

Carnegie Mellon University Environmental Health & Safety FIRE LAB WORK	Environmental Health and Safety Laser Cutter Safety - Guideline
Date of Issuance: 3/26/2019	Revision Date:
Revision Number: Initial	Prepared by: EH&S

1. Purpose

Carnegie Mellon University has developed this guideline to cover general procedures for the safe use and operation of laser cutters.

2. Scope

This guideline applies to all Carnegie Mellon faculty, staff, and students that use and operate laser cutters.

3. Introduction

A laser cutter uses the intense energy of the laser beam to vaporize material placed on the laser cutter work surface.

Materials can be engraved/etched, cut or scribed.

Engraving or etching is the technique where the laser beam transverses left and right, etching horizontal lines of material as it steps down the material vertically, similar to a laser or inkjet printer. The depth of material removed in etching is typically no more than 0.001" or 0.0254 mm, while engraving has a depth of 0.020" to 0.125" or 0.5 mm to 3.2 mm. Engraving is either done via vector engraving or raster engraving.

Cutting or scribing is the technique in which the laser beam follows a path to cut or mark a desired outline.

Due to the nature of laser cutter operations, there are several risks that must be considered.

4. Roles and Responsibilities

- a. Carnegie Mellon University Environmental Health and Safety is responsible for:
 - i. Developing the written Laser Cutter Safety Guidelines and revising as necessary;
 - ii. Completing hazard assessment and reviewing manufacturer's instructions and any applicable Safety Data Sheets (SDS) prior to obtaining new laser cutters;
 - iii. Developing a training program on the safe use and operation of laser cutters; and
 - iv. Conducting routine inspections to ensure the proper use and operation of laser cutters.
- b. Departments will be responsible for:
 - i. Understanding and complying with the requirements of this guideline;
 - ii. Contacting EH&S prior to obtaining a laser cutter and assisting in the hazard assessment review;

- iii. Purchasing laser cutters in accordance with the EH&S “Hazardous Materials Purchasing Guideline (<https://www.cmu.edu/ehs/hazmat-pcard/index.html>);
 - iv. Ensuring the safe use and operation of laser cutters according to this Guideline;
 - v. Conducting and documenting laser cutter-specific training for each user prior to initial use;
 - vi. Submitting “Permission to Work Alone Forms” when activities conducted are covered under the EH&S “Working Alone Guideline” (<https://www.cmu.edu/ehs/Guidelines/index.html>);
 - vii. Maintaining a clean and dust free work area in rooms where laser cutters are housed; and
 - viii. Contacting CMU EHS if assistance is needed.
- c. Users will be responsible for:
- i. Completing training prior to initial use. Training is provided on-line through BioRAFT: <https://www.cmu.edu/ehs/BioRAFT/>;
 - ii. Complying with the procedures outlined in this Guideline; and
 - iii. Informing their supervisor of any problems, defective equipment, or any other issues relating to laser cutters and associated equipment.

5. Risks

The risks addressed by this guideline include, but are not limited to, the following:

a. Fire Creation

The high intensity laser beam can produce extremely high temperatures and significant amounts of heat as the substrate material is burned away while cutting. This high temperature and heat can lead to a fire inside the laser cutter. Some materials such as cardboard are prone to fire creation and extreme care and vigilance must be taken when cutting such materials.

b. Exposure to Laser Generated Air Contaminants (LGAC)

Laser generated air contaminants result from the laser cutter beam striking the material to be cut/engraved. These contaminants can be hazardous particulates, vapors/gases or both. The type of contaminant generated depends on the material being cut/engraved (see Table 1).

Table 1-Common Laser Cutter Emissions by Substrate

Substrate	Emissions
Metals	Heavy metals
Wood (incl. MDF and plywood)	Soot, benzene, formaldehyde, acrolein, Polyaromatic hydrocarbons (PAHs)
Polyamide (Nylon)	Cyanide, nitrogen oxides
Polycarbonate	Benzene, toluene, xylene, cresol, PAHs
Polymethylmethacrylate	MMA and ethyl acrylate, acetone, formaldehyde, phenol, PAHs
Polyoxymethylene (Delrin)	Formaldehyde
Polystyrene	Styrene monomer
Polytetrafluoroethylene (Teflon)	Fluorocarbons, HF
Polyvinylchloride (PVC)	HCl, possible phosgene, benzene, trace dioxins/furans and PCBs

c. Other Chemical Hazards

The materials used in laser cutting can be flammable, cause irritation, skin sensitivity and may contain small amounts of toxic components

d. Exposure to High Voltage

Laser cutters are high voltage pieces of equipment and interaction with the cutter power supply may result in exposure to high voltage.

e. Exposure to Laser Radiation

Typically, LASER cutters are classified by the American National Standards Institute (ANSI) as Class 1 LASERs. Class 1 LASERs emit low levels of energy that are not hazardous to the eyes or skin. However, enclosed within these devices are often Class 3B or 4 LASERs, which are capable of emitting high levels of energy, and are hazardous to the eyes and skin.

f. Exposure to Sharp Edges

Jagged edges can exist on materials processed in the laser cutter. This can lead to cuts, abrasions, and other skin injuries.

6. Exposure Controls

- a. Engineering controls
 - i. Laser cutters may only be used in well ventilated areas (at least 15 air changers per hour) to reduce personnel exposures and the risk of fire or explosion.
 - ii. Laser cutters should only be used in work areas having a dedicated exhaust or appropriate air filtration system.
 - iii. In the absence of enclosure/ventilation the placement of a laser cutter in any area should be reviewed by EH&S before proceeding. EH&S will review information including, but not be limited to, type(s) of materials used, size of the area, operating parameters of the area ventilation system, and other factors.
 - iv. Ventilation controls must be turned on prior to laser cutter operation.
- b. Administrative controls
 - i. Follow the manufacturer's documentation for safe use of laser cutters.
 - ii. Register laser cutters on the appropriate groups' BioRAFT equipment page.
 - iii. Consult safety data sheet (SDS) for all materials being processed in laser cutters.
 - iv. Maintain a clean and dust free working area in rooms where laser cutters are housed.
 - v. Conduct and document a pre-hot-work check prior to work to ensure that all equipment is safe and hazards are recognized and protected. At a minimum this pre-hot-work check shall include, but not be limited to, the following (see Appendix A for a template):
 1. Laser cutter is in satisfactory operating condition and in good repair
 2. Areas immediately adjacent to laser cutter are clear of combustibles or combustibles are protected
 3. Floors and surfaces around and interior of laser cutter are clean
 4. Laser cutter will be attended at all times when operating
 5. Carbon dioxide fire extinguishers are present and in good condition.
 - vi. Auto-focus the laser prior to each laser cutting task.
 - vii. Use the air assist feature and verify it is working properly when cutting.

- viii. Keep the laser cutting grid area clutter free by cleaning frequently with cloth, brush, or a vacuum. If laser cutter area does not allow unauthorized users to clean the grids, the laser cutter shall not be used until the grid can be cleaned.
 - ix. Turn off the cutter using the emergency stop button when fires occur or when mechanical issues are encountered.
 - x. Keep operating laser cutters attended at all times and use the stop/pause feature if available when leaving the area.
 - xi. Never override laser cutter safety features.
- c. Training
- i. Laser cutter safety training must be completed by all personnel using laser cutters prior to initial use.
 - ii. Cutter-specific training must be completed and documented prior to initial laser cutter use. This training must include but not be limited to, working alone restrictions, safe operating procedures, material-specific cutter procedures, operation of air assist and ventilation controls, housekeeping procedures, fire prevention, fire response, and fire extinguisher use. Retraining may be required when modifications have been made to the laser cutter system that impact use and operating parameters.
 - iii. Fire extinguisher training must be completed by personnel using laser cutters prior to initial use.
 - iv. For additional information on training, please visit: <https://cmu.bioraft.com/raft/training/courses>.
- d. Personal Protective Equipment (PPE)
- i. Eye Protection
 - 1. Safety glasses must be worn when the potential for creation of projectiles exists.
 - ii. Gloves.
 - 1. Heat-resistant gloves must be worn when there is the potential to come into contact with the hot surfaces.
 - 2. Abrasion-resistant gloves must be worn when using sharps and other jagged items to remove support media.
- e. Emergency Equipment
- i. Laser cutters may only be installed in areas that have adequate and appropriate fire suppression systems.
 - ii. Dry powder or CO2 fire extinguishers must be present in laser cutter areas.
 - 1. When practical and feasible, install fire extinguishers adjacent to or on the laser cutter and extinguisher cylinders must not exceed 5 lbs (2.3 kg)

7. Other Considerations

When purchasing and/or installing a laser cutter, the following options/features must be considered when practical, feasible, and available:

- a. Tempered glass windows that offer greater fire resistance and visibility of laser cutter operation compared to tinted acrylic windows
- b. Active enable switches that requires operators to remain at the laser cutter during operation
- c. Airflow sensors that cause the cutter to be inoperable when the air assist feature is not functioning properly
- d. Ventilation systems that shut down when laser cutter emergency stop button is activated
- e. Access controls that prohibit laser cutter operation by untrained users

8. Waste Disposal

- a. Sharps
 - i. All sharps must be disposed of in a sharps container appropriate for the type of contamination present on the sharp.
 - ii. Please contact safety@andrew.cmu.edu for additional information.

9. Emergency Procedures

- a. Personal Injury
 - i. For small burns, keep affected area clean and apply burn cream or antibiotic ointment if accessible and reach out to University Police at 412-268-2323 for additional medical help if needed. Contact EH&S at 412-268-8182.
- b. Small Fires (a fire the size of a typical household wastebasket)
 - i. Keep the exit at your back.
 - ii. Use the nearest fire extinguisher.
 - iii. Pull the pin to break the seal.
 - iv. Aim at the base of the fire.
 - v. Squeeze handle grips or trigger.
 - vi. Sweep the fire, spraying side-to-side at the base of the flames.
 - vii. Ventilate the area after the fire is completely extinguished
 - viii. Contact University Police at 412-268-2323 and EH&S at 412-268-8182 and
- c. Large Fires (a fire larger than the size of a typical household wastebasket)
 - i. Activate the nearest fire alarm pull station and alert others.
 - ii. If safe to do so, assist others who may be in danger. However, do not put yourself at risk.
 - iii. Evacuate the area, use stairs and close doors behind you.
 - iv. Contact University Police at 412-268-2323 and EH&S at 412-268-8182 and report location, injuries and other hazards.
 - v. Move away from the building exterior and assemble with floor marshal.
 - vi. Inform emergency responders of any hazards, injuries, or locations of persons remaining inside.
 - vii. Remain outside the building until cleared for re-entry.

10. Dangerous Items Policy

In line with CMU's "Deadly Weapons Policy," the following items are forbidden from laser cutting:

- Knives with blades larger than that of a folding pocket knife;
- Switchblades;
- Daggers;
- Striking instruments, including clubs, truncheons, blackjacks, metal knuckle;
- Martial arts weapons, including nunchakus, tonfas, staffs and throwing stars; and
- Bow and arrow combinations.

For information on this Policy, please visit: <https://www.cmu.edu/policies/safety-and-security/deadly-weapons.html>.

For additional questions or concerns please contact EH&S: safety@andrew.cmu.edu