

# Guide to Purchasing a Laser Engraver Cutter

By Greg Bell

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## **Introduction**

The purpose of this white paper is to provide enough information so that the reader can purchase the best laser engraver or laser cutter for their needs. This paper focuses on the most popular laser engravers and cutters sold on the market. These are the Carbon Dioxide (CO<sub>2</sub>) laser engravers and cutters utilized for engraving and cutting identification badges, wood, acrylic, and many additional materials for many different uses.

Often, detailed specifications are offered by manufacturers and salespeople without a thorough explanation to the buyer. The specifications come in the form of printed or published product brochures as well as salespeople verbally explaining the laser machinery. Buyers are uninformed of the complete benefits and drawbacks of the specified equipment because the information is presented by a biased source. The result is that often buyers do not make the best purchasing decisions for their needs.

This paper first introduces the types of laser machinery available on the market and identifies the most popular types purchased today. The focus of this paper is on the popular laser engraving and laser cutting market.

Next, the major and minor specifications for these machines are defined, along with their advantages and benefits and in comparison and contrast to other models. Two groupings are considered and analyzed. The first grouping is the small or desktop laser engraver cutter. The second grouping is the larger laser cutter engraver. By evaluating these two groups, the reader is able to assess the wide variety of machines available on the market including the ones that lie in between these sizes. This comprehensive specifications list, combined with the major and minor specifications, covers the complete offering available on the market today for the popular laser engravers and laser cutters.

The analysis of both the standard features and options are combined in a table format, focusing on one set of specifications at a time. This row by row comparison of different manufacturers permits the reader to analyze the offering and understand why the laser machines are technologically different as well as priced differently.

Discovering your laser engraver cutter needs is important to making the best purchasing decision. Some buyers have a product in mind that they want to produce, and others take a more general approach—whether it is laser engraving identification badges or signs or customization of products. The Specifications section provides an analysis of several different laser machinery manufacturers. For the buyers taking the general capabilities approach, the Specifications Section can be read first and the samples approach skipped..

The second approach to evaluating your needs—the samples oriented approach, provides an alternative method to identifying the laser machine best for you. In this approach, getting a laser cut sample completed is discussed. Many laser laboratory samples reports are provided as examples. The process ends with the definition of the specification

required by the laser to meet your needs from both a costs benefits perspective and a general business perspective.

Used laser machinery offers opportunities and drawbacks. With its own unique risks and benefits, this section discusses many important considerations when looking at used laser machinery.

Laser safety is something to keep in mind. The laser is a tool that when used improperly can be dangerous. Guidelines and sources for safety regulations and instructions are identified.

The section on further consideration discusses important matters beyond the specifications to consider prior to the purchase. Also presented are common mistakes and considerations in the selection, purchase, installation, startup, and lifetime of ownership.

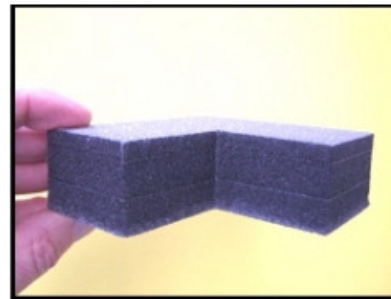
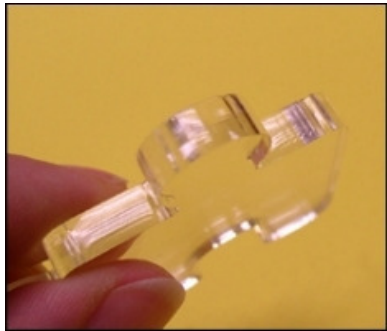
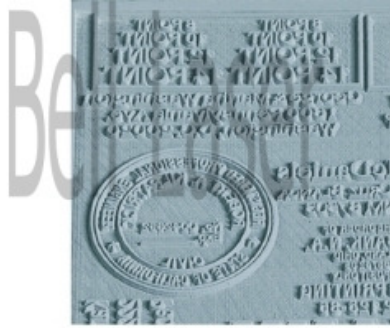
The appendices offer additional information including what materials can be processed.

I hope that you enjoy this white paper and find it a valuable resource in your laser engraver cutter machine purchase process.

Below are examples of laser engraving and laser cutting samples done utilizing the small laser engraver cutter and the large laser engraver cutter. Photos provided by [www.laserbits.com](http://www.laserbits.com) and [www.synrad.com](http://www.synrad.com).

Author and Publisher, Greg Bell





## Section I: Laser Machinery Meets Many Needs

Laser machinery is suited for many needs. This paper is dedicated to the popular laser engraving and cutting machinery. The products and services performed within these laser types are demonstrated. Within this section these laser types are discussed as well as other laser types for reference.

Both the small and large laser engravers and cutters utilize the CO<sub>2</sub> laser. This laser was invented in the 1960s and has been the leading seller in industrial and commercial uses for two reasons. The CO<sub>2</sub> laser can cut and engrave many common materials. It can laser engrave anodized aluminum, wood, acrylic, leather, and much more. (See Appendix A for a more complete listing)

The second reason is that the CO<sub>2</sub> laser is the lowest cost laser to own and operate. Initially it was a flowing gas laser that required gas bottles. Now, it is a sealed tube with CO<sub>2</sub> and other gases inside the laser tube that produces the power to process these materials. Over the years the cost for CO<sub>2</sub> lasers has slowly dropped. The metal tube lasers, as opposed to glass, offered a new compact design (see Synrad story), that enabled them to be put on machines. They use the RF switching technology to achieve high rates of engraving speed, though comes with a much higher prices tag than the traditional glass tube laser. The glass tube laser utilizes high voltage and costs much less though it is larger in size.

### 48-series lasers

Synrad's original "all-metal" tube technology opened the door for sealed CO<sub>2</sub> lasers in many industrial applications. After 20 years, it remains the industry standard for performance, reliability, long lifetime and low cost.



Many machinery manufacturers incorporate the laser within their machines. The machines enable shape cutting, or two dimensional laser engraving and laser cutting. These machines utilize different methods to get the laser beam to the work surface. In some cases the laser beam is reflected to the work surface using mirrors. In other cases the laser is transported on the laser machine and rides atop the work surface, moving along with the shape engraving or cutting process.

Today, scientists have discovered many types of lasers other than CO<sub>2</sub> lasers. Other types of lasers include YAG lasers, excimer lasers, high power metal cutting lasers, and more. These lasers have differing effects on materials. In a few cases they can process the same materials as the CO<sub>2</sub> laser, and in other cases they can process different materials. This paper does not discuss these other lasers or their application in machinery, as they are not within the same cost range nor do they provide the capabilities required by our readers.

So what CO<sub>2</sub> laser brand or model lasers do the buyers choose and why? Do they get the machine to meet their expectations? Where does the machinery fall short? Was it worth the money? These buyers had salespeople and product brochures to review to make the best decision. The information included specifications. Did the buyers understand the specifications and choice differences between all manufacturers? This is difficult to answer, but probably the answer is no, as the technology is still newer to the market place. A heavy reliance on the salesperson and brochure guided their decision.

In the following section we will review the major and minor specifications in depth. The manufacturers selected provide the common variety of technologies offered for each

specification. The technology choices, their application and costs are analyzed. With this information, you can begin to examine your needs and compare to the technology offered in order to begin to form your decisions for direction in choosing a laser machine.

## **Section II: Specifications for Laser Machinery**

What makes a laser engraver cutter different? Different manufacturers offer different CO<sub>2</sub> laser machinery. For you to make the best decision for your needs, a good understanding of the specifications and their type, application, and cost is a great starting point.

### *Product and Market Evolution*

If we examine the history of laser machinery sales we can see how the market grew. At first, there were major American suppliers that invented and sold the first laser engraving machinery. Preco offered a laser engraver featured in the 1986 Engravers Journal. It was a huge machine with a very high price tag. Then, the big cost break through came with a Roland plotter retrofitted with a metal tube laser. The product sold well, and after a business breakup then Universal Laser offered its own laser machine to the market. Later, after supplying metal tube lasers from Synrad, Universal Laser began to manufacture their own metal laser tubes. This action further reduced the cost of the laser engraving machinery. Another American company, Epilog laser, offered a similar quality machine to the Universal Laser and both companies with sales representatives worked to create the market world-wide. Smaller players and niche players arose and captured a small portion of the market, including Trotec (rubber applications) and Xenotech (Mechanical engraving market turned laser).

Next came the re-introduction of the glass tube laser machines from China. By dramatically reducing the upfront cost and cost of ownership over the lifetime of the laser machine, the Chinese manufacturers quickly changed the market landscape. As the price reduced the quantity of laser buyers increased. During this time, both Epilog Laser and Universal Laser targeted the broader market by offering a newer lower cost and smaller laser (Epilog Mini and Versa Laser). Bypassing their sales representatives (which make a significant commission), they offer these smaller laser engravers through other resellers and direct sales to lower the cost to the buyer.

For all size laser machines the Chinese put up a good fight, though at this time the US manufacturers still have a quality advantage, though that is shrinking as time passes. The Chinese are adopting many changes and the cost to manufacture and produce is still much lower than in the United States. Is the best value a US/European machine or a China machine?—that really depends upon your needs and use.

### *Specifications Explained*

Below is an examination of the specifications of laser machinery offered on the market today. This a broad sampling that covers approximately 98% of the offering today by any manufacturer or model for its class. Two groupings of classes are presented. The two classes are a small laser engraver cutter and a large laser engraver cutter. The importance of these two selections is not only to examine the specifications within each, but to compare and contrast the two types. In fact, the smaller laser engraver cutter is much better at engraving than the bigger laser engraver cutter—though from an examination of the specifications the technology utilized by the larger unit appears better! Physics plays the important role here. The smaller engraver is lighter weight so it moves faster and with a smaller area to move the motion is inherently more accurate. So, for finest engraving the smaller machine is best. Cutting thicker material is better done with higher power and the right laser lens. Acrylic ½ inch thick should be cut on the larger laser engraver cutter, and gives better results. The smaller laser engraver cutter may not be able to accommodate the different lens due to limitations in table height. These factors are why there are two sizes for evaluation. The manufacturer and product model brochures rarely explain these differences.

### *Small Laser Engravers Cutters*

The specifications are presented in priority order. These specifications present the most important ones followed by the less important. The importance is gauged by capability and needs for the majority of buyers. Some specifications provide less value to the buyer and are rated toward the bottom. However, your application may re-order the priority for your specific needs. Below is the presentation.

### *Small Laser Engraver Cutter Specifications*

#### *Laser Table Specification:*

MFR	Product Line	Model	Work Area	Table Size
Universal Laser	VersaLasers	VLS2.30	16" x 12", or 406 x 305 mm	18.75" x 14.6" or 476 x 370 mm
Epilog Laser	Mini	Mini 18	18" x 12" (457 x 305 mm)	Not specified
World Lasers	LR Series	LR1612	16" x 12"	Not specified
XYZ-Tech	Stamp Making	WK40	8" x 8"	Not specified



The working area of the table is the available space for the laser to laser cut and engrave shapes. In some cases, the working area is a different size from the table size. Therefore, the material placed on the laser table can be larger than the working area. Typically, the



space is only a bordering area around the material. For example, a 16" x 12" laser engraver cutter may hold a 16.5" x 13" material.

The small laser engraver cutter typically has the laser tube installed behind the laser table. This prevents the ability to pass through a larger sheet of material. The larger laser cutters often permit material that is the width of the laser table to be pass-through the laser table at any length. Therefore, large signs can be cut on a table in sections. Unfortunately, the human eye can detect small differences in light, so laser engraving in sections for a single photograph or image does not give good results.

Some small laser engravers front access so larger objects can be inserted for laser engraving. For example, baseball bats can be inserted into LR Series machines.

Some laser machines only engrave. This is the case with the XYZ-Tech WK-40 that utilizes the Moshi control software. It is important to note this machine's capability is limited to engraving only.

*Laser Height Specification:*

MFR	Product Line	Model	Height
Universal Laser	VersaLasers	VLS2.30	4" Maximum part size
Epilog Laser	Mini	Mini 18	4" Maximum material thickness 6" Maximum with table removed
World Lasers	LR Series	LR1612	3" work area (height)
XYZ-Tech China	Stamp Making	WK40	0" maximum material thickness

The height specification is called by several different names, though the meaning is inherently the same. The maximum height of the part, the parts thickness, or part size identifies the largest part that can be laser engraved or laser cut. Keep in mind, the laser engraves or cuts on a plane, meaning the laser is focused to a point in height and can perform a cut or engraving pattern at that plane and not at two different levels in one setting.

Most buyers of laser machines will engrave on a single material or part with a single thickness. For example, acrylic may come in a 1/4" sheet and can be laser engraved on its surface. For the specifications above, all machines can laser engrave the acrylic. However, if the acrylic is one inch thick, then the WK40 will not hold a material this thickness. The WK40 is equipped with a special holder that is a spring tensioned clamp to hold a piece of rubber to make a stamp. The clamping mechanism holds the material so that it is flush, or flat to the fixed table. See picture below. And, as this laser machine is not equipped with a movable laser lens assembly, it means that the only parts that can be laser engraved art parts that are positioned flush with the table.



Many promotional items, such as square wooden pen holders require a 3” or larger height to laser engrave a logo or name on them. Many acrylic or glass trophies are quite thick and need this height for laser engraving.

The Epilog Mini offers 6” height if the laser table is removed. Though it takes time and effort to remove the laser table, the advantage is the capability to engrave a part that is 6 inches tall.

*Laser Rotary Specification:*

MFR	Product Line	Model	Height
Universal Laser	VersaLasers	VLS2.30	360 degrees max part 4” with 2.0” laser lens (optional upgrade)
Epilog Laser	Mini	Mini 18	Not offered
World Lasers	LR Series	LR1612	Not offered
XYZ-Tech China	Stamp Making	WK40	Not offered

A rotary attachment is useful for laser engravers to engrave wine bottles or glasses. Typically, these rotary devices are good for promotional items. The Versalaser is the only model offering the rotary in this size of laser machine. This item is an additional cost for the option upgrade.. Larger laser machines by the other manufacturers can accommodate a rotary fixture, as will be seen in the second grouping below.

*Laser Machine Dimensions:*

MFR	Product Line	Model	Machine Dimensions
Universal Laser	VersaLasers	VLS2.30	26” x 14” x 25” or 476 x 370 x 102mm
Epilog Laser	Mini	Mini 18	27.8” x 26” x 13.5” or 706 x 660 x 343 mm
World Lasers	LR Series	LR1612	43” x 25” x 17” or 1100 x 640 x 440 mm
XYZ-Tech China	Stamp Making	WK40	800 x 500 x 260 mm 31” x 20” x 10.5”

All four laser models are large desktop models, approximately the same size as large laser printers.

Notice that the Universal Laser and the Epilog Laser brands are shorter in length. This is due to the fact that these companies incorporate the metal tube laser in their product. The longer two, the World Lasers and XYZ-Tech, both utilize the glass tube laser in their product—that is longer than the metal tube laser. This is the primary reason for the difference in size.

Some buyers put the lasers on carts or stands with casters so they can be moved around the workshop or working area.

*Laser Power or Wattage Specification:*

MFR	Product Line	Model	CO <sub>2</sub> Laser Output Power
Universal Laser	VersaLasers	VLS2.30	10, 25, 30 watts
Epilog Laser	Mini	Mini 18	30 or 40 watts
World Lasers	LR Series	LR1612	40 watts
XYZ-Tech China	Stamp Making	WK40	40 watts

Laser output power is one of the most important specifications in the laser machine. It heavily affects price and capability. For laser engraving wood, plastic, and anodized aluminum, the lowest power laser will do the job—the VersaLaser offers a 10 watt laser. However, to laser engrave these same materials faster, increase the laser power to 30 or 40 watts.

To add additional laser engraving capability, you need a 30 or 40 watt laser when utilizing the Cermark product to engrave on stainless steel or other metals. As stated, a ceramic coating product like Cermark is utilized to prepare a metal surface for CO<sub>2</sub> laser engraving. This product creates a thin black film on the metal surface after the CO<sub>2</sub> laser has engraved over top of it.



Laser cutting materials requires 30 watts or more for practical purposes. ¼” acrylic can be laser cut with these powers, as well as 1/8” plywood. Hardwoods and softwoods can be laser cut to ¼” inch. No metals can be cut with CO<sub>2</sub> lasers under 100 watts, so none of these lasers are useful for metals cutting.

For production, 30 or more watts is recommended.

There are two types of laser tubes offered on the market, the metal tube and the glass tube. The glass tube is the original laser tube design. In this case however, the glass tube is sealed so it has the required gases inside. Once they are consumed, which can range from 1000 hours to 3000 hours depending upon the laser source, the glass tube is replaced.

The replacement process for a glass tube is typically a simple job of removing the laser tube with two screws from its braces, removing the power lines, two wires, and removing the water lines.

Note, that glass tube lasers require a water circulator that comes with the laser. The metal tube lasers are air cooled and more compact. Also, they may last 4000 hours or much longer. However, these lasers will require a recharge when the CO<sub>2</sub> gas is consumed.

The cost of a glass tube is one quarter to one tenth of a metal tube laser. Therefore, the initial cost of a glass tube laser machine is significantly less than a metal tube laser. The glass tube lasers need to be changed more frequently, but their cost to change laser over that of a recharge is about one quarter of the cost. Overall, the cost of ownership of the laser machine with a glass tube is far less than a metal tube, when the laser time is less than two shifts per day.

When is it recommended for a metal tube laser? When the jobs run daily two to three shifts or 16 to 24 hours per day it is more cost effective to purchase a metal tube laser machine.

*Laser Speed Specification:*

MFR	Product Line	Model	Speed
Universal Laser	VersaLasers	VLS2.30	Not specified
Epilog Laser	Mini	Mini 18	Computer or manually control speed in 1% increments to 100%.
World Lasers	LR Series	LR1612	60 inches per second
XYZ-Tech China	Stamp Making	WK40	Not specified

Speed is an elusive specification. World Lasers specifies 60 inches per second, and this is the maximum capability that the laser focus head will move. The other manufacturers do not specify a speed rating. Epilog Laser identifies how the laser speed can be controlled. The other manufacturers have similar control capability.

How fast can the laser engrave a picture is a common question. The answer lies not in the specification but in several factors. Because there is more than one factor that contributes to the overall throughput or time it takes to engrave or cut a job, then the answer has to be computed.

For example, how long does it take to laser engrave a persons photograph on black marble? The factors that affect speed are laser power (10 watts, 30 watts, or 40 watts),

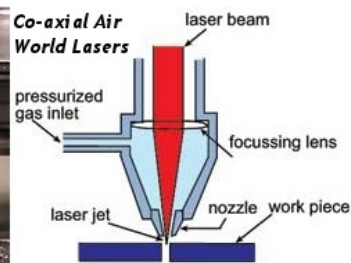
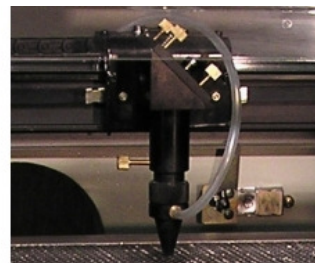
the size of the picture (4" x 6", 5" x 8"), the resolution of engraving (75 dots per inch can be seen well at 3 feet away, 300 dpi can be seen well at one foot away, 1000 dpi looks good with your eye up to it). With 75 dpi the laser must move across the black marble and laser engrave a 75 lines per inch. For 1000 dpi, that takes a lot longer.

For wood, and acrylic, higher laser power will benefit you by laser engraving at a higher speed. Always try to minimize the dpi (dots per inch), to reduce the time it takes to run a job and retain the quality that you require.

For a database of cut speeds and engraving speeds, you can subscribe to Laser University by laserbits.com to get a better idea of laser speeds for all materials and all laser wattages.

*Laser Nozzle Specification:*

MFR	Product Line	Model	Nozzle
Universal Laser	VersaLasers	VLS2.30	Not specified
Epilog Laser	Mini	Mini 18	Air assist. Attach an air compressor to remove heat and combustible gases from the cutting surface by directing a constant stream of compressed air across the cutting surface.
World Lasers	LR Series	LR1612	Coaxial air nozzle
XYZ-Tech China	Stamp Making	WK40	Fixed position. No air.



For laser engraving, a general air supply is adequate. The air hose will blow smoke and fumes away from the laser engraving beam and material, to ensure unencumbered laser engraving.

For laser cutting, coaxial air provides a cleaner and higher quality laser cut. The co-axial air nozzle blows air directly down with the laser beam. The air helps to create the pierce cut (first penetration) with the laser beam, and assists with laser cutting throughout the process. Adjusting the air pressure can provide excellent results including glass finish edge appearance for acrylic cutting, less soot or blackening for wood cutting, less re-cast or particulate material casting back onto the underside and top side of the laser cut surfaces. World Lasers offers the coaxial air nozzle.

The WK40 has no air supplied during laser engraving. There is a risk of laser smoke accumulating and depositing on the laser lens and mirrors. Therefore, it is very important

to check for dirt and clean regularly, and make sure that the exhaust system is pulling smoke and fumes out of the machine.

#### Laser Computer Specifications

MFR	Product Line	Model	Computer Specifications
Universal Laser	VersaLasers	VLS2.30	Windows XP/Vista USB 2.0 1 li speed compliant Dedicated PC required 2 GIG processor, 1 GIG RAM, VGA 1024 x 768, CD ROM drive burner, mouse, keyboard Windows Print Driver
Epilog Laser	Mini	Mini 18	Stores unlimited files to 64 MB, Rolling buffer allows files of any size to be engraved. Laser dashboard operates with many design software to spreadsheet to CAD packages. Optimized raster, vector, or combined modes USB and Ethernet
World Lasers	LR Series	LR1612	Windows 2000/XP CorelDraw (BMP, DXF) Vector, Raster, Mixed Mode USB Onboard program storage Flash drive download
XYZ-Tech China	Stamp Making	WK40	Parallel port 1 MB storage BMP, PLT

The VersaLaser requires a newer dedicated computer with high processing speed. The operating system is compatible with Windows XP and Vista. The Epilog Mini 18 does not specify a PC, rather that the laser dashboard software is compatible with many design software and spreadsheet and CAD packages. The World Lasers LR1612 requires a PC with USB port and accepts major file formats including BMP (engraving or graphics) and DXF (CAD or vector). The XYZ-Tech WK40 will accept BMP and PLT (plot or vector) files. Note that VISTA is not compatible with the LR1612 and the WK40.

Installing the laser software on the computer can be the most challenging part of the setup of a laser machine. In some cases, pre-installed software conflicts with the laser software, including virus checking software and others. These manufacturers do not supply the PC, so they are not able to control what is previously loaded onto the PC. Microsoft's VISTA was a very different product from other Windows operating systems like XP, and overall, VISTA has been troublesome to many manufacturers and is not universally support like Windows XP and 2000. Universal Laser attempts to minimize

problems by providing the strictest specification for the PC and USB. Though this specification will reduce problems installing software and connecting to the laser, it also drives up the cost for the buyer.

Most laser machine operators utilize a PC to run the laser machine. The PC permanently resides beside the laser machine. However, some buyers have several laser machines. In this case, the buyers of the LR1612 can utilize a flash drive to download jobs to the laser machines, and thus save the cost of purchasing one PC per laser machine.

USB file transfer to the laser machine is adequate. The time that it takes to transfer any vector file will generally be in one or two seconds. Very large engraving files, such as files with 1000 dpi and 4 inches square or larger can take 20 seconds or larger to transfer to the laser machine. The Epilog offers Ethernet transfer which is much faster than USB. The parallel port of the XYZ-Tech WK40 is limited in speed and the 1MB storage greatly limits the engraving size.

The WK40 will not permit vector cutting using the Moshi software. Only engraving is permitted. The other three models can both laser engrave and laser cut in the same run file. For example, if the user wants to laser engraving a logo then cut the circle around the logo, these laser settings can be entered at one time in the same job. This greatly simplifies aligning work and running it. Another software utilized for laser engraving, and more capable is Newlydraw. This software, a little more expensive than Moshi, provides for laser vector cutting and is sold as an upgrade option. However, though the software provides for vector cutting, the immovable focus lens and lack of air supply during cutting make for low quality cutting.

The design software is very important for preparing files to run on the laser machine. None of these manufacturers supply a comprehensive design software. What they do provide, is the ability to import the files from a design software and control the laser parameters and laser process on their respective machines.

The buyer must purchase and learn design software. The most popular design software is CorelDraw. CorelDraw can create both graphics for engraving and vectors for cutting. This software has many features simplified to help the beginner get a fast start. At the same time, CorelDraw has many advanced features that the user can learn over time. Purchasing this design software can be the only package purchased to run the laser machine to full capability.

Other software packages include MS-Paint that comes free with Windows. It can be used to create bmp files that the laser machinery control software can import. Though extremely simple and limited MS-Paint will do the job for starters.

CAD or computer aided design software such as AutoCAD can produce vector format files for cutting. The output file format, dxf, can be imported and run on every laser machine except for the XYZ-Tech WK40 that only engraves with Moshi software.

The control software that comes with each machine can be used for design as well. Though it is limited and users who want more capability quickly turn to third party packages CorelDraw and AutoCAD.

Additional software can be useful as well. Photograv is a software that specifically enhances photos for laser engraving. For example, it has a simple function to put a halo-effect around a character in a photograph to enhance their appearance.

Processed **Without** PhotoGrav



Processed **WITH** PhotoGrav



*Laser Accuracy Specifications:*

MFR	Product Line	Model	Accuracy
Universal Laser	VersaLasers	VLS2.30	Stepper motors
Epilog Laser	Mini	Mini 18	High speed continuous loop DC servomotors using linear and rotary encoder technology for precise positioning Advanced B style Kevlar Belts
World Lasers	LR Series	LR1612	Stepper motors Kevlar belts
XYZ-Tech China	Stamp Making	WK40	Stepper motors Belt driven





The accuracy of a machine is dependent upon several factors. The motor resolution, or fineness of motor pitch, is one factor. All manufacturers have microstepping, for stepper motors, or high encoder counts for servo motors. From this perspective, all the manufacturers laser machines have the ability to be highly accurate and produce detailed work. However, belt driven systems can have reduced accuracy if the belts stretch or slacken over time with use. Epilog identifies a B style belt. World Lasers uses kevlar as well for the belt material. Universal Laser does not specify their belt material, nor does XYZ-Tech.

Epilog utilizes linear encoders for precise positioning. In this method, even if the belt slackens over time, the feedback position is taken from a strip of lines (it looks like a ruler with all the lines the same height and no numbers). Therefore, more accurate position readings are fed back to the laser machine making it inherently more accurate than the other laser machines specified.

In most cases, the laser machines are accurate enough for the majority of applications, including photograph engraving and laser cutting acrylic and woods. In the event high accuracy is required, it can be better to purchase a high accuracy laser machine with precision ground ball screws over that of a belt drive system. In other words, these manufacturers systems tend to be accurate enough for the common applications for which they are utilized.

*Miscellaneous Laser Machine Specifications:*

MFR	Product Line	Model	Miscellaneous
Universal Laser	VersaLasers	VLS2.30	Red dot pointer
Epilog Laser	Mini	Mini 18	Red dot pointer External exhaust port
World Lasers	LR Series	LR1612	External exhaust port
XYZ-Tech China	Stamp Making	WK40	External exhaust port

The red dot pointer option is offered by Universal and Epilog Laser. The red dot pointer is useful to position the laser material at a starting location. And, it is useful to see that the laser perimeter cut or engrave on a piece of material. However, the red dot pointer is newer in recent years, to be offered on these systems, as its cost has dropped significantly. Using the World Lasers nozzle center, the operator can eyeball the location rather easily. Unlike the XYZ-Tech, there is not red dot pointer nor nozzle to eyeball, so a red dot pointer would be helpful.

The external exhaust port brings up an important point. Laser engravers and cutters utilize heat to transform materials. As a result, gases, smoke, and fumes are a byproduct that must be exhausted. Each laser manufacturer offers an external exhaust fan produced by a third party. In some cases, buyers will purchase a filtration system to filter the exhaust prior to sending the air to the outdoors or indoors. In some cases, materials may require filtration by law and for the operator safety. PVC will produce chlorine gas when laser engraved or cut and requires a carbon filtration system to reduce the chlorine gas emitted into the air. Teflon produces fluorine gas and should not be processed by laser unless the proper filtration system has been purchased.

By and large, most laser machine buyers simply send the exhaust through a blower and outdoors, as they cut acrylic, wood, and other materials.

### ***Pricing***

Pricing for the manufacturers machines are as follows. The Universal Laser and Epilog Laser are roughly the same price, as they employ similar technology including a metal tube laser and are primarily manufactured in the United States. The World Lasers employs the glass tube laser and is primarily manufactured in China. The XYZ-Tech WK40 is manufactured in China and utilizes the legacy technology and is lowest cost.

### ***Specifications Summary***

The specifications provided should help you to evaluate any laser machine of this size and caliber for your purchase. Thee specifications for laser work area (area and height), laser type (metal and glass tube), nozzle type (general or co-axial), computer requirements (design software, control software, PC operating system), speed and accuracy, and others are the primary factors in specifications. By understanding the meaning and how it affects you and your work, you can make the best purchase decision.

## ***Larger Laser Cutters Engravers***

This section describes the larger laser cutter engravers. You may have noticed that the word cutters is before the word engraver. This is because the primary use for these larger bed machines is laser cutting. With higher laser power these machines are outstanding for their laser cutting capability—for cutting acrylic, wood, textiles, and more. For engraving, however, the higher power lasers are not as good as the lower power (30 and 40 watt and 60 watt) laser engravers. This is due to the fact that laser engraving requires lower power typically. And, finer adjustment within the lower power range is needed to tune in the best laser engraving. Therefore, if you want the best laser engraving then purchase a lower power laser. If you want excellent cutting capability and good engraving capability with a large bed size, then these machines with higher laser power will fit your needs.

The specifications are presented by the author in priority order. These specifications present the most important ones followed by the less important. The importance is gauged by capability and need. Some specifications provide less value to the buyer and are rated toward the bottom. However, your application may re-order the priority for your specific needs. Below is the presentation.

### ***Larger Laser Cutter Engraver Specifications***

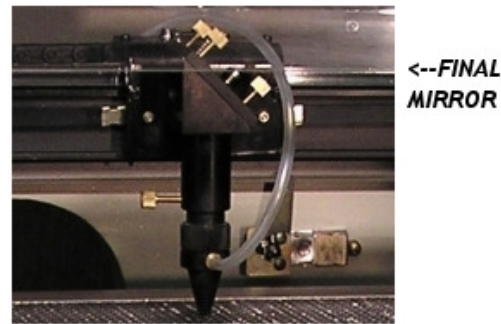
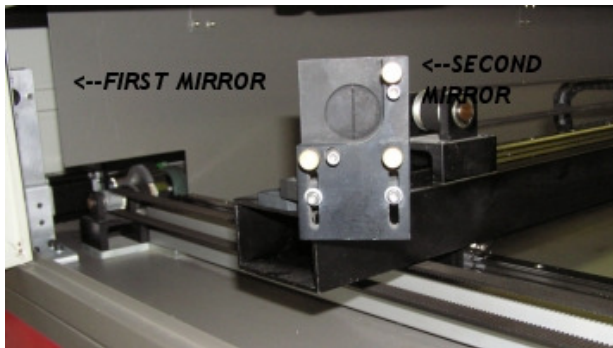
#### ***Laser Table Specification:***

MFR	Product Line	Model	Classification
Kern Lasers	52 Series	52" x 25"	Full Gantry
Universal Lasers	ILS	ILS 12.75	Flying Optic
World Lasers	LR Series	LR4832	Flying Optic
World Lasers	GM Series	GM4040	Galvanometer Mirror (Galvo)

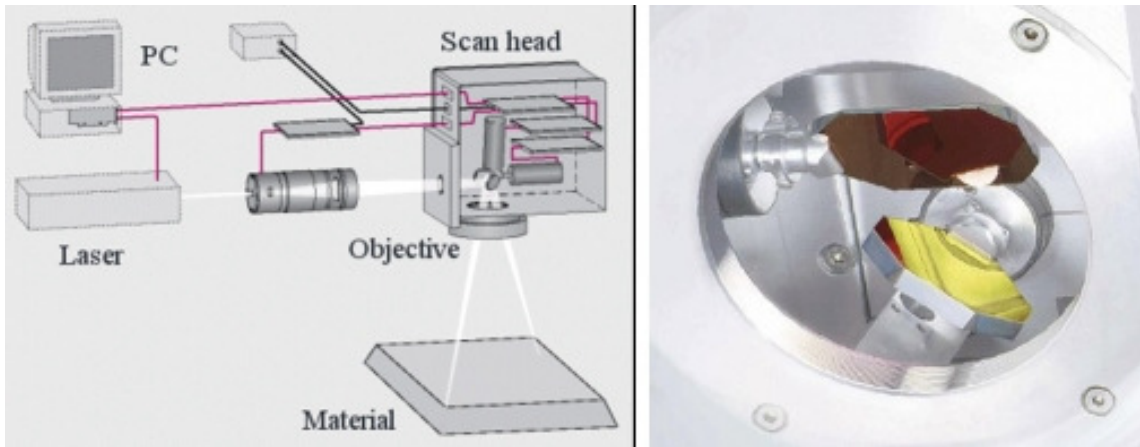


There are three classifications of machines. The Kern Lasers is a fully gantry machine. The gantry or beam rides the depth of the table. It is carrying the laser on it, and moves the laser across the table along with the focus nozzle. With this machine, the distance between the laser and the focused material never changes, so the laser beam holds the spot size the same. For highest accuracy cutting this machine maintains the tool diameter at all locations on its cutting/engraving table—where the laser beam has a diameter and is considered the tool. The tradeoff is speed. The heavy gantry is slower than the other three machines.

The Universal Laser ILS12.75 and World Lasers LR4832 are classified as flying optics laser machines. The laser is stationary in both machines. Both manufacturers mount the laser behind the cutting/engraving table. Using one mirror at the back corner, the laser beam is routed to the gantry. Then, the laser beam is directed across the gantry to the laser focus nozzle and down to the work surface. The benefit of flying optics is a lightweight, higher speed laser cutting and engraving system. However, the laser beam mode, or shape, changes slightly from the closest corner of the table to the furthest corner. The result is slightly different beam shape or cutting tool diameter and slightly reduced laser power (the further away from the laser the laser beam loses power). The results are typically not seen in cutting applications but are more apparent in large engraving applications.



The World Lasers GM4040 utilizes a galvo system for laser beam delivery. The galvo, or galvanometric motors with mirrors attached is a high speed ultra-accurate laser machine. This same technology is employed for laser vision correction in the medical industry. It is also used to produce laser light shows. The galvo mirrors can move up to 60 inches per second and carry almost no weight as there is not gantry and no focus head. Therefore the result is extremely fast engraving and cutting. However, the focus is generated far away from the work surface, so the laser spot size is much larger. To picture it, consider a flashlight. As you shine it close to the wall it is the smallest spot size. As you walk away, it is larger. Using this analogy, the focused spot size is, even though focused, a larger spot size than a focus lens two inches from the material. With the galvo, the focus lens is 40 inches from the material. As a result, the laser power is greatly reduced with a larger spot size. And, the galvo has limited applications. It is utilized for high speed laser cutting of paper, such as greeting cards, and textiles, such as singly ply cutting of apparel.



Pricing for the four machines is as follows. The flying optic systems utilize the least costly components. The Universal laser employs the metal tube laser, so it is more expensive than the World Lasers glass tube laser machine. The full gantry system is a heavier duty machine and utilizes the metal tube laser. It costs more than the flying optic machines. The galvo machine employs the high technology galvo and a metal tube laser. It is the most expensive.

*Laser Table Specification:*

MFR	Product Line	Model	Work Area	Table Size
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	52" x 25"	52" x 25"
Universal Lasers	ILS	ILS 12.75	48" x 24" (1219 x 610mm)	52.5" x 30" (1334 x 762mm)
World Lasers	LR Series	LR4832	48" x 32"	Not specified
World Lasers	GM Series	GM4040	40" x 40"	Not specified

The laser tables are similar in size. The Kern Lasers 52 Series offers an open table style. This open table is convenient for loading and unloading material and laser cut parts. The 52" wide width accommodates many material sizes which come from the manufacturer at 48" wide or slightly larger. However, the open laser table means that the laser beam is open and this laser machine has a CLASS IV rating by the FDIC. This rating requires that all people in the room with the laser have laser training and a laser training officer is assigned, and that everyone in the room wear laser safety glasses.

The ILS 12.75 and the LR4832 utilize an enclosure with a lid that lifts. The lid is closed and interlocked during operation to ensure safety. However, the ILS 12.75 can laser cut wider materials as can be seen in the photograph with the open side doors. In this capacity the laser machine is operated as a CLASS IV laser machine and requires the above mentioned safety. The limitation of the table is the 24" depth.

The LR4832 has a front and rear opening for laser cutting and engraving larger materials. The laser cut width is 48 inches by any length. However, running with an open front and rear panel for longer goods requires CLASS IV safety operation.

The GM4040 has an enclosure with interlock and requires the door be shut for operation. This is very important, not only from a regulatory standpoint but from a practical standpoint. The laser beam is invisible and is directed from above down to the work surface.

*Laser Height Specification:*

MFR	Product Line	Model	Height
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	Maximum clearance for materials: 3-10"
Universal Lasers	ILS	ILS 12.75	12" Maximum Part Height 8" Maximum Part Height pass-through (optional upgrade)
World Lasers	LR Series	LR4832	16" Maximum Part Height 5/8" Maximum Part Height pass-through
World Lasers	GM Series	GM4040	Not specified

The 52 Series offers 3" to 10" clearance for materials. The clearance with the vacuum table mounted on the table (normal operation) is 3". By removing the 7" tall vacuum table, a part can be 10" tall and be laser engraved on its surface. Laser cutting is typically performed on the vacuum table, whereby the vacuum draw down removes smoke and fumes from the bottom side of the laser cut material.

The ILS 12.75 has a motors table that can move down 12 inches to accommodate a twelve in tall part for laser engraving. An example of laser cutting is a plastic panel box, where a cutout can be performed on a box. The sides open and an eight inch tall parts can be laser engraved or laser cut. This is an optional upgrade for an additional cost.

The LR4832 has 16 inches of height with its motorized table. The operator can set table height to run the job. The LR4832 is designed to run large panels, such as plexiglass or acrylic, utilizes its pass-through. The 5/8" pass through can handle a thick sheet for laser cutting a sign. Laser engraving on a single graphic is not recommended to be done with the pass through, as the eye can catch a slight variation caused by manual alignment of the material. Most operators perform laser cutting and engraving in sections, though cutting can be designed with continuous cut lines using proper techniques.

The GM4040 utilizes a third dimension with its focus to maintain a set spot size over the entire 40" x 40" area. Though this is properly termed a 3<sup>rd</sup> dimension of motion, the result is still cutting or engraving on a flat material. The height of the material can be raised or lower, especially with the forgiving focus depth from this height. It is estimated that most materials can be raised at least 3 inches without a dramatic difference in results.



*Laser Rotary Specification:*

MFR	Product Line	Model	Rotary
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	Not specified
Universal Lasers	ILS	ILS 12.75	Optional
World Lasers	LR Series	LR4832	Optional
World Lasers	GM Series	GM4040	Not specified

The ILS 12.75 and the LR4832 feature the rotary device as an option. The rotary for the Universal Lasers machine is a center driving rotary and requires the diameter of the part be entered prior to running the rotary. The LR4832 rotary is a surface drive rotary and does not require the diameter to be measured and entered prior to operation.

*Laser Machine Dimensions and Weight:*

MFR	Product Line	Model	Dimensions and Weight
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	70" x 50" x 55" (W, D, H) 2100 lbs
Universal Lasers	ILS	ILS 12.75	69" x 43.5" x 46" (1448 x 1105 x 1168mm) 400 lbs (181 kg)
World Lasers	LR Series	LR4832	68" x 48" x 42" (1730 x 1220 x 1070mm) 815 lbs (370 kg)
World Lasers	GM Series	GM4040	Not specified

These dimensions and weights are important when considering your size facility and moving.

The Kern Laser machine has a heavy duty table to insure stability, as it is moving the laser on the gantry. The gantry extends beyond the table width to 70 inches. The length of the table is far beyond the working area of 25 inches. This is required for the large gantry that is holding a long laser. To operate the machine, an even larger area should be taped off or fenced off to prevent the operator or bystanders from being hit by the moving gantry.

The ILS 12.75 and LR4832 are enclosed machines with approximately 70 inches of width and 50" and 43.5" depth respectively. The height is 46 inches and 42 inches respectively. Though the LR machine is twice the weight of the ILS machine. Both come on casters and can be wheeled around.

The GM Series does not specify dimensions and weights.

*Laser Power Wattage Specification:*

MFR	Product Line	Model	Rotary
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	30, 50, 150 watts
Universal Lasers	ILS	ILS 12.75	10, 25, 30, 35, 40, 45, 50, 55, 60, 75 watts
World Lasers	LR Series	LR4832	80 watts (standard) 60 watts optional
World Lasers	GM Series	GM4040	100, 200, 400 watts

The 52 Series offers three metal tube laser power options. The 30 watt, 50 watt, and 150 watt. The 30 and 50 watt are air cooled. The 150 watt is water cooled. The metal tube lasers are higher investment cost lasers than the glass tube lasers.

The ILS offers a wide range of metal laser tube powers. The buyer can choose a power setting that fits their need. For cutting, the maximum power is generally recommended. In cases where paper only is being cut, a much lower wattage power can be used for laser cutting. Engraving is best done with lower power lasers for fine tune adjustment.

The LR4832 comes standard with the 80 watt glass tube laser. A much lower cost initial investment for the machine buyer, the glass tube is highly recommended for those running less than two shifts.

The GM4040 offers the metal tube laser for high speed galvo laser cutting and engraving. Much higher powers are offered because the laser spot size is much larger due to the focus lens height above 40 inches away from the work surface.

*Laser Speed Specification:*

MFR	Product Line	Model	Speed
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	10"/sec Max Cutting Speed 30"/sec Max Engraving Speed
Universal Lasers	ILS	ILS 12.75	Not specified
World Lasers	LR Series	LR4832	40"/sec
World Lasers	GM Series	GM4040	Not specified

The 52 Series specifies a maximum cutting speed of 10 inches per second and engraving speed of 30 inches per second. In most cases, the limiting factor in both cases is the material and quality. In other words, laser cutting quarter inch thick wood will not occur at ten inches per second. The wood is too thick to cut at that speed. Very thin materials can cut at high speeds, though lasers are often used for thicker materials. However, the accelerations and decelerations can be more important than the rated speeds. Even



though the laser can cut in a straight line at this speed, if it is engraving or moving back and forth to raster an image, then the turnaround time is very important for the throughput of the work. As an analogy think of a sports car. It's maximum speed is very fast. But, ask it to do a U turn and these are where the accelerations and decelerations come into play. Now consider a big vehicle that can achieve a high speed. This big car can go fast, but it took longer to hit high speed. And, a turn around takes much longer.

The flying optics of the ILS and LR Series are much faster at acceleration and deceleration and will provide much higher throughput. Most laser cutting jobs are not made up of straight lines, but of intricate patterns. Laser engraving is rastering back and forth. Therefore, the speed specification can be misleading to most buyers.

The galvo has by far the highest acceleration and deceleration. Think of a laser light show. It is one laser spot moving so fast that your eye cannot track it, and in turn sees shapes that it creates. The galvo is always limited by the material cutting and engraving speed, not the capability of its motion.

*Laser Nozzle Specification:*

MFR	Product Line	Model	Nozzle
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	Co-axial air assist
Universal Lasers	ILS	ILS 12.75	General air assist Co-axial as an option
World Lasers	LR Series	LR4832	Co-axial air assist
World Lasers	GM Series	GM4040	None

The 52 Series, ILS, and LR Series all offer co-axial air assist for high quality laser cutting. Though not necessarily needed for engraving, it can help.

For laser cutting, coaxial air provides a cleaner and higher quality laser cut. The co-axial air nozzle blows air directly down with the laser beam. The air helps to create the pierce cut (first penetration) with the laser beam, and assists with laser cutting throughout the process. Adjusting the air pressure can provide excellent results including glass finish edge appearance for acrylic cutting, less soot or blackening for wood cutting, less re-cast or particulate material casting back onto the underside and top side of the laser cut surfaces. World Lasers offers the coaxial air nozzle. The ILS offers it as an optional upgrade.

The GM Series does not offer air onto the material. The result can be a lower quality that makes laser cutting and engraving not capable for certain applications.

*Laser Computer Specifications:*

MFR	Product Line	Model	Nozzle
Kern Lasers	Standard Full Gantry	52" x 25"	Dell PC provided

	52 Series		
Universal Lasers	ILS	ILS 12.75	Requires dedicated PC with Windows XP/VISTA and USB 2.0 connection
World Lasers	LR Series	LR4832	Windows XP/2000 USB connection
World Lasers	GM Series	GM4040	PCI card installation to operate galvos Dedicated PC

The ILS requires a newer dedicated computer with high processing speed. The operating system is compatible with Windows XP and Vista. The World Lasers LR4832 requires a PC with USB port and accepts major file formats including BMP (engraving or graphics) and DXF (CAD or vector). The GM4040 requires a dedicated PC with a PCI slot available for the control card.

Installing the laser software on the computer can be the most challenging part of the setup of a laser machine. In some cases, pre-installed software conflicts with the laser software, including virus checking software and others. These manufacturers do not supply the PC, so they are not able to control what is previously loaded onto the PC. Microsoft's VISTA was a very different product from other Windows operating systems like XP, and overall, VISTA has been troublesome to many manufacturers and is not universally support like Windows XP and 2000. Universal Laser attempts to minimize problems by providing the strictest specification for the PC and USB. Though this specification will reduce problems installing software and connecting to the laser, it also drives up the cost for the buyer. Kern Lasers simply provides a new Dell PC. There is no option to the buyer.

Most laser machine operates utilize a PC to run the laser machine. The PC permanently resides beside the laser machine. However, some buyers have several laser machines. In this case, the buyers of the LR4832 can utilize a flash drive to download jobs to the laser machines, and thus save the cost of purchasing one PC per laser machine.

USB file transfer to the laser machine is adequate. The time that it takes to transfer any vector file will generally be in one or two seconds. Very large engraving files, such as files with 1000 dpi and 4 inches square or larger can take 20 seconds or larger to transfer to the laser machine.

The design software is very important for preparing files to run on the laser machine. None of these manufacturers supply a comprehensive design software. What they do provide, is the ability to import the files from a design software and control the laser parameters and laser process on their respective machines.

The buyer must purchase and learn design software. The most popular design software is CorelDraw. CorelDraw can create both graphics for engraving and vectors for cutting. This software has many features simplified to help the beginner get a fast start. At the

same time, CorelDraw has many advanced features that the user can learn over time. Purchasing this design software can be the only package purchased to run the laser machine to full capability.

Other software packages include MS-Paint that comes free with Windows. It can be used to create bmp files that the laser machinery control software can import. Though extremely simple and limited MS-Paint will do the job for starters.

CAD or computer aided design software such as AutoCAD can produce vector format files for cutting. The output file format, dxf, can be imported and run on every laser machine except for the XYZ-Tech WK40 that only engraves.

The control software that comes with each machine can be used for design as well. Though it is limited and users who want more capability quickly turn to third party packages CorelDraw and AutoCAD.

*Laser Accuracy Specification:*

MFR	Product Line	Model	Accuracy Specifications
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	Fixed Beam Length Servo motors Belt drive
Universal Lasers	ILS	ILS 12.75	Stepper motors Belt drive
World Lasers	LR Series	LR4832	Stepper Motors Belt drive
World Lasers	GM Series	GM4040	Galvo Motors

Some folks argue that servo motors are better than stepper motors because servo motors provide feedback to the computer regarding current position. Stepper motors do not provide feedback. So, if the stepper motor machine, while processing a pattern, loses its position, then it has no way of knowing and correcting. However, the risk of losing position is high when there is more weight moving around, than less. A full gantry machine requires servo motors or very large stepper motors to offset the weight.

The 52 Series requires servo motors to operate effectively. The sheer weight of the laser on top of the gantry needs the feedback loop required by servo motors to ensure the positional accuracy. The fixed beam length adds to the accuracy by providing a laser whose beam (or mode) never changes. This is the most accurate laser cutter/engraver of the four evaluated.

The ILS and LR Series both utilize stepper motors. The flying optics have little weight, so servo motors are not required. These systems are accurate for most applications, except precise laser machining. Laser machining requires precision ball screw technology over belt drive.

The Galvo system is highly accurate unto itself. What this means is that the galvo motors are extremely precise and can laser engrave or cut a pattern. However, from this height, the expansion and contraction due to temperature make the location of the laser cut to the table less accurate. An example is that when laser cutting a textile part and trimming it, there is no issue because the whole part is created from the galvo. However, aligning the galvo to a pre-printed part from this height will require calibration (or a test cut) to ensure that it begins the cut at the right location relative to the material. The variation is slight but can make a difference.

*Miscellaneous Laser Machine Specifications:*

MFR	Product Line	Model	Miscellaneous Specifications
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	Vacuum Table 7" Depth Vacuum Blower 2 2HP
Universal Lasers	ILS	ILS 12.75	Auto Focus Red Dot Pointer External Exhaust Port
World Lasers	LR Series	LR4832	External Exhaust Port
World Lasers	GM Series	GM4040	Not Specified

The 52 Series includes a downdraft vacuum table that is 7 inches tall. The downdraft, with its high power vacuum pumps (blowers), pulls a tremendous amount of air downward. The result is that all smoke and fumes generated on the bottom side of the laser cut are pulled down through the vacuum table and ported to a filtration or to the outside air. This system is quite useful for laser cutting wood panels, that generate thick sticky smoke. It does not provide a benefit for laser engraving.

The ILS includes an Auto Focus feature. The auto focus is useful for laser engraving because the system automatically raises and lowers the table to the precise location for laser engraving. However, for laser cutting, the focus point depends upon the material. Depending upon the type of material and its thickness the laser operator may want to focus the laser cutting spot on the top, middle, or bottom of the material. This is due to the fact that the laser beam is shaped like an hourglass, and has an angle or kerf. An example is a floor inlay. If the wood floor pieces are a quarter inch thick, and the operator is cutting the material with the bottom side up, then the focus, or smallest spot, will be at the bottom of the material. This way, the gap causes by the angle will appear at the bottom of the material rather than where the people see the wood going together at the top—no gaps. Therefore, the Auto Focus is useful primarily for engraving rather than cutting.

The Red Dot Pointer is useful for aligning material. The exhaust port is available and a blower must be purchased to exhaust the smoke and fumes.

The LR Series laser has an exhaust port available and a blower must be purchased to exhaust the smoke and fumes.

The GM Series laser has an exhaust port available and a blower must be purchased to exhaust the smoke and fumes.

*Options Laser Machine Specifications:*

MFR	Product Line	Model	Options Specifications
Kern Lasers	Standard Full Gantry 52 Series	52" x 25"	Metal Cutting
Universal Lasers	ILS	ILS 12.75	Downdraft honeycomb cutting table Cone option for air assist Pass through Additional focus optics rotary
World Lasers	LR Series	LR4832	External Exhaust Blower Additional focus optics Rotary High performance cutting head Air pump for nozzle
World Lasers	GM Series	GM4040	Not Specified

There are a variety of options offered by each manufacturer.

The Kern Lasers machine offers few options and has chosen to make most items standard. The metal cutting option requires the highest power laser offered and includes options required for thin metals cutting.

The Universal Laser has many options offered for an additional cost. Some of these options are required to operate the machine in its most basic functions. For example, the honeycomb cutting table is required for almost any laser cutting application. The cone option for air assist (co-axial air flow) is required to achieve adequate quality for laser cutting. The pass-through option is required for cutting materials larger than the table size. These options are standard with the LR Series machine.

The additional focus lenses can be useful for cutting very thick materials. The 100 mm lens (4" lens) has a smaller kerf and larger. With the high performance cutting head, laser lenses to 10" are available. See example below.

## ***Cutting Foam***

Process Date: May 2002

We achieved these cuts on the 0.6" thick foam using a Synrad EVO 125W laser with a cutting speed of 420 inches per minute and a spot size of 0.012". The 2" thick foam was cut at a speed of 75 inches per minute and required a longer focal length lens of 7.5 inches. The same results can also be achieved using our 200W laser with faster cutting speeds!

Edge quality with this type of foam is excellent, with no discoloration or melting. The walls are parallel, making this an exceptionally good application for CO<sub>2</sub> lasers.



***Laser cutting results in no discoloration, distortion or melting!***

The LR Series offers an option for an air pump. The pump offered has an on and off setting, and no pressure regulator. This is adequate for laser engraving, however, to improve quality for cutting then a regulated air compressor with pressures up to 20 pounds is recommended. Also, an in-line filtration system is necessary to remove water

and particulate. These components are readily available at your local industrial supply company, such as Grainger.

### **Section III: Other Laser Options**

Additional laser options and configurations are available beyond the examples provided. Though an exhaustive list is too much for this white paper, examples are provided to help the reader understand the basics.

#### *Camera Recognition*

A camera recognition system is useful for laser engraving patterned materials where the laser cutting follows a pattern on the material. The pattern can be a printed outline, embroidered patches, identification tags, or simply registration marks. The software that comes with the camera system can provide a simple training for the camera to recognize parts shapes. Below is shown a camera mounted along side the laser focus nozzle, and the application is cutting printed keyboard membrane graphics:



#### *Conveyor and Unwinder*

A conveyor bed, rather than a table, is often used to convey flexible goods to the laser. For example, a camera recognition system may be used to laser cut a roll of preprinted product. The roll may contain 100 feet of material. Or, without a camera, a conveyor system can convey a roll of fabric for laser cutting patterns. Note the rounded front edge of the conveyor table below.



### *Shuttle Table*

Another type of automated material handling is the shuttle table. With this mechanism, the laser operator can unload laser engraved/cut parts and load material for laser engraving/cutting while the laser is processing. Shuttle tables come in small to large sizes. The shuttle operates by indexing to two positions. In one position the operator unloads/loads from the left side. In the second position, the operator unloads/loads from the right side. See below.

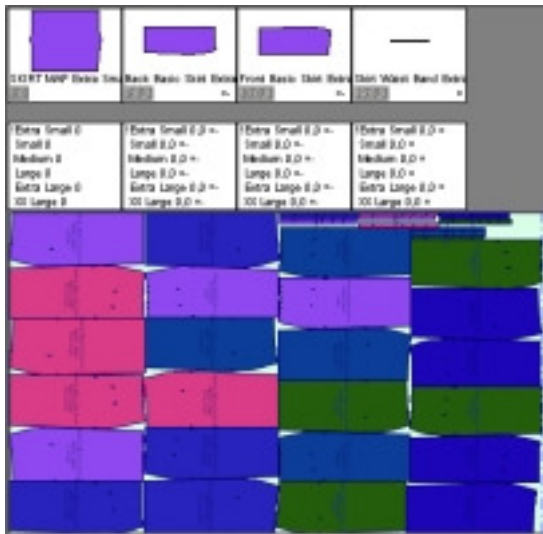


### *Software*

There is a variety of design software available. As mentioned earlier, Corel Draw and AutoCAD are two commonly used design software. And there is application specific software. Optitex is a software utilized by the apparel industry to create clothing designs. For example, the designer can create a shirt, then create all its sizes. After the sizes are



stored in the database, then the user can decide how many of each side to produce. Next, the software automatically calculates all parts of all shirts in every size and positions them for laser cutting where the fabric waste is minimized. See example below.



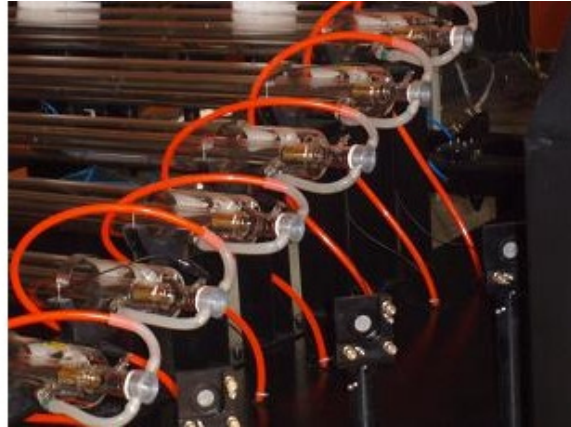
### *Multiple Tools*

In some applications, more tools are required. In some cases the laser can be mounted with a pen, or a depth scanner, or a router tool. See example below with a CNC router and laser cutter.



### *Multiple Lasers*

In some applications the throughput can be increased by the use of multiple laser heads. See the example below with seven lasers. Note that the table space is greatly reduced. These lasers are cutting relatively small parts.



### *Fixturing*

Often times, laser machines require a fixture to hold the part in place for manufacturing. Consider the example below where a flexible web is centered to a known location for parts cutting.



## **Section IV: Additional Factors to Consider in Purchasing a Laser Machine**

Additional factors beyond specifications are necessary to make the best decision for purchasing a laser machine. These factors are discussed below.

The company and its experience in laser machines tells much about its capabilities. For example, some companies are setup to manufacture and sell a line of laser machines. These machines come with no modifications and any changes are the responsibility of the buyer. For example, Epilog Laser and Universal Laser have a standard product line for sale.

World Lasers offers customization including custom fixturing, automatic handling, additional software, and standard laser machines.

Some companies are sales organizations for other manufacturers. Their value add is a local face and local assistance. These organizations tend to provide a good interface between the laser manufacturer and support and the customer. They can quickly explain the issue in order to get it resolved. The drawback is that in some cases the local sales representative is not very technical and the help is limited.

Other organizations sell direct, as the laser machine has been simplified over the years and can be considered a glorified laser printer or plotter. Many buyers purchase through these channels to save money and rely on their own technical capability for self training. Bell Lasers offers direct sales without the markup of a sales representative.

## **Section V: A Samples Approach to Choosing a Laser Machine**

A samples approach to selecting a laser machine is commonly done by product manufacturers with a specialized need. For example, cost reduction by laser cutting a product rather than an antiquated method. Or, laser cutting a new product is the most cost-effective process. Products include, laser cutting acrylic parts, or trimming an injection molded part.

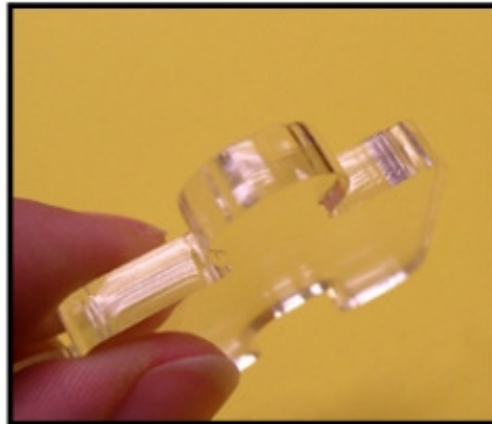
The first step is to get a sample laser processed. Below are a number of examples run by the metal laser tube manufacturer Synrad. These samples come from their laser laboratory. Note the laser parameters provided. This step is to determine whether the laser is the right tool for your application.

## **Cutting Acrylic**

Acrylic is an excellent material to cut with a CO<sub>2</sub> laser. The cut mechanism is the result of material vaporization and with 100% absorption of the 10.6-micron wavelength even a 25-watt laser can cut 1" thick acrylic! Simple acrylic cutting is straightforward enough—just select a laser power for the required speed. However, when material thickness increases and a flame-polished square edge is required, the set-up becomes more critical. Before continuing, ensure that you are using cast, not extruded, acrylic.

### **Lens selection**

Because acrylic acts as a waveguide to CO<sub>2</sub> radiation, a 63.5 mm (2.5") focal length lens provides reasonable results on 25.4 mm (1.0") thick acrylic. This gives any cutting system a great range on thickness for a single set-up if a perfect cut is not necessary. Generally, for thicker material, a 127 mm (5.0") lens is recommended. When cutting acrylic thicker than 8 mm (0.312"), defocusing into the material helps achieve the best square edge.



*We cut this ¼" thick acrylic puzzle piece using 100 W at a speed of 50 IPM.*

### **Gas assist**

Gas assist is key to achieving a polished edge. Air must be delivered into the cut area at a pressure that just enables the vaporized acrylic to be ejected through the cut; too much air pressure induces frosting as the edge cools too quickly.

As a rough guide, start with an air pressure of approximately 0.07–0.28 bars (1–4 PSI) although these values are totally related to the nozzle diameter and the stand-off distance from the nozzle to the material. A nozzle diameter around 3.2 mm (0.125") and positioned about the same distance above the acrylic is recommended. This combination provides a decent tolerance on the gas pressure setting.

When cutting material less than 3.2 mm (0.125") thick, adjust gas pressure experimentally to find the correct level. Look for an edge that is consistent through the depth of the cut. With thicker acrylic, finding the correct gas pressure is a little easier—initiate the cut with no gas pressure and slowly increase pressure until the topside flaming disappears.

## **Cutting EVA Foam Gaskets**

Ethylene-vinyl acetate (EVA) foam is used in a variety of industrial and consumer applications ranging from floatation vests to shoe insoles to gasketing applications. This flexible, closed-cell copolymer has excellent chemical resistance, good thermal insulation, and retains its flexibility even at subzero temperatures.

EVA foam cuts extremely well using a CO<sub>2</sub> laser, which is perfect for low-volume or custom applications where tooling for die cutting is too expensive. Non-contact laser cutting is also appropriate in high-volume manufacturing as it eliminates maintenance downtime resulting from cutter adjustment or replacement and product changeovers are simply a matter of loading a new cut file into the motion system.



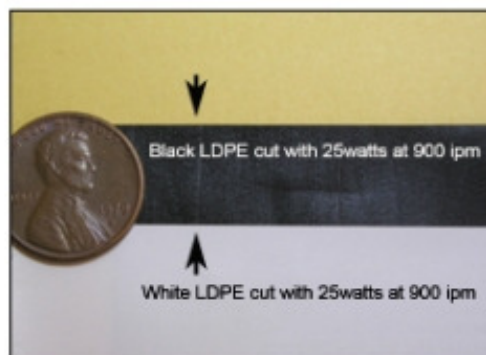
*Using a Synrad 100W laser customized gaskets were easily created from a 6.5mm thick sheet of Ethylene-vinyl acetate (EVA) foam.*

This application involved cutting gaskets from a sheet of 0.256" (6.5 mm) thick EVA foam. A CAD file containing a full-scale drawing of the gasket drives the XY motion system, which in turn, controls a cutting head containing a 2.5-inch positive meniscus lens. Focused spot size is 0.004" with a 0.07" depth of focus. Using 100 watts of power and 10 PSI of air assist, each gasket is cut at a velocity of 275 inches per minute for an overall cycle time of 4.84 seconds per part.

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## **Cutting Low Density Polyethylene (LDPE) Film**

Low Density Polyethylene (LDPE) is the workhorse of polymer packaging films. It has good tensile strength, impact resistance, is easily printable, and inexpensive to manufacture. Like most polymer materials, LDPE is altered to provide other features such as UV resistance for outdoor use, anti-static/conductive properties for semiconductor applications, or is formulated to be heat-sealable/shrinkable for general product packaging.



*The LDPE sheets above were cut using 25 watts of power.*

For this cutting application, we installed a 2.5" positive meniscus lens in our XY cutting head. This lens provides a 0.004" (100 micron) focused spot with a 0.07" (1.8 mm) depth of focus. For gas assist, we chose 10 PSI of high-purity CDA (compressed dry air) delivered coaxially with the focused beam.

Both black and white sheets of six mil (0.15 mm) thick LDPE film were cut using 25 watts of power at line speeds of 900 inches per minute. Cut edges are clean and smooth with no dross or discoloration. For a given thickness, polyethylene cut speeds are relatively linear, so achieving higher line speeds is a simple matter of increasing laser power proportionally.



## **Cutting Spherical Rubber Discs**

This application calls for cutting 51-mm (2.0") diameter spherical discs from molded silicon rubber sheet stock. The rubber sheet consists of a layer of 0.6-mm (0.022") thick rubber that is backed with a 0.038-mm (0.0015") thick protective film.

We set up our XY beam delivery system with a 63.5 mm (2.5") positive meniscus lens that provides a 100-micron (0.004") spot and a 1.8 mm (0.07") depth of focus. For gas assist, we used 1.4 bar (20 PSI) of breathing-grade bottled air.

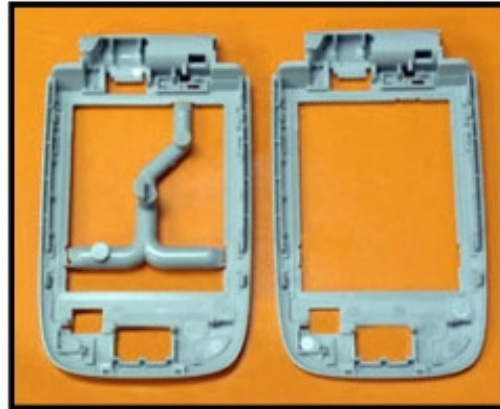
Using 100 watts of power, we achieved cut speeds of 8.9 meters per minute (350 inches/minute) in an overall cycle time of approximately 1.08 seconds per disc. The combination of silicon rubber and backing material exhibit cleanly cut edges as seen in the photo.



*This spherical rubber disc was cleanly cut using 100 watts of power at a speed of 350 inches per minute in a cycle time of 1.08 seconds per part.*

## **Degating Cell Phone Components**

The traditional injection molding process creates parts where a gate or sprue is still attached to one or more pieces in each shot. Because the sprue is removed before assembly, it is typically removed at or near the injection mold so that the plastic material can be reground, remelted, and reused. Although hand trimming by workers using sharp razor knives is commonplace, the production volume and complexity of today's consumer products dictates a faster, more precise trimming solution. To support high-throughput speeds, the best solution is the installation of a Firestar sealed CO<sub>2</sub> laser from SYNRAD. Beam delivery to the part surface is accomplished through fixed or flying optics, by moving the laser, by moving the part, or by galvanometer beam steering. The result is a perfect cut every time on every part.



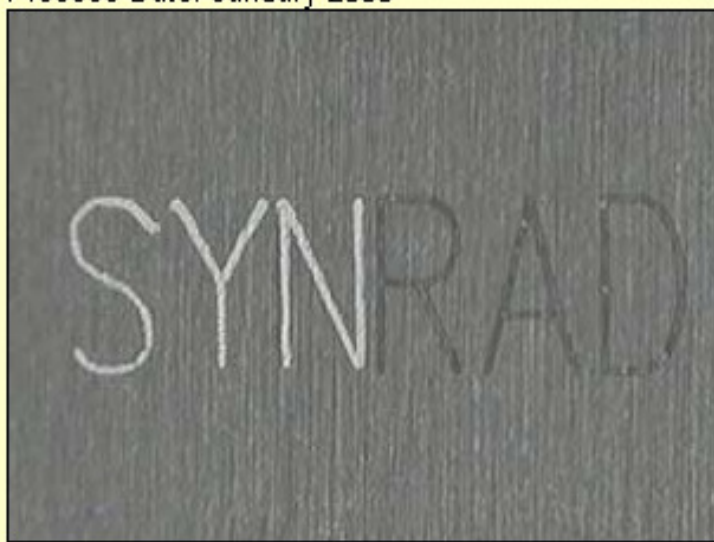
*The polycarbonate sprue inside the cell phone case (above left) was precisely cut at three different points in a cycle time of only 0.3 seconds per part. The finished piece is shown on the right.*

The accompanying photograph shows before and after views of a polycarbonate cell phone case where the task was to trim the sprue from each part at three different attachment points. Our setup consisted of a Firestar 100 watt laser connected to an FH Series marking head and 125 mm high-power optic that provides a 180-micron (0.007") focused spot with a 3-mm (0.118") depth of focus. The maximum width of each sprue attachment point was 5.1 mm (0.2"), so we created a mark file with three lines measuring 5.1 mm (0.20") in length and used WinMark Pro's precise positioning capabilities to place each line accurately within 0.0025 mm (0.0001"). To cut through the 1-mm thick (0.04") polycarbonate case, we set a *Power* (duty cycle percentage) corresponding to 100 watts and set a cutting *Velocity* of 50.8 mm per second (2 inches/sec). Using these parameters, we successfully trimmed each case in a cycle time of only 0.3 seconds per part. The cut edge is clean with no residue and a very slight amount of melt back.



**Marking Clear  
Anodized Aluminum**

Process Date: January 2000



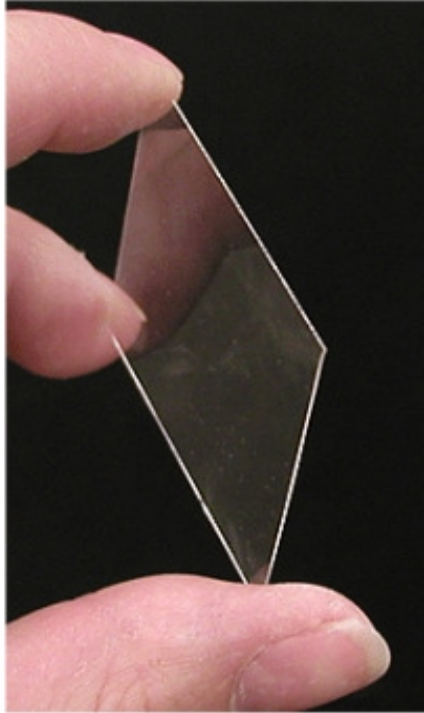
***White mark - Marked with 20 watts of laser power at a speed of 30"/s***

***Dark mark – Marked with 10 watts of laser power at a speed of 2"/s***

Because of its resulting highly contrasting marks, anodized aluminum is frequently marked with CO<sub>2</sub> lasers. While Black and colored anodized aluminum are commonplace, clear anodized aluminum is less frequently used. It does, however, offer a unique marking capability - the ability to produce either a light or dark mark, according to laser parameters. In this case, a dark mark resulted from the use of 10 watts of power, while the use of 20 watts resulted in a white mark. This type of mark contrast control is uncommon for CO<sub>2</sub> laser processing.

It is also worth noting that in-between these two marking styles, a "no mark" region exists. In this case, for example, using somewhere between 10 and 20 watts of power will result in no mark at all.

## **Cutting Thin Glass Substrates**



These glass sheets, measuring only 30–600 microns (0.0012–0.0236") in thickness, are easily cut with CO<sub>2</sub> lasers.

Over the past several years, glass marking has developed into one of the premier CO<sub>2</sub> laser applications, especially in the commercial, industrial, and automotive glass industries. Until now however, glass cutting with CO<sub>2</sub> lasers was not feasible since the thickness of typical glass products exhibited substantial fracturing caused by the stress of localized heating effects. For glass between 1 and 10 mm thick, laser cutting becomes a two-step process of scribing and snapping.

Today though, products ranging from microscope slides to covers for flat-panel displays on laptop computers and cell phones are made from thin glass substrates. These glass sheets, measuring only 30–600 microns (0.0012–0.0236") in thickness, are easily cut with CO<sub>2</sub> lasers and demonstrate the same fine edge quality seen in many other laser cutting applications.

The section of glass shown in the photo is 150 microns (0.006") thick and was cut on our XY stage using 100 watts of power at a speed of 550 inches per minute (IPM). The laser was gated with 1.2 ms pulses at a frequency of 750 Hz through a UC-2000 Universal Laser Controller. A 2.5" positive meniscus optic (0.004" spot size and 0.07" depth of focus) provided beam focus while 10 PSI air provided the gas assist.

## **Cutting TPO (Thermoplastic Olefin)**

Thermoplastic Elastomer Polyolefin, TPO for short, is another plastics polymer that has recently taken hold in the automotive industry as both plastics manufacturers and end-users fine tune formulation and molding processes. TPO is easily thermoformed (which lowers unit cost) and is designed to be readily recycled at the end of its product life. Another advantage is that TPO does not contain plasticizers (unlike many other thermoplastics), which means that parts retain the same degree of flexibility regardless of temperature. In addition to the automotive industry where TPO is used to create fenders, bumpers, running boards, splashguards, and instrument panel skins; TPO also shows up in applications as diverse as imitation-slate roofing tiles, ATV body parts, and shells for ski boots.



*This automotive part exhibits cleanly cut edges after trimming operations using 400 watts of power at a cut velocity of 150 inches per minute.*

For this TPO automotive component, the task was to trim edges and openings in the part at a minimum rate of 2.2 meters per minute (86 inches/minute). The laser setup for our applications test consisted of a [Firestar 400 laser](#) with beam delivery through a set of XY flying optics into a cutting head. The cutting head holds a 101.6 mm (4") focusing lens with a 150 micron (0.006") focused spot and a 4.3 mm (0.17") depth of focus. Nitrogen assist gas at 2.4 bar (35 PSI) is delivered coaxially with the beam, which serves to protect the lens and blow vaporized debris through the cut kerf. The thermoformed TPO, having a consistent thickness of 3.2 mm (0.125"), was cut using 400 watts of power at a cut speed of 3.8 meters per minute (150 inches/minute)—a speed increase of 56% over the original requirement.

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Many companies can run laser samples. Comprehensive reports tend to come from manufacturers, where sales representatives equipped with laser machines tend to point and shoot and may not get the best results. So, if the sales rep failed, consider going to the manufacturer.

After running the samples to determine whether the laser is a good tool to provide the quality you desire, then the next step is to get the production timing. First, consider your design pattern to cut or engrave. For cutting, produce the pattern and have it run through a timing program or better, have it run on the laser and get an actual time. Remember that the cut speed provided by the lab for good quality may be improved. Also, remember that the cut speed provided represents a straight line cut speed, where turns and corners require acceleration and deceleration that decreases the overall cycle time to produce one part.

In some cases, a short production run can be completed by the manufacturer's laser laboratory. Typically a fee is charged for this service.

After determining that the laser provides the quality and the throughput required then get a machinery price quotation. Include all the options necessary for your application, whether it include automated material handling or simply a table to stack the parts.

Perform a financial analysis to decide which laser machine to purchase. If you have options for a larger or smaller machine, purchase the one with the flexibility and capability that meets your financial and business needs.

A typical cost benefits analysis includes the fixed costs, such as space rental, and executive salaries. Variable costs (dependent on how much is produced) includes materials used in laser processing, operator time, utilities costs, shipping costs, and sales commissions.

## **Section VI: Is A Used Laser Machine a Good Purchase?**

Used laser machines are available on the market. However, newer laser machines have the benefit of advanced technology at a lower cost. Therefore, by and large, it is better to purchase a new machine, or if used, a near new machine.

Older laser machines have both high risk and the potential for reward. The high risk comes in the cost to get them running properly. Expensive components for repair or refurbishment include the following: (1) Recharging the metal tube laser. This can run \$2,500 for a 50 watt laser tube that needs to be re-gassed and needs corroded internal electronics replaced. (2) Optics replaced. Replacing all mirrors and focus lens is not uncommon and can run several hundred to more than a thousand dollars. (3) Slop in mechanicals. Linear rails and gearing wears over time. Replacing these parts typically requires a skilled repair person and manufacturer supplied parts. The repairs are typically under one thousand dollars for a small laser machine. (4) Other parts.

Make sure that the spare parts are readily available and a repair person is lined up prior to purchasing a used laser machine. If possible, send a technician in to evaluate the laser machine prior to purchase. Be very cautious in the purchase as there are many risk areas and the costs to get the laser machine fully operational can be high.

## **Section VII: Cautions regarding purchasing the Laser**

The top ten most common mistakes made (by some people) when purchasing a laser machine are:

1. Neglecting to purchase design software and get trained on it. This software is provided by third parties. Local training or training online or by CD is available. Evaluate all costs and make sure the salesperson understands your needs prior to the purchase.

2. Neglecting to purchase proper exhaust. Make sure that an exhaust blower is purchase, and if required, and filtration system is purchased. Ask the salesperson what you should purchased based upon the materials you expect to laser process and the quantity.
3. Neglecting to purchase an air compressor. If the application includes laser cutting acrylic to a glass finish, then purchase a pressure regulator, water and particulate filter, and air compressor prior to getting the laser machine.
4. Having trouble installing the software so the process is time consuming. If a computer is not provided, then make sure you know the specifications and the salesperson can assist in some manner with the software installation.
5. Getting poor quality in laser cutting after the laser laboratory or manufacturer showed terrific results. Ask the salesperson to match the quality of any trials, or be available to tell you how to get the same results with your newly purchased laser machinery. In some cases, a quick change in material suppliers or type of material will provide a dramatic improvement in cut quality. Cast acrylic laser cuts with a fire polished edge while extruded acrylic does not. Some baltic birch plywood work better with a laser than others, and cost less.
6. Not understanding all the steps required to laser process your part. Ask the salesperson to explain each and every step so you can get what you want to purchase. For example, if you plan on laser processing stainless steel mugs with logos, get it explained. The process is as follows. Get a logo from a customer and import it into your design software. Make any necessary changes (be trained in Corel Draw). Then, import the bmp file format into your laser control software. Next, get the mug and put in on the rotary, connecting the rotary device that you purchased in the laser machine. Spray Cermark (metal coating spray that you purchased) on the mug evenly. Next, test a small area to ensure that you have the correct settings. Then, when satisfied, run the job. Wash the excess Cermark and rub hard with a rag to make sure you set the laser power properly and the logo is permanently adhered. Prior to the purchase make sure you have enough laser power to utilize Cermark.
7. Not understanding that it takes a little time to master the laser machine. Though it is like a laser printer, and you can be engraving within two hours of setting up, there are tricks to learn that come with time and practice. Be patient and learn.
8. Not using the laser machine. There are many profitable ways to utilize the laser machine. If you find your laser machine idle, contact your manufacturer for advice to make more money.
9. Throughput too slow. If you find that it takes to long to run a repetitive job, then ask your manufacturer how to speed things up. Often times, a simple jig can greatly simplify the process and speed things up tremendously. Also, a different focus lens may speed the laser time up dramatically.



10. Laser cut and engrave quality degrades because the laser machine is not properly maintained. Make sure you clean your laser mirrors and lenses when they get dirty. Check the laser alignment and make sure the laser beam is centered out the laser focus lens nozzle.



#### Top Five Additional Costs Discovered After Purchasing a Laser Machine

1. Purchasing exhaust blower and setting up to port outside
2. Purchasing third party design software and getting trained
3. Purchasing air compressor with pressure regulator and inline filters
4. Purchasing additional laser lens for finer laser cutting per the application
5. Purchasing a new laser lens because the lens was not cleaned when dirty

#### Top Ten Uses For Laser Engravers and Cutters

1. Laser Engraving identification tags
2. Laser Engraving awards and recognition products
3. Laser Engraving customized office products (pens, business card holders, etc.)
4. Laser Engraving parts (scales)
5. Laser Engraving personal customized products (photos in marble, picture frames)
6. Laser cutting acrylic for commercial use (from signs to parts)
7. Laser cutting acrylic for personal use (picture frames, key holders)
8. Laser cutting parts for commercial use (plastic delrin to replace metal, textiles)
9. Laser cutting intricate wood parts (smooth edges and intricacy are unmatched by other cutting tools versus costs)
10. Laser cutting leather and laser engraving leather

## **Section VIII: Laser Safety**

Laser safety is important for the operator and people in the area. The areas of concern in operating a laser machine include fume extraction, risk of fire, and laser beam hazards.

Operating the fume extraction is important to get rid of unhealthy smoke and fumes. Porting these outdoors or through a filtration system is important. Identify the materials you are laser processing, read the Material Data Safety Sheet (MSDS) that comes from the supplier under the What to do in case of Fire section and review the recommendations. Laser cutting uses heat and produces similar results.

Acrylic cutting risks fire in the laser machine. Always operate the laser machine with a person present. Acrylic can flair up and burn. Laser machines get damaged from acrylic fires. Wood can also burn, so be careful of this as well, through it typically smolders so laser processed parts should be handled as necessary.

The laser machine comes with a classification by the FDA, such as Class I or Class IV or other. Class I is as safe as a laser printer and requires no laser training. However, if you perform maintenance on the laser machine then you are at risk for laser burning. Once an eye is burned it cannot be repaired. Always wear safety glasses with side shields when performing maintenance on a laser. The laser beam is invisible and can reflect on a metal surface. It is dangerous. Laser burns are too common when performing maintenance. Do not bypass any safety features of the laser machine. A Class IV laser requires safety training and a safety officer assigned. For safety glasses that are certified, [www.synrad.com](http://www.synrad.com) sells glasses. For laser safety information the Laser Institute of America (LIA) has a guide book that is well worth the \$75 investment.

## **Conclusion**

I hope that you received value from the White Paper. Now you can review the document as required and make your best decision for a laser machinery purchase. Many buyers have purchased their first laser machine, and grown their business, and subsequently purchased many additional laser machines. Most business owners retain their first machines and continue to use them, along with their newer purchases of bigger and more powerful machines. The laser has many capabilities, and there are too many to list in this guide. However, the buyers find that they learn more about the laser and its ways to make them money, or perform their work better with practice. There is nothing like operating the laser machine to truly understand how the tool can best serve you!

## **Appendix I Materials Engraved and Cut by a CO<sub>2</sub> Laser**

### **MATERIALS**

#### **Laser Engraving**

- Acrylic
- Anodized Aluminum
- Ceramic
- Cloth
- Coated Metals
- Cork
- Delrin
- Fiberglass
- Glass
- Leather
- Marble
- Matte Board
- Melamine
- Mylar
- Paper
- Plastic
- Pressboard
- Rubber
- Wood
- Wood Veneer

#### **Laser Cutting**

- Acrylic
- Cloth
- Cork
- Delrin
- Fiberglass
- Leather
- Matte Board
- Melamine
- Mylar
- Paper
- Plastic
- Pressboard
- Rubber
- Wood
- Wood Veneer

#### **Laser Marking**

- Anodized Aluminum
- Ceramic
- Coated Metals
- Painted Metals
- Stainless Steel