

TECHNICAL DATA

Thread and Form Rolling

Reed
Machinery, Inc.

*10A New Bond Street
tel: 1-508-595-9090*

Worcester

Massachusetts

fax: 1-508-595-0002

01606

USA

www.reed-machinery.com

CONTENTS

	Page No.
History and Development	4
Thread Rolling Process	5
Advantages	6
Application	9
Equipment and Tools	12
Reciprocating (Flat Die) Machines	12
Rotary Planetary Machines	12
Cylindrical Die Machines	13
Rates of Production	15
Machine Recommendations	15
Thread Rolling Attachments and Holders	16
Thread Rolling Tools	18
Rollability of Materials	21
Material Selection	23
Rollability Ratings	26
Machinability Ratings	27
Material Grading Reference	33
Reed Thread Rolling Equipment Selection	34
Reed Thread Rolling Tool Selection	35

History and Development

Although widespread knowledge of thread rolling is a fairly recent development, the process itself is not new. Records now available indicate that it was first demonstrated early in the nineteenth century. Patent office files show that many different people worked on its development, and that most of its fundamentals were known nearly a hundred years ago. It did not, however, begin to be used in regular production until about 1880, and its use from then until the early 1940's was confined almost entirely to the fastener industry.

The slowness of industry to accept the rolling process is a little hard to explain. It was probably due in part to inertia that has, in a similar way, retarded the development of even older processes such as broaching and honing. It was also due to the inferior quality of the early cold forged fasteners, and to the lack of versatility of the production tools and equipment then available.

It must be admitted that the first cold forged fasteners were decidedly inferior products. They were weak and unreliable because the wrought iron and Bessemer steel, commonly used as raw material, tended to fold and fracture during heading and split during rolling. They varied widely in diameter and roundness because of the difficulties in controlling wire and header die sizes. Thread form and lead were also unreliable because accurate thread rolling dies were difficult to obtain, and machines were light and without means for easily making fine adjustments.

Unfortunately, for the rolling process, it became the practice to market these inferior cold forged fasteners under the "Rolled Thread" label to distinguish them from the first-quality fasteners, then cut from the bar, that were marketed under the "Cut Thread" label. It was natural, therefore, that the term "Rolled Thread" came to be associated in the minds of the public with an inferior and unreliable product.

Progress was made, however, in overcoming these early defects. Open hearth steels, including high strength alloys, were soon developed with excellent cold forging properties, so that weak heads and split threads were practically eliminated.

The extruding process, for the production of blanks with full-sized bodies and ends reduced to rolling diameter, was developed during the 20's and widely adopted, making possible the economical production of bolts with uniform diameter of body and thread.

The use of tungsten carbide in wire drawing, heading and extruding dies, that became prevalent

in the 30's, made possible closer tolerances on diameter and roundness of blanks.

Thread rolling machines were made heavier and more reliable, thread rolling dies were developed with accuracy comparable to the accuracy of thread gauges, and operating techniques were steadily improved.

Thus, all the defects that characterized the early cold forged fasteners were finally overcome and, in addition, it was found that with proper materials, tools and fabricating techniques, cold working actually strengthened the products so that by the late 30's thread rolling had been accepted throughout the fastener industry as the preferred method of threading its highest quality products.

It is interesting that, as these improvements were being made, no point was found at which the labels could conveniently be changed, and first-quality fasteners continued to be referred to as "cut thread," even after their makers had adopted the cold forging processes of heading, extruding and rolling. There can be little doubt, therefore, that this nomenclature which was so firmly imbedded throughout the metalworking industry perpetuated the prejudice against rolled threads in the minds of otherwise well-informed purchasers and engineers long after the faults of the early cold forged fasteners had been completely eliminated. It was not until the second world war, that the production of fasteners for the aircraft industry finally and conclusively proved to remaining skeptics the true worth of the rolling process.

The reciprocating flat die thread rolling machine which was the only type commercially available prior to early 40's, is ideally suited for high speed threading of fasteners up to approximately one inch diameter, but has been used in a limited way for the threading of component parts other than fasteners.

To provide greater ease in obtaining accurate threads on precision fasteners and to expand the application of thread rolling to all types of component parts, cylindrical die machines were developed. This type of machine extends the range of thread rolling to a wide variety of formed and threaded parts.

Thread rolling on automatic screw machines and automatic lathes is now accepted as a standard economical method of producing smooth precision threads at high production rates. This acceptance by the trade has been brought about by the steady improvements in the design of the thread rolling attachments now available.

The development of the thread rolling process and thread rolling equipment is by no means completed. On the contrary, there is more interest and activity in the process now than at any time in its history. New types of machines and attachments are constantly being developed, and the pro-

cess is daily finding new applications where its speed, accuracy, uniformity, and the strength that it adds to the parts rolled, can be used to reduce costs and improve the quality of an endless number of threaded parts.

The Thread Rolling Process

Thread and form rolling is a simple cold forging process confined almost entirely to external threads. It is referred to as a cold forging process because most rolling is done on cold blanks. However, rolling of threads on heated blanks has been beneficial on some applications. Today, thread and form rolling is accepted by many industries as a preferred method of producing uniform, smooth, precise threads of superior physical qualities.

Hardened steel dies are used to roll the threads. The threaded faces of these dies are pressed against the periphery of a plain cylindrical blank and re-form the surface of the blank into threads

as the blank rolls on the die faces (Fig. 1). The working faces of the dies have a thread form which is the reverse of the thread to be produced. In penetrating the surface of the blank, the dies displace the material to form the roots of the thread and force the displaced material radially outward to form the crests of the thread. The blank has a diameter part way between the major and minor diameter of the thread.

A comparison of a cut and rolled thread is shown in Fig. 2. Unlike other threading processes, no material is removed and consequently no chips are produced.

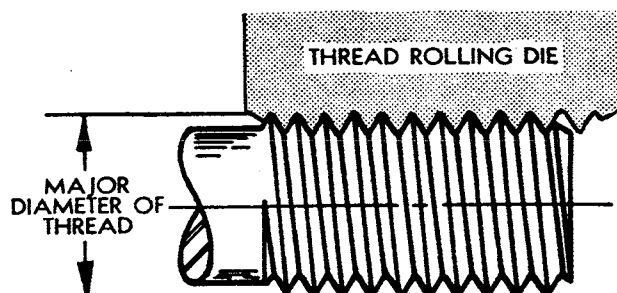
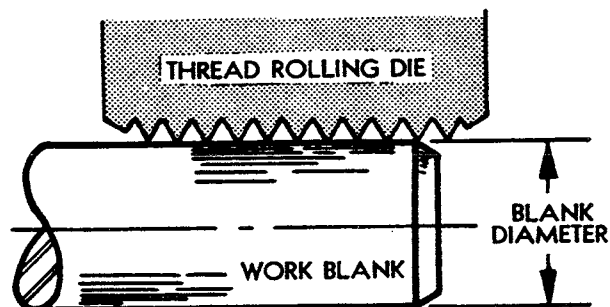
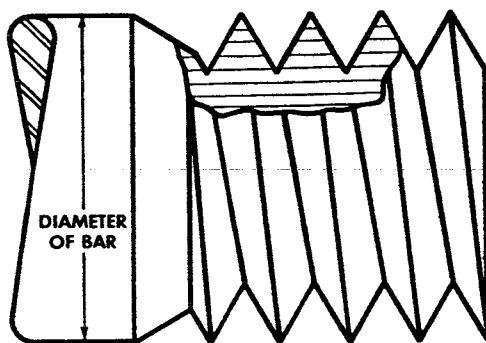
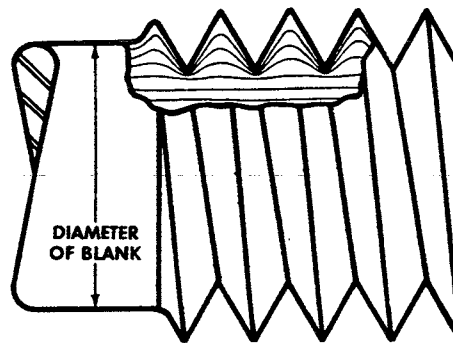


FIG. 1



Cut Thread



Rolled Thread

FIG. 2

Advantages of Rolled Threads

Rolled threads have improved physical characteristics, greater accuracy and a high degree of surface finish. They are uniformly produced at high rates of production with no wasting of material. These six major advantages account for the increased use of thread rolling.

Physical Characteristics

The cold forging that threads receive during the rolling process strengthens them in tension, shear and fatigue.

Tensile Strength

The cold working of the surface increases the tensile strength of the metal worked, and static tensile tests have frequently recorded increases on the order of 10% in the breaking strength of the parts.

Shear Strength

When a thread is rolled the fibers of the material are not severed as they are in other methods of screw thread production, as shown in Fig. 3, but are re-formed in continuous unbroken lines following the contours of the threads, as in any good forging as shown in Fig 4. Rolled threads resist stripping because shear failures must take place across rather than with the grain.

Resistance to Fatigue

Thread rolling increases the part's resistance to fatigue failure in several different ways.

Rolling between smooth dies leaves the thread with smooth burnished roots and flanks, free from tears, chatter or cutter marks that can serve as focal points of stress and, therefore, starting points for fatigue failures.

Rolling also leaves the surface layers of the thread, particularly those in the roots, stressed in compression. These compressive stresses must be

overcome before the tensile stresses can be built up which alone, can cause fatigue failures. This increase in root hardness, up to 30%, adds considerably to the parts resistance to fatigue.

It has been repeatedly demonstrated that any fastener that is properly tightened when it is installed, and remains tight throughout its life, is less likely to fail by fatigue than one that is assembled loosely, or that becomes loosened in service. Threads produced by any of the cutting methods have a surface condition consisting of partly torn-away particles that gradually beat down in service permitting the fastener to loosen. Rolled threads, on the contrary, which are compacted and burnished during threading, are less prone to loosen, and, thus ordinarily have longer fatigue lives.

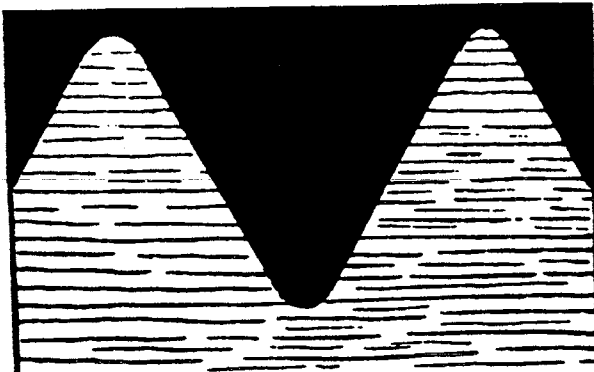
Rolled threads show no loss of fatigue strength when heated for several hours to temperatures up to 500° Fahrenheit; whereas, fatigue strengths of threads produced by other means are lowered by as much as 25% by the same treatment.

Improved fatigue strength, resulting from all the above factors, is reported to be on the order of 50-75%. On heat-treated bolts from Rockwell C36 to 40 hardness, that have the threads rolled after heat-treatment, tests show increased fatigue strength of 5 to 10 times that of cut threads.

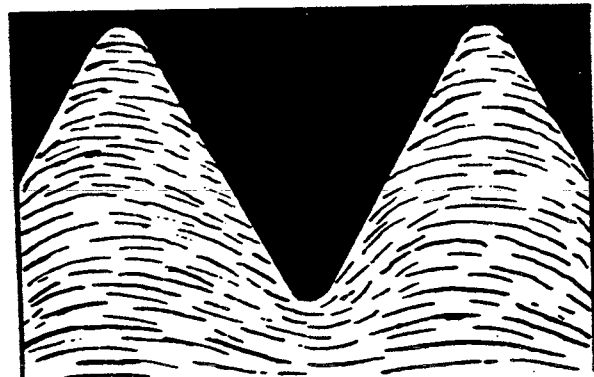
Accuracy

The production of accurate threads normally requires that close control be exercised over pitch diameter, thread angle, lead, taper, roundness and drunkenness.

There are a number of reasons why it is inherently easier to achieve accuracy on pitch diameter, thread angle, lead and taper by rolling than by other processes and, what is often equally important, to maintain that accuracy over long periods. Control over roundness and drunkenness, while no easier to maintain by rolling than by other processes, is usually within the capacity of the average operator.



Cut Thread
FIG. 3



Rolled Thread
FIG. 4

Diameters

Major, pitch and minor diameters as shown in Fig. 5 are dependent upon the diameter of the blank, the thread form of the dies, and the setup and rigidity of the equipment used.

Controlling the diameter of plain cylindrical blanks within close tolerances is relatively easy and economical either by using carbide dies, if the blanks are cold forged or cold drawn, or by turning, shaving or centerless grinding if blanks are made from a bar stock. Thread rolling dies of either the flat or cylindrical types can now have their thread forms ground to the degree of accuracy required. The more modern thread rolling machines are rugged and easily adjusted. Thus, all diameters of the thread are readily controlled.

The tolerances specified for pitch diameter include all deviations of pitch diameter, lead and angle. Taper on pitch diameter depends upon the straightness of the blank and the setup of the machine, both of which are easily controlled on modern machines.

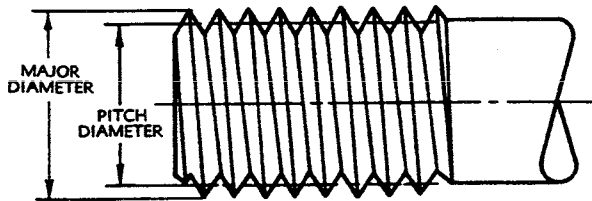


FIG. 5

Thread Angle and Lead

The accuracy of the thread angle and the lead produced as shown in Fig. 6, is almost entirely dependent upon the accuracy of the dies. In most cases, the thread angle and lead of the thread on the die is exactly reproduced on the material rolled.

The accuracy of the lead produced can also be influenced by the setup of the dies and the material being rolled. Some types of harder and stiffer materials have a tendency to "spring back" after rolling with the result that the lead on the work may be contracted a very small amount. In such cases, dies with expanded lead may be used and will uniformly produce threads of the correct lead.

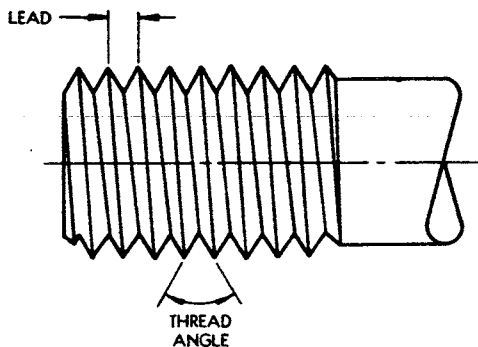


FIG. 6

Drunkenness

The control of drunkenness is dependent upon using dies with correct lead angles and upon careful matching and proper feeding and positioning of the blank in relation to the dies. Refer to Fig. 7.

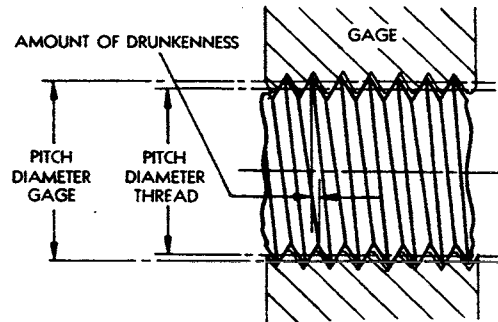


FIG. 7

Roundness

Roundness is dependent upon the roundness and uniformity of hardness of the blank, and upon the rate of application and release of the die pressure. If the dies are designed and set up to apply and release pressure gradually and uniformly, close tolerances on roundness may be steadily maintained. Refer to Fig. 8.

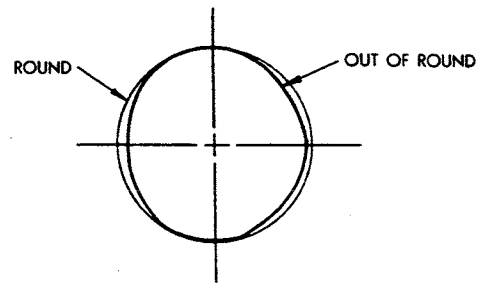


FIG. 8

Uniformity

If sufficient care is used it is possible to produce extremely accurate threads by any of the common threading methods, but rolling is unique in its inherent ability to maintain the accuracy of the original setup during long runs of high speed production.

The thread form of a set of thread rolling dies is faithfully reproduced on the parts, and does not change appreciably during the entire life of the dies. Thread rolling dies do not wear out in the same manner as do other threading tools. Wear, instead of being concentrated on a sharp cutting edge, is distributed over a broad surface, and the rolling action is relatively free from friction. Therefore, the thread form of a rolling die is not changed by erosion, nor does it fail to reproduce itself because of dullness or adhesion. It cannot be altered by improper sharpening, as sharpening is never required.

Thread rolling dies fail either by fatigue crumbling of the crests, or by spawling away of entire threads. Either type of failure is readily detected on the dies, which may be removed as soon as the failure has proceeded far enough to be noticed on the threads.

It should be noted that it is often possible to continue to use dies long after the first signs of failure begin to appear, as subsequent contacts of the work with undamaged portions of the dies will iron out marks made by the crumbled portions.

It has been found in practice that if the blanks are uniform the dimensions of the finished threads will change very little, if at all, so long as the dies remain whole. This saves much expensive inspection as, by watching the dies and by occasional checking, the operators can obtain accurate and uniform threads over long runs of work.

Smooth Finish

In cold forming operations the surface finish left on the work is a close approximation of the surface finish of the dies. This holds true in the case of thread rolling except that the threads produced are ordinarily smoother than the dies or rolls. This improvement is accounted for by the slight slipping and burnishing that the thread always receives as it rolls against the dies.

**Table I
Comparison of
Common Thread Finishes**

TYPE OF THREAD	SURFACE ROUGHNESS — MICRO INCHES							
	250	125	63	32	16	8	4	2
SCREW MACHINE CHASED THREADS								
MILLED THREADS								
GROUND THREADS								
ROLLED THREADS								

By using carefully ground and polished dies and smoothly finished blanks, the ultimate in burnished threads can be attained. Even when dies have been intentionally roughened to prevent slipping, the finishes secured will compare favorably with the finishes that are produced by other threading processes.

Rolling produces much the same finish on the work regardless of the properties of the material being rolled. For example: fully annealed 1010; free cutting screw stock, such as 1112 or 1335; alloy steels, such as 2330, 3140, and 6150, either annealed or heat-treated to as high as RC35; the various stainless steels and tool steels, including high speed steel, all come out with the same characteristic burnished finish and are hardly distinguishable from each other. Similarly most non-ferrous metals, regardless of hardness of cutting properties, may be rolled with a smooth finish.

A comparison of thread finishes commonly produced by the various threading methods is shown in Table I.

Material Savings

Where blanks are prepared by heading, extruding or stamping, or where the thread is the largest diameter on the part, as in the case of a stud, rolling will save material. No chips are produced in the rolling process. The blank is made smaller than the finished thread, and material that is pressed out of the roots of the thread is rolled up to form the crests.

This results in savings ranging from about 15% on larger diameter threads to over 27% on smaller diameter threads. Table II shows the savings for a number of representative thread sizes when the blanks can be drawn or extruded to the rolling diameters.

On stampings, the thickness of metal from which the stamping is made can often be reduced. This also reduces the weight of the scrap strip or sheet from which the stamping is made.

Table II — Material Savings

Thread Size	Material Saving	Thread Size	Material Saving
8-32	24%	¾-10	16%
¼-20	25%	1-8	18%
⅜-16	27%	1¼-7	16%
½-13	19%	1½-6	16%
⅝-11	19%	2-4½	15%

Speed and Economy

Rolling has long been conceded to be the fastest method of producing screw threads. Thread rolling machines may be manually loaded or arranged with semiautomatic or completely automatic feeding devices. Fully automatic hopper-fed thread rolling machines can be operated in batteries with several machines to each operator. Although it is generally appreciated that thread rolling has proved economical on large quantity production, similar savings and economies are realized on small lot production.

Threads may be rolled on automatic screw machines without reducing spindle speeds, and the fact that rolling can be done on the collet end of the part behind a shoulder often saves a secondary threading operation.

Thread rolling dies do not require sharpening. Therefore, down time is reduced and sharpening and resetting labor is saved. The inherent uniformity of rolled threads also saves inspection labor.

Application

Versatility of Application

Thread rolling is a versatile process capable of forming a wide variety of threads on many different materials and, in addition, capable of performing several non-threading operations.

Thread Forms

All of the commonly used thread forms can be produced by rolling, including

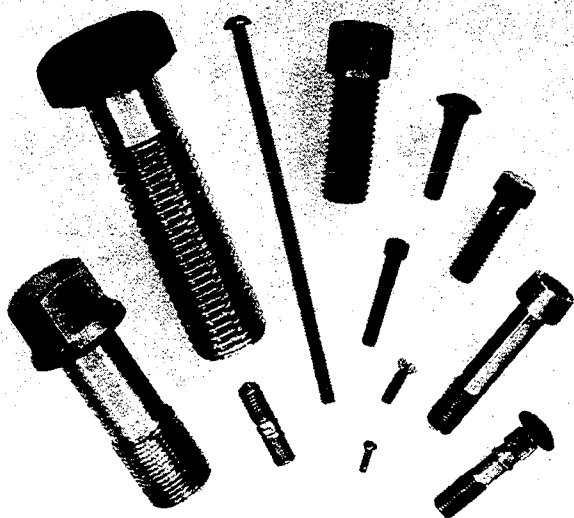
Unified and American Standard
Acme
Worm
Spark Plug
Whitworth

Aeronautical National Taper Pipe (ANPT)
Gimlet Point Wood and Lag Screw
Type A Tapping Screw
Type B and BP Tapping Screws

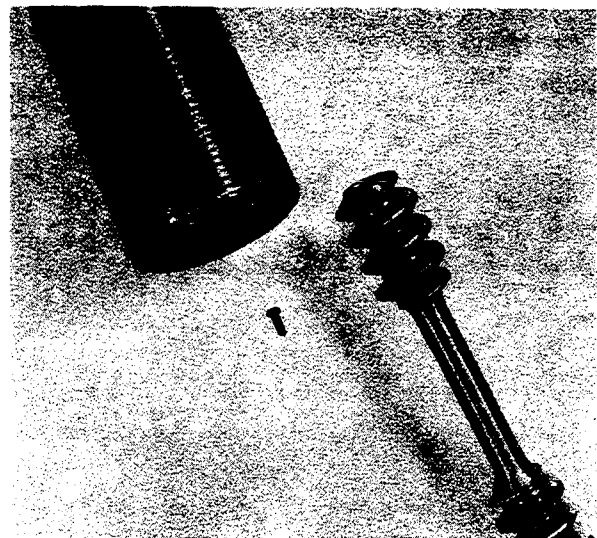
British Association International Standard Metric
American Standard Taper Pipe (NPT)
American Standard Dryseal Taper Pipe (NPTF)
American Standard Straight Pipe for mechanical joints (NPSM)
American Standard Straight Pipe for locknut pipe threads (NPSL)
American Standard Coupling Thread for hose couplings and nipples (NPSH)
American Standard Taper Pipe for railing fittings (NPTR)

Type C Tapping Screw
Type F and BF Tapping Screws
Type U Metallic Drive Screw
Drive Screw for Wood Drive Nail
Screw Nail
Screw Extractor
Tap
Aero
Screw Shell for Lamp Sockets
Dardelet and "Lok-Thred"
Buttress
Lowenherz

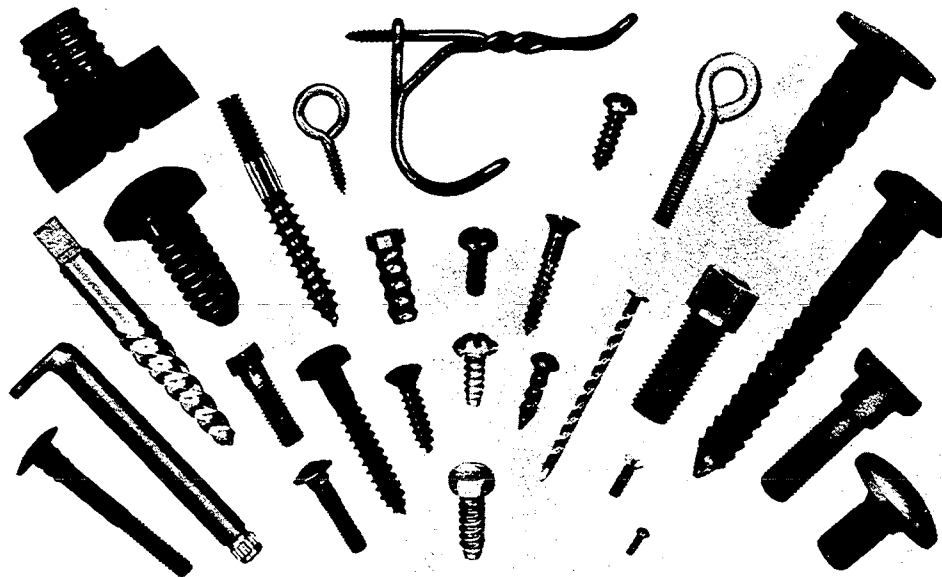
*Licensed Thread



Screws, Bolts and Precision Heat-treated Aircraft Parts



Diameters from .060" to 5" with 2 to 80 threads per inch are readily rolled.



Miscellaneous Parts with Straight, Gimlet Point and Special Threads, Knurling and Other Rolled Forms

Left-hand Threads, Annular Rings and Multiple Threads

By using suitable dies and making no other change in the setup or operation, it is possible to roll left-hand threads, annular rings, multiple threads.

Piloted and Step Threads

Fasteners with two or three undersized threads on the outer end to serve as a pilot, and several oversized threads on the inner end to serve as a locking device can be rolled in a single operation.

Rolling Chamfer During Threading Operation

Under certain conditions, the ends of blanks can be slightly chamfered or beveled during the thread rolling operation.

Tapered Threads

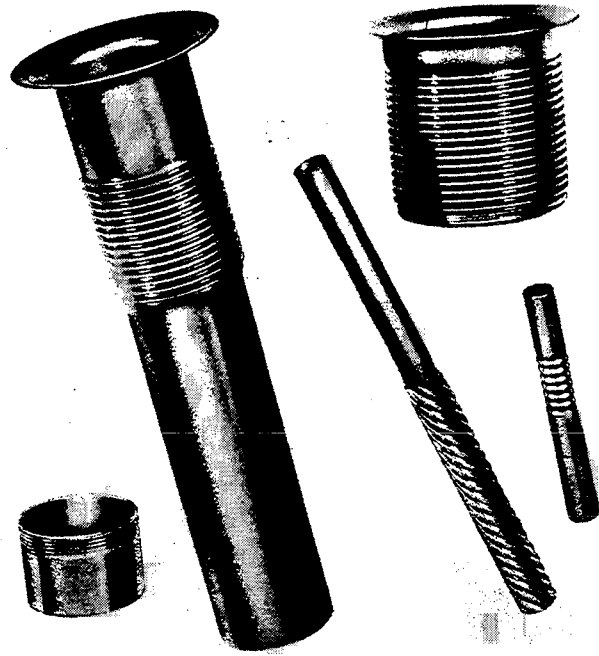
Threads with either front or back taper can be easily rolled by simply adjusting dies regularly used for straight threads. Tapered dies are required for pipe and similar threads.

Hollow Parts

Cylindrical Three Die Machines can thread hollow cylinders either by forging the thread in the usual manner, if the wall is thick enough, or by crimping the entire wall where it is very thin.

Metal Stampings

Threads on metal stampings can be rolled easily due to the ductility of the material used in the stampings. In many instances, thinner metal can be used because the diameter of the portion to be threaded need only be made to the approximate pitch diameter of the thread without making any

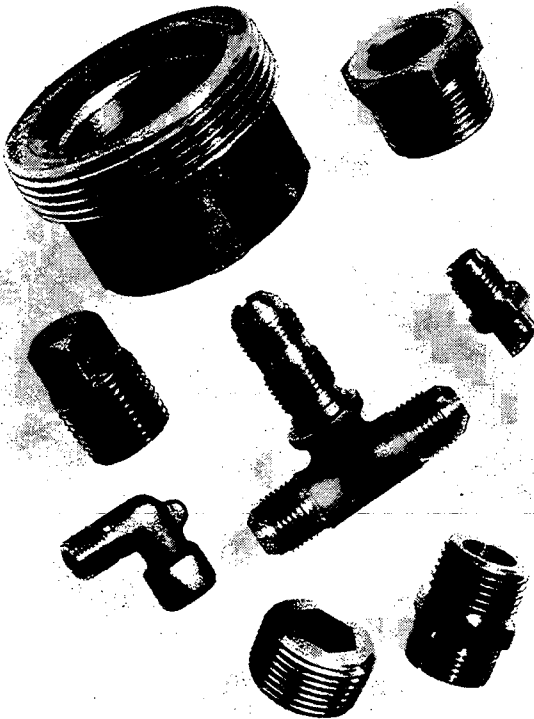


Hollow Parts are Rolled with Forged or Crimped Threads Depending Upon Thickness of Metal

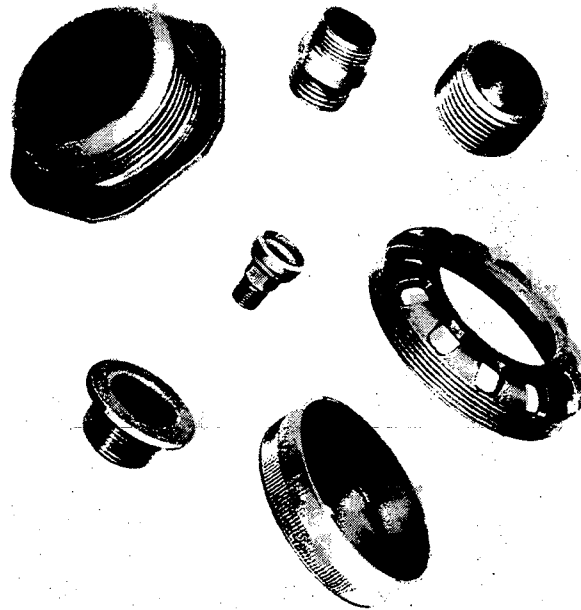
reduction to the corresponding inside diameter of the stamping.

Screw and Washer Assemblies

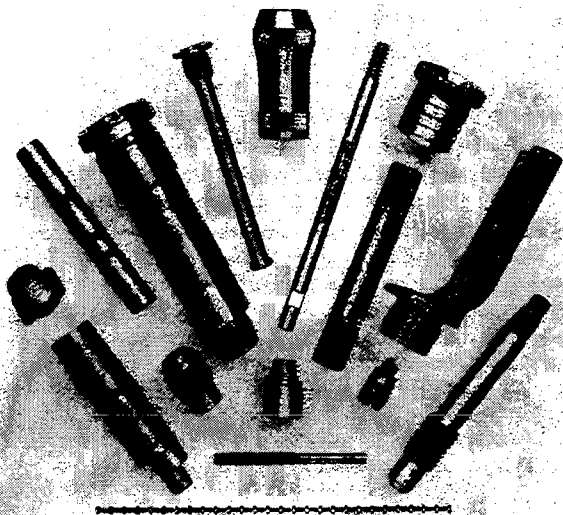
Manufacturers of screws that have washers assembled under the heads take advantage of the increased diameter of the rolled threads to keep these washers from falling off. The washers are usually assembled automatically on the blank during the thread rolling operation.



Pipe Fittings with Straight and Tapered Threads, Including ANPT and Dryseal



Threads are Easily Rolled on Metal Stampings and Rolling Permits Use of Thinner Metals



Component Parts of Various Shapes and Materials with Precision Threads, Knurling, Splines, Serrations, Grooves, Burnished Surfaces and Other Special Forms.

Simultaneous Threading and Fluting

The flutes and threads of self-tapping and special screws are frequently rolled simultaneously.

Knurling, Splines and Serrations

Thread rolling machines are used to produce straight, diagonal and diamond knurling and involute splines and serrations.

Oil Grooves

Oil grooves rolled in the surfaces of shafts before the final operation, have proved very satisfactory because of their low cost and smooth finish.

Non-Uniform Leads

It is possible to roll threaded parts with pilot threads that are axially displaced a few thousandths from helical continuity with the rest of the threads.

Burnishing

Thread rolling machines fitted with flat or

formed dies are used to burnish parts that have been preformed on lathes or screw machines.

Irregular Shaped Parts

Since it is unnecessary to grip the part in any holding device during the rolling operation, thread rolling provides a method for easily threading irregular shaped parts.

Threading Close to Shoulders

Though dies usually have small bevels to prevent breakage along the edge, it is possible to use them with blunt starts to produce a full thread close to the shoulder.

Thru-Feed Rolling of Long Threads

While most thread rolling is done by the in-feed method, in which the entire length of thread is formed simultaneously, cylindrical die machines can be adapted to feed long lengths of thread either by thru-feed or end-feed method.

Sizes That Can Be Rolled

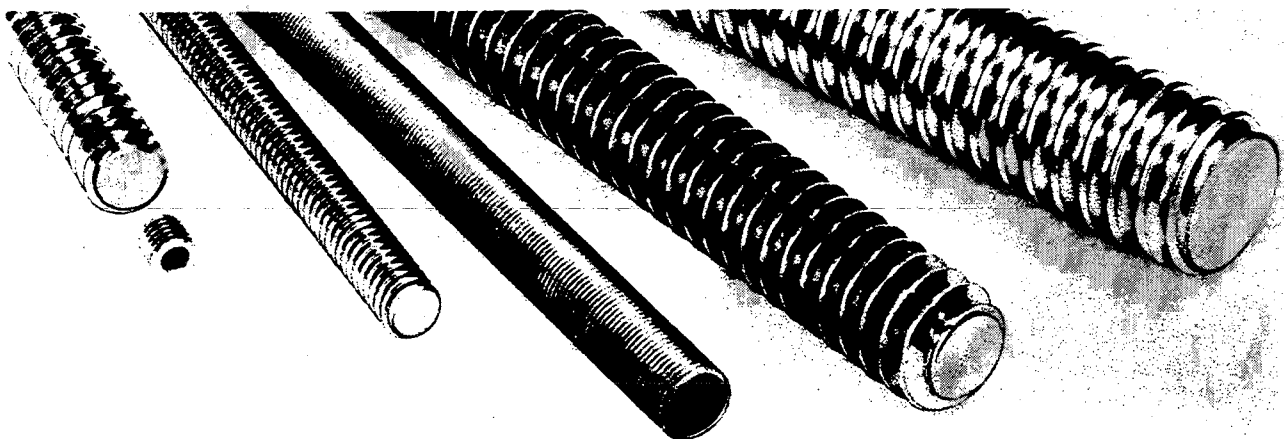
Diameters from .060" to 5" can be readily rolled on existing equipment, and special equipment for both larger and smaller threads can be developed when required. Threads per inch ranging from 2 to 80 are commonly rolled, and dies for both finer and coarser threads can be produced.

Threading Hard Blanks

Thread rolling is feasible on practically all malleable materials of hardnesses through Rockwell C40 and in some instances higher. Wide differences will be observed in the die life, however. Dies will produce several million pieces per setting on soft ductile materials down to only a few thousand pieces per setting on harder heat-treated and less ductile materials.

Materials That Can Be Rolled

Practically all of the commonly used carbon and alloy steels including stainless and tool steels are regularly threaded by the rolling process. Non-ferrous metals including brasses, bronzes, aluminums, copper, beryllium copper, titanium, nickel, silver, gold, monel, Everdur and some die casting alloys are also rolled in regular production runs.



Thru-feed Rolling is Used for Continuous Threading of Long Bars and Short Headless Parts.

Equipment and Tools

The equipment and tools used for producing rolled threads are usually dependent on the nature of the part, the type and specifications of thread and the quantities required. Small, as well as large quantities may be rolled economically on hand-feed machines since the setup is normally simple and quick, and very little time is consumed in rolling a thread. The uniformity of the threads produced by thread rolling eliminates costly inspection. A guide for the selection of Reed Thread Rolling Equipment and Tools appears in Tables XI and XII on pages 34 and 35.

To secure the most satisfactory rolling conditions and die life, it is important that the proper type and size of equipment be used. Rugged equipment with ample power is required to roll threads on heat-treated parts.

The best rolling conditions and maximum die life can only be obtained when correct die speeds and number of blank revolutions are used for rolling the thread. This is particularly true when close accuracy for roundness and size is required, especially on harder materials. Too many revolutions of the blank may have a tendency to work-harden some types of materials, and thereby reduce the life of the dies.

Equipment

Most of the threads produced today are rolled on thread rolling machines and automatic screw machines and automatic lathes. The thread rolling machines use flat and cylindrical dies, while the automatic screw machines use cylindrical thread rolls. In most instances, the entire length of thread is formed by the in-feed method without endwise feeding of the blanks or dies. Thru-feeding of the blanks is used on cylindrical die machines for continuous threading of long bars and short headless parts.

Reciprocating (Flat Die) Machines

Flat dies as shown in Fig. 9 are used in reciprocating type of thread rollers, including boltmaking

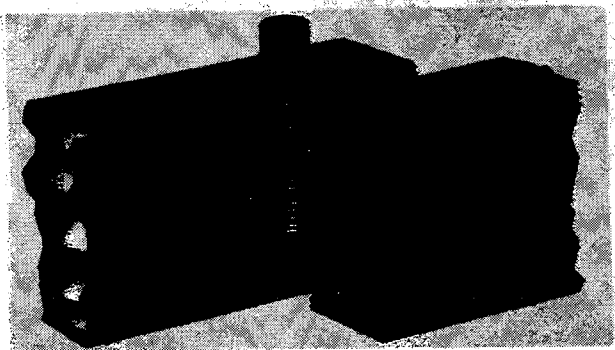


FIG. 9
Flat-die Thread Rolling

type machines. These machines are made in a number of sizes, each for a limited diameter range and with a specified length of die.

Two dies are used; one stationary and one moving — and the rolling faces of the dies are located opposite each other. A thread is rolled on one blank at a time during the forward stroke of the machine. There is no appreciable axial movement of the blank during rolling. The diameter of the finished thread is controlled by the diameter of the blank and the distance between the faces of the dies at the finish end of the stroke. Refer to Fig. 10.

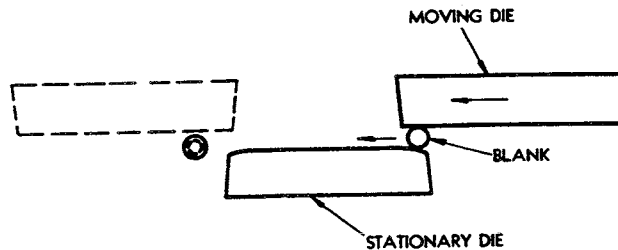


FIG. 10
Reciprocating (Flat-Die) Machine

The number of revolutions provided for rolling a thread on a blank is dependent on the die length, and the rate of penetration is determined by the shape of the die. The largest size threads rolled on reciprocating machines approximate 1 inch.

The penetration rate is usually much greater at the beginning of the rolling stroke than at the end. When rolling steel parts on a reciprocating type of machine, long threads of the maximum diameter capacity usually require more revolutions of the blank than short threads. Therefore it is sometimes necessary to use the next larger size machine.

Although taper pipe threads are most commonly rolled on cylindrical die machines, reciprocating machines are used for rolling pipe plugs in some limited cases. However, it should be understood that considerable care must be exercised when rolling taper pipe threads on reciprocating machines.

Considerable heat is generated in rolling heat-treated blanks, especially larger sizes, and slower rolling speeds are required on reciprocating machines to minimize this heating condition. A copious supply of coolant is commonly used to reduce the temperatures of both the blanks and the dies. Special refrigerated coolant units are sometimes used for this purpose.

Rotary Planetary Machines

These recently developed machines have one central rotary die on a fixed axis and one or more stationary concave segment dies located to the outside of the rotary die as shown in Fig. 11.

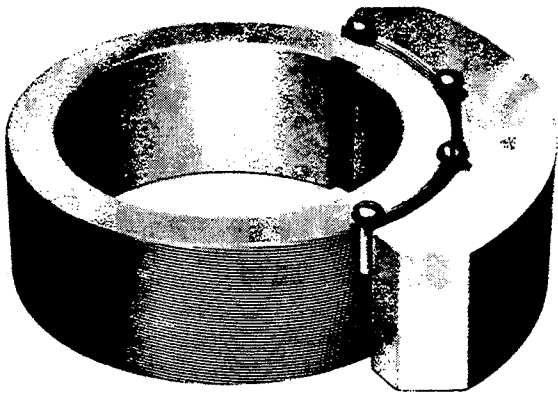


FIG. 11
Rotary Planetary Thread Rolling

The starting end of the segment die is set so the segment and rotary dies will just contact the blank. The finishing end of the segment die is set closer to the axis of the rotary die so the thread is fully formed when the blank rolls past the finish end of the segment die. One or several blanks may be rolling in a segment die at one time dependent on the setup. There is no appreciable axial movement of the blank during rolling. Refer to Fig. 12.

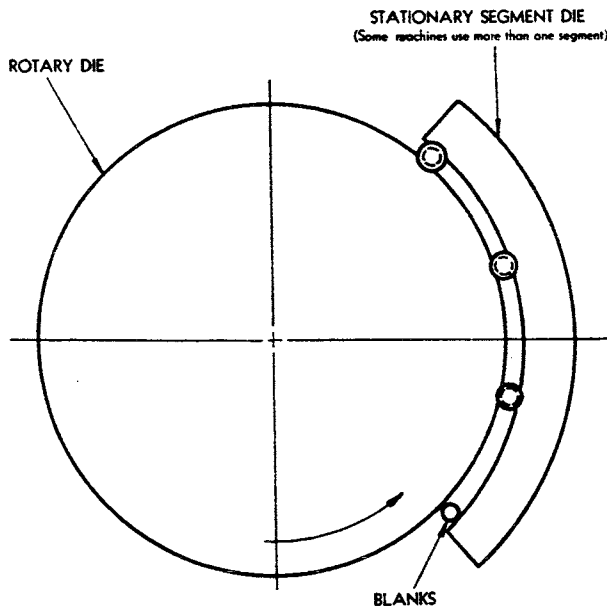


FIG. 12
Rotary Planetary Machine

These machines are made in several sizes, with limited diameter ranges. Each size machine has a specified length of segment die and the number of revolutions provided for rolling a thread on a blank is dependent on the segment die length. Speeds may be varied to accommodate the rolling of different kinds and hardnesses of materials.

Cylindrical Die Machines

Cylindrical die machines have a wide range of speeds and feeds, and are widely used for in-feed rolling with no appreciable axial movement of the blank during rolling. Since the dies are circular in shape there are no limitations on the number of work revolutions provided for the rolling of a thread or the rate at which the dies feed into the work.

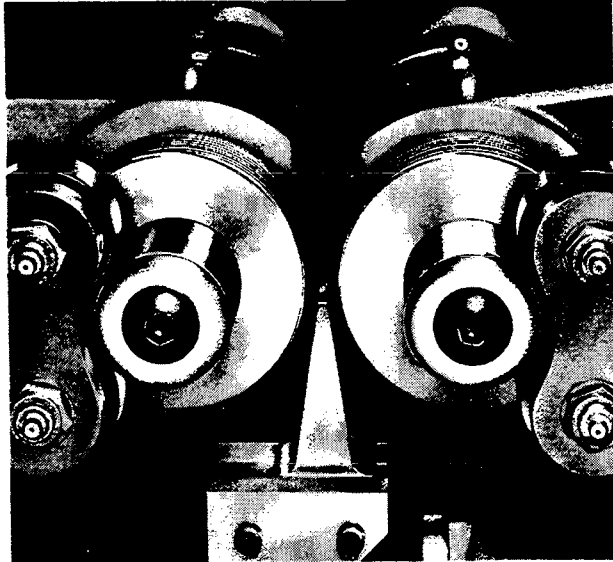


FIG. 13
Two Cylindrical Die Thread Rolling

Cylindrical die machines are made with two or three dies as shown in Figs. 13 and 14, diameter capacities up to 5 inches.

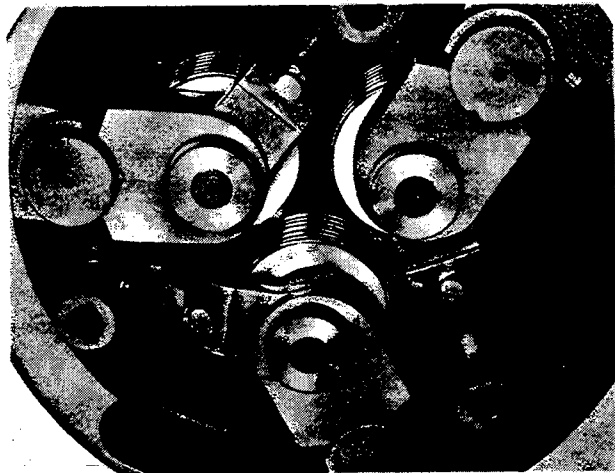


FIG. 14
Three Cylindrical Die Thread Rolling

Both types of cylindrical die machines can be adapted to feed the blank axially which is known as thru-feed rolling. Either short parts or long lengths of bars, up to approximately 20 feet long, can be rolled. The three-die machines can feed either hollow or solid blanks through the dies.

On cylindrical machines the rate of penetration is controlled by the amount of feed applied to the dies for each revolution of the blank. The total die penetration per revolution of the blank varies with different machines, kinds of work and types and hardnesses of materials rolled. Lower penetration rates apply to the harder materials, hollow parts or parts with non-rigid cross section. Materials with work hardening characteristics are usually rolled at higher penetration rates. Awkward top-heavy shaped work is ordinary rolled at slower speeds and sometimes supported by simple work supports or counterbalanced fixtures.

The speeds for rolling depend on the type and size of work, material and equipment used. High production rates can be maintained on cylindrical machines when rolling harder materials by increasing die speeds when a reduced rate of penetration is required.

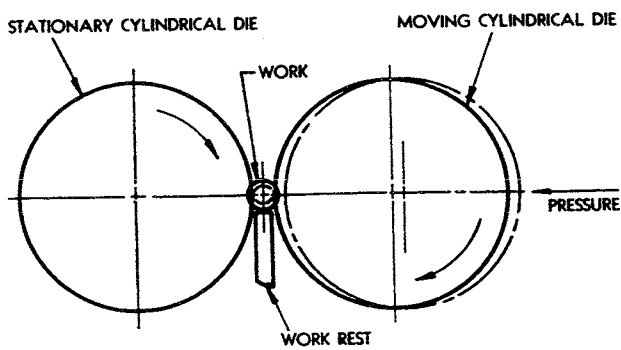


FIG. 15

Cylindrical Die Machine — 2 Die Type

Two cylindrical die machines have two opposed dies mounted on parallel axes and the blank to be rolled is supported on a work rest between the dies as shown in Fig. 15. The dies rotate in the same direction.

For in-feed rolling, the axis of one die is stationary and the axis of the other die moves toward the axis of the stationary die to roll the thread

on the blank. The moving die then recedes to release the threaded blank. The diameter of the finished thread is controlled by the size of the blank, the distance between the dies and the position of the center of the blank in relation to the centers of the dies. The center of the blank raises from the stationary work rest as the diameter of the blank increases during rolling.

Three cylindrical die machines are made in both vertical and horizontal types and have three dies equally spaced around the blank which floats between them (Fig 16). The dies are mounted on parallel axes and rotate in the same direction. For in-feed rolling, all of the dies move toward the center of the blank to roll the threads and then recede to release the threaded blank. The diameter of the finished thread is controlled by the size of the blank and the distance between the three dies.

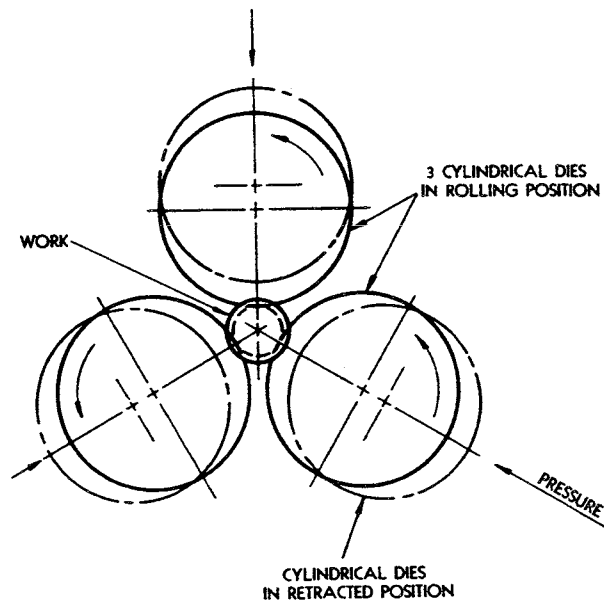


FIG. 16

Cylindrical Die Machine — 3 Die Type

Thru-Feed Rolling — Cylindrical Die Machines

Both types of cylindrical die machines can be adapted to feed the blank axially which is known as thru-feed rolling. This principle of thread rolling may be used with dies set at either parallel or skewed axis for thru-feeding of the work.

Parallel axis dies have their axes positioned parallel to the axis of the work — 0° skew. The feeding of the work is accomplished by using a different lead angle on the dies than the lead angle on the thread being rolled. The relationship of these lead angles determines the rate at which the work is fed between the dies.

With skewed axis rolling, the axes of the dies are skewed in relation to the axis of the work to provide the difference in lead angles for the feeding of the work.

For continuous thru-feed rolling of long bars or short headless parts, the axes of the dies in

either type of machine are located on a fixed center distance. After the work is brought in contact with the dies, it is automatically fed thru the dies as it is rolled. It is then discharged from the rear of the machine. Generally, skewed axis is more widely used on smaller work because of the higher production rates obtainable.

Thru-feed rolling with opening or closing of the dies is used when it is not possible to pass the work thru the machine because of shoulders or other obstacles. The work may be first thru-fed and the dies opened at the desired position to clear the shoulder; or the dies may be closed adjacent to the shoulder and the work is thru-fed out from the dies. Parallel axis dies are most often used for this operation.

Dies for parallel and skewed axis thru-feed rolling are designed differently.

Rates of Production

Production rates vary with the nature of the work, hardness and kind of material, and the equipment used. The rate of production is usually less for harder materials and where the work is difficult and slow to handle. Table III includes a comparison of approximate production rates in

pieces per minute for in-feed rolling based on the different types of thread rolling machines. Approximate production rates in inches per minute for thru-feed rolling with parallel and skewed axis dies in cylindrical die machines are also included. The rates given apply to thread diameters of 1/8" through 4" for parts made of soft carbon steels.

Table III – Approximate Production Rates – Thread Rolling Machines

Actual production rates depend on equipment used and the nature of the part

Diameter of Thread	In-feed Rolling Pieces Per Minute			Thru-feed Rolling Inches Per Minute	
	Rotary Planetary Machine	Reciprocating Machine	Cylindrical Die Machine	Cylindrical Die Machine	
				Parallel Axis	Skewed Axis
1/8	450-1800	40-400	20-250	20-40	140-280
3/16	350-1500	40-300	20-225	20-40	170-340
1/4	250-1200	30-225	20-200	20-40	200-400
5/16	200-600	30-175	15-180	25-50	160-330
3/8	150-500	30-125	15-160	25-50	130-260
1/2	100-400	25-90	15-140	25-55	110-240
5/8		25-70	10-120	30-70	90-275
3/4		20-60	10-100	25-65	80-300

Diameter of Thread	In-feed Rolling Pieces Per Minute			Thru-feed Rolling Inches Per Minute	
	Rotary Planetary Machine	Reciprocating Machine	Cylindrical Die Machine	Cylindrical Die Machine	
				Parallel Axis	Skewed Axis
1		20-50	8-80	20-50	70-225
1 1/2			6-60	15-30	50-130
2			4-40	10-20	30-80
2 1/2			4-25	6-15	20-50
3			2-15	4-10	15-40
3 1/2			1-10	2-5	10-25
4			1-5	1-3	5-10

Table IV – Thread and Form Rolling Machine Recommendations

Class of Work	Recommended Machines	Remarks
Commercial screws and bolts	Flat die, planetary, cylindrical two-and three-die types	Planetary machines are faster for small screws.
Gimlet-point threads	Flat die type, planetary type	Type machine depends upon requirements.
Precision threads	Flat die type, cylindrical two-die type, cylindrical three-die type	Cylindrical die machines preferred for speed and accuracy of setup.
Knurling	Flat die type, cylindrical two-die type, cylindrical three-die type	Flat die machines usually faster. Cylindrical die machines generally more positive when it is necessary to obtain an exact number of teeth.
Splines and Serrations	Special flat die type, and cylindrical die type	Type machine depends upon requirements.
Heat-treated work	Flat die type, cylindrical two-die type, cylindrical three-die type	Cylindrical die machines preferred when material is too hard to form satisfactorily in the limited number of revolutions available on flat die machines.
Tapered threads	Flat die type, cylindrical two-die type, cylindrical three-die type	Three-die cylindrical die machines preferred as three line contact prevents tendency to skew which causes spoiled work and short die life.
Long threads	Flat die type, cylindrical two-die type, cylindrical three-die type	Depths of die faces vary for each machine. Consult machine manufacturers for special lengths. Continuous threads may be rolled on cylindrical-die machines.
Short threads	Cylindrical two-die type, cylindrical three-die type	Threads less than one diameter long, particularly if work is long or heavy, can best be held in aligned rolling position with outboard support.
Hollow parts	Cylindrical two-die type, cylindrical three-die type	Slower penetration available in cylindrical die machine prevents crushing, which commonly occurs in flat die rolling of hollow cylinders. Three-die type gives better support than two-die type.
Large diameters	Cylindrical two-die type, cylindrical three-die type	Flat die machines limited to work about 1" in diameter. Cylindrical-die machines can accommodate work up to 6" in diameter under conditions within horsepower capacity.
Short runs and great variety	Flat die (hand feed), cylindrical two-die type, cylindrical three-die type	Cylindrical die machines have greater range of capacity and can handle short threads and hollow work that are impractical in flat die machines. Cylindrical machines more adaptable to small quantity production.

Thread Rolling on Screw Machines

Rolling threads by the in-feed method at high production rates on automatic screw machines and automatic lathes is done with attachments using one or two thread rolls. The thread is rolled very rapidly in one pass with relatively few revolutions of the work spindle required. Rolling threads close to a shoulder is readily performed, and as rolling threads on the collet end of the part behind a shoulder is possible, a secondary operation is often eliminated.

When rolling with one thread roll, the pressure is usually directly against the spindle and the blank. With two opposed rolls that form the thread between the rolls as they straddle the blank, the direct pressure on the spindle and blank is considerably less than the pressure exerted by one roll. Consequently, there is less spring of the blank and reduced wear on the spindle bearings when using two rolls.

Holders with a single roll, Fig. 17, ordinarily apply the rolling pressure on a blank radially with the roll feeding directly toward the center of the blank.

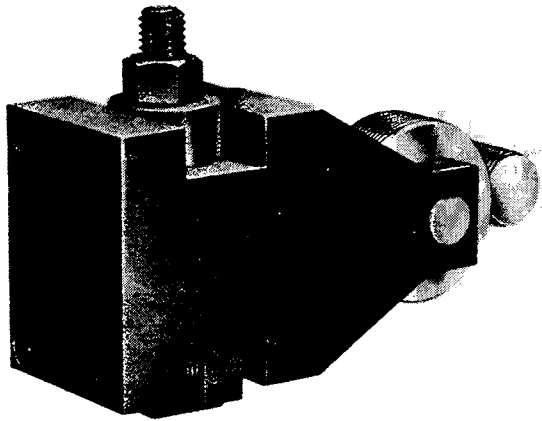


FIG. 17

The size of the finished thread is controlled by the size of the blank and the final positioning of the cross slide which determines the center distance between the roll and the blank at the time of completing the thread, Fig. 18.

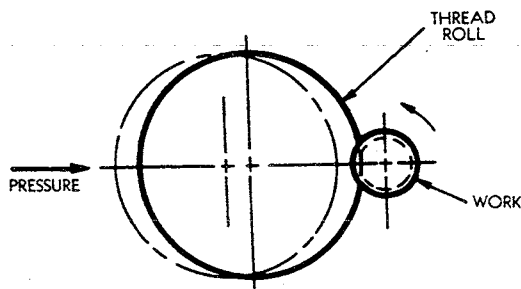


FIG. 18

When rolling taper pipe threads with single rolls, the most common method in use for applying the roll is shown in Fig. 19. The axes of the roll and the work are parallel and the small diameter of the roll rotates with the large diameter of the work.

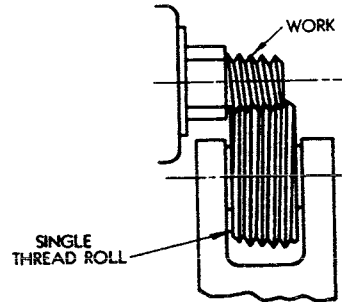


FIG. 19

Attachments for tangential in-feed rolling with two rolls using the cross slide travel usually have two opposed thread rolls which form the thread between the rolls as they straddle the blank, Fig. 20.

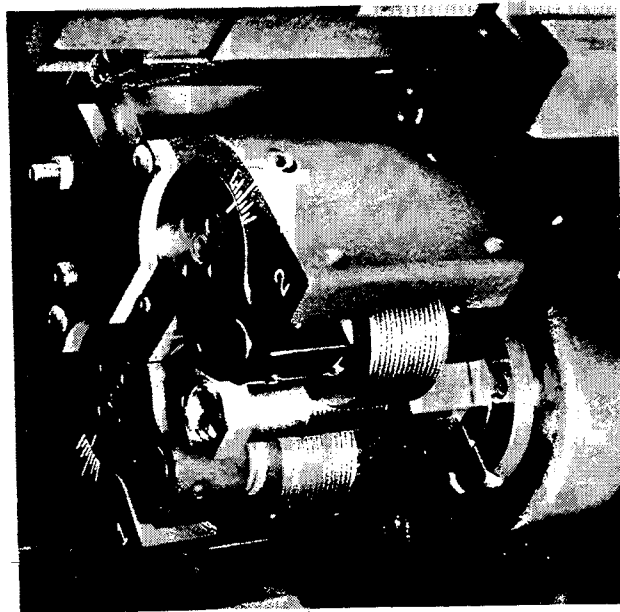


FIG. 20

The final size of the thread is obtained when the rolls reach the center of the work. The finished thread size is controlled by the fixed setting of the rolls in the attachment, as shown in Fig. 21. The cross slide travel is only used as a means of supplying movement to the rolls.

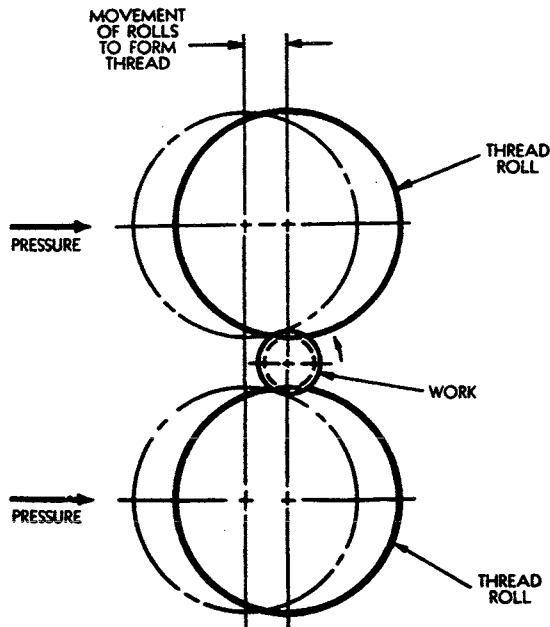


FIG. 21

Attachments that provide their own radial in-feed usually have two opposed rolls which form the thread through radial in-feeding of the rolls after they have been positioned at the center of the blank by the cross slide. The final size of thread is obtained when the rolls reach their full radial in-feed movement, Fig. 22.

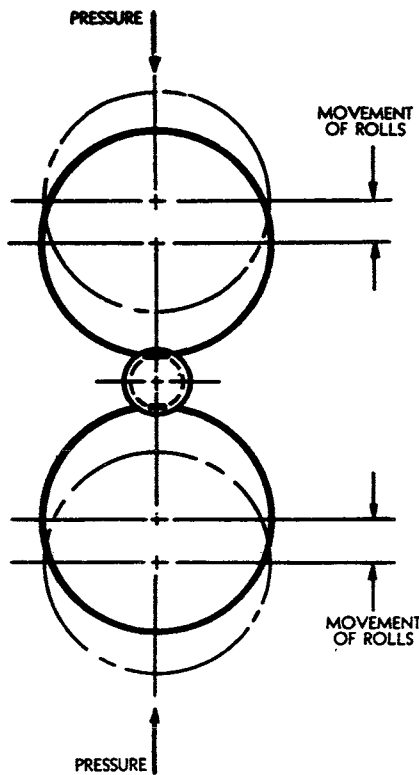


FIG. 22

Self-opening, end-feeding thread rolling heads operate similar to self-opening die heads and are used to roll straight threads. These heads may be used as either non-rotating or rotating types. The rotating types are used with rotating threading spindles, while the non-rotating types are used where the work revolves. Upon completion of the threading, the head opens and withdraws the thread rolls from the work in a manner similar to a pull-off type of die head.

Threads are rolled on screw machines and turret lathes with as few revolutions as possible. The spindle speeds used are the same as those for other operations. Table V shows the approximate thread rolling time in seconds at different spindle speeds with tangential in-feed two roll attachments.

Less rate of penetration is normally used for single rolls unless the work and blank are of a heavy nature. Upon reaching full thread depth, the thread rolls should be immediately withdrawn from the work.

Table V – Approximate Thread Rolling Time – in Seconds for Tangential In-Feed Two Roll Attachments

Threads Per Inch	Approx. Work Rev.*	Revolutions of Spindle per Minute				
		500 R.P.M.	1000 R.P.M.	1500 R.P.M.	2500 R.P.M.	5000 R.P.M.
32	11-27	1.3-3.2	.7-1.6	.4-1.1	.3-.6	.1-.3
24	14-31	1.7-3.7	.8-1.9	.6-1.2	.3-.7	.2-.4
18	17-35	2.0-4.2	1.0-2.1	.7-1.4	.4-.8	.2-.4
14	20-39	2.4-4.7	1.2-2.3	.8-1.6	.5-.9	.2-.5
10	23-43	2.8-5.2	1.4-2.6	.9-1.7	.6-1.0	.3-.5
8	26-47	3.1-5.6	1.6-2.8	1.0-1.9	.6-1.1	.3-.6

* The actual work revolutions used within the ranges shown depends on the material rolled and the size of thread rolling attachment used.

Thread Rolling Tools

To roll uniform, accurate threads and obtain maximum die life, it is necessary that the dies used be of highest quality from the standpoint of dimensional accuracy and uniformity. Also, the material from which the dies are produced must have the correct chemical analysis and physical structure. The die thread form and its surface finish must meet the requirements and specifications for a particular job.

The Reed Rolled Thread Die Company has for many years specialized in producing dies of high quality, and rigid standards are adhered to throughout the entire process of manufacture, heat-treatment, and inspection.

Reed dies are of superior quality. They are designed to produce uniformly accurate threads and can be set up in the thread rolling equipment with ease and precision. The use of these precisely made dies helps to minimize machine down time and to improve die life.

Tool Life

The life of a set of thread rolling dies is determined primarily by the rate at which the profile of the die threads progressively deteriorates under action of complex stress systems imposed by the thread forming operation. The dies must be discarded when this deterioration has progressed to the point where threads can no longer be rolled to meet the requirements of appearance and dimensional specifications.

It should be noted that it is often possible to continue to use dies long after the first signs of failure begin to appear, as subsequent contacts of the work with undamaged portions of the dies will iron out marks made by the crumbled portions.

With high quality dies, properly used, tool costs per thread produced can be lower by thread rolling than by other methods. The tool life for single setting in-feed dies, depending on the equipment used, may range from a few hundred thousand pieces, to as high as several million pieces on the softer materials such as straight carbon steels, copper base alloys and some grades of aluminum. When it is possible to use dies that permit multiple settings, tool life would be increased by the number of settings used. On soft materials, dies used for continuous thru-feed rolling of long bars will produce from a few thousand feet to over a hundred thousand feet. When short headless parts are rolled by the thru-feed method, tool life may be somewhat lower. Tool life is less for harder materials.

From a simplified viewpoint there are two ways in which maximum die life may be obtained in the rolling of a specified thread. The dies should first of all be of high quality from the standpoint of structure, dimensional precision and finish.

Whether or not the potential life of a set of dies is actually realized depends largely upon the care with which they are used. The machine setup man and operator thus play a very important part in obtaining optimum die life.

On a more detailed basis, die life depends upon a large number of factors, some of the most important of which are as follows:

1. Design and quality of the dies.
2. Size and form of thread to be rolled.
3. Nature of material on which the thread is formed.
4. Degree of fullness of thread crest to be formed.
5. Design and preparation of the blanks.
6. Type and size of equipment used.
7. Installation and use of the dies.

A detailed discussion on these items, as well as other material in reference to tool life, will be found in other Reed publications.

Selection of Tools - Dies and Thread Rolls

The general specifications of the dies or thread rolls are dependent on the equipment and attachments selected for the job. The particular design of the dies or rolls, however, is determined according to the method of processing and the specific details of the work. Shoulder diameters on the work should be checked for clearances with machine and tooling selected. Auxiliary work holding or supporting fixtures may affect clearances and should also be considered where the nature of the work demands such tooling.

Under ordinary conditions each thread diameter and pitch requires a set of dies or rolls made especially for the diameter and pitch specified. The same dies or rolls are not used for different diameters of the same pitch.

It is well to remember that even though the threads to be rolled do not necessarily have to be held to close limits, precision-made dies are always more economical to use. Accurate dies can be set up more quickly and more precisely, with the result that not only is down time reduced, but the life of the dies is increased.

For precision threading, precision-made dies are absolutely essential. Accurate threading requires dies that have accurate thread form and lead, straight pitch lines and accurate lead specifications. In the case of flat and planetary dies, the reliefs at the ends of the stationary die should be parallel with the axis of the work blank. The thread form of the reliefs should be as accurate as the form on the face of the die and should be correctly blended with it. Flat and planetary dies should be precisely matched.

Width of Die Face — IN-FEED ROLLING

The width of face on a die or thread roll is very important. The proper face width and the correct bevels on the dies not only prevent chipping of the end threads or breakage in the dies, but determine the number of settings possible for rolling on the face of the die.

The width of the die or thread roll faces for in-feed rolling must always be greater than the length of thread to be rolled. The approximate amounts to add to thread lengths to determine the minimum widths of die faces for in-feed rolling of Unified and American Standard external screw threads, Acme threads, Taper Pipe threads and Worm threads for various single settings of dies are shown in Table VI, page 20. The actual amount the die face is greater than the length of the thread is dependent on the nature of the thread, equipment used, design of the die and other factors determined by experience with rolling.

Width of Die Face — THRU-FEED ROLLING

Dies for thru-feed rolling are designed to suit the job and the width and design of die face should be determined by the manufacturer of the dies. When rolling next to a shoulder with thru-feed dies, the shoulder on the work is usually fed away from the dies and from three to five leads of the thread should be allowed for the dies to reach full depth of the thread.

Single and Multiple Settings — IN-FEED ROLLING

Thread rolling dies for machine screw threads may be selected for either single or multiple settings as illustrated in Figs. 23, 24 and 25.

When using double settings, the edges of the dies are repositioned so the unused portion of the die face is made available for rolling (Fig. 24). For multiple settings (Fig. 25) the condition is the same as the double settings except the work is

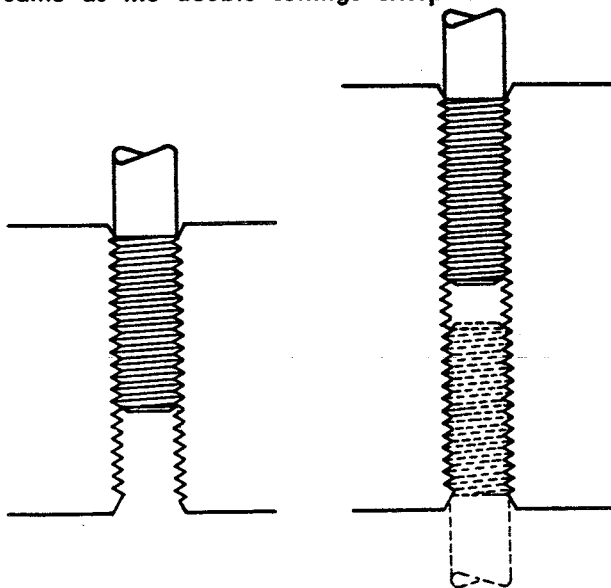
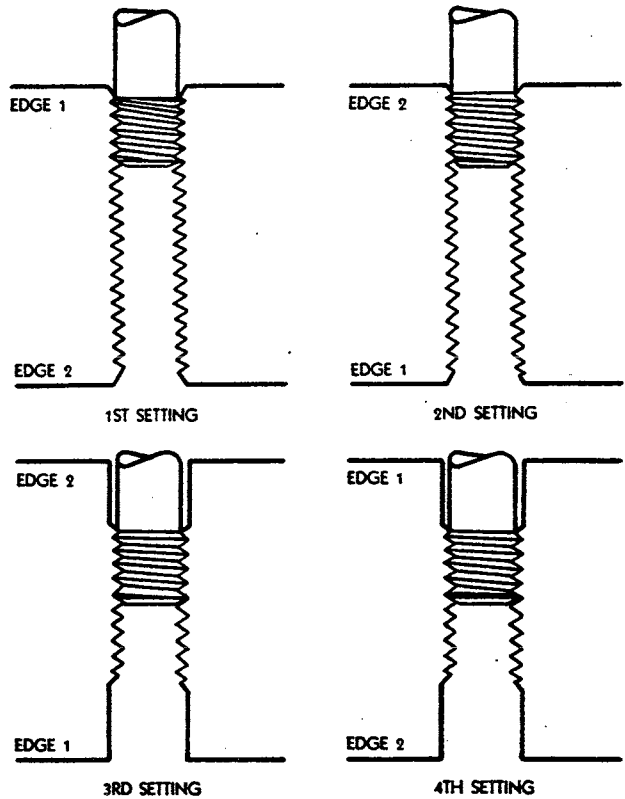


FIG. 23
Single Setting

FIG. 24
Double Setting

placed in different positions along half of the die face before the die is repositioned.



RELIEVE EDGES 1 AND 2 FOR 3RD AND 4TH SETTINGS AS SHOWN

FIG. 25
Multiple Setting

Dies for gimlet point threads are made for single settings and are always single faced as shown in Fig. 26. They are made for a given length of thread. The rise on the face of the die which rolls the gimlet point, prohibits the use of duplex dies and also prevents the use of double settings as illustrated.

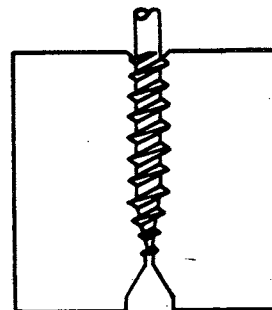


FIG. 26
Single Faced Dies
with Single Setting
for Gimlet Point Screws

Reed gimlet point dies are furnished with blank pointing features which allow straight blanks to be used instead of blanks with preformed points. The use of these dies reduces the headed blank costs as well as the size of blank inventories.

Dies for boltmaking type machines are always single faced and with few exceptions for single settings due to the design of the die face.

On reciprocating thread rolling machines both single and duplex face flat dies are used. The single face dies have a threaded surface on one side of the die, while duplex face dies have threaded surfaces on opposite sides. Duplex face dies are widely used. It is common practice to roll on both sides by reversing the die faces in a machine and also use double settings on each face — making possible a total of four settings on one pair of dies.

Planetary dies are single faced and may be used for single or multiple settings.

Use Standard Die Faces

When ordering dies and thread rolls, specify the die manufacturers nearest larger standard die face, wherever possible, for reasons of economy.

For single setting dies, as shown in Fig. 23, the

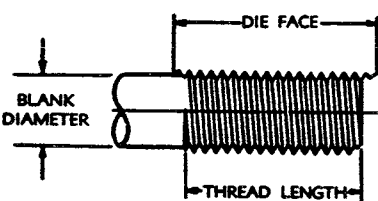
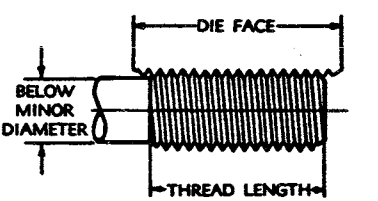
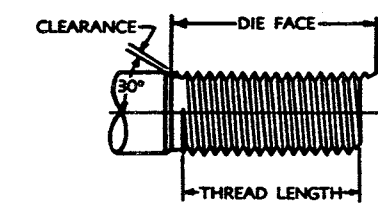
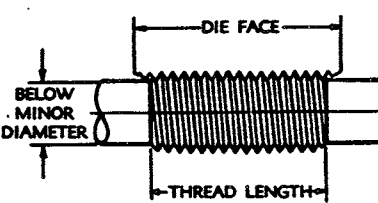
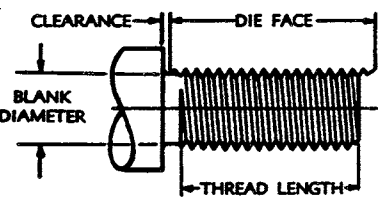
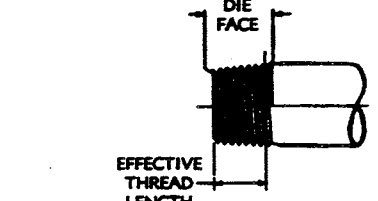
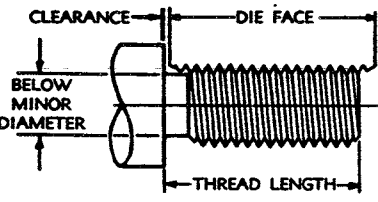
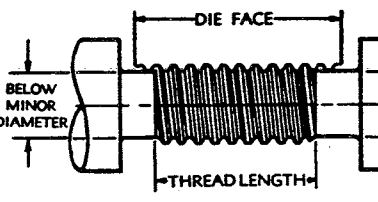
minimum widths or die faces are shown in Table VI. The minimum width of die face required for double settings is equal to 2 x die face required for single settings. For multiple settings, the minimum width of die face is equal to the number of settings x die face required for single settings.

If it is desired to roll two threads of the same diameter and pitch but of different thread lengths, it is customary to roll each thread length with a separate setting. A double setting die is therefore used, and the minimum die face may be determined by the addition of the two thread lengths plus the 5½ or 6 pitches of thread shown in Fig. 24.

Complete information for determining the width of flat die faces for lag bolts, drive screws, tapping screws and gimlet point threads is available in other Reed publications.

Table VI — Minimum Die Face Width — approximate

Amount to add to thread length for single setting dies

TYPE OF WORK	Amount to Add to Thread Length	TYPE OF WORK	Amount to Add to Thread Length
	2¼ pitches		3 pitches
	2¼ pitches		3 pitches
	2¼ pitches		3 pitches
	1 pitch		3 pitches

Note: On work where it is necessary to roll closer to a shoulder than the standard recommended die bevels will permit, dies can be furnished with special bevels or machined breakouts which will reduce the minimum widths of die face required.

Rollability of Materials

Rollability expresses the behavior of different materials during the thread rolling process. It is believed to be related to established material properties such as chemical analysis, hardness, strength, ductility and toughness, although no predictable relationship has been established between any one or combination of these properties and rollability. Many theories have been offered on the subject and no doubt the results of experimental research in the future will supply some much needed practical data.

Rollability may be reviewed from three rather distinct considerations:

1. The resistance of the material to plastic deformation.
2. The behavior of the material during displacement.
3. The degree of smoothness of the material rolled.

Resistance to Plastic Deformation

The resistance of the material to plastic deformation is probably the most important element of rollability. This element determines the load placed on the dies and the number of pieces the dies will produce before die failure occurs. It also determines the power required to roll the material. The total resistance to plastic deformation is made up of a combination of several properties. Among these are yield point, hardness of the material, the internal frictional resistance developed during plastic deformation and work hardenability.

The yield point strength may be defined as the stress, in pounds per square inch (psi), beyond which a material will undergo permanent or plastic deformation. The yield point commonly reported is that obtained from standardized tensile tests. In the cases of compression of cylindrical bars of lengths equal to two or three times the diameter, the compressive yield point is very nearly the same as that obtained from standard tensile tests. However, in the case of localized compression between surfaces where the contact area is relatively small compared to total surface area, the resistance to permanent or plastic deformation may reach several times the magnitude of the tensile yield point. This resistance to compression may even reach values several times the ultimate tensile strength.

Comparison of the tensile yield points of carbon steel (AISI-C1015) and 18-8 stainless steel (302) shows tensile yield points averaging approximately 45,000 psi. Yet there is a vast difference in the behavior of these materials in that it takes over twice as much power to roll 18-8 as it does the low car-

bon steel. Heat-treated alloy steel of Rockwell C40 hardness has a yield point of approximately 150,000 psi and it takes three times as much power to roll this heat-treated steel as it does low carbon steel.

In the thread rolling process, the fundamental phenomenon is one which dies are progressively forced and rolled into a blank. This penetration is resisted by the strength of the material being rolled. The resistance is primarily compression, although the final dislocation and movement of the material takes place in the form of a sliding action within the internal structure of the material.

For some materials there is rather good correlation between tensile yield strength and the resistance to plastic deformation in compression. With these materials, relative resistance to thread formation (one phase of rollability) may be predicted on the basis of tensile yield point strength.

Other groups of materials, particularly the 300 group of stainless steels, which exhibit marked work-hardening properties, cannot be classified according to a tensile yield point strength. The resistance to further plastic deformation increases as the thread formation progresses.

The internal friction developed during plastic deformation makes some materials much harder to move than others. It does not appear to be correlated with tensile yield strength, since some materials with high yield strength are easier to move than some with much lower yield strength. The force required to overcome this internal resistance of the material to move during deformation seems to be related to the amount of axial elongation that occurs during rolling. Low carbon steels and soft materials elongate during rolling, while heat-treated alloy steels are much stiffer and sometimes spring back after rolling. The added stiffness of some of the free machining steels accounts for their greater resistance to rolling.

An important property of materials that affects their rollability is their work-hardening characteristics. Rolled threads are stronger than cut threads because of this property. Most materials work-harden, but some do so to a much greater extent than others. Because they do, they offer increasing resistance to plastic deformation while it is taking place. 302 stainless (18-8) is outstanding in this respect, while 416 stainless (12% Cr) is not.

The results of recent and continuing research indicate that the Rockwell or Brinell (BHN) Hardness Numbers give a very good indication of relative resistance to thread formation so long as the same general group of materials are being dealt with. At present it does not appear promising that a single physical property may be used as the final criterion of rollability. There is a vast difference in the manner in which different groups of material behave during the formation of threads.

Behavior During Displacement

Some materials roll with a fold in the crest of the thread. This fold is of varying degrees and is not always visible to the eye, but can be revealed by etching and magnification. Those familiar with the process are aware of this and appreciate that it has little, if any, effect on the strength of the thread. Threads do not fail through the crest, either in static loading or fatigue. Loaded threads are most highly stressed in the root, and this is the area most benefited by thread rolling. It is an accepted fact that rolled threads are stronger than any type of cut threads both in static loading and especially in fatigue. The universal preference for rolled threads by the aircraft industry after exhaustive tests supports this fact.

Materials displace differently during rolling. Fig. 27 shows how some materials are affected when the dies first penetrate the blank. The area affected is large and relatively deep. The areas worked by each die crest overlap causing the section midway between the roots of the thread to ultimately move upward faster than the material at the flanks of the threads. Fig. 28 illustrates several stages in the rolling of the thread and explains why material behaving in this manner rolls without a crest fold.

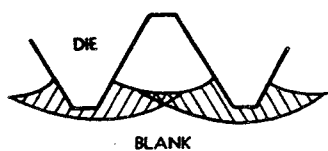


FIG. 27

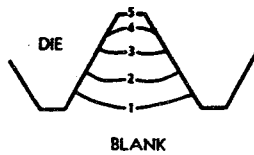


FIG. 28

Fig. 29 shows how other materials are affected when the dies first penetrate the blanks. The areas affected are small and confined to the surface layers. The section of the blank midway between the crests of the die has not been affected at all.

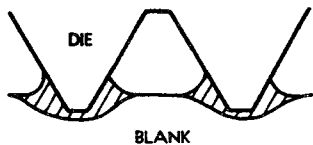


FIG. 29

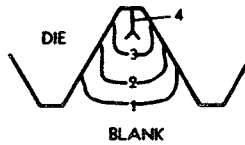


FIG. 30

Fig. 30 illustrates several stages of die penetration and the evolution of the crest fold in the final full thread. It is possible to roll full enough so that the fold in the crest is so tightly squeezed that it is not visible to the eye. No amount of squeezing, however, will eliminate the fold once it has formed.

Several factors influence the behavior of materials in respect to the fold in the crest. Some of these are the physical properties of the materials

themselves; some are factors of the thread rolling process.

If the material has a high degree of stiffness or internal friction, it will be more difficult to move the surface layers over the deeper layers. The deeper layers will be moved too, and the area affected by the die penetration will be deeper and more extensive.

As small surface areas are plastically deformed they work-harden and have a higher yield point. By the time the next die contact is made, the strength of the surface layer may be high enough so that the unworked layer under it reaches its yield point before the surface layer does. Thus the areas affected extend rapidly with each die contact.

The width of the crest flat of the die in relation to the pitch will obviously influence the area of material affected by each contact as shown in Figs. 31 and 32.

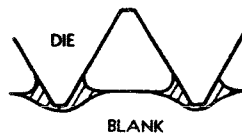


FIG. 31

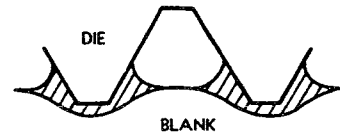


FIG. 32

Experience has shown that the rate of die penetration per contact affects the extent of the fold. Rates of penetration are considerably higher in flat-die rolling than they usually are in cylindrical-die rolling, and the extent of fold produced is somewhat less in flat die rolling. When comparable penetration rates are obtained on cylindrical-die machines by suitable feed and die speed combinations, comparable crest fold conditions are also obtained.

While high rates of penetration may be effective in reducing the extent of the fold, the fact remains that as yet there appears to be no completely effective method of rolling some materials without producing a fold in the crest, even though the fold can be hidden from the eye by rolling the thread full.

Recent developments in cylindrical die design and operating techniques have indicated it is possible to control formation of the material by thru-feed rolling to eliminate crest folds.

Smoothness

Ductility of materials has an important effect on the use of the thread rolling process. Ductility appears to be closely related to the degree of surface smoothness obtained, and the most ductile materials roll with the smoothest surfaces. Most materials, however, roll with smooth surfaces.

Some products, such as metal stampings, require the use of ductile materials. It is very difficult to cut smooth threads in such materials used in cold stamping and forming because of their extreme ductility. Such materials roll easily and lend themselves readily to rolled threads. 18-8 stainless, high speed and high carbon steels roll with a very smooth thread surface.

Free machine steels and nonferrous metals are widely used for rolling American Standard and similar threads. Sulphur and manganese are added to steels and lead to nonferrous materials, for the purpose of making chips more brittle and thereby break as they are removed. These elements in the materials are also apt to cause flaking when rolling 29° Acme and worm threads, and give roughened roots to these and similar threads with wide root flats.

Overrolling may also result in flakes on the flanks of the threads on some materials and should be avoided by correcting the blank diameters or setting of the dies.

Selection of Materials for Rolling

For the most part, straight carbon steels, structural alloy steels, high speed steels, nonleaded brasses, and copper constitute the majority of the materials used in producing parts calling for rolled threads and forms. Among this wide variety of materials, variations in rolling characteristics and finishes are experienced.

Selection of materials often depends upon an optimum combination of rollability and machinability of the material. To aid in making selections for the more commonly used carbon and alloy steels, Tables VII and VII-A show material rollability and machinability ratings. The machinability ratings for steels are related to the hardnesses more commonly machined. Tables VIII and IX show similar information for nonferrous and aluminum alloys.

Carbon Steels

Straight carbon steels, with standard allowable quantities of phosphorous and sulphur, are perhaps ideal materials to roll. Excellent finishes are obtained with the minimum rolling pressures.

Free cutting steels having sulphur in the amounts of .08% to .33% require about the same amount of power as straight carbon steels for rolling but the finish is not quite the same as straight carbon steels. The finish is good on standard 60° threads but not as good on threads with wide root or crest flats, and steep sidewalls, such as 29° Acme threads. Finish is improved by modification of thread form using root and crest radii, and by selecting grades of steel which have smaller percentages of sulphur and phosphorous. For example, C1115 is preferred over B1113.

Leaded Steels

The addition of lead to carbon as well as to standard alloy steels is often made to improve machinability of screw stock. The rollability of these steels on standard 60° threads is comparable to the standard analysis steels and in some cases better than the unleaded B1100 series. Where severe displacement of metal takes place as in steep sidewall or wide root flat threads, some flaking may result.

Alloy Steels

Nickel in the amounts of 3.25% to 3.75% such as in the 2330 or 2340 nickel steel contributes to the strength and ductility of the alloy and makes a very suitable material for rolling. The material is apt to be springy and requires more revolutions of the blank to obtain the desired displacement. Because of the greater tendency to work-harden, the power requirements are slightly increased.

Manganese steels containing manganese in the amounts of 1.5% to 2% tend to increase the resistance of the material to rolling, however, the material rolls well and good finishes are obtained. Manganese steels behave very much the same as nickel steels.

Nickel chromium structural steels such as 3120 or 3140, containing 1% to 4% nickel and .5% to 1.75% chromium are commonly used for shafts and various machinery parts. Threads on these parts may be rolled with very satisfactory finishes with pressure requirements similar to those of nickel or manganese steels.

Molybdenum in the amounts of .15% to .3% is usually combined with chromium or nickel to form high grade structural alloy steels such as 4140, 4340, 4640 and 4820. This material is almost always used in the hardened state and very frequently the rolling is done after the heat-treatment. The material rolls well and pressures required depend largely upon the hardness of the material at the time of rolling.

Nitriding Steels

Nitriding steels are suitable for rolling prior to nitriding and behave very similarly to molybdenum steels.

Stainless Steels

Stainless steels of the 400 series may be heat-treated and for the most part do not work-harden as much as the 300 series of stainless steels. The rolling of the material results in an excellent finish. However, considerable pressure is required and a slight to moderate seam in the crest may be detected.

The 300 series stainless steels, such as 18-8, work-harden rapidly and are harder to roll than the 400 series. The finishes obtained are excellent but the rolling loads are higher and die life expectancy is less than that of the 400 series. No fold is produced at the crest and even the incompletely rolled threads have smooth crests.

Nonferrous Metals

Among the nonferrous materials available for rolling, copper and many copper base alloys possess excellent cold working properties and are good materials for rolling.

Brasses, such as Commercial Bronze, Cartridge Brass and Yellow Brass, are preferred for rolling. The finish obtained is excellent and the power to roll is a little less than that required to roll mild steel.

The inclusion of lead in brasses for the improvement of machinability tends to cause slivering at the crests of fine threads and flaking in the roots of coarse threads with wide root flats. Although a maximum of .5% lead is preferred for rolling, much rolling in screw machines is done on free cutting brasses having a lead content as high as 3%. Using higher leaded brasses to obtain greater machining speeds, or because of their general availability, presents certain requirements for the material, depending upon the degree of finish required on the rolled thread.

Free cutting brasses with not more than 15% reduction in area to finish size after the last anneal are recommended as the optimum for thread rolling. Further, it is desirable that the material be properly processed at the mill to minimize the amount of beta structure which is hard and brittle and detrimental to good rollability. **Where free cutting brass must be used, orders for the material should stress that the material is to be used for thread rolling.**

Commercially pure aluminum such as the 2S and 3S series is soft and ductile and can be easily thread rolled. Due to its low strength and rather poor machining properties, aluminum is often alloyed with other elements to give it greater strength and improved cutting properties. The 17S and 24S series are the common alloys used for high strength headed parts and are readily thread rolled. Alloying of aluminum and the various hardening processes tend to decrease ductility which in turn affects the rollability of the material. As far as possible, the annealed or softer grades of these alloys are preferred for rolling. Heating aluminum alloys increases ductility and this may be helpful when required to roll low ductility alloys.

Titanium

Recent demands for titanium fasteners have presented some new problems not only in fabricating but in thread rolling of this material. The most common of the alloys used in threaded fasteners are the 4% aluminum, 4% manganese, and the 6% aluminum, 4% vanadium alloys. These alloys are of about 33 to 38 Rockwell C hardness and work-harden very rapidly. Currently, titanium fasteners are used almost exclusively for aircraft applications. Because of super-critical quality require-

ments of these fasteners, special precautions are required to produce satisfactory threads.

Due to the high work-hardening properties of titanium, high penetration rates are required. The best quality screws are produced with the minimum number of revolutions and minimum dwell after rolling to full depth. It is essential to use an extreme pressure lubricant on the thread rolling dies to prevent an inherent tendency for this material to seize on the dies. The coolant should be of such viscosity as to be able to carry away heat from the dies and it should be directed in a copious flow to completely cover the entire die surfaces. The coolant oil should be well filtered and auxiliary coolant refrigeration may be considered where operating temperatures become excessive.

Titanium blanks should have excellent finish with no blemishes, scratches, or imperfections. Such defects will show up in the rolled threads as laps or folds.

The dies for rolling titanium should have a radius crest thread form and have a high surface finish. Accuracy of all die elements is essential. The thread rolling equipment must provide for accurate matching of the dies and must be able to maintain the match during rolling. The machines should be tuned and maintained for precision operation, that is, properly fitted slides, bearings, and accurate functioning of all moving parts. The machines must have adequate power to do the job.

Die Castings

Most of the popularizing and aluminum base die cast alloys permit rolling of threads. Since the ductility of these materials is low, carefully controlled penetration rates are essential to the rolling of smooth threads. Threads on most aluminum base die cast alloys and zinc base alloys such as ZAMAK 3, have excellent rolled finishes. The die life experienced in rolling die castings is outstanding and makes rolling a most desirable manufacturing method for threading. Since the surface of a die casting usually has a draft taper and is apt to crumble and flake during rolling, a machined blank surface is preferred for best thread size control and finish.

Other Materials

Although the most commonly used materials have been listed, it is possible to roll other materials with varying results. These include:

- Magnesium
- Molybdenum
- Zirconium
- Powdered Metals
- Bakelite
- Fibre

Information regarding the rolling of such material will be furnished upon request.

Thin Wall Sections

The effect of rolling threads on work with thin wall sections varies considerably with the thread size and length, material, location of the thread on the work, the fullness of thread required and the equipment used. Wall thickness, as it will be referred to, is the measurement between the blank surface to be threaded and the internal diameter of the section. The minimum wall thickness required usually ranges between the equivalent of 1 to 3 thread depths on smaller diameters to 4 to 8 thread depths on larger diameters up to 5". Because of the variables involved in rolling threads and forms on hollow cylinders with thin walls, blank diameters are usually determined by experimentation.

When threads are rolled on work having insufficient wall thickness, collapsing of the internal diameter on the part may occur. In some cases where the collapsing is uniform this may not be objectionable, but it should be understood that the thread may have some amount of out-of-roundness. Thin-walled hollow cylinders are usually supported by mandrels during rolling. Mandrels should be the correct size. Undersize mandrels will allow the hole in the cylinder to close in and the thread diameter to go undersize. Tight-fitting mandrels and high die pressures will sometimes stretch the walls of the cylinders making both the internal diameter and thread oversize. Endwise stretching also occurs where there is a very thin wall between the root of the thread and the internal diameter.

In general, the best results are obtained on equipment where the rate of penetration and the number of work revolutions can be controlled. On screw machine work the sequence of operations should be planned to roll on a solid blank or to provide the maximum wall thickness at the rolling position. Three die type cylindrical die machines confine the blank and usually allow rolling on thinner walls than the two die type machines. Seamless tubing is generally preferred since it eliminates the possibility of cracking at the seam which may occur on thin wall welded tubing.

Data on the preparation of blanks for rolling threads on thin wall sections is available in other Reed publications.

Burnishing

The ability of the rolling process to produce exceptionally smooth surfaces, because of the inherent burnishing action, has provided industry with a fast and economical method of finishing cylindrical surfaces. Improved bearing qualities and the elimination of surface defects which may be points of fatigue failure, are also benefits achieved by the cold forming process of burnishing. Newer techniques in the use of thread rolling equipment adapted to burnishing and the development of precision dies has brought about greater possibilities of applying burnishing to a wide variety of parts including bearing diameters and armature shafts, involute gear tooth finishing, ball suspension joints, fillet radii on bolts.

Burnishing is the process of rolling with smooth dies on cylindrical work to improve the surface characteristics with only minor dimensional changes. The work revolutions required to provide a sufficient amount of die contacts with the blank, to smooth out irregularities on the surface, varies depending on several factors including material, hardness, finish before rolling, diameter and die finish. Best results are achieved on equipment that is capable of providing an adequate range of work revolutions. Burnishing is mostly done on cylindrical die machines — by either the in-feed or thru-feed methods of rolling.

Although most burnishing is done on soft material, it is possible to apply the process to the harder materials. In general, burnishing of soft material results in a better surface finish than harder materials — often resulting in a finish on the work that is better than that on the dies. A smoother surface finish of the blank before burnishing is usually required on harder materials.

Since rolling cannot remove material and compresses it very little, it is necessary that blanks for burnishing be held to a few tenths of a thousandth of an inch larger than the finished burnished diameter. When burnishing irregular contours, the profile of the blank should match the profile of the die precisely. To accomplish this, the dimensions of the forming tools for the blanks must be exactly the same as the profile on the die. With only minor dimensional changes in burnishing, this will assure uniform die contact over the entire surface.

Materials Used for Thread Rolling

Table VII — Comparative Rolled Thread Finishes and Relative Tool Life

With the increased application of thread rolling, new materials are constantly being added.
Refer to our factory or representative for information on any materials not shown.

Carbon and Alloy Steels

Material		Rollability Rating					Remarks	
		Description	AISI No.	Finish on Thread	Relative Tool Life			
Soft	15-25 RC				26-32 RC	33-40 RC		
Carbon Steels	Straight Carbon	C1005-C1095	E	H	H-M	M	L	Preferred for rolling. Lower carbon ranges commonly used for headed and stamped parts.
	Free Cutting	C1111-C1144	G	H	H-M	M	—	These are basic open-hearth steels and are the preferred substitutes for straight carbon steels when machinability is required. C1113, C1119 and C1144 have higher sulphur content and are not as desirable.
		B1111-B1113	F	H	—	—	—	These are acid Bessemer steels having high sulphur and phosphorous content, and while the material produces satisfactory finishes on 60° and 55° threads it is not suitable for rolling wide root or crest flats such as Acme threads.
Leaded Steels (Carbon and Alloy)	Free Cutting	C1018-L ^F	E	H	—	—	—	Refer to page 23.
		C1045-L	E	H	M	—	—	
		C1117-L	G	H	—	—	—	
		C1141-L	G	H	M	—	—	
		C1213-L	G	H	M	—	—	
		4140-L	E	H	M	—	—	
		4150-L	E	H	M	—	—	
		8620-L	E	H	—	—	—	
Alloy Steels	Manganese	1320-1340	E	H	H-M	M	L	Moderately higher pressures are required to roll. Work-hardening characteristics increased by alloying elements. Lower carbon ranges are in the carburizing class, and the material is commonly rolled in the soft stage. Carbon in excess of .25 brings the steel into the oil-hardening stage and these steels are commonly rolled in the heat-treated condition.
	Nickel	2317-2345 2512-2517	E	H	H-M	M	L	
	Nickel Chromium	3115-3150 3310-3316	E	H-M	M	M-L	L	
	Molybdenum	4017-4068	E	H-M	M	M-L	L	
	Chromium Molybdenum	4130-4150	E	H-M	M	M-L	L	
	Nickel Chromium Molybdenum	4317-4340 8615-8660 8719-8750 9310-9317 9437-9445 9747-9763 9840-9850	E	H-M	M	M-L	L	
	Nickel Molybdenum	4608-4640 4812-4820	E	H-M	M	M-L	L	
	Chromium	5045-5046 5120-5160 50100-52100	E	H-M	M	M-L	L	
	Chromium Vanadium	6120-6152	E	H-M	M	M-L	L	
	Silicon Manganese	9255-9262	G	H-M	M	M-L	L	
Tool and Die Steel	High Carbon High Chromium	—	E	—	M	L	—	

See footnotes, page 32.

Table VII – (Continued) Carbon and Alloy Steels

Material		Rollability Rating					Remarks	
		Finish on Thread	Relative Tool Life					
Description	AISI No.		Soft	15-25 %RC	26-32 %RC	33-40 %RC		
Stainless Steels	301-347	—	E	—	M	L	—	These are Chromium Nickel types which are non-hardenable by heat-treatment. Hardening properties increase rolling pressures and tend to lower die life. No fold in crest is produced.
	403-446	—	E	—	M	L	—	These are hardenable stainless types and are easier to roll than the 300 series. Slight to moderate folds in the crest of the thread may be expected.
High Speed Steels	Tungsten High Speed (18-4-1)	—	E	—	M	L	—	
	Molybdenum High Speed (M-2)	—	E	—	M	L	—	
Nitriding Steels	Nitalloy 135, 230, N, EZ	—	E	—	M	M-L	L	Must be rolled before nitriding.

Table VII-A – Machinability Rating for Carbon and Alloy Steels

Material		Hardness			Machinability Rating (B1112=100)	
		Brinell	Rockwell			
Description	AISI No.		B Scale	C Scale		
Carbon Steels	Straight Carbon	C1008	126-163	72- 85	-(3)	50
		C1010	131-170	74- 87	-(5)	50
		C1015	131-170	74- 87	-(5)	50
		C1020	137-174	76- 88	-(6)	65
		C1022	159-192	84- 92	(2)-(12)	70
		C1030	170-212	87- 96	(5)-(16)	65
		C1035	174-217	88- 97	(6)-(19)	65
		C1040	179-229	89- 98	(8)- 21	60
		C1045	179-229	89- 98	(8)- 21	60
		C1050	179-229	89- 98	(8)- 21	50
	C1070	183-241	90-100	(9)- 23	45	
	Free Cutting	C1109	136-166	76- 86	-(4)	85
		C1115	143-179	79- 89	-(8)	85
		C1117	143-179	79- 89	-(8)	85
		C1118	143-179	79- 89	-(8)	80
		C1120	143-179	79- 89	-(8)	80
		C1132	187-229	91- 98	(10)- 21	75
		C1137	187-229	91- 98	(10)- 21	70
		C1141	183-241	90-100	(9)- 23	65
		B1111	179-229	89- 98	(8)- 21	95
B1112		179-229	89- 98	(8)- 21	100	
B1113	179-229	89- 98	(8)- 21	135		
Leaded Steels (Carbon and Alloy)	Free Cutting	C1018-L ^F	135-172	75- 88	-(6)	80
		C1045-L	179-229	89- 98	(8)- 21	75
		C1117-L	143-179	79- 89	-(8)	130
		C1141-L	183-241	90-100	(9)- 23	90
		C1213-L	179-229	89- 98	(8)- 21	180
		4140-L	187-229	91- 98	(10)- 21	90
		4150-L	187-235	91- 98	(10)- 21	85
		8620-L	170-215	87- 96	(5)-(16)	90
8647-L	183-235	90- 99	(9)- 22	77		

See footnotes, page 32.

Table VII-A – (Continued) Machinability Rating for Carbon and Alloy Steels

Material		Hardness				Machinability Rating (B1112=100)		
		Brinell	Rockwell					
			B Scale	C Scale				
Description	AISI No.							
Alloy Steels	Manganese Steels	1320	170-229	87- 98	(5)- 21	50		
		1330	179-235	89- 99	(8)- 22	50		
		1335	187-241	91-100	(10)- 23	50		
		1340	187-241	91-100	(10)- 23	45		
	Nickel Steels	2317	174-217	88- 96	(6)- (16)	55		
		2330	179-229	89- 98	(8)- 21	50		
		2340	187-241	91-100	(10)- 23	45		
		2515	179-229	89- 98	(8)- 21	30		
	Nickel Chromium Steels	3120	163-207	85- 95	(3)- (15)	60		
		3130	179-217	89- 96	(8)- (16)	55		
		3140	187-229	91- 98	(10)- 21	55		
		3145	187-235	91- 99	(10)- 22	50		
		3310	170-229	87- 98	(5)- 21	40		
	Molybdenum Steels	4023	157-207	83- 95	(1)- (15)	70		
		4027	166-212	86- 96	(4)- (16)	70		
		4032	170-229	87- 98	(5)- 21	65		
		4037	179-229	89- 98	(8)- 21	65		
		4042	183-235	90- 99	(9)- 22	60		
		4047	183-235	90- 99	(9)- 22	55		
	Chromium Molybdenum Steels	4130	187-229	91- 98	(10)- 21	65		
		4137	187-229	91- 98	(10)- 21	60		
		4145	187-229	91- 98	(10)- 21	55		
		4150	187-235	91- 98	(10)- 21	50		
	Nickel Chromium Molybdenum Steels	4320	179-228	89- 98	(8)- 21	55		
		4340	187-241	91-100	(10)- 23	45		
		8620	170-215	87- 96	(5)- (16)	60		
		8630	179-229	89- 98	(8)- 21	65		
		8640	179-229	89- 98	(8)- 21	60		
		8645	183-235	90- 99	(9)- 22	55		
		8650	183-241	90-100	(9)- 23	50		
		8720	170-217	87- 96	(5)- (16)	60		
		8730	179-229	89- 98	(8)- 21	65		
		8740	179-229	89- 98	(8)- 21	60		
		8745	183-235	90- 99	(9)- 22	55		
		8750	183-241	90-100	(9)- 23	50		
		9315	179-229	89- 98	(8)- 21	40		
	9440	179-229	89- 98	(8)- 21	60			
	Nickel Molybdenum Steels	4615	174-217	88- 96	(6)- (16)	65		
		4640	187-235	91- 99	(10)- 22	55		
		4815	187-229	91- 98	(10)- 21	50		
Chromium Steels	5120	170-212	87- 96	(5)- (16)	65			
	5140	174-229	88- 98	(6)- 21	60			
	5150	179-235	89- 99	(8)- 22	55			
Chromium Vanadium Steels	6120	179-217	89- 96	(8)- (16)	50			
	6145	179-235	89- 99	(8)- 22	50			
	6152	183-241	90-100	(9)- 23	45			
Silicon Manganese Steels	9260	187-255	91-102	(10)- 25	45			
	9261	179-217	89- 96	(8)- (16)	50			
Tool and Die Steel	High Carbon High Chrome	—	192-241	92-100	(12)- 23	25		
Stainless Steels	301-347	302	150	82	—	25		
		303	160	84	(2)	55		
		316	150	82	—	25		
		321	160	84	(2)	25		
		347	160	84	(2)	25		
	403-446	410	155	83	(1)	50		
		416	155	83	(1)	60		
		420	179	89	(8)	45		
		430	155	83	(1)	45		
		440	223	97	(19)	35		
		443	187	91	(10)	50		
		High Speed Steels	Tungsten (18-4-1)	—	192-241	92-100	(12)- 23	30
			Molybdenum (M-2)	—	192-241	92-100	(12)- 23	35
Nitriding Steels	Nitr alloy 135, 230, N, EZ		223-263	97-103	(19)- 27	45		

Rockwell C values in parenthesis are beyond normal range and are to be used only as a guide.
See footnotes, page 32.

Table VIII – Nonferrous Alloys

Material Classification	Commonly Used Name	Approximate Composition		Rollability Rating		Machinability Rating (Free Cutting Brass=100)	Remarks
				^D Finish on Thread	^E Relative Tool Life		
Copper	Electrolytic Copper	Copper	99.9	E	H	20	
	Oxygen-Free Copper	Copper Phosphorous	99.98 .02	E		20	
	Arsenical Copper	Copper Arsenic	99.7 0.3	E		20	
	Phosphorized Copper	Copper Phosphorous	99.97 .03	E		20	
	Leaded Copper (Free Machining)	Copper Lead	99.0 1.0	G		80	
Copper-Zinc Alloys	Commercial Bronze	Copper Zinc	90.0 10.0	E	H	20	
	Red Brass	Copper Zinc	85.0 15.0	E		30	
	Fourdrinier	Copper Zinc	83.0 17.0	E		30	
	Low Brass	Copper Zinc	80.0 20.0	E		30	
	Cartridge Brass	Copper Zinc	70.0 30.0	E		30	
	Yellow Brass 66%	Copper Zinc	66.0 34.0	E		40	
	Yellow Brass 62%	Copper Zinc	62.0 38.0	F-G		40	
	Muntz Metal	Copper Zinc	60.0 40.0	F		40	
Free Cutting Copper-Zinc Alloys	Free Cutting Brass	Copper Zinc Lead	61.5 35.5 3.0	F	H	100	Most commonly used in screw machine applications. Refer to page 24.
	High Leaded Brass	Copper Zinc Lead	62.5 35.75 1.75	F-G	H	90	
	Medium Leaded Brass	Copper Zinc Lead	64.5 34.5 1.0	G-E	H	70	
Tin Bronzes	Admiralty Metal	Copper Zinc Tin	71.0 28.0 1.0	E	H	30	
	Naval Brass	Copper Zinc Tin	60.25 39.0 0.75	F-G	H	30	
	Leaded Naval Brass	Copper Zinc Lead Tin	60.5 36.75 2.0 0.75	P	H	70	
	Tobin Bronze	Copper Zinc Tin	60.0 39.25 .75	F-G	H	30	
	Trumpet Brass	Copper Zinc Tin	81.0 18.0 1.0	E	H	20	

See footnotes, page 32.

Table VIII – (Continued) Nonferrous Alloys

Material Classification	Commonly Used Name	Approximate Composition	Rollability Rating		Machinability Rating (Free Cutting Brass=100)	Remarks
			^D Finish on Thread	^E Relative Tool Life		
Phosphor Bronzes	Phosphor Bronze	Copper 95.0 Tin 5.0 Phosphorous 0.1	E	H	30	These Alloys have just enough Phosphorous for deoxidation of the alloy. Tin is the prominent element and contributes to the cold working properties of these alloys.
	4% Phosphor Bronze (Grade A)	Copper 95.75 Tin 4.00 Phosphorous .25	E	H	20	
	5% Phosphor Bronze (Grade A)	Copper 95.00 Tin 4.75 Phosphorous .25	E	H	20	
	8% Phosphor Bronze (Grade C)	Copper 92.0 Tin 7.75 Phosphorous .25	G	H	20	
	10% Phosphor Bronze (Grade D)	Copper 89.50 Tin 10.50	F	H	20	
	Leaded Phosphor Bronze (Grade B)	Copper 94.00 Tin 5.00 Lead 1.00	F	H	50	
	Free Cutting Phosphor Bronze	Copper 88.00 Zinc 4.00 Tin 4.00 Lead 4.00	F	H	90	
Copper Silicon Alloys	Everdur No. 1010 Everdur No. 1012 Everdur No. 1015		E G E	M	30 60 30	Composition of Copper Silicon Alloys varies over wide limits. Usually these alloys contain 1 to 4% Silicon, .25-1.5% Manganese, .5 to 1% Iron, when present, and up to 22% Zinc. The Low-Silicon Alloys have particularly good rolling characteristics.
	Duronze I or 609 Duronze II or 606 Duronze III or 707		E G P	M	20 25 70	
	Olympic Bronze A Olympic Bronze B Olympic Bronze D Olympic Bronze G		E E G E	M	30 30 60 30	
	Herculoy No. 418 Herculoy No. 419 Herculoy No. 420 Herculoy No. 421		G E G E	M	30 30 30 30	
Aluminum Bronze	5% Aluminum Bronze	Copper 95.0 Aluminum 5.0	E	H	20	
	8% Aluminum Bronze	Copper 92.0 Aluminum 8.0	G	M	20	
	Nickel Aluminum Bronze		P	M	20	
	5% Nickel Aluminum Bronze		P	M	20	
	Nickel Aluminum Bronze (Type A)		E	H	20	
	Nickel Aluminum Bronze (Type B)		E	H	20	
Cupronickels	15% Cupronickel 20% Cupronickel 30% Cupronickel		E E G	M	20	
Nickel Silver	Nickel Silver	Nickel 10-20 Copper 55-75 Zinc 5-27	E	H	20	
	Leaded Nickel Silver	Nickel 12.0 Copper 65.0 Zinc 22.0 Lead 1.0	G-F	M	50	
	Extruded Nickel Silver	Nickel 10.0 Copper 46.5 Zinc 40.75 Lead 2.75	P	M	80	

See footnotes, page 32.

Table VIII — (Continued) Nonferrous Alloys

Material Classification	Commonly Used Name	Approximate Composition	Rollability Rating		Machinability Rating (B1112=100)	Remarks
			^D Finish on Thread	^E Relative Die Life		
Nickel and Nickel Alloys (Wrought)	Nickel "A"	Nickel 99.4 Carbon .1	E	M	30	Rapid Work-hardening.
	Low-Carbon Nickel	Nickel 99.4 Carbon .01	E	M	30	
	D Nickel	Manganese 4.65	E	M	30	
	Z Nickel	Aluminum	G	M	25	
	Monel	Copper 70.0 Nickel 30.0	E	M	60	Work-hardening Alloy.
	R Monel	Sulphur added to Monel	E	M	70	Lower toughness and ductility. Improved machinability.
	K Monel		E	M	30	Can be cold worked with ease
	KR Monel		G	M	70	Free machining grade of K Monel.
	Inconel	Nickel Chromium Iron Silicon	F	M	25	Readily cold worked.
Hastelloy A, B, C	Nickel Molybdenum Iron	F	L	30	Difficult to cold work — best conditions for rolling when fully annealed.	
Titanium	AMS 4900	Commercially pure Titanium	E-G	M-L	45	Refer to page 24.
	AMS 49AA	Aluminum 6 Vanadium 4 Titanium 90	E-G	L	25	
	AMS 4925	Aluminum 4 Manganese 4 Titanium 92	E-G	L	25	
Other Alloys	Phosnic Bronze	Copper 98.7 Nickel 1.1 Phosphorous 0.2	E	H	—	
	Tellurium Copper	Copper 99.5 Tellurium 0.5	G	H	—	
	Manganese Bronze (A)	Copper 58.5 Tin 1.0 Iron 1.0 Manganese 0.25 Zinc Balance	P	M	—	
	Beryllium Copper	Copper 97.60 Nickel .35 Beryllium 2.05	G	M	—	
	Beryllium Copper Hardened	Copper 97.60 Nickel .35 Beryllium 2.05	P	L	—	

See footnotes, page 32.

Table IX – Aluminum and Aluminum Alloys

Alloy Designation		Condition	Tensile Yield Strength psi	Relative Ductility	Rollability Rating		Machinability Rating ^c	Remarks
					^d Finish on Thread	^e Relative Die Life		
New	Old							
1100-O	2S-O	Annealed	5,000	100	E	H	G	These alloys are commercially pure aluminum and the hardness is imparted by cold working. They are the most suitable of the aluminum alloys for rolling where higher tensiles are not required.
1100-H12	2S-¼H	¼-Hard	13,000	55	E		G	
1100-H14	2S-½H	½-Hard	14,000	45	E		G	
1100-H16	2S-¾H	¾-Hard	17,000	38	G		G	
1100-H18	2S-H	Hard Temper	21,000	33	G		G	
3003-O	3S-O	Annealed	6,000	89	E		G	
3003-H12	3S-¼H	¼-Hard	15,000	45	E		G	
3003-H14	3S-½H	½-Hard	18,000	36	G		G	
3003-H16	3S-¾H	¾-Hard	21,000	31	F		G	
3003-H18	3S-H	Hard Temper	25,000	22	F		G	
2011-T3	11S-T3	Heat-treated and Aged	47,000	33	G-F	H	E	These alloys contain copper, lead and bismuth and are not ordinarily used for rolling.
2011-T3	11S-T8	Heat-treated and Aged	44,000	31	F		E	
2014-O	14S-O	Annealed	14,000	40	G	H	G	Higher strength alloys of aluminum used in airplane fittings.
2014-W	14S-W	Quenched	40,000	55	E		G	
2014-T	14S-T	Heat-treated and Aged	60,000	29	F		G	
2017-O	17S-O	Annealed	26,000	49	E	H	G	Good cold working properties. Used for headed parts and rolled thread fasteners.
2017-T4	17S-T	Heat-treated and Aged	62,000	49	E		E	
2117-T4	A17S-T	Heat-treated	24,000	60	E		E	
2024-O	24S-O	Annealed	11,000	49	E	H	G	Good cold working properties. Used for headed parts and rolled thread fasteners and aircraft parts.
2024-T4	24S-T	Heat-treated	46,000	49	E		E	
5052-O	52S-O	Annealed	14,000	67	E	H	G	
5052-H32	52S-¼H	¼-Hard	26,000	40	G		G	
5052-H34	52S-½H	½-Hard	29,000	31	F		G	
5052-H36	52S-¾H	¾-Hard	34,000	22	F		G	
5052-H38	52S-H	Hard Temper	36,000	18	P		G	
6053-O	53S-O	Annealed	7,000	78	E	H	G	Good rolling material – high non-corrosive properties.
6053-T4	53S-W	Quenched	20,000	67	E		G	
6053-T6	53S-T	Heat-treated	33,000	44	E		G	
5056-O	56S-O	Annealed	20,000	78	E	H	G	Magnesium included. Suitable for rolling in soft stage.
5056-H38	56S-H	Hard Temper	48,000	15	P		G	
6061-O	61S-O	Annealed	8,000	49	E	H	G	
6061-T4	61S-W	Quenched	21,000	49	E		G	
6061-T6	61S-T	Heat-treated	39,000	27	F		G	
7075-O	75S-O	Annealed	20,000	27	F	H	G	
7075-T6	75S-T	Heat-treated	80,000	22	P		E	









^a American Iron and Steel Institute. ^b Rockwell Hardness, C scale. ^c Machinability Rating: E, excellent; G, good.

^d Finish on Thread Ratings are indicated as follows: E, excellent; G, good; F, fair; P, poor.

^e Relative Die Life is indicated as follows: H, high; M, moderate; L, low.

^f L indicates addition of lead to standard steels to improve machining properties.

Table X – Material Grading Reference

Specification					Specification (no grade marking)	
S.A.E. Grade No.	A.S.T.M.	I.F.I. Grade No.	Material General Description	Grade Marking for Steel Bolts	I.F.I. Grade No.	Material General Description
0 1 2	A307	S0 S1 S2	Steel Low Carbon Steel Low Carbon Steel	 No Mark	S10 annealed	Low Carbon Steel, annealed
					SS1	Stainless Steel, 12% Chromium
3	—	S3	Medium Carbon Steel, cold worked		SS2 annealed	Stainless Steel, 18% Chromium
5	A449	S5	Medium Carbon Steel, quenched & tempered		SS3 annealed	Stainless Steel, 18% Chromium, 8% Nickel
					C1 as fabricated	Commercially Pure Copper
—	A354 Grade BB	—	Low Alloy Steel, quenched & tempered (medium carbon steel, quenched and tempered, may be substituted where possible).		C2	Commercial Bronze
					C3	Heading Brass
—	A354 Grade BC	—	Low Alloy Steel, quenched & tempered (medium carbon steel, quenched and tempered, may be substituted where possible).		C4 as fabricated annealed	Silicon Bronze
					A1	Aluminum (2S) -0- condition
6	—	—	Medium Carbon Steel, quenched & tempered		A2	175-T4 Condition
7	—	—	Medium Carbon Alloy Steel, quenched & tempered (roll threaded after heat treatment).		A3	24S-T4 Condition
					N1	Nickel
8	A354 Grade BD	S8	Medium Carbon Alloy Steel, quenched & tempered		N2 annealed	Monel
					N3 annealed	Inconel

S.A.E. — Society of Automotive Engineers, Inc.
A.S.T.M. — American Society for Testing Materials
I.F.I. — Industrial Fasteners Institute

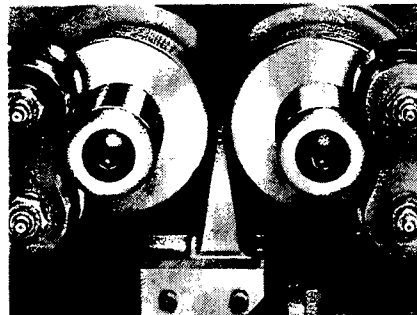
Table XI – Reed Thread Rolling Equipment Selection Chart

THREAD ROLLING MACHINES

Three Die Type



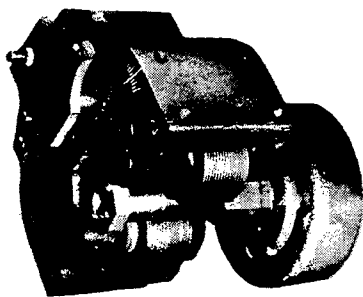
Two Die Type



Model	Type	Diameter Capacity Range		Remarks
		In-feed	Thru-feed*	
A22	Three Die Vertical	$\frac{3}{32}$ - $2\frac{5}{8}$	$\frac{1}{4}$ - $\frac{5}{8}$	For in-feed rolling general purpose work – manual operation. Also used for high speed automatic operation.
22HD	Three Die Vertical	$\frac{3}{4}$ - $1\frac{1}{8}$		Heavy duty in-feed rolling of a range of parts with longer thread lengths on harder materials.
A23	Three Die Horizontal	$\frac{3}{32}$ - $2\frac{5}{8}$	$\frac{1}{4}$ -1	For work which is easily supported in horizontal position – manual or automatic operation.
A25	Three Die Horizontal	—	$\frac{1}{2}$ - $2\frac{1}{2}$	Especially for thru-feed rolling – with adjustable axis die holders.
A34A	Three Die Horizontal	$\frac{3}{4}$ -4	$\frac{3}{4}$ - $2\frac{1}{2}$	Heavy duty in-feed rolling of large diameters. Also used for thru-feed rolling.
A425	Three Die Horizontal	—	16/32 D.P. Max. Splines & Serrations	For rolling precision involute splines and serrations.
B112	Two Die Horizontal	0-3	0-3	Unusual wide range for in-feed and thru-feed rolling of either large or small quantity production.

*Lengths up to 20 feet except Model A22

THREAD ROLLING ATTACHMENTS

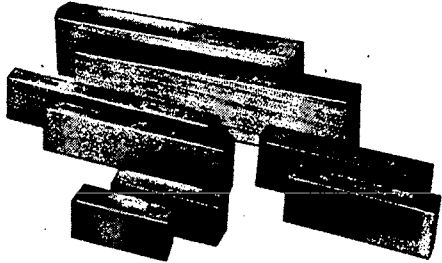
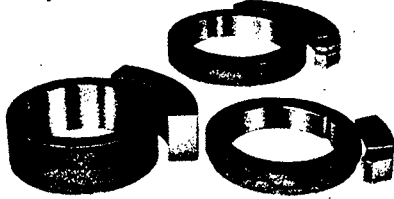
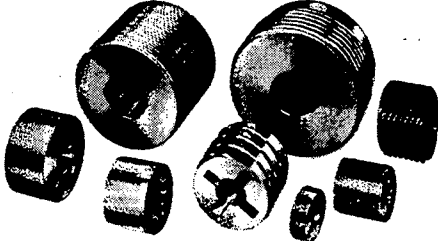
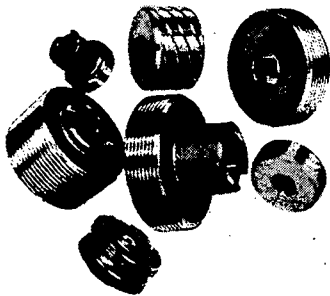
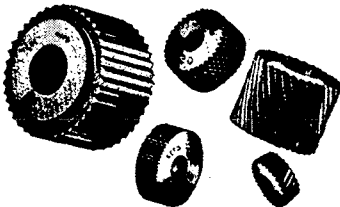


Each of the six standard sizes of Reed Thread Rolling Attachments accommodates a complete range of work diameters. They are used on over 100 different single and multiple spindle screw machines and automatic lathes.

Model No.	Straight Threads		Pipe Threads – Straight and Taper	
	Diameter Capacity Range	Approx. No. of Threads*	Diameter Capacity Range	Approx. No. of Threads*
B5	0- $\frac{5}{16}$	45	—	—
B8	0- $\frac{1}{2}$	70	$\frac{1}{16}$ - $\frac{1}{4}$	5
B10	0- $\frac{5}{8}$	80	$\frac{1}{16}$ - $\frac{3}{8}$	7
B13	$\frac{1}{8}$ - $1\frac{1}{16}$	90	$\frac{1}{16}$ - $\frac{1}{2}$	9
B18	$\frac{1}{4}$ - $1\frac{1}{8}$	105	$\frac{1}{8}$ - $\frac{3}{4}$	15
B36	$\frac{3}{8}$ - $2\frac{1}{4}$	185	$\frac{1}{4}$ - $1\frac{1}{2}$	18

*Standard Threads

Table XII – Reed Thread Rolling Tool Selection Chart

THREAD ROLLING TOOLS	Description		Remarks
<p>Flat Dies</p> 	For Machine Screw Threads	Duplex Face	Most popular die for rolling machine screw threads on Waterbury Farrel, Manville and Hartford Special Machines. Dies are threaded both sides for maximum economy.
		Single Face	Used principally on National Machinery Machines and for special thread and form rolling applications on all types of reciprocating machines.
	For Gimlet Point Threads	Used on all types of Reciprocating Machines for rolling a wide variety of gimlet point type threads.	
<p>Planetary Dies</p> 	For Machine Screw Threads		To roll threads at high production rates on rotary type machines.
	For Gimlet Point Threads		Used for rolling gimlet point type threads on rotary machines.
<p>Cylindrical Dies</p> 	For Reed Thread Rolling Machines		Selected to provide maximum performance on all Reed Thread Rolling Machines.
	For Other Thread Rolling Machines		Dies specially made for use on all types and makes of cylindrical die thread rolling machines.
<p>Thread Rolls</p> 	For Reed Thread Rolling Attachments		Pre-matched rolls made to assure outstanding performance of Reed Thread Rolling Attachments.
	Standardized Rolls for Single Roll Applications		Used principally for single roll applications, these standardized rolls have eliminated need for special rolls.
	For Other Thread Rolling Attachments		Rolls specially made for use on all types and makes of holders for a wide variety of applications.
<p>Knurls</p> 	Circular Pitch		Used in holders on all types of screw machines and lathes for rolling straight, diagonal and diamond circular pitch knurling.
	Diametral Pitch		Developed for precise rolling of straight and diagonal diametral pitch knurling on fractional increments of blank sizes.

