirrors are the third type of optic in high-power laser systems, and their installation also is critical. It is easy to identify the high-reflection surface of a mirror because it is highly polished and usually has a thin, visible film coating. Obviously, this coated surface must face the laser beam.

Manufacturers place edge markings on optics as an aid in identifying surfaces. Usually, this edge marking is an arrow that points toward one of the surfaces, but it also could be a special bevel shape or a spot bevel.

Each optic manufacturer has a scheme for how these marks are placed on the optic. However, a common rule is that the arrow points toward the high-reflection surface if the optic is a mirror or output coupler and toward the concave or plano side if the optic is a lens. Sometimes, the optic's label will note the edge marking scheme used for that particular optic.

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Precaution Brings Reward

When optics are cleaned and handled properly, their life and performance can be improved significantly. Taking the few simple precautions discussed in this article will help ensure that CO_2 laser optics last longer and perform better.

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