

Purpose

This guidance reviews the potential hazards of laser cutters and engravers and describes methods of controlling those hazards. It provides information to assist laser cutter owners in understanding infrastructure needs for a proposed laser cutter, creating or updating laser cutter Standard Operating Procedures (SOPs), training users, recognizing maintenance needs important to safety and responding to flare-ups and fires.

Background

Laser cutters and engravers have long been a useful and now increasingly common digital fabrication tool in shops, makerspaces and even research laboratories. They use a thin, focused, laser beam to vector cut or raster engrave various materials into precise designs, patterns, and shapes.

While most laser cutters at MIT use a carbon dioxide (CO₂) laser source there are some fiber laser users and operators of laser cutters should be aware of the variability in laser cutters and engravers in power, size and allowable materials. Familiarity with one laser cutter in a particular location may be helpful but does not necessarily translate into expertise with other manufacturers/models and the procedures in another shop or lab.

Not all laser engravers are capable of cutting, but they are still subject to the same hazards and safety practices as laser cutters. Wherever this document refers only to laser cutters, the guidance applies to laser engravers as well.

Those responsible for the safe use of laser cutters should read the owner's manual and any lab developed procedures and receive lab-based user training.

Planning to Purchase a Laser Cutter?

Before purchasing a laser cutter, the following should be considered.

- Consider only reputable commercial manufacturers that have an eye safe interlocked enclosure, emergency power off, air assist and other safety features. A good assurance of quality is purchasing equipment that has been listed or labeled by UL or another [Nationally Recognized Testing Laboratory](#) (NRTL).
- Does your space have adequate infrastructure to support the facility requirements outlined in the laser cutter's technical specifications. Laser cutter exhaust, discussed in more detail later in this guidance, is often lacking. Be sure that your space can accommodate all other infrastructure needs and that you have a location with a level noncombustible surface away from flammable materials.

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- Most, but not all, laser cutters are sold as Class 1 laser products, meaning that the laser is fully enclosed. Some laser cutters, especially large format cutters capable of cutting large sheets of material, are sold as Class 4 laser products. Contact the Radiation Protection program if you are considering a Class 4 laser cutter, as these may be subject to additional requirements.
- While hobby level laser cutters without an enclosure can be appealing due to their low cost and ease of modifying, they do not meet EHS requirements and may present hazards to the user and bystanders.
- Notify your department, lab, center, or institute (DLCI) Facility Manager and EHS Coordinator that you are planning on a laser cutter purchase.

Potential Hazards

Users should be trained on the hazards of laser cutters and know that when a laser cutter is properly setup and operated, the potential for these hazards is greatly minimized. All laser cutter users should be aware of the following:

Fire Risk

Even a properly maintained and exhausted laser cutter may occasionally have flare-ups that unobserved can progress to a larger fire. Knowing how to respond to flare-ups and fires is key information for every user and is discussed later in this guidance.

Laser cutter fires usually have one of more of the following contributing factors:

- Not observing the laser cutter while operating
- Incorrect power and pulse settings
- Insufficient exhaust
- Unsuitable material
- Dirty optics
- Laser cutter not cleaned out regularly

Respiratory Hazard

The high heat from laser cutting as it burns, melt or vaporizes material can generate the same combustion by-products as a fire, therefore inhaling smoke from a laser cutter can have health concerns similar to smoke from burning materials. These include respiratory irritation and inhalation of toxic particles and gases.

By using a properly setup laser cutter and following established procedures, these air contaminants will be exhausted completely. Note that it is best practice to leave a completed job in the laser for 10 to 15 sec or longer depending on the material to allow the piece time to cool, and any residual smoke and odors to exhaust and off-gas.

Laser Hazard

Most commercially available laser cutters are housed inside an enclosure that reduces the hazard level of the Class 4 laser to Class 1. Damage or injury to the eye or skin is

possible with laser cutting or etching equipment if the equipment laser interlocks are tampered with, bypassed or if optics maintenance is not conducted in accordance with the manufacturer's specifications (usually by a trained manufacturer service rep). Viewing windows are designed to allow visual observation of flare ups, and should not be covered to "keep the laser in." Contact the Radiation Protection Program with any questions concerning laser safety.

Laser Cutter Exhaust and Air Assist

Ensuring that your laser cutter is adequately exhausted according to manufacturer recommendations is critical for safe and effective use. Both exhaust for the unit itself and general room ventilation with single-pass air and would be an inappropriate location for a laser cutter.

Exhaust System

In most cases, only specially designed exhaust systems generate enough static pressure to support most laser cutters. Before purchasing a laser cutter, provide EHS and DOF with the laser cutter exhaust requirements and ask them to evaluate the ventilation where the laser cutter will be located. If you have questions about an existing laser cutter's exhaust, contact EHS to evaluate and discuss options to improve the exhaust if necessary.

Laser cutters with insufficient exhaust do not remove debris and heat as efficiently. The laser optics will get dirty quicker resulting in poorer focusing and laser beam scatter, both of these conditions may contribute to the likelihood of a fire.

Filtration Systems

When the existing exhaust system does not have sufficient static pressure or capacity (cfm), there are a few options such as using a filtration unit to exhaust your laser cutter. Filtration systems, if properly designed and meticulously maintained, also clean the airstream in addition to exhausting the laser cutter. However, there have been several instances at MIT of poorly designed or maintained filtration units leading to odors in labs and shops. It is recommended that the filtration unit output into an exhaust system when feasible. If your laser cutter is only used occasionally, you have good general ventilation and you limit use to a few materials, then a filter unit exhausting into the shop may be an option. Discuss with the filter vendor whether or not a filtration unit would work for your laser cutter and for your planned usage. They can assist in ensuring you obtain the right system for your laser cutter. EHS may also be able to assist.

Best practice for filtration systems

- Conduct routine filter replacements on a schedule as suggested by the ventilation system manufacturer, or as indicated by the system.
- Keep a set of replacement filters on hand for quick replacement.

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- Leave the filtration system on for 10-15 seconds after the laser has finished operating.
- If filters recirculate back into the space, do not cut any material that you are not sure is appropriately captured by the filtration system.
- If odors are detected do not use the laser cutter until the problem is resolved.

Air Assist

The air assist provides compressed air to remove debris and heat at the laser cut point and can be helpful in preventing flare-ups and charring especially for more combustible materials. If this is an optional feature, EHS recommends including this feature when specifying your laser cutter. Know how your air assist functions; there is a wide variation in how they are integrated into laser cutters depending on manufacturer and model. Check before laser cutter use that the air assist is functioning properly.

Registration

Laser cutters contain Class 4 lasers, even if the overall classification is lower, these devices must be included in the central laser inventory according to ANSI Z136.1-2022. Inform the Radiation Protection program of the location, manufacturer, model, serial number and/or MIT property number of all laser cutters on campus. This registration must be updated whenever some of the information changes, typically a responsible person or location of the device, or if the device is transferred or disposed.

Training

Training is required on the safe use and operation of a laser cutter. It should be specific to the equipment manufacturer/model and be consistent with other shop/lab specific rules. The following topics should be included:

- Describe the potential hazards, e.g., hazards of cutting PVC, laser, fire.
- Explain how improper laser cutter settings can increase the likelihood of a fire besides warping, charring, and damaging the project.
- Explanation of the controls, air assist, ventilation, and other safety devices.
- Emphasize that you should never leave the laser cutter during operation. You need to be able to clearly see the cut while the laser cutter is in operation to detect flare-ups or excessive smoke.
- What the user can safely do in the event of a flare-up/fire and when to call 617-253-1212/ evacuate.
- How to do the laser cutter maintenance that each user is responsible for and what should be reported to the supervisor/rep.
- Why you shouldn't defeat the enclosure interlock(s).

Allowable and Prohibited Materials

Each laser cutter owner should develop a list of allowable and prohibited materials. These lists may vary between shops due to laser cutter model, type of

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shop/makerspace and whether the laser cutter is exhausted by a filtration system or building exhaust. Common considerations when developing your list include:

- Prohibit PVC and other chlorinated thermoplastics because processing them in a laser cutter generates hydrogen chloride and corrodes optics.
- Consider including thickness parameters with some materials, for instance, Delrin should only be cut as thin sheets.
- Polycarbonate cuts poorly and generates soot.
- Foam core has been involved in fires at MIT and other locations. Suggest other means of cutting to users.

Manufacturers such as [Epilog](#), [Trotec](#) and [ULS](#) provided have developed material libraries to aid users in evaluating whether materials are suitable for laser processing. These libraries should be used with caution as they may not exclude materials susceptible to fire or provide thickness limits. Most large manufacturers will also evaluate whether a material is laserable for a fee. Their technical support may also be helpful.

Shops should have processes in place to evaluate materials if they allow users to bring in their own. Do not allow materials of unknown composition to be cut. Safety Data Sheets (SDS) when available can be a useful resource for evaluating new materials. The section of most use is usually Section 10 since it covers the hazardous decomposition products generated by cutting or engraving. For instance, if a shop supervisor was evaluating whether neoprene was ok to cut, in Section 10 of a neoprene SDS, it is indicated that hydrogen chloride is a hazardous decomposition product.

Responding to Flare-ups and Fires

The appropriate response to a flare-up or fire may vary based on training, whether one is a student or supervisor and level of comfort. Shop or lab specific procedures for responding to flare-ups and fires should be in the user training. Keep in mind that no one is required to fight a fire at MIT and no one should use a fire extinguisher without the [Fire Extinguisher Familiarization](#) training.

If a flare-up is detected immediately shut off the laser cutter, air assist and filtration unit (if applicable). This may extinguish any flames. Some shops may have the ability to temporarily shut off the ventilation to 'starve' the flare-up of oxygen. If the small flare-up still remains, using a [fire blanket](#) or other non-combustible material to smother the flare-up is recommended.

A fire extinguisher near the laser cutter that can be used by trained users is required. While a Class ABC dry chemical extinguishers are standard in labs and shops, adding a carbon dioxide or Halotron extinguisher is an additional option since these extinguishers are less likely to damage the laser cutter optics.

Laser Cutter Maintenance

Laser cutter owners should establish a process to ensure that proper maintenance of their laser cutter(s) is not neglected. Consider a maintenance logbook kept near the laser cutter to document the completion of required maintenance activities.

Although there may be some adjustments for periods of high or low use, laser cutter maintenance should follow the manufacturer's recommendations. Typical weekly activities for most laser cutters include optics cleaning, cleaning of other internal components and debris removal. Ensure other activities that may be on a longer interval are also completed and that any other manufacturer-recommended preventive maintenance is also performed.

Filtration systems have other maintenance requirements in addition to changing filters, that should be included in a log book to ensure completion.

Laser Cutter Disposal and Recycling

Ensure that your laser cutter is disposed of properly at the end of its useful life. This is especially important given the Class 4 laser present within these systems. Contact the Radiation Protection Program when disposing of a laser cutter. Larger manufacturers may have a process for recycling their laser cutters or just the laser; contact the manufacturer for information. Laser cutters may not be sold or transferred to off-campus parties without the approval of the Radiation Protection Program.

SOP Procedures/Rules for Laser Cutter Use and Operation

Every owner (supervisor/mgr. of the area that uses a laser cutter) should develop a policy/SOP that governs the use of the laser cutter. Elements in the policy should include: training, maintenance, log book, allowed materials, hours of use, and working alone policy. Because there are many variables, each owner should tailor the policy depending on the area, model, ventilation, and user population. The shop or makerspace should have a working alone policy that the laser cutter SOP is consistent with.

Best Practices Checklist for Safe Operation

Administrative

- Only users trained by a qualified individual should operate laser cutters.
- A written laser cutter SOP is recommended. It should cover maintenance requirements for both the equipment and filtration system along with response to flare-up and fires.
- **Never** leave an operating laser cutter unattended. Users should observe the cutting/engraving process. A sign on the laser cutter can be a helpful reminder.
- Keep a logbook with details on laser cutter runs including material cut, cutting time, thickness and parameters like the pulse rate and power.

Procedural

- Develop a list of allowable and prohibited materials. Have a process in place to vet new materials prior to use.
- Avoid placing the laser cutter on wood and other combustible surface. Keep the area around the laser cutter free of clutter and flammable or combustible materials. Never obscure the viewing window.
- Never defeat laser cutter interlocks. This could allow the beam to escape from the laser cutter.

Equipment and Infrastructure

- Regular vacuuming of the cutting deck and the internal cavity of the laser cutter is very important for preventing fires! Ensure all other required maintenance activities are completed.
- A fire extinguisher should be mounted on the wall near the laser cutter.
- Ensure the air assist is working before each run, especially before vector cutting.