

## Choosing Cutters

### About 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 centre producing a "single-lip" tool which is one of having only one cutting edge. 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. 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.

### 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.

#### The Clearance Angle

R 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.

#### The Cutting Angle

I 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.

#### 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.)

#### Cutter Width

I 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" × .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.

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The cutting edge on an engraving cutter is the junction of the face and the back of the cutter. If either of these surfaces have 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 Antares carbide tipped and solid carbide cutters feature our exclusive Microedge® finish that provides optimum performance and tool life.

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.

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.

### 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 travelled 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. 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, phenol i.e., 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 a 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.

## Engraving Cutters

### Diamond Gravers

The most common engraving tool used in the trophy and awards industry is the diamond graver which is a non-rotating, diamond-tipped tool that is used to scratch lettering into metal - usually brass or aluminum. It consists of a steel shank which has a diamond set in one end that is ground and lapped to a conical point. It is used without a depth nose and, as downward spindle pressure is applied, the point penetrates the surface of the metal and scribes a fine line as the character is formed. Diamond gravers are not available in different tip sizes so we are limited to a rather fine, delicate line of about ten thousandths (.010) in width. A common practice used to enhance the effect of scratch engraving is to trace the letters two or three times. This tends to broaden the stroke and smooth it out. The

use of multiple line fonts is also a good way to add dimension to this type of engraving and the lettering can be blackened with oxidizer to give it contrast.

### **Burnishers**

Burnishing is a method of engraving on metals that tends to bridge the gap between scratch engraving and rotary engraving. It is capable of producing wider line widths than a diamond graver without having to rout deeply into the metal. It is a surface marking technique that is generally done on coated metals. It is most commonly used to produce decorative effects on trophy and plaque plates. The tool used for burnishing is called a "burnisher" which is a rotating tool that is used in a motorized spindle. It is usually a carbide or carbide tipped-tool that is ground with four facets that form a cutting edge to the desired tip size. A burnisher is not a cutter. Its function is to remove the surface coating from the material and expose the bare metal.

### **Rotary Cutters**

Rotary engraving is a term that is commonly applied to the type of engraving done on plastics and metals where we cut into the surface of the material. As the name implies, it is done with a rotating cutting tool in a motorized spindle. The rotary cutter is generally a single-flute tool (one with only one cutting edge) that works much like a router bit and produces a cut of specified depth and width. Depending upon how they are made and sharpened, rotary cutters can be used to engrave a wide variety of materials with plastic and metal being the most common. Typically, engraving cutters are single-flute tools, which means they have only one cutting edge. The cutting edge is highlighted in the picture, note the direction of rotation of the cutter.

While there is a seemingly infinite number of cutter sizes and shapes, engraving tools fall into two basic categories - conical and parallel. Most standard cutters are available with either a stainless steel shaft or a micrograin carbide shaft. 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. Typically, engraving cutters are single-flute tools, which means they have only one cutting edge. The cutting edge is highlighted, see Figure 1. Note the direction of rotation of the cutter.

### **Types of Rotary Cutters**

#### **Conical Cutters**

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

#### **Parallel Cutters**

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 4.43 mm wide).

#### **Half Round Cutters**

Half-round cutters are made from blanks that have been "split" or "halved" approximately on centre 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.

#### **Quart Round**

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, they provide more clearance than half-round cutters.

#### **Profiling Cutters**

Cutters that have a narrow angle and are used for cutting through material in similar applications to the parallel cutter, but produce a slight bevel on the edge of the material.

#### **Ball Nose Cutters**

Have a radius at the tip rather than a flat. They produce a cut with a rounded bottom and are typically used for reverse engraving.

#### **Dovetail Cutters**

Produce a cut that has a reverse bevel and are used for making signs that have removable legend strips.

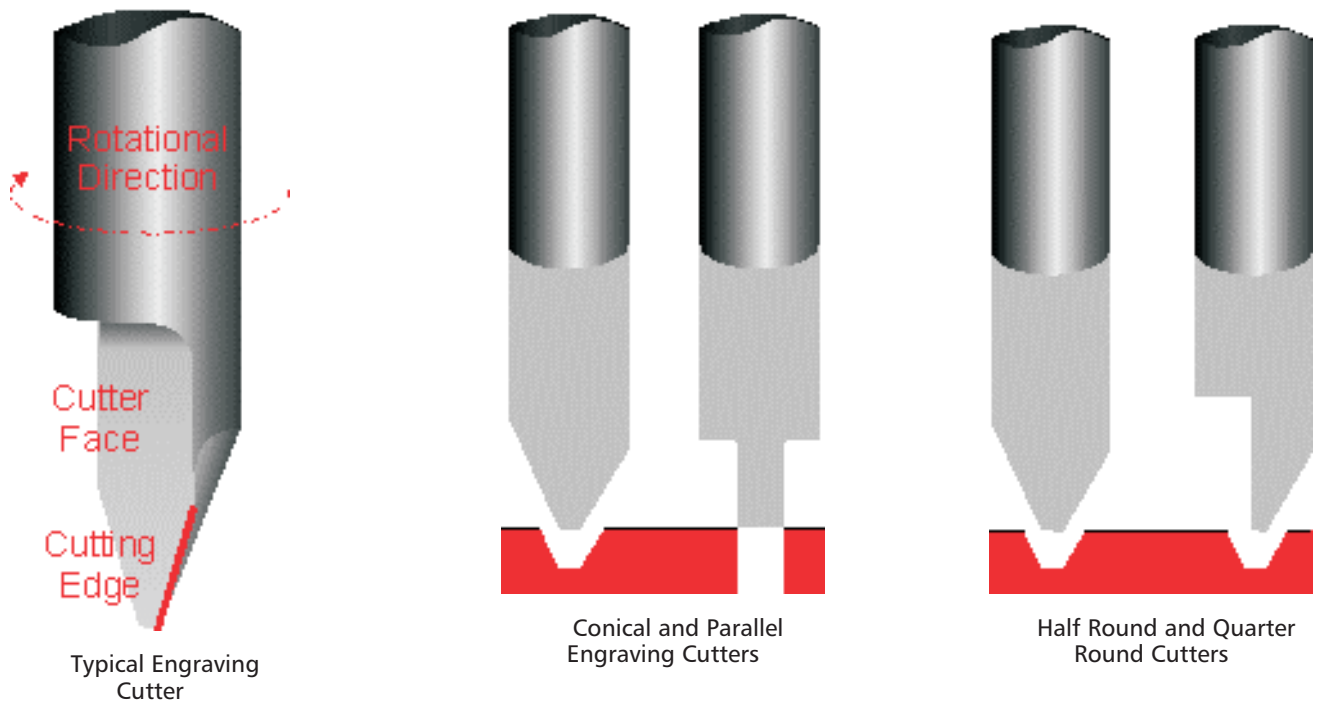
#### **Rotating Diamonds**

Faceted diamond tools that are used in rotating spindles to engrave glass.

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### Typical Engraving Cutters



### Available Cutters

Figures 1, 2, 3 and 4 show you most types of cutters that are readily available and their effect on material.

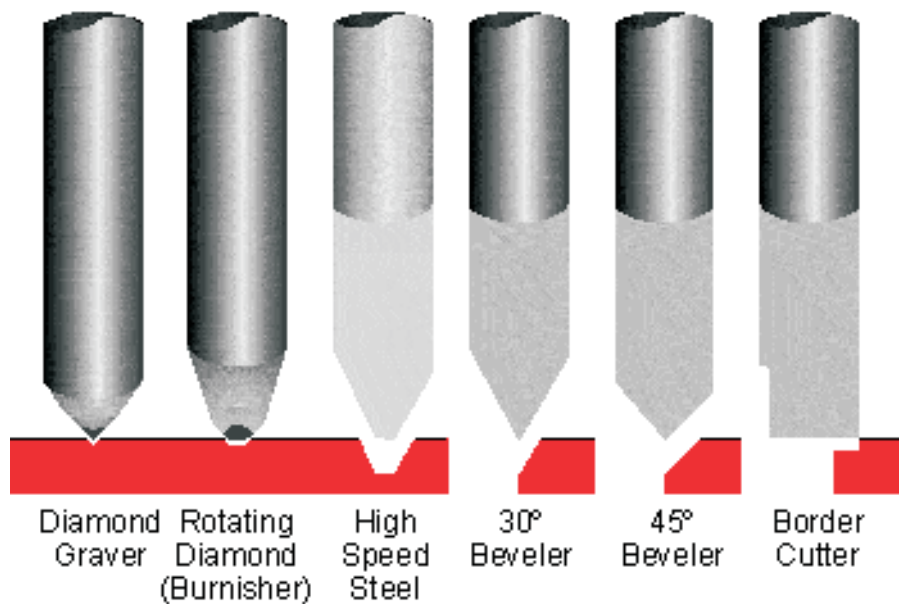


Figure 1

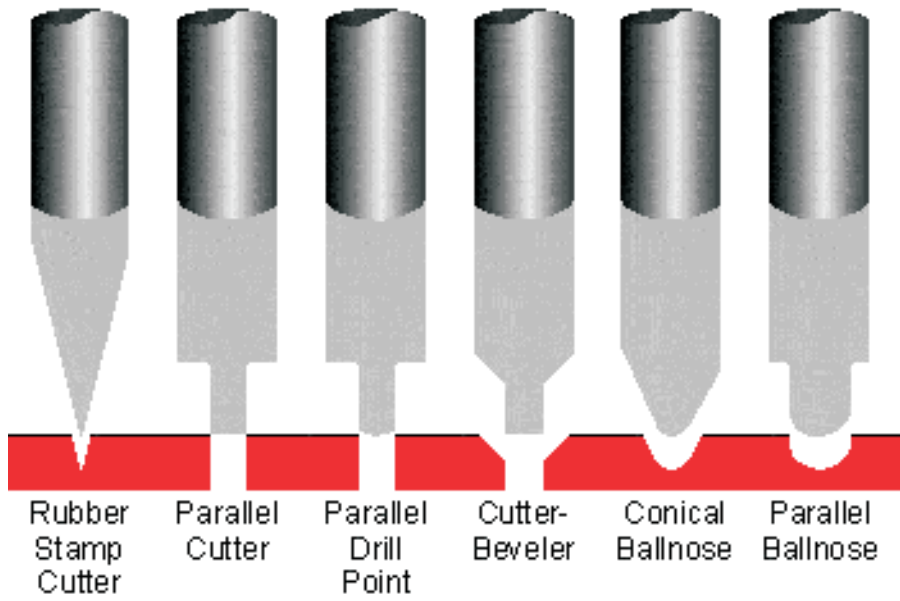


Figure 2

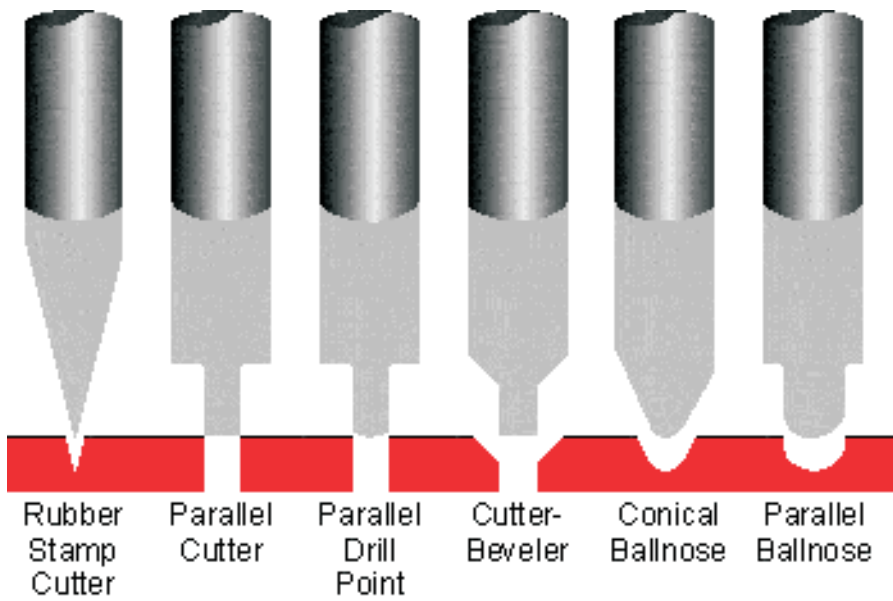


Figure 3

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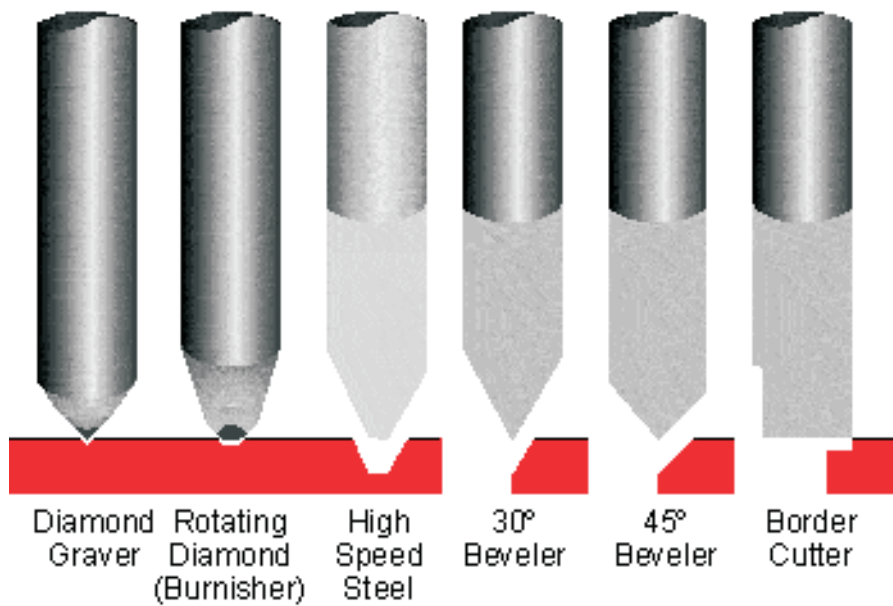


Figure 4

## Angles

### Cutting 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.

### Include Angle

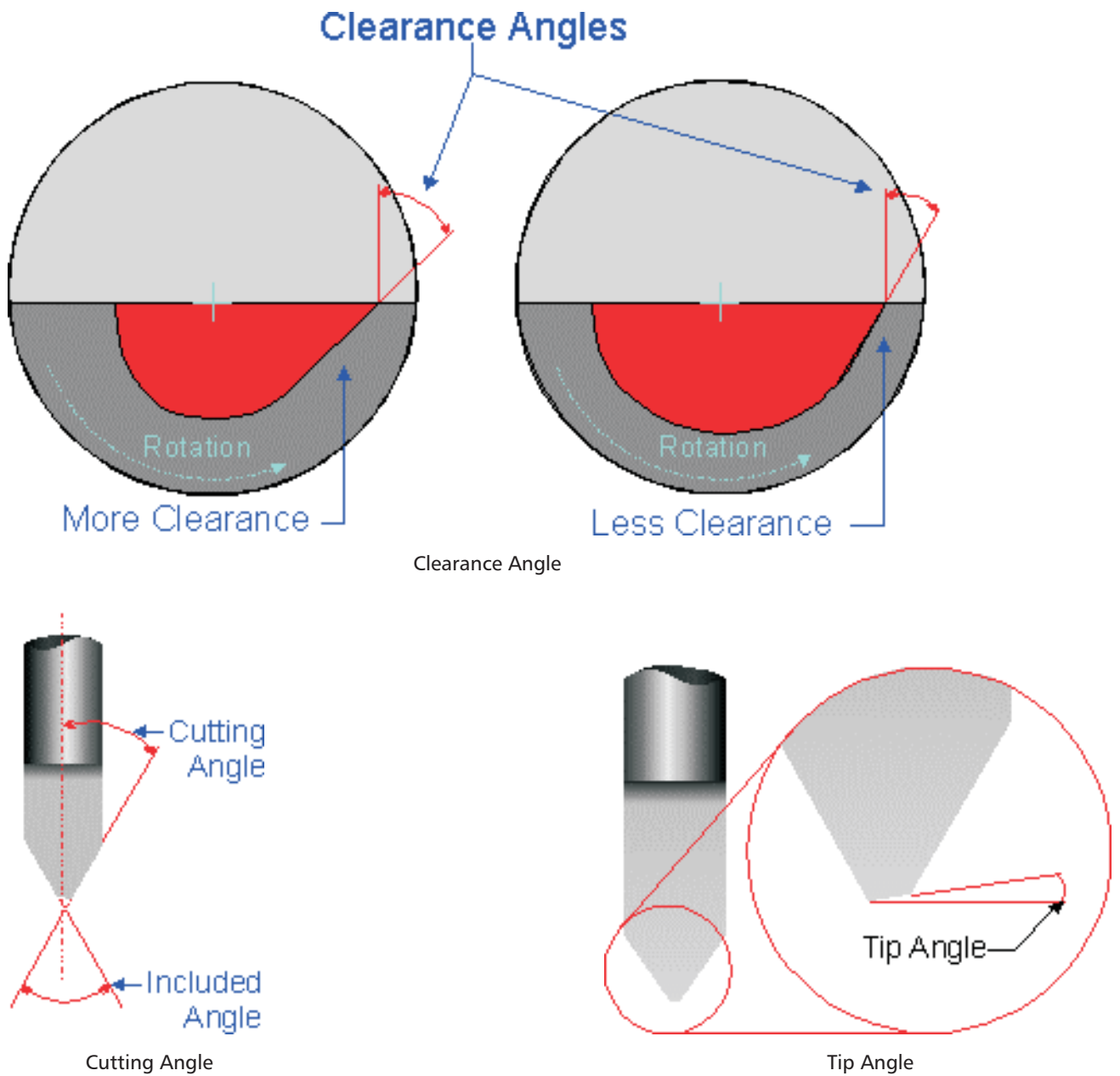
The included angle is double the cutting angle.

### 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.

**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 provide clearance for the tip.

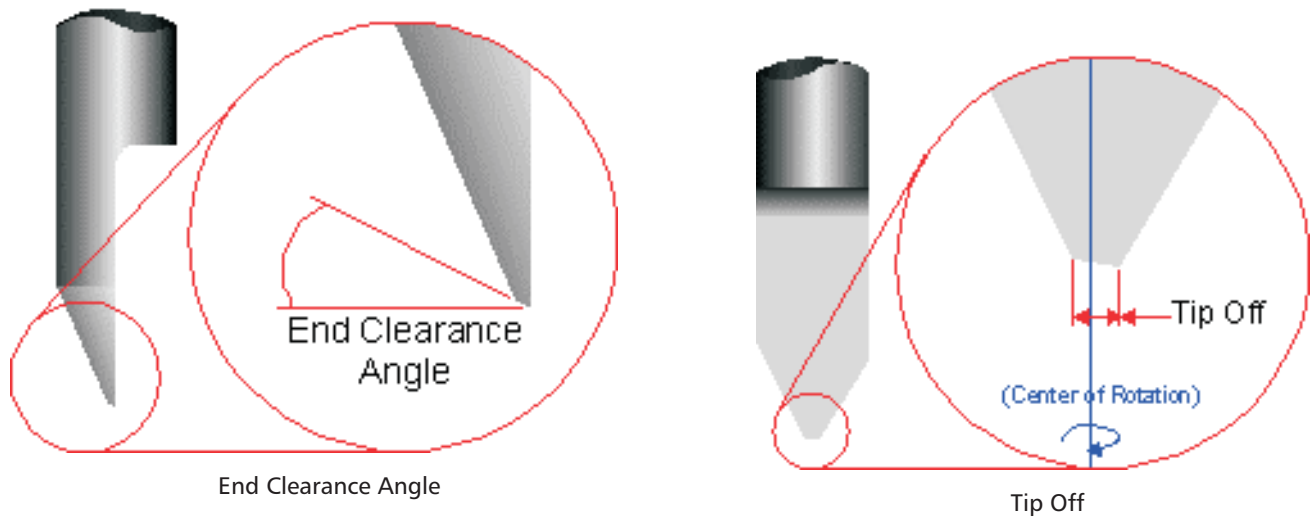
**Tip Off**

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.

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#### Tip Width

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.

## Burnishing

Burnishing is a surface marking technique intended for coated metals - usually lacquered brass - where the coating is removed to expose the bare metal. It is a method of rotary engraving on metals that tends to bridge the gap between diamond drag (scratch engraving) and routing. The biggest advantage of burnishing is that it enables the engraver to produce wider line widths than are obtainable with a diamond graver without having to cut deeply into the metal. Burnishers can be used with single and multiple line fonts, and are excellent for producing detailed line and logo work on metal. Burnishing offers the ability to create enhanced effects on both lettering and graphics and is relatively simple process.

#### Application

The most common application is on the brass plates on trophies and plaques. This "trophy brass" is a relatively hard material that yields excellent burnishing results. It is available in various gold tones with clear or coloured lacquer coatings. When burnishing the gold material, the lacquer is removed exposing the bare metal. The burnished areas can then be oxidized or blackened resulting in a gold plate with contrasting black letters. (See "Colour Filling Fact Sheet"). When burnishing the coloured materials, the result is a coloured plate with contrasting gold letters without the need for further treatment.

Burnishing can also be done on materials other than brass. However, much of the success or failure depends on the hardness of the material. Since burnishing is a surface marking technique, it is critical that the tip of the burnishing tool does not penetrate the surface of the material by an appreciable amount. Hard materials tend to prevent deep penetration of the burnisher forcing the tool to work on the surface as it was designed. However, on softer materials the tool is able to penetrate deeper and can produce ragged edges and unacceptable results. Many of the coloured aluminum products on the market fall into this category and are not ideal choices for burnishing although some can be burnished effectively using a diamond burnisher. There are also harder aluminum products available with clear or black anodize treatments that can be effectively burnished.

It is also possible to burnish metals such as steel and stainless steel. Since the burnishing tool produces a swirled pattern, the mark is visible and may be suitable for some marking applications not requiring a sharp, well defined character. Generally speaking, however, these metals do not have coatings and therefore, the burnishing can not be blackened to add contrast.

#### Burnishing Tool

A burnishing tool is normally a diamond-tipped tools (diamond burnishers or rotating diamonds) similar to those used in glass engraving. These tools produce a more brilliant effect and have a longer life, but are considerably more expensive. Diamond burnishers are available in standard tip sizes of .005", .010", .015", .020" and .030". Larger sizes are available as special orders.

When selecting a tip size, follow the same guidelines that are used for standard engraving cutters. For example, if you were to use a .030" cutter when engraving plastic, you would use a .030" burnisher when burnishing a brass plate with the same font and letter size. Since burnishing is generally done with small, multiple-line fonts, the most common tip sizes are between .005" and .030".

Burnishers are quite durable and are capable of producing thousands of characters. Like cutters, they do become dull, however, and require periodic sharpening. As a burnisher dulls, the chisel edge becomes rounded. This produces rough edges and if allowed to continue, will result in the surface coating being smeared in to the burnished stroke and can hamper oxidizing.

**Process**

Since the purpose of burnishing is to remove the coating from the surface the material, the key to achieving successful results lies in the amount of downward pressure that is exerted on the tool. A burnishing tool is not a cutter and if too much pressure is applied, the tool will be forced into the material resulting in a rough, ragged stroke. Ideally, the tip of the tool should “float” over the surface with only enough pressure to remove the coating without digging into the metal.

To set the machine for burnishing, remove the depth nose and lower the spindle to its down position. Next, screw the knob into the spindle, slide the burnisher down through the knob until the tip contacts the plate and then tighten the set screw in the knob. Raise the spindle and then increase the “depth” a few thousandths of an inch by either adjusting the down stop on the spindle or sliding the burnisher further through the knob. Since the bases and tables of all machines are not perfectly level and material thickness can vary, it is important to set the tool at the lowest point on the plate. This will ensure that the tip of the tool will remain in contact with the entire surface of the plate. The spindle motor speed should be relatively fast and the engraving speed should be at about the middle of its range. A slower engraving speed will produce a smoother finish in the burnished stroke.

One way to simplify the burnishing process and achieve consistent results is through the use of a spring loaded burnishing attachment (Light Touch). These devices are used in place of the conventional knob and have an internal spring that applies the correct amount of pressure.

**Engraving**

When engraving, it is extremely important to ensure you use the correct cutter size. This will give that professional finish that you and your customer demand.

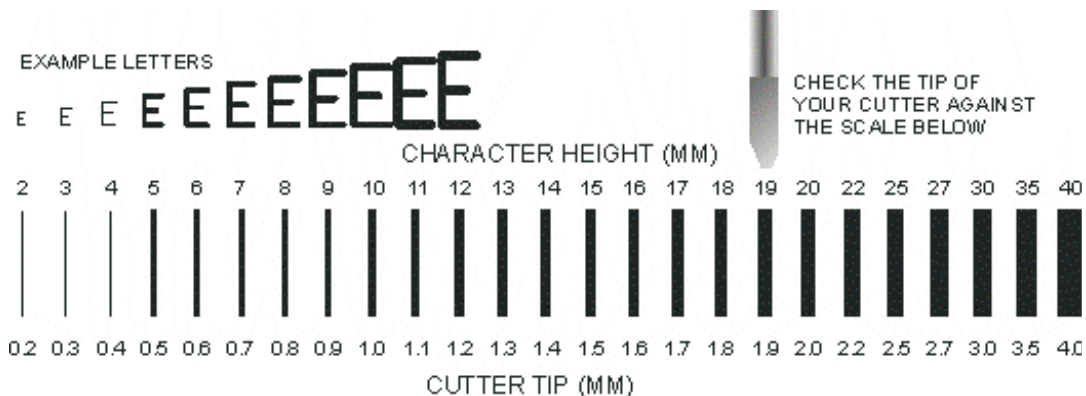


Figure 1

**Single Line Text**

Normally when engraving single stroke text you would check the text height, it is now simply a case of rounding this off to the nearest mm i.e. 6.11 would be 6, then refer to the chart in Figure 3

**Multi Stroke Text**

When engraving using a Multi Stroke Text, it is important to ensure you use the correct cutter size to clear out the engraving. To do this is very simple, If using a three line font eg. Times Engraving, Helvetica 3 Line, simply take your character height and divide by 20.

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#### **Example**

Character Height 10mm,  $10 \text{ divided by } 20 = 0.5$ . Cutter required is therefore a 0.5mm tipped cutter. Character Height 5mm,  $5 \text{ divided by } 20 = 0.25$ . Cutter required is therefore a 0.25mm tipped cutter.. With this example you need to round the figure up to your nearest possible cutter size, in this case 0.3m. If using a five line font in the same manner take you character height and divide by 26.