Section 3 Non-threaded fasteners

Rivets

RIVETS are low-cost, permanent fasteners well suited to automatic assembly operations. The primary reason for riveting is low in-place cost — the sum of initial rivet cost and costs of labor and machine time to set the rivets in the parts. Initial cost of rivets is substantially lower than that of threaded fasteners because rivets are made in large volumes on high-speed heading machines, with little scrap loss. Assembly costs are low. Rivets can be clinched in place by high-speed automatic machinery.

Other advantages include:

- Dissimilar materials, metallic or nonmetallic, in various thicknesses can be joined. Any material that can be cold-worked makes a suitable rivet.

- Rivets may have a variety of finishes such as plating, parkerizing, or paint.

- Parts can be fastened by a rivet if flat parallel surfaces exist for both the rivet clinch and head and there is adequate space for the rivet driver during clinching.

- Rivets can serve as fasteners, pivot shafts, spacers, electric contacts, stops, or inserts.

- Parts that are painted or have received other finishes can be fastened by rivets.

On the negative side, tensile and fatigue strengths of rivets are lower than for comparable bolts or screws. High-tensile loads may pull out the clinch, or severe vibrations may loosen the fastening. Riveted joints are normally neither watertight nor airtight. However, such joints may be attained at added cost by using a sealing compound, rivet coating, or special washer.

Riveted parts cannot be disassembled for maintenance or replacement without destroying the rivet.

Rivets produced in volume are not normally made with the same precision as screw-machine parts. Normal tolerance on major dimensions are +0.005 in., although closer shank-diameter tolerances can be held. Rivets should not be used where dimensional variation must be maintained as low as +0.001 in.

There are two basic families of rivets: tubular and blind. The main difference between them is blind rivets require access to only one side of the assembly for installation.

Tubular rivet characteristics

Optimum diameter for a tubular rivet is determined by economics, not performance requirements. Rivet shank length is fixed by the amount of the rivet material needed for clinching and the total material thickness.

To minimize initial cost, a rivet of standard shank diameter, length increment, and tolerances should be specified. Some high-volume rivet sizes are particularly low cost. For example, 1/8 in. is by far the most popular nominal shank diameter. In shank lengths over 9/16 in., a 1/8-in. carbon-steel rivet costs less than rivets with shank diameters from 0.085 to 0.089 in. Unless limited by load-carrying requirements, the 1/8-in. rivet should be used

Larger rivet shank diameters have higher feeding efficiency in automatic assembly operations while low-carbon steel and brass rivets are most easily handled in riveters. Extremely soft, low-density rivet materials can cause feeding and clinching difficulties.

Rivet length-to-diameter ratio should be limited to a maximum of 6:1 when possible so standard barrel hoppers can be used. At higher length-to-diameter ratios, special feeding devices such as continuous hopper drives or vibratory feeders may be necessary. For rivets above the 6:1 ratio and sizes below this ratio but with long shanks, the head diameter should be about twice the

Metal-piercing rivets

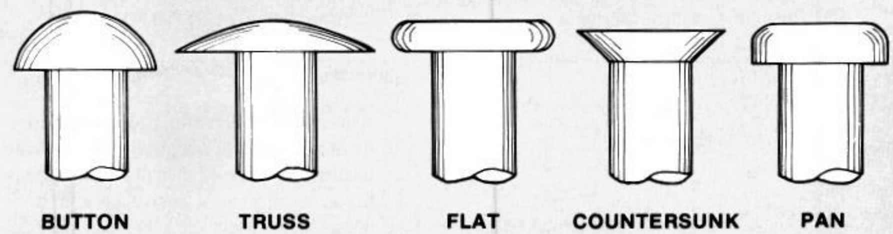
There are three common types of metal-piercing rivets: split, semitubular, and pointed. Pointed rivets are more like nails than rivets, since they have no clinch and do not pass entirely through the substrate. They are intended for light duties such as attaching nameplates to metal parts.

Split rivets use two prongs to pierce the materials to be joined. Semitubular rivets pierce with the rivet wall surrounding the hole at the end of the shank. This area may be specially hardened. Pointed rivets pierce with the point, forming a crater in the substrate. Lips of the crater are swaged and forced into a groove in the point by a hard shoulder.

Split and semitubular rivets are used with rather thin sections. Maximum sandwich thickness is around 0.15 in. Shank diameters are in the range of 1/8 to 9/64 in. and shank lengths range from 5/32 to 1/4 in. Pointed rivets are used with substrates significantly thicker than the point length, which ranges from 0.072 to 0.116 in.

Split rivets have long been used to assemble nonmetallic parts, but are seldom used for piercing metals other than aluminum. Semitubular rivets are used with low-carbon steels, aluminums, and stainless steels, usually with hardnesses around RB 50. Steels in the range of RB 90 may fragment under the piercing action and produce a rough clinch. Pointed rivets are used with steels, aluminums, stainless steels, and castings.

AMERICAN STANDARD RIVET HEADS



shank diameter for the most efficient automatic handling.

Steel, aluminum, or brass are considered standard cold-heading materials. Almost any soft grade of aluminum — 1100, 3003, 2017, 2024, 5052, 5056 — can be cold-formed into rivets. Carbon steels from grades AISI 1006 through 1035, 1108, and 1109 provide good strength at reasonable cost.

The location of the rivet in the assembled product influences both joint strength and clinching requirements. The important dimensions are edge distance and pitch distance.

Blind rivets

Because blind rivets can be installed in a joint which is accessible from only one side, these fasteners are considered separately. When a blind rivet is set, a self-contained mechanical, chemical, or other feature expands the rivet's shank, securing the parts being joined.

Blind rivets are also used where both sides of the joint are accessible to simplify assembly, improve appearance, or decrease cost. Blind riveting has the added virtue of portability—the riveting can be brought to the work. This is especially valuable for large assemblies.

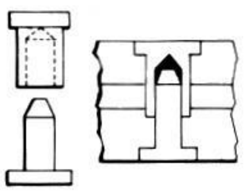
Blind rivets should be considered when:

- Fastener removal is not necessary for maintenance.
- A high vibration environment exists.
- A temporary fastener is needed.
- Uniform clamping is desirable.
- Repair fasteners for field use by untrained personnel are needed.

Blind rivets are classified according to the methods with which they are set—pull-mandrel, threaded, and drive-pin.

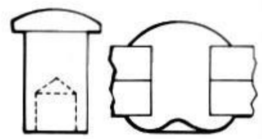
Physical Characteristics: Core style of the axially located hole in the rivet body is based on its post-setting condition. A filled rivet

Tubular rivet types



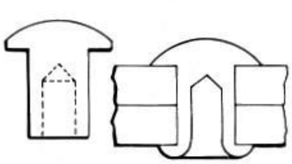
COMPRESSION

Male and female members form an interference fit when pressed together. The heads of both members can be produced to close tolerances, therefore these rivets are commonly used when appearance from both sides of the work must be uniform and heads must be flush to prevent accumulation of dirt or waste. Compression rivets can be used in wood, brittle plastics, or other materials with little danger of splitting during setting.



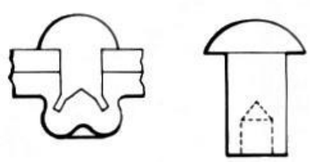
SEMITUBULAR

The most widely used rivet type, this fastener has a straight or tapered hole in its end with a depth that never exceeds 1.12 times shank diameter. When properly specified and set, this rivet becomes essentially a solid member because the hole depth is just enough to form the clinch. Strength of semitubular rivets in shear or compression is comparable to that of solid rivets.



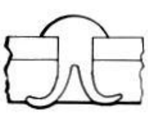
FULL TUBULAR

Rivet shanks have hole depths greater than 1.12 times shank diameter. They can punch their own holes in fabric, some plastic sheet, and other soft materials. Shear strength is less than that of semitubular rivets.



METAL PIERCING

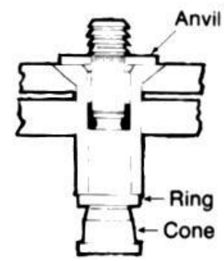
Designed much like semitubular rivets, the metal-piercing rivet has greater column strength. These rivets can pierce a total sandwich of about 0.15 in. Material to be fastened is limited in hardness to around RB 50.

BIFURCATED

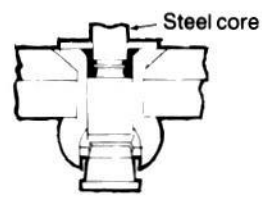
Also called split rivets, these fasteners have bodies that are punched or sawed to produce prongs that make their own holes through fiber, wood, plastic, or metal.

Bulbed rivets



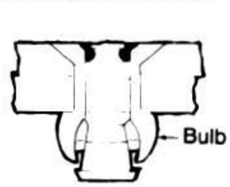
INITIAL INSTALLATION

Blind rivets of this type are designed chiefly to provide a high clamping force with thin sections. Typical applications include repair when holes have become enlarged or when all-aluminum rivets must be replaced with higher-strength, steel-stem rivets.



PARTIALLY SEATED

Cone has begun to expand the rivet sleeve and the locking ring has started to compress against the anvil.



FULLY SEATED

Ring has sheared from the cone allowing complete expansion of the bulb. Locking ring is fully compressed securing the steel stem and the rivet pull section has sheared leaving a flush surface.

contains enough of the mandrel or pin so that the break point of the mandrel or the end of the pin is approximately flush with the top of the rivet head. This style provides high shear strength. A semifilled rivet contains a short length of the mandrel in its core. A hollow rivet has a completely empty core, as in a pull-through mandrel rivet, and is advantageous when light weight is important.

Diameter is based on the measurement of a blind rivet's shank. Sizes are usually in increments of 1/32 in.

Grip range is the minimum-to-maximum total thickness of component materials that can be joined properly with a blind rivet of a given length. Manufacturers usually furnish specific recommendations.

Sealing properties vary considerably, often depending on the style of the blind end. If sealing is critical, it should always be checked under operating conditions.

Design Considerations: Joint design factors that must be known include allowable tolerances of rivet length versus assembly thickness, type and magnitude of loading, hole clearance, and joint configuration.

For most rivets, installation is fastest and most efficient with power tools. However, drive-pin rivets are most quickly installed with an ordinary hammer, and have even won speed contests against ordinary rivets installed with power tools. Manual tools for installing rivets can usually be used efficiently with little or no training.

In-place costs of blind rivets are often lower than solid rivets or tapping screws because of low tooling investment, high installation speed, and single operator requirements. Also, inventory savings can be realized if one rivet with a large grip range is used for several joints of different thicknesses.

Loading of a blind-rivet joint is usually in shear, which the rivets can support better than tensile loading. Rivets subject to vibration will perform more efficiently if minimum hole clearance specified by the manufacturer is maintained.

Material thickness requirements can be as thin as 0.020 in. with some rivets. If one component is of compressible material, rivets with extra large head diameters should be used on that side of the application to uniformly distribute the load over a larger area.

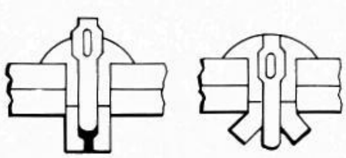
Blind rivet types

Two-part rivets consist of a body (head, shank, and blind end) and a mandrel preassembled within the body. After the rivet is inserted into the joint, the mandrel is gripped and pulled axially so that its head upsets the blind end of the rivet body to form a set rivet.

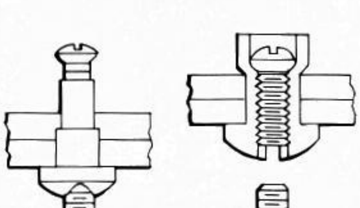
Three subclassifications of pull-mandrel blind rivets are: pull-through, break, and nonbreak. In the pull-through type, the mandrel is pulled completely through the rivet body, leaving a hollow rivet. A plug may be inserted to seal the hole.

A mandrel of the break type is pulled into or against the rivet body and then breaks off, leaving part of the mandrel in the body as a plug. The retained mandrel section increases the shear strength of the installed rivet. The rivet may have a completely closed blind end to prevent liquid or gas leakage after installation.

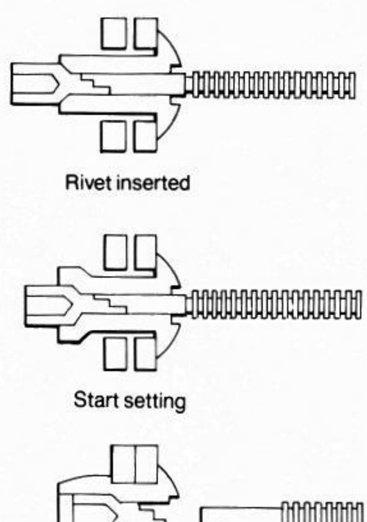
In the nonbreak type, the mandrel is pulled into or against the rivet body, but does not break. The mandrel is removed in a subsequent operation. A drive-pin that is part of the rivet is hammered into the body to flare out the blind side of the rivet. Threaded blind rivets consist of an internally threaded rivet and an externally threaded mandrel which is torqued or pulled, with a special tool. This expands the walls of the rivet body to form a blind head.



DRIVE-PIN



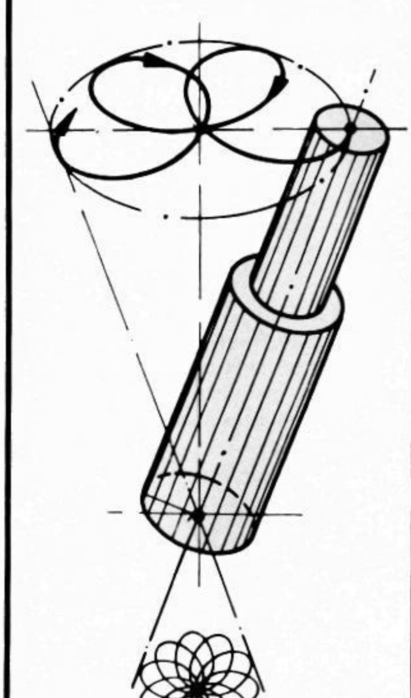
THREADED



PULL MANDREL

Noiseless riveting

The impact force of most riveters produces noise and often damages workpieces. The radial riveting machine developed by the Bracker Corp., however, secures the rivet with a gradual motion instead of a hammering impact to reduce noise and damage. Held at a 3° to 6°angle from the workpiece, the riveting tool is guided through an 11-point rosette in which overlapping loops cover the head. Total forming time is 0.5 second. Minimum size of solid rivets is 0.01 to 0.2 in. diameter. Maximum size for solid rivets is 1 to 1.5 in.



Installation Costs: Blind rivets, although costing slightly more than conventional tubular ones, allow faster installation and reduced assembly costs that can quickly make up the initial price difference. Blind rivets were originally developed for fastening applications where only one side of the workpiece was accessible. However, these rivets now are often used in other applications specifically to reduce assembly time.

Break-stem blind rivets consist of a body and mandrel. Grasped by the jaws of a setting tool, the mandrel head is pulled into the rivet body, which expands and clinches against the back of the work surface. When the assembly is tight, the mandrel breaks away under predetermined tension and falls away.

The cost-savings provided by break-stem blind-riveting is somewhat reduced because rivets usually are handled individually, and the broken mandrels must be removed from the work area. Broken mandrels sometimes are left in a workpiece, resulting in further production delays and associated costs. Cartridge-fed blind-riveting systems overcome these disadvantages with packaged sets of rivets installed with a tool having a built-in permanent mandrel. Production rates for this system are up to six times faster than those of break-stem systems, with a proportionate reduction in assembly costs.

Like other blind rivets, drive-pin rivets offer speedy installation, but the pin remains in the rivet. This increases rivet shear strength and eliminates the housekeeping problem of broken mandrels.

Retaining rings

RETAINING rings, also called snap rings, provide a removable shoulder to accurately locate, retain, or lock components on shafts or in bores and housings. They are usually made of spring steel, and have a high shear strength and impact capacity. Some rings are designed for taking up end play caused by accumulated tolerances or wear in the parts being retained. In general, these devices can be placed into three categories based on their fabrication: stamped retaining rings, bent-wire rings, and spiral-wound retaining rings.

Stamped rings

Stamped retaining rings have a tapered radial width that decreases symmetrically from the center section to the free ends, in contrast to wire-formed rings, which have a uniform cross-sectional area. The tapered construction permits the rings to remain circular when they are expanded for assembly over a shaft, or contracted for insertion into a bore or housing. This constant circularity assures maximum contact surface with the bottom of the groove.

Stamped retaining rings can be classified into three groups: axially assembled rings, radially assembled rings, and self-locking rings that do not require grooves. Axially assembled rings slip over the ends of shafts or down into bores, while radially assembled rings have side openings and are snapped directly into grooves on a shaft.

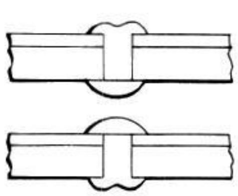
Most axially assembled rings have holes in the lugs at the free ends for special pliers that expand or contract the rings for installation or removal. Radially assembled rings are installed with an applicator and removed with a screwdriver or other hand tool. Self-locking rings are available for assemblies in which the fastener need not absorb any sizable thrust, but instead serves mainly as a positioning and locking device.

Most stamped retaining rings are manufactured of high-carbon spring steel and are supplied with corrosion-inhibiting finishes such as phosphate coating, cadmium or zinc plating and chemical conversion coatings for special applications. Rings made of aluminum or beryllium copper are available for special assembly requirements, usually without any protective finish. Corrosion-resistant stainless steel rings also are available; these generally are passivated.

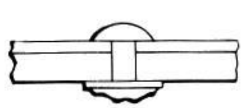
Design considerations

Sizes of standard rings range from 0.040 to 10-in. diameter. Rings as large as 40-in. diameter have been made. Rings are also

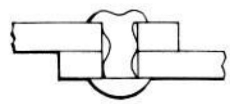
Tubular rivet design tips



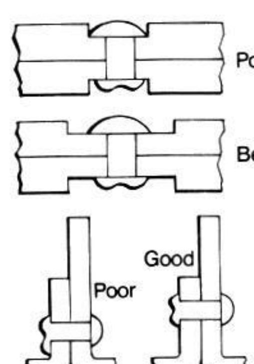
Stock size. Rivet head should be on the side of the thinner material. With dissimilar materials the head should be on the side of the softer material.



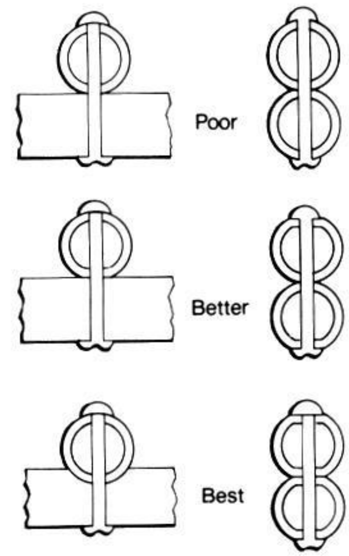
Weak materials. When material is compressible or brittle, use a washer on the clinched end.



Hole size. Use recommended allowances. Long rivets may buckle in an oversized hole.



Clearance. Do not forget to allow space for the riveting machine.



Rods and tubes. When joining circular members, keep rivets as short as possible to prevent buckling. For the most secure joint, roll or machine flats in the circular section.

manufactured for metric shaft and bore diameters. In selecting specific ring types, both ring and groove load capacities should be considered; the lower of the two will be the limiting factor in the assembly. The ultimate thrust load to which a ring may be subjected depends upon the ring's shear resistance; ultimate groove thrust load capacity depends on a factor of compressive resistance.

The retained part should, for optimum ring performance, have an abutting face that is straight with sharp corners. Loads are then transmitted as closely as possible to the groove wall, utilizing the thickness of the ring to resist shearing and provide maximum uniform compression loading for the groove wall. If the abutting face is curved, and the resultant of the forces is transmitted to the ring at a distance from the shaft or bore circumference, then a bending moment is created that will cause the ring to dish. The groove wall will not be loaded uniformly, reducing the ultimate thrust capacity.

Retaining ring manufacturers specify the maximum allowable corner radii and chamfers for each ring size with corresponding static thrust capacities. If thrust capacities are insufficient for the assembly, a rigid, square-cornered, flat washer should be inserted between the ring and the retained part. The washer is mandatory if the assembly is subject to dynamic loading conditions and the retained part has a corner radius or chamfer.

Clearance depends on the type of ring to be used. A crescent ring, for example, has a substantially lower shoulder than an E-ring, and for many assemblies supplies a sufficiently large bearing surface. Rings with inverted lugs form a uniformly circular protruding shoulder and similarly provide more clearance than the basic internal and external types.

Edge margin is the shoulder between the outer groove wall and the end of the shaft or housing. Minimum is generally considered to be three times the nominal groove depth specified for the ring.

Axial-type rings generally have higher rotational speed limits and present a neater appearance. Radial rings are usually easier to install and remove.

Axial play in the assembly can be compensated for by bowed rings where resilient end-play take-up is permissible. Beveled rings can be used for rigid take-up. Self-locking rings, which can be positioned at any point on a shaft or in a housing, also can compensate for accumulated tolerances.

Wire-formed rings

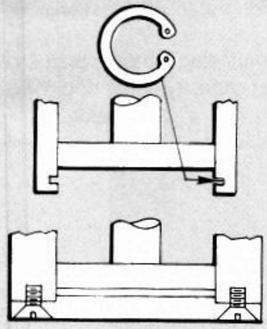
Wire-formed retaining rings are split rings formed and cut from spring wire of uniform sectional size and shape.

Rings are available in many cross-sectional shapes, but the most commonly used have rectangular or round cross sections. Rectangular-section rings are made for internal or external applications. Round section rings are for external use on shafts only and are used where the expected load is light.

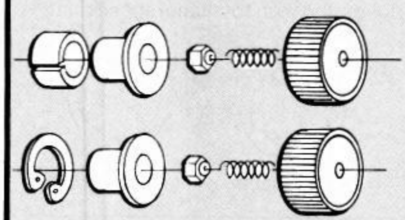
Ring assembly and disassembly tools range from a screw driver to automatic tools, depending on the ring application.

Carbon spring steel (SAE-1060) is the standard material used in retaining rings. In addition, a wide range of carbon steels (SAE-1010 to SAE-1095) are used, including include pre-oil-tempered and alloy steels. Hardnesses range from 43 to 53 Rockwell C, with tensile strengths from 200,000 to 280,000 psi. Other materials used are stainless steel, yellow brass, silicon or phosphor bronze, Inconel X, beryllium copper, aluminum, and K-Monel.

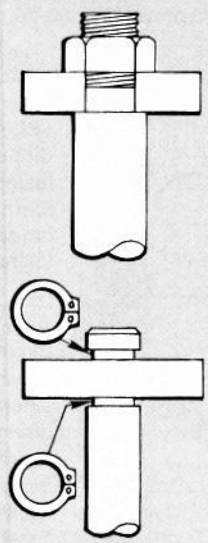
Retaining-ring uses



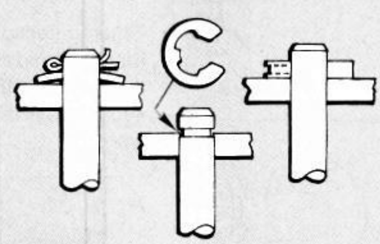
Replaces housing end plate



Replaces retaining sleeve



Replaces nut and shouldered shaft

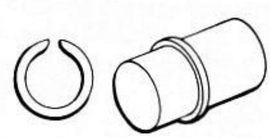


Replaces cotter pin and washer or set screw and collar

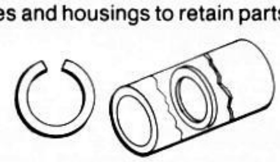
Based on material supplied by Truarc Retaining Rings Div., Waldes Kohinoor, Long Island City, NY.

Wire-formed rings

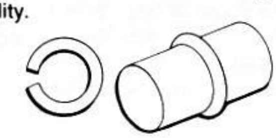
External rectangular-section rings come in standard sizes ranging from 1/8 to 5 in. They are assembled axially to hold parts on shafts. Special materials, finishes, or sections can be obtained. Several series of these rings are made to retain snap ring-type bearings.



Internal rectangular-section rings have a standard size range of 7/8 in. to 5 in. diameter for general application — up to 8 in. for standard SAE bearings. Ring is mounted axially in bores and housings to retain parts.



Round-section external rings are offered in standard sizes ranging 1/8 to 2 1/4 in. They are used in the same general applications as rectangular rings but have less load-bearing ability.



Design considerations

Wire-formed rings are available for shafts or housings in diameters from 1/8 to 30 in. The controlling factor in selecting or designing a wire-formed ring (other than size) is the amount of thrust the ring is to absorb. In most cases, the retaining ring will withstand greater shear loads than the groove material because of the strength of the hardened, spring-steel ring section.

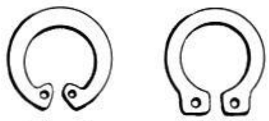
The controlling factor in size selection is the thrust capacity of the ring. Wire-formed retaining rings, because of their configuration, usually do not fail in shear. Under an increasing load, the ring deflects and finally jumps out of the groove.

The resistance of the ring to this type of failure can be increased by increasing the

Stamped retaining rings

AXIALLY ASSEMBLED

Beveled ring has a 15-deg bevel on the groove-engaging edge and is installed in grooves having corresponding bevel on the load-bearing wall. Ring acts as a wedge between retained part and groove wall. It seats deeper into the groove to compensate for tolerances or wear.

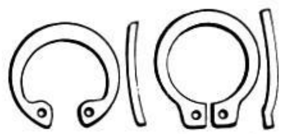


Internal External

Basic internal ring is compressed and inserted into a bore or housing; external ring is expanded and assembled over shaft. Both rings seat in deep grooves and are secure against heavy thrust loads and high rotational speeds.

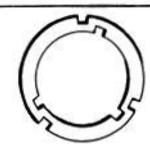
Internal External

Bowed rings' construction provides resilient end-play take-up in the axial direction while maintaining tight grip against the groove bottom.



Internal External

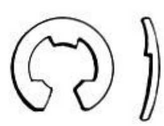
Permanent-shoulder ring has notches that compress when the ring is forced into V-shaped groove. The ring grips the groove tightly and provides a 360-deg shoulder against heavy thrust loads.



RADIALLY ASSEMBLED

Crescent ring has a tapered section similar to that of basic axial types. It remains circular after installation on a shaft and provides a tight grip against the groove bottom.

E-ring provides a larger bearing shoulder on small-diameter shafts and often is used as a spring retainer. Three heavy prongs seat in deep groove for increased thrust capacity.



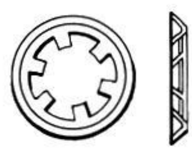
Interlocking ring has identical semicircular halves held together by interlocking prongs at the free ends. It forms high circular shoulder concentric with shaft. Attractive appearance makes fastener suitable for exposed applications.

Locking-prong ring has two prongs which grip shaft and prevent ring from being forced from groove. To be removed, ring must be flattened so that prongs clear groove.

High-strength radial ring has large lobes which function as shoulders. They are connected by tapered bending arms that exert strong spring pressure at the groove bottom.

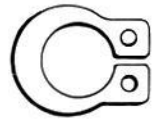
SELF-LOCKING

Circular external ring is a push-on type fastener with inclined prongs. Extra-long prongs on ring with arched rim accommodate wide shaft tolerances.



Circular internal ring, used in bores and housings, functions in same manner as external types except that locking prongs are on outside of rim. Tapered-section clamp ring exerts a frictional hold against axial displacement from either direction. It is substantially thicker than basic external type.

Tapered-section clamp ring exerts a frictional hold against axial displacement from either direction. It is substantially thicker than basic external type.



Triangular retainer provides larger shoulder than circular push-on types and has greater gripping strength. Dished body holds retained part.

ring width (section height measured in plane of diameter). Wider rings have more resistance to expansion forces that would work the ring out of the groove.

Although rings can be made with almost any combination of section width and thickness, rectangular-section thicknesses are usually 2 to 5% of the diameter of the shaft or bore. Width of these sections varies from two to three times the thickness.

Ideally the shaft and the retained part should have strength equal to or better than the ring. The groove should be square, concentric, and held to such dimensions that a close slip fit is provided with the sides of the ring. The bearing surface of the retained part should be perpendicular to the axis of the shaft with no corner radius.

If these conditions cannot be met in practice wire-section corner radius, mating-part radius, and tolerances should provide an adequate flat surface for the ring to bear against.

Shear strength of the groove material can be increased by increasing the edge margin (distance from edge of groove to end of shaft) or by increasing the strength of the groove material.

Sufficient design clearance should be allowed to assemble the rings with a minimum of effort. Radially assembled, or clip, retaining rings require accessibility to the side of the shaft. Rings used internally in bores require adequate space for tool insertion.

External closed rings are assembled axially over the end of the shaft. A radius or 30 deg chamfer on the end of the shaft greatly assists the assembly operation. A small edge margin also makes assembly easier.

Tolerances of ring thickness, groove location, or retained components may add up to cause objectionable end play. Tolerances can be taken up, to some extent, by using tapered-keystone or beveled sections. The narrow portion of the section thickness is in the groove, and the wide portion bears against the part.

External clip rings are easier to install than axially assembled rings, and require fewer tools. These rings are designed to be driven on gap ends first, over the bottom of the groove.

Axially assembled rings usually have better external appearance and higher rotational speed limits than the external clip rings.

Grooves for retaining rings vary according to the type of ring used and the type of service. Radius (rounded) grooves are used for round-section retaining rings.

For external rectangular-section clip and closed rings, groove width should be 1.15 times the ring-section thickness. This width is the absolute minimum that will accept standard rings. It may be desirable to specify larger minimums and tolerances to be consistent with design requirements.

Spiral-wound rings

Spiral-wound retaining rings consist of one or more turns of rectangular edge wound wire to provide a coil. It can be installed or removed using automatic equipment or simple hand tools. When required, a

Sizing ring gap

Sizes of wire-form retaining rings are usually limited by the sizes of the parts accommodating the rings. Thickness, radial width, and radius are fixed; the real design problem is selecting an angular gap that provides the required deflection under load.

The accompanying graph and equations can be used to find the gap if the ring has a constant rectangular cross section; radial width of the spring is small compared to the main radius of curvature; the neutral axis of the ring coincides with the mean radius of curvature; and deflections under load are small, so the ring does not deform greatly from its initial circular shape.

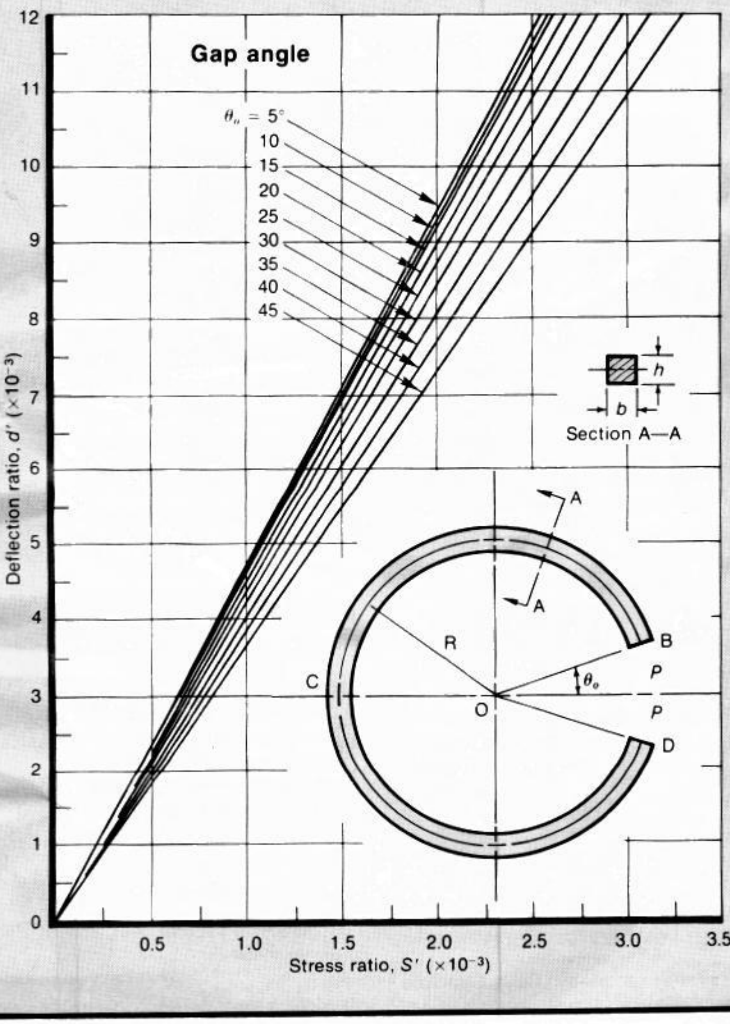
To find the gap, use the equations

$$d' = dh/R^2$$

$$S' = S_m/E$$

where d' = deflection ratio; d = total deflection of ring ends, in.; h = thickness of ring, in.; R = mean radius of curvature, in.; S' = stress ratio; S_m = maximum allowable bending stress, psi; and E = modulus of elasticity, psi.

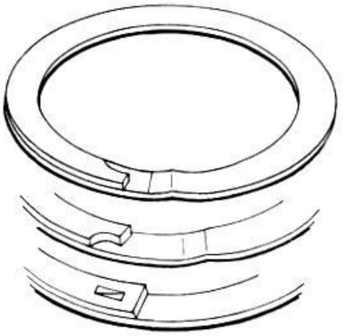
The two equations give crossing lines on the accompanying chart. Gap angle is found at the point where the lines intersect.



Spiral wound rings

STANDARD

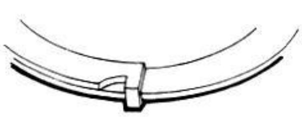
Standard spiral wound rings are inserted and removed using conventional hand tools. Removal notch for external and internal rings is shown. Slotted ring can be used as an internal or external ring.



SPECIAL

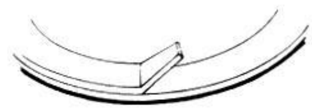
Special spiral wound rings are available to meet a variety of design requirements.

Locking tab keeps rings from spinning and is suitable for assemblies subject to rapid acceleration and deceleration.

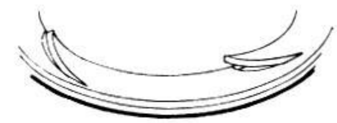


Positive lock allows a much higher rotational speed than with standard rings.

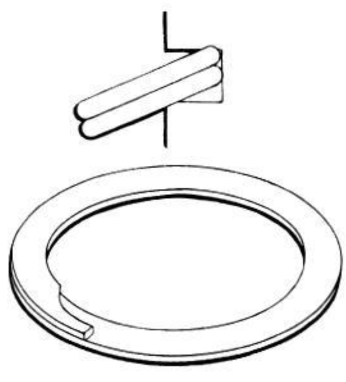
Prominent tab facilitates removal and is used where frequent disassembly is anticipated.



Spring tabs are used when the ring must exert a light load.



Dished ring takes up accumulated tolerance.



360° uniform thickness can be obtained by offsetting one material thickness at the coil ends.

The standard material for spiral-wound retaining rings is carbon spring steel. A portion of each series of standard rings is available in other materials such as 302, 316, and 17-7 PH/C stainless steel, NS A286 alloy, beryllium copper, and Inconel X-750.

Time and stress greatly influence the allowable operating temperature. For those applications near the maximum temperature, the ring stress under load should be minimized by using a sharp-cornered retained part, a groove material with a high yield strength, and a ring from the series that uses the deepest grooves.

Carbon steel rings are normally given an oil-dip treatment to retard rust. Cadmium plating and phosphate coating are other standard finishes readily available. Specials include black oxide and parkerized finishes. Zinc, chrome, copper, and gold plates are also available. Plating adds approximately 0.002-in. to the maximum thickness of the ring.

Standard rings are available for shafts and bores ranging from 15/32 to 15-in. in diameter. Rings for shafts and bores ranging from 3/8 to 72-in. diameters can also be manufactured.

Design considerations

A retaining ring may fail in two ways: through shear, or from overstressing due to axial deflection. For shear failure to occur the groove material must have a compressive yield strength greater than 45,000 psi; the load must be applied through a retained part that has a sharp corner and a yield strength greater than 45,000 psi; the ring must be thin in section compared to the ring diameter.

Under axial deflection the maximum stress on a ring subjected to a uniform twisting moment is a tensile stress at the inner corner of the ring. If the ring is stressed past the yield point it will tend to grow in diameter and become dished.

Retaining ring manufacturers generally specify the maximum radius or chamfer on the retained part. Excessive chamfer sizes cause drastic reductions in allowable thrust loads.

The shallowest possible groove should be selected to minimize cost of the ring and of machining the groove, and to provide ease of ring installation. The minimum permissible groove depth is determined by:

- Thrust load to be absorbed.
- Size of chamfer on the retained part.
- Yield strength of groove material in compression.

Rotation of a retained part against a spiral-wound retaining ring must be limited to one direction only — the direction that would tend to wind the ring into the groove. Spiral-wound rings are available in both left and right hand winds.

Pins

THESE inexpensive and effective fasteners are used where loading is primarily in shear. They are separated into two general groups: semipermanent and quick release.

Semipermanent pins

These general design rules apply to all types of semipermanent pins:

- Avoid conditions where the direction of vibration parallels the pin axis.
- Keep the shear plane of the pin a minimum distance of one diameter from the pin end.
- Allow pins to protrude the length of the chamfer at each end for maximum locking effect in applications where engaged length is at a minimum and appearance is not critical.

Removal and installation of semipermanent pins requires the application of pressure or the aid of tools. The two basic types of pins are machine pins and radial-locking pins.

Machine Pins can be separated into four categories: dowel, taper, clevis, and cotter.

Hardened and ground dowel pins are

standardized in nominal diameters ranging from 1/16 to 7/8 in. Standard pins are 0.0002 in. oversize on the nominal diameter; oversize pins are 0.001 in. oversize.

Standardized pin lengths vary with nominal diameter, ranging from a minimum of 3/16 in. (1/16-in. size) to a maximum of 5½ in. (7/8-in. size).

Some dowel pins are threaded and tapered for use with a tapered sleeve. The threaded section allows the pin to be pulled from the sleeve, and a special sleeve puller removes the sleeve. This dowel-and-sleeve combination is reusable and can properly align holes as much as 0.001 in. oversize. It is said to speed machine-shop operations by eliminating knock-out holes, eliminating the need to turn dies to remove dowels, and enabling machinists to remove and replace die sections while the die is in the press.

Taper pins have a taper of 1/4 in. per ft measured on the diameter. Basic dimension is the diameter of the large end. Diameter d of the small end is given by $d = D - 0.02088L$ where D = diameter of large end, in., and L = pin length, in.

A series of numbered pin sizes has been standardized, ranging from No. 7/0 (0.0625 in. large end) to No. 10 (0.7060 in. large end).

Clevis pins have nominal diameters from 3/16 to 1 in. Corresponding shank lengths vary from 19/32 in. for 3/16-in. size to 2⅝ in. for 1-in. size. Standard material is steel, either soft or cyanide-hardened to meet service conditions.

Cotter pins have been standardized into 18 sizes with nominal diameters ranging from 1/32 to 3/4 in. Available materials include mild steel, brass, bronze, stainless steel, and aluminum. Cotter pins come in a number of point styles.

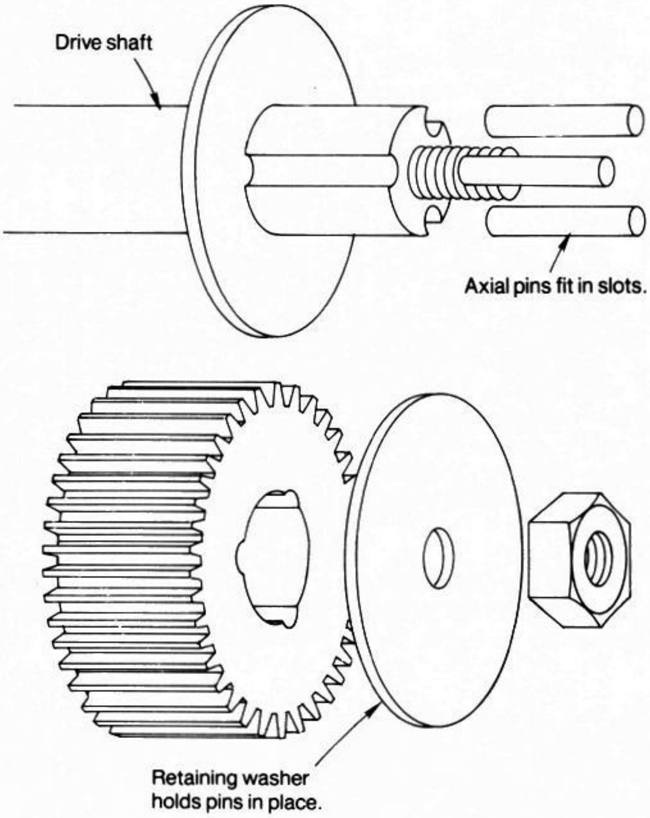
Grooved straight pins have a locking action provided by parallel, longitudinal grooves uniformly spaced around the pin surface. Rolled or pressed into solid pin stock, the grooves expand the effective pin diameter. When the pin is driven into a drilled hole slightly larger than the nominal pin diameter, elastic deformation of the raised groove edges produces a secure force-fit with the hole wall.

Standard groove-pin sizes cover a range of nominal diameters from 1/32 to 1/2 in. in varying lengths from 1/8 to 4½ in. Standard materials include cold-drawn steel, alloy steel, stainless steel, and copper alloys.

Groove pins made of low-carbon steel have load capacity in single shear from 110 lb for a 3/64-in. size to 10,300 lb for a 1/2-in. size. Higher shear strength may be obtained from heat-treated pins.

Pins eliminate backlash

Locking technique for mounting rotating components on driveshafts allows exact axial positioning, produces no backlash, and requires less machining than splined couplings. The technique uses axial pins that require only six slots, three in the shaft and three in the mating component. The part is placed on the shaft so that the slots align, and the pins are then inserted and held in place with a retaining washer. The technique has been used successfully in a number of aerospace applications.



Locking force developed by a groove pin in assembly is a function of pin diameter and effective length of engagement. Best results under average assembly conditions are obtained with holes drilled the same size as the nominal pin diameter. Undersize holes must be avoided. This practice can lead to deformation of the pin in assembly, damage to hole walls, and shearing-off of the raised groove edges, thus reducing holding action and preventing reuse of the pin. When the part material is appreciably harder than that of the pin, chamfered or rounded hole edges should be specified to avoid shearing of the expanded pin section.

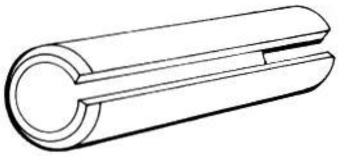
Shearing may be avoided by using through or case-hardened pins. Hardness of the pin and the metal fastened should be equal.

Spring pins use the resilience of hollow cylinder walls to hold in place. The two main types are spiral-wrapped and slotted-tubular pins. Both pin forms are made to controlled diameters greater than the holes into which they are pressed. Compressed when driven into the hole, the pins exert spring pressure against the hole wall along their entire engaged length to develop locking action.

Spiral-wrapped pins come in standard sizes that cover a range of nominal diameters from 1/32 to 1/4 in., in lengths from 1/8 to 6 in. Standard materials are heat-treated 1070 to 1095 carbon steel, stainless steel (302, 420), and alloy steel (6150).

Locking force of a spiral-wrapped pin is a function of length of engagement, pin diameter, and wall thickness. Three pins are available for light, medium, and heavy-duty applications.

Slotted tubular pins come in standard sizes from 1/16 to 1/2 in., in lengths from 1/8 to 5½ in. Standard materials are heat-treated carbon steel, corrosion-resistant steel, and beryllium-copper. Readily adaptable to manual or power assembly techniques, these pins offer a tough yet resilient, self-locking fastener that can withstand high shock and vibration loads. For maximum shear strength, the pin should be assembled so that the gap is in line with the



SLOTTED TUBULAR PINS

direction of load and 180 deg away from the point of application. The maximum shear strength value provided by this gap orientation represents an increase of about 6% over the minimum value.

Quick-release pins

Rapid manual assembly and disassembly are the main uses of quick-release pins. They employ some form of detent mechanism to provide a locking action. Quick-release pins use a clearance fit in holes formed to nominal diameters. They are divided into two major types—push-pull pins and positive-locking pins.

Push-pull pins are made with a solid or a hollow shank containing a detent assembly in the form of a locking lug, button, or ball which is backed up by some type of resilient core, plug, or spring.

These pins are made 0.002 to 0.004-in. undersize to fit any standard hole drilled to nominal-diameter dimensions. Holes up to 0.010-in. oversize are permissible. Pull-out loads can be expected to decrease as looseness of fit increases. Hole edges should be deburred or slightly chamfered to ease pin assembly.

Primary function of these pins is to fasten parts under shear loading. Ideally, the direction of load should be at right angles to the shank of the pin. Locking mechanisms are designed to provide secure retention against accidental disassembly. These pins are not recommended for tension load applications.

Positive-locking pins have a locking action that usually is independent of insertion and removal forces. These pins are also primarily suited for shear-load applications. However, some degree of tension loading usually can be tolerated without affecting the pin function.

Positive-locking pins are divided into three categories: heavy-duty cotter pins; single-acting pins; and double-acting pins.

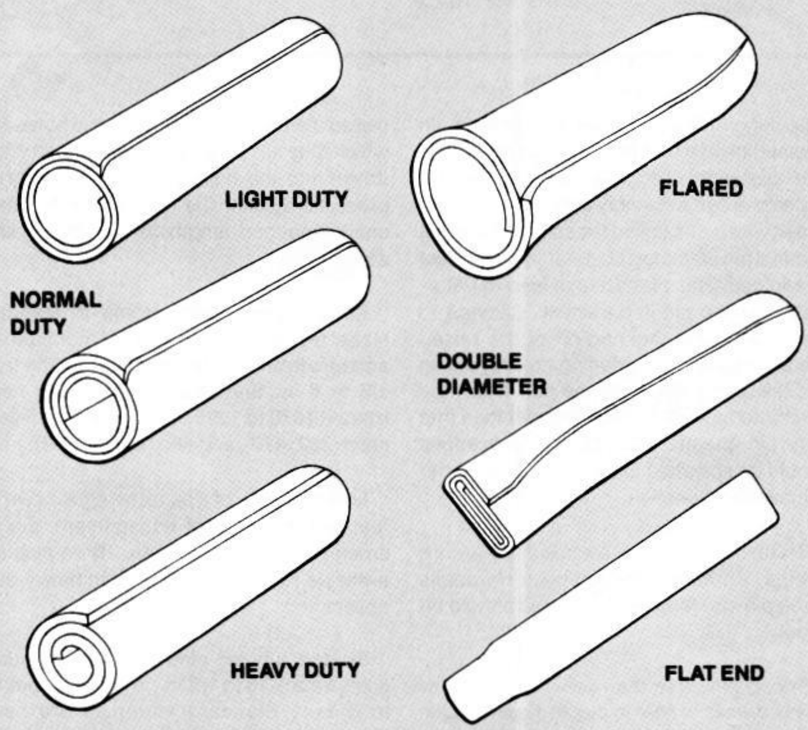
Heavy-duty cotter pins employ a forged, high-carbon-steel body to replace the conventional split-cotter construction. Locking action is provided by a tempered-steel snap ring mounted on the head of the pin.

Single-acting pins have locking action controlled by a plunger-actuated locking mechanism. In the locked position, the locking element projects beyond the surface of the pin shank to provide a positive lock. When the plunger is moved by means of a button or lever assembly at one end of the pin, the locking element retracts.

A number of head styles and release mechanisms have been developed for these pins.

Double-acting pins are a modification of single acting types, and have a bidirectional, spring-located plunger. Movement of the plunger in either direction releases the locking balls.

Spiral-wrapped pins



Washers

WASHERS are used primarily as a seat to distribute load in a fastener system. Washers also may provide spring tension, span oversize holes, insulate, seal, lock the fastener, protect the surface, or provide electrical connection.

Flat washers, also called plain washers, primarily provide a bearing surface for a nut or screw head, cover large clearance holes, and distribute fastener loads over a large area, particularly on soft materials such as aluminum or wood.

Two types of washers are covered in ANSI B27.2 — 1965 for general use. Type A is a series of steel washers with broad tolerances, where design refinement is not important. They range from No. 6 to 3-in. hole size and from 3/16 to 5 1/2-in. OD. Type A washers are generally satisfactory for most assemblies.

Type B washers are of higher quality and are specified in narrow, regular, and wide diameters for each screw size from No. 0 to 3 in. ANSI B27.2 — 1965 gives washer, hole, outside, and inside dimensions.

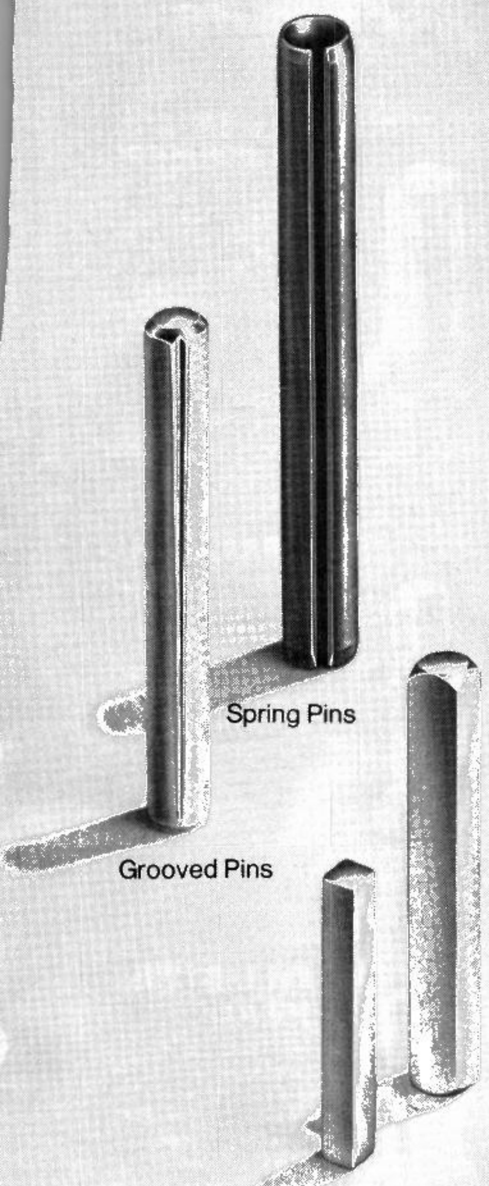
Conical washers are used with screws to add spring takeup to screw elongation. Type L conical washers are designed for use with

CONICAL WASHERS

DRIV-LOK

Pins, Studs, Keys

infinite selection of fasteners... ...infinite number of applications



Spring Pins

Grooved Pins

Machine Keys

When you specify fasteners for metal or plastics, get an engineering sample from DRIV-LOK. Send a print or sketch, and you'll receive unbiased application aid from the only manufacturer of a complete line of Pins, Keys and Studs to approved A.N.S.I. Standards.

Gain the advantage of over 40 years of experience helping design engineers with fastening problems. Also high quality combined with competitive pricing and reliable delivery.

GROOVED PINS — solid holding action resists shock, vibration, fatigue; 8 standard types in wide selection of materials and finishes.

SPRING PINS — economical and self-locking; meet or exceed all applicable specifications; chamfered for easy insertion.

MACHINE KEYS — no head, no taper keys to your specifications for materials, configuration, heat treat, plating, machining.

KNURLED PINS — both diamond and straight knurls with variety of end configurations.

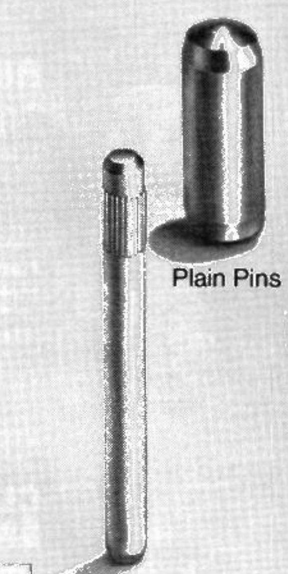
BARBED STUDS — unique design of impressed barbs for fastening plastics parts; reduce assembly time and costs.

STANDARD STUDS — economical fastening of light metals; complete selection of head and shank configurations.

CLEVIS PINS — with annular groove or drilled hole to facilitate fast assembly, disassembly.

PLAIN PINS — plain or centerless ground; can be hardened and chamfered.

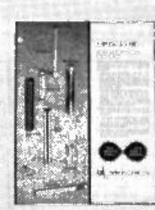
SPECIAL PINS — engineering and manufacturing capabilities to meet your special pin requirements.



Plain Pins

Knurled Pins

FREE FULL LINE BULLETIN



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Standard Studs

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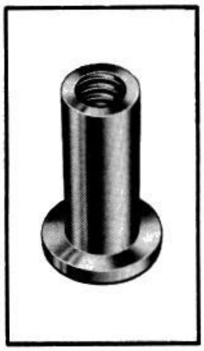
Special Pins

Barbed Studs

We've got all kinds of RIVNUT® fasteners for all kinds of jobs.



STANDARD

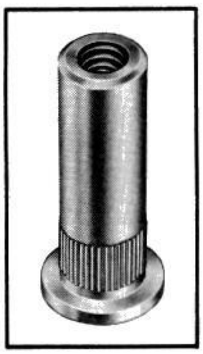
A tubular rivet with internal threads which is installed in seconds from one side of the work. Unified or metric threads. For installation in materials up to 7/8" thick. NAS1329 and 1330 specifications.

HEX

Hexagonal shanks provide excellent torque-out resistance. Low profile, high thread strength. Recommended for a wide range of rugged applications. Unified or metric threads.

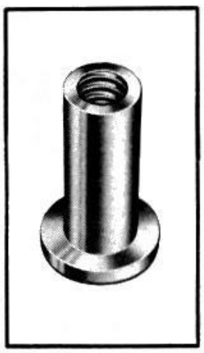
PLUSNUT® FASTENER

For rigid fastening in light sheet metal, fiberglass and plastics. Slotted shanks split to form flaps that distribute loads evenly over a large area. Excellent pull-out, torque and thread strength. Unified or metric threads.



RIBBED

The addition of ribs to the standard Rivnut® fastener provides extra resistance against torque-out when installed in most materials. Standard hole preparation. Unified or metric threads.

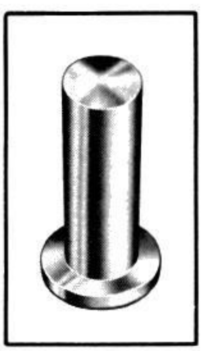


UNILOCK® FASTENER

Crimped at the end to provide an all-metal interference fit with attaching screw. Provides a tight assembly which helps resist vibration. Unified threads. Countersunk or flat head. Keyed and open-end. NAS1329 and 1330 specifications.

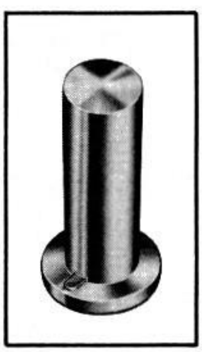
SEAL-HEAD

Alloy steel fasteners sealed by fuel-resistant rubber "O" rings against low and high pressures. Approved for primary aircraft structures.



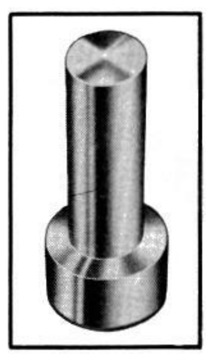
CLOSED END

Used to help keep low pressure gas and liquid from escaping through the fastener point. Also helps keep dirt out. Unified or metric threads.



KEYED

Assists torque resistance in vibration applications and where frequent assembly and disassembly is required. Unified or metric threads.



FILLISTER HEAD

Provides stand-off or spacer up to 3/8" in small thread sizes and up to 5/8" in larger thread sizes. Unified or metric threads.

For complete information about RIVNUT® fasteners, send for a copy of our **Design Guide.** Write to The BFGoodrich Company, Aerospace & Defense Division, Dept. 1810, 500 S. Main Street, Akron, Ohio 44318, U.S.A.

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CIRCLE **52**

unhardened screws. Type H series is for hardened screws. Conical washers are designed to flatten at approximately one-half the ultimate load of the screw.

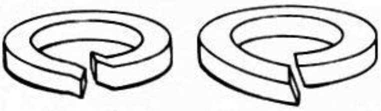
Cone washers do not have any auxiliary locking features other than friction. In the flattened position they are equivalent to any flat washer as far as locking action. When the tension in the screw relaxes and the washer assumes a cone shape there is less frictional area between the base of the cone and the part surface because the washer is resting on its rim. The frictional area at the nut or screw head is similarly reduced.

"Belleville washer" is a term commonly, but incorrectly, applied to conical washers. The Belleville washer, the invention of Julien Francais Belleville, has precise dimensional relationships. It gives greater spring action with load-bearing strengths comparable to a conical washer of the same size.

Some conical washers incorporate an off-center, circular plane, creating a secondary system which reinforces and increases the spring action of the basic coned washer.

Another conical washer with a flexible conical rim for initial loads and an arched secondary square cone for secondary loads gives more consistent clamp loads under a variety of conditions. It is frequently possible to replace a flat washer used in conjunction with a spring washer with this type fo conical washer.

Helical spring washers are made of slightly trapezoidal wire formed into a helix of one coil so that the free height is approximately twice the thickness of the washer section. They are usually made of hardened carbon steel, but are also fabricated from aluminum, silicon bronze, phosphor bronze, stainless steel, and K-Monel.



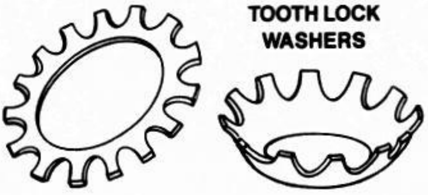
HELICAL SPRING WASHERS

The most commonly used regular helical spring washer has a spring reactance that comes into play when the tension in the bolt is reduced. Bolt tension is maintained by the expansion of the washer. When flattened, this washer becomes equivalent to a flat washer.

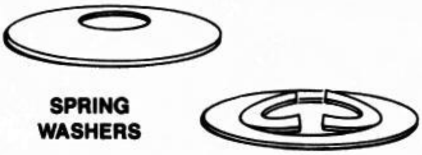
Tooth lockwashers are used with screw and nuts to add spring takeup to the screw elongation and to increase the frictional resistance under the screw head or nut face. They bite into both the head of the screw and the work surface to provide an interference lock. Even at zero tension the tooth lockwasher will provide frictional resistance to loosening.

A mechanical-interference tooth lockwasher has a series of shaped forms in its top surface. It is used with a screw that has mating wedge shapes formed on the under side of the head. Unlocking action increases the tension in the bolt. This washer is used where high heat might normally destroy the washer's spring characteristics.

TOOTH LOCK WASHERS



Spring washers have no industry standards except shapes. Except for the cone shape, they usually do not have a high value of spring reactance, but can be designed to have greater distance of spring action.



SPRING WASHERS

Spring washers are generally made of spring steel, but spring bronze or any other resilient material can be used.

Special-purpose washers, such as the finishing washer, eliminate the need for a countersunk hole and are used extensively for attaching fabric coverings. The outer rim grips the material over a large area.

The fairing washer, an aircraft development, is used with flat-head screws on aluminum skins. Holding pressure is spread over a large area, eliminating localized strains around the screws. The shape of this washer allows for flush surfaces.

Finishes of washers are generally unplated or uncoated unless a corrosion preventative treatment is specified. Unhardened flat washers are sometimes manufactured from precoated galvanized stock.

Heat-treated helical, flat, conical, and tooth washers are frequently electroplated with zinc or cadmium plate, and must be baked after plating to prevent hydrogen embrittlement. These parts can also be furnished with a phosphate and oil finish.

On very heavy platings (over 0.0005-in. thick) or on very thin heat-treated washers, it is generally better to specify mechanical cadmium or zinc plate in place of electro-cadmium or zinc.

Metric washers can be obtained from suppliers and usually are dimensioned as a direct conversion of the inches into metric dimensions.