



Rotary Engraving Fact Sheet

Description

Rotary engraving is the term used to describe engraving done with a rotating cutting tool in a motorized spindle. The tool, or cutter, cuts into the surface of the material to a predetermined depth and produces a groove of the same shape and dimension of the cutter. Rotary engraving can be performed on a wide variety of materials with plastic, brass, and aluminum being the most common in the awards industry.

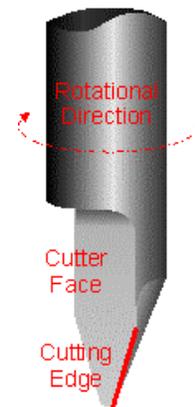
Rotary engraving can be done using the simplest pantographs to the most complex computerized engraving machines. The principles are the same on all. On a pantograph, the operator lowers the cutter into the material and then forms the character by tracing a master (copy type, template, etc.). On a computerized machine, the cutter spindle (Z-axis) is lowered mechanically and then is moved laterally (X-axis / Y-axis) by stepper motors to form the characters.

Engraving Cutters

The tools used for rotary engraving are generally referred to as "cutters." Cutters are manufactured from different materials and are produced in a variety of configurations specific for certain applications and materials. Most engraving cutters are "half-round" tools which means the blank is split or halved on center producing a "single-lip" tool which is one of having only one cutting edge.

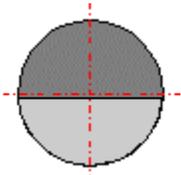
Typically, engraving cutters are single-flute tools.

This means they have only one cutting edge. The cutting edge is highlighted in the picture at right. Note the direction of rotation of the cutter.

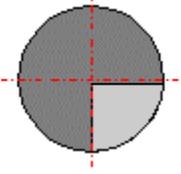


This configuration affords a significant amount of clearance and allows the tool to run at relatively high speeds to maximize material removal and produce good finishes. Some cutters are also made as "quarter-round" tools which allow even greater clearance, but they are inherently weaker and are recommended for specific applications.

Cutters also can be classified as half-rounds or quarter-rounds. This refers to how the blank carbide shafts are split during the manufacturing process.



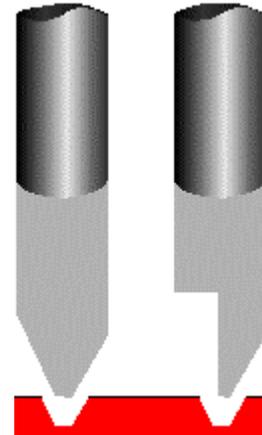
Half Round Section



Quarter Round Section

Half-round cutters are made from blanks that have been "split" or "halved" approximately on center through a grinding process. This tool has a cross-section that is half of a cylinder and is the choice for most engraving cutter applications.

Quarter-round tools are half-round tools that have a secondary split at 90 degrees to the original flat producing a tool that has a cross-section that is one quarter of a cylinder



Half vs. Quarter Round

The majority of the engraving machines used in the awards and engraving industry have spindles that use "top-loading" cutters. These are cutters that are inserted into the spindle from the top and are typically held in place by means of a threaded knob. This arrangement allows for easy cutter adjustments and changes. Top-loading cutters are most commonly available in 1/8", 11/64", 1/4", 4mm, and 6mm shank diameters. Cutter lengths vary to accommodate machine spindles and accessories (burnishing attachments, vacuum chip removers, etc.).

Some machines, particularly industrial ones, utilize collet spindles. The cutter is inserted into the top or the bottom (usually the bottom) of the spindle and is held in place by a collet. A collet is a segmented, clamping device somewhat similar to a drill chuck. By means of a "drawbar," the collet segments are tightened against the shank of the tool, holding it securely in place. This arrangement is more rigid and precise than the top loading spindle, but does not offer the ease of cutter change and adjustment.

Most engraving cutters are manufactured from carbide or high speed steel (HSS). Carbide is an extremely hard and abrasion resistant material and is recommended for the majority of engraving applications due to its toughness and durability. Generally speaking, carbide cutters will outlast HSS cutters by a factor of 5-10 times depending on the material being cut. Cutters manufactured from high speed steel do not have the hardness or strength of carbide. Therefore, they become dull more quickly than carbide tools. On the other hand, high speed steel cutters are not as brittle as carbide, and tend to be the best choice when making deep, fine cuts in metal such as those required for making seal dies.

Terminology

While there are a seemingly infinite number of cutter sizes and shapes, engraving tools fall into two basic categories - conical and parallel. Conical cutters have an angled cutting edge and produce a "V" shaped, flat-bottomed cut. Parallel cutters have a straight cutting edge that is parallel to the cutter's axis of rotation and produce a cut with straight walls and a flat bottom.

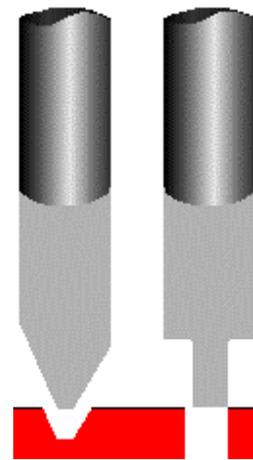
Cutter Geometry

The various angles on a cutter are referred to as its geometry. Each angle plays an important role in how well a cutter performs for a particular application.

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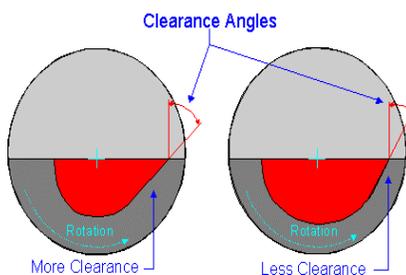
Conical cutters have an angled cutting edge and produce a "V" shaped, flat-bottomed cut.

Parallel cutters have a straight cutting edge that is parallel to the cutter's axis of rotation and produce a cut with straight walls and a flat bottom. The width of the cut can be as large as the diameter of the shaft (i.e. 11/64" parallel tool can be made to cut up to .171" wide)



Conical vs. Parallel

The **CLEARANCE ANGLE** refers to the angle of the cutting edge with respect to the face of the cutter. This angle allows for chip clearance and determines how fine the cutting edge is. The clearance angle is determined by the properties of the material being engraved. Generally, softer materials require a larger clearance angle for chip removal than that needed for hard materials. Most cutters fall into one of five clearance classifications:



Clearance Angle

The **clearance angle** refers to the angle of the cutting edge with respect to the face of the cutter. This angle allows for chip clearance, determines how fine the cutting edge is and is selected based on material properties.

ACR (acrylic)

FLX (soft plastics - flexible engraving stock)

PHN (rigid plastics - phenolic)



BAL (soft metals - brass, aluminum)

SSS (harder metals - steel, stainless steel)

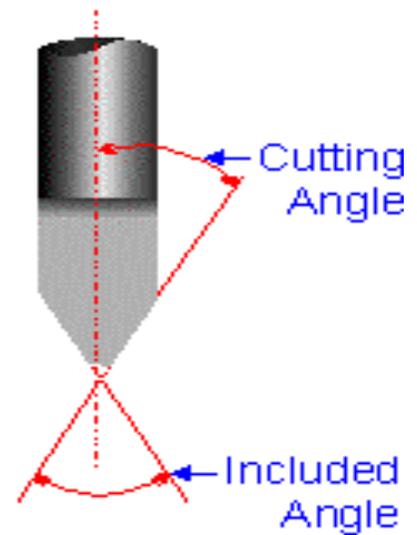
A cutter for flexible engraving stock has a high degree of clearance and a correspondingly fine edge. If this cutter were used to engrave hard steel, it would be dulled rather quickly. Conversely, a cutter sharpened with a smaller clearance angle for harder materials will not produce clean, quality cuts in softer materials.

The **CUTTING ANGLE** is the angle formed between the cutter's axis of rotation and its cutting edge. This determines the shape of the cut. Higher angles produce stronger tools and broader cuts and are recommended for harder materials. As a generalization, the standard cutting angle for most materials and applications is 30° . For harder materials like steel and brass a 40° angle is recommended and 20° would be choice for extremely fine or delicate work in soft materials.

Cutting Angle and Included Angle

The **cutting angle** is the angle formed between the cutter's axis of rotation and its cutting edge. This determines the "V" shape of the groove produced by conical cutters.

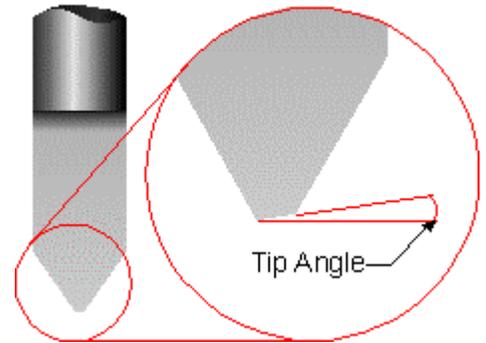
The **included angle** is double the cutting angle.



The **TIP** is the flat at the tip of the cutter which determines the width of the cut. Since an engraving cutter needs to be "end-cutting" as well as "side-cutting," the tip is actually a cutting edge. It is formed by two angles that provide clearance and are selected based on the material being engraved. Tip width is most accurately defined and measured as the as twice the distance from the tool centerline to the cutting edge. The width of cut is most correctly defined as the width produced at the bottom of the cut. (Note: even though the flat at the cutter tip is angled for clearance, the bottom of the cut will be flat – not angled.)

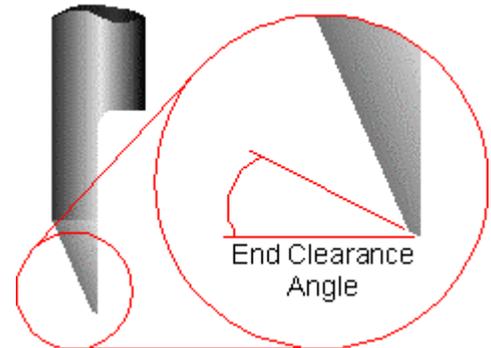
Tip Angle

The **tip angle** is the angle at the tip of the cutter. Sometimes called the tip-off. Determines the width of the flat at the bottom of the cut.



End Clearance Angle

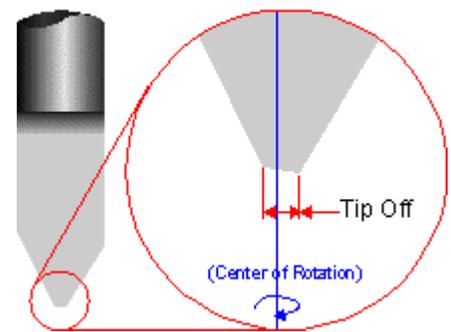
The **end clearance angle** is the angle on the back side of the tip that provides clearance for the tip.



Tip-Off or Tip Width

The **tip-off** refers to the flat on the tip of an engraving cutter that determines how wide the cutter will cut. When we refer to tip width or tip size, we are describing the width the cutter produces at the bottom of the cut.

Tip widths are most accurately measured by doubling the dimension from the cutter's centerline to the cutting edge. In the sharpening process, material is removed from the back of the tool to provide clearance; therefore the dimension across the tip will be smaller than the cut produced. For example, a .030" cutter for flexible engraving stock will only measure about .025".



Tip width is selected based on character height and font style. In general, single stroke characters should have a width that is approximately 12% of the character height. For example, a quarter inch (.250") letter should have a .030" tip ($.250" \times .12 = .030"$). It may be desirable to decrease tip width on condensed fonts and increase it on extended ones. On multiple line fonts, the cutter width should be such that there will be slight overlap on each pass.

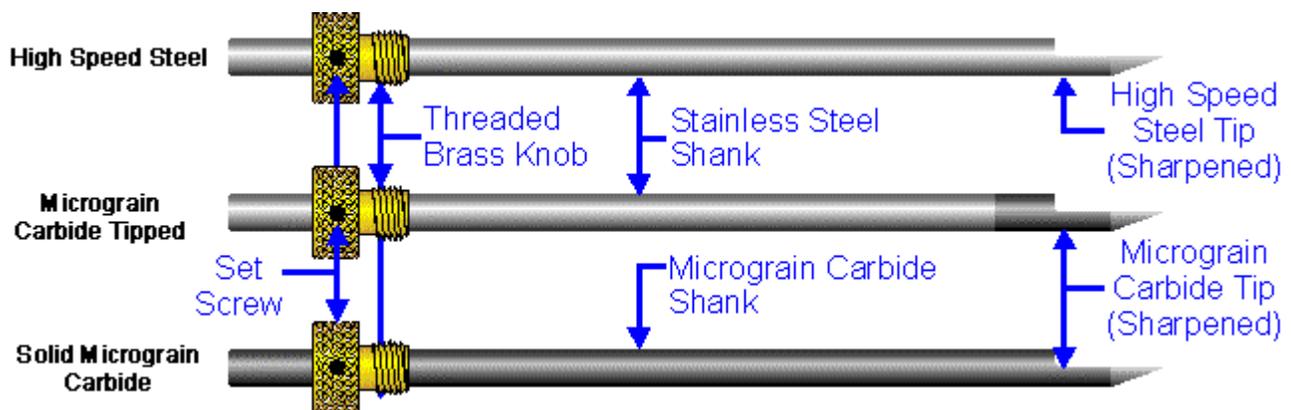


The finishes on the cutting surfaces are also very important in terms of the quality of the cut and the durability of the cutter. A grinding wheel contains abrasive particles (grit) that act like miniature cutting tools and produce a series of grooves in the surface of the part. The finer the grit of the wheel, the smaller the grooves and the better the finish.

The cutting edge on an engraving cutter is the junction of the face and the back of the cutter. If either of these surfaces has grinding marks produced by coarse grits or improper grinding procedures, the result will be a cutting edge that is irregular and serrated. Depending on the severity of the marking, it can lead to rough and burred cuts with poor surface finishes. Additionally, each serration is a weak point that can quickly dull or break off, exaggerating the problem further. All 908 carbide tipped and solid carbide cutters feature an exclusive Microedge® finish that provides optimum performance and tool life.

A cutter is an all-inclusive term used to describe the rotating cutting tools used in the engraving operation. Cutters can be manufactured from high speed steel or carbide and are available in a variety of configurations for specific applications.

Most standard cutters are available with either a stainless steel shaft or a micrograin carbide shaft (see below). The stainless steel shank is less expensive than the solid carbide shaft. The solid carbide shaft provides more rigidity and is better for engraving in harder materials such as stainless steel. Both of these types of cutters have micrograin carbide tips. Therefore, the cutting edge is of the same quality. All of these cutters are available with a threaded brass knob for top-loading engraving machines. The knob has a set screw to allow adjustment of the vertical position of the cutter and to hold it in place.





During the engraving process, the cutter rotates and moves through the material. The actual cutting is produced by a shearing action between the cutter and the material. As the cutter engages the material, the cutting edge meets with resistance and slices off a piece of the material.

Speeds and Feeds

The rate of the cutter rotation is referred to as the cutting speed, and the lateral movement is the feed rate. Each has a profound effect on the quality of the finished cut. The cutting speed is actually the measure of the distance traveled in surface feet per minute (sfpm) by the cutting edge and varies proportionally with tip size. For example, a .030" tipped cutter turning at 10,000 rpm has a speed of approximately 75 sfpm while a .060" tipped cutter rotating at the same speed generates about 150 sfpm. It is apparent then, that small cutters need to turn faster to achieve the same results as larger ones and vice versa. Cutter speed is determined primarily by the material being engraved. The following table and graph can be used as a guide.

Cutter Speed in Revolutions Per Minute

Material	Cutter Width						
	.015"	.030"	.060"	.090"	.125"	.171"	.250"
Plastic Engraving Stock	15,000 - 20,000				12,000	10,000	
Engravers Brass	10,000 - 15,000			13,500	9,500	6,500	5,000
Free-Cutting Aluminum	15,000 - 20,000				14,000	10,000	7,500
Mild Steel	15,000	10,000	5,000	3,500	2,500	1,500	1,200
Hard Steel / Stainless Steel	12,000	6,000	3,000	2,000	1,500	1,000	750
Wood	20,000						

Cutter speeds can vary greatly based on factors such as feed rates, depth of cut, and the use of cutting fluid. The above chart is intended to serve primarily as a comparison of cutter speeds in various materials.

Feed rate should be proportionate to cutter speed and is dictated by material properties, horsepower, and torque. At a given cutter speed, a slow feed will produce more, smaller cuts and finer finishes. A higher feed rate will produce fewer, larger cuts and rougher finishes. Due to its single-lip design, an engraving cutter makes an "interrupted cut" which means the cutting edge is not continually engaged in the material. At each rotation, the cutting edge hits the material as it starts the cut. On harder materials, the shock created by this impact can damage the cutter and quickly destroy its edge, thus slower feed rates are dictated.

While the above situation not as dramatic and detrimental when involving softer materials, a cutter still needs time to cut. Too high a feed rate tends to tear the material rather than cut it cleanly, resulting in rough, burred cuts. As a rule-of-thumb, the feed rate should be adjusted to allow maximum engraving speed without sacrificing the quality of the finished cut.

On softer, free-cutting materials like flexible engraving stock, one pass is generally sufficient to produce a good, smooth cut. On harder materials such as steel, brass and even acrylic, two or more passes are recommended. The first does most of the cutting, while the second cleans out the chips and removes the burrs.



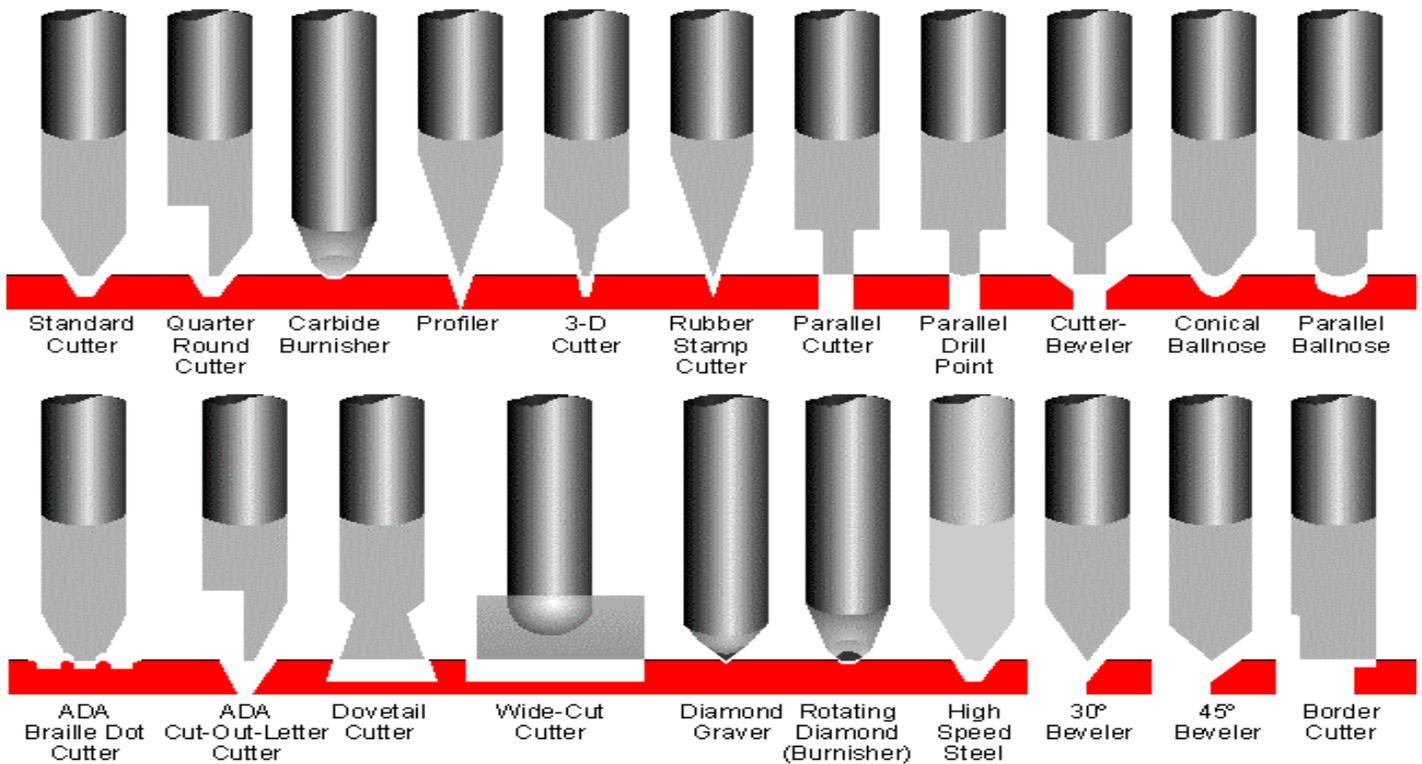
One problem inherent to some machines common to the awards and engraving industry is their lack of power and torque at lower speeds. If the cutter speed is reduced appropriately for harder materials, there is insufficient power to produce a quality cut. Engraving machines are not milling machines and care must be taken to not exceed their capabilities.

Cutting Fluids

Many of the materials common to the awards and engraving industry can be cut effectively without the use of cutting oils or lubricants. Flexible engraving stock, phenolic, engravers brass, and aluminum all fall into this category. There are many other materials, however, that must be cut with a cutting fluid to achieve satisfactory results and maintain reasonable cutter life. Cutting fluids keep the cutter cool and prevent chips from adhering to the cutting edge. The subject of cutting oils is very specific and complex, but the following are generalizations that may be helpful as guidelines.

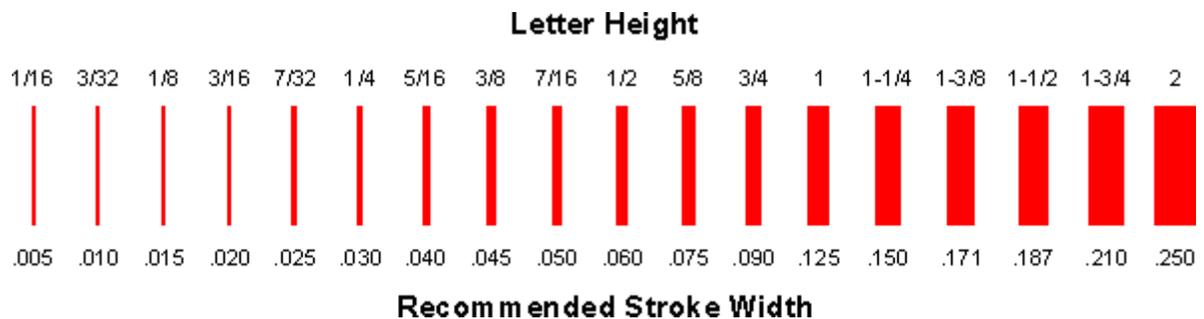
All steels should be engraved using an appropriate cutting fluid to improve the cut and extend tool life. Soft aluminum that is not "free-machining" can usually be engraved effectively using kerosene or a tapping fluid specifically formulated for aluminum. Plastics that tend to melt when engraved can often be engraved very successfully with the use of water-soluble cutting oil. Engraving acrylic is a good example of this. The use of cutting fluids, even on materials that can be cut dry, will often improve the finish of the cut and extend tool life.

The full spectrum of cutter types and their effect on material can be seen below.



How do I select the right cutter width?

Choosing the right cutter width is one of the most important aspects in producing engraving that is properly proportioned and visually appealing.



Cutter width is selected based on character height and font style. In general, single stroke characters should have a stroke width that is approximately 12% of the character height. For example, a quarter inch (.250") letter should have a .030" tip (.250" × .12 = .030"). It may be desirable however to decrease tip width on condensed fonts and increase it on extended ones so the appearance is more proportional.

The image shows a hand-drawn logo for 'gog ltd'. The letters 'g', 'o', and 'g' are drawn in a light blue color, while the letters 'ltd' are drawn in a grey color. The font is a simple, rounded, sans-serif style. The 'g' has a long, curved tail that extends downwards and to the left. The 'o' is a simple circle. The 'g' is a simple 'g' shape. The 'ltd' is written in a smaller, simpler font.

On multiple line fonts, the cutter tip size is frequently specified in the engraving software which eliminates the guesswork. Basically, the width of the tip should be such that there will be slight overlap on each pass in order to prevent ridges in the bottom of the cut. If, for example, you were engraving a three-line font and the desired stroke width was .090", you should use a .035" cutter rather than a .030" to achieve the overlap.