

# Plasma Table CNC Workshop



# Outcomes

1. Explain the basics of operating the Plasma Table CNC machine safely.
2. Demonstrate turning on, jogging, referencing, and running a toolpath on the CNC machine safely.
3. Understand the basics of feeds, plasma cutter settings, and materials,  
Work in a 2D environment.

***Plasma is hot ! 24,000 degrees F !***

***Metal coming off the Plasma Table will be Hot !***

# Assumptions

You want to get started using this machine.

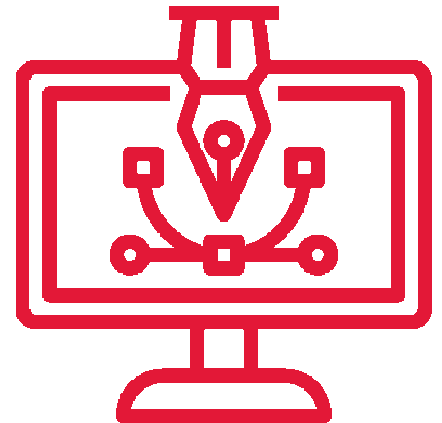
Your CNC parts are usually 1 off or low quantity.

You accept that there may be faster and more robust methods for higher volume production.

Our Plasma CNC Table is a Makerspace build using BlackBox stepper drivers and other hardware that we made ourselves. (So, it's a hobby level machine. Advanced hobby to be sure. But not a commercial machine.)

# CAD

CAD is Computer Aided Design - it's the software that you use to make/draw/design the thing you want to cut. At its most basic that could be a vector drawing program. If you're doing 2D cutting, you can draw in Adobe Illustrator, Corel Draw, Inkscape, Fusion 360 and others. You can even draw in Vcarve.

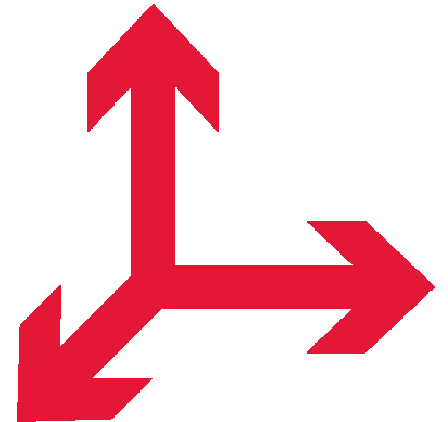


# CAM

CAM is Computer Aided Manufacturing - is the software that takes your CAD drawing and generates the code that tells a machine what tool you're using, how fast to move and where to move. For most Makersmiths members that is VCarve or Fusion360.

OpenBuilds has a tool specific to their hardware:  
<https://cam.openbuilds.com/#>

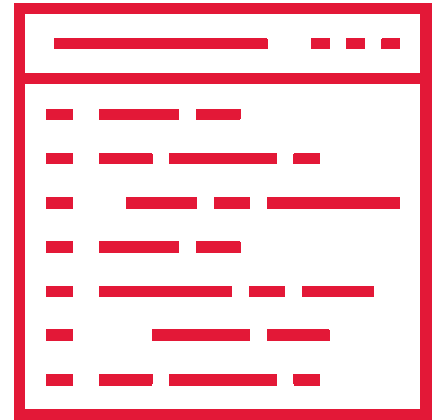
Note that you can do both CAD and CAM in VCarve and Fusion360, but you don't necessarily have to.



# GCode

GCode is the code that tells the machine where to start, where to move, how fast, how high to move between cuts. etc. You save your GCode from your preferred CAM software.

You will 'most likley' have to modify your gcode for the plasma cutter.



# Some GCodes

G0 = Rapid Motion

G1 = Controlled Motion X#, Y# and/or Z# = Move machine  
(dependent on absolute or relative setting and rapid or controlled motion)

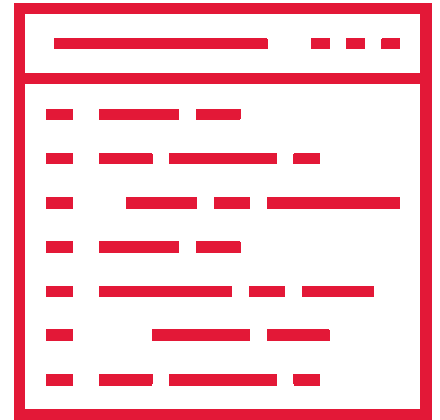
F= Feed Rate Use F30.0 as a starting place

S= Spindle Speed S1000 (required, even though no spindle)

M03 = Plasma On

M05 = Plasma Stop

G04 Snn or Pnn = Dwell S/P (by itself requires 'return' to continue – recommended ! ) Used with a 2 second delay (S2) to allow the plasma arc to stabilize. (P is ms)



# Some GCodes

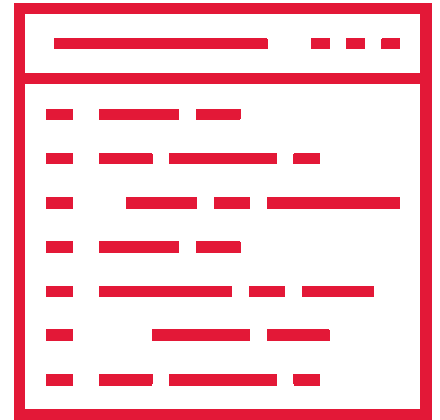
G20 = all measurements in inches

G21 = all measurements in millimeters

A 'Lead in' is where a Gcode generator creates a short cut that moves to the actual cut line.

Ideally, the Plasma Cut starts at the edge of the material.

The Plasma can 'Pierce' (start cutting in the middle of a piece of material by making a hole). This may require some additional dwell time for the plasma to dig through the material. Test.





# Gcodes Mods

You will need to find the start of each cut segment in your gcode

Add:

G01 Z 0.0 F10 (go to cutting z height)

M03 S1000 (turn on plasma Speed is meaningless, but seems to be required for OpenControls)

G04 P2.2 (pause to allow plasma trigger to cycle and plasma arc to stabilize 2.2 seconds in this case)

----- your gcode that cuts the path -----

M05 (turns off plasma at end of each cut.

G00 Z 0.125 (moves the plasma tip up to clear the material)

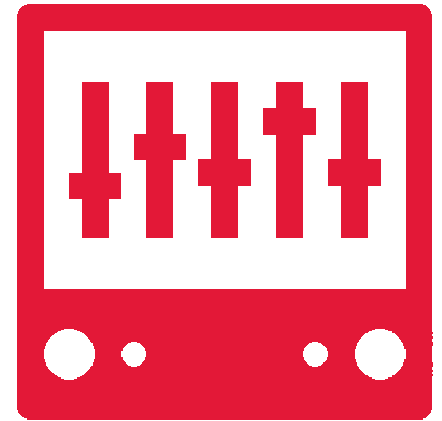
Your Gcode generator may put these in for you.



# Controller

After saving your GCode from your preferred software package, you execute/run that Gcode in OpenBuilds Control. Function is to convert a Gcode line into steps on stepper motors or other control switches.

OpenBuilds Control is loaded on the Makerspace laptops, or you can download and install on your own laptop. License is free.



# Feeds

How fast the machine moves:

- Too fast and the plasma is unable to cut all the way through the metal.
- Too slow and you get a wider kerf, melted material, warped material, or it just takes too long to cut your piece and wastes energy.



# Depth

The plasma cutter will cut up to ¼ inch material.

Thickness of material determines cut speed.  
Cut speed is about 10 ipm (inches per minute)  
for ¼ inch material

Faster for thinner material – but you ‘will’  
need to experiment to find the optimal cut  
speed.

Width of the cut (kerf) is about 1-2 mm.



# Depth

Plasma cutter tips.

Remove the 'training wheels' from the plasma torch.

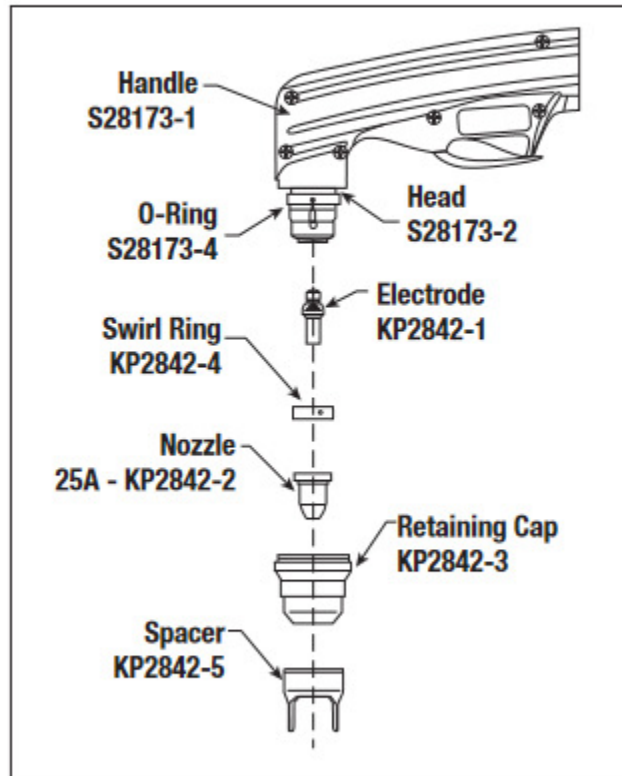
Consumable supplies are in the Welding Shop cabinet.

Be Careful ! Tip is hot after cutting !



## REPLACEMENT TORCH CONSUMABLES

### Lincoln Electric LC25 Parts



### TOMAHAWK® 375 AIR TORCH CONSUMABLES

Product Number	Description
KP2842-1	Electrode
KP2842-2	Nozzle
KP2842-3	Retaining Cap
KP2842-4	Swirl Ring
KP2842-5	Spacer

#### Consumable Wear

- It is normal for the electrode and nozzle to wear during operation.
- Electrodes should typically be replaced when erosion reaches 0.025 in. (0.65 mm).
- A green and erratic arc will indicate end of electrode life. The electrode should be immediately replaced.
- It is recommended that the KP2842-1 Electrode and KP2842-2 Nozzle (25A) be replaced as a complete set.



# Fixturing

- Heavy steel (like 1/4 plate of any size) does not move much on the table. Lighter gauge steel may need some sort of holding mechanism (clamps, weights, magnets, other) to prevent possible movement on the table



# Toolpath Prep

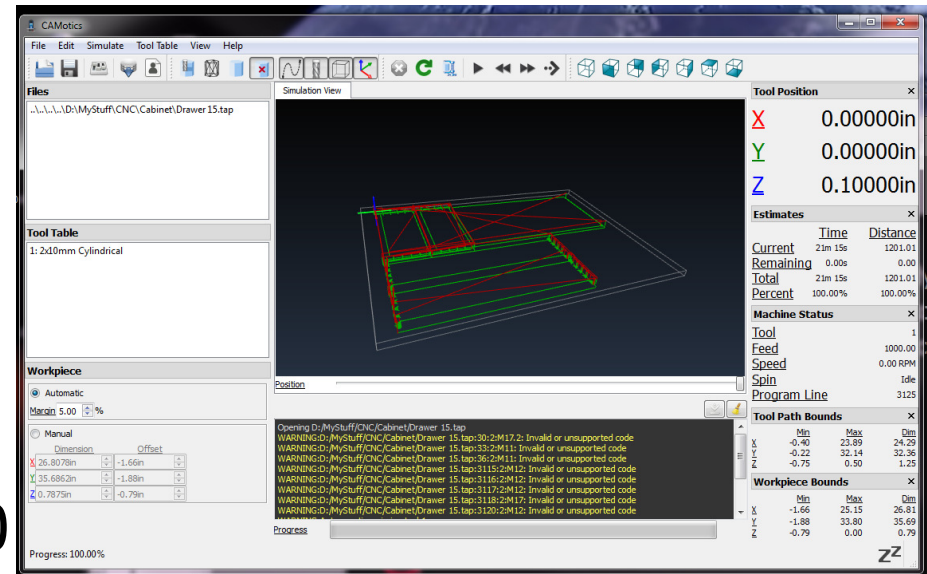
This class assumes that you have already saved your Gcode and have used a simulator to *'absolutely confirm'* that your code is solid and only cuts where you want it to.

Gcode Simulators:

CAMotics

NC Viewer

Simulator in Fusion 360





# Referencing

Whenever you start a new project on the Plasma table, you will want to be sure that you set a local X and Y Zero for your material and design.

Homing the machine is not required.

Set the Z zero height of the plasma tip to just above the surface of the material. You want it to just clear the material (and not drag on the surface of the material).

# Referencing

***STRONGLY SUGGEST YOU 'CUT AIR' FIRST***

Set the Z Zero height above the metal. Leave the Plasma cutter turned off and run your gcode.

You will be able to confirm your cut is on your metal and resolve any difficulties.

# Important!!!

You need to be with the machine while it's cutting and be ready to stop the machine if something goes wrong.

Always have quick access to the Stop button. OpenBuilds controls has an elegant restart.

Have a Fire Extinguisher ready

Double check that the Plasma cutter height is just above the surface of your metal and any retract and Z moves are high enough to clear any clamps or fixture pieces.

Make sure your toolpaths aren't going to accidentally cut your clamps or fixture locating pieces.

Be sure there are no flammables below the table (leaves, etc.)

Be careful of anything you put on the bed that you don't want cut or knocked over.

Always raise the Z axis first

Be sure the ground clip has a good connection.



# Jogging

The screenshot displays the OpenBuilds CONTROL v1.0.170 software interface. The top menu bar includes 'Control', 'Grbl Settings', and 'Troubleshooting'. Below this is a toolbar with buttons for 'Disconnect', 'Reset', 'Settings', 'Open G-CODE', 'Run Job', 'Stop Job', 'Check Size', 'Tool On', 'Tool Off', 'Home All', 'Wizards & Tools', 'Unlock Alarm', 'Stop Job', and 'OpenBuilds.com'. The main interface is divided into sections: 'Machine Interface' (with 'mm-mode' and 'inch-mode' tabs), 'Control' (with directional jog buttons for X, Y, Z and X-, Y-, X+, Z-), 'E-Stop' (with 'reset' buttons for 'Feed: 100%' and 'Tool: 100%'), and 'Visit' (with 'reset' buttons). The 'Machine Interface' section shows 'setzero' coordinates for X (0.00mm), Y (0.00mm), and Z (0.00mm), along with a 'gotozero' button. The 'Control' section includes 'Incremental Jog' and 'Continuous Jog' options, with 'Jog: 4999.9 mm/min' displayed. The bottom section features a 'Serial Console' with a log of system messages and a 'Send' button. The status bar at the bottom indicates 'Port: Connected', 'Controller: Idle', and 'Job Queue: 0'.

```
[10:48:47] [ 3D Viewer ] WebGL Support found! success: this application will work optimally on this device!  
[10:48:47] [ Websocket ] Bidirectional Websocket Interface Started  
[10:48:48] [ update ] Checking for Updates  
[10:48:49] [ update ] You are already running openBuilds CONTROL 1.0.170  
[11:00:33] Detected a change in available ports: [COM3]  
[11:00:38] [ connect ] PORT INFO: Port is now open: COM3 - Attempting to detect Firmware  
[11:00:38] [ connect ] Checking for firmware on COM3  
[11:00:38] [ connect ] Detecting Firmware: Method 1 (Autoreset)  
[11:00:39] [ connect ] Detecting Firmware: Method 2 (Ctrl+X)  
[11:00:40] [ connect ] Detecting Firmware: Method 3 (Smoothieware)  
[11:00:40] [ ] Grbl 1.1g ['$' for help]  
[11:00:40] [ ] [MSG:'$H'!'$X' to unlock]  
[11:00:40] [ $$ ] $0=10 ;step pulse time, microseconds  
[11:00:40] [ $$ ] $1=255 ;step idle delay, milliseconds  
[11:00:41] [ $$ ] $2=0 ;step pulse invert, mask  
[11:00:41] [ $$ ] $3=4 ;step direction invert, mask  
[11:00:41] [ $$ ] $4=1 ;invert step enable pin, boolean  
[11:00:41] [ $$ ] $5=0 ;invert limit pins, boolean  
[11:00:41] [ $$ ] $6=0 ;invert probe pin, boolean  
[11:00:41] [ $$ ] $10=1 ;status report options, mask
```

# Connecting

You will need:

The Plasma Table Electronics box

Heavy extension cord for the plasma cutter

Plasma Cutter

Laptop computer

A regular extension cord for the Plasma Table Electronics Box (and your laptop, if needed)

Air line

Plug the plasma table connections into the Plasma Table Electronics Box.

4 connections. Connectors will all only fit in one configuration.

Plug in electronics box power cord.

Turn on Black Box power switch.

Launch Black Box Controls on your laptop and connect the USB cable.

Your computer should automatically detect and set up the correct COM port. Connect Open Controls to the COM port.

# Connecting

Plug the Plasma Cutter into the large extension cord.

Mount the Plasma Torch on the Z axis (gently)

Connect the Plasma Cutter Ground clamp to the table – be sure you have a good ground.

# Z Clearance

Your CAM software may have a setting for the safe clearance height for the end mill between cuts.

Safe height above your material may not be a safe height above clamps or positioning blocks. Adjust accordingly.

# Before GO

1. Are the X, Y, Z zeroed/set for the toolpath you're about to cut?
2. Is there anything on the rails or bed that could get hit?
3. Is your material secured down?
4. Is the stop button ready?
5. Confirm plasma settings





# During Job

Stay with the machine

*Have a fire extinguisher handy and ready*

Be ready to hit the Stop Button if necessary

Be ready to turn off the Plasma Cutter if necessary

Listen to the sound of the machine - you'll get used to the sound it should make depending on the material you are cutting. A good sound is ripping fabric or frying bacon

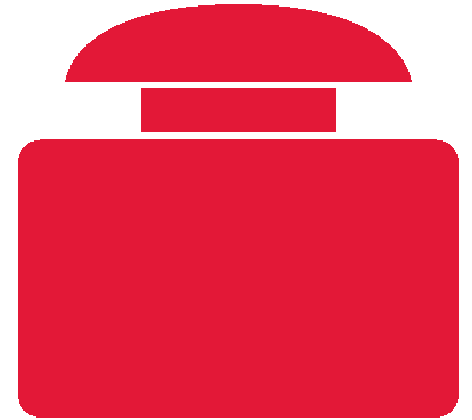
Once you have a little bit of experience, you can change the feed speed of the cut



# Recovery

## **Recovering from Stop**

Turn the Stop switch to release.  
Click resume on control screen  
or, abort the job and restart.



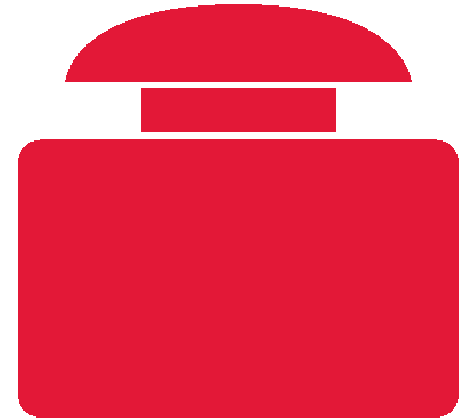
# Recovery

## **Recovering from Alarm**

Resolve the issue.

Click to clear the alarm

Continue or restart



# Recovery

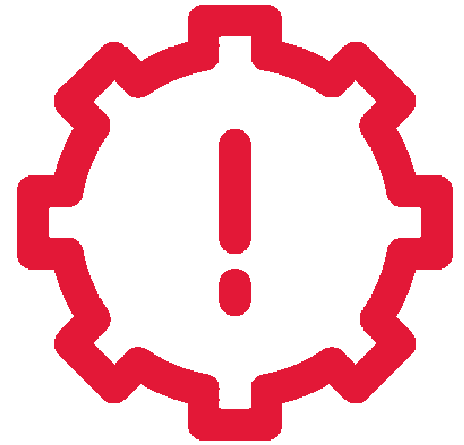
## **Hitting a Limit Switch**

The machine is set up with limit switches which automatically stop the machine moving X, Y or Z too far. If you hit a limit switch while jogging the machine or during an operation, the machine will stop.

You will need to re-set the machine, perhaps move your material, and start over.

# Going Wrong

1. Hit a clamp, screw, or other object you didn't mean to cut - Stop the machine,, re-reference the machine, start over.
2. Plasma stops cutting – replace consumables.
3. Plasma not cutting – No plasma stream or feed is too fast.
4. Toolpath not cutting in the right place – check gcode, restart
5. Material moves – stop, secure material, restart
6. You hit the limit switches – move material, restart



# After Job

- Jog the machine out of the way of your material as needed
- Turn off Plasma machine
- Remove Plasma Torch from Z holder (careful – may be hot)
- Disconnect USB
- Turn off and unplug electronics.
- Remove your material
- Tidy up
- Move Plasma Cutter, electronics, cables, etc. back to the Welding shop
- Cover the plasma table

# Materials

## Do and Do Not Cut List

### DO cut

Steel plate 20 gauge up to  $\frac{1}{4}$  inch (and perhaps a bit thicker, depending on alloy and cut speed)

Thinner sheet is 'possible' (at some point the plasma torch cannot move fast enough and warping of the metal becomes a problem)

Test first.

Aluminum

Any conductive metal (sheet gold, silver, platinum)

### DO NOT CUT

Galvanized material (zinc)

Sheet metal (too thin, zinc)

Magnesium (fire), sodium metal (fire), any hazardous stuff.

# Other Tips

If something goes wrong, try not to move your piece or change X,Y,Z zero

You can do repeatable cuts by putting your material in exactly the same place each time, or leaving enough room for error

A good fixture will help with repeatability and consistency.

Consider using a registration mark to confirm X Y Zero

The Plasma Table is a 'work in progress'.



# Other Info

Independent access is allowed after completing this workshop.

This workshop covers a lot, but probably not everything. Independent research, reading, watching, and study is recommended. Please share your findings !

We believe the information herein and communicated is accurate, but please independently verify to your own satisfaction.

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