Fab Lab Safety Handbook

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Introduction

There is a potential risk of injury when working with the Fab Lab equipment. It is every individual's personal responsibility to follow the instructions, recommendations and precautions outlined in this guide, as these will help you significantly reduce the risk of injury to yourself and others.

The safety guidelines described in this document are based on the Fab Lab standard equipment list (available in annex A) but may also apply to equipment with comparable characteristics from various manufacturers. Make sure to read the manufacturers specific recommendations and safety guidelines for the equipment in your lab in conjunction with this document.

The following safety guidelines are suggestions based on experience and common sense, they are meant to complement but not supersede any regulations which may be in place in your community regarding health and safety in the workplace such as guidelines or protocols in effect at your institution (school, university, etc) or OSHA laws and regulations.

For more information please contact your institution's health and safety officer or OSHA (osha.gov).

Please note that this is a working document, evolving as Fab Labs evolve. The content herein has been developed by members of the global Fab Lab community for the Fab Lab community. This is an open-source document. The work is provided as is; no warranty is provided, and users accept all liability.

Personal Safety Basics

Workshop safety begins with the individual, make sure you take personal responsibility for your own safety by adhering to the following basic measures regarding your person:

- **Never** wear loose fitting clothing.
- **Never** wear neckties or scarfs.
- **Never** wear jewellery.
- **Never** wear open shoes such as sandals or flip-flops.
- **Always** wear long hair in a ponytail or other restraint method.
- **Always** wear **ear** and **eye** protection as well as **gloves** when working in the lab.

General Fab Lab Safety Guidelines

From the moment you set foot in a Fab Lab, follow these simple guidelines to ensure you have a productive and safe experience:

1   Do not bring food or drink into the Fab Lab!

2   Know where the fire extinguishers and first aid kit are located and how to use them.

3   Never work impaired! Be it by medication, drugs, alcohol, or sleep deprivation.

4   Know the hazards associated with your work. Be sure you are fully educated on the proper use and operation of any tool before beginning a job. If you cannot do a job safely, don't do it!

5   Think through the entire job before starting. If you are unsure about how to safely operate a tool, ask for help. Have the lab technician assist, demonstrate, while you observe until you become familiar and comfortable with the process or tool.

6   If you have not worked with a specific material before, consult with the lab technician for precautions, methods, and instructions prior to beginning work.

7   Never work in the lab if you are in a hurry, this likely outcome is ruining your work and can easily result in injury.

8   Leave tool guards in place. These safety features are there for your protection.

9   Before starting any machine, be sure it is set up correctly and fully operational.

10   Check power cords and plugs on portable tools for damage before using them.

11   Use a brush or special tool for removing chips, shavings, and debris. Never use your hands to clean shavings or cuttings – they may be sharp.

12   When sanding, face masks or respirators should always be worn.

13   Keep your fingers clear from the point of operation of machines by using special tools and devices such as push sticks and paddles. Never use a rag near a moving machine.

14   Keep the work area free of debris, clean spills immediately and remove all sawdust and wood chips.

15   Keep in mind that all Fab Labs are unique and have their own safety protocols, make sure that you complete all necessary training at that particular lab.

16   Always monitor the equipment while it is running.

17   **Clean up after yourself!** Before you leave the lab, be sure all tools are returned to their appropriate position and all the machines are clean and the floor is swept. Always allow enough time for your cleanup procedure.

Environmental Factors

Hearing Protection Milling machines, dust collectors and other machines found in the Fab Lab can be really loud. Basic sound insulation is in place at the Fab Lab, however, it is at times unavoidable to be in the same space as a loud machine, in which case you should always wear ear protection like ear muffs or ear plugs.

Hearing damage can occur not only when exposed to extremely loud noises momentarily, such as being close to an explosion, but can also occur as an effect of prolonged exposure to relatively manageable noise. This second scenario is much more treacherous, as symptoms may present themselves gradually making it difficult for the individual to notice them.

Eye Protection When using milling machines, chemicals, soldering irons and the like, always wear safety goggles or glasses.

Even if you are wearing safety glasses, keep in mind they are not indestructible nor do they fully seal your eyes from the outside. You should still attempt to mitigate the risk of injury by avoiding being at eye-level with a moving tool or flying sparks and debris.

Respiratory Protection - Particles and fumes can disrupt and damage our respiratory system. To keep the air quality at acceptable levels in Fab Labs, precautions can be taken to initially contain air contaminants, and personal protection devices (air-purifying respirators) can be worn to protect from air contaminates that cannot be immediately removed form the environment.

Note that not all masks and respirators protect from both fumes and particles, most only protect from particles!

Some types of dust are worse than others, fiberglass and carbon fiber dust can cause long-term respiratory damage. Note that although the circuit boards that we mill in Fab Labs do not have fiberglass in them like other circuit boards, but they are still and epoxy-based and the dust created from milling them is toxic, make sure to vacuum it versus blowing it away and thus making it airborne.

All epoxy glues and casting resins come with a Material Safety Data Sheet (MSDS) that alert you to the dangers of working with that specific substance and what the precautions should be in order to utilise them safely. Annex B of this document contains all MSDS sheets for the materials most commonly used in Fab Labs. Constant exposure to epoxies and urethanes (even through inhalation only!) may lead to sensitization and eventually acute allergic reactions. The specific resins and epoxies used in Fab Labs have been selected for their low toxicity, but they should still be treated carefully!

Skin Protection When dealing with chemical substances, always wear appropriate gloves, different materials require different gloves. Glues and casting resins are not only difficult to wash off, they contain molecules that can closely mimic human hormones and disrupt your endocrine signalling system. These problems may only become apparent years later, or even manifest in your offspring. If you get chemicals on any other part of your body, wash immediately according the the instructions in the material safety data sheet (MSDS).

Fire Hazards

Basics With time you will develop a sixth sense for detecting smoke, until then, double and triple check any unusual smells. Turn off soldering irons and ovens if you leave the area! Besides being a fire hazard, leaving the soldering iron on with no solder on the tip will oxidize it and make it harder to solder with in the future.

Dealing with Small Burns If someone is burned, cool the affected area of the skin immediately. If the heat has to dissipate into the surrounding flesh versus cold water or a burn spray / gel, it will injure a larger area of the body.

Laser Cutter Laser cutters or engravers basically "burn" material away in order to make a cut, making them inherently prone to starting fires. Never leave the laser cutter while it is running! Once a fire starts, it can quickly get out of control.

It is important to always remember to turn on the fume extraction system before starting any laser cutter job, as this will significantly reduce the chance of starting a fire, as well as protecting you from potentially noxious fumes. If your material is burning too much in the laser cutter, try increasing the speed and/or lowering the power. If you cannot cut all the way through at a higher speed, try increasing the PPI or cutting in two passes.

As soon as any amount of fire is detected on the laser cutter bed (or even too much smoke), pause your file and leave the extraction system on in order to clear the smoke. If the fire does not subside, open the lid (with the extractor still running) and use a piece of acrylic or another fireproof material at hand to smother the flame. In the even this does not deal with fire, use a fire extinguisher to put out the fire. Note that fire extinguishers should only be used when there is no other solution available, as this will almost certainly damage the machine.

Ideally, a Halotron Fire Extinguisher should be placed in a visible location next to the laser cutter. This type of extinguisher is the best compromise between it's ability to put out the fire and potential damage to the machine from the extinguishing chemicals dispersed by the extinguisher. CO2 extinguishers may also be used and are safe for the machine, but may not put out Class A fires as well as a Halotron extinguishers.

Shopbot On the ShopBot fires can start due to dull end-mills or too-high spindle speeds. Make sure your end-mills are sharp and your cuts are not leaving behind charred or discolored edges. Charring is a sign that too much heat is building up due to friction. Friction can also be reduced by reducing the cutting depth (increasing the number of passes) or reducing the number of cutting flutes on the end-mill (i.e. a 2-flute end mill instead of a 4-flute).

Once a fire starts on the ShopBot bed, it quickly jumps to the dust collector due to embers being vacuumed up. Sawdust is extremely flammable. Never leave the ShopBot while it is running for these reasons.

Electrical Fires Electrical fires due to overloading extension cords (daisy-chaining) or damaged wires can occur even when you are not actively using anything in your lab. Make sure your machines are plugged into outlets that are rated for the power consumption of your machine. Keep all machines on surge protectors to make sure they are not damaged in lightning storms or other electrical phenomena.

Tool Safety - Machines

The machines available in Fab Labs have been selected, amongst other factors, for their relative safety when compared to other models and manufacturers. Yet, digital fabrication equipment is still inherently dangerous and specific safety guidelines must be followed with each machine.

Laser Cutter

Follow these basic guidelines in order to safely operate the Laser Cutter:

1	Make sure that your material is appropriate for laser cutting. The Machine's manual includes a list of safe materials. When in doubt, don't cut and consult the lab technician!
2	Check that the machine appears to be in working order and notify staff if something looks wrong. Check the lenses and mirror, and clean them if necessary. Make sure to empty the debris tray if needed.
3	Turn on the filtration system and air assist system before running the laser.
4	Always monitor the laser while it is running!
5	If you can suddenly smell a combustion (burning), pause the file, but leave the filtration system and air assist on. This could mean a blockage in the extraction system. Seek help from a member of staff.
6	If you notice a flame, immediately pause the file. This indicates that something is wrong with your settings or with the material.
7	If your file catches on fire, immediately notify lab staff. Use a piece of acrylic or other flame-retardant material to suffocate the flames. If for some reason there is a large fire, use the fire extinguisher.
8	After the laser has finished cutting, leave the filter and air assist on for another 30 seconds to a minute to remove all particles and off-gassing.
9	Make sure to turn off all equipment when you are finished.
10	Inspect the machine again. Make sure to clean the lenses or empty the debris tray if necessary.

Large CNC Router

Follow these basic guidelines in order to safely operate the Shopbot:

1	Wear eye protection, ear protection and work gloves.
2	Check that the machine appears to be in working order and notify staff if something looks wrong. Make sure the bed and rails are clean and free of debris.
3	Check that your material is clean, free of defects and that it is properly secured to the spoil board or sacrificial layer.
4	Make sure that you are using the appropriate cutting bit, and that the bit and collet are in good condition. Disengage the spindle using the key while you are changing out cutting bits or working on the machine. Make sure that the collet and bit are properly inserted and secured.
5	Turn on the dust collector before running the machine.
6	Closely monitor the machine while it is running. If necessary, hit the spacebar to pause the file, or hit the emergency stop to stop the machine.
7	If you see any pieces look like they might come loose, or if you hear a strange sound, pause the file immediately, and remediate the situation or ask a technician for assistance.
8	After your file is finished, remove your part and clean up any debris.
9	Check over the machine again to see if everything appears to be in working order. Notify the lab staff if anything appears to be out of order.
10	Turn off the machine.

3D Printer

Follow these basic guidelines in order to safely operate the 3D Printer:

1	Check that the machine appears to be in working order and notify staff if something looks wrong.
2	Be careful when touching the print bed or anywhere inside the machine. 3D printers use high temperatures both to extrude their filament, and to heat the build platform to minimize warping. Use work gloves if needed.
3	Use gloves if using a palette knife or scraper to remove a model from the build platform.

Mini Mill

Follow these basic guidelines in order to safely operate the Modela Mini Mill:

1. Check that the machine appears to be in working order and notify staff if something looks wrong.

2. Check that your material is clean, free of defects and that it is properly secured to the spoil board or sacrificial layer.

3. Make sure that you are using the appropriate cutting bit, and that the bit and collet are in good condition. Disengage the spindle while you are changing out cutting bits or working on the machine. Make sure that the collet and bit are properly inserted and secured.

4. Make sure that the protective cover is on when running the machine.

5. Closely monitor the machine while it is running.

6. If you see any pieces look like they might come loose, or if you hear a strange sound, pause the file immediately, and remediate the situation or ask a technician for assistance.

7. After your file is finished, remove your part and clean up any debris.

8. Check over the machine again to see if everything appears to be in working order. Notify the lab staff if anything appears to be out of order.

9. Turn off the machine.

Vinyl Cutter

Follow these basic guidelines in order to safely operate the Vinyl Cutter:

1. Check that the machine appears to be in working order and notify staff if something looks wrong.

2. Wear eye protection and gloves while using any type of tool with an exposed blade, there is always a chance that an accident might occur.

3. Carefully check that the blade is sharp, that the length of blade and pressure are at the correct setting, and that your cutting stock is clean and free of defects and dirt. If adjustments need to be made to the blade, handle with extreme care!

Soldering Stations

Follow these basic guidelines in order to safely use the Soldering Stations:

1	Wear eye protection when soldering.
2	The soldering iron should have a stand for it to rest on. Never rest a hot soldering iron on your work surface.
3	Never touch the tip of the soldering iron when in use. Hold wires and other elements to be soldered with tweezers or soldering clamps.
4	Turn the soldering iron off when not in use!
5	Use proper ventilation such as a fume hood or portable filter.
6	Use lead-free solder.
7	Wash hands thoroughly with soap and water after soldering.

Tool Safety - Hand Tools

These include wrenches, hammers, chisels, screw drivers, and other hand-operated mechanisms. Even though hand tool injuries tend to be less severe than power tool injuries, hand tool injuries are more common. Because people take everyday hand tools for granted, simple precautions for safety are easily forgotten.

The most common hand tool accidents are caused by the following:

- Failure to use the correct tool for the job.
- Failure to use a tool correctly.
- Failure to keep edged tools sharp.
- Failure to replace or repair a defective tool.
- Failure to safely store tools.

Follow these guidelines for hand tool safety:

1	Wear safety glasses whenever you hammer or cut, especially when working with materials that chip or splinter.
2	Never use a tool for a purpose than that for which it is intended.
3	Never carry a screwdriver or chisel in your pocket. If you fall, the tool could cause a serious injury, use a tool belt instead.
4	Use the proper wrench to tighten or loosen nuts. Pliers can chew the corners off a nut and the pliers can become damaged.
5	When using a chisel or cutting tool, always chip or cut away from yourself.
6	Direct saw blades, knives and other tools away from aisle areas and people.
7	Keep knives and scissors sharp. Dull tools are as dangerous as sharp ones.
8	Improper tool storage is responsible for many shop accidents. Return each tool to its marked location for proper tool storage.

Tool Safety - Power Tools

Power tools can be extremely dangerous if they are used improperly. Common accidents associated with power tools include abrasions, cuts, lacerations, amputations, burns, electrocutions, and broken bones.

These accidents are often caused by the following:

- Touching the cutting, drilling, or grinding components.
- Getting caught in moving parts.
- Suffering electrical shock due to improper grounding, equipment defects, or misuse.
- Being struck by particles that normally eject during operation.
- Touching hot tools or work pieces.
- Falling in the work area.
- Being struck by falling tools.

In addition to general lab guidelines, follow these guidelines for working with power tools:

1	Do not turn on, use, repair, or operate any machine, tool, or equipment unless authorized by the lab technician or manager.
2	Use the correct tool for the job. Do not use a tool or an attachment for something it was not designed to do.
3	Keep all guards in place. Cover exposed belts, pulleys, gears, and shafts that could cause injury.
4	Always operate tools at the correct speed for the job. Working too slowly can cause an accident just as easily as working too fast.
5	Watch your work when operating power tools. Switch off the equipment and stop working if something distracts you, before looking away from the work.
6	Do not rely on strength to perform an operation. The correct tool and method should not require excessive force. If undue force is necessary, you may be using the wrong tool or have a dull blade or tool.
7	Before clearing jams or blockages on power tools, disconnect from the power source. Do not use your hand to clear jams or blockages, use an appropriate tool
8	Never reach over equipment while it is running.
9	Never disable or tamper with safety releases or other automatic switches.
10	When the chance for operator injury is great, use a push stick to move material through a machine.
11	Disconnect power tools before performing maintenance or changing components.
12	Keep a firm grip on portable power tools. These tools tend to "get away" from operators and can be difficult to control.
13	Never leave chuck key in chuck.
14	When possible, secure work pieces with a clamp or vise to free hands and minimize the chance for injury.

Responsible Disposal of Chemicals

Many casting resins, paints, batteries and other chemicals should be thrown away as special chemical trash. Electronics are also considered dangerous trash which must be disposed of accordingly.

Your local city government is able to provide information regarding safe disposal of these items.

When working with bi-component resins and elastomers, spills may be better dealt with if you allow the materials to fully catalyse before attempting cleanup. If you have already mixed both parts / components and the spill is not affecting any tools, electronics, personal items (such as on the floor or a work surface / tabletop) allow the materials to set before attempting to clean. This will be easier and safer, as fully catalysed materials are no longer harmful. Check the information on the package to find out how long it will take the material to fully cure.

⚠ Be aware of your environment!

Many accidents occur because two people are using the same machine or workspace at the same time.

While it is important to focus on what you are doing, try to keep an eye out for those around you and for what is happening in the workshop, for your own safety as well as that of others.

Always be aware of what is happening around you! Others may not be as careful as you!

Fab Lab Standard Machine List

Laser Cutter

Manufacturer:	Epilog
Model:	Mini 24
Power:	40W
Bed Size:	24x12 (Inches)
Website:	www.epiloglaser.com/products/legend-laser-series.htm

Large CNC Mill

Manufacturer:	Shopbot
Model:	PRSAlpha
Spindle:	HSD (4HP)
Bed Size:	96x48 (Inches)
Website:	www.shopbottools.com/mProducts/prSalpha.htm

Mini Mill

Manufacturer:	Roland DG
Model:	monoFab SRM-20
Power:	N/A
Bed Size:	9.14x6.17 (Inches)
Website:	www.rolanddg.com/product/3d/3d/srm-20/index.html

3D Printer

Manufacturer:	Ultimaker
Model:	Ultimaker 2
Power:	N/A
Build Volume:	9x8.85x8 (Inches)
Website:	www.ultimaker.com/en/products/ultimaker-2-plus

Vinyl Cutter

Manufacturer:	Roland DG
Model:	Camm-1 GS-24
Power:	N/A
Bed Size:	N/A
Website:	www.rolanddg.com/product/cutting/gs-24/index.html

Appendix B

MSDS (Material Safety Data Sheets)