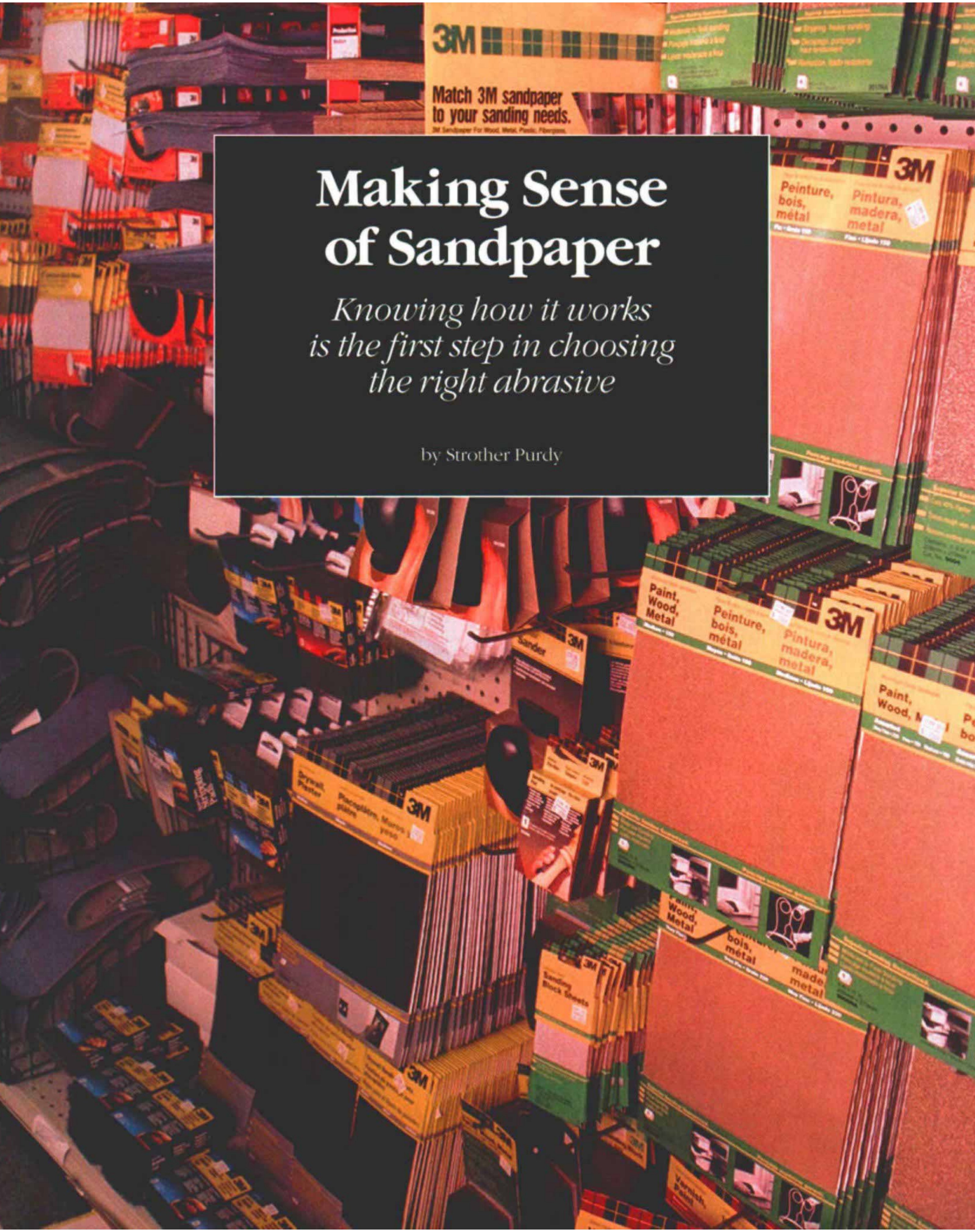
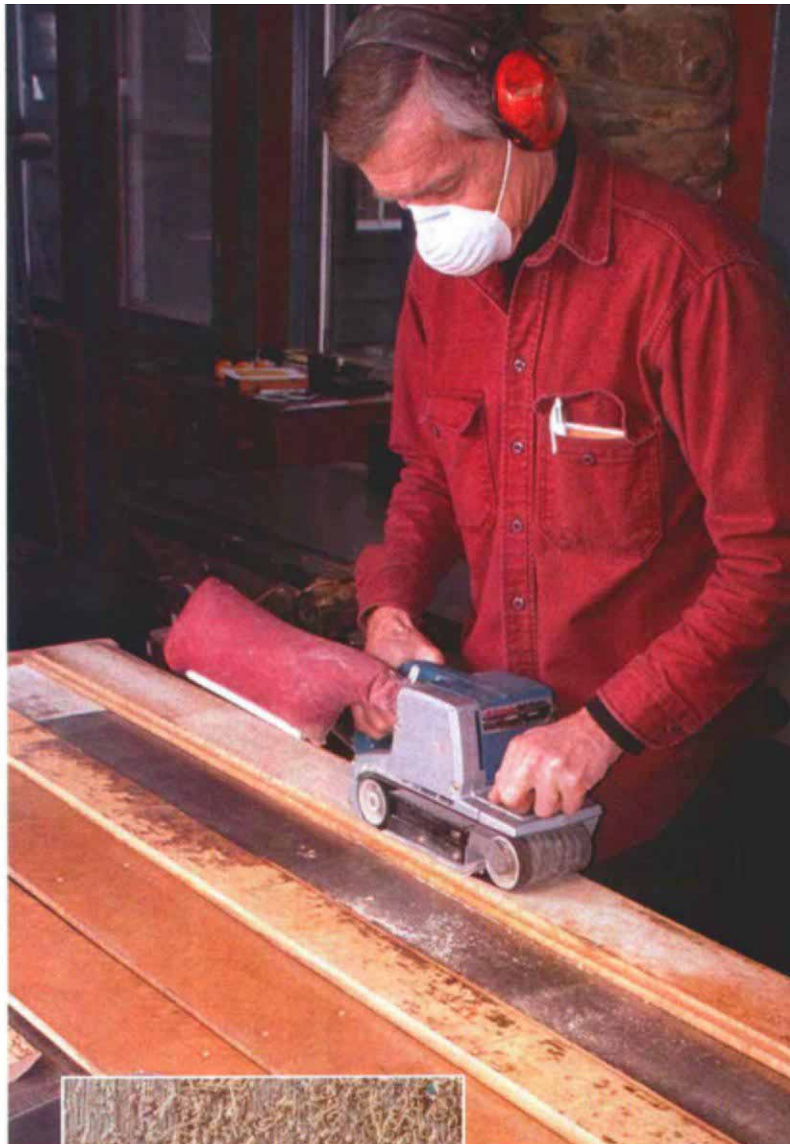
Making Sense of Sandpaper

Knowing how it works is the first step in choosing the right abrasive

by Strother Purdy





What goes on between belt sander and board? *Sandpaper is a kind of cutting tool, like a saw or a plane. Magnified at left, swarf from sanding with the grain looks like shavings from a ripsaw.*

Years ago at a garage sale, I bought a pile of no-name sandpaper for just pennies a sheet. I got it home. I sanded with it, but nothing came off the wood. Sanding harder, the grit came off the paper. It didn't even burn very well in my wood stove.

Sanding is necessary drudge work, improved only by spending less time doing it. As I learned, you can't go right buying cheap stuff, but it's still easy to go wrong with the best sandpaper that's available. Not long ago, for example, I tried to take the finish off some maple flooring. Even though I was armed with premium-grade, 50-grit aluminum-oxide belts, the work took far too long. It wasn't that the belts were bad. I was simply using the wrong abrasive for the job. A 36-grit ceramic belt would have cut my sanding time substantially.

The key to choosing the right sandpaper is knowing how the many different kinds of sandpaper work. Each component, not just the grit, contributes to the sandpaper's performance, determining how quickly it works, how long it lasts and how smooth the results will be. If you know how the components work together, you'll be able to choose your sandpaper wisely, and use it efficiently. Then you won't waste time sanding or end up burning the stuff in your wood stove.

Sandpaper is a cutting tool

What sandpaper does to wood is really no different from what a saw, a plane or a chisel does. They all have sharp points or edges that cut wood fibers. Sandpaper's cutting is simply on a much smaller scale. The only substantial difference between sandpaper and other cutting tools is that sandpaper can't be sharpened.

Look at sandpaper up close, and you'll see that the sharp tips of the abrasive grains look like small, irregularly shaped sawteeth (see the drawing on p. 67). The grains are supported by a cloth or paper backing and two adhesive bonds, much the way that sawteeth are supported by the sawblade. As sandpaper is pushed across wood, the abrasive grains dig into the surface and cut out minute shavings, which are called swarf in industry jargon. To the naked eye, these shavings look like fine dust. Magnified, they look like the shavings produced by saws or other cutting tools (see the inset photo at right).

Even the spaces between the abrasive grains serve an important role. They work the way gullets on sawblades do, giving the shavings a place to go. This is why sandpaper designed for wood has what's called an open coat, where only 40% to 70% of the backing is covered with abrasive. The spaces in an open coat are hard to see in fine grits but are very obvious in coarse grades.

Closed-coat sandpaper, where the backing is entirely covered with abrasive, is not appropriate for sanding wood because the swarf has no place to go and quickly clogs the paper. Closed-coat sandpaper is more appropriate on other materials such as steel and glass because the particles of swarf are much smaller.

Some sandpaper is advertised as non-loading, or stearated. These papers are covered with a substance called zinc stearate—soap, really—which helps keep the sandpaper from clogging with swarf. Stearated papers are only useful for sanding finishes and resinous woods. Wood resin and most finishes will become molten from the heat generated by sanding, even hand-sanding. In this state, these substances are very sticky, and given the chance, they will firmly glue themselves to the sandpaper. Stearates work by attaching to the molten swarf, making it slippery, not sticky, and preventing it from bonding to the sandpaper,

Methods for sanding efficiently

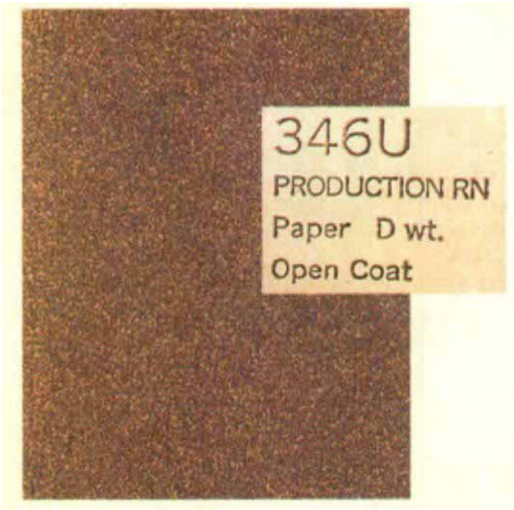
Sanding a rough surface smooth in preparation for a finish seems a pretty straightforward proposition. For a board fresh out of the planer, woodworkers know to start with a coarse paper, perhaps 60-grit or 100-grit, and progress incrementally without skipping a grade up to the finer grits. At each step, you simply erase the scratches you made previously with finer and smaller scratches

Photos: Strother Purdy

Aluminum oxide

Trade names

Adalox
Aloxite
Imperial
Metallic
Production
Three-M-ite



Aluminum oxide is a sharp and blocky mineral. It is the most common, all-purpose woodworking abrasive, and for good reason. It is the only abrasive mineral that fragments under the heat and pressure generated by sanding wood. This characteristic is called friability and is highly desirable. As you sand, aluminum oxide renews its cutting edges constantly, staying sharp and cutting much longer than other minerals.

Aluminum oxide is also a relatively tough abrasive, which means that its edges won't dull much before they fragment. Its friability and toughness make aluminum oxide the longest lasting and the most economical mineral.

All aluminum oxides are not created equal. 3M alone manufactures 26 different kinds, ranging greatly in toughness and friability. The toughest grades are nearly white in their raw form and are used on premium-grade sandpapers. The softest grades are dark brown and more appropriate for sandblasting than sanding. Some cheap sandpapers have blast-grade aluminum oxide on them. No manufacturer is going to tell you which kind is on which sandpaper, however, and it's impossible to judge by the color of the sandpaper because a size coat covers and colors the mineral. If one brand's aluminum-oxide paper doesn't work well, don't judge all aluminum oxides by it. Simply try another.

Silicon carbide

Trade names

Durite
Tri-M-ite
Fastcut
Powerkut
Wet-or-dry

Silicon carbide is black and iridescent, and the grains are shard-shaped (see the photo below). Unlike aluminum oxide, there is only one kind of silicon carbide. It is harder and sharper than most aluminum oxides, making it the better choice for cutting hard materials, such as finishes, paint, plastic and metal. Consequently, you'll probably find the widest range of silicon carbide sandpapers in a good auto-body supply store.

Silicon carbide sandpapers for woodworking are almost always on waterproof paper and intended for sanding finishes. Though silicon carbide is a friable mineral, it is so hard that sanding wood will not cause it to fragment and renew its cutting edges. Though it will sand faster at first, it will dull more quickly than aluminum oxide. It is also generally more expensive than aluminum oxide.

Abrasive grains are little sawteeth. *This is 24-grit silicon carbide sandpaper before a size coat has been applied. It is easy to see how sharp the particles are.*

until, at 180-grit or 220-grit, the scratches are too small to see or feel. But there are a fair number of opinions on how to do this most efficiently.

Don't skip grits, usually—Skipping a grit to save time and sandpaper is a common temptation, but not a good idea when working with hardwoods. You can remove the scratches left by 120-grit sandpaper with 180-grit, but it will take you far more work than if you use 150-grit first. You will also wear out more 180-grit sandpaper, so you don't really save any materials. When sanding maple, for instance, skipping two grits between 80 and 180 will probably double the total sanding time. This, however, is not as true with woods such as pine. Soft woods take much less work overall to sand smooth/Skipping a grit will increase the work negligibly and may save you some materials.

Sand bare wood to 180- or *220-grit—For* sanding bare wood, 180-grit will generally give you a surface that looks and feels perfectly smooth and is ready for a finish of some kind. Sanding the surface with a finer grit is only necessary if you're going to use a water-based finish. These finishes will pick up and telegraph the smallest scratches. Sanding the wood to 220-grit or finer will pre-

Ceramics

Trade names
Norzon
Dynakut
Regalite

Ceramics come in a wide variety of shapes, from blocks and heavy wedges to flake-like shards. They're all more costly and less common than other abrasive minerals. All of them are very tough and very aggressive.

Like silicon carbide, ceramics are not friable, and do not renew their cutting edges when sanding wood. But they don't dull as quickly because of their extreme toughness. This makes them the best choice for hogging off stock, roughing out shapes, removing finish and leveling uneven boards. For this reason, they are generally available only in coarse-grit cloth belts for stationary and portable sanders.

Ceramic mineral names and the trade names they're sold under are not easy to sort out. Though Cubitron sounds like a trade name, it's a ceramic mineral. One of its trade names is Cubicut. When mixed with aluminum oxide, it's sold as Regalite. Alumina zirconia is the name of a ceramic mineral. Sometimes it's marketed as aluminum zirconia, as if it were another type of mineral. It's also sold under the trade names Norzon and A2 as a ceramic mineral.

Abrasive manufacturers make these names intentionally confusing to avoid losing their copyrights. If a trade name becomes synonymous with the product in the public's mind (think of a thermos), then any company can use it.

Garnet

Trade names
None

Garnet is the only natural abrasive mineral still widely used for woodworking. Like aluminum oxide, it is blocky in shape. Unlike aluminum oxide, it is non-friable, not very tough and dulls very quickly. This is not necessarily a defect. The softer cut of a garnet paper, though slow, will produce the smoothest finish of all the abrasives within a given grit size. Because it is so soft, garnet will not leave pigtail-like scratches the way an aluminum oxide will when used on a random-orbit sander. This makes it well-suited for final sanding of wood surfaces.

Garnet is an excellent choice for final sanding end grain and blotch-prone wood. Garnet's peculiar tendency to burnish wood—close off pores—makes a stain penetrate far more evenly though less deeply (see the photo at left).

Pigmented stain prefers a garnet-sanded surface. *Both sides of this test board were sanded to 150-grit, the left with an aluminum-oxide paper and the right with a garnet paper.*

pare the surface better. However, it's not always wise to sand to a finer grit. You will waste your time if you can't tell the difference, and you may create problems in finishing. Maple sanded to 400-grit will not take a pigmented stain, for example. Pigments work by lodging themselves into nooks and crannies on the surface; without them, they will have no place to stick.

***Sand faster across the** grain—How* many times have you been told never to sand across the grain? True enough. The scratches are much more obvious, look terrible and are hard to remove with the next finer grit. But what holds true for planing wood is also true for sanding. You will plane and sand faster and more easily when the direction of your cuts is between 45° and 60° to the grain, because the wood-fiber bundles offer the least resistance to the cutting edges. Cross-grain scratches are harder to remove simply because they are deeper.

Use a combination of cross-grain and with-grain sanding to get the smoothest surface in the fastest manner. First make passes at 45° to 60° to both the left and the right, making an X-pattern on the workpiece. Then, with the same grit, sand with the grain to remove the cross-grain scratches. Do this with each grit when belt-sanding and hand-sanding. The non-linear sanding action of random-orbit

Abrasive grading systems

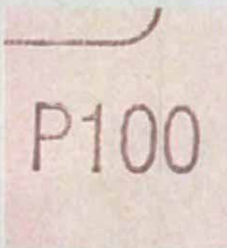
The most common grading systems used in North America are CAMI, FEPA and micron grading. CAMI and FEPA are similar in grades up to about 220. Beyond that, they diverge greatly.

finishing — *smoothing* — *shaping*

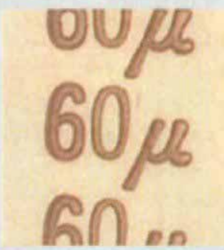
CAMI (U.S. Std.)	FEPA (P-scale)	Micron (μ)
		5
1,200		
		9
1,000		
800		
		15
	1,200	
600		
	1,000	
500		
		20
	800	
400		
	600	
360		
		30
	500	
	400	
320		
		40
	360	
280		
		45
	320	
		50
	280	
240	240	
		60
	220	
220		
180	180	
		80
150		
	150	
		100
120		
	120	
100		
		150
	100	
		180
80		
	80	
	60	
60		
	50	
50		
	40	
40		
	36	
36		
	30	
30		
24		
	24	
20		
	20	
16		

The three systems grade particle size to different tolerances but by the same methods. From the coarsest grits up to about 220, particles are graded through a series of wire mesh screens. The smaller grit sizes are graded through an air- or water-flotation process that separates particles by weight.

CAMI-graded abrasives tolerate the widest range of particle sizes but are perfectly good for sanding wood.



P-graded abrasives are to tighter tolerances than the CAMI grades.



Micron-graded abrasives are most uniform in size and best for sanding finishes.

and orbital sanders can't take advantage of the wood's grain properties. When I use my orbital, I just sand with the grain.

Choosing from the four abrasive minerals

Four common abrasive minerals are aluminum oxide, silicon carbide, ceramics and garnet. Except for garnet, they are all manufactured, designed if you will, for different cutting properties. Harder and sharper minerals cut deeper scratches and, consequently, sand the wood faster. But these deep scratches leave a coarse finish, whether you sand with or across the grain.

Softer minerals within the same grit size will cut far more slowly but leave a smoother finish. For example, if you sand a board on one side with a 120-grit ceramic, the hardest abrasive mineral, and the other side with 120-grit garnet, the softest, you will be able to feel a distinct difference between the surfaces. It will seem as if you sanded the two sides with different grit sizes.

It's easy to rate each mineral's hardness and sharpness, but it's not as simple to prescribe specific uses beyond generalizations. There are many other factors that influence the appropriateness of a sandpaper for a job (see the boxes on pp. 64-65).

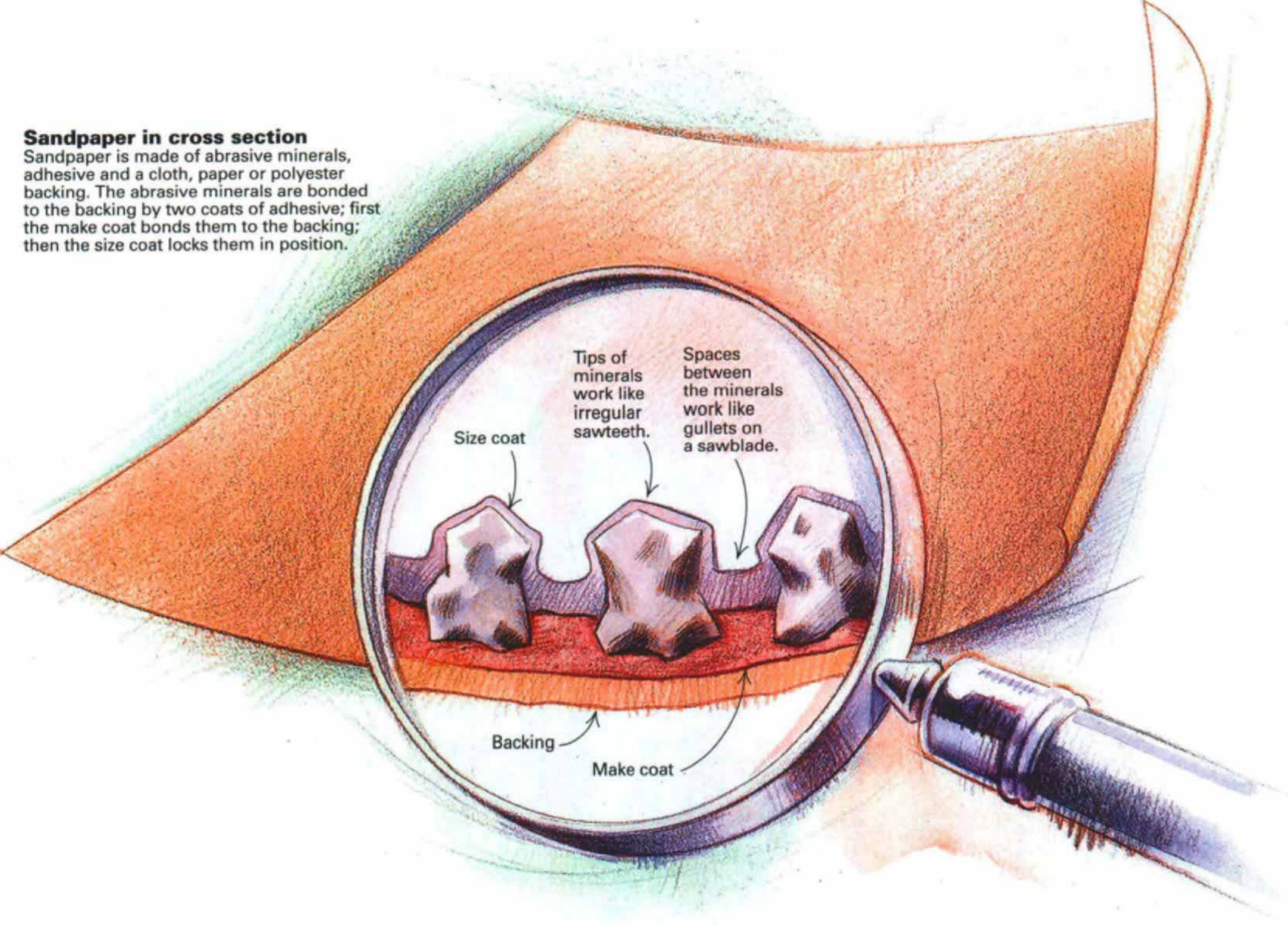
Some fine points about grading scales

If you don't mind that we have two measurement systems, the U.S. Customary (foot, gallon) and the International (meter, liter), then you won't mind that we have three major abrasive grit-grading systems. In North America, the Coated Abrasives Manufacturers Institute (CAMI) regulates the U.S. Standard Scale. CAMI-graded sandpapers simply have numbers, such as 320, printed on them. The Europeans have the P-scale, regulated by the Federation of European Producers Association (FEPA). These abrasives are identifiable by the letter P in front of the grit size, such as P320. Finally, to make sure everyone is really confused, there is a totally different micron grading system. This system is identified by the Greek letter mu, as in 30μ.

The chart at left is helpful in comparing grits of the three grading systems, but it doesn't tell the whole story. Abrasives on the P-scale are graded to tighter tolerances than CAMI-graded abrasives. This means that the CAMI-scale tolerates a wider range of grain sizes within the definition of 180-grit than the P-scale. Tolerances are even tighter for micron grading. P-graded and micron-graded abrasives give more consistent cuts with fewer stray scratches from outsized minerals.

Micron-graded abrasives on polyester films are about three times as expensive as paper products and probably not worth it for sanding wood. I have a hard time telling the difference between wood sanded with a 100μ finishing film abrasive and standard 120-grit sandpaper. But for polishing a high-gloss finish, I find micron-graded abrasives make a substantial difference.

Discs don't flex, they break. *The adhesive and backing on a random-orbit sanding pad can crack if the disc is folded like ordinary sandpaper.*



The supporting role of backings and bonds

The backing's stiffness and flatness influence the quality and speed of the sandpaper's cut. For the most part, manufacturers choose adhesives and backings to augment the characteristics of a particular abrasive grit. You will have a hard time finding an aggressive abrasive mineral, for example, on a backing suited to a smooth cut.

The stiffer the paper, the less the abrasive minerals will deflect while cutting. They will cut deeper and, consequently, faster. Soft backings and bonds will allow the abrasives to deflect more, giving light scratches and a smooth finish. You must even consider what's behind the backing. Wrapping the sandpaper around a block of wood will allow a faster cut than sanding with the paper against the palm of your hand. For instance, an easy way to speed up your orbital sander is by exchanging the soft pad for a stiff one (see the photo at left). The other consideration is the flatness of the backing, which has nothing to do with its stiffness. Flat backings position the minerals on a more even level so they cut at a more consistent depth, resulting in fewer stray scratches and a smoother surface.

Soft pads let the sandpaper deflect. *Soft backings on sanding tools won't support the sandpaper and make it cut more slowly.*

Cloth is the stiffest but least-fiat backing. It will produce the coarsest and fastest cut. Cloth comes in two grades, a heavy X and a light J. Paper is not as stiff as cloth but it's flatter. It comes in grades A, C, D, E and F (lightest to heaviest). A-weight paper that has been waterproofed is approximately equivalent to a B-weight paper, if one existed. Polyester films, including Mylar, look and feel like plastic. They are extremely flat and pretty stiff. They will give the most consistently even cut and at a faster rate than paper.

The backings for hand sheets and belts are designed to flex around curves without breaking. This is not true for sanding discs for random-orbit sanders. They are designed to remain perfectly flat, and if used like a hand sheet, the adhesive will crack off in large sections (see the bottom photo on the facing page). This is called knife-edging because the mineral and adhesive, separated from the backing, form knife-like edges that dig into and mark the work.

Adhesive bonds on modem sandpaper are almost exclusively urea- or phenolic-formaldehyde resins. Both are heat-resistant, waterproof and stiff. Hide glue is sometimes used in conjunction with a resin on paper sheets. It is not waterproof or heat-resistant, but hide glue is cheap and very flexible.

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Drawing: Tim Langenderfer