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CUTTING TOOLS

Tool Contour.—Tools for turning, planing, etc., are made in straight, bent, offset, and other forms to place the cutting edges in convenient positions for operating on differently located surfaces. The contour or shape of the cutting edge may also be varied to suit different classes of work. Tool shapes, however, are not only related to the kind of operation, but, in roughing tools particularly, the contour may have a decided effect upon the cutting efficiency of the tool. To illustrate, an increase in the side cutting-edge angle of a roughing tool, or in the nose radius, tends to permit higher cutting speeds because the chip will be thinner for a given feed rate. Such changes, however, may result in chattering or vibrations unless the work and the machine are rigid; hence, the most desirable contour may be a compromise between the ideal form and one that is needed to meet practical requirements.

Terms and Definitions.—The terms and definitions relating to single-point tools vary somewhat in different plants, but the following are in general use.

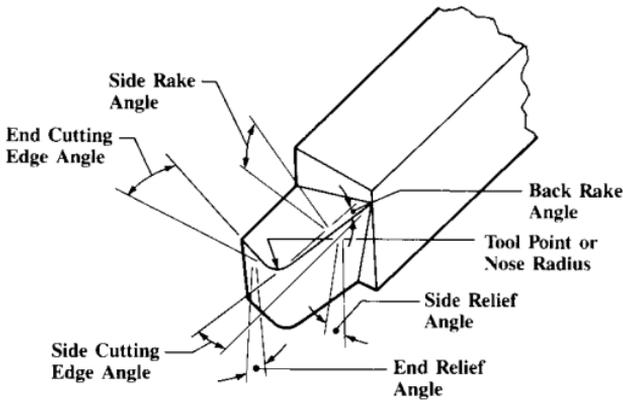


Fig. 1. Terms Applied to Single-point Turning Tools

Single-point Tool: This term is applied to tools for turning, planing, boring, etc., which have a cutting edge at one end. This cutting edge may be formed on one end of a solid piece of steel, or the cutting part of the tool may consist of an insert or tip which is held to the body of the tool by brazing, welding, or mechanical means.

Shank: The shank is the main body of the tool. If the tool is an inserted cutter type, the shank supports the cutter or bit. (See diagram, Fig. 1.)

Nose: A general term sometimes used to designate the cutting end but usually relating more particularly to the rounded tip of the cutting end.

Face: The surface against which the chips bear, as they are severed in turning or planing operations, is called the face.

Flank: The flank is that end surface adjacent to the cutting edge and below it when the tool is in a horizontal position as for turning.

Base: The base is the surface of the tool shank that bears against the supporting tool-holder or block.

Side Cutting Edge: The side cutting edge is the cutting edge on the side of the tool. Tools such as shown in Fig. 1 do the bulk of the cutting with this cutting edge and are, therefore, sometimes called side cutting edge tools.

End Cutting Edge: The end cutting edge is the cutting edge at the end of the tool.

On side cutting edge tools, the end cutting edge can be used for light plunging and facing cuts. Cutoff tools and similar tools have only one cutting edge located on the end. These

tools and other tools that are intended to cut primarily with the end cutting edge are sometimes called end cutting edge tools.

Rake: A metal-cutting tool is said to have rake when the tool face or surface against which the chips bear as they are being severed, is inclined for the purpose of either increasing or diminishing the keenness or bluntness of the edge. The magnitude of the rake is most conveniently measured by two angles called the back rake angle and the side rake angle. The tool shown in Fig. 1 has rake. If the face of the tool did not incline but was parallel to the base, there would be no rake; the rake angles would be zero.

Positive Rake: If the inclination of the tool face is such as to make the cutting edge keener or more acute than when the rake angle is zero, the rake angle is defined as positive.

Negative Rake: If the inclination of the tool face makes the cutting edge less keen or more blunt than when the rake angle is zero, the rake is defined as negative.

Back Rake: The back rake is the inclination of the face toward or away from the end or the end cutting edge of the tool. When the inclination is away from the end cutting edge, as shown in Fig. 1, the back rake is positive. If the inclination is downward toward the end cutting edge the back rake is negative.

Side Rake: The side rake is the inclination of the face toward or away from the side cutting edge. When the inclination is away from the side cutting edge, as shown in Fig. 1, the side rake is positive. If the inclination is toward the side cutting edge the side rake is negative.

Relief: The flanks below the side cutting edge and the end cutting edge must be relieved to allow these cutting edges to penetrate into the workpiece when taking a cut. If the flanks are not provided with relief, the cutting edges will rub against the workpiece and be unable to penetrate in order to form the chip. Relief is also provided below the nose of the tool to allow it to penetrate into the workpiece. The relief at the nose is usually a blend of the side relief and the end relief.

End Relief Angle: The end relief angle is a measure of the relief below the end cutting edge.

Side Relief Angle: The side relief angle is a measure of the relief below the side cutting edge.

Back Rake Angle: The back rake angle is a measure of the back rake. It is measured in a plane that passes through the side cutting edge and is perpendicular to the base. Thus, the back rake angle can be defined by measuring the inclination of the side cutting edge with respect to a line or plane that is parallel to the base. The back rake angle may be positive, negative, or zero depending upon the magnitude and direction of the back rake.

Side Rake Angle: The side rake angle is a measure of the side rake. This angle is always measured in a plane that is perpendicular to the side cutting edge and perpendicular to the base. Thus, the side rake angle is the angle of inclination of the face perpendicular to the side cutting edge with reference to a line or a plane that is parallel to the base.

End Cutting Edge Angle: The end cutting edge angle is the angle made by the end cutting edge with respect to a plane perpendicular to the axis of the tool shank. It is provided to allow the end cutting edge to clear the finish machined surface on the workpiece.

Side Cutting Edge Angle: The side cutting edge angle is the angle made by the side cutting edge and a plane that is parallel to the side of the shank.

Nose Radius: The nose radius is the radius of the nose of the tool. The performance of the tool, in part, is influenced by nose radius so that it must be carefully controlled.

Lead Angle: The lead angle, shown in Fig. 2, is not ground on the tool. It is a tool setting angle which has a great influence on the performance of the tool. The lead angle is bounded by the side cutting edge and a plane perpendicular to the workpiece surface when the tool is in position to cut; or, more exactly, the lead angle is the angle between the side cutting edge and a plane perpendicular to the direction of the feed travel.

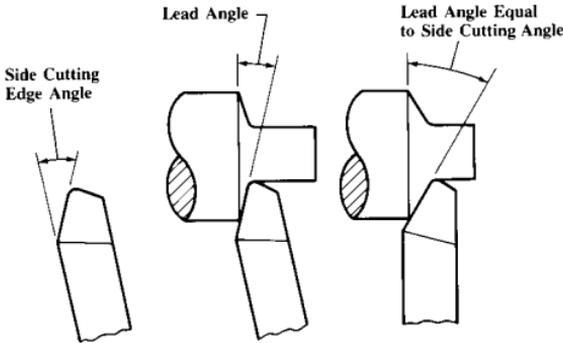


Fig. 2. Lead Angle on Single-point Turning Tool

Solid Tool: A solid tool is a cutting tool made from one piece of tool material.

Brazed Tool: A brazed tool is a cutting tool having a blank of cutting-tool material permanently brazed to a steel shank.

Blank: A blank is an unground piece of cutting-tool material from which a brazed tool is made.

Tool Bit: A tool bit is a relatively small cutting tool that is clamped in a holder in such a way that it can readily be removed and replaced. It is intended primarily to be reground when dull and not indexed.

Tool-bit Blank: The tool-bit blank is an unground piece of cutting-tool material from which a tool bit can be made by grinding. It is available in standard sizes and shapes.

Tool-bit Holder: Usually made from forged steel, the tool-bit holder is used to hold the tool bit, to act as an extended shank for the tool bit, and to provide a means for clamping in the tool post.

Straight-shank Tool-bit Holder: A straight-shank tool-bit holder has a straight shank when viewed from the top. The axis of the tool bit is held parallel to the axis of the shank.

Offset-shank Tool-bit Holder: An offset-shank tool-bit holder has the shank bent to the right or left, as seen in Fig. 3. The axis of the tool bit is held at an angle with respect to the axis of the shank.

Side cutting Tool: A side cutting tool has its major cutting edge on the side of the cutting part of the tool. The major cutting edge may be parallel or at an angle with respect to the axis of the tool.

Indexable Inserts: An indexable insert is a relatively small piece of cutting-tool material that is geometrically shaped to have two or several cutting edges that are used until dull. The insert is then indexed on the holder to apply a sharp cutting edge. When all the cutting edges have been dulled, the insert is discarded. The insert is held in a pocket or against other locating surfaces on an indexable insert holder by means of a mechanical clamping device that can be tightened or loosened easily.

Indexable Insert Holder: Made of steel, an indexable insert holder is used to hold indexable inserts. It is equipped with a mechanical clamping device that holds the inserts firmly in a pocket or against other seating surfaces.

Straight-shank Indexable Insert Holder: A straight-shank indexable insert tool-holder is essentially straight when viewed from the top, although the cutting edge of the insert may be oriented parallel, or at an angle to, the axis of the holder.

Offset-shank Indexable Insert Holder: An offset-shank indexable insert holder has the head end, or the end containing the insert pocket, offset to the right or left, as shown in Fig. 3.

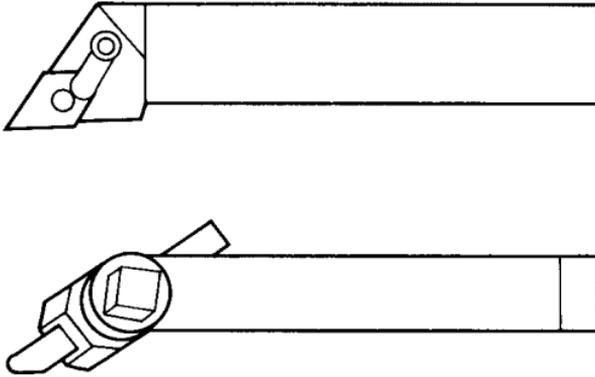


Fig. 3. Top: Right-hand Offset-shank, Indexable Insert Holder
Bottom: Right-hand Offset-shank Tool-bit Holder

End cutting Tool: An end cutting tool has its major cutting edge on the end of the cutting part of the tool. The major cutting edge may be perpendicular or at an angle, with respect to the axis of the tool.

Curved Cutting-edge Tool: A curved cutting-edge tool has a continuously variable side cutting edge angle. The cutting edge is usually in the form of a smooth, continuous curve along its entire length, or along a large portion of its length.

Right-hand Tool: A right-hand tool has the major, or working, cutting edge on the right-hand side when viewed from the cutting end with the face up. As used in a lathe, such a tool is usually fed into the work from right to left, when viewed from the shank end.

Left-hand Tool: A left-hand tool has the major or working cutting edge on the left-hand side when viewed from the cutting end with the face up. As used in a lathe, the tool is usually fed into the work from left to right, when viewed from the shank end.

Neutral-hand Tool: A neutral-hand tool is a tool to cut either left to right or right to left; or the cut may be parallel to the axis of the shank as when plunge cutting.

Chipbreaker: A groove formed in or on a shoulder on the face of a turning tool back of the cutting edge to break up the chips and prevent the formation of long, continuous chips which would be dangerous to the operator and also bulky and cumbersome to handle. A chipbreaker of the shoulder type may be formed directly on the tool face or it may consist of a separate piece that is held either by brazing or by clamping.

Relief Angles.—The end relief angle and the side relief angle on single-point cutting tools are usually, though not invariably, made equal to each other. The relief angle under the nose of the tool is a blend of the side and end relief angles.

The size of the relief angles has a pronounced effect on the performance of the cutting tool. If the relief angles are too large, the cutting edge will be weakened and in danger of breaking when a heavy cutting load is placed on it by a hard and tough material. On finish cuts, rapid wear of the cutting edge may cause problems with size control on the part. Relief angles that are too small will cause the rate of wear on the flank of the tool below the cutting edge to increase, thereby significantly reducing the tool life. In general, when cutting hard and tough materials, the relief angles should be 6 to 8 degrees for high-speed steel tools and 5 to 7 degrees for carbide tools. For medium steels, mild steels, cast iron, and other average work the recommended values of the relief angles are 8 to 12 degrees for high-speed steel tools and 5 to 10 degrees for carbides. Ductile materials having a relatively low modulus of elasticity should be cut using larger relief angles. For example, the relief angles recommended for turning copper, brass, bronze, aluminum, ferritic malleable

iron, and similar metals are 12 to 16 degrees for high-speed steel tools and 8 to 14 degrees for carbides.

Larger relief angles generally tend to produce a better finish on the finish machined surface because less surface of the worn flank of the tool rubs against the workpiece. For this reason, single-point thread-cutting tools should be provided with relief angles that are as large as circumstances will permit. Problems encountered when machining stainless steel may be overcome by increasing the size of the relief angle. The relief angles used should never be smaller than necessary.

Rake Angles.—Machinability tests have confirmed that when the rake angle along which the chip slides, called the true rake angle, is made larger in the positive direction, the cutting force and the cutting temperature will decrease. Also, the tool life for a given cutting speed will increase with increases in the true rake angle up to an optimum value, after which it will decrease again. For turning tools which cut primarily with the side cutting edge, the true rake angle corresponds rather closely with the side rake angle except when taking shallow cuts. Increasing the side rake angle in the positive direction lowers the cutting force and the cutting temperature, while at the same time it results in a longer tool life or a higher permissible cutting speed up to an optimum value of the side rake angle. After the optimum value is exceeded, the cutting force and the cutting temperature will continue to drop; however, the tool life and the permissible cutting speed will decrease.

As an approximation, the magnitude of the cutting force will decrease about one per cent per degree increase in the side rake angle. While not exact, this rule of thumb does correspond approximately to test results and can be used to make rough estimates. Of course, the cutting force also increases about one per cent per degree decrease in the side rake angle. The limiting value of the side rake angle for optimum tool life or cutting speed depends upon the work material and the cutting tool material. In general, lower values can be used for hard and tough work materials. Cemented carbides are harder and more brittle than high-speed steel; therefore, the rake angles usually used for cemented carbides are less positive than for high-speed steel.

Negative rake angles cause the face of the tool to slope in the opposite direction from positive rake angles and, as might be expected, they have an opposite effect. For side cutting edge tools, increasing the side rake angle in a negative direction will result in an increase in the cutting force and an increase in the cutting temperature of approximately one per cent per degree change in rake angle. For example, if the side rake angle is changed from 5 degrees positive to 5 degrees negative, the cutting force will be about 10 per cent larger. Usually the tool life will also decrease when negative side rake angles are used, although the tool life will sometimes increase when the negative rake angle is not too large and when a fast cutting speed is used.

Negative side rake angles are usually used in combination with negative back rake angles on single-point cutting tools. The negative rake angles strengthen the cutting edges enabling them to sustain heavier cutting loads and shock loads. They are recommended for turning very hard materials and for heavy interrupted cuts. There is also an economic advantage in favor of using negative rake indexable inserts and tool holders inasmuch as the cutting edges provided on both the top and bottom of the insert can be used.

On turning tools that cut primarily with the side cutting edge, the effect of the back rake angle alone is much less than the effect of the side rake angle although the direction of the change in cutting force, cutting temperature, and tool life is the same. The effect that the back rake angle has can be ignored unless, of course, extremely large changes in this angle are made. A positive back rake angle does improve the performance of the nose of the tool somewhat and is helpful in taking light finishing cuts. A negative back rake angle strengthens the nose of the tool and is helpful when interrupted cuts are taken. The back rake angle has a very significant effect on the performance of end cutting edge tools, such as cut-off tools. For these tools, the effect of the back rake angle is very similar to the effect of the side rake angle on side cutting edge tools.

Side Cutting Edge and Lead Angles.—These angles are considered together because the side cutting edge angle is usually designed to provide the desired lead angle when the tool is being used. The side cutting edge angle and the lead angle will be equal when the shank of the cutting tool is positioned perpendicular to the workpiece, or, more correctly, perpendicular to the direction of the feed. When the shank is not perpendicular, the lead angle is determined by the side cutting edge and an imaginary line perpendicular to the feed direction.

The flow of the chips over the face of the tool is approximately perpendicular to the side cutting edge except when shallow cuts are taken. The thickness of the undeformed chip is measured perpendicular to the side cutting edge. As the lead angle is increased, the length of chip in contact with the side cutting edge is increased, and the chip will become longer and thinner. This effect is the same as increasing the depth of cut and decreasing the feed, although the actual depth of cut and feed remain the same and the same amount of metal is removed. The effect of lengthening and thinning the chip by increasing the lead angle is very beneficial as it increases the tool life for a given cutting speed or that speed can be increased. Increasing the cutting speed while the feed and the tool life remain the same leads to faster production.

However, an adverse effect must be considered. Chatter can be caused by a cutting edge that is oriented at a high lead angle when turning and sometimes, when turning long and slender shafts, even a small lead angle can cause chatter. In fact, an unsuitable lead angle of the side cutting edge is one of the principal causes of chatter. When chatter occurs, often simply reducing the lead angle will cure it. Sometimes, very long and slender shafts can be turned successfully with a tool having a zero degree lead angle (and having a small nose radius). Boring bars, being usually somewhat long and slender, are also susceptible to chatter if a large lead angle is used. The lead angle for boring bars should be kept small, and for very long and slender boring bars a zero degree lead angle is recommended. It is impossible to provide a rule that will determine when chatter caused by a lead angle will occur and when it will not. In making a judgment, the first consideration is the length to diameter ratio of the part to be turned, or of the boring bar. Then the method of holding the workpiece must be considered — a part that is firmly held is less apt to chatter. Finally, the overall condition and rigidity of the machine must be considered because they may be the real cause of chatter.

Although chatter can be a problem, the advantages gained from high lead angles are such that the lead angle should be as large as possible at all times.

End Cutting Edge Angle.—The size of the end cutting edge angle is important when tool wear by cratering occurs. Frequently, the crater will enlarge until it breaks through the end cutting edge just behind the nose, and tool failure follows shortly. Reducing the size of the end cutting edge angle tends to delay the time of crater breakthrough. When cratering takes place, the recommended end cutting edge angle is 8 to 15 degrees. If there is no cratering, the angle can be made larger. Larger end cutting edge angles may be required to enable profile turning tools to plunge into the work without interference from the end cutting edge.

Nose Radius.—The tool nose is a very critical part of the cutting edge since it cuts the finished surface on the workpiece. If the nose is made to a sharp point, the finish machined surface will usually be unacceptable and the life of the tool will be short. Thus, a nose radius is required to obtain an acceptable surface finish and tool life. The surface finish obtained is determined by the feed rate and by the nose radius if other factors such as the work material, the cutting speed, and cutting fluids are not considered. A large nose radius will give a better surface finish and will permit a faster feed rate to be used.

Machinability tests have demonstrated that increasing the nose radius will also improve the tool life or allow a faster cutting speed to be used. For example, high-speed steel tools were used to turn an alloy steel in one series of tests where complete or catastrophic tool failure was used as a criterion for the end of tool life. The cutting speed for a 60-minute tool

life was found to be 125 fpm when the nose radius was $\frac{1}{16}$ inch and 160 fpm when the nose radius was $\frac{1}{4}$ inch.

A very large nose radius can often be used but a limit is sometimes imposed because the tendency for chatter to occur is increased as the nose radius is made larger. A nose radius that is too large can cause chatter and when it does, a smaller nose radius must be used on the tool. It is always good practice to make the nose radius as large as is compatible with the operation being performed.

Chipbreakers.—Many steel turning tools are equipped with chipbreaking devices to prevent the formation of long continuous chips in connection with the turning of steel at the high speeds made possible by high-speed steel and especially cemented carbide tools. Long steel chips are dangerous to the operator, and cumbersome to handle, and they may twist around the tool and cause damage. Broken chips not only occupy less space, but permit a better flow of coolant to the cutting edge. Several different forms of chipbreakers are illustrated in Fig. 4.

Angular Shoulder Type: The angular shoulder type shown at A is one of the commonly used forms. As the enlarged sectional view shows, the chipbreaking shoulder is located back of the cutting edge. The angle a between the shoulder and cutting edge may vary from 6 to 15 degrees or more, 8 degrees being a fair average. The ideal angle, width W and depth G , depend upon the speed and feed, the depth of cut, and the material. As a general rule, width W , at the end of the tool, varies from $\frac{3}{32}$ to $\frac{7}{32}$ inch, and the depth G may range from $\frac{1}{64}$ to $\frac{1}{16}$ inch. The shoulder radius equals depth G . If the tool has a large nose radius, the corner of the shoulder at the nose end may be beveled off, as illustrated at B, to prevent it from coming into contact with the work. The width K for type B should equal approximately 1.5 times the nose radius.

Parallel Shoulder Type: Diagram C shows a design with a chipbreaking shoulder that is parallel to the cutting edge. With this form, the chips are likely to come off in short curled sections. The parallel form may also be applied to straight tools which do not have a side cutting-edge angle. The tendency with this parallel shoulder form is to force the chips against the work and damage it.

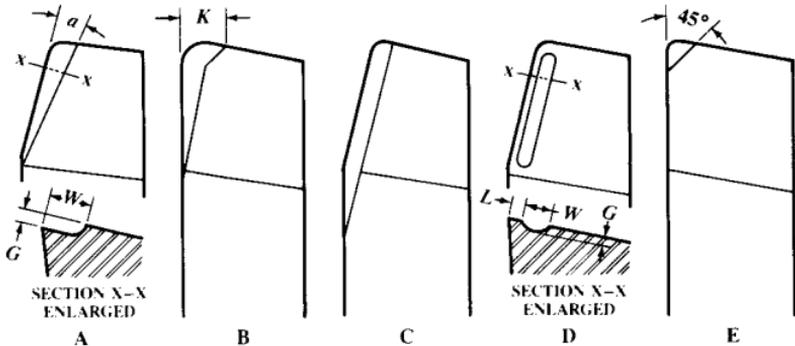


Fig. 4. Different Forms of Chipbreakers for Turning Tools

Groove Type: This type (diagram D) has a groove in the face of the tool produced by grinding. Between the groove and the cutting edge, there is a land L . Under ideal conditions, this width L , the groove width W , and the groove depth G , would be varied to suit the feed, depth of cut and material. For average use, L is about $\frac{1}{32}$ inch; G , $\frac{1}{32}$ inch; and W , $\frac{1}{16}$ inch. There are differences of opinion concerning the relative merits of the groove type and

the shoulder type. Both types have proved satisfactory when properly proportioned for a given class of work.

Chipbreaker for Light Cuts: Diagram E illustrates a form of chipbreaker that is sometimes used on tools for finishing cuts having a maximum depth of about $\frac{1}{32}$ inch. This chipbreaker is a shoulder type having an angle of 45 degrees and a maximum width of about $\frac{1}{16}$ inch. It is important in grinding all chipbreakers to give the chip-bearing surfaces a fine finish, such as would be obtained by honing. This finish greatly increases the life of the tool.

Planing Tools.—Many of the principles which govern the shape of turning tools also apply in the grinding of tools for planing. The amount of rake depends upon the hardness of the material, and the direction of the rake should be away from the *working part* of the cutting edge. The angle of clearance should be about 4 or 5 degrees for planer tools, which is less than for lathe tools. This small clearance is allowable because a planer tool is held about square with the platen, whereas a lathe tool, the height and inclination of which can be varied, may not always be clamped in the same position.

Carbide Tools: Carbide tools for planing usually have negative rake. Round-nose and square-nose end-cutting tools should have a “negative back rake” (or front rake) of 2 or 3 degrees. Side cutting tools may have a negative back rake of 10 degrees, a negative side rake of 5 degrees, and a side cutting-edge angle of 8 degrees.

Indexable Inserts.—A large proportion of the cemented carbide, single-point cutting tools are indexable inserts and indexable insert tool holders. Dimensional specifications for solid sintered carbide indexable inserts are given in American National Standard ANSI B212.12-1991. Samples of the many insert shapes are shown in Table 3. Most modern, cemented carbide, face milling cutters are of the indexable insert type. Larger size end milling cutters, side milling or slotting cutters, boring tools, and a wide variety of special tools are made to use indexable inserts. These inserts are primarily made from cemented carbide, although most of the cemented oxide cutting tools are also indexable inserts.

The objective of this type of tooling is to provide an insert with several cutting edges. When an edge is worn, the insert is indexed in the tool holder until all the cutting edges are used up, after which it is discarded. The insert is not intended to be reground. The advantages are that the cutting edges on the tool can be rapidly changed without removing the tool holder from the machine, tool-grinding costs are eliminated, and the cost of the insert is less than the cost of a similar, brazed carbide tool. Of course, the cost of the tool holder must be added to the cost of the insert; however, one tool holder will usually last for a long time before it, too, must be replaced.

Indexable inserts and tool holders are made with a negative rake or with a positive rake. Negative rake inserts have the advantage of having twice as many cutting edges available as comparable positive rake inserts, because the cutting edges on both the top and bottom of negative rake inserts can be used, while only the top cutting edges can be used on positive rake inserts. Positive rake inserts have a distinct advantage when machining long and slender parts, thin-walled parts, or other parts that are subject to bending or chatter when the cutting load is applied to them, because the cutting force is significantly lower as compared to that for negative rake inserts. Indexable inserts can be obtained in the following forms: utility ground, or ground on top and bottom only; precision ground, or ground on all surfaces; preformed to produce a slight rounding of the cutting edge; and precision molded, which are unground. Positive-negative rake inserts also are available. These inserts are held on a negative-rake tool holder and have a chipbreaker groove that is formed to produce an effective positive-rake angle while cutting. Cutting edges may be available on the top surface only, or on both top and bottom surfaces. The positive-rake chipbreaker surface may be ground or precision molded on the insert.

Many materials, such as gray cast iron, form a discontinuous chip. For these materials an insert that has plain faces without chipbreaker grooves should always be used. Steels and other ductile materials form a continuous chip that must be broken into small segments

when machined on lathes and planers having single-point, cemented-carbide and cemented-oxide cutting tools; otherwise, the chips can cause injury to the operator. In this case a chipbreaker must be used. Some inserts are made with chipbreaker grooves molded or ground directly on the insert. When inserts with plain faces are used, a cemented-carbide plate-type chipbreaker is clamped on top of the insert.

Identification System for Indexable Inserts.—The size of indexable inserts is determined by the diameter of an inscribed circle (I.C.), except for rectangular and parallelogram inserts where the length and width dimensions are used. To describe an insert in its entirety, a standard ANSI B21.2.4-1986 identification system is used where each position number designates a feature of the insert. The ANSI Standard includes items now commonly used and facilitates identification of items not in common use. Identification consists of up to ten positions; each position defines a characteristic of the insert as shown below:

1	2	3	4	5	6	7	8 ^a	9 ^a	10 ^a
T	N	M	G	5	4	3			A

^aEighth, Ninth, and Tenth Positions are used only when required.

1) *Shape*: The shape of an insert is designated by a letter: **R** for round; **S**, square; **T**, triangle; **A**, 85° parallelogram; **B**, 82° parallelogram; **C**, 80° diamond; **D**, 55° diamond; **E**, 75° diamond; **H**, hexagon; **K**, 55° parallelogram; **L**, rectangle; **M**, 86° diamond; **O**, octagon; **P**, pentagon; **V**, 35° diamond; and **W**, 80° trigon.

2) *Relief Angle (Clearances)*: The second position is a letter denoting the relief angles; **N** for 0°; **A**, 3°; **B**, 5°; **C**, 7°; **P**, 11°; **D**, 15°; **E**, 20°; **F**, 25°; **G**, 30°; **H**, 0° & 11°*; **J**, 0° & 14°*; **K**, 0° & 17°*; **L**, 0° & 20°*; **M**, 11° & 14°*; **R**, 11° & 17°*; **S**, 11° & 20°*. When mounted on a holder, the actual relief angle may be different from that on the insert.

3) *Tolerances*: The third position is a letter and indicates the tolerances which control the indexability of the insert. Tolerances specified do not imply the method of manufacture.

Symbol	Tolerance (± from nominal)		Symbol	Tolerance (± from nominal)	
	Inscribed Circle, Inch	Thickness, Inch		Inscribed Circle, Inch	Thickness, Inch
A	0.001	0.001	H	0.0005	0.001
B	0.001	0.005	J	0.002–0.005	0.001
C	0.001	0.001	K	0.002–0.005	0.001
D	0.001	0.005	L	0.002–0.005	0.001
E	0.001	0.001	M	0.002–0.004 ^a	0.005
F	0.0005	0.001	U	0.005–0.010 ^a	0.005
G	0.001	0.005	N	0.002–0.004 ^a	0.001

^aExact tolerance is determined by size of insert. See ANSI B94.25.

4) *Type*: The type of insert is designated by a letter. **A**, with hole; **B**, with hole and countersink; **C**, with hole and two countersinks; **F**, chip grooves both surfaces, no hole; **G**, same as **F** but with hole; **H**, with hole, one countersink, and chip groove on one rake surface; **J**, with hole, two countersinks and chip grooves on two rake surfaces; **M**, with hole and chip groove on one rake surface; **N**, without hole; **Q**, with hole and two countersinks; **R**, without hole but with chip groove on one rake surface; **T**, with hole, one countersink, and chip groove on one rake face; **U**, with hole, two countersinks, and chip grooves on two rake faces; and **W**, with hole and one countersink. *Note*: a dash may be used after position 4 to

* Second angle is secondary facet angle, which may vary by ± 1°.

separate the shape-describing portion from the following dimensional description of the insert and is not to be considered a position in the standard description.

5) *Size*: The size of the insert is designated by a one- or a two-digit number. For regular polygons and diamonds, it is the number of eighths of an inch in the nominal size of the inscribed circle, and will be a one- or two-digit number when the number of eighths is a whole number. It will be a two-digit number, including one decimal place, when it is not a whole number. Rectangular and parallelogram inserts require two digits: the first digit indicates the number of eighths of an inch width and the second digit, the number of quarters of an inch length.

6) *Thickness*: The thickness is designated by a one- or two-digit number, which indicates the number of sixteenths of an inch in the thickness of the insert. It is a one-digit number when the number of sixteenths is a whole number; it is a two-digit number carried to one decimal place when the number of sixteenths of an inch is not a whole number.

7) *Cutting Point Configuration*: The cutting point, or nose radius, is designated by a number representing $\frac{1}{64}$ ths of an inch; a flat at the cutting point or nose, is designated by a letter: **0** for sharp corner; **1**, $\frac{1}{64}$ inch radius; **2**, $\frac{1}{32}$ inch radius; **3**, $\frac{3}{64}$ inch radius; **4**, $\frac{1}{16}$ inch radius; **5**, $\frac{5}{64}$ inch radius; **6**, $\frac{3}{32}$ inch radius; **7**, $\frac{7}{64}$ inch radius; **8**, $\frac{1}{8}$ inch radius; **A**, square insert with 45° chamfer; **D**, square insert with 30° chamfer; **E**, square insert with 15° chamfer; **F**, square insert with 3° chamfer; **K**, square insert with 30° double chamfer; **L**, square insert with 15° double chamfer; **M**, square insert with 3° double chamfer; **N**, truncated triangle insert; and **P**, flatted corner triangle insert.

8) *Special Cutting Point Definition*: The eighth position, if it follows a letter in the 7th position, is a number indicating the number of $\frac{1}{64}$ ths of an inch measured parallel to the edge of the facet.

9) *Hand*: **R**, right; **L**, left; to be used when required in ninth position.

10) *Other Conditions*: The tenth position defines special conditions (such as edge treatment, surface finish) as follows: **A**, honed, 0.0005 inch to less than 0.003 inch; **B**, honed, 0.003 inch to less than 0.005 inch; **C**, honed, 0.005 inch to less than 0.007 inch; **J**, polished, 4 microinch arithmetic average (AA) on rake surfaces only; **T**, chamfered, manufacturer's standard negative land, rake face only.

Indexable Insert Tool Holders.—Indexable insert tool holders are made from a good grade of steel which is heat treated to a hardness of 44 to 48 Rc for most normal applications. Accurate pockets that serve to locate the insert in position and to provide surfaces against which the insert can be clamped are machined in the ends of tool holders. A cemented carbide seat usually is provided, and is held in the bottom of the pocket by a screw or by the clamping pin, if one is used. The seat is necessary to provide a flat bearing surface upon which the insert can rest and, in so doing, it adds materially to the ability of the insert to withstand the cutting load. The seating surface of the holder may provide a positive-, negative-, or a neutral-rake orientation to the insert when it is in position on the holder. Holders, therefore, are classified as positive, negative, or neutral rake.

Four basic methods are used to clamp the insert on the holder: 1) Clamping, usually top clamping; 2) Pin-lock clamping; 3) Multiple clamping using a clamp, usually a top clamp, and a pin lock; and 4) Clamping the insert with a machine screw.

All top clamps are actuated by a screw that forces the clamp directly against the insert. When required, a cemented-carbide, plate-type chipbreaker is placed between the clamp and the insert. Pin-lock clamps require an insert having a hole: the pin acts against the walls of the hole to clamp the insert firmly against the seating surfaces of the holder. Multiple or combination clamping, simultaneously using both a pin-lock and a top clamp, is recommended when taking heavier or interrupted cuts. Holders are available on which all the above-mentioned methods of clamping may be used. Other holders are made with only a top clamp or a pin lock. Screw-on type holders use a machine screw to hold the insert in the

pocket. Most standard indexable insert holders are either straight-shank or offset-shank, although special holders are made having a wide variety of configurations.

The common shank sizes of indexable insert tool holders are shown in Table 1. Not all styles are available in every shank size. Positive- and negative-rake tools are also not available in every style or shank size. Some manufacturers provide additional shank sizes for certain tool holder styles. For more complete details the manufacturers' catalogs must be consulted.

Table 1. Standard Shank Sizes for Indexable Insert Holders



Basic Shank Size	Shank Dimensions for Indexable Insert Holders					
	A		B		C ^a	
	In.	mm	In.	mm	In.	mm
$\frac{1}{2} \times \frac{1}{2} \times 4\frac{1}{2}$	0.500	12.70	0.500	12.70	4.500	114.30
$\frac{3}{8} \times \frac{3}{8} \times 4\frac{1}{2}$	0.625	15.87	0.625	15.87	4.500	114.30
$\frac{3}{8} \times 1\frac{1}{2} \times 6$	0.625	15.87	1.250	31.75	6.000	152.40
$\frac{3}{4} \times \frac{3}{4} \times 4\frac{1}{2}$	0.750	19.05	0.750	19.05	4.500	114.30
$\frac{3}{4} \times 1 \times 6$	0.750	19.05	1.000	25.40	6.000	152.40
$\frac{3}{4} \times 1\frac{1}{2} \times 6$	0.750	19.05	1.250	31.75	6.000	152.40
$1 \times 1 \times 6$	1.000	25.40	1.000	25.40	6.000	152.40
$1 \times 1\frac{1}{2} \times 6$	1.000	25.40	1.250	31.75	6.000	152.40
$1 \times 1\frac{1}{2} \times 6$	1.000	25.40	1.500	38.10	6.000	152.40
$1\frac{1}{4} \times 1\frac{1}{4} \times 7$	1.250	31.75	1.250	31.75	7.000	177.80
$1\frac{1}{4} \times 1\frac{1}{2} \times 8$	1.250	31.75	1.500	38.10	8.000	203.20
$1\frac{3}{8} \times 2\frac{1}{16} \times 6\frac{3}{8}$	1.375	34.92	2.062	52.37	6.380	162.05
$1\frac{1}{2} \times 1\frac{1}{2} \times 7$	1.500	38.10	1.500	38.10	7.000	177.80
$1\frac{3}{4} \times 1\frac{3}{4} \times 9\frac{1}{2}$	1.750	44.45	1.750	44.45	9.500	241.30
$2 \times 2 \times 8$	2.000	50.80	2.000	50.80	8.000	203.20

^a Holder length; may vary by manufacturer. Actual shank length depends on holder style.

Identification System for Indexable Insert Holders.—The following identification system conforms to the American National Standard, ANSI B212.5-1986, Metric Holders for Indexable Inserts.

Each position in the system designates a feature of the holder in the following sequence:

1 2 3 4 5 — 6 — 7 — 8^a — 9 — 10^a
C T N A R — 85 — 25 — D — 16 — Q

1) *Method of Holding Horizontally Mounted Insert:* The method of holding or clamping is designated by a letter: **C**, top clamping, insert without hole; **M**, top and hole clamping, insert with hole; **P**, hole clamping, insert with hole; **S**, screw clamping through hole, insert with hole; **W**, wedge clamping.

2) *Insert Shape:* The insert shape is identified by a letter: **H**, hexagonal; **O**, octagonal; **P**, pentagonal; **S**, square; **T**, triangular; **C**, rhombic, 80° included angle; **D**, rhombic, 55° included angle; **E**, rhombic, 75° included angle; **M**, rhombic, 86° included angle; **V**, rhombic, 35° included angle; **W**, hexagonal, 80° included angle; **L**, rectangular; **A**, parallelogram, 85° included angle; **B**, parallelogram, 82° included angle; **K**, parallelogram, 55° included angle; **R**, round. The included angle is always the smaller angle.

3) *Holder Style:* The holder style designates the shank style and the side cutting edge angle, or end cutting edge angle, or the purpose for which the holder is used. It is design-

nated by a letter: **A**, for straight shank with 0° side cutting edge angle; **B**, straight shank with 15° side cutting edge angle; **C**, straight-shank end cutting tool with 0° end cutting edge angle; **D**, straight shank with 45° side cutting edge angle; **E**, straight shank with 30° side cutting edge angle; **F**, offset shank with 0° end cutting edge angle; **G**, offset shank with 0° side cutting edge angle; **J**, offset shank with negative 3° side cutting edge angle; **K**, offset shank with 15° end cutting edge angle; **L**, offset shank with negative 5° side cutting edge angle and 5° end cutting edge angle; **M**, straight shank with 40° side cutting edge angle; **N**, straight shank with 27° side cutting edge angle; **R**, offset shank with 15° side cutting edge angle; **S**, offset shank with 45° side cutting edge angle; **T**, offset shank with 30° side cutting edge angle; **U**, offset shank with negative 3° end cutting edge angle; **V**, straight shank with $17\frac{1}{2}^\circ$ side cutting edge angle; **W**, offset shank with 30° end cutting edge angle; **Y**, offset shank with 5° end cutting edge angle.

4) *Normal Clearances*: The normal clearances of inserts are identified by letters: **A**, 3° ; **B**, 5° ; **C**, 7° ; **D**, 15° ; **E**, 20° ; **F**, 25° ; **G**, 30° ; **N**, 0° ; **P**, 11° .

5) *Hand of tool*: The hand of the tool is designated by a letter: **R** for right-hand; **L**, left-hand; and **N**, neutral, or either hand.

6) *Tool Height for Rectangular Shank Cross Sections*: The tool height for tool holders with a rectangular shank cross section and the height of cutting edge equal to shank height is given as a two-digit number representing this value in millimeters. For example, a height of 32 mm would be encoded as 32; 8 mm would be encoded as 08, where the one-digit value is preceded by a zero.

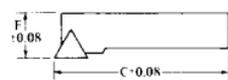
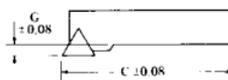
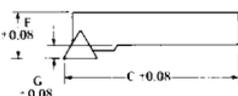
7) *Tool Width for Rectangular Shank Cross Sections*: The tool width for tool holders with a rectangular shank cross section is given as a two-digit number representing this value in millimeters. For example, a width of 25 mm would be encoded as 25; 8 mm would be encoded as 08, where the one-digit value is preceded by a zero.

8) *Tool Length*: The tool length is designated by a letter: **A**, 32 mm; **B**, 40 mm; **C**, 50 mm; **D**, 60 mm; **E**, 70 mm; **F**, 80 mm; **G**, 90 mm; **H**, 100 mm; **J**, 110 mm; **K**, 125 mm; **L**, 140 mm; **M**, 150 mm; **N**, 160 mm; **P**, 170 mm; **Q**, 180 mm; **R**, 200 mm; **S**, 250 mm; **T**, 300 mm; **U**, 350 mm; **V**, 400 mm; **W**, 450 mm; **X**, special length to be specified; **Y**, 500 mm.

9) *Indexable Insert Size*: The size of indexable inserts is encoded as follows: For insert shapes **C, D, E, H, M, O, P, R, S, T, V**, the side length (the diameter for **R** inserts) in millimeters is used as a two-digit number, with decimals being disregarded. For example, the symbol for a side length of 16.5 mm is 16. For insert shapes **A, B, K, L**, the length of the main cutting edge or of the longer cutting edge in millimeters is encoded as a two-digit number, disregarding decimals. If the symbol obtained has only one digit, then it should be preceded by a zero. For example, the symbol for a main cutting edge of 19.5 mm is 19; for an edge of 9.5 mm, the symbol is 09.

10) *Special Tolerances*: Special tolerances are indicated by a letter: **Q**, back and end qualified tool; **F**, front and end qualified tool; **B**, back, front, and end qualified tool. A qualified tool is one that has tolerances of ± 0.08 mm for dimensions *F*, *G*, and *C*. (See Table 2.)

Table 2. Letter Symbols for Qualification of Tool Holders — Position 10
ANSI B212.5-1986

		Letter Symbol		
		Q	F	B
Qualification of Tool Holder				
	Back and end qualified tool	Front and end qualified tool	Back, front, and end qualified tool	

Selecting Indexable Insert Holders.—A guide for selecting indexable insert holders is provided by Table 3b. Some operations such as deep grooving, cut-off, and threading are not given in this table. However, tool holders designed specifically for these operations are available. The boring operations listed in Table 3b refer primarily to larger holes, into which the holders will fit. Smaller holes are bored using boring bars. An examination of this table shows that several tool-holder styles can be used and frequently are used for each operation. Selection of the best holder for a given job depends largely on the job and there are certain basic facts that should be considered in making the selection.

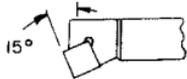
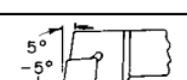
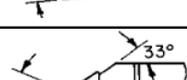
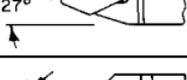
Rake Angle: A negative-rake insert has twice as many cutting edges available as a comparable positive-rake insert. Sometimes the tool life obtained when using the second face may be less than that obtained on the first face because the tool wear on the cutting edges of the first face may reduce the insert strength. Nevertheless, the advantage of negative-rake inserts and holders is such that they should be considered first in making any choice. Positive-rake holders should be used where lower cutting forces are required, as when machining slender or small-diameter parts, when chatter may occur, and for machining some materials, such as aluminum, copper, and certain grades of stainless steel, when positive-negative rake inserts can sometimes be used to advantage. These inserts are held on negative-rake holders that have their rake surfaces ground or molded to form a positive-rake angle.

Insert Shape: The configuration of the workpiece, the operation to be performed, and the lead angle required often determine the insert shape. When these factors need not be considered, the insert shape should be selected on the basis of insert strength and the maximum number of cutting edges available. Thus, a round insert is the strongest and has a maximum number of available cutting edges. It can be used with heavier feeds while producing a good surface finish. Round inserts are limited by their tendency to cause chatter, which may preclude their use. The square insert is the next most effective shape, providing good corner strength and more cutting edges than all other inserts except the round insert. The only limitation of this insert shape is that it must be used with a lead angle. Therefore, the square insert cannot be used for turning square shoulders or for back-facing. Triangle inserts are the most versatile and can be used to perform more operations than any other insert shape. The 80-degree diamond insert is designed primarily for heavy turning and facing operations, using the 100-degree corners, and for turning and back-facing square shoulders using the 80-degree corners. The 55- and 35-degree diamond inserts are intended primarily for tracing.

Lead Angle: Tool holders should be selected to provide the largest possible lead angle, although limitations are sometimes imposed by the nature of the job. For example, when turning and back-facing a shoulder, a negative lead angle must be used. Slender or small-diameter parts may deflect, causing difficulties in holding size, or chatter when the lead angle is too large.

End Cutting Edge Angle: When tracing or contour turning, the plunge angle is determined by the end cutting edge angle. A 2-deg minimum clearance angle should be provided between the workpiece surface and the end cutting edge of the insert. Table 3a provides the maximum plunge angle for holders commonly used to plunge when tracing where insert shape identifiers are *S* = square; *T* = triangle; *D* = 55-deg diamond, *V* = 35-deg diamond. When severe cratering cannot be avoided, an insert having a small, end cutting edge angle is desirable to delay the crater breakthrough behind the nose. For very heavy cuts a small, end cutting edge angle will strengthen the corner of the tool. Tool holders for numerical control machines are discussed in the NC section, beginning page 1280.

Table 3b. (Continued) Indexable Insert Holder Application Guide

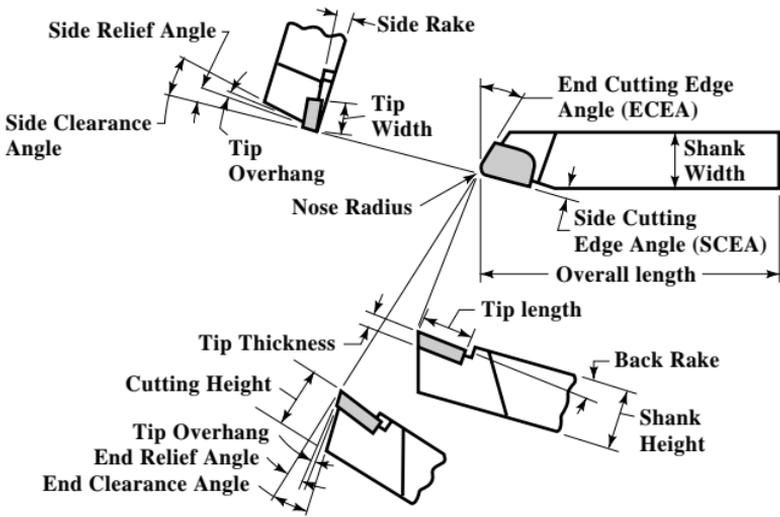
Tool	Tool Holder Style	Insert Shape	N-Negative P-Positive	Application									
				Turn	Face	Turn and Face	Turn and Backface	Trace	Groove	Chamfer	Bore	Plane	
	K	S	N	●	●							●	
			P	●	●							●	
	K	C	N	●	●							●	
			P										
	L	C	N			●	●						
			P										
	N	T	N	●	●			●					
			P	●	●			●					
	N	D	N	●	●			●					
			P										
	S	S	N	●	●	●		●		●	●	●	
			P	●	●	●		●		●	●	●	
	W	S	N	●	●								
			P										

Sintered Carbide Blanks and Cutting Tools.—As shown in Table 4, American National Standard ANSI B212.1-1984 (R1997) provides standard sizes and designations for eight styles of sintered carbide blanks. These blanks are the unground solid carbide from which either solid or tipped cutting tools are made. Tipped cutting tools are made by brazing a blank onto a shank to produce the cutting tool; these tools differ from carbide *insert* cutting tools which consist of a carbide insert held mechanically in a tool holder. A typical single-point carbide-tipped cutting tool is shown in the diagram on page 740.

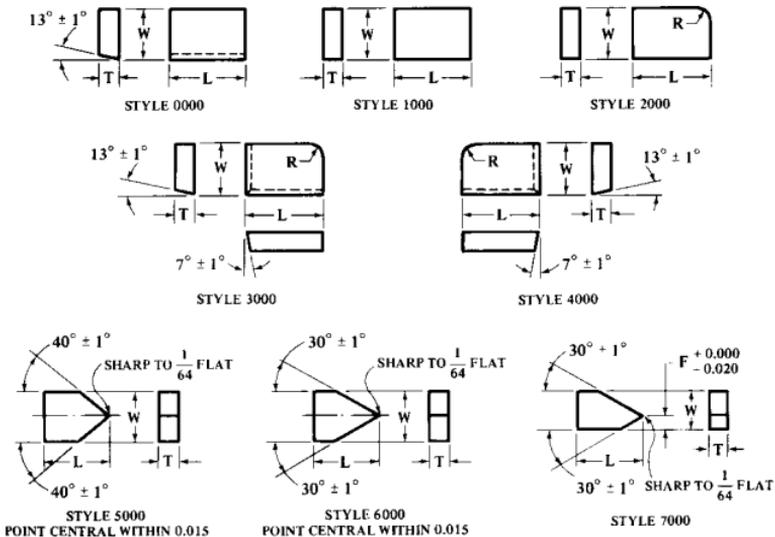
Table 4. American National Standard Sizes and Designations for Carbide Blanks
ANSI B212.1-1984 (R1997)

T	W	L	Style		T	W	L	Style			
			1000	2000				0000	1000	3000	4000
			Blank Designation					Blank Designation			
1/16	1/8	3/8	1010	2010	1/4	3/8	9/16	0350	1350	3350	4350
1/16	5/32	1/4	1015	2015	1/4	3/8	3/4	0360	1360	3360	4360
1/16	3/16	1/4	1020	2020	1/4	7/16	5/8	0370	1370	3370	4370
1/16	1/4	1/4	1025	2025	1/4	1/2	3/4	0380	1380	3380	4380
1/16	1/4	5/16	1030	2030	1/4	5/16	1	0390	1390	3390	4390
3/32	1/8	3/4	1035	2035	1/4	5/8	5/8	0400	1400	3400	4400
3/32	3/16	5/16	1040	2040	1/4	3/4	3/4	0405	1405	3405	4405
3/32	3/16	1/2	1050	2050	1/4	1	1	0410	1410	3410	4410
3/32	1/2	3/8	1060	2060							
3/32	1/4	1/2	1070	2070	5/16	7/16	5/8	0420	1420	3420	4420
					5/16	7/16	15/16	0430	1430	3430	4430
					5/16	1/2	3/4	0440	1440	3440	4440
3/32	5/16	3/8	1080	2080	5/16	1/2	1	0450	1450	3450	4450
3/32	3/8	3/8	1090	2090	5/16	5/8	1	0460	1460	3460	4460
3/32	3/8	1/2	1100	2100	5/16	3/4	3/4	0470	1470	3470	4470
3/32	7/16	1/2	1105	2105	5/16	3/4	1	0475	1475	3475	4475
					5/16	3/4	1 1/4	0480	1480	3480	4480
1/8	3/16	3/4	1110	2110							
1/8	1/4	1/2	1120	2120	3/8	1/2	3/4	0490	1490	3490	4490
1/8	1/4	3/4	1130	2130	3/8	1/2	1	0500	1500	3500	4500
1/8	1/4	3/4	1140	2140	3/8	5/8	1	0510	1510	3510	4510
1/8	5/16	7/16	1150	2150	3/8	5/8	1 1/4	0515	1515	3515	4515
1/8	5/16	1/2	1160	2160	3/8	3/4	1 1/4	0520	1520	3520	4520
					3/8	3/4	1 1/2	0525	1525	3525	4525
1/8	5/16	5/8	1170	2170	1/2	3/4	1	0530	1530	3530	4530
1/8	3/8	1/2	1180	2180	1/2	3/4	1 1/4	0540	1540	3540	4540
1/8	3/8	3/4	1190	2190	1/2	3/4	1 1/2	0550	1550	3550	4550
1/8	1/2	1/2	1200	2200							
1/8	1/2	3/4	1210	2210							
1/8	3/4	3/4	1215	2215							
									Style		
					T	W	L	F	5000	6000	7000
5/32	3/8	5/16	1220	2220	1/16	1/4	5/16	...	5030	...	...
5/32	3/8	3/4	1230	2230							
5/32	5/8	5/8	1240	2240	3/32	1/4	3/8	1/16	...	...	7060
					3/32	5/16	3/8	...	5080	6080	...
3/16	5/16	7/16	1250	2250	3/32	5/8	1/2	...	5100	6100	...
3/16	5/16	5/8	1260	2260	3/32	7/16	1/2	...	5105	...	...
3/16	3/8	1/2	1270	2270	1/8	5/16	5/8	3/32	...	...	7170
3/16	3/8	5/8	1280	2280							
3/16	3/8	3/4	1290	2290	1/8	1/2	1/2	...	5200	6200	...
					5/32	3/8	3/4	1/8	...	...	7230
3/16	7/16	5/8	1300	2300	5/32	5/8	5/8	...	5240	6240	...
3/16	7/16	15/16	1310	2310							
3/16	1/2	1/2	1320	2320	3/16	3/4	3/4	...	5340	6340	...
3/16	1/2	3/4	1330	2330	1/4	1	3/4	...	5410	...	...
3/16	3/4	3/4	1340	2340							

All dimensions are in inches.
See diagram on page 740.



A typical single-point carbide tipped cutting tool. The side rake, side relief, and the clearance angles are normal to the side-cutting edge, rather than the shank, to facilitate its being ground on a tilting-table grinder. The end-relief and clearance angles are *normal* to the end-cutting edge. The back-rake angle is parallel to the side-cutting edge. The tip of the brazed carbide blank overhangs the shank of the tool by either $\frac{1}{32}$ or $\frac{1}{16}$ inch, depending on the size of the tool. For tools in Tables 5, 6, 7, 8, 11 and 12, the maximum overhang is $\frac{1}{32}$ inch for shank sizes 4, 5, 6, 7, 8, 10, 12 and 44; for other shank sizes in these tables, the maximum overhang is $\frac{1}{16}$ inch. In Tables 9 and 10 all tools have maximum overhang of $\frac{1}{32}$ inch.



Eight styles of sintered carbide blanks. Standard dimensions for these blanks are given in Table 4.

Table 5. American National Standard Style A Carbide Tipped Tools
ANSI B212.1-1984 (R1997)

Designation		Shank Dimensions			Tip Designation ^a	Tip Dimensions		
Style AR ^a	Style AL ^a	Width A	Height B	Length C		Thickness T	Width W	Length L
Square Shank								
AR 4	AL 4	¼	¼	2	2040	⅜	⅜	⅜
AR 5	AL 5	⅜	⅜	2¼	2070	⅜	¼	½
AR 6	AL 6	⅜	⅜	2½	2070	⅜	¼	½
AR 7	AL 7	⅜	⅜	3	2070	⅜	¼	½
AR 8	AL 8	½	½	3½	2170	⅜	⅜	⅜
AR 10	AL 10	⅜	⅜	4	2230	⅜	⅜	⅜
AR 12	AL 12	¾	¾	4½	2310	⅜	⅜	1⅜
AR 16	AL 16	1	1	6	{ P3390 P4390	¼	⅜	1
AR 20	AL 20	1¼	1¼	7	{ P3460 P4460	⅜	⅜	1
AR 24	AL 24	1½	1½	8	{ P3510 P4510	⅜	⅜	1
Rectangular Shank								
AR 44	AL 44	½	1	6	P2260	⅜	⅜	⅜
AR 54	AL 54	⅜	1	6	{ P3360 P4360	¼	⅜	¾
AR 55	AL 55	⅜	1¼	7	{ P3360 P4360	¼	⅜	¾
AR 64	AL 64	¾	1	6	{ P3380 P4380	¼	½	¾
AR 66	AL 66	¾	1½	8	{ P3430 P4430	⅜	⅜	1⅜
AR 85	AL 85	1	1¼	7	{ P3460 P4460	⅜	⅜	1
AR 86	AL 86	1	1½	8	{ P3510 P4510	⅜	⅜	1
AR 88	AL 88	1	2	10	{ P3510 P4510	⅜	⅜	1
AR 90	AL 90	1½	2	10	{ P3540 P4540	½	¾	1¼

^a "A" is straight shank, 0 deg., SCEA (side-cutting-edge angle). "R" is right-cut. "L" is left-cut. Where a pair of tip numbers is shown, the upper number applies to AR tools, the lower to AL tools. All dimensions are in inches.

Single-Point, Sintered-Carbide-Tipped Tools.—American National Standard ANSI B212.1-1984 (R1997) covers eight different styles of single-point, carbide-tipped general purpose tools. These styles are designated by the letters A to G inclusive. Styles A, B, F, G, and E with offset point are either right- or left-hand cutting as indicated by the letters R or L. Dimensions of tips and shanks are given in Tables 5 to 11. For dimensions and tolerances not shown, and for the identification system, dimensions, and tolerances of sintered carbide boring tools, see the Standard.

Table 6. American National Standard Style B Carbide Tipped Tools with 15-degree Side-cutting-edge Angle ANSI B212.1-1984 (R1997)

Designation		Shank Dimensions			Tip Designation ^a	Tip Dimensions		
Style BR	Style BL	Width A	Height B	Length C		Thickness T	Width W	Length L
Square Shank								
BR 4	BL 4	¼	¼	2	2015	⅜	⅜	¼
BR 5	BL 5	⅜	⅜	2¼	2040	⅜	⅜	⅜
BR 6	BL 6	⅝	⅝	2½	2070	⅜	¼	½
BR 7	BL 7	⅞	⅞	3	2070	⅜	¼	½
BR 8	BL 8	½	½	3½	2170	⅜	⅜	⅜
BR 10	BL 10	⅝	⅝	4	2230	⅜	⅜	¾
BR 12	BL 12	¾	¾	4½	2310	⅜	⅜	1⅜
BR 16	BL 16	1	1	6	{ 3390 4390	¼	⅜	1
BR 20	BL 20	1¼	1¼	7	{ 3460 4460	⅜	⅜	1
BR 24	BL 24	1½	1½	8	{ 3510 4510	⅜	⅜	1
Rectangular Shank								
BR 44	BL 44	½	1	6	2260	⅜	⅜	⅜
BR 54	BL 54	⅝	1	6	{ 3360 4360	¼	⅜	¾
BR 55	BL 55	⅝	1¼	7	{ 3360 4360	¼	⅜	¾
BR 64	BL 64	¾	1	6	{ 3380 4380	¼	½	¾
BR 66	BL 66	¾	1½	8	{ 3430 4430	⅜	⅜	1⅜
BR 85	BL 85	1	1¼	7	{ 3460 4460	⅜	⅜	1
BR 86	BL 86	1	1½	8	{ 3510 4510	⅜	⅜	1
BR 88	BL 88	1	2	10	{ 3510 4510	⅜	⅜	1
BR 90	BL 90	1½	2	10	{ 3540 4540	½	¾	1¼

^a Where a pair of tip numbers is shown, the upper number applies to BR tools, the lower to BL tools. All dimensions are in inches.

A number follows the letters of the tool style and hand designation and for square shank tools, represents the number of sixteenths of an inch of width, W , and height, H . With rectangular shanks, the first digit of the number indicates the number of eighths of an inch in the shank width, W , and the second digit the number of quarters of an inch in the shank height, H . One exception is the $1\frac{1}{2} \times 2$ -inch size which has been arbitrarily assigned the number 90.

Table 7. American National Standard Style C Carbide Tipped Tools
ANSI B212.1-1984 (R1997)

Designation	Shank Dimensions			Tip Designation	Tip Dimensions		
	Width A	Height B	Length C		Thickness T	Width W	Length L
C 4	1/4	1/4	2	1030	1/16	1/4	3/16
C 5	3/16	3/16	2 1/4	1080	3/32	5/16	3/8
C 6	3/8	3/8	2 1/2	1090	3/32	3/8	3/8
C 7	7/16	7/16	3	1105	3/32	7/16	1/2
C 8	1/2	1/2	3 1/2	1200	1/8	1/2	1/2
C 10	3/8	3/8	4	1240	5/32	3/8	3/8
C 12	3/4	3/4	4 1/2	1340	3/16	3/4	3/4
C 16	1	1	6	1410	1/4	1	3/4
C 20	1 1/4	1 1/4	7	1480	5/16	1 1/4	3/4
C 44	1/2	1	6	1320	3/16	1/2	1/2
C 54	3/8	1	6	1400	1/4	3/8	3/8
C 55	3/8	1 1/4	7	1400	1/4	3/8	3/8
C 64	3/4	1	6	1405	1/4	3/4	3/4
C 66	3/4	1 1/2	8	1470	5/16	3/4	3/4
C 86	1	1 1/2	8	1475	5/16	1	3/4

Note – Tool must pass thru slot of nominal width “A”

All dimensions are in inches. Square shanks above horizontal line; rectangular below.

Table 8. American National Standard Style D, 80-degree Nose-angle Carbide Tipped Tools
ANSI B212.1-1984 (R1997)

Designation	Shank Dimensions			Tip Designation	Tip Dimensions		
	Width A	Height B	Length C		Thickness T	Width W	Length L
D 4	1/4	1/4	2	5030	1/16	1/4	3/16
D 5	3/16	3/16	2 1/4	5080	3/32	5/16	3/8
D 6	3/8	3/8	2 1/2	5100	3/32	3/8	1/2
D 7	7/16	7/16	3	5105	3/32	7/16	1/2
D 8	1/2	1/2	3 1/2	5200	1/8	1/2	1/2
D 10	3/8	3/8	4	5240	5/32	3/8	3/8
D 12	3/4	3/4	4 1/2	5340	3/16	3/4	3/4
D 16	1	1	6	5410	1/4	1	3/4

Note – Tool must pass thru slot of nominal width “A”

All dimensions are in inches.

Table 9. American National Standard Style E, 60-degree Nose-angle, Carbide Tipped Tools ANSI B212.1-1984 (R1997)

Designation	Shank Dimensions			Tip Designation	Tip Dimensions		
	Width A	Height B	Length C		Thickness T	Width W	Length L
E 4	1/4	1/4	2	6030	1/16	1/4	3/16
E 5	3/16	3/16	2 1/4	6080	3/32	3/16	3/8
E 6	3/8	3/8	2 1/2	6100	3/32	3/8	1/2
E 8	1/2	1/2	3 1/2	6200	1/8	1/2	1/2
E 10	3/8	3/8	4	6240	3/32	3/8	3/8
E 12	3/4	3/4	4 1/2	6340	3/16	3/4	3/4

All dimensions are in inches.

Table 10. American National Standard Styles ER and EL, 60-degree Nose-angle, Carbide Tipped Tools with Offset Point ANSI B212.1-1984 (R1997)

Designation		Shank Dimensions			Tip Designation	Tip Dimensions		
Style ER	Style EL	Width A	Height B	Length C		Thick. T	Width W	Length L
ER 4	EL 4	1/4	1/4	2	1020	1/16	3/16	1/4
ER 5	EL 5	3/16	3/16	2 1/4	7060	3/32	1/4	3/8
ER 6	EL 6	3/8	3/8	2 1/2	7060	3/32	1/4	3/8
ER 8	EL 8	1/2	1/2	3 1/2	7170	1/8	3/16	3/8
ER 10	EL 10	3/8	3/8	4	7170	1/8	3/16	3/8
ER 12	EL 12	3/4	3/4	4 1/2	7230	3/32	3/8	3/4

All dimensions are in inches.

Table 11. American National Standard Style F, Offset, End-cutting Carbide Tipped Tools ANSI B212.1-1984 (R1997)

Designation		Shank Dimensions					Tip Designation	Tip Dimensions		
Style FR	Style FL	Width A	Height B	Length C	Offset G	Length of Offset E		Thickness T	Width W	Length L
Square Shank										
FR 8	FL 8	1/2	1/2	3 1/2	1/4	3/4	{ P4170 P3170	1/8	5/16	5/8
FR 10	FL 10	5/8	5/8	4	3/8	1	{ P1230 P3230	5/32	3/8	3/4
FR 12	FL 12	3/4	3/4	4 1/2	5/8	1 1/8	{ P4310 P3310	3/16	7/16	1 1/16
FR 16	FL 16	1	1	6	3/4	1 3/8	{ P4390 P3390	1/4	9/16	1
FR 20	FL 20	1 1/4	1 1/4	7	3/4	1 1/2	{ P4460 P3460	5/16	5/8	1
FR 24	FL 24	1 1/2	1 1/2	8	3/4	1 1/2	{ P4510 P3510	3/8	5/8	1
Rectangular Shank										
FR 44	FL 44	1/2	1	6	1/2	3/8	{ P4260 P1260	3/16	5/16	5/8
FR 55	FL 55	5/8	1 1/4	7	5/8	1 1/8	{ P4360 P3360	1/4	3/8	3/4
FR 64	FL 64	3/4	1	6	5/8	1 3/16	{ P4380 P3380	1/4	1/2	3/4
FR 66	FL 66	3/4	1 1/2	8	3/4	1 1/4	{ P4430 P3430	5/16	7/16	1 5/16
FR 85	FL 85	1	1 1/4	7	3/4	1 1/2	{ P4460 P3460	5/16	5/8	1
FR 86	FL 86	1	1 1/2	8	3/4	1 1/2	{ P4510 P3510	3/8	5/8	1
FR 90	FL 90	1 1/2	2	10	3/4	1 5/8	{ P4540 P3540	1/2	3/4	1 1/4

All dimensions are in inches. Where a pair of tip numbers is shown, the upper number applies to FR tools, the lower number to FL tools.

Single-point Tool Nose Radii.—The tool nose radii recommended in the American National Standard are as follows: For square-shank tools up to and including 3/8-inch square tools, 1/64 inch; for those over 3/8-inch square through 1 1/4-inches square, 1/32 inch; and for those above 1 1/4-inches square, 1/16 inch. For rectangular-shank tools with shank section of 1/2 × 1 inch through 1 × 1 1/2 inches, the nose radii are 1/32 inch, and for 1 × 2 and 1 1/2 × 2 inch shanks, the nose radius is 1/16 inch.

Single-point Tool Angle Tolerances.—The tool angles shown on the diagrams in the Tables 5 through 11 are general recommendations. Tolerances applicable to these angles are ± 1 degree on all angles except end and side clearance angles; for these the tolerance is ± 2 degrees.

Table 12. American National Standard Style G, Offset, Side-cutting, Carbide Tipped Tools ANSI B212.1-1984 (R1997)

Designation		Shank Dimensions					Tip Designation	Tip Dimensions		
Style GR	Style GL	Width A	Height B	Length C	Offset G	Length of Offset E		Thickness T	Width W	Length L
Square Shank										
GR 8	GL 8	1/2	1/2	3 1/2	1/4	1 1/16	{ P3170 P4170	1/8	5/16	3/8
GR 10	GL 10	3/8	3/8	4	3/8	1 3/8	{ P3230 P4230	5/32	3/8	3/4
GR 12	GL 12	3/4	3/4	4 1/2	3/8	1 1/2	{ P3310 P2310	3/16	7/16	1 5/16
GR 16	GL 16	1	1	6	1/2	1 11/16	{ P3390 P4390	1/4	9/16	1
GR 20	GL 20	1 1/4	1 1/4	7	3/4	1 13/16	{ P3460 P4460	5/16	5/8	1
GR 24	GL 24	1 1/2	1 1/2	8	3/4	1 13/16	{ P3510 P4510	3/8	5/8	1
Rectangular Shank										
GR 44	GL 44	1/2	1	6	1/4	1 1/16	{ P3260 P4260	3/16	5/16	5/8
GR 55	GL 55	5/8	1 1/4	7	3/8	1 3/8	{ P3360 P4360	1/4	3/8	3/4
GR 64	GL 64	3/4	1	6	1/2	1 7/16	{ P3380 P4380	1/4	1/2	3/4
GR 66	GL 66	3/4	1 1/2	8	1/2	1 5/8	{ P3430 P4430	5/16	7/16	1 5/16
GR 85	GL 85	1	1 1/4	7	1/2	1 11/16	{ P3460 P4460	5/16	5/8	1
GR 86	GL 86	1	1 1/2	8	1/2	1 11/16	{ P3510 P4510	3/8	5/8	1
GR 90	GL 90	1 1/2	2	10	3/4	2 1/16	{ P3540 P4540	1/2	3/4	1 1/4

All dimensions are in inches. Where a pair of tip numbers is shown, the upper number applies to GR tools, the lower number to GL tools.