K40 Laser Beginner Insights – Preliminary Draft

Based on the large number of posts here that begin with “I have just bought (*or am about to bu*y) a K40 laser. What should I look for/do/try/etc., etc.?”

Topic List

What materials can a K40 engrave and/or cut? What materials should be avoided and why?

In general, materials that absorb the deep infra-red beam (10um) that the CO2 laser puts out are most affected. Materials that reflect it are not very affected, and the reflected beam can be dangerous to eyes and skin, as well as damaging the laser lens. **Organics such as paper, wood, and organic fibers** absorb strongly and can be cut and engraved. **Glass** absorbs, and can be etched easily. **Stones** generally absorb and can be etched. Bare metals generally reflect and can't be cut. Marking bare metals needs special coatings. **Plastic or paint coated metals** can be marked, but this amounts to burning off the coating under the laser. Anodized and dyed aluminum can be marked fairly easily; this amounts to burning the dye out of the anodized layer. **Plastics** can in general be melted or burned by the K40, but the results depend heavily on the exact materials. **Acrylic** cuts easily and nicely, some plastics only melt and discolor. Plastics and adhesives in composite materials may give off toxic or corrosive gasses.

There is an appendix at the end with many materials and their engraving and cutting ease, and any warnings I've run into.

Where should I buy my K40? Which vendor? Ebay? Amazon? Other vendor?

There are many "manufacturers" of K40 style lasers. In fact, the term "K40" is best understood as a style of CNC laser rather than a model number. In general, the actual manufacturer if any given K40 is is unknown. They are sold on ebay, and increasingly on Amazon by either trading companies who did not manufacture them, or importers who buy wholesale lots from either one of the manufacturers or from trading companies, then do a variable amount of cleanup, alignment, testing and so on.

Often, the total amount of care and "quality" in a machine id reflected in the price. K40 makers have been in a race to the bottom on price for some years now, so there is always a fight for cheapest on ebay, and sometimes on Amazon. The more care and effort expended in pre-testing and setting up a K40, the more you can expect it to cost.

There are some people who report receiving a K40 which could be used right out of the box with only the minimum necessary set up of cooling water, exhaust air and checking for safety and water leaks. There are also people who receive dented boxes, cracked laser tubes, units with alignment and focus problems, loose belts, or simply non-functioning electronics. Most often, the cheapest ones can be expected to have more problems. Of course there are very high price bad ones too. It's a difficult and opaque issue. At the end, you pays your money and takes your chances.

That being said, sellers in the US$400 – US$450 range are beginning to provide the "just works" pretested and aligned version more often as measured by posting in forums. In the US$350 to US$400 range, you're taking more chances on getting a not-as-well made and/or tested one.

What is a K40 Mini?

It's a smaller, but lower power version of the K40. Where the K40 struggles to output a 40W beam, the Mini struggles to output a 30W beam from its shorter tube. See "Some of them look different" below.

Some of them look different. Which version/type should I buy?

First of all, the paint colors mean nothing whatsoever. There is nothing you can determine from the colors other than whether you like the colors or not. One vendor may like certain colors better, too.

What does make a difference is getting one with an analog meter, not the digital display version. The analog meter version tells you more useful information about what power the tube is using. A common upgrade for the digital meter version is to add on an analog meter somehow.

There has recently appeared a **"mini-K40"** on ebay. This is a smaller unit, which may suit your needs as the original K40 style is BIG. It eats up a lot of workbench space. The "Mini" version solves this by a slight repackaging to get smaller height and less width. It is virtually certain that the shorter, lower power laser tube in the Mini is cheaper, as is a smaller case.

And shorter is lower power in laser tubes. In CO2 gas lasers, all other things being roughly equal, power is proportional to length. The original K40 uses a 700mm to 720mm long tube, and claims 40 watts. It is best thought of as a 30-35W tube. You can't stuff a higher power laser tube into the width of the K40. It would be longer than the box is wide. Some "K40" boxes were made with a hole on the right/control side to accommodate a higher power (and therefore longer) 50W tube inside a bolt-on metal shield. **The Mini has a 600mm long tube, probably 20-25 "real" watts**, advertised as a 30W tube if you buy a tube, and maybe advertised as 40W in the ebay advertising.

Some people have reported ordering a full size K40, and receiving a full-size K40 case, but the laser tube inside was only 600mm long. The manufacturer/seller was making more profit by substituting in a cheaper, lower power laser tube. **If you intend to buy a K40, make sure it comes with the longer tube.**

Get the M2 Nano controller version

Some early K40 style lasers came with a "Moshi" controller and used "MoshiDraw" software. These are both judged to be difficult to use and get good results with. Most current ones have the "M2 Nano" style controllers. The controller board has "M2 Nano" labeling on the control board. These can be used with the maker-supplied (and probably cracked, illegal) CorelDraw and CorelLaser software. However, the M2 Nano controller can be used with the free "k40 whisperer" software. This gets more user comments about being easier to use and more reliable. So if you have a choice, get the M2 Nano controller.

If you have a dead M2 Nano, you can buy a new one from Cloudray for US$25.00.

Is the K40 safe to use as it comes? What needs changed or updated for safety?

No. It's not safe as it comes out of the shipping crate. Specifically, the electrical grounding is only one wiring failure away from putting deadly voltage onto the shell of the machine or into the cooling water.

See the section titled "More on Electrical Safety" below for more on what needs done.

The K40 style machines come with labeling that they are "CE" and FDA approved / registered / compliant. This is at least an exaggeration, if not an outright lie. The grounding scheme would invalidate it from CE marking, for one thing. The FDA marking is intended to say that it's safe for the laser classes recommended by the USA Food and Drug Administration. It is not.

The K40 style lasers all produce so much laser power that they're in the most dangerous Class 4 category per the FDA's rating scheme. Class 4 lasers require a complete enclosure that prevents even accidentally reflected laser light from escaping the enclosure, and also requires safety interlocks to stop the laser firing if the enclosure is opened. The "accidental escape" is arguable; ask the people with burned tables and work benches from that hole in the bottom. But there is no hint of an enclosure interlock. The K40 is unsafe without an enclosure interlock on the opening panels to the bed, electronics, and laser tube sections of the box. See "What other things need added or changed?" for more of what to do.

Finally, there is a very real danger of starting fires with the K40 laser. Never operate it without a fire extinguisher nearby. See "Fire danger!" below.

Fire danger!

The K40 and all other high power lasers are burning tools. They do what they do by burning. If the high temperatures and airflow manage to start a self-supporting flame inside the box, this can – and has – expanded to open flames engulfing the entire machine, with the real possibility of burning down the building.

All you can do is:

- use air assist; this can often "blow out" smaller flames at the focus point before they build into self-sustaining flames
- keep the inside of the machine clean; the more scraps of previous work present in the bottom of the box, the more chance that a poorly focused beam can heat them to ignition
- for God's sake, keep a fire extinguisher nearby, and watch your burn jobs so you can put out any flames that happen to start.

Your new/prospective laser is NOT a complete solution that you can simply open the box and run. To get it to be that cheap, the manufacturers (and there are several or many) cut a lot of corners. One big range of corner cutting was in the original objectives. The K40 was originally designed strictly for engraving or cutting rubber stamps. Very few users have desires that limited, so the expectations you probably have are higher than the machine was designed for. You're going to have to work at it.

I personally would never plug my K40 into the wall power without having a five pound CO2 fire extinguisher ready in case there is a fire. But then I value my family, myself, and my house, in that order. The cheapest CO2 fire extinguishers cost US$80 and up at the time of this writing. $100 is a better estimate. Replacing your K40 will cost $400, replacing the upgrades another $100-$300. Hospital stays for smoke inhalation get rapidly more expensive.

I have seen some university web sites where they post instructions and cautions to students that use their CNC laser labs in which they advise/require the students to keep a plastic spray bottle of water beside the laser while lasing. They are instructed to spray water on any "minor" flames if they appear. I have a horror of spraying water into a working electrical machine, but then maybe this would work OK. I have not tried it. You have been informed. And warned.

Is the K40 ready to start using as it comes, or do I need to modify it or set it up differently?

It varies, as mentioned in "Where should I buy my K40?" above. If you buy the lowest price unit, you are at risk of getting a unit with some dints and dings, bad alignment, incorrect focus. Some people report that they just did the minimal amount of setup (setting up cooling water and pump, setting up the exhaust fan and tube, running water tubes, etc.) and their unit turns out good engraving and cutting on thin materials. About the only way to get a "good one" is to see what the most current comments on the various K40 laser forums say about which vendor is doing good ones recently. I prefer to both consult that repository of information and learn to do the various setup and adjustment procedures.

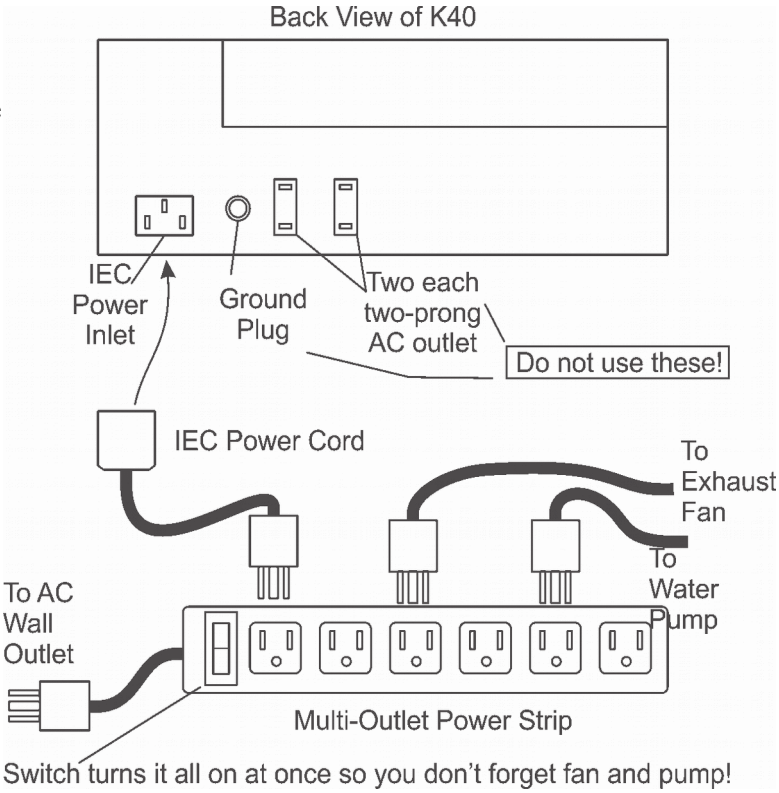
There are a number of things that people have done to make their K40 lasers more usable, more convenient, and ideally, more reliable. See "Enhancements and modifications" below.

Set Up and Adjustments

You will probably have to do adjustments on the machine you get it to work right. Even if you got lucky and your machine's supplier went the extra distance to send you a well-prepared and well-set up unit, you will eventually have to tinker with mirror adjustment and focus.

This includes focusing the lens on the bed accurately, adjusting the mirrors to actually hit the middles of the three mirrors, or even adjusting the squareness of the X and Y axes. Some buyers get machines that work well to start with, but these are the exceptions. Get ahead of the game and be prepared to learn how to do these adjustments yourself. If you bought a K40 to save money over the US$3k to US$15k that US CNC laser suppliers charge, it is unlikely that you can afford to pay someone else to adjust and maintain your machine, even if you could find someone willing to do so.

Here is one suggested way to plug in the K40, exhaust fan, and water pump. The grounding plug and two-wire outlets on the back of the machine are safety hazards unless you are an electrical expert. See what to do in "electrical safety" or better yet, use a multi-outlet power strip to turn on the laser, fan and water pump all at the same time. You could also plug your air assist pump into this as well.



Is the K40 complete as shipped or do I need to add things to make it work?

The K40 is incomplete as shipped. You need to add, at a minimum a cooling water reservoir; this can be as simple as a 5 gallon (20L) plastic pail, a 5+ gallon insulated cooler, something like that. It is highly advisable to add:

- A remote-sensor thermometer (~ US$10, ebay, amazon, etc.) to be able to see the temperature of your cooling water. Running with cooling water over about 20C/68F will shorten the life of your US$100 laser tube.
- Metal vent tube for the exhaust fan. The supplied tube is essentially useless. Home improvement stores, hardware stores, HVAC and hot water tank suppliers generally carry a 100mm/4" flexible ribbed aluminum vent tube that is much better than the stock plastic tube.
- That power strip thing above is a really good idea if similar things exist in your country.

Is the exhaust fan that comes with it OK? Do I need a different one?

The exhaust fan that ships with the K40 style lasers is somewhere between marginal and useless. It's a bathroom exhaust fan that might, possibly be OK for a little while – but only if you're willing to take chance on breathing foul smelling and possibly toxic burning fumes.

DO NOT turn it on without the ventilation hooked up. The vapors and particles the laser beam makes in burning most targets are toxic to you and in some cases the machine itself. Do not even try to run this thing in a room without specific ventilation. That exhaust fan and flexible tubing that came with the machine are minimal, but they may be enough to keep you from poisoning yourself and/or your family. Don't run the machine without something sucking air out of the back of the machine. Ventilate to the outdoors: blow that stuff out a window. In most cases, it stinks even if it's not immediately deadly.

Is the exhaust vent tube that comes with it OK? Do I need a different one?

You need a different one. You need an all-metal vent tube at least the same size as the vent fan you use, generally about 100mm/4" diameter. There are flexible aluminum vent hoses for household dryers at most home improvement stores. Get one and use it, at a minimum.

The supplied exhaust tube is plastic, and will either melt if temperatures get too high, or may burn in the event of a fire inside the enclosure. If it's a fire, this lets flames out into your work area.

Is the water pump that comes with the K40 OK, or do I need a different/better one?

The supplied water pump is actually OK. The amount of water flow through the laser tube needs to be at least 0.5 to 1.0 liters per minute. The supplied pump can do this.

TEST your pump. It's easy. Set up your cooling water reservoir and hook up the tubes and such. Then instead of running the return water tube back into the cooling water reservoir, drop its end into a 2-4 liter (½ to 1 gallon) bottle, jar, pan, or other receiver, and plug the pump into the wall all by itself. Run it for one minute, and see if you got your ½ to 1 liter/quart. If you did, you have enough water flow. If you didn't get this much flow, you would be endangering your ($100!) laser tube by running it with poor water flow.

The stock pump passes this test.

What other things need added or changed?

Air assist

There is strong agreement among experienced K40 owners that the first addition you need is air assist. This is a jet of air blown right at the focus point. Air assist does at least a couple of good things. One is to forcefully clear away smoke and globules of debris from the cutting/engraving spot and make better cuts. Another is to actually blow out tiny flames at the focus spot, reducing fire risk.

Air assist is usually done by buying a biggish-capability aquarium air pump ($30-$100) to supply the air, and then routing a tube along the X-Y framing to the moving head so it can blow through either an after-market focus cone on the moving head, or a metal tube aimed at the focus spot. The picture shows one of the common of this type pump. This particular one is on Amazon for US$39 at the time of writing. Even smaller US$10-US$20 pumps are thought to be an advantage.

The air from the pump is conveyed to the laser cutting head through a plastic tube which needs to end at the cutting head, and there is some mechanical work involved in getting the air tube to follow the head without impeding its motion while cutting.

Generally, there is some kind of metal tube that conveys the stream of air right down to the focus/cutting spot. Many K40s use a length of small metal tubing (4mm copper tubing, small automotive brake tubing, both cheap and widely available) bent to point the air at the spot. The high-dollar Epilog CNC lasers use the bent-tube method.

Another way is to put a metal or plastic air assist head on the lens holder. The air assist head adapter can be 3-D printed or bought. The 3-D printed versions get comments like "after a while, my cone

started to melt", so your mileage may vary. There is a lot of forum commentary on how to do air assist. Go do your homework when you get to this.

It may be useful to put an aquarium air valve in the air tubing line so you can tune the amount of air to the material being cut, the cutting speed, power and so on. This can get complicated, but offers the possibility of really clean cutting.

Engraving/Cutting Bed

The K40 style lasers were originally designed to engrave patterns and pictures on thin sheets, or to make rubber stamps by engraving rubber sheets. That is – the bed was not designed to adapt to the kinds of materials most K40 owners want. The stock bed is set up with a spring arrangement to hold small sheets. Unless your work uses thin sheets like the original design, and doesn't vary in thickess much, you'll likely want a different bed. The deluxe beds have height adjustment so you can move the material up and down so the (fixed height) focus spot is right on the material. This is a big deal, as a poor focus is one of the most reported problems with bad engraving or cutting performance. Changeable height beds make moving the material to the correct focus height easy.

Added Power Supply

The K40's stock power supply is adequate, just barely, for K40 operations. If you add stuff on, like LED strips for

Is there any special setup I need to do when I first set it up?

Do-s and Don't-s

Do:

- Do set up your cooling water reservoir, pump, and water tubing before even plugging the laser power cord into the wall.
- Do test the reservoir, pump and tubing for leaks before even plugging the laser into the wall. The pump can be plugged into the wall all by itself.
- Do check for water leakage inside the laser tube compartment before running the laser.
- Do use an analog meter to check tube current. Add an analog current meter of 0-30ma range to do power checking.
- Do study online sources for how to adjust and set up your laser. You may need to do it. This includes:
    - how to adjust focus
    - how to adjust mirrors for proper light path
    - how to adjust the X-Y axes to be perpendicular
    - how to tension belts
- Do learn, at some point before you need them, sources for and prices of spare parts like mirrors, lenses, belts, power supplies, and so on. Someday you'll need them. See "Spare parts and replacements" below.

Don't:

- Don't ever fire the laser, even for a second, without water in the tube. You risk instant damage the tube to some degree – all the way up to instantly fatally – by blipping the laser on with no water in the tube. Set up a cooling water tank and circulating pump before ever turning on the laser, even for an instant.
- Don't ever fire the laser, even for a second, without cooling water flowing through the tube. It can overheat quickly if the water is not flowing.
- Do not rely on the digital display as an indicator of laser power.
- Don't run the laser with the lid open, or with the laser compartment or controls compartment open. The laser and controls compartment are dangerous electrically. They contain either exposed AC mains voltage than can electrocute you, or 10,000 to 20,000 volts DC that can not only electrocute you, it can jump out of exposed wires you are not even touching.

  The laser compartment and main bed get watts of laser light. This can blind you instantly, even from a merely "shiny" reflection. This is the reason the FDA requires case interlocks to disable lasers when the case is opened. Some people are so fascinated by watching the laser burn things that they leave the lid open all the time. Mostly they get away with it. Do you want to take the chance that one day you'll accidentally scar both corneas at the same time?

Do I need to use that Ground Plug on the Back of the K40?

Maybe.

If your AC mains electrical supply has three prongs, one of which is a "safety ground", and the grounding inside the machine is either OK as it arrives or has been fixed, then no, you do not have to use the ground plug/socket on the back of the machine. Most of the industrialized world has electrical plugs that are this way.

You might be in a country or region that has electrical plugs that only have two prongs. In this case, there cannot be a safety ground wire in the AC cord, and you are exposed to electrical shocks by any electrical equipment, and by the K40 in general. In this case, you may have to use the ground plug on the back to connect your K40 case to an earth ground. See the discussion below.

If you determine that you must use the ground plug on the back for safety grounding, then you should make sure that the ground socket actually connects to the metal case by sanding the paint off the case where the ground plug/socket bolts into the case, much like the diagram for grounding below.

More On Electrical Safety

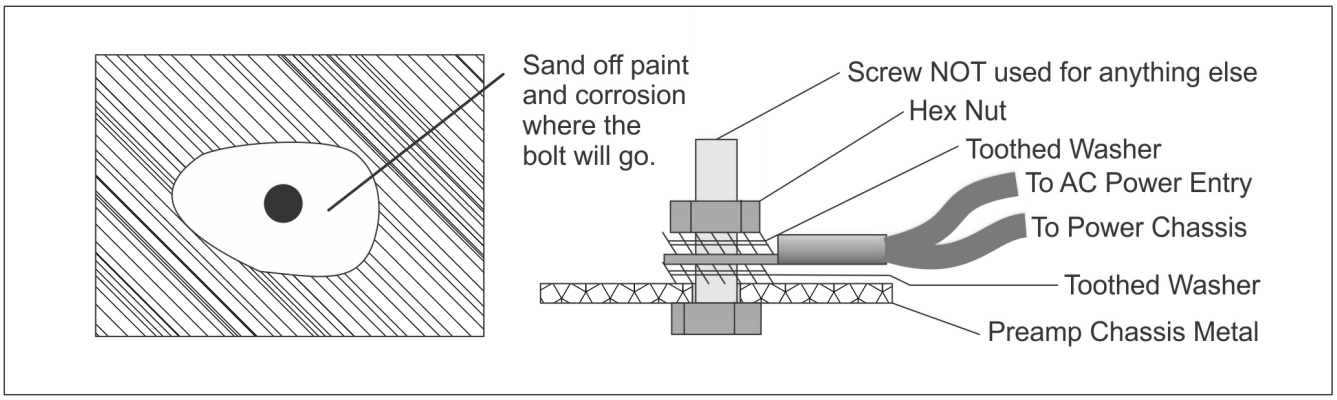
Grounding

Electrical grounding works by setting up a solid, continuous path to earth ground from all the user-touchable metal parts to a metal conductor buried in the ground. That way, any electrical leakage or short that "energizes" some metal part you can touch is "shorted" to ground. This usually pops a breaker or blows a fuse, but it prevents you from being electrocuted. Modern electrical codes require three (or more) prong electrical outlets, one contact of which is this earth safety ground. In most countries, using this third wire ground to ground your machine through the AC power cord is all you need to do, other than perhaps checking to see that your outlets themselves are correctly grounded.

Electrical Outlets and Inlets

The electrical outlets on the back of the K40 are in general not only useless, they're a positive electrical danger. The wiring is often not well done and may come loose, and in most K40s they are two-wire outlets, so anything you do manage to plug into them cannot be grounded. That's what that ground terminal on the back panel is probably for, maybe. However, that ground terminal is often insulated from the chassis by plastic washers and/or paint, making it misleadingly dangerous.

The picture below is how I reworked the ground lug inside my K40.



I have professionally designed AC powered equipment since the mid 1970s, so electrical safety is near and dear to my heart. So are the legal implications of electrical safety. I must make this disclaimer: This is based on the advice I got from a real, no-fooling safety engineer that did safety inspections of industrial equipment for certification. That being said, I do not know if his advice is enough to ensure safety, and I can not and do not recommend that you use this for your machine. I merely present it for your consideration. If you do it this way it is at your own risk, and you take all responsibility for your safety doing it this way. I trust this for my safety, but you must decide on your own about your safety.

I hate disclaimers, but they're necessary.

Along the same lines, including the same disclaimers, here's how I solved the (in my opinion) unsafe wiring inside the box, in general.

New electical outlets on back: If you plan to use the electrical outlets, they need replaced with three-wire outlets. I used Qualtek 739W-X2/32 that I bought from Mouser Electronics. They cost me US$1.28 each. They required me to cut and file a rectangular hole in the back of the K40 for each one. This has to be the correct size, so some skill in placing and filing the holes to the proper shape was needed.

Note that it's handy to just not use them, and to use a multi-outlet power strip to turn on laser, fan and water pump all at the same time.

Replace the AC line cord entry with an IEC style entry module if yours did not come with one already. The "IEC style" modules are like the power cords and inlet on most PC style computers.

Rewire AC mains wiring to power supply or supplies.

Wire fixed electrical outlets.

Replace the two electrical outlets in the back of the box with proper snap-in or bolt-on outlets for your country's electrical system.

Rewire the electrical grounds inside the box. Make a proper grounding stud. Properly crimp terminals for safety grounding the electrical outlets and power supply.

Cooling Water Ground

It's really smarter to put a safety-grounded conductor into the cooling water. This way, leakage current that somehow manages to get into the water path is reduced to a safe potential by the grounding conductor.

I only bring this up because I have seen some forum posts from people who report slight electrical shocks when putting their hands in the cooling water. It would be a really ugly surprise to be electrocuted by touching the cooling water in the reservoir. Using non-conductive (i.e. distilled) cooling water makes such a shock less likely. A leak of the cooling water inside the enclosure can short to either the AC mains voltages or the 10kV to 20kV that the laser tube runs on. Either of these are bad news to the human body.

More Cooling Considerations

Cooling water really ought to be distilled water. Water is actually an electrical insulator, but anything dissolved in the water makes it conductive. Conductive water in a K40 laser stresses the laser tube and power supply because of the 10kV to 20KV that the laser needs to operate. Distilled water is a reasonably good insulator, so use distilled. Most tap water contains from some to a lot of dissolved solids and other crud that make it more conductive; this stuff can also deposit out on the glass inside the laser tube or support algae growth inside the plumbing tubes or laser tube. Keep it clean, use distilled cooling water.

Dunk the attached pump into the water, and connect the supplied tubing to the ports on the back of the laser. One tube connects to the output of the pump, the other tube returns water to the reservoir. Before you plug the laser proper in, set up the water tank, pump and tubing, and do a test run by plugging the pump into the wall power socket. Any water leaking out may have damaged your laser or electrocuted you if you haven't already fixed the electrical safety grounding fixes above. Note that the pump supplied with the laser will not pump water any more than about 5-6 feet high, so the pump really ought to be no more than three feet or so below the laser tube.

Cooling your cooling water

Read the two files on cooling in the files section.

Software Considerations

The earliest control cards with the K40 style machines was a "Moshi" and it came with only its own special "Moshi Draw software". This is generally agreed to be useless. The later lasers used a "M2 Nano" controller that was packaged with the Corel stuff above. There is a free alternate program called "K40 Whisperer" that works with the M2Nano controller. It frees you from the poor software that is bundled with the machine, at no more cost. You can buy more expensive control cards (up to hundreds of dollars) and fancier control software that may enable you to do fancier burns. As you learn the machine, you can figure out how much you want to spend.

The CorelDraw supplied with the K40 is probably a hacked/cracked version of the commercial Corel Draw package. The Corel Laser supplied with the K40 is not a Corel product, it's a separate add-on. Corel Laser requires the USB dongle supplied with the machine to operate. You can buy additional dongles, but they're expensive, about US$30-$50 last time I looked. The dongle is an active USB processor/encryptor and cannot be copied or hacked in any simple way. So the K40 uses more advanced piracy protection for their add-on driver, and gives you a pirated Corel Draw package. Go figure.

Which materials can you cut/engrave safely?

There are certain materials you should not burn in your laser. PVC (polyvinyl chloride) releases hydrochloric acid as it burns. Many other materials involving chlorine in the chemical makeup do too. Some materials release HCN (that's "hydrogen cyanide"!) gas as they burn. Wood, leather, and acrylics are fine, but check before burning others. In general, people on forums have reported success (and no health issues!) from working on:

- Wood and wood products like plywood, masonite, and similar. Variable results are reported depending on what adhesives are used to make up the wood products.
- Paper, cardboard, etc.
- Fabrics and felt
- Acrylic (plexiglas, perspex, etc.)
- Leather (which may require special dance steps like wetting, etc.)
- Glass – your K40 will most likely engrave but not cut through ordinary glass
- ABS to some degree. My friend with the Epilog cuts acrylic all the time, but he has a good vent system. ABS is reputed to give off hydrogen cyanide (HCN) when lased. Don't try this until you have a GOOD vent system, and then don't vent it into your neighbor's window.
- Coatings on metals; the K40 doesn't have the power to cut metals. It ...might… cut thin aluminum foils. Maybe. But it's dandy at engraving away coatings like aluminum anodizing, paints and other such.
- Marking compounds on metals. There are several spread-on compounds that are catalyzed/burned by the laser so they leave a permanent mark on metals when lased. Cermark is one brand name, but some people report good results with molybdenum greases.

Enhancements and modifications

Added Power Supply

The K40's stock power supply is adequate, just barely, for K40 operations. If you add stuff on (like LED strips for viewing the lasing through the window while engraving, or for better visibility to set up stock to work on) it may cause issues because the power supply is just barely able to put out the power.

There is a cheap alternative that will let you add on many more electrical mods. I bought a Mean Well RT-85D power supply for US$25.79 from Jameco Electronics. This supply provides 24Vdc at 2A, 12Vdc at 1A, and 5Vdc at 6A. This is plenty to provide all of the +24V the K40 needs for its X-Y motors, vastly more +5V than it needs for the logic and controls, and also gives you 1A of 12V for anything else, like maybe those LED strips. It takes the 24V and 5V loading off the stock power supply entirely, and so the stock power supply is not running so near the edge of the power cliff. There are probably other 2- and 3-output power supplies that would do much the same. A 24V and 12V supply would do most of this, and maybe be cheaper.

Good general K40 tech notes

I very much like DonKJr's blog for no-nonsense tech info on the K40. It's sometimes difficult to find things, but reading it all will make you much more knowledgeable about your K40. Don sells kits of parts for useful hacks. I have not bought any of these, but I like the free tech information. Seriously, about 2/3 of the beginner's mystification could be cleared up by just reading this blog.

http://donsthings.blogspot.com/2016/11/the-k40-total-conversion.html

Spare parts, replacements

- Laser tube

  The laser tube in the K40 is what industry calls a "wear item", and it will wear out in the normal and proper use of the machine. Glass CO2 lasers are often rated for a life of ~5000 power-on hours. When they are misused by running them with too much current (power) they wear out faster. When they are poorly cooled, they wear out faster. When they are just abused by letting their cooling water freeze inside, or get full of thick algae, or mis-wired, they can fail completely. General wear-out causes a long, slow loss of cutting power.

  The tubes in K40s are not first-quality tubes in general, because of the intense pressure on the sellers to offer the lowest price. You can get replacements from some online vendors. I have seen reports of good results, including "Wow! This is great! It never cut/engraved like this with the original tube!" Some vendors that come to mind from forum posts include Ten High, Cloud Ray, and Lightobjects.

  You're looking for a 700mm to 720mm max length and 50mm diameter. That's the biggest that will all fit inside the enclosure. This limits you to 35-40W rated tubes. Your original tube was probably only producing 25-30W max, and possibly much less, as the OEM tubes were generally not the first, best quality tubes. Here are some links I found on a quick search. They are in no particular order.

  - https://www.lightobject.com/Laser-Tubes/SPT-35W-CO2-Sealed-Laser-Tube-for-Small-K40-Laser-Engraving-Machine
  - https://www.amazon.com/TEN-HIGH-AC110V-engraving-cutting-machine/dp/B00BKWOS1E
  - https://www.amazon.com/SenTECH-Engraving-Cutting-Machine-Discounts/dp/B07RX5V42F/ref=sr_1_2?keywords=glass+laser+tube+40w&qid=1573619022&s=home-garden&sr=1-2-catcorr
  - https://www.cloudraylaser.com/collections/cloudray-laser-tube/products/35-45w-720mm-co2-laser-upgraded-metal-head-tube-cr35?variant=12782294270003
  - https://www.cloudraylaser.com/products/cloudray-tongli-700mm-40w-co2-laser-tube-glass-pipe-for-co2-laser-engraving-cutting-machine-tl-tlc700-50?variant=12816467296307

  If you have the "Mini" version, you're going to have to find a vendor for the 600mm long shorter laser tube. Start with the vendors above and see if they carry it.

- power supply

  There are many replacement power supplies. I hope to expand this section.

- lenses

  The stock lenses are 12mm diameter zinc selenide (ZnSe) material and have a yellow-orange

cast to my eye. Zinc selenide is toxic and fairly fragile, so always handle your lens with care when cleaning it.

CO2 laser lenses can also be made from GaAs (gallium arsenide) and Ge (germanium). These more esoteric lenses may appeal to you. Read up on them before spending a lot of money on therm.

- Mirrors

  Common mirror materials are Si (silicon) with gold plating, polished copper, molybdenum, and perhaps others. If I understand what I read, the gold plated silicon has the possibility of being the absolute best reflectance, but may also degrade quickly, and may also be poorly made. Copper is not often seen in K40s. Molybdenum (MO) mirrors are solid polished metal, and probably the toughest and most reliable, even though they are slightly less reflective. MO seems to be the most resistant to damage and/or poor cleaning technique.

  One reference I read said that the coating or reflective surface of the mirrors – may – degrade over a fairly short time, leading to a 25-50% power loss through the mirrors absorbing the heat.

- belts

  The belts are NOT the common hobby-CNC GT2 toothed belts. I still need to track down what they are – I've never replaced mine, and I need to follow my own advice and get a spare set before mine fail.

Regular Maintenance

The K40 contains some parts that will break or wear out, and some that need regular care. I'll just mention some obvious ones and add to them as I think of more.

- Lens and mirror cleaning

  Your lenses either pass or reflect the entire power of the laser beam. This is fine as long as very little of the power in the beam stays inside the lens or makes it past the shiny surface to the inside of the mirror. A layer of dirt, condensed oils and plastic vapor, smoke particles and such can absorb a lot of the power and transfer it to the lens or mirror.

  This picture is a bad example. And that is AFTER I cleaned it with acetone. I got my K40 used, and I suspect that the seller thought he was taking me for a sucker. It simply cannot have been working well for him. Don't let this happen to your lens or mirrors.

- Lenses can fracture or spall off a piece of the lens, which of course ruins its ability to focus laser light, and makes it fail even more. What happens to the mirrors depends on what they're made of. Some mirrors are silicon crystal (semiconductor wafer stuff) coated with a whiff of condensed gold vapor and some kind of coating over the gold. These are the cheapest, and also the most likely to break if dirty and then

overheated. Molybdenum metal mirrors are much more durable and only mildly more expensive. A good thing to do is to replace any unsatisfactory mirror with MO (molybdenum) mirrors.

The actual cleaning is tricky if done right. Most of the commercial laser sites I've read recommend cleaning the mirrors with acetone – not water, not alcohol – and lens papers, not cotton swabs. I first used alcohol and swabs on mine until I read better. The best thing is probably to do a web search for laser optics cleaning procedures that are (a) recommended by professionals and (b) something you can actually accomplish.

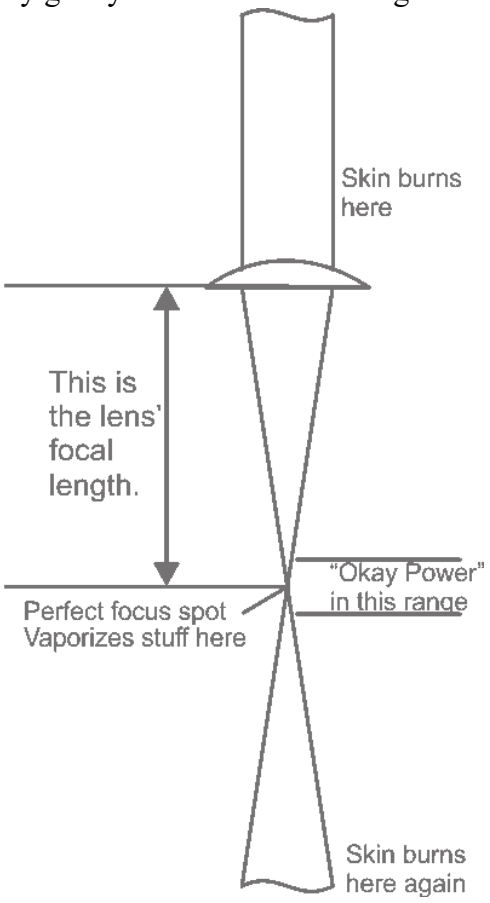
The worst cleaning is no cleaning at all.

- Focus Set Up

  You have to adjust the bed of the machine to hold the material you're cutting or engraving to nearly exactly the focus length of the lens. Here's why.

  Your laser beam emerges from the tube about 5-7mm diameter (¼ inch, more or less), is reflected by three mirrors, and then focused by the lens down to a small spot. In a perfect world, the beam would be perfectly round in shape and "Gaussian" as well as "single mode". These are not perfect lasers, so the beams are not perfectly round nor "Gaussian" nor "single mode", so they will not focus to a supremely tiny focus spot.

  This is only work knowing because it means that your focused laser burning spot will only get so small, and no smaller. If you're getting 30W of laser light out of the tube, you will lose a few percent in the mirrors before the lens. Even then, if you accidentally get your finger or other body part into the beam, the 30W of laser light will instantly give you second or third degree burns in the roughly quarter-inch size of the beam. The lens can focus all that ~30W onto a spot maybe 0.010"/ 0.25mm diameter. The power to burn things at any point in the beam is dependent on how much power is in the area of the beam that hits. Since the area of a circle is proportional to the square of the radius, the same power that hits a ¼ inch diameter in the unfocused beam is concentrated into a spot (0.01/0.125) squared smaller, so the power per unit area goes up by 156 times. The power at the beam focus from a 30W laser is ~3000W in that tiny spot if everything is just right.

  The spot power is close to this much for a short distance above and below the true focal spot. Depending on the material, there may be enough "depth of focus" to cut through a material in one pass. How thick the laser can cut through depends on the power density (power per unit area) the material needs to burn/cut it.

  The "Okay Power" range is not very thick. If your material is higher or lower than the tight, small spot region, it will be scorched or partially cut, but won't cut through. The spot size is bigger both higher and lower than the perfect focus spot, so resolution suffers from poor focus too. For the K40, the OK power zone is probably no more than 6-7mm thick.

The classical way to test focus is to set up some material purposely slanted so the laser hits it at different distances from the lens. If you do this right, you can lase multiple lines and pick the thinnest line. That's very near the true focus length. Then you set up your bed so new sheets of material are close to this perfect distance.

The "perfect focus distance" is the lens focal distance. K40s ship with 50.8mm (2.0") focus length lenses. You can get 38.5mm (~1.5") lenses, which have a shorter focus length and so a narrower "Okay Power"range. Some people like to use this for engraving.

Appendix 1. Materials

This material was gathered from the web in the recommendations of either laser manufacturers for use with their CO2 lasers, or from user groups, maker spaces, or university advice/rules/cautions to student users. It is certainly not complete, and may contain errors, but it's better than asking a fresh new question about "Can I cut/engrave XXX material in the K40?" every time. Please help enlarge and refine this list.

The materials are grouped by classes:

- I = inorganic, or mineral but not metals
- M = metals
- O = organics
- P = plastics; yes, I know most plastics are technically organic, but for lasers, they're special

Material	Class	Engrave	Cut	Cautions	Why/Notes
Organics					
Cardboard, corrugated	o	Y	Y	Flames!	
Cloth	o	Y	Y		
Cork	o	Y	Y		
Cork (composite)	o	Y	Y	caution	Adhesives may cause poor results
Fabric (natural, not poly)	o	Y	Y		Synthetics are woven plastics.
Felt/cloth/cotton/hemp	o	Y	Y		Wool felt stinks
Leather	o	Y	Y	Stinks!!	No, really, it stinks horribly
Leather/Suede	o	Y	Y	Stinks!!	Note: artificial leather is PVC or PU
Matte Board	o	Y	Y		
MDF/Engineered woods	o	Y	Y	caution	Adhesives may cause poor results
Mother of Pearl	o	Y	Y		
Paper	o	Y	Y		
Paper, card stock	o	Y	Y		
Pressboard/chipboard	o	Y	Y		
Woods (general)	o	Y	Y		
Solid Wood		Y	Y		
Plywood/Composite woods		Y	Y	caution	Adhesives may cause poor results
Wood Veneer	o	Y	Y		
Plastics					
Acrylic/Lucite/Plexiglas/ PMMA	p	Y	Y		Good results usually. Can give nice polished edges.
Coroplast ('corrugated plastic')	p	Y	Y	Flames!	Reputed to catch fire easily.
Delrin (POM)	p	Y	Y		
Depron foam	p	Y	Y		
Gator foam	p	Y	Y		
Kapton tape (Polyimide)	p	Y	Y		
Mylar (PET)	p	Y	Y		
Nylon	p	Y	Y		
Polycarbonate (Lexan)	P	~	~	Poor results	Melts and discolors, not clean
PETG (polyethylene	p	Y	Y		

terephthalate glycol)					
Solid Styrene	p	Y	Y	Flames!	Catches fire easily
Teflon (PTFE)	p	Y	Y		
Thin Polycarbonate/Lexan Sheeting (<1mm)	p	Y	Y		Works better than thicker
PVC (“vinyl”)	P	Y	Y	Toxic	Toxic/corrosive HCl released , eats machines and lungs
Polyurethane	P	Y	Y	Toxic	Releases hydrogen cyanide (HCN)
Inorganics					
Carbon fiber mats/weave	I	N	Y	~	Non-epoxied mat, weave only
Ceramic (e.g. decorative tile)	I	Y	N		
Corian	I	Y	N		Corian is powdered stone in resin
Fiberglass	I	Y	N		
Glass	I	Y	N		
Magnetic Sheet	I	?	Y		
Marble	I	Y	N		
Marble, Stone, Soap stone, Granite, Onyx.	I	Y	N		
Melamine	I	Y	Y		
Rubber	I	Y	Y	Varies	Some rubbers have chlorine, like vinyl
PCB (fiberglass, FR4, etc.)	I	?	~		Varied reports
Bare Metals in general	m	N	N		
Aluminum	m	N	N		
Anodized Aluminum	m	~	N		Laser can burn out the dye
Brass	m	N	N		
Stainless Steel	m	N	N		
Titanium	m	N	N		
Painted/coated metals	m	Y	N		Laser can burn away the coating/paint

Appendix 2. Material Sources

Most cities have suppliers of plastic sheet, wood products and paper products. Use the internet and search for what's local to you, or for a mail order supplier. I could do a list, but it would be enormous and always out of date.