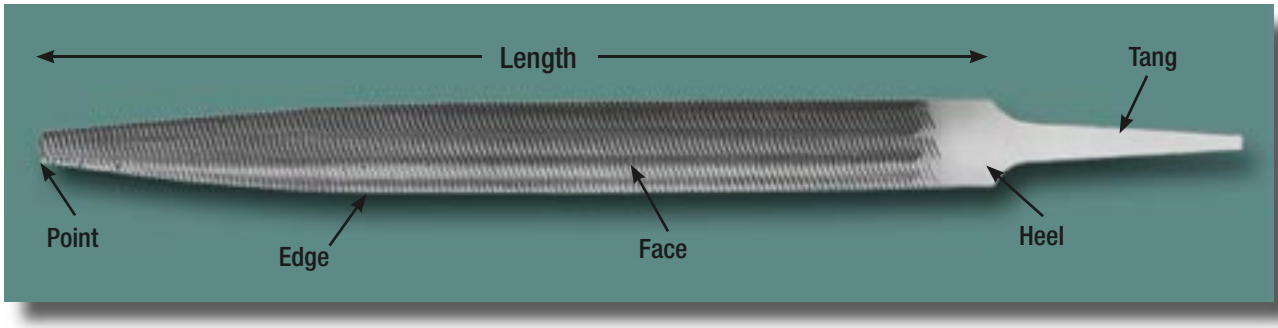
➤ BY LAROUX K. GILLESPIE



Baby Teeth, BIG BITE

Files and rotary burs are common metalworking tools, but choosing and using them correctly takes practice.

With their ability to deburr parts, files and rotary burs are staples of every shop—but do you know how to choose and use them properly? The following covers how to select different files, good filing techniques, rotary bur options and deburring safety.

File Like an Egyptian

While files and burs have smaller cutting teeth than other tools, they can be used to remove heavy amounts of material or impart fine finishes. The common hand file dates back 3,400 years to the Egyptians, who used it to remove burrs, chamfer edges, change dimensions, flatten surfaces and smooth surfaces and edges. It is still used in machine shops today.

At least 2,300 different geometries and sizes of files are available, and they are not limited to manual operations. Reciprocating filing machines are popular mold and die tools. The three basic types of metal-toothed files are: American and British pattern files, Swiss precision files and Swiss precision rifflers (Table 1). They can be used manually or in a machine.

Single-cut files (Figure 1) remove stock quickly while double-cut files, which are used for operations like fine deburring, impart finer finishes. Teeth on both file types typically run at an angle to the sides of the file. Note that the single-cut file in Figure 1 is designed for right-handed users. Left-handers naturally tend to move the tool to their left side, which is parallel to the teeth, resulting in little cutting action. Left-handers would be more productive using double-cut files or diamond-plated files for finishing edges.

The small Swiss files (which

Table 1. Definition of file cuts

File No.	Name of cut	Teeth per inch (tpi)		
		Swiss	American	British
000	Rough		Not widely available. Has fewer than 30 tpi	
00	Bastard		25-70	
0	Between bastard and second	40-70	35-60	42-65
1	Second	75-88	55-75	57-80
2	Smooth	88-104	80-95	72-95
3	Dead smooth	100-130	80-120	87-110
4	Dead smooth	120-160	125-135	102-125
6	No name used	180-200	160-200	132-155
7	No name used	213		147-170
8	No name used	295		162-185

include pattern, escapement and needle files) are distinguished by their fine tooth spacing (up to almost 300 tpi) and fine taper. Also, the teeth extend to the very ends and edges of the file. Swiss precision files and rifflers come in over 700 shapes and many sizes. Swiss precision rifflers, which have curved or bent bodies, are available in over 600 styles.

Swiss files—with a width of about ¼" and thickness of 1/16"—are narrower and much thinner than typical shop files. They can reach into most small areas of parts. Some are as thin as 0.014". The needle file variation has a round handle. The number of teeth per inch on a Swiss file increases as the length of the file decreases.

In addition to these standard files, special files are gaining acceptance. For example, diamond-coated files offer long tool life. They are particularly useful when filing abrasive plastics and composites and are relatively inexpensive ($10 to $28 each).

Miniature flexible files (distinct from Swiss files) are another type. Made of a special electrical-steel alloy having a hardness of 66 HRC, they can be bent without breaking to enter into and around hard-to-reach areas to deburr or polish.

File Under 'Good Technique'

Consider the work material when choosing a file. For example, files designed for iron or steel are often not suitable for brass. In filing steel, second-cut files work better than coarser files. A sharper file is needed for brass, copper, aluminum, zinc and cast iron than for wrought iron or hard steel. Broad surfaces require sharper files than narrow ones.

When filing a large part, clamp it in a vise or to a stable surface and cover the tang with a handle. Many a user has jabbed the sharp tang into the palm of his hand because he did not think he needed a handle. Hold the file with both hands, one at the handle and the other at the tip. This provides directional and pressure control.

Right-handers grasp the file handle in the right hand, thumb on top. For light work, hold the point, or tip, of the file with the thumb and first two fingers of the left hand, thumb on top and fingers below. For heavy cuts, the heel of the left hand may be placed on top and the fingers closed on the underside of the file.

Materials	Single cut	Double cut	Chip-breaker	Diamond cut	Nonferrous	Coarse cut	Fine cut
Aluminum					X		
Brass, bronze, copper	X	X	X			X	
Carbon fiber						X	
Fiberglass				X			
Cast iron	X	X	X			X	
Plastics					X	X	
Hard rubber							

Table 2. Recommendations for bur fluting choices

Figure 1: Single- and double-cut files.

Filing is done only on the forward stroke. For best results, move the file slightly sideways on the forward stroke, alternating from right to left every few strokes. File narrow surfaces in the direction of their length—not across. Single-cut files are best for thin work. Apply a coarse file first to remove the majority of material, followed by a finer one to finish the work.

When rough-filing surfaces, make short cross-strokes, which create an "X" pattern on the part. This keeps the surface flat and straight. To round a corner, rough-file across the workpiece. Reduce the corner by filing a series of angles until the proper radius is achieved. Finish the corner with a fine-cut file.

Use a file cleaner regularly to remove chips left in the teeth when cutting soft metals and parts contaminated with grease, plastic or other soft materials (fine chips being trapped in the file openings is called "pinning"). Fine wire brushes or file cards are commonly used to clean files. Use a soft iron or copper "scorer," a special scraper that slides in the teeth, when filing wrought iron and steel. When filing aluminum, turpentine or paraffin may be used on file surfaces to minimize pinning, which can cause scratching of the work surface. The fine chips pinned in the file openings come loose and rise above the teeth and get caught between the teeth and the part, resulting in scratching.

Rubbing chalk against the teeth before filing also helps minimize pinning. Some chips can be removed by gently rapping the edge of the file against a hard surface. In some instances, water-based, ultrasonic cleaning can remove particles in the teeth, but this can cause teeth to rust, ruining their sharp cutting edges. Demagnetize files occasionally to prevent ferrous chips from sticking in the spaces between the teeth.

When filing aluminum, use lard oil or another lubricant, which will produce better results than filing dry. It is most effective to file crosswise to the direction in which the steel has been rolled. The rolling direction is normally parallel to the bar stock's length.

Don't rub your hand or fingers over a cast iron or brass surface. Oil from your skin may be deposited on the metal, causing the file to slide over the work instead of cutting it.

Materials	Single cut	Double cut	Chip-breaker	Diamond cut	Nonferrous	Coarse cut	Fine cut
Steel, 40-55 HRC	X	X	X	X			X
Steel, 55-60 HRC	X	X	X	X			X
Steel, carbon	X	X	X				
Steel, nickel chrome	X	X	X	X			
Steel, stainless	X	X	X				X
Steel, weldments	X	X	X				
Titanium	X	X	X				
Zinc					X	X	

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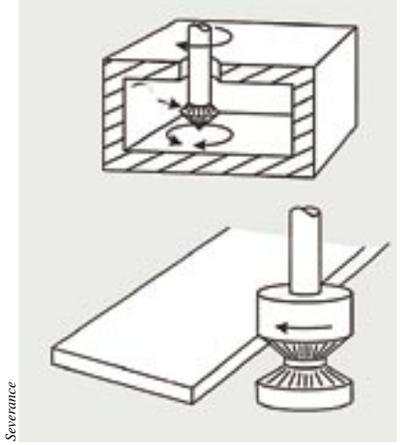
(Table 2 continued)



Severance

Figure 2: Sheet metal edger.

Deburring with Burs

Like Swiss files, burs have been used since the 1700s to deburr, chamfer holes and remove excess material from molds and dies. While the tool name is often misspelled "burrs," the correct spelling is "burs." Burs are also known as rotary files and rotary mills.

Their distinctive fine-tooth spacing readily identifies them as burs rather than countersinks. A bur has two to five times more teeth than a countersink. These numerous small teeth give the bur its smooth finish-cutting action. The small teeth prevent excessive digging into surfaces and they reduce chatter, thereby minimizing tool-related surface degradation.

Burs come in over 400 shapes and range in size from a 0.004" bur ball up to 2"-dia. tools. In addition to the ball and cylinder shapes, burs come in cone and inverted-cone shapes, flat discs, cups, U-shapes and other configurations. Tube-end burs deburr and chamfer both the ID and OD of tubes in a single pass. Similarly, sheet metal edgers chamfer and deburr both sides of sheet metal edges simultaneously (Figure 2).

Most burs are short, with overall lengths of 2" to 3" being common. Extra-long versions are available with 18"- to 36"-long shanks. The snake bur, as the name implies, flexes along its 36"-long shaft to deburr deep into the part.

Bur Buyer Beware

While manufacturers offer tools with common angles and teeth shape, there is no guarantee these tools will perform equally. Burs come in positive-, negative- and radial-cut rake angles. They are made from carbon steel, HSS, vanadium-HSS, tungsten-vanadium steel, tungsten carbide, tungsten-carbide-coated steel, TiN-coated tungsten carbide and diamond-plated steel. Tooth spacing ranges from 5 tpi to 62 tpi.

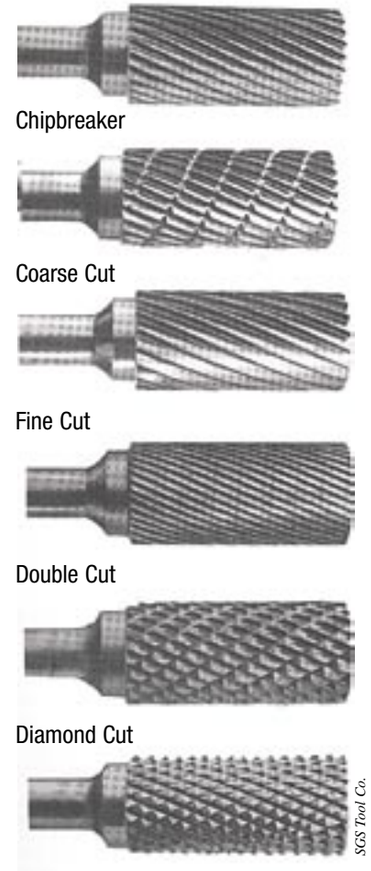
Burs are typically used in two different manners. For rapid, heavy stock removal of up to ⅛" or more, operators apply heavy forces using ⅓-hp or ¼-hp motors. Casting shops are common users of heavy-duty tools to remove flash and excess metal. Both the tool and the operator will be working hard in these situations!

In contrast, for precision edge finishing, a delicate, feather-like touch is required to remove burrs. In this instance, hand-held air motors with outputs as little as 0.1-hp are used. Care must be exercised, though, because the motor will stall if too much force is exerted.

Most hand-held motors run between 20,000 and 60,000 rpm. To machine productively, an operator must run tools at higher speeds as their diameters decrease. To illustrate, a ⅝"-dia. bur ball at 20,000 rpm has a surface velocity of 3,272 sfm. A 0.062" bur ball at the same rotation has a surface velocity of only 327 sfm.

The choice of fine, medium or coarse flute spacing depends on the material to be machined or deburred (Table 2). The medium cut is appropriate for general-purpose deburring of steel, cast iron and other ferrous materials. Finer burs are used to impart a finer surface finish.

The diamond-cut flute cuts quickly and offers better control when the



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Bur fluting patterns.

tool is used in a hand-held motor. Stringy materials are easily cut with a diamond-pattern tool because its hundreds of chisel-like edges produce a powdery chip.

For aluminum alloys, choose a tool with large flutes, deep and rounded gullets, small primary tooth clearance angle, a large secondary clearance angle and a positive rake angle. When removing cast flash, gates and risers, the bur diameter should be at least five times larger than the material being removed.

Practice Safe Deburring

Files and burs, in general, do not pose out-of-the-ordinary safety hazards. However, they can grab and throw parts. Fast-moving cutters produce flying chips, so wear eye protection. Heavy cutting creates heat in parts that can burn hands, and long, thin tool shanks bend and wrap around hands when tools are running too fast. When trimming fiberglass, wear a mask since the operation throws fiber and dust into the air.

Metal dust also presents hazards:

- It can contribute to chronic breathing problems;
- nickel dust is a suspected carcinogen and dust from beryllium alloys can cause chronic beryllium disease;
- magnesium and titanium chips can be fire hazards; and
- extensive amounts of fine dust from any material can explode.

And, lastly, use dust-removal systems wherever possible to prevent dust accumulation. △

About the Author

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