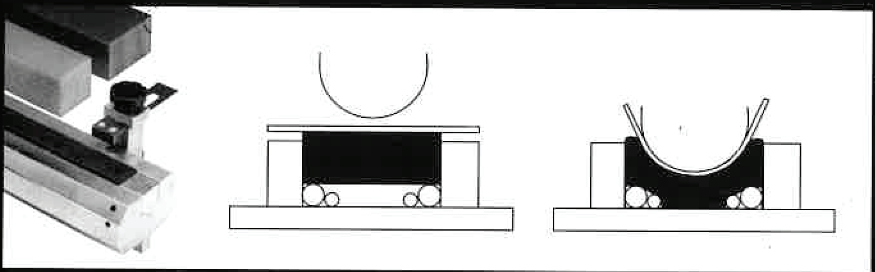
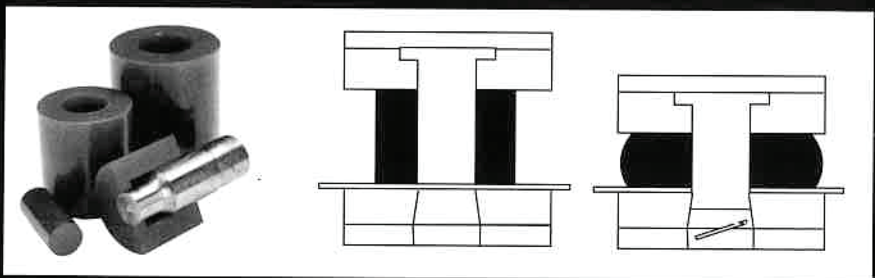
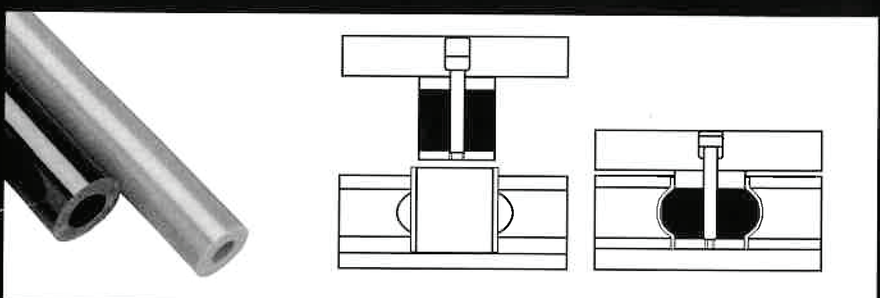
Metalforming with K•Prene® Urethane







ACROTECH

K•Prene® the *unequaled* urethane

Introduction

Our purpose here is to present the basic principles of metalforming with K•Prene® urethane based on proven field experience and research. The principles outlined in this literature should enable you to design a variety of die setups with K•Prene®. If you prefer, Acrotech, Inc. can design and build custom dies for you, allowing you to benefit from some of the best experience and technical knowledge in this segment of metalforming.

There are four basic ways that K•Prene® is used in metalforming – (1) as female dies, (2) as punches, (3) as die inserts, and (4) as springs or pressure pads. Within these four categories the applications are as extensive as the imagination and skill of the designing tool engineer.

Please note that only K•Prene® urethane, manufactured by Acrotech, Inc. was used to accomplish the applications in this book! Because urethane is a generic term the physical properties and performance can vary significantly depending on how it is formulated, mixed, and cured by other manufacturers. In this book, four of Acrotech's formulations (K-420, K-100, K-167, and K-315) are referred to because they were used and developed specifically for metalforming.

The use of K•Prene® in metal forming has gained wide acceptance over the years, and due to its versatility and cost effectiveness, there will be continued usage in the future.

Please Note!

Part Number Conversions

Old Numbers	"New" Numbers
K - 420	K - 800A
K - 100	K - 900A
K - 167	K - 950A
K - 315	K - 750D

Old numbers appear throughout this book.

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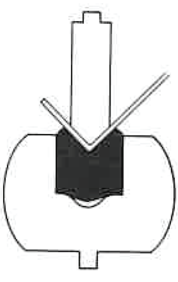
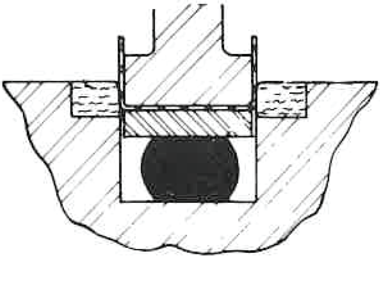
Section 3 – K•Prene® Characteristics and Properties

SECTION NUMBER I

GENERAL INFORMATION





URETHANE – WHAT IT IS

Urethane is an elastomer with properties not available in rubbers, metals, or plastics. It has higher oil and solvent resistance and better thermal stability than most general-purpose rubbers and plastics. It also has greater abrasion and tear resistance in combination with increased load-bearing capacity than do the neoprene or natural rubbers. Its extensibility and impact strength is greater than most plastic materials.

BASIC URETHANE BEHAVIOR

To visualize applications of urethane in metalforming, it is helpful to understand the basic behavior of the material. Urethane behaves as a "solid fluid," changing its shape under load while its volume remains constant. In this respect it is very much like water. As it deforms or deflects, it transmits the applied force in all directions, exerting high, uniform, and continuous counterpressure. Because it has a memory, it quickly returns to its original shape when the load is removed, like rubber.

In terms of die operation, this "solid fluid" property of urethane means that unlike conventional in-the-air-bending steel dies, urethane forms metal under continuous pressure during the entire press stroke. At the beginning of the stroke, it will resist deflection, thus generating high blankholding pressure before any forming occurs. Then, as press tonnage overcomes this resistance, it deflects in every direction in which it is free to bulge, exerting high forming pressure which must be contained and controlled to perform the desired work.

K-PRENE® – WHAT IT IS

K-Prene is the trade-name of various grades of urethane formulated especially for metalforming and marketed by Acrotech.

Urethane can be formulated to provide a variety of properties, and even within one grade of a given urethane formulation, cured properties can vary widely. If you were to buy the same grade from two different manufacturing sources, you would probably get two different products and different results.

Unfortunately, a widespread misconception in the metalworking industries is that urethane is urethane — a single product which is a cure-all in metalworking. This is simply not true, and many efforts to use urethane have turned out unsatisfactorily as a result.

Extensive experimenting and testing was required in the development of K-Prene — thousands of hours over the course of several years spent checking various bends, deflections, resistance to abrasion, etc. It is produced according to extremely close specifications to obtain precise product consistency. This is essential in urethane metalforming operations.

The four grades of K-Prene available from Acrotech are described on Page 8. The right choice of grades depends upon the type of application, available press tonnage, and characteristics of the metals to be formed.

K-420. This is a very flexible urethane which requires less press tonnage to deflect than most urethanes, and it withstands greater deflection. Its best use is in the area of lighter metals, less than 20 gauge mild steel, and it has a good life deflection capacity of up to 35%.

K-100. This is probably the most versatile of the four K-Prene grades. K-100 withstands consistent flexing, has a good cut and tear resistance, good load-bearing capacity, best abrasion-wear resistance, and has a good life deflection capacity of up to 30%.

K-167. This grade is formulated to compare with K-100, but differs in that when a higher press tonnage is available it can be used to provide a higher tensile strength for higher blank holding pressure. In addition to high load-bearing capacity, it has extremely good tear strength and cut resistance. Where high blank holding pressure is required, this is the grade to use. Its maximum recommended good life deflection is 25%.

K-315. This grade is very free machining, and it can be drilled and tapped. It has the highest load-bearing capacity of all the K-Prene grades. It is used principally as wiping blanks, inserts and chuck jaws. K-315 has good abrasion and wear resistance, and offers the greatest rigidity, but it will deflect to accommodate maximum variations in metal thicknesses and castings. Recommended good life deflection is 5%.

K-PRENE®– ITS BASIC PRODUCTION ADVANTAGES

In brief, K-Prene in metalforming saves money, results in an improved final product, and cuts lead time. Here are a few reasons why:

1. It eliminates the expense of mating male and female dies.
2. It eliminates the expense of tool steels and hardening.
3. It eliminates the expense of grinding and fitting.
4. Many times you can use the same female die for several jobs.
5. You can work with pre-polished or pre-painted materials.
6. It eliminates the necessity of using special protective coverings on pre-polished or pre-painted material.
7. Basis for direct labor costs are reduced because specialists such as tool and die makers are not necessarily required.
8. Forming operations can be simplified. Over-forming can be accomplished without expensive cam action tools. Embossing, bulging, and drawing can be accomplished without expensive components.
9. K-Prene automatically compensates for material thickness variations saving on die wear.

This is how it improves product quality:

1. It is non-marring.
2. It provides better dimensional stability because there are no clearance problems. It automatically compensates for material thickness variations, permitting close inside dimensions where K-Prene is used as a female, or permitting close outside dimensions where K-Prene is used as a male.
3. On draw die operations, K-Prene eliminates shock marks, draw marks, and will also reduce thin-out.

Add to the advantages listed above the fact that with K-Prene, the time required to make a die is greatly reduced. Also, there are no delays from heat-treating or re-grinding.

DIE DESIGN CONSIDERATIONS

Again, the characteristics of the material to be formed, part configuration, and available press tonnage dictate the overall die design. However, there are four basic design considerations in metalforming with K-Prene® – (1) control pressure, (2) control deflection, (3) avoid unnecessary strain and heat buildup, and (4) avoid cutting.

CONTROL PRESSURE Unlike a sponge, cast K-Prene cannot be compressed. You must think of it as a solid mass that is deflectible but not compressible. Force from one direction will result in movement of the mass in another direction. If the K-Prene is not restricted it will deflect, or bulge, in all directions as force is applied. Containing the pressure means to restrict this deflection.

Pressure is generated by the applied force, and the resistance of the K-Prene to deflect. Of course, pressure is generated also by the deflection itself – the movement of the K-Prene mass in directions where it is less restricted, or not restricted at all.

Keep in mind that sufficient pressure is required for blankholding on the down stroke, then to form the blank cleanly, and on the up stroke to provide sufficient shedding or stripping.

CONTROL DEFLECTION You might think of "controlling deflection" as allowing the K-Prene to flow in a desired direction as force is applied. Like water, the K-Prene will flow in the direction of least resistance. As a rule the design will be such that work is accomplished as the K-Prene flows. (In some cases, however, it is advantageous to not restrict, or control deflection.)

AVOID UNNECESSARY STRAIN Remember that K-Prene is working or straining when the die pad undergoes a change in cross section (forcing the K-Prene to flow, or bulge) and when it is returning to its original form. For long production runs it is important to design the die so that the work is accomplished with minimum deflection. But in some cases the designer may knowingly over-strain the K-Prene because it is advantageous and more economical to do so – to build a die that will produce the desired number of parts at the least cost.

The most common way to design special dies for minimum strain is to provide backups and supports so as to concentrate forces while at the same time to minimize the flow of K-Prene.

It is also necessary to avoid excessive heat buildup in the die pad because the urethane will lose modulus or its ability to do work. Heat buildup is a function of work done or pad penetration and increases over time if not allowed to dissipate. The die pad penetration for a given job can not very well be changed, but the strokes per hour can be regulated to allow heat dissipation. Limitations range from 3,000 strokes/hour for shallow penetration to as low as 400 strokes/hour for deep penetration.

AVOID CUTTING In regard to cutting, K-Prene behaves somewhat like any other plastic – it resists cutting to a point, but once the cut is there it increases more easily. To avoid cuts, sharp edges should be kept to a minimum. When a sharp edge is required, as on the forming edge of a V-press brake punch, stoning off the ends of the punch will reduce damage. Another suggestion is to run the burr side away from the K-Prene where possible.

THE ACROTECH TRU-FORM® DIE

The Tru-Form Die available from Acrotech as an off-the-shelf catalogued item illustrates a good, standard die design.

The Tru-Form retainer is designed to control pressure – to provide the necessary control. When using a short punch and a long die in the Tru-Form Die, there is a loss of direction of pressure around the ends of the punch. When forming 14 gauge mild steel or lighter, it is no problem because resistance to the initial deflection is sufficient to form the metal and because the pressure that was lost over the ends of the die wasn't needed anyway. In this example we are talking in terms of K-100, and assuming there is ample press tonnage. When forming material heavier than 14 gauge mild steel, we suggest cutting a block of K-Prene to the size of the metal punch and replacing the excess area in the die retainer with a solid block of wood or metal.

In the Tru-Form die there is an air space under the K-Prene pad. This allows for downward movement of the K-Prene into the space to reduce strain and extend the life of the K-Prene, and also to reduce required tonnage. To visualize the value of this feature, picture a flat bottom container that would allow the K-Prene to deflect upward only. This would increase strain and press tonnage requirements. The degree of metalforming deflection upward, and in fact the exact direction for the deflection, can be altered by using additional K-Prene pads in the air space, and by using steel insert rods.

BLANKHOLDING REQUIREMENTS

To provide the right amount of blankholding pressure in a die design it is necessary to select the right K-Prene grade. This is not difficult.

Because K-167 is a higher modulus (load-bearing) material than K-100 or K-420, it has great resistance to being deflected. It is this resistance to deflection that provides initial blankholding pressure. Experimentation has shown that even with an air channel under the K-Prene, K-420 provides sufficient blankholding pressure when forming soft aluminum. When forming mild steel, K-100 provides sufficient blankholding pressure. When forming higher yield strength metals, K-167 is needed to provide sufficient blankholding pressure.

To provide a higher forming resistance (greater blankholding pressure), a K-Prene bar can be inserted into the air space. This pad does not have to be a different grade; in most cases the same grade can be used for the insert pad as well as the forming pad.

Keep in mind that K-167 will do everything that K-100 and K-420 will do, but it requires more tonnage, so you must look at the total job and equipment available before arriving at conclusions.

BASIC K-PRENE® APPLICATIONS

AS A FEMALE DIE The K-Prene deflects and wraps the blank around the punch. K-Prene forming dies will produce sharp, mar-free bends.

AS A PUNCH High modulus (load-bearing) K-Prene will change its shape to suit a female die – even do additional work at the bottom of the stroke.

AS A DIE INSERT A K-315 grade K-Prene is used as a wiping block, eliminating marring and compensating for gauge variations. A wipe-down die is a good example of this type of application where the K-Prene is actually compensating for the material variations and at the same time, forming the material. Blocks can be set to zero and even negative clearance to produce close-tolerance work.

AS A SPRING As springs, strippers, shedders and pressure pads, K-Prene offers major advantages. It provides far more pressure for a given size without sacrificing spring life, and in many cases it provides longer spring life. Often K-Prene is the only way to provide sufficient blank-holding pressure short of getting into sophisticated hydraulic piston systems. With K-Prene you can go well beyond rated compressable capacity. This is impossible with a steel spring because when you go just so far it becomes a solid. When steel springs shatter they shrapnelize, and pieces of spring may damage the die. K-Prene cannot shatter, only split. K-Prene springs are easier to assemble. No spring cage is required. On K-Prene the I.D. is a wring fit for standard dowel diameters and can be held on by friction. K-Prene can also be quickly machined for special shapes. K-Prene offers many advantages when used in stripping as part of punching operations. Again, the I.D. is a wring fit for standard shank diameters.

BASIC APPLICATIONS OF K-PRENE IN METALFORMING

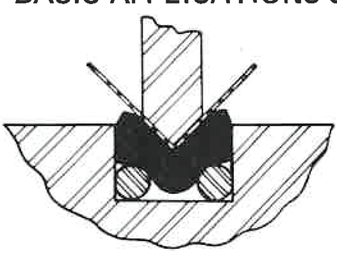


Figure 1
1. FEMALE DIE

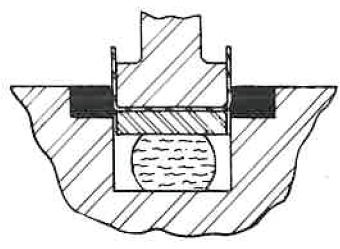


Figure 3
3. DIE INSERT

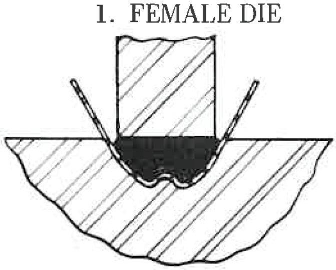


Figure 2
2. PUNCH

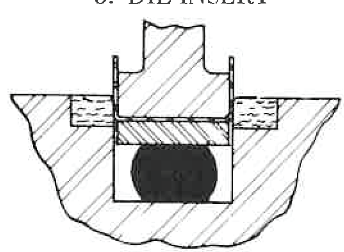


Figure 4
4. SPRING

SPECIFIC K-PRENE® FORMING APPLICATIONS

Before going into more detailed discussion, it should be helpful to further mention briefly the function of K-Prene in specific applications:

PRESS-BRAKE DIES Control is attained through a die-pad retainer that is used to enclose the pad. Under penetration of the punch, the K-Prene deflects to become a female die which literally wraps the metal around the punch. In multi-purpose dies, or for bending heavy gauges, standard and non-standard retainers, as well as pressure rods, contoured pads, and other special devices are used to form the metal.

WIPING DIES Retainers are not necessary. An extra-hard grade of K-Prene is used as forming blocks which deflect the metal and force it against a steel die. Softer grades are used as pressure pads.

EMBOSSING DIES The K-Prene acts as a male die. Used in the form of a thick pad, it first provides high blankholding pressure, then deflects and acts as a "universal" male punch, forcing metal into cavities of the lower die with uniform pressure throughout.

DRAW DIES Thin pads or wafers of K-Prene, acting in conjunction with a K-Prene ring "spring," draw blanks into cups or shells. This technique is often employed in combination with bulging. In addition, the process can also be reversed, with K-Prene rings of blocks drawing the metal over a steel punch.

BULGING DIES The K-Prene is also used as a punch. Under force, it bulges as it is compressed, forcing the blank into the die cavity.

STRIPPING, SHEDDING OR PURE PRESSURE APPLICATIONS K-Prene in the form of cylinders, solid rounds, rectangular bars, or pads acts as springs that provide many times the force per unit area than is possible with conventional steel springs.

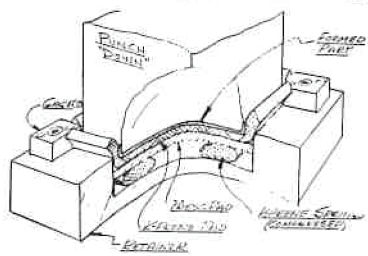
IN CLAMPS AND FIXTURES K-Prene is used in clamps and fixtures to prevent marring of plated or finished parts while providing sufficiently high pressures to permit machining or assembly. The material although extremely hard is still flexible enough to accommodate the variations in castings and forgings yet still hard enough to avoid chatter.

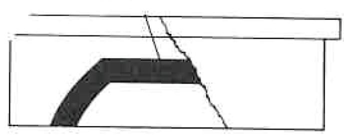
WEAR-PAD APPLICATIONS K-Prene serves as a protective buffer between metal blank and die pad, thereby extending the life of the pad and the punch, and preventing metal marring as when all-steel dies are used.

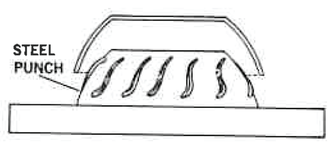
Section number two covers each of these eight application areas in detail.

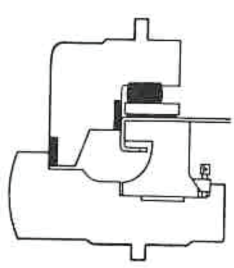
SECTION NUMBER II

K-PRENE® APPLICATIONS IN DETAIL









K-PRENE® USED AS FEMALE DIES

K-Prene as a female die is essentially in V-forming and similar applications, and in forming heavy metals and/or more complicated jobs requiring special deflection-control methods.

V-FORMING AND SIMILAR APPLICATIONS

A K-Prene die pad in a standard ready-to-use press brake die retainer represents a basic, and perhaps the most simple and versatile method of metalforming. Often a single setup will accomodate many jobs with different metals, such as mild steel or aluminum. Furthermore, simply by changing the punch, or by changing the die-pad thickness or hardness, a multitude of forms and bends can be tested and then produced.

A standard retainer (Tru-Form) is not absolutely essential, although it provides the critical provision for deflection control – the air-space channel beneath the die pad. It also provides the necessary side restraints to contain the pressures generated in the urethane. The retainer will withstand bottoming pressures of up to 50 tons per lineal foot.

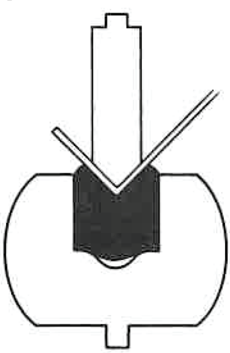


Figure 5

Shown is a standard die setup for V-forming. The radiused air channel at the bottom minimizes undue strain on the K-Prene pad as it deflects during stroke.

An important advantage of a K-Prene die pad is its combination of blankholding and forming pressures. With a conventional all-steel bending die, the blank seldom wraps tightly around the punch, and it is often necessary to smash out distortions due to a crown on either side of the punch point at bottoming. This usually results in score marks, poor definition, and springback. With the urethane die, the blank is in tight contact with the deflecting K-Prene throughout the press stroke, and along with the continuous wrapping or folding action, it has no chance to crown.

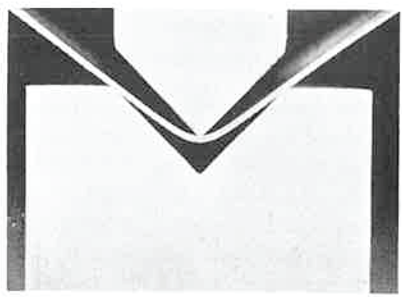


Figure 6

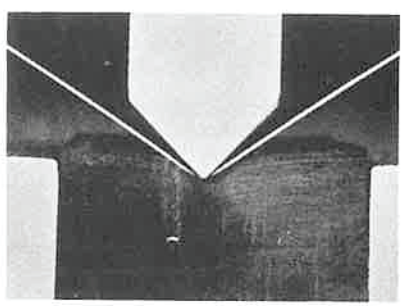


Figure 7

In forming with conventional press brake dies the blank crowns as the punch penetrates the female die, figure 6, causing distortion. With a K-Prene die pad, figure 7, the blank is wrapped around the punch from beginning of pad penetration through bottoming. High blankholding pressure of the K-Prene prevents blank from slipping.

In simple V-forming, maximum metal capacity is 1/4-inch-thick steel. However, pad life is limited for this severe application. For lighter metals, die-pad life may be expected to exceed 50,000 press strokes. In all cases, full life of the urethane can be realized by adhering to sound design limits.

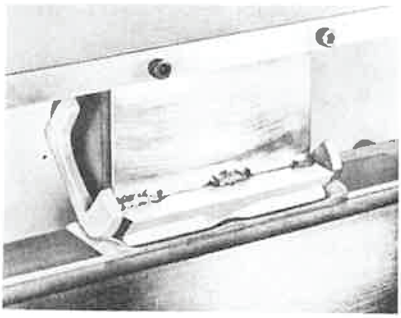


Figure 8

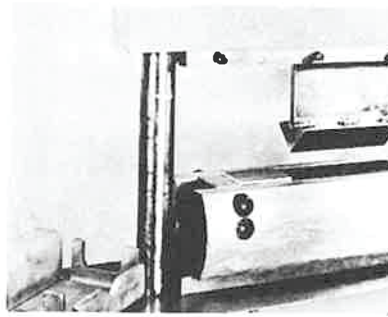


Figure 9

A steel plate 1/4 inch thick is bent 90 degrees to an inside radius of 1/16 inch without fracturing. Retainer is a standard Tru-Form® section 1 foot long. The die pad is K-167.

Other similar applications of simple press-brake forming include channel and U-forming, as well as some compound bending. In all die set-ups, the important thing is to develop enough bottom and side pressure during the stroke to form the material without over-stressing the die pad. It is therefore necessary to consider die penetration and die-pad size, grade, and size of retainer. For example, the finished part width should not exceed 60 per cent of die-pad width; punch penetration should not exceed 5/8-inch for a 2x2 inch die pad of K-167 K-Prene®.

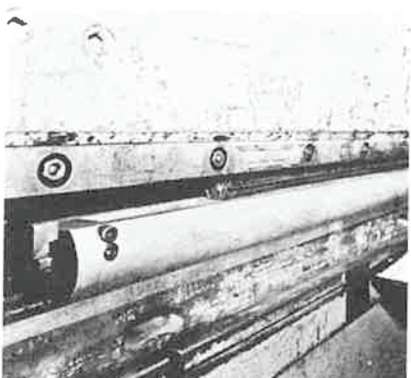


Figure 10

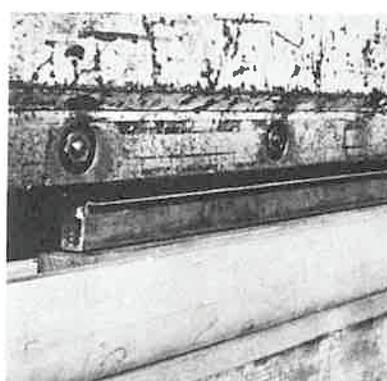


Figure 11

Shown is a K-Prene press-brake die being used to form 8-foot-long channels from 16-gauge HRS. The standard 12-foot-long retainer is also used to V-bend 12-gauge Cor-Ten.

ADVANCE DESIGNS IN K-PRENE® FEMALE DIES

To form heavy metals or to perform complicated jobs, more sophisticated deflection control methods are usually required than the radiused air channels in V-forming.

Some of the methods for controlling deflection are: specially engineered air channels, special die-pad retainers, steel inserts, steel or K-Prene deflector bars, K-Prene die-block or wafer-pad systems, and a variety of standard K-Prene die-pad sizes, thicknesses, and grades. In addition, contoured die pads, K-Prene springs and/or pressure pads, and steel spacer blocks may be used. These various deflection-control methods are presented according to type of forming operation.

U-Forming Dies An adjustable die retainer (see figure 12) is one technique for U-forming. In this design, removable spacers along the sides are used to confine die pads of various sizes. Instead of a machined air channel, deflector rods provide deflection control of the flat K-Prene die pad when it is compressed by the punch. The rods also create the necessary air space for proper stress relief.

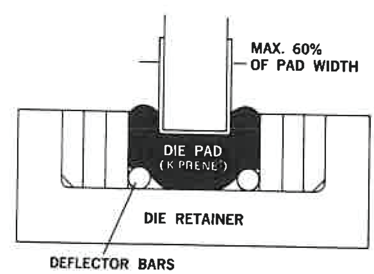


Figure 12

This is a basic U-forming die. The design lends itself to a wide range of U-bends and other forms. End caps should be used for confinement of the die pad.

Use of hard K-Prene (grade K-315) as forming blocks is another method of U-forming. In this design a block on each side of the die is used to wipe the sides up or down. This method is discussed in greater detail in the section on K-PRENE AS A WIPING DIE.

Radius-Forming Dies When standard press-brake retainers cannot be used because of part dimensions or other part design considerations, a die retainer can be fabricated to do the job. One design (see figure 13) provides for the greater bottom pressure necessary to form curved ribs while curving the blank, and without putting undue strain on the urethane pad. The die incorporates a metal or wood insert beneath the K-Prene pad. The pad folds around the punch rather than being deeply penetrated. The design extends the life of the pad, and is ideal for long runs.

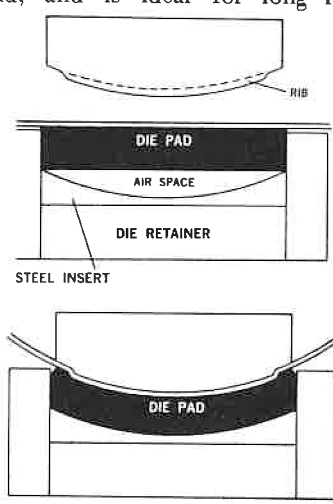


Figure 13

This shows a radius-forming K-Prene die with metal or wood insert. Insert is machined or sawed to the radius of the finished part plus the thickness of the die pad.

Box-Forming Dies One-stroke box forming is readily accomplished with a design that incorporates a single K-Prene pad, usually grade K-100. The pad is notched at the corners so it will freely deflect upward and literally fold the blank (also notched) around all four sides of the punch. This unique folding action places minimum strain on the urethane, assuring long service life of the die. The design is limited, however, to metals no heavier than 22 gauge. When heavier gauges are to be formed, greater blankholding pressure can be provided easily by modifying the above die design. The steel deflector bars are replaced by a steel pressure plate that is placed under the die pad. K-Prene® pressure pads or springs, rather than filler bars, are used between the pressure plate and bottom of the retainer. These pressure pads or springs produce many times more blankholding pressure than conventional springs of the same size. In operation, the die pad again folds the blank around the punch.

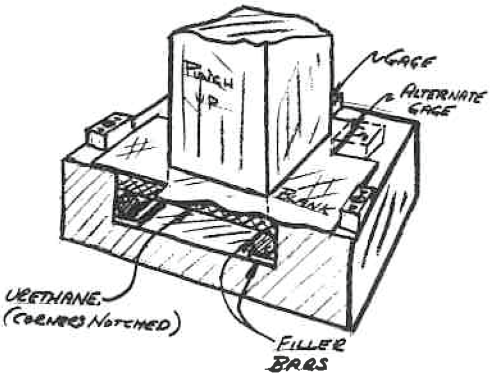


Figure 14

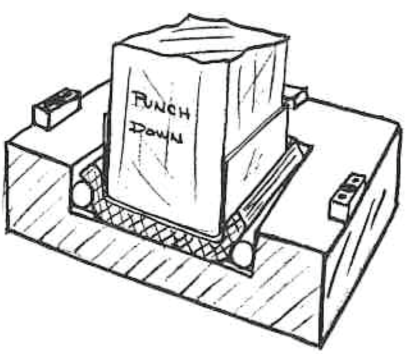


Figure 15

The above drawings show a box-forming die for lighter gauge metals. Round steel deflector bars, placed under the die pad and against four sides of retainer, create blankholding pressure and pad-deflection control.

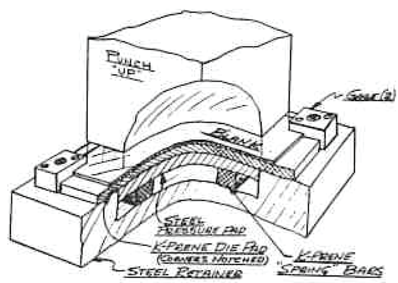


Figure 16

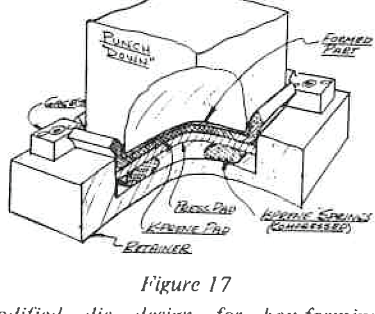


Figure 17

Modified die design for box-forming metals of 22 gauge and heavier.

Compound – Bend Dies Fabricated die retainers and standard flat K-Prene die pads can also be used to form difficult, compound bends. In designing such a die, the width of the die pad should be such that the formed part width is no greater than 60 percent of the die-pad width. Again, deflector bars beneath the die pad provide air space to permit a wrapping action rather than deep penetration into the die pad. The design is applicable to forming parts where sharp bends at the concave sections are not required. Also, definition is better with lighter gauges.

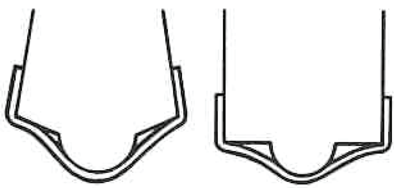


Figure 18

These are typical compound bends that can be formed with K-Prene.

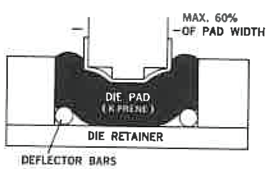


Figure 19

This is a typical die design for compound bends.

Over-Forming Dies Dies with contoured K-Prene® pads can be used to great advantage in over-forming flanges, or when either very deep penetration or special side pressure is required. The die pad is cast or machined to the shape of the part, and is used in either a standard or fabricated retainer. With a fabricated retainer deflector bars must be used to provide an air space and control the urethane upward along the sides. Care should be taken with this, as well as with all other fabricated dies, to provide a sufficient number of gussets along the sides because extremely high side pressures are frequently generated.

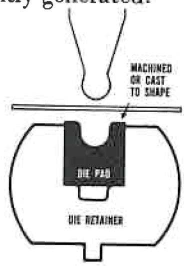


Figure 20

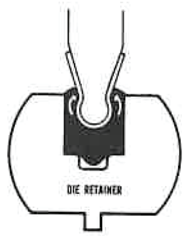


Figure 21

Side-pressure forming in a standard die retainer

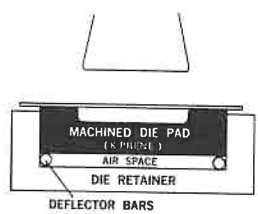


Figure 22

Figure 23

Over-forming in a fabricated die retainer

This die design, with correctly developed punch, has the advantage of compensating for springback. (All K-Prene® dies automatically compensate for gauge variations.) In some applications it provides such great pressures that even side embossing can be accomplished. Because of the side-forming action the design has replaced expensive cam-action dies in some cases.

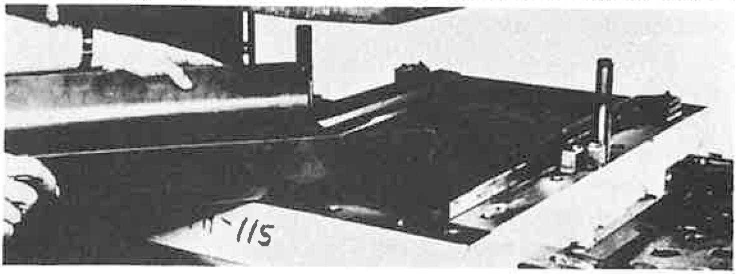


Figure 24

Contoured K-Prene die pad for forming garden tractor hoods. Pad was cast to shape in grade K-100.

Contour-Bending Dies The full extent of contour bending possible with K-Prene dies is shown in Figures 25, 26 and 27. With this die saddle-shaped bends with reverse and re-entrant curves of a surgical retractor are formed in one stroke. The punch is machined to the desired shape, while the female die is a simple box for holding the K-Prene® pad, heavily braced with gussets. Under the die pad are steel deflector bars which provide high clamping pressure at the outside edges to hold back metal during drawing.

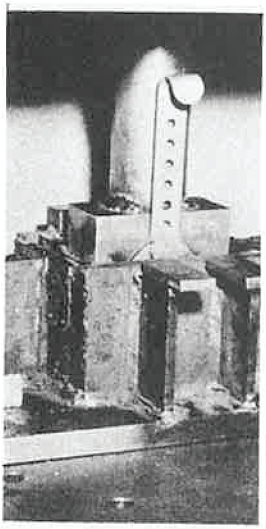


Figure 25

K-Prene pad deflecting at bottomming to force metal tightly against punch.

Figure 26

Die open, showing punch and K-Prene pad, grade K-100 Retainer was fabricated by user.

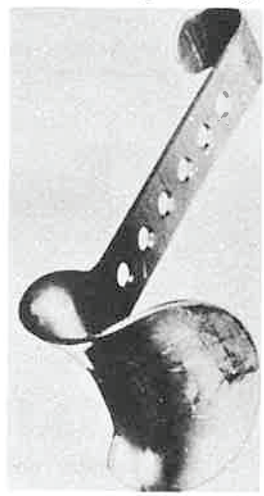


Figure 27

Surgical retractor of 13-gauge, No. 304 SS, formed in die shown. Small bend at top was made in previous operation.

Another approach to extremely difficult bending jobs is the use of a cast-to-shape or contoured K-Prene female die, as first introduced in the section on Over-Forming Dies. Intricate shapes can be bent, such as bending across corrugations. In such a die, the steel punch is machined to the pattern of the corrugation, including the angle that is to be formed in the panels. The urethane female die is cast to the desired pattern but is flat. A panel is used as part of the mold. The design concept is particularly noteworthy because it eliminates otherwise unavoidable wrinkling. This is accomplished by bulging the excess metal into recesses, which at the same time enhances the esthetic appearance of the finished panels and permits interlocking of panels.

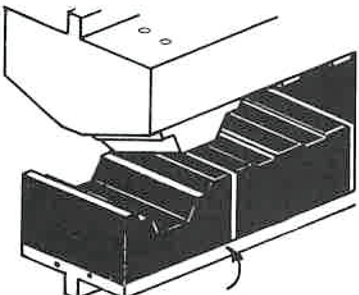


Figure 28

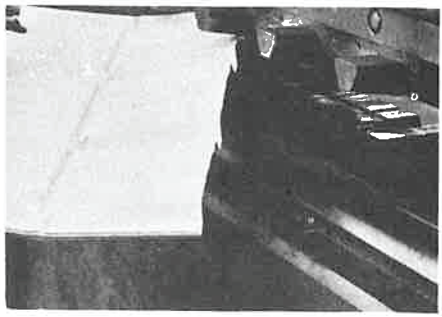


Figure 29

This die is for bending prepainted, 26-gauge corrugated panels, 1 to 12 pitch, in one stroke. We also have made these dies of up to 4 to 12 pitch on one stroke. K-Prene die pad, cast of grade K-100, requires no retainer, and is hot-bonded to base.

In the fabrication of contoured airfoil fan blades made of 10 gauge high tensile steel, two urethane dies are used. In the first operation die, the flat blank is formed into a gull-wing shape, while in the second operation, the leading edge is formed around a contoured punch to the desired airfoil shape; the trailing edges touch and do not spring open.

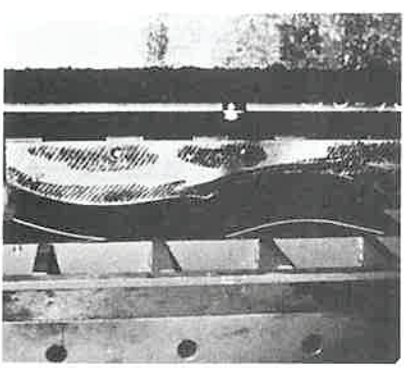


Figure 30

In first forming operation, a contoured steel punch is used in combination with a urethane pad placed on top of a contoured, wood insert. (Sawed to approximate shape).

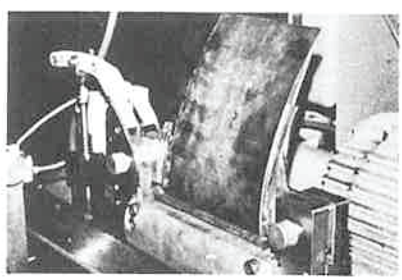


Figure 31

For the second operation, a standard urethane press-brake die is mounted in a special hydraulic press. A developed punch penetrates the die pad, forcing the gull-wing shaped blanks tightly against the punch and into the desired contour. The die pad was cast to shape to permit forming the leading edge up and around the sides without straining the Urethane. *See Tru-Form die illustrations on page 19.*

K-PRENE® USED IN BENDING METAL BY WIPING

In wiping applications an extremely hard grade (K-315) of urethane is used as forming blocks to produce highly accurate flanges without score marks. While this grade is much harder than grades previously discussed, it is still sufficiently resilient to deflect slightly during the press stroke. Thus, the metal blank is confined as the K-Prene forms it tightly against the punch, resulting in a perfect 90-degree bend.

The slight resiliency of the urethane also permits the forming block to compensate for variations in stock thickness. Thus it can be used in close-tolerance, negative-clearance dies. Elimination of score marks and other marring is particularly important in forming pre-finished metals. In practically all cases easy setups are possible.

BLANKHOLDING PRESSURE

To produce sharp definition in wiping, sufficient blankholding pressure is necessary to eliminate any bowing or distortion of the blank. If the pressure is inadequate the metal will rise up and create a crown. In a conventional die a typical way to compensate for inadequate blankholding pressure is to smash the part at the bottom of the stroke. This corrects for crowning, but some distortion or score marks will result.

Resilient K-Prene springs or pressure pads have been used with great success in providing blankholding pressure. Economy is one advantage, but the major advantage is that far more pressure per inch is offered by urethane springs or pads than is possible with steel springs; space limitation is common in die design.

STANDARD WIPING DIES

A die design for press brakes, developed as a standard off-the-shelf item, will produce sharp, mar-free bends without sheet flip-up while cutting setup time and tool cost. The die can be used to form single and reverse flanges in thicknesses up to 16-gauge mild steel or equivalent. It has a fast thumb-screw adjustment for metal clearance, and is provided with K-Prene wear pad, backup heel, as well as pressure pad and forming block.

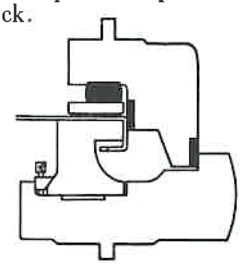


Figure 32
Shown is a standard wipe-down die during stroke (after forming reverse flange).

Figure 33

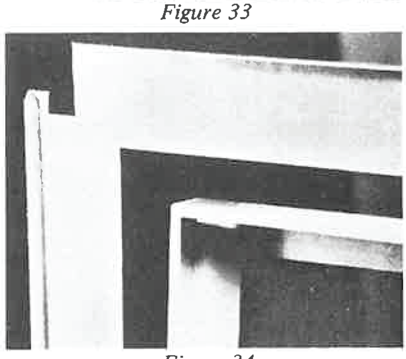


Figure 34
Here reverse flanges are being formed in standard 8-foot-long wipe-down die. Interchangeable horns on die permit forming reverse bend on three or four sides in each of three different-size parts. The part shown is 20-gauge steel for a vending machine door panel.

FABRICATED WIPING DIES Wiping dies can be fabricated for use with either punch presses or press brakes. Figure 35 shows a simple design with a K-Prene pressure pad and a K-Prene wiping block, grade K-315.

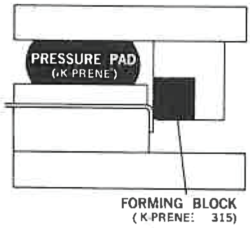


Figure 35

Here is a simple setup for punch press, showing one-stroke wiping action. Block of K-315 can deflect .010 to .020 inch during stroke, then resumes its original shape.

U-Forming Dies _ Fabricated U-forming dies can be made with a single flat, K-Prene® pad. Or, they can be made with two forming blocks of hard K-Prene, as shown in figure 36. In this design the steel plate on top of the pressure pad maintains bottom flatness of the piecepart. The same setup can be used for a wide range of metal gauges by shimming behind the forming blocks.

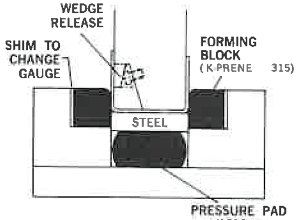


Figure 36

In this die for U-forming, two hard forming blocks of K-Prene grade K-315 are used to wipe up flanges. A softer grade serves as a pressure pad. Wedge release is optional.

Flange-Forming Dies The design concept for U-forming dies can be expanded readily to flange-forming dies for long and wide parts. Figure 37 shows how two sides are formed. The die can also be made to form three or four sides at one time, and also can be made so it will emboss the bottom of the part. (See section on "COMBINATION DIES.")

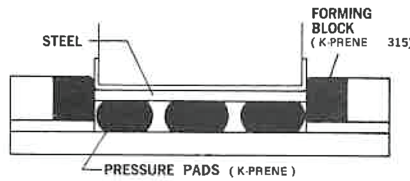


Figure 37

This shows a flange-forming die for wiping up, with a steel plate to maintain bottom flatness and K-Prene pressure pads.

Wiping With Negative Clearance An application of wiping with negative clearance is shown in Figure 38 below. The flanging die uses hard forming blocks to bend .091-inch thick 505H2 aluminum. A similar second operation die forms three reverse flanges in one stroke. Both dies utilize K-Prene pressure pads for high clamping pressure and thus sharp definition.

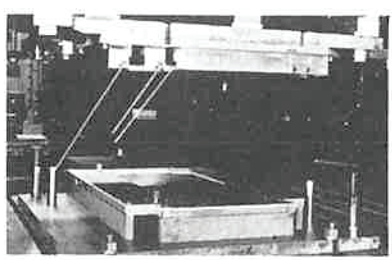


Figure 38

In this negative-clearance flanging die for wiping down, forming blocks of K-Prene (grade 315) form three flanges and two lips in one stroke. Arrows point to forming blocks.

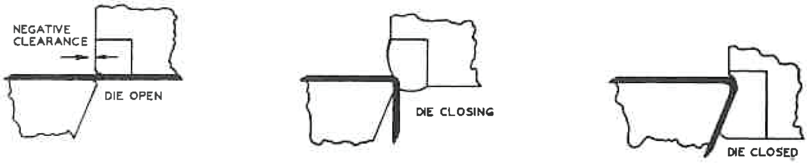


Figure 38A

Shown here is the forming sequence for negative-clearance die setup.

Flange forming with K-Prene blocks need not be restricted to right-angle bends, and more than one bend can be formed simultaneously in one flange. In the die shown below, four acute angles are formed in vinyl-clad, 22-gauge steel blanks having large cutouts in one press-stroke. Again, two grades of urethane are utilized – K-167 for the grooved blocks used to form the two outer bends in the ventilator component, and softer grade K-100 for the pressure pads below the steel plate. In operation the blank is first clamped by the pressure plate as the lower urethane pads deflect. As the press stroke continues, the two inside bends are formed. Then, just before bottoming, the two outer bends are reformed as the hard urethane blocks deflect.

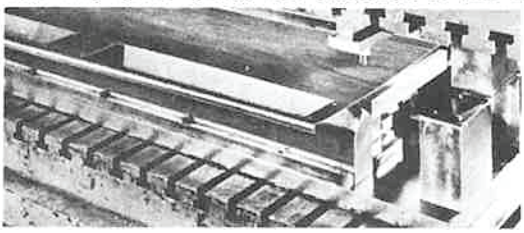


Figure 39

Figure 40

Short prototype die is shown at right with finished ventilator component. The prototype was made to develop angles that compensate for springback. Arrows point to hard K-Prene blocks that form the outer angles. Shown at left is a 41-inch-long production die mounted in press.

Forming Dies With Bronze, Aluminum and Steel Alloy Inserts Dies that utilize the features of K-Prene® but that are designed so that metal inserts only are in contact with the piece being formed are employed in two general cases:

1. The metal being formed is simply too heavy for K-Prene forming blocks. A basic rule of thumb is that blanks heavier than 16-gauge mild steel require metal die inserts.
2. The metal being formed has holes in it or is otherwise too abrasive for long production runs.

A typical die utilizing metal inserts is a "breathing die" shown below. It minimizes score marks and other marring because the stripper or shoulder bolts allow the metal inserts to yield under pressure, deflecting the K-Prene blocks behind the inserts. This type of die offers high production runs, close dimensions, and minimum scoring.

This is an example of how dies can be designed to utilize the benefits of K-Prene even when the part being formed is not suitable for direct contact with the K-Prene. The stripper or shoulder bolts allow aluminum inserts to yield under load and deflect the K-Prene blocks.

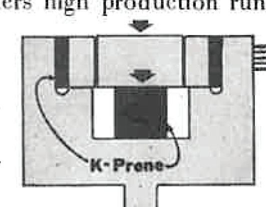


Figure 41

K-PRENE® USED AS EMBOSSING PUNCHES

In embossing dies, K-Prene first provides high blankholding pressure, then deflects and acts as a universal male punch, forcing metal into the cavities of the lower die with uniform pressure. Since only the female die has to be made, and there are no die-alignment steps, setups take only minutes. Sometimes, however, it is advantageous to make the male in steel and use urethane as the female die.

EMBOSSING DIE DESIGN

When designing embossing dies with K-Prene urethane, the surface area of the piecepart, its thickness, and the extent of forming will dictate proper die-pad size, and whether a die retainer is necessary. In general, pad thickness should be a minimum of three times the depth of the embossing. Usually K-Prene grades K-100 or K-167 are used (see "CHARACTERISTICS & PROPERTIES OF K-PRENE URETHANE").

A die retainer is usually not required for embossing dies because of low pressure loss. However, greater press tonnage will be needed. Thicker pads will create increased side pressures, thus requiring a strong die retainer.

Rib Embossing Die An example of a rib-embossing die, which does not require a retainer, is shown in Figure 42. For this design, machining the rib cavities into the steel die is the only major tooling work required.

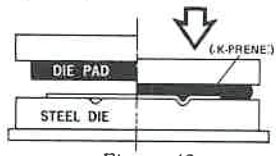


Figure 42

Rib-embossing K-Prene die set. Die pad may be bonded or taped to sub-plate.

Rib and Cavity Embossing Dies Embossing a rib and cavity with the same stroke can be accomplished easily with a die designed along the lines of the one shown in Figure 43. It utilizes a die pad held by a retainer. The pad could also be held by adhesive or double-face clamping tape, depending upon amount of deflection.

Embossing Die Pads and Punches for Difficult Shapes For embossing more complex shapes, a special cast or machine-to-shape K-Prene pad is used to provide the necessary side pressures without over-deflecting the pad (Figure 44).

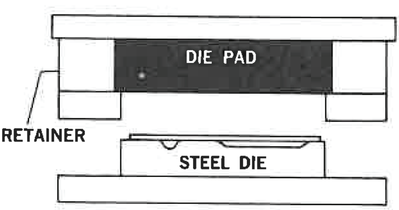


Figure 43

Rib and cavity embossing die.

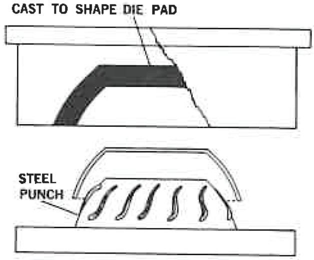


Figure 44

Embossing a drawn shape. The punch could be made of urethane and the die of steel.

K-PRENE® USED TO DRAW METAL

Draw dies using K-Prene urethane have the advantage of drawing spherical and tapered wall shells without puckering because the metal is supported throughout the stroke. Also, pre-finished or highly polished metal can be drawn without marring, scoring, or shock-marks. The tool cost is low because, again, there is no mating of male and female.

DRAW DIE DESIGNS

Cups or shells can be drawn with a die built along the lines of the design shown in figure 45. In this die, the forming action resembles a combination of drawing and bulging. Under compression the blank is drawn upward. The steel or urethane insert is at the bottom of the retainer. It controls pad deflection and concentrates the forces during the stroke. It also provides stress relief. Blankholding pressure is built into the die pad. Construction of the die consists of a circular retainer and 3, 4, or 5 round K-Prene "wafers" or pads, 1/2 inch thick. These wafers function as both punch and blankholder. The reason for using thin wafers, rather than a solid punch, is that they deflect upward more easily into the female die cavity. Also, blankholding pressure can be adjusted to a greater extent for different metals or thicknesses by merely adding to, or subtracting from, the number of wafers used.

Draw Die Designs For Higher Blankholding Pressure When higher blankholding pressure is required, as for heavier gauges or more difficult-to-draw metals, only two K-Prene wafers are used and a K-Prene ring "spring" is fitted around the steel or urethane insert, as shown in figure 46. This spring restricts bottom deflection of the wafer pad. It thereby concentrates higher pressures upward around the periphery of the part, and prevents wrinkling.

A variety of K-Prene dies can be used with the same K-Prene retainer.

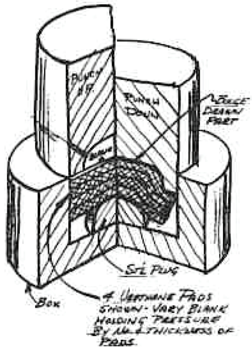


Figure 45

Draw die design using multiple K-Prene ® wafers or pads. The wafers can be interchanged as they wear, thus extending service life. (Patent No. 3382690)

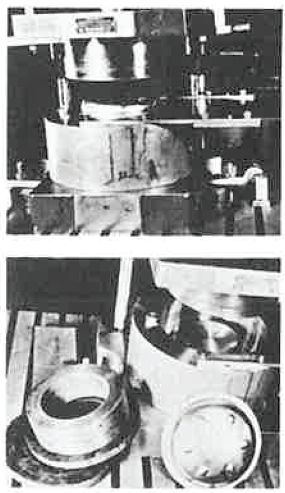


Figure 46

K-Prene die for blanking, drawing, and embossing Hastaloy-X in one operation. The die holds very close tolerances since there are no clearance considerations; the metal is literally bulged up the side of the female die. Finished part is shown in front of the steel retainer. To left of retainer is K-Prene spring which fits around the steel riser block. The two 1/2-inch-thick wafers fit on top of springs and function as both blankholder and punch.

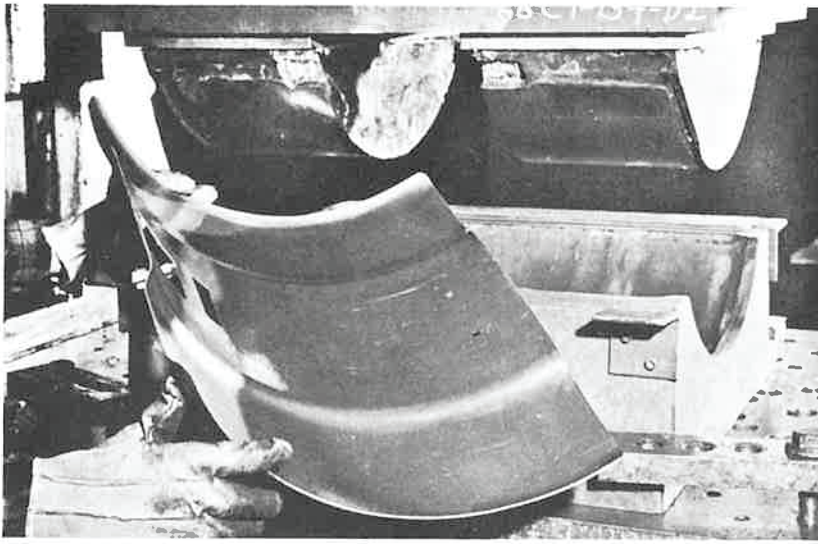


Figure 47

Solid K-Prene® punch and steel female die for drawing 16-gauge CRS in one stroke. The two punches partially air-form curvature at beginning of stroke, then deflect fully at bottoming to draw metal into female cavities.

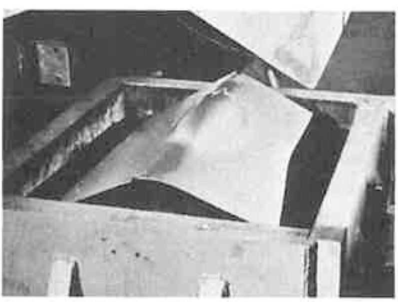


Figure 48

Prototype draw die for first forming operation on bumper ends in one stroke from 12-gauge CRS blanks. The V-shape is formed at beginning of stroke, then the bubble is bulge-drawn. A thin diaphram of urethane is affixed across the die opening to eliminate thin-out and draw marks.

Figure 49

Shaped K-Prene die pads are positioned for proper deflection during stroke, thereby creating high blankholding and forming pressures to draw the metal. Blocks of K-Prene, positioned in bottom of die, act like springs to provide high blankholding pressures.

K-PRENE® USED AS EXPANDING PUNCHES FOR BULGING

In bulging applications, K-Prene offers much longer service life than conventional elastomers because it has a high load-bearing capacity, exerts high pressure, and resists wear. In some applications it outlasts rubbers by factors up to 10:1. In addition, it offers economy over expanding steel punches. K-Prene grade K-100 is usually used in bulging, although grades K-167 and K-420 also find application in this process. (See "CHARACTERISTICS & PROPERTIES OF K-PRENE URETHANE".)

BULGING DIE FOR PRE-DRAWN PAN (SHAPES) In Figure 50, the displacement of the K-Prene punch under compression forces the metal of the pre-drawn pan outward into the die cavity. In this design, the degree of the bulge is determined by the depth of the stroke.

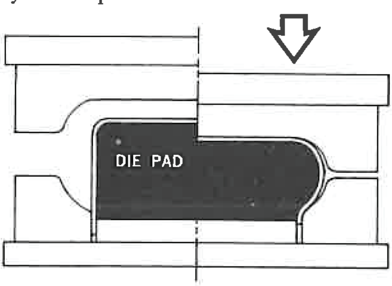


Figure 50

This is a typical K-Prene bulging die. When ram is raised after the stroke, urethane returns to its normal position, permitting removal of formed part.

BULGING DIE FOR NIPPLES For bulging nipples into such shapes as tubing, the round K-Prene punch (Figure 52) is deflected by a plunger and forces the metal into the open die cavity. In this manner, even convolute shapes may be bulged without surface marring.

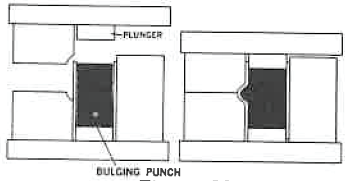


Figure 51

K-Prene® punch for bulging die can be made by simply cutting standard round to desired length.

SPLIT DIE FOR BULGING In the bulging die (Figure 52) a split female die of steel and a round punch of K-Prene is used. Designed for bulging shells, the punch is held by a stripper bolt and bulges in proportion to the stroke length.

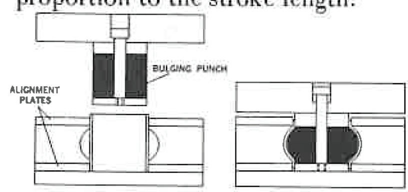


Figure 52

This drawing shows how a K-Prene punch is used in a split die. To remove finished part from this die, the top alignment plates must be dismantled.

Figure 53

This partial brass ball was bulged with K-Prene punch and split-cavity die. The part was produced on a 30-ton mechanical press.

K-PRENE® DEFLECTS INWARD TO CRIMP Crimping dies utilizing K-Prene simply act in reverse from bulging dies. Such K-Prene dies eliminate critical mating tolerances, and cost a fraction of conventional cam-operated dies or electro-magnetic forming equipment, which they can replace. In addition, the high blankholding pressure of the K-Prene can be utilized to advantage, as shown in Figure 54.

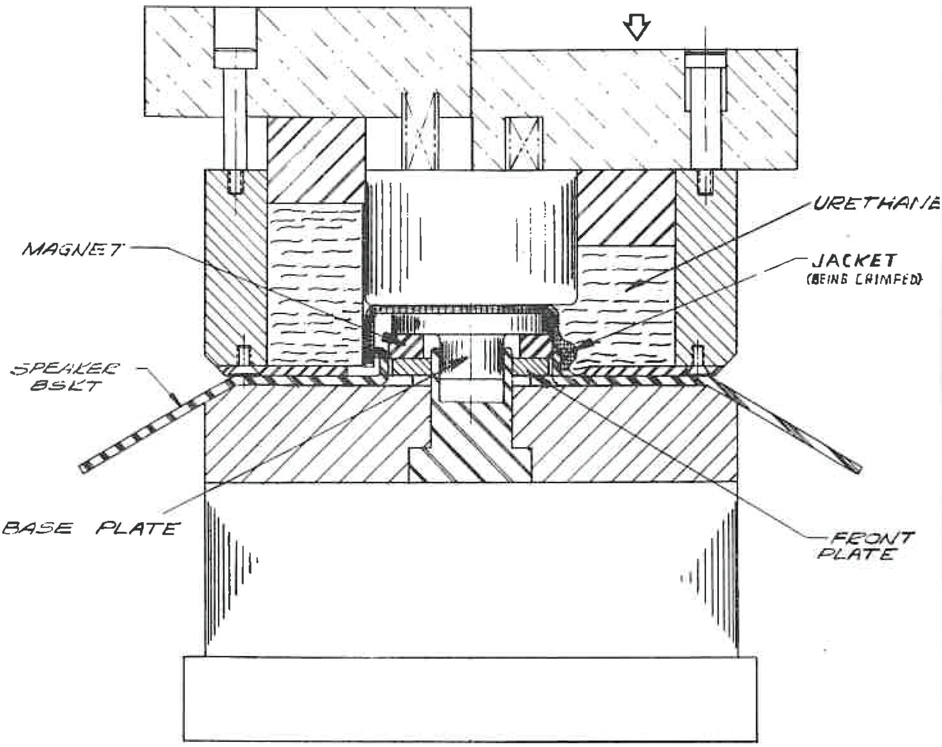


Figure 54

A K-Prene crimping die is used in assembling voice-coil housing. The ring of K-Prene inside the circular steel die, deflects inward to crimp housing jacket around speaker lips in one press stroke. The ring also holds the internal components against the aluminum jacket during crimping, thereby assuring accurate gap tolerance which in this application is critical.

Figure 55

K-PRENE® USED IN COMBINATION DIES

Due to the unusual characteristics of K-Prene it is frequently possible to combine two or more metal-forming operations in a single die and in one stroke. For example, flanging or drawing can be combined with embossing. A great variety of combination dies is possible because of the high blankholding pressure provided by K-Prene, various methods of close deflection control, and the variety of shapes and grades of K-Prene. These factors give the engineer wide latitude in designing dies to meet specific needs and produce mar-free, wrinkle-free parts.

FLANGING-EMBOSSING DIE
Three flanges and four letters are formed in one stroke. The die has two gauge blocks for accurate alignment of the blank, and the K-Prene wafers are notched at the corners so they can easily deflect upward to form the flanges.

FLANGING - FORMING - EMBOSSING DIE An example of a combination flanging-forming-embossing die is shown in figure 56 in a two-station setup. In the first station of this die, flanges are formed with grade K-315 forming blocks. Parts are also precurved at this station so the flanges will be perfectly parallel after the second operation. The second station forms the radius and embosses the ribs with a 1-inch-thick grade K-100 die pad. A machined steel insert at the bottom of the die (refer also to "Radius Forming Dies" in section "K-PRENE AS A FEMALE DIE") cuts the amount of deflection required by the K-Prene to form the part, and thereby lengthens service life.

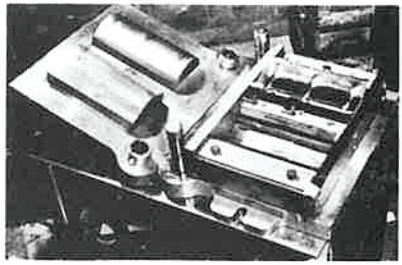


Figure 56

Two-station die for forming and embossing pre-finished stainless steel mirror-backplates. K-Prene pad is underneath part in second station.

DRAWING - EMBOSSING DIE
The K-Prene punch (Figure 57) is used to draw-emboss snow shovels in the last station of a progressive die. The K-Prene punch and die accurately forms both 12-gauge aluminum and 14-gauge stainless steel without downtime for changeover. Other advantages of this die include reduced springback, compensation for metal-thickness variation, and better draw quality at the side of the shovel.

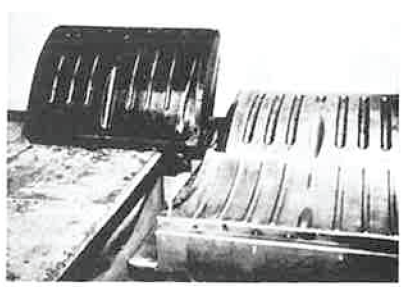


Figure 57

K-Prene punch was cast onto steel backup plate using existing steel female die (shown) in foreground) as part of mold. Original steel punch is in right background.

K-PRENE® FOR BLANKHOLDING, STRIPPING, SHEDDING

For good die operation, sufficient blankholding pressure must be provided on the downstroke, and sufficient stripping or shedding pressure must be provided on the upstroke. With conventional steel springs, the heaviest of which generates only 488 pounds per 1/8-inch deflection, it is frequently impossible to obtain enough pressure in the space available.

K-Prene springs and strippers provide up to 2593 pounds per 1/8-inch deflection, while bars provide up to 90,000 pounds. The amount of pressure that can be generated with K-Prene slabs is unlimited. Thus higher pressure per given unit can be readily provided with these components. A K-Prene pressure pad or bar retains its resiliency and load-bearing capacity for literally hundreds of thousands of strokes since there are no strain points as with forming pads. When replacement does become necessary, it can be accomplished in a matter of minutes.

To design a die with K-Prene pressure components, three unknowns must be determined – (1) the dimensions and the grade of the K-Prene for a given force, (2) how much tonnage is required to deflect a given size of K-Prene, and (3) whether to use K-Prene pressure pads, bars, or solid rounds. On this last point, a detailed outline ("ENGINEERING PRESSURE/DEFLECTION DATA") is presented on page 33.

K-PRENE DEFLECTS TO STRIP OR SHED PERFORATING OR BLANK DIES For perforating dies, K-Prene springs consist of off-the-shelf cylindrical tubes and caps. The cylinders are cast of high-modulus K-167 to fit standard punches, and can be used independently or fitted with one or two caps, as shown in the figures below. The caps are made of grade K-315, fiber-reinforced. They can be drilled, pierced, or machined to the contour of the punch, thereby assuring positive stripping while at the same time dampening punch vibration.

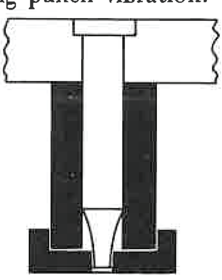


Figure 58

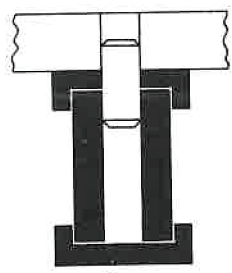


Figure 59

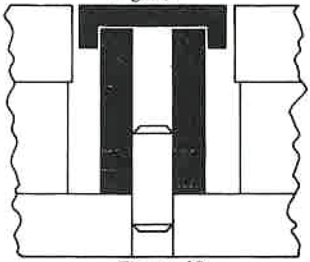


Figure 60

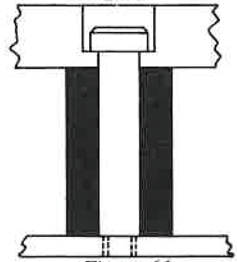


Figure 61

This shows use of one cap on piercing die, two caps for stripping, one cap for shedding, and no cap for pure spring application.

LARGE STRIPPING, SHEDDING, OR BLANKING APPLICATIONS For relatively large stripping, blanking or shedding applications, blocks of K-Prene® are readily machined to fit die openings. Figure 62 shows sections of a compound die for piercing 3/8-inch and 7/16-inch steel engine support plates. Machined K-Prene blocks are used for stripping/shedding. The blocks deflect at the bottom of the 3/4-inch stroke to produce four to six times greater stripping pressure than available with standard springs.

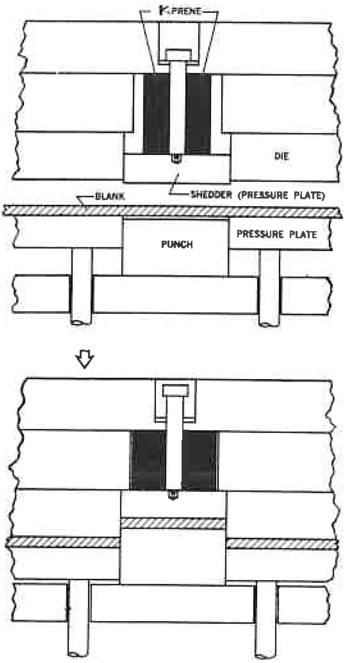


Figure 62

K-Prene blocks of grade K-167 machined to fit various 3-inch to 5-inch round and contoured die openings.

K-PRENE DEFLECTS TO STRIP BLANKING DIE Strips of K-Prene are fastened around punch and in die cavity to strip metal from blanking die. This application, shown in Figure 63, can be used with template, steel rule, and conventional blanking dies.

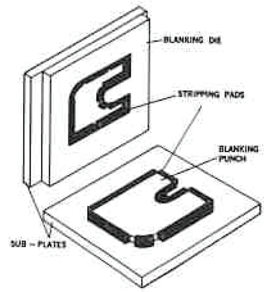


Figure 63

K-Prene stripping pads used with blanking die. Pads can be fastened with adhesive or double-faced clamping tape. Die shown is usually used with master die set.

K-PRENE USED FOR BLANK-HOLDING PRESSURE K-Prene generates more pressure per unit area than conventional steel springs. Conversely, the same pressure can be achieved in a more confined space – an ideal situation for the small areas in dies and fixtures. Springs may take the shape of the previously mentioned cylinders. For greater pressures, solid rounds, square or rectangular pressure pads, or pressure slabs may be used. These shapes are made in four grades, and care should be taken to select the correct grade for the pressure desired.

An example of a K-Prene pressure pad used to provide high blank-holding pressure in a small area is shown in Figure 64. In this conventional U-forming steel die, extremely high pressure is generated upward by the K-Prene pad to maintain perfect flatness at the bottom of the part.

Figure 64

K-Prene pressure pad, shown under steel plate, in U-forming die used for bending 12-gauge steel blank.

ENGINEERING PRESSURE/DEFLECTION DATA

When selecting K-PRENE® Urethane springs, strippers, and pressure pads, major consideration should be given to two factors: the Modulus of Elasticity and the Shape Factor.

The Shape Factor accounts for urethane blocks or cylinders bulging at their sides when under a compressive load. Increasing the area that is free to bulge permits greater vertical displacement, or the same displacement with less force. Conversely, decreasing the area that is free to bulge decreases vertical displacement, or for the same displacement requires greater force.

The concept of Shape Factor is numerically defined as the area of one loaded surface divided by the total area of the unloaded surfaces that are free to bulge. Dimensionally, this may be written as:

$$S.F. = \frac{lw}{2t\,(l+w)}$$ for rectangular shaped blocks

or $$S.F. = \frac{d}{4h}$$ for solid discs and cylinders

Where: l=length, w=width, t= thickness, d=diameter, h=height.

These equations are limited to:
1. *pieces which have parallel loading faces;*
2. *pieces whose thickness is not more than twice the smallest lateral dimension.*

The Modulus of Elasticity, E, is defined as the force per unit area (stress) divided by the percentage of the change in height (strain); or:

$$E = \frac{F/A}{\Delta H/H_T}$$

Where: F=force, A=area, ΔH= change in height, H_T =total height.

For many of the common engineering materials, such as steels, E is a specific value that remains constant within the elastic range of the material. With urethane, however, the E value changes as the Shape Factor changes. Further, its value also changes with each specific compound, see curves on Page 36, 37.

The test data for these curves was determined by Kaufmann Tool & Engineering Corp. during a two-year period. Testing was conducted under controlled conditions, and the data reflects the variation of E vs. Shape Factor for three K-Prenes with dry and lubricated surfaces.

The curves represent a statistical average of the test results, and are offered as a guide to help the engineer predict his forces, size and grade of urethane required, or percent deflection.

OTHER ENGINEERING CONSIDERATIONS

Heat build-up, due to internal friction (hysterisis effect), is the most common cause of premature failure of urethane. The amount of heat generated is a direct function of effective strokes per hour and/or degree of deflection per stroke. Thus, in selecting K-PRENE springs or pressure pads, minimize the percentage of deflection for longer life – particularly when exceeding 700 strokes per hour.

For high-speed applications (12,000 strokes per hour), select the size that will provide the least deflection, or no greater than 15 per cent of total height. For intermittent operation (700 effective strokes per hour), it is safe to select a size which will have as much as 25 per cent deflection.

For short runs or slow-speed operations (200 effective strokes per hour) where long life is not important, the maximum recommended deflection of 25 per cent can be exceeded. There is no bottom position as in steel coil springs.

K-Prene urethane can withstand temperatures up to 250°F, although it may soften before that point and lose some load-bearing capacity. However, upon cooling, it will return to its original physical characteristics. The urethane will also withstand temperatures down to –70°F. If stored in the cold, it should be brought up to room temperature before it is used.

Lubricated or dry condition of load-bearing area is another factor that affects the stress-strain relationship. For urethane compressed between parallel plates, there is a tendency for the surfaces to spread laterally. While a clean, dry loaded surface offers some resistance to this lateral movement, a lubricated surface will offer essentially none. If extremely high pressures are required, lateral movement can be prevented by bonding the urethane to metal with double-faced tape or K-20 adhesive.

Cut resistance of the K-Prene Urethane is very high. However, placing it near a sharp metal edge or permitting it to bulge over a sharp edge should be avoided. With the forces involved, the urethane may fail due to cutting or fracturing.

A final factor that the engineer should consider is permanent set which, like heat build-up is a function of the percentage of deflection. If a small amount of permanent set does occur, the engineer can compensate for it by shimming the urethane.

HOW TO USE THE CURVES

In solving problems, the engineer should first determine the Shape Factor using the formula previously introduced, and assume a particular size of urethane pressure pad.

Having once determined the Shape Factor, the engineer can then select the appropriate grade of K-Prene Urethane, and come horizontally across on the chart to find E. With the Modulus of Elasticity known, he can then apply the basic formula of E to solve for either force or percentage of deflection. That is:

$$F = \frac{\Delta H}{H_T} AE^* = (\%\ \text{Deflection})\ AE^*$$

$$\%\ \text{Deflection} = \frac{\Delta H}{H_T} = \frac{F}{AE^*}$$

NOTE For deflections more than 20%, E must be modified by the multiplier derived from the small curve. (see page 36) For deflections equal to or smaller than 20%, this multiplier is one.*

EXAMPLE 1

Problem A: A forming job on a 15-ton press requires a pressure pad which will exert no less than six tons at bottom of stroke. It cannot exert more than 11 tons of force since four tons will be used for the actual forming. Die design has fixed height of pressure pad as 2", amount of deflection as 3/8" and space available for pad as 4" x 7". For blank holding near bend lines, force must be maintained near periphery of pressure plate (same size as die opening). Thus, pressure pad can be no less than 2" x 4".

Determine size and grade of K-Prene urethane pressure pad.

Assuming the largest pad that will fit into the given die opening, allowing space for bulging, is 3" x 6", we solve for the Shape Factor.

$$S.F. = \frac{lw}{2(t)(l+w)} = \frac{(3)(6)}{2(2)(3+6)} = \frac{18}{36} = .5$$

With F_{MAX} = 11 T. = 22,000 lb.

$$E = \frac{F/A}{\Delta H/H_T} = \frac{22{,}000/18}{.375/2} = 6{,}520 \text{ psi.}$$

On the graph we find that the junction point of E and S.F. falls between the curve for K-167 dry and K-100 dry. Therefore, we must select K-100 and check that the pressure does not fall below the six-ton minimum. Note that if we used K-167, we would exceed the 11-ton limit.

For K-100 @S.F. = .5, E = 4,750 psi.

$$F = \frac{\Delta H}{H_T} EA = \frac{.375}{2} (4{,}750)(18) = \mathbf{16{,}000\ lb.}$$

The tonnage at the bottom of the stroke, therefore, is about eight tons, which is satisfactory.

Problem B: If a change in die design permitted a pad 1-1/2" thick, what grade of K-Prene should be used?

$$S.F. = \frac{(3)(6)}{2(1\frac{1}{2})(3+6)} = \frac{18}{27} = .667$$

$$E = \frac{F/A}{\Delta H/H_T} = \frac{22{,}000/18}{.375/1.5} = 4{,}900 \text{ psi.}$$

Since the deflection in this case is 25%, we find the multiplier for E from the curve in the upper left-hand corner. For 25%, this is 1.09.

Therefore, E=(4,900) (1.09) = 5,340 psi.

On the graph we find that the new junction point for E and S.F. falls between K-100 dry and K-420 dry. Thus, we would choose K-420. Again checking the bottoming force:

$$F = \frac{\Delta H}{H_T} EA = \frac{.375}{1.5}(1.09)(3{,}900)(18) = 19{,}000 \text{ lb.}$$

We find that our bottoming force has now increased to almost 10 tons, which is still between the 6-ton and 11-ton limits.

EXAMPLE 2

Problem: Assume a forming job on a 300-ton press. The die opening and pressure-plate area both are 22" x 40". Die design dictates pressure pad 2" high, to be mounted fairly close to edge of pressure plate, taking space for urethane bulging into consideration.

Travel of pressure plate is 1/2", which consists of 1/8" for preload and 3/8" for forming. Minimum blankholding pressure when forming begins (after preload) is 30 tons. Forming job itself requires 100 tons, and therefore, pressure pad cannot exceed 200 tons at bottom of stroke.

What size and grade of urethane should be used?

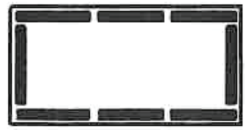
Assume a solid pressure pad of 20" x 38", which leaves a one-inch space around periphery of plate for bulging. Then:

$$S.F. = \frac{lw}{2t\,(l+w)} = \frac{(20)\,(38)}{(2)\,(2)\,(20+38)} = 3.28$$

$$E = \frac{F/A}{\Delta H/H_T} = \frac{400{,}000/760}{.5/2} = 2{,}100 \text{ psi.}$$

The intersecting point for these E and S.F. values falls well below the K-420 (dry) curve. Therefore, this size pressure pad will exceed the maximum permissible limit of 200 tons.

Since a solid pressure pad does fall so far below the permissible limit on the graph, we must use pressure bars. These bars will be placed along the periphery as shown in the accompanying sketch:



Bars are 12" long, with 1" space between bars and 1" space along periphery.

With this configuration, the problem simplifies itself to finding the desired grade of urethane and width of 12" long by 2" high bars from charts in K-Prene Price List No. 20.

Solving for pressure per bar after ⅛" deflection:

$$\frac{(30)\,(2000)}{8 \text{ bars}} = 7{,}500 \text{ lb./bar/⅛" deflection}$$

From the table, we find that a bar 2" x 2" x 12" of K-167 exerts 9,290 lb. per 1/8" deflection, and is therefore satisfactory for the preloading requirement. (Note that if we wanted to change our original configuration of pressure bars and use 3" x 2" x 12", we could use any of the three K-Prenes, K-420, K-100, or K-167.)

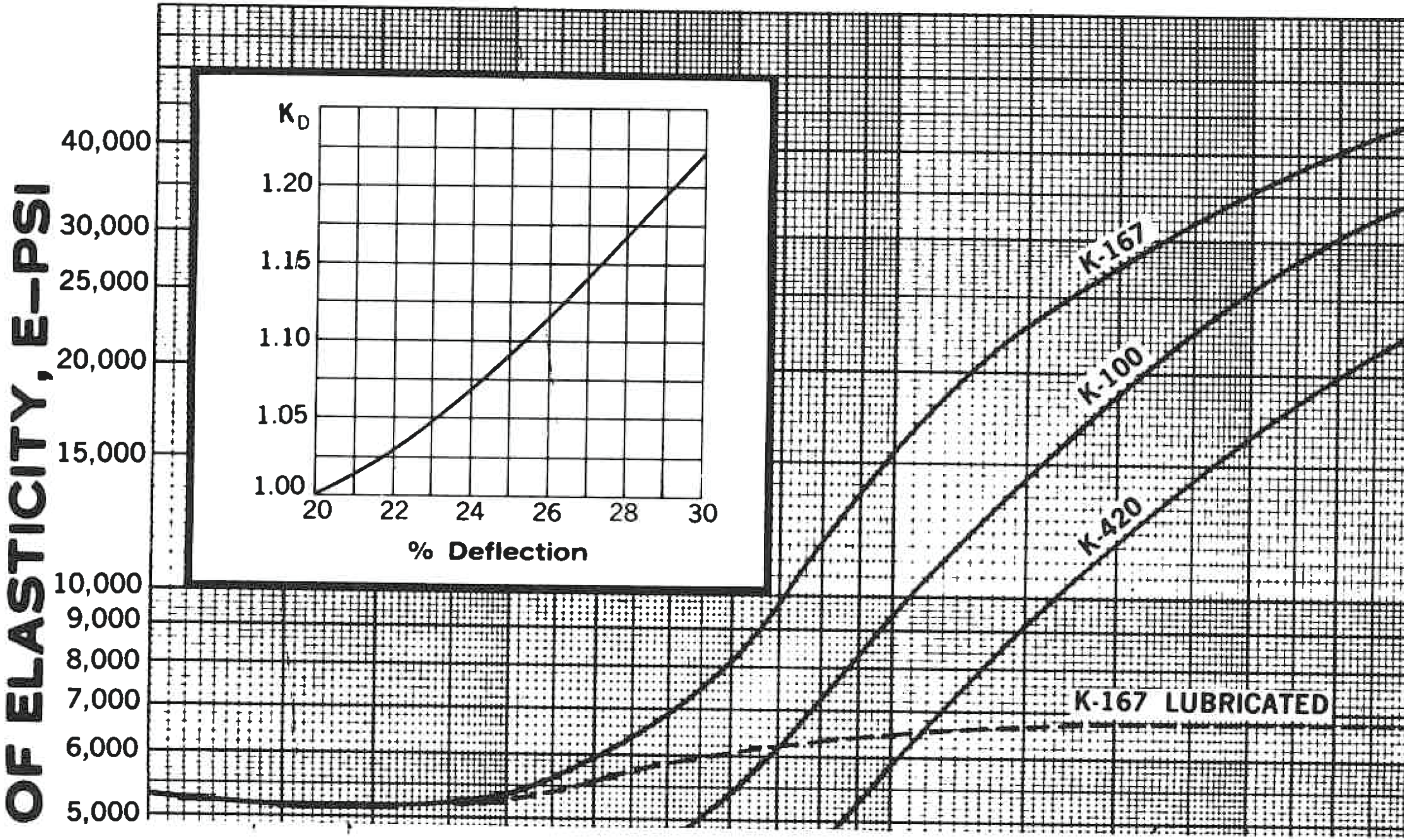
In checking to see that maximum pressure-pad force of 200 tons is not exceeded by the K-167 bar, we must find the actual force after 1/2" deflection.

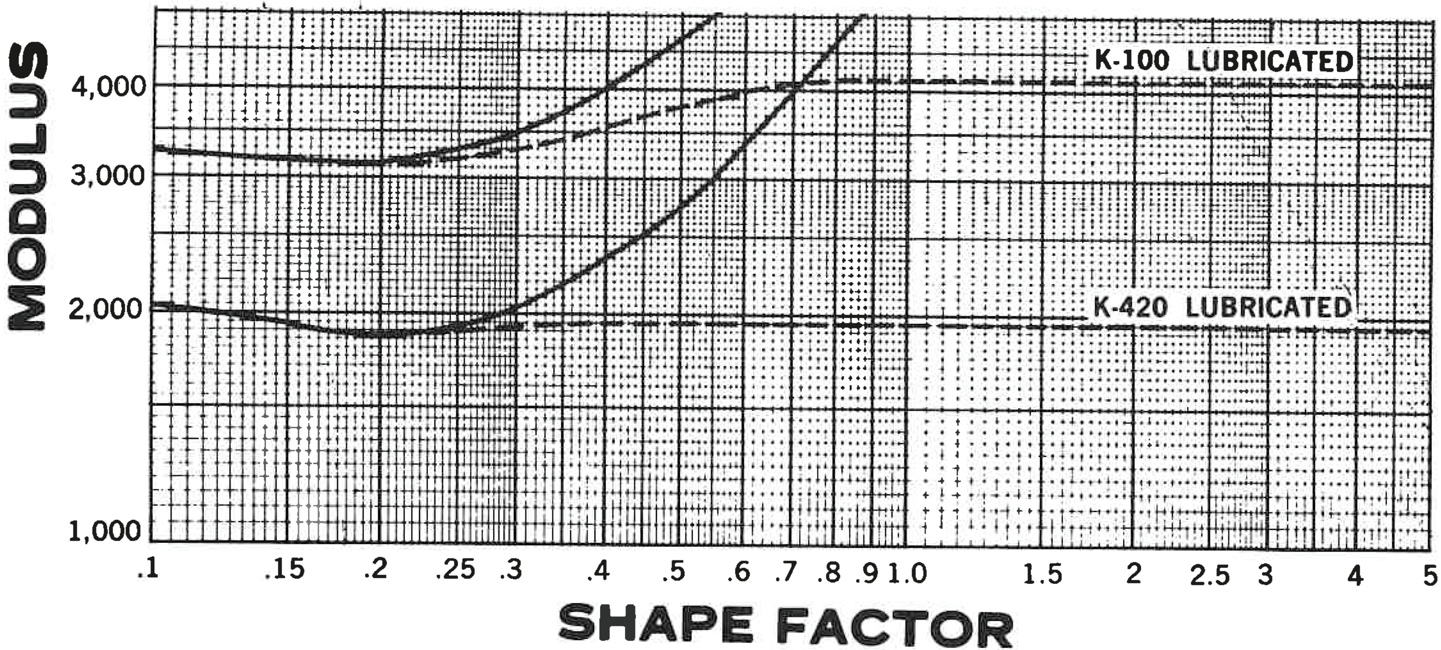
Since total deflection of 1/2" is equivalent to 25%, use the graph in the upper left-hand corner on page 36 showing the multiplier for greater than 20% deflection. Thus, the force actually equals: (9,290) (1.09) = 10,120 lb / 1/8" deflection. Or, (4) (10,120) = 40,480 lb force for 1/2" deflection. Then total force = (40,400) (8) ≐ 323,840 lb.

This value is well below 400,000 lb (200 T.) and is therefore satisfactory.

VARIATION OF MODULUS WITH SHAPE FACTOR

Inset Curve for Greater Than 20% Deflection





To solve for either force (F) or percentage of deflection ($\Delta H/HT$), first determine shape factor (S.F.) and then Modulus of Elasticity (E) from above chart. Use formulas below.

$$F = \frac{\Delta H}{H_T} AE^* = (\%\ \text{Deflection})\ AE^*$$

$$\%\ \text{Deflection} = \frac{\Delta H}{H_T} = \frac{F}{AE^*}$$

NOTE For deflections more than 20%, E must be modified by the multiplier derived from the small curve. (see page 36) For deflections equal to or smaller than 20%, this multiplier is one.*

$$S.F. = \frac{lw}{2t\ (l+w)}$$ for rectangular shaped blocks

or

$$S.F. = \frac{d}{4h}$$ for solid discs and cylinders

Where: l=length, w=width, t=thickness, d=diameter, h=height.

These equations are limited to:

1. ***pieces which have parallel loading faces;***
2. ***pieces whose thickness is not more than twice the smallest lateral dimension.***

K-PRENE® FOR CLAMPS & FIXTURES

K-Prene is used with excellent results in clamping jaws, chuck jaws and positioning fixtures. All K-Prene grades can be used, depending upon rigidity required. K-315 is widely used where contours are machined into a K-Prene block, yet will still deflect to accommodate part size variations, such as when clamping castings.

CHUCK JAWS Complete surface protection is possible when machining either super-finished parts or irregular-shaped rough castings if clamped with K-Prene K-315 chuck jaws. Softer grades can replace costly steel jaws with built-in equalizers and compensators.

CLAMPING JAWS K-Prene can also be machined or cast-to-shape to the approximate contour of the part, and then bonded to steel plates, as shown in the drawing below.

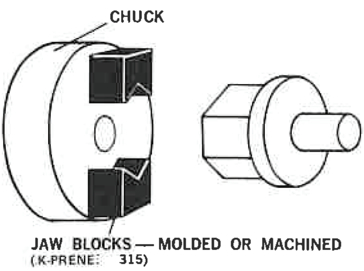


Figure 65

Jaw blocks of K-315 can be molded or machined.

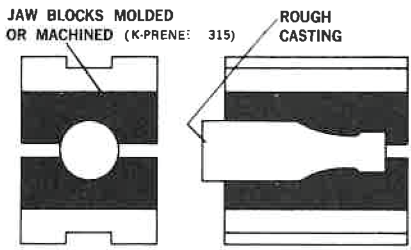


Figure 66

Clamping jaws of K-315 molded or machined to basic contour of part.

POSITIONING BLOCKS Even pre-finished parts like washer-dryer control panels can take the impact of many rugged assembly operations without surface marring when K-Prene® grade K-315 is used for positioning blocks. The machinability of K-315 makes it ideal for making fixtures.

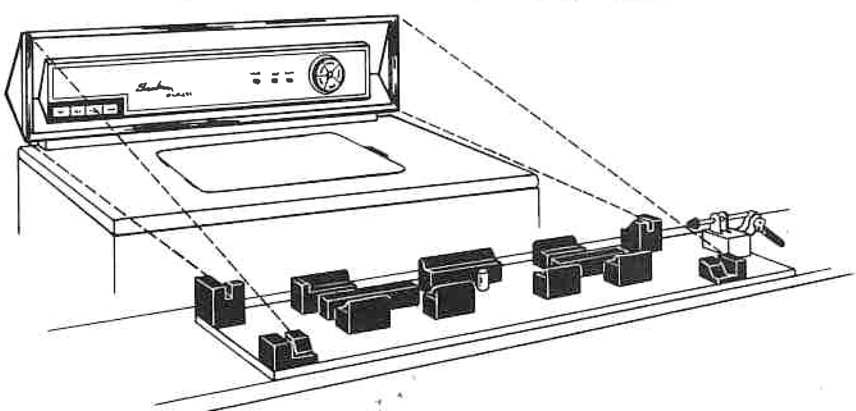


Figure 67

K-315 positioning blocks used in assembly of washer-dryer control panels.

K-PRENE® FOR WEAR PADS

Wear pads are useful in any situation where it is desirable to protect pre-finished or highly polished metals from marring while they are being handled, transported, or worked on.

K-Prene sheets and slabs for wear pads are available in standard and non-standard sizes, and in four grades as well as in two grades reinforced. Thicknesses range from 1/16 inch up to 4 inches.

K-Prene is particularly suitable as wear pads because of its toughness, high resiliency, high load-bearing capacity, and excellent abrasion, oil and ozone resistance. When used as wear pads K-Prene prevents marring and distortion of piece-parts, extends the life of the K-Prene die pad, and prevents marring of metal dies. K-Prene wear pads can be used for most of the die designs described in this literature. In almost every instance, the wear pad serves as a protective buffer between the metal blank and die pad.

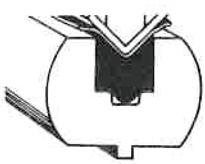


Figure 68

K-Prene wear pad protects die pad in simple press-brake forming operation.

WEAR PADS WITH ALL-STEEL DIES An example of using K-Prene wear pads with all-steel dies is shown in figure 69. The pad is attached to one side of the die. The K-Prene flows along with the punch part to protect against surface marring. The pad also permits a tighter fit between the punch and die when bottoming, and equalizes bottoming pressure to improve bend definition.

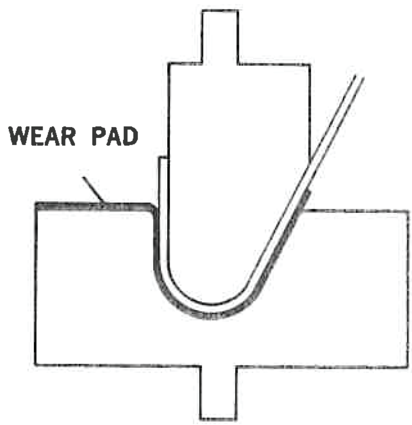


Figure 69

When using K-Prene wear pad in all-steel die, an extra clearance of approximately 80 percent of wear pad thickness must be allowed per side if using pads.

WEAR PADS WITH STEEL STRIPPING PLATES In the use of wear pads with steel stripping plates, surfaces are protected to eliminate marring, and pressures are equalized, compensating for mismatch.

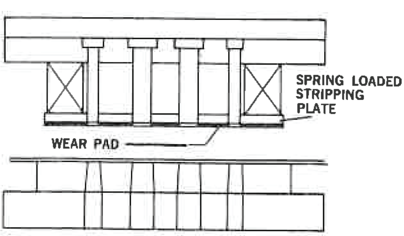


Figure 70

A conventional design, showing K-Prene wear pad bonded to bottom of spring-loaded stripping plate.

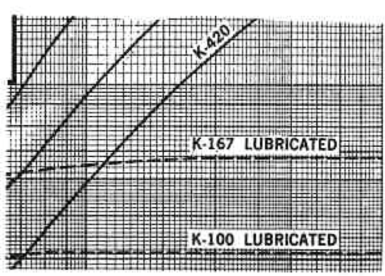
SECTION NUMBER III

K-PRENE®
CHARACTERISTICS AND PROPERTIES

$$S.F. = \frac{lw}{2t\ (l+w)} \quad \text{for rectangular shaped blocks}$$

or

$$S.F. = \frac{d}{4h} \quad \text{for solid discs and cylinders}$$



GENERAL PRECAUTIONS – MACHINING DATA

General The basic behavior of K-Prene® in metalforming has been discussed previously. More specific information on the four K-Prene grades available is provided on page 45. Durometers are intentionally ommitted since they can be misleading; various urethane brands with the same durometer may have completely different characteristics, load-bearing capacity, and other metalforming properties. Again, the type of application, available press tonnage, and characteristics of the metal to be formed will assist in selecting the best grade and size.

PRECAUTIONS

As with any other material, K-Prene® can be damaged if used improperly. The following suggestions are for guidance only.

Prevent Punches From Cutting K-Prene Sharp punch ends will eventually penetrate the K-Prene and start a cut, resulting in pressure loss. For long pad life, stone off any sharp ends on punches to minimize this problem. A K-Prene wear pad will provide considerable protection, but the above steps should also be taken.

Unless care is taken, metal chips may become embedded in the pad surface, resulting in a scratch hazard. However, flat die pads can be turned over or machined smooth again.

Prevent Overdeflection For longer life, K-Prene die pads should not be deflected beyond "maximum deflection" as stated in the table on page 45.

Stock Extra Die Pads For production runs, it is recommended that extra pads be available for repairs. However, short sections may be butted together in a die retainer to replace damaged pads (they perform like one piece under compression).

Strong Retainers Required For dies requiring metal retainers to enclose the K-Prene, be sure they are designed with sufficient strength to withstand the high side pressures transmitted during compression.

Machining K-Prene The following table is based on our experience in machining various grades of K-Prene. Generally, the hard grade K-315 can be machined in virtually any manner with excellent results – like machining aluminum or magnesium with very similar tools, speeds, and feeds. Grade K-420 is considerably limited due to its relative softness. Grades K-100 and K-167 have very similar machinability characteristics, and evidence indicates that machinability can be improved by freezing the K-Prene.

It is important that work and tools be kept cool for greater accuracy and tool life. In all instances, ordinary lubricant is adequate. K-Prene can be polished with emery cloth after machining.

K-PRENE® MACHINING CHART

MACHINING APPLICATION	Recommended Tools	Size Limitations	Grades	Max. Speeds	Workholding Recommendations	Suggestions
BANDSAWING:	Sharp 2-4 hook carbon blade with raker set	Max., 8" thick; min., 1/8" thick sheets	All Grades	1800 ft./min. (Reduce to 1200 ft./min. with Grades L-420 and L-100)	Vises or clamps (Not required with flats and sheets)	—Rotate rounds when sawing —Maintain high blade tension
CUTTING/SHEARING/ SLITTING:	Shears or belt-cutting machines with up to 1/8" knife blade	Thin sheets only (up to 1/2")	All Grades	—	Friction clamps	—Use bevel edge blades (square edges compress urethane, resulting in uneven cuts)
DRILLING:	High-speed 90° + twist drills with blunt point	Min. of 3/8" (No min. if clamped between steel)	All Grades	600 to 800 RPM	Vises or clamps	—Good tolerances possible with L-315; for other grades, use OVER-SIZE drills
TAPPING:	Regular high-speed taps	None	All Grades	—	Vises or clamps	—Except for L-315, use OVER-SIZE taps to allow for shrinkage of urethane
TURNING/BORING:	H.S.S. tool bits with positive rake of 5° to 10°	No limit on dia., but length restricted (long, softer bars may flex)	All Grades (More rake required for softer grades)	800 surface ft./min.	Angle of cut to work: 90° to 120°	—Form tools may be used (especially when machining L-315)
MILLING:	Sharp single-blade flycutters, with 10° back rake and good clearance	Min., 3/8" thick	—Grade L-315 best for end-milling —With L-100 and L-167, cutters must have extreme back clearance	Approx, 2000 surface ft./min. (with 3" cutter)	Vise or double-face clamping tape	—Flycutting at approx. 3" dia. gives best results

SELECTING K-PRENE® URETHANE MATERIALS

ACROTECH K-PRENE has advanced to the heavy-duty, high-production stage of metal forming because it has a unique combination of physical properties. Its modulus is high enough to generate high blankholding pressure, yet resilient enough to deflect and pressure-form the metal — and then return to its original shape. Its non-compressibility and high modulus permits control for consistent forming accuracy. Because it is resistant to abrasion, oil, and ozone, it withstands adverse operating conditions.

WHY K-PRENE: Solid, cast urethanes have different physical properties which, even within one family, can vary depending upon formulation, additives, and processing methods. ACROTECH K-PRENE Urethane is based on the polyether family, and in addition to its other unique advantages, has a cut-resistant surface because it is cast in enclosed molds. And, an as-cast surface has better fracture resistance than a machined or ground surface. In applications where surface cutting is predominant, reinforced pads greatly minimize cut propagation, and considerably prolong service life.

The K-PRENE materials presented are available in four grades, unless otherwise noted. The type of application, available press tonnage, and characteristics of metal to be formed will assist in selecting the best grade and size. In the table below, durometers are intentionally not shown because they can be misleading; various urethane brands with the same durometer may have completely different characteristics, load-bearing capacities, and other metalforming properties.

Refer to "new" formula numbers when ordering K-Prene.

K-420

Requires lower tonnage. Withstands greater deflection.
Should not be used for material heavier than 20 gauge mild steel except in special applications.
Maximum recommended. deflection: 35%
Should be used with 1/8" thick K-167 wear pad.
Tensile Strength: 2,600 PSI

K-100

Withstands constant flexing.
Good cut resistance
Good load-bearing capacity
Recommended for most applications where large radius bends or difficult bends require large deflection or flow of K-Prene.
Maximum recommended deflection: 30%
Tensile Strength: 4,500 PSI

K-167

High tensile strength for higher blank-holding pressure.
High load-bearing capacity
Best tear strength
Best cut resistance
Best abrasion/wear resistance.
Recommended for most applications.
Maximum recommended deflection: 25%
Tensile Strength: 5,200 PSI

K-315

Greatest load-bearing capacity.
Excellent machinability
Good abrasion/wear resistance.
Offers greatest rigidity, yet will deflect.
Maximum recommended deflection: 5%
Tensile Strength: 11,000 PSI

Hopefully this information has been educational and proves to be valuable.

Remember the following when starting to look into a forming application where K•Prene® may be an option:

1) How long is the part?
2) How deep is it?
3) Quality required?
4) Is marring a problem?
5) Are tool cost economies a problem?
6) Are material costs a problem?
7) How many production parts make up the run?

Specialized K•Prene® Tool Design - If extensive K•Prene® tooling experience is required to solve unusual production problems, please submit details and piecepart drawings to receive our recommendations.

Custom Die Design-Manufacture - If your tooling is urgently needed, Acrotech can adapt any of the die designs shown to meet your application requirements. We will furnish complete, ready-to-use K•Prene® dies.

Stocked K•Prene® Fabrication Tooling - 1) K•Prene® female bottom dies in 90 and 30 degree styles. 2) K•Prene® inserts for use with steel "V" dies conform to the punch tip being used. 3) Tru-Form® dies which work on the same principle as an insert but include an aluminum extrusion that acts as the retainer. 4) AcroHyde™ film, available in .015 or .030 thicknesses. **1–4 will prevent die marks when forming stainless steel, aluminum, pre-painted material, etc., eliminating the removal time and expense.** 5) K•Prene® punch strippers in standard and metric sizes. 6) K•Prene® sheets, bars, tubes/springs.

Our **Industrial Products Catalog** features the above stocked products and more, complete with sizes and prices. Be sure to ask for one!

Additional Acrotech, Inc. Products and Services

Because K•Prene® can solve so many diverse applications, please take a moment to read about our other products and services.

Stocked K•Prene® Products–Sheets, rods, tubes, bars, and bumpers in a variety of sizes and styles.

Versa Roll™–a wheel/roller product available in several OD and ID combinations. Outer tire ghardness can match your need.

Slick Strip™ Tape–a friction reducing tape that also prevents damage to finished parts.

Custom Molding–Often more cost effective than repeatedly machining parts to size. Submit a print and/or sample to receive a quote. We can provide any metal inserts required.

Re-covering of Shafts, Hubs, etc. and/or Complete Manufacturing–Submit a print or sketch to receive a quote, or use form on page 49.

One Pass Roll Bending Machines–Designed for production and precision. These machines roll a wide variety of sheet metal including perforated or die cut blanks into cylinders with little or no flat on the ends.

Custom Rolling–If you only have sporadic, low volume, or difficult to roll parts, Acrotech will roll them for you on our one pass machines. Submit prints, or complete form on page 48 and fax in to receive a quote. (See back cover.)

Wood Industry–Variety of common replacement parts for molders, feeders, double end tenoners, etc.

High Performance–Primarily for racing application – spring rubbers, bushings, bump stops, etc.

Di-Acro Fabrication Equipment–finger brakes, shears, notchers, rod parters, punches, slip rolls, benders and power benders!

Please contact Acrotech, Inc. if you have questions or would like to receive information about any of our products and services!

See Back Cover!

Quote Request - Custom Rolling

Please complete the following for each part!

Material	Thickness	OD	Length	Qty

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________

Company ______________________________

Contact ______________________________

Address ______________________________

City ________________ State ______ Zip __________

Phone ________________ Fax ________________

E-mail ______________________________

If you would like rolled samples of each part or if you would like a quote on the machine required, please contact our machine applications department!

ACROTECH

E-Mail: acrotech@acrotechinc.com
Website: www.acrotechinc.com

800-345-0583 • 651-345-3362 • FAX: 651-345-3759

Custom Roll Manufacturing & Re-Covering Form

Date ____________ Company ______________________________ Name ______________________

Address ______________________________________ City____________ State ____ Zip __________

Phone ____________________ Fax ______________________ E-mail ________________________

New or existing part (please circle) If existing, what is current material?

Requirements: ____________________________ **Fill in dimensions below with tolerances.**

Manufacture complete Part number ______________ Durometer ________ Average order size

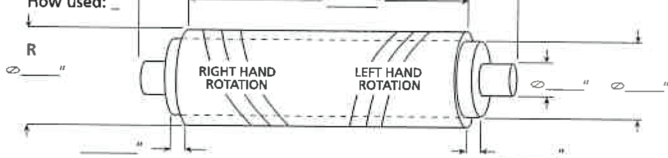
Coat only ________ Color ______________

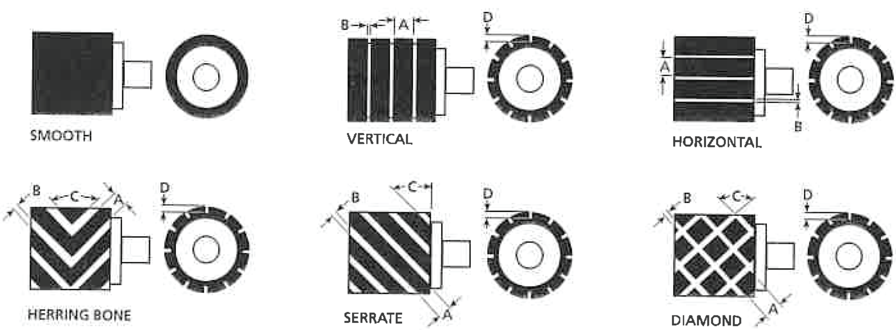
Strip & recovery How used: _

Regrind only

Bevel ends

Balance RPM





Dim "A"(Land) ______" Dim "B" (G. Width) ______" Dim "C" (Angle) ______° Dim "D" (G. Depth) ______"

Groove rotation ________________ Groove type ________________

For all your custom molding needs contact:

ACROTECH

E-Mail: acrotech@acrotechinc.com
Website: www.acrotechinc.com

800-345-0583 • 651-345-3362 • FAX: 651-345-3759

Notes

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