



LASER CUTTER STANDARD OPERATING PROCEDURE

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PURPOSE:

This document outlines Standard Operating Procedure (SOP), the usage and safety procedures on the MornTech Laser cutter located in JBE-138. The laser cutter uses a 130W CO2 laser to cut through materials such as wood, paper, and acrylic up to $\frac{1}{4}$ " thickness. The laser cutter is an extremely useful and safe device with many safety features that prevent misuse. However care must be taken to match the settings to material used or there exists a possibility of fire. Safety procedures for dealing with fire in the machine are outlined below.

OVERVIEW:

As part of the ECE118 course, you will use a MornTech MT-L1290 CNC laser cutting machine. This is a precision machine that allows you to cut geometry from a two-dimensional .dxf files into MDF, acrylic, and foamcore. It is an ideal tool for cutting intricate shapes with sharp internal corners. It is also excellent for creating quick prototypes and for building things that can be assembled from 2D (and essentially flat) components.

The laser cutter is a very powerful tool, and therefore can be very dangerous. Use it with care and caution. This current model has a 48"x36" bed with a 130W CO2 laser. It fires a laser into the material to burn away a cut or etch a surface. It is very precise ($\pm .001$ "") with $\sim .030$ " cut width. The best way to think of it is as a printer, except instead of outputting ink of various colors, it outputs cuts at various speeds and powers.

To use it, you start with a .dxf drawing. Using RDWorks software, you convert this drawing into a series of cuts. You then "print" it directly onto your chosen material.

This SOP (Standard Operating Procedure) goes over the safety procedure, set-up procedure, and operating procedure. Please use only materials listed in this SOP on the laser cutter.

Note that usage of the laser cutter will require supervision until you have demonstrated competency in using the machine by one of the designated laser cutter trainers. Further details are below.



Figure 1: MornTech Laser Cutter

SAFETY:

The laser cutter is a very powerful tool, and therefore can be very dangerous if used incorrectly. Use it with care and caution. Some basic rules are:

1. There is a black rectangle on the floor around the laser cutter, called the “watchbox.” There **MUST** be at least one person in the watchbox whenever the laser cutter is operating.
2. **DO NOT** use the laser cutter alone. Always have at least 2 people when cutting.
3. **DO NOT OPERATE** the laser cutter while **SLEEPY** or **INTOXICATED**. This applies to both partners in the team. It is essential to your safety and that of others that you are awake, coherent and alert while operating the system. Operating while sleepy or intoxicated will result in an immediate ban from the fabrication lab. Treat operating the laser cutter as if you were driving a vehicle.
4. **DO NOT** remove the “Do Not Touch” plate on the control panel. If the plate is not present, do not use the laser cutter. The button under this plate (the “pulse” switch) allows the laser to operate while its safety switches are open. **DO NOT** press this button at any time.
5. **DO NOT** use the laser cutter without the blower on. The blower is essential to proper operation.
6. If anything odd happens during your cut or you collide the head with something, immediately notify the authors of this SOP of the details and **PUT A NOTE** on the laser cutter, over the power switch. **DO NOT** attempt to fix it yourself.
7. **DO NOT** use any materials other than those documented in this SOP and approved materials document. Ensure that you are using reasonable power settings and speeds as learned from your training. If you are having difficulty achieving a clean cut using settings in the accompanying approved materials document, consult the authors or training staff.
8. Any use of non-standard materials needs prior approval of the authors and they **MUST BE PRESENT** when attempting to cut that material.

FIRE SAFETY:

In all cases, fires in the laser cutter have been caused by unattended operation (even when the users were in the same room, but not paying attention to the laser cutter). **DO NOT LEAVE THE LASER CUTTER UNATTENDED. PERIOD.**

While it is not unusual for there to be a flame for the first few seconds or on a small part, it is a concern if there is a persistent or growing flame. FOAMCORE is especially flammable; but any material can catch on fire under certain circumstances. Be careful with parts with lots of intricate detail that are very close to each other or jobs that take a long time to complete.

In order for fire to persist, three things are required: (1) heat source, (2) fuel, and (3) airflow. In the laser cutter, the heat source will be the laser, the fuel will be the material, and the airflow will be from the air in the room. Removing these any of these three things will put out the fire. Small fires are very easy to put out (think candle), but they will grow into big ones if you do not act promptly.

If there is a fire, **DO NOT PANIC**. You have time to stop and think clearly, but you will need to take actions to put out the small fires **BEFORE** they grow into big ones.

FIRE PROCEDURES:

1. If you have a persistent flame that is more than 2 inches tall, or lasts for more than 10 seconds, **STOP THE LASER CUTTER** by pressing **PAUSE**. Immediately use the **UP** arrow key to move the head to the top of the bed. Do not turn the laser cutter off, as this will prevent you from moving the laser cutter head out of the way. Most flames extinguish themselves quickly.
2. If step (1) fails to extinguish the flame, and if the flame is small and unthreatening (it is smoldering, smoking or the size of a few candle flames), then blow on the material like a candle to extinguish the flame.
3. If step (2) fails to extinguish the flame, or if the flame has grown larger than 2 inches tall, use the fire blanket in the red pouch. Remove the blanket, and open it fully. Put on leather gloves, and drape the blanket over the flame.

4. If step (3) fails, or if you feel a fire extinguisher is necessary, pull the fire alarm. Then, someone trained to use the fire extinguisher may attempt to use it to put out the fire. Call 911 immediately.

Once you have taken care of the flame, determine what caused it:

- Are you using the correct material? Does it have a coating?
- Are you running your cutting speed too slow or is the beam out of focus?
- Are your cuts too close together?
- Could the laser possibly have been bumped or the z-axis moved out of focus?

Rectify the problem (remove the material, change your cut, or get the TAs).

EYE SAFETY:

The greatest danger to you in using any laser is to your retina. The amount of power concentrated on a very small area will create a permanent blind spot in your vision. The laser cutter is equipped with safety interlocks to disable the beam when the lid is opened.

DO NOT, under any circumstances, attempt to override any of the safety interlocks on the laser. These include the interlocks on the door, the flow sensor on the chiller, or the software locks in place. Doing so is expressly prohibited, and will permanently ban you from laser Cutter use.

OPERATIONAL SAFETY:

Make sure you re-read the above sections several times to make sure you completely understand them. Do not operate the laser cutter alone, and do not leave it unattended (this includes being nearby but not paying attention to it). If you cannot observe the cut, then the laser cutter is effectively unattended.

Re-read the safety rules above. Make sure you understand them and why they are in place.

Have a plan. Before you start cutting, have a plan for what you will do if things go wrong. Ask yourself hypothetical questions about what you would do “if” for various scenarios, and make sure you can execute your plan. For example, if you plan in case of fire is to use the fire extinguisher, make sure you know where it is, read the instructions on it so you know how to use it, etc.

At the time that things are going wrong, you won’t be able to make clear headed decisions. Having thought through them before gives you the ability to execute your plan without having to make decisions in the moment.

Lastly, **do not panic!** The laser cutter machine is designed to be extremely safe to the users. You might damage the machine, but are very unlikely to hurt yourself unless you really are being very careless. In general, you have time to evaluate the situation, and then calmly execute your plan. If your plan did not help, re-evaluate and come up with a new plan. Keep your interventions simple, and get help as soon as you can (often post event).

LIST OF APPROVED MATERIALS:

The SOP contains a list of approved materials on the approved materials document. These materials have been used very frequently in laser cutting, and are known to be quite safe. Only use these materials in the laser cutter.†

Any material not in the approved materials supplement is considered prohibited; **DO NOT USE THEM**. Use of prohibited materials merits an immediate ban from the cutter for the remainder of the quarter. Do not even bring prohibited materials into BE-138, as they may be mistaken for acceptable materials.

When cutting approved materials, ensure that the speed at which you cut is greater than the noted minimum speed in the approved materials document. If you find yourself needing to go slower, something else is wrong. Cutting at a slower speed is a violation of this SOP.

† For certain research purposes, there might be a need to cut non-standard materials. This can ONLY be done with prior approval of the authors and with them present for the attempt to cut these non-standard materials.

LASER CUTTER USAGE INSTRUCTIONS

OVERVIEW:

This section of the laser Cutter SOP defines how to use the software and the MornTech ML-1290 Laser Cutter in order to prototype your parts out of MDF, Foamcore, or Acrylic. It details how to use RDWorks to set up a job, send it to the laser cutter, and ensure that you get a good quality cut out of it.

THE RDWORKS SOFTWARE INTERFACE:

The interface to the laser cutter is through custom software called RDWorks.

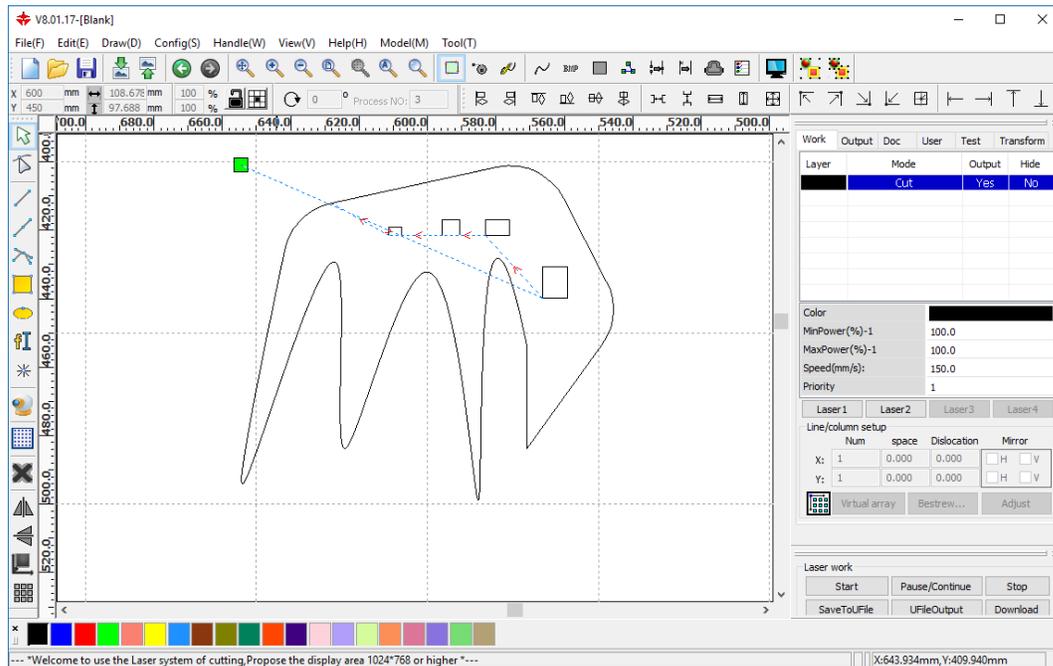
RDWorks is a program to run the cutting job on the laser cutter. While it has the ability to manipulate the drawings, you will not be using it to modify the cutting job. DXF files nominally exported from SolidWorks will be imported to RDWorks for cutting.

RDWorks is available on the desktop of the laser cutter computer. It is fully featured and details can be found in the user manual. For normal laser cutter usage, we will only be using a small subset of its capabilities.

Note that you will only be using RDWorks to insert/move your test cuts. Change colors on parts for selective cutting, and sending jobs to the actual laser cutter. All other manipulation needs to be done elsewhere.

THE RDWORKS SOFTWARE INTERFACE:

RDWorks runs the laser cutter. The interface of the entire program is shown below, with the important tools called out.



Object selection tool: Use the arrow tool to grab and move objects. Black squares (called “handles”) will appear at the corners, which allow you to stretch and resize the shape. Objects can be moved around. This is also where you can change the color of an object (for your test cuts).

Draw rectangle tool: Draws a rectangle. Use to draw test cut rectangles.

Color bar: If you have an object selected, this is where you select the color of the object. RDWorks allows you to control your cutting settings by color, therefore this is where you choose selective cutting (e.g.: only your test rectangles).

Show Path: This tool shows the path that the laser will take when cutting out your parts. It should be on by default, and is extremely informative in showing you what will happen.

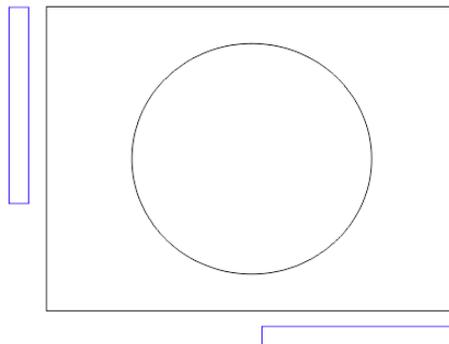
Laser Control Settings: Panel where you set the laser controls (cutting mode, speed, power settings). This is also where you will download the cutting job to the laser cutter itself.

It is important to have your drawing in SolidWorks set up correctly such that small changes (e.g.: wrong scaling or material thickness) can be accommodated quickly and your DXF file regenerated for cutting. You will not be fixing this in RDWorks on the laser cutter computer.

LOADING YOUR DXF INTO RDWORKS:

Launch RDWorks on the laser cutter computer, and import your DXF file using File->Import. This will place your cutting job into the main window. The green square at the top left corner of your job shows the job origin. Use the rectangle tool to add in your test cuts.

Insert your test cut rectangles (these should be at least 2.5" on their long directions, one vertical one horizontal). The test cut rectangles should be changed to a different color than the rest of your drawing.



OPERATING THE LASER CUTTER:

Before you begin, open the lid and make sure the laser cutter workspace is ready; the cutting bed should be free of debris and material. The fire blanket and fire extinguisher should be within easy reach.

Put on a blue lab coat (all teammates should do this, as well as anyone coming near the laser cutter).

Turn on the laser Cutter using four red buttons on the lower front panel. These are twist to turn on, push to turn off. Be gentle in your twisting.

DO NOT PROCEED until you have ensured that both the chiller and blower are turned on. The machine will go through a calibration step of moving the gantry all way to the stops and then returning to the origin.

From here on, someone should be in the watchbox until the machine is turned off.

Open the lid and place your material on the laser cutter bed, being careful not to bump the laser cutter head with the material when doing so.

Set the origin: Use the arrow keys to move the head to the upper left corner of where you want to cut on the material. Move the material if necessary to make minute adjustments.

Press “Origin” on the control panel. This tells the laser cutter that its current head location should coincide with the top-left corner of your job.

Note that “origin” sets that spot to the duration for all subsequent cuts. It does not return the head to the origin.

Close the lid: Gently pull down on the center handle. It will not cut if not fully closed.

Focus the beam: Using the arrow keys on the laser cutter keypad, move the laser head over your material where the job will be cut. You will be focusing the machine manually using the Z-axis move and the manual focus jig (see Fig. 2). Press the Z/U button to put the machine into the “Z-axis move” mode. The left arrow moves the bed up, and the right arrow moves the bed down.

Adjust the height using the left/right buttons until the manual focus jig just fits between your material and the bottom of the laser head (see Fig. 3). This should be a tight fit; you should be able to slide the jig between your material and the laser head without visible gaps.

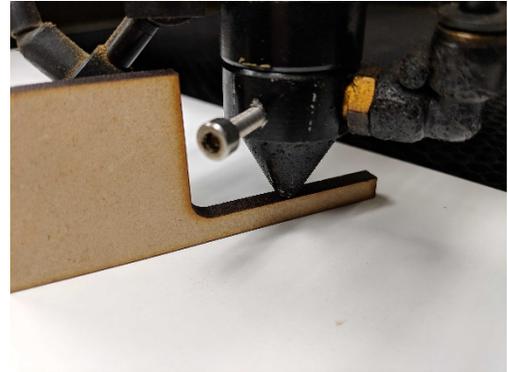


Figure 3: Using the Manual Focus Jig to Focus on Material

WARNING: DO NOT, under any circumstances, trigger the autofocus function. This will crash the head into your material, and could damage the machine. It will require (at a minimum) inspection before the machine can be used again.

Test cuts: for the next three steps, one teammate should be at the computer, and one should be at the laser cutter control panel, watching the cutter head and ready to press the start/pause button. The blower is loud, so make sure that you can communicate over the noise.

Turn the output of your test cut rectangles color to “yes” and all your other colors’ outputs to “No.” Ensure the test cut color speed matches your material required cut speed. Double click on the color in the WORK tab, to bring up the parameters.

Change the settings in terms of *Is Output* (YES/NO), speed, and power setting. Note that the maximum power on the laser is 63% and that the power settings will clip the value to 63% on the machine if you put anything over 63% for the power level. *If blowing* should **ALWAYS** be yes.

Press the Download button to download your job to the laser cutter. A pop up box will emerge. Give the project a name eight letters or less and press ok (or leave it as DEFAULT). A pop up box will tell you if you are successful. If the name is not unique, you will get an additional dialog box to overwrite the old one.

DO NOT PRESS START ON THE SCREEN as it immediately starts the cutter. If the computer operator accidentally presses “Start,” the teammate in the watch box should press start/pause immediately. This will halt the job. The teammate should then press escape and start the process over again. Finally the teammate in the box should reset the origin if they have moved the head in this process.

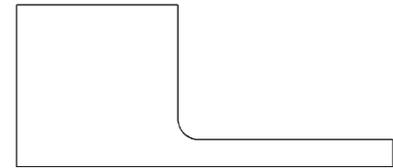


Figure 2: Manual Focus Jig

Teammate in the watchbox will see file count increment by one. Teammate in the watchbox will double check to ensure nothing is in the head's path.

Teammate in the watchbox will press the "FRAME" button on the laser cutter. This will cause the laser to move at high speed around the perimeter of the cutting area. Verify that your material is well placed and that all of your parts will be cut on the material. Open the lid and adjust your material location until the frame pass is entirely on your material. You can repeat the frame command as many times as you need to adjust your material.

Cut Test Cuts: Teammate in the watchbox should press start and observe the cutting process; be ready to pause the job and stop the process if necessary. The laser cutter will cut out the test rectangles. This ensures you are cutting at the correct speed for the material. It also ensures you don't start large fires with this material.

HIT PAUSE IF YOU SEE ANY SIGNS OF FIRE OR COLLISION. See fire safety for what to do.

Check if your cuts can pop out. They should be visibly popped down or they pop out when you open the door and press on them. If the cuts have not fully popped out, move your test cuts in RDWorks and then adjust the settings. Don't retrace half-cut lines – this is not an effective test.

Three things you can do: (1) Make sure the laser is focused and the material is flat, (2) Move your material to a more appropriate place (center of the bed tends to work best), (3) Adjust your speed to be slower. Repeat until they fall through.

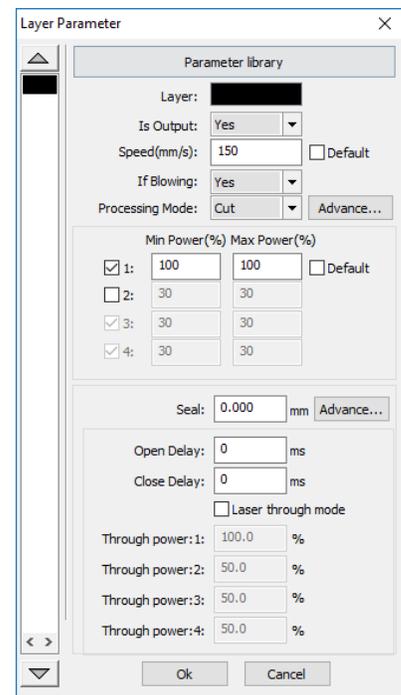
Cutting Your Parts: Turn the output of your material color to Yes at the same settings as for your test rectangles, and everything else to no. Make sure your material speed matches your adjusted test cut speed.

Download the file as you did before; make sure everything looks good. Teammate in watch box hits start and again observes the cutting process. Again, be ready to pause to terminate the process if things go wrong.

If you see flame for more than 2 seconds, press pause and then "esc." Something is wrong with your material or your cut speed or the laser cutter itself (e.g.: the blower is off). Abort the cut and try again.

Teammate in watch box will not leave watch box **FOR ANY REASON** and will keep checking on the material until it is done. Once done, wait ten seconds before opening the door. This allows the smoke/smell to clear out, and lets the material cool.

Test to make sure all material has cut by pressing down on the material. If pieces break out, it has cut. If they don't, rerun the cut on the pieces that didn't cut out. To do this, in the RDWorks program, change the color of the pieces that have not cut to some other color. Rerun the job and repeat the steps above to cut only the pieces still colored the material color.



SHUTTING DOWN THE LASER CUTTER:

Remove all your parts from the laser cutter. Make sure no small parts are left on the bed. While you can throw away small (less than 4") pieces inside the lab garbage cans, place large scrap pieces in the dumpster outside of JBE.

Check bed to ensure nothing is left on it. If any debris is left on the bed, clean it with a dust broom.

The teammate in the watchbox can click "File" and then select "Delete All Files." Press Enter to delete all the files, thus making life easier for the next users.

Use the Z/U button to put the machine into "Z-axis move" mode and use the right arrow key to move the bed downwards so the next team can put their material in the bed easily.

Turn off laser cutter, but pushing down on all four red switches. Teammate in the watchbox may now leave the watchbox.

Log out of your account (NOT "switch user").

Take your cut parts OUTSIDE of BE-138 to assemble and test. Clean up the little pieces with a vacuum or with a broom. **DO NOT** litter small parts around on the tables and floor. **DO NOT LEAVE ANYTHING ON THE COMPUTER TABLE or MIDDLE TABLES.**

Leaving scraps in BE-138 is a violation of the SOP. Doing so will have the same penalties as ignoring the safety procedures. Again, be neat and tidy; clean up after yourselves.

LASER CUTTER TRAINING PROCESS

OVERVIEW:

This section of the laser cutter SOP defines at which point in the training process the students must go through to gain unattended usage access to the laser cutter.

ECE118/218/L:

As part of the lab section of the Introduction to Mechatronics course, the students will be instructed and tested on the fire safety procedures, as well as general usage of the laser cutter and how to assemble physical prototypes from the parts cut. In addition to the initial labs that the students complete, they will use the laser cutter in the project phase of the class. By the end of the quarter, the students will be competent to run the laser cutter on their own, and will have access to it for the following six months post class.

BELS TRAINED STUDENTS:

Students (grad/undergrad) who are trained by the BELS staff on the laser cutter usage will be considered to have the equivalent of the first lab introduction to the machine (fire safety, laser safety, machine usage). They are not considered to have enough experience to use the machine without supervision from a designated trainer until they are signed by the trainers as competent to run the machine on their own.

LASER CUTTER USAGE CHECKLIST

These steps are meant as a quick reference. More details can be found in previous sections of this document.

1. Sign in on the laser cutter log sheet.
2. Document setup:
 - a. Login to the computer with your ADCRM account.
 - b. Open RDWorks.
 - c. From RDWorks, import your .DXF file to cut.
 - d. Draw test cut boxes ensuring that they are long and skinny in both horizontal and vertical directions.
3. Laser cutter setup:
 - a. Make sure the bed is free of debris.
 - b. Turn on laser cutter systems (all 4), wait for laser head to calibrate.
 - c. Place cutting material in the bed.
 - d. Position the head at the top left corner of your material and press the "origin" button.
 - e. Move cutting head to center of expected cutting area.
 - f. Use the Z-axis move to adjust the focus height and check with the manual focus jig
4. Cutting Test Cuts:
 - a. In RDWorks set every layer off except for your test rectangles
 - b. Download your file to the laser cutter and use the FRAME button to ensure that the cuts will fit on your material.
 - c. Cut your test rectangles and ensure they are cut through.
5. Cutting Your Parts:
 - a. Set every layer to OUTPUT = OFF except for the layer you want to cut.
 - b. Click "download" and choose a name (or leave as DEFAULT).
 - c. On the laser cutter, press "start/pause."
 - d. While the laser is cutting, watch the cutter and be ready to engage in fire safety protocols.
 - e. Wait 10 seconds for blower to remove smoke before opening the lid.
6. Cleanup:
 - a. Move the laser head away from your material.
 - b. Remove your material from the cutting bed. Make sure to clean up tiny pieces that were left behind.
 - c. Remove your waste material from BE-138, DO NOT put it in lined trash cans.
 - d. Delete your files from the laser cutter.
 - e. Turn off all 4 laser cutter systems.
 - f. Log off of ADCRM account.
 - g. Sign out on laser cutter log sheet.