# CRUSH CUTTING REFERENCE GUIDE

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# About this Slitting Guide

To compliment our Shear Slitting Reference Booklet, we are very pleased to provide a Quick Reference Guide for Crush Cutting.

With this guide we offer some theory on geometric and force relationships, information on common set-up techniques, trouble-shooting answers, and other generally useful cutting facts. In addition we would like to introduce the reader to our line of crush cut knife holders and the various types of crush cut knives and their product applications.

*Once again we wish to share credit for this booklet with our colleagues in Spencer, MA, USA and those at Dienes Werke, Overath, Germany who have also made significant contributions.*

*We hope the information presented helps your operation in a positive way.*

# Contents

# The DIENES Group Locations:

DIENES WERKE
Overath, Germany
Founded 1913
Manufactures knives, holders
and positioning systems.
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DIENES CORPORATION
Spencer, MA USA
Founded1977
Manufactures knives,
holders and positioning systems.
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NEUENKAMP REMSCHEID
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Founded 1926
Manufactures metal roll
shear knives (metal slitting)
components and systems.
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EUROKNIFE
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Founded 1995
Manufactures slitting knives,
holder components.
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# Introduction to Crush Cutting

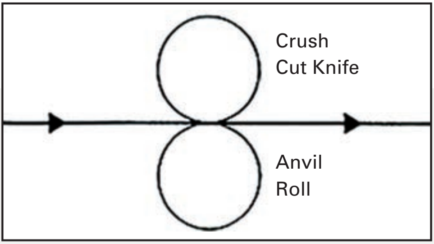
Crush cutting uses brute force to penetrate a knife blade through materials. Usually this force is applied via a pneumatic powered knife blade holder against a hardened anvil roll. Blade radius and cutting angle selection can significantly influence the effectiveness and quality of the cut.

Crush cutting equipment costs less than shear components, is easier to set up for different widths, but delivers rougher edge cut quality. Each application requires subjective analysis by both the converter and end user.

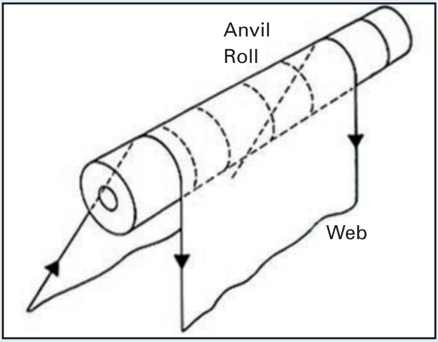
Also, in general terms, knife life is typically less because of the cutting methods and forces employed. Very high speed operation is impractical. Dust levels are higher as well.

# Crush Cutting Web Paths

As with shear slitting, either "tangential" or "wrap" web paths can be used. When slitting with a wrapped web, the anvil roll should rotate at line speed; especially with easily damaged materials. A tangential web path is preferred, and generally, because contact is slight, a 3% to 5% anvil roll over-speed should be used to enable the crush cut knife to keep up with web pressure yielding a smooth, break free slitting process.




*Tangential Web Path or Tangential Cutting*




*Wrap Web Path or Wrapped Cutting*

Crush cutting is generally better for slitting very tough materials such as rubber or sand paper, although some lightweight tissue grades, laminates and adhesive materials fair well with this technique. With some laminate webs, crush cutting can provide a temporary seal of the multiple layered materials. Crush cutting lends itself to heated knife cutting which is useful when cutting adhesive backed webs.

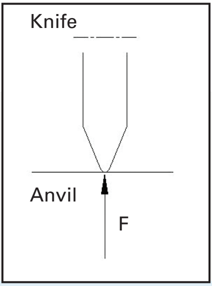
Even though the terms “crush” and “score” cutting are used to mean the same thing, technically there is a difference. Crush cutting completes material penetration to create two separate pieces. Score cutting partially penetrates the material leaving one piece that can easily be folded, or, in the case of a laminate, only cutting one layer of material.

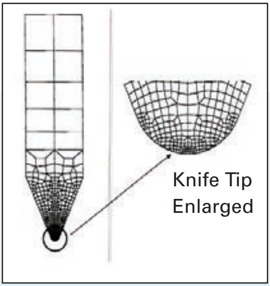
# Force Analysis

### Fracture Theory

Any steel has compressive yield strength. The blade material is somewhat elastic, even in a hardened condition. Its shape can be altered under force.

Because there is always severe contact between a crush cut blade and the harder anvil roll, a basic understanding of material fracture theory should be of benefit.




**Fracture Theory Analysis:**

DS = F/A, whereby F is the applied cutting load and represents the Cross Sectional Area of the Knife and
DS = Design Stress of the Knife material
More Radius = More Load Capability

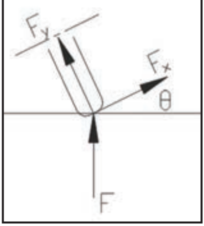
When a knife is pneumatically loaded against an anvil, the force of the contact is applied back up to the blade tip. The material strength of the blade is then opposed by the force being applied down through the knife holder over the area that the knife edge creates against the anvil roll. If a knife edge cannot carry the applied load, it will quickly deform to create enough area for load support.

Most knife materials have about ½ million pounds per square inch compressive yield strength. As long as the ½ million pounds is not exceeded, the blade will not fail or break. Increasing force levels or decreasing knife blade contacts areas (radius), that causes higher forces, will cause blade failure.

## Fatigue Reality

In reality, there are factors inherent to manufacturing capabilities that adversely compound the force stress levels seen by the knife holder, the knife blade and the anvil roll. When a knife is not orientated 90 degrees to an anvil roll, two force components are developed. One coming back up through the knife blade and one trying to twist or bend the knife, because it is not square, or it has excessive holder looseness.

Knife Misalignment



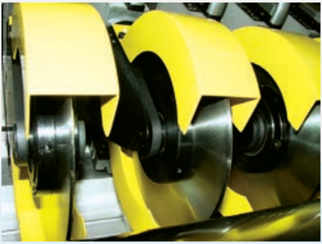

**Fatigue Reality:**

Applied load splits with misalignment
Fy remains as compressive loading
Fx introduces fluctuating bending load
Load not static or pure compressive
Always misalignment, out of square
Side loading concerns; bearings, mounting, etc.
More Fx = Less Knife Life, Less Holder Life

When the knife experiences this bending effect, it is actually operating in a fatigue failure mode; like a coat hanger being bent and re-bent until it breaks into two pieces. With every revolution the knife bends like the coat hanger. Premature blade and holder component failure is the end result.

## Shock (Impact) Loading

Shock or impact loading is the most common problem seen in crush cutting. The nature of crush cutting guarantees the blade and anvil will experience impact loads. High impact loads are caused by a rapid surge of full shop air pressure into the holder pneumatic cylinder from an unregulated supply that drives the knife blade into the anvil. A flat or chip is formed on the O.D. of the blade. With continued use, the chipped area impacts with every revolution until it eventually work-hardens to a level greater than the anvil hardness. Then grooves or gouges can be seen in the anvil roll with continued running.



*Shock (Impact)*

Shock loading can also result from "out-of-balance" or poor concentricity of the blade or anvil. Out-of-balance vibration effects at higher rotating speeds can cause changes in contact force levels. Though of lesser degree than full pressure engagement, over a short time blade life will deteriorate.

With certain materials, such as fiberglass, fiberglass filled, or abrasive webs, the blade force required to cut the material can only be realized when the knife is positioned directly over the web. This means the blade rides up and over hard spots or fibers in the material and then breaks through onto the anvil causing an impact force spike. Most often a grinding type noise is generated during this situation.

Blade chipping can also be a result of poor heat treatment of the blade. Retained austenite, under force, will convert to un-tempered martensite, which is extremely brittle. This will lead to grooves in the anvil roll.

Unregulated air pressure and geometric run out problems can be controlled in design and manufacturing. Crush resistant material cutting may be improved on with higher cutting forces or larger diameter blades.

### Blades and Anvils Will Experience Shock Loading!

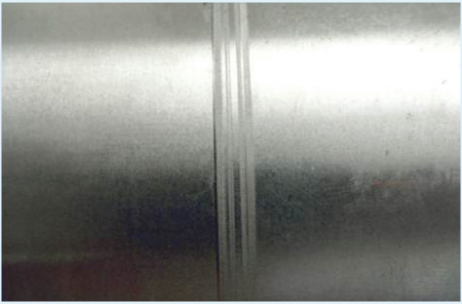
1. Advancement of blade to anvil; chipping, work hardening (Air flow control valves = a way to prevent knife damage/ chipping)
2. Out of balance and/or concentricity of blade or anvil
3. Blade falling off material onto anvil roll (certain materials only) 1 & 2 are within design control 3 only, operating dynamic that effects the life of the blade and anvil

### Surface Shear (Pitting)

Surface shear, or anvil roll pitting, develops over time from an ongoing applied force running against the roll. Roll material below the surface enters a fatigue failure mode and begins to break down. This begins as roll pitting and if a lubricant is in use an effect similar to a street pothole takes place. Under the surface, water sees the load from a passing automobile and short term, very high-pressure spikes are created that erode the roads' ability to support vehicle weights.

### Develops Below Surface of Blade and Anvil

- Shear stress created to support force
- Initiates fatigue failure; aggravated by lubricants
- Propagates to surface
- Relocate holders occasionally or increase blade radius
- Quality of manufacturing relative to life of components is extremely important!

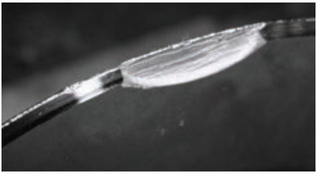


### Work Hardening

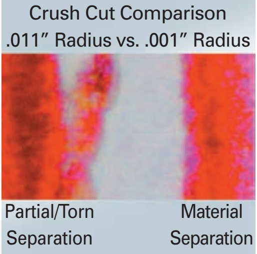
When a fatigue failure occurs (due either to running the crush cut blade at yield strength limits, or due to high impact loading that causes blade chipping), and the blade is allowed to continue running, it will "work-harden" to a hardness higher than the anvil roll. Gouging (grooving) of the anvil roll and a poor cut edge quality will result. This should be avoided because anvil rolls are more expensive than holder blades and a longer production down time occurs than when replacing blades only. Certain hardened sleeve type products are available that can lessen down-time due to grooved anvil rolls.

### When Fatigue Failure Causes Chipping…

- Shear stress areas increase in blade; small radius'
- Blade hardness levels increase beyond anvil hardness
- Grooving in anvil roll if continuing to run



*Knife Chipping*




*Cut Radius Comparison*

# Crush Cut Knife Radii

Blade radius and support angle trade-offs:

- Increasing blade angle will provide more radius support with poorer edge quality
- Increasing the radius will increase knife life but lessen cut quality
- The smaller the radius the less dust generated with a cleaner cut but less knife life

Dienes carries a wide variety of blade angles and radii to suit crush cutting of many different materials.

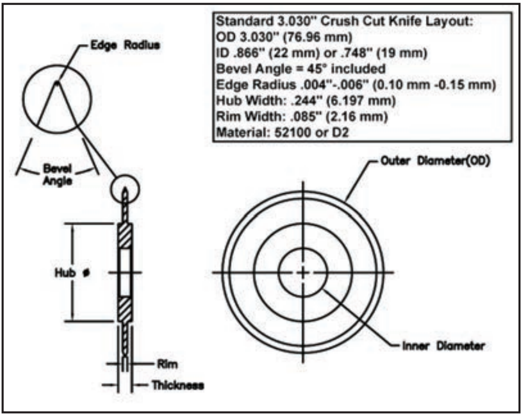
| 30° included radius 0.002-0.004 | 30° included radius 0.006-0.008 | 45° included radius 0.006-0.008 | 45° included radius 0.010-0.012 | 60°included radius 0.006-0.008 | 60°included radius 0.010-0.012 |
|---|---|---|---|---|---|
| Cellophane<br>Pressure-sensitive Tape<br>Cork<br>Linoleum<br>Acetate | Board<br>Rubber<br>Pulp<br>Paper Back foil<br>Plastic >.01<br>Surgical<br>Adhesives | Glassine<br>Tissue<br>Light Papers<br>Kraft Paper<br>Masking Tape<br>Plastic <= .01<br>Newsprint<br>Crepe Paper<br>Mica Tape<br>Coated Paper | Waxed Paper<br>Impregnated-Paper | Gauze<br>Textiles<br>Nonwovens | Sandpaper<br>Abrasive-Fabrics |

The most common crush blade sold today has a 0.004" - .006" (0.10mm - 0.15mm) radius with a 45-degree angle. For new applications this would be a good starting point. Empirical analysis can confirm which specific blade is best for each application. If knife life is too short then a larger radius or support angle may be considered.

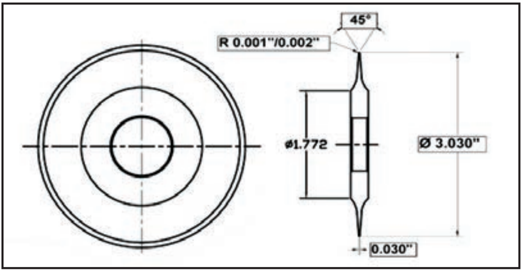
How long should a knife blade last? This is a common question without a specific answer. Blade life (whether crush or shear) is dependent on many different factors.

# Crush Cut Knives and Holders

Most commonly used knife is the 3.030″ OD version with a .866″ or .748″ inner diameter and a 45° included bevel angle. Edge radius .004″ - .006″.




A variation of the standard knife is the THIN RIM version, narrower rim and less edge radius .001″ - .002″. Better material penetration but less knife life.

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• Blade material; 52100 has good impact resistance and average wear qualities. D2 is more susceptible to shock loading damage but if carefully loaded, will last much longer than 52100.

• Blade diameter; a small 3 inch diameter blade sees many more revolutions, or load cycles than a 6 inch blade. Given the same radius and angle, thickness and material grade, the 6 inch blade will run longer.

• Knife holder integrity; loose blades fail early. Tight holders that maintain blade perpendicularity to the anvil roll support longer knife life.

• Anvil run-out geometry; anvil roll run-out should not exceed 0.004” (0.10mm). As run-out increases blade life will shorten.

• Blade radius and angle; basically blades with sharper radii and less angle support have shorter knife lives.

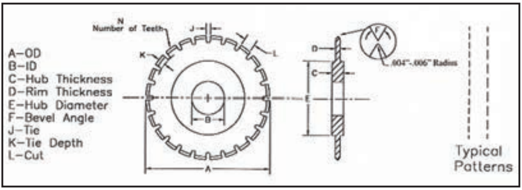
• Applied force; operating a crush blade at a force beyond what is required for a given material will needlessly shorten blade life.

# Crush Cut Perf Knives

Crush cut perf knives are used to convert products that require tearing or ripping to access a wide variety of goods. Examples are toilet tissue, paper towels, frozen foods, re-sealable plastic bags, multi-part business forms, etc.

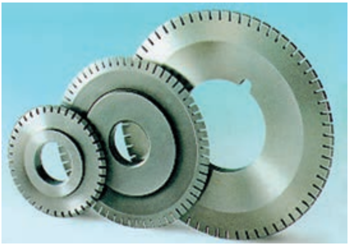
There are many different varieties of perf blades and they are made to order depending on the “cut and tie” dimensions.

The smallest perforator that can be made is a very fine 72 teeth per inch (.007″ cut and .005″ tie).




Dienes can provide hundreds of different types to suit any application.

The critical dimensions that need to be considered are the “cut”, or length of the tooth, “L” on the diagram, and, the “tie”, or distance between the teeth, “J” on the diagram.



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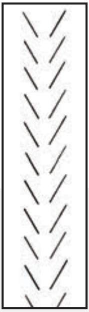
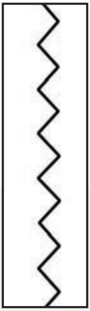
# Crush Cut Specialty Knives

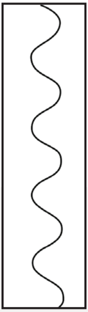
Dienes sells specialty crush knives like “zip” wheels that are used in the fabrics industry. “Pinking” wheels and “scallop” wheels are used on different plastic material for a wide variety of purposes.



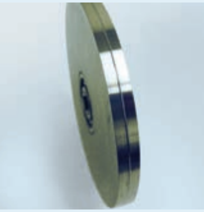
Zip



Pinking



Scallop



Another partial cut technique where the knife blade is manufactured to expose a minimal amount of cutting edge to a laminated product. The very narrow and short cutting edge is surrounded by roller like surfaces which limits blade travel as it meets the web on the anvil.

*Controlled Depth Score Cutting = Crack & Peel Knives*

# Crush Knife Holders

Dienes offers the widest variety of crush cut knives and holders available on the market today. We cut the toughest materials and run at the highest speeds. We also offer heated knife blades for adhesive slitting and razor holders for film slitting. We can manufacture pre-set holder packages for dedicated slit width operations.

We will also support your application with simple manual or precise fully automatic positioning systems for our crush cut products.

PQAS - 1/4 "
- Width: 0.25"
- Cut Force: 50#
- Speed: 600 fpm

PQAS - 3/8 " & 1/2 "
- Width: 0.375" - 0.50
- Cut Force: 55-75#
- Speed: 950 fpm

PQA-MC-HP
- Width: 0.50"
- Cut Force: 135#
- Speed: 950 fpm

PQD-MC3
- Width: 0.79"
- Cut Force: 360#
- Speed: 1250 fpm

# Crush Knife Holders (continued)

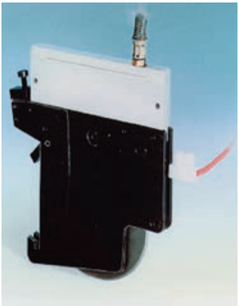
Score Pak
• Width: 0.157″ min
• Cut Force: 50# min
• Speed: 500 fpm min

PQG
• Width: 4.5″
• Cut Force: 225#
• Speed: 2500 fpm

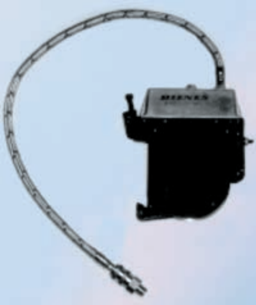
PQA-DF-30
• Width: 1.18″
• Cut Force: 125#
• Speed: 2600 fpm



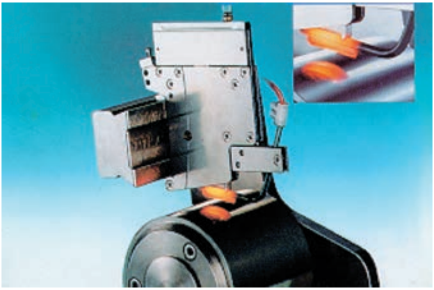
PQA-DF-50
• Width: 2.0″
• Cut Force: 250#
• Speed: 4000 fpm



PQAS - 3/8 “
Heated Blade
- Width: 0.37″
- Cut Force: 55#
- Speed: 950 fpm
- Temp: 75° C



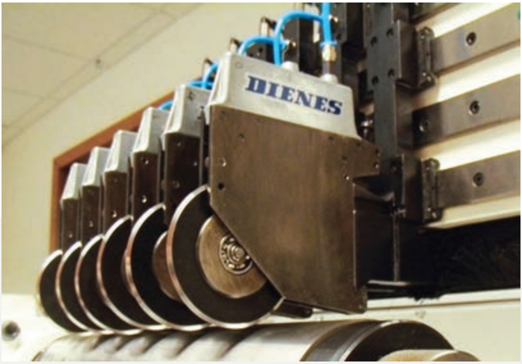
PQAS - 1/2 “
Adjustable Depth Blade
- Width: 0.50″
- Cut Force: 75#
- Speed: 950 fpm
- Stroke: 1/2″

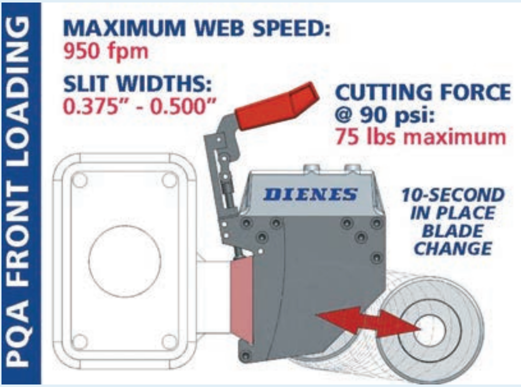


PQAS - 3/8 “
Heat Cut Adapter
- Width: 0.37″
- Cut Force: 55#
- Speed: Material dependent
- Temp: 750° C

# Front Load Crush Cut Knife Holder

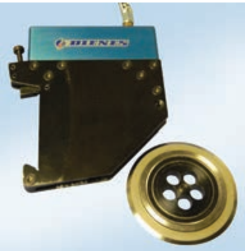
Knife change is possible without removing knife holder assembly from dovetail bar or any other mounting structure.

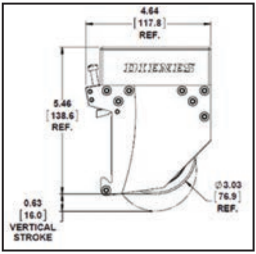


# High Speed Crush Cut Knife Holder






PQAS-1/2″ HS (High Speed) Crush Cut Knife Holder.
Speed Capability up to 2000 ft/min.

- Minimum Cut Width: 1/2″ (12.70 mm)
- Cutting Force @ 90 psi (6 bar) = 75 #s (333 N)
- 3.030″ (76.96 mm) Knife Diameter
- Maximum Speed: 2000 ft/min (610 m/min)
- Front Load Design
- Fully interchangeable with all PQAS Holders
- Setscrew or Quick Clamp Mounting

# Crush Cut Anvil Sleeves

Of importance to crush  cutting applications is the choice of anvil surface the blades must run against. The anvil must be very smooth, geometrically accurate (round with minimum run-out), and of sufficient hardness to outlive the knife blade.

The operating reality is that because of shock impact and fatigue, eventually the anvil surface will require resurfacing (precision grinding) or replacement.

*CASE Hardened Shafts*

Case hardening of solid shafts provide a less expensive way to fit many applications. The downside of case hardening is that the amount of hardness varies with depth into the shaft. With each regrind the case hardness level will lower. Remembering that a typical anvil hardness is only 0.5 to 5 Rockwell Rc points harder than the blade running against it, consecutive regrinds can quickly make the shaft useless.

Through hardened or near through hardened sleeves offer operating flexibility, longer anvil life, and less costly replacement. Anvil sleeves slide over the shaft with a very close tolerance fit to lessen run-out effects. High-end sleeves can be radially adjusted for dimensionally true rotation. They are typically keyed to the shafts and secured by lock-nuts on both ends of the shaft. If or when a groove forms in the anvil sleeve by a chipped blade or localized fatigue takes place, the lock-nuts may be loosened and the sleeve(s) shifted along the shaft to offer a fresh surface to the crush blade.

When regrinding through hardened sleeves is required, there is little compromising of surface hardness until many regrinds have taken place. Anvil sleeves have a higher up-front cost that is easily balanced by multiple regrind capability and repositioning flexibility.

Sleeves

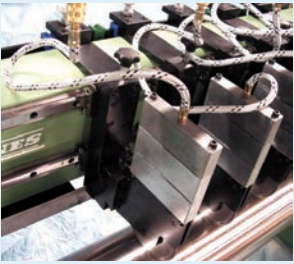
- 4″ to 16″ length
- 4″ O.D. x 3″ I.D.
- 6.25″ O.D. x 5″ I.D.

# Crush Cut Positioning Methods/Systems

Because Dienes has developed many different knife holders since 1913, we have also been involved in developing methods to retain these holders in position and accurately change location easily. Our sales and engineering team members remain available to help in many ways because of these options developed over the years.

Manual, Dovetail Mounted Holders with Quick-Clamp Handle, as shown or with standard clamping screw (not shown).

Dovetail mounting is less critical for crush cutting than it is for the shear cutting equipment. When the Dienes Quick-Clamp is employed, changing position is very easy and accurately located.



Dual linear rail and linear bearing design with manual clamping. Easy movement along linear rails, precise holder location, secure and quick clamping.

# MD-Easy Set

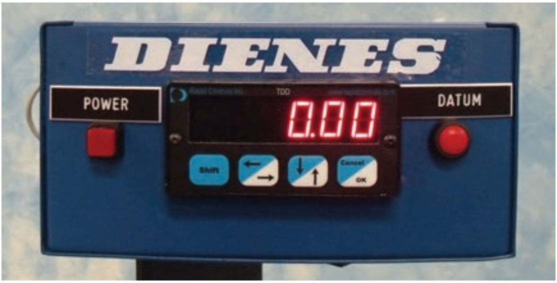
### Electro-Mechanical Positioning, Manual

Dienes' reliable Quick Clamp mounting system with electronic positioning accuracy.

**Features & Benefits**

- Replaces Tape Measuring
- Improved Set-Up Efficiency & Accuracy
- Push Button Activation – LED Signals
- Setup Incremental or Absolute
- ½″ Slit Width Capability
- Retrofit Suitable



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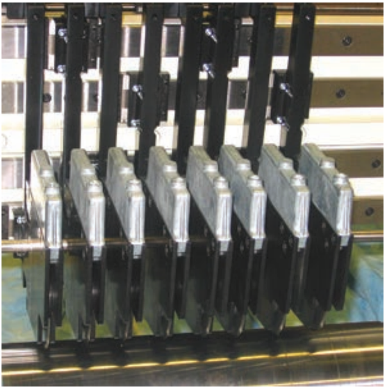
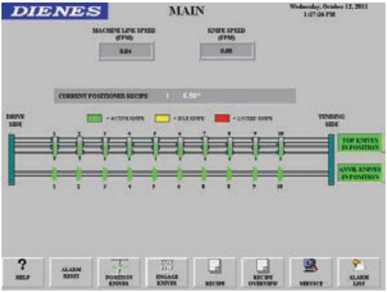
# Automatic Servo Driven, Linear Bearing Mount

## Quick Set

DIENES crush cut holder designs are employed, to allow the achievement of slit widths down to ½″ (12.70 mm).

Fully automatic slitting positioning system "QUIK SET. The innovative technology developed by the Dienes Group is capable of simultaneously positioning all knife holders in a matter of seconds, while guaranteeing high levels of accuracy and repeatability. The positioning process is accomplished via a menu drive touch screen where a recipe for specific cutting widths are selected and the position process is executed within seconds.



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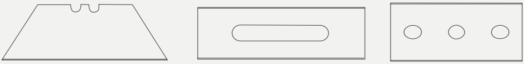
# Razor Slitting

## Razor Blade Materials

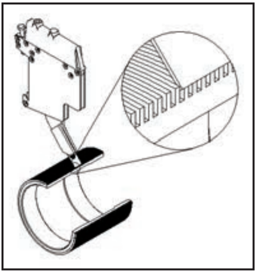
- Solid Tungsten Carbide
  Paper, Polyester, Cellophane, Nonwovens
- Solid Ceramic
  Films, Copper Foil, Magnetic Tape, Nylon LLDPE
- Ceramic Coated and TiNI coated
  Aluminum Foil, Label Stock, PVC, OPP, Stretch Film

Razor slitting yields cleaner edges than shear slitting. The main drawbacks are that blade life is considerably shorter than shear or crush blades and they are not practical for heavier materials. Therefore, it is mostly used in the plastic film and metallizing industries.

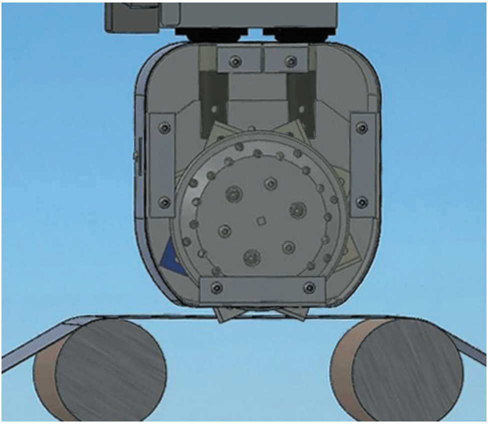


## Supported Web

- Grooved Roll



## Unsupported Web (In-Air Cutting)



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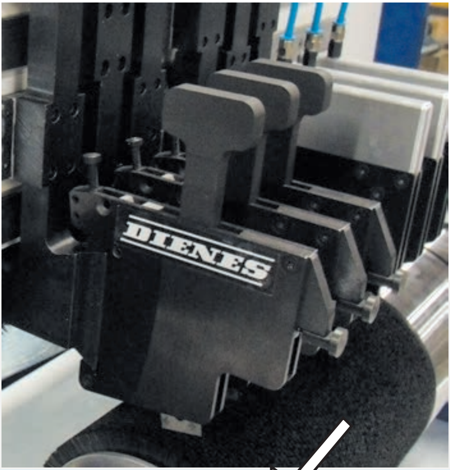
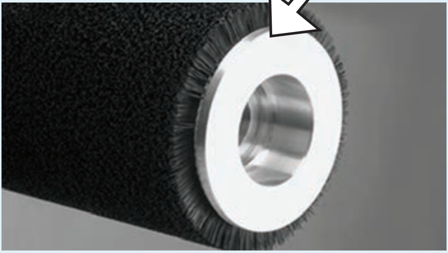
# Razor Slitting (continued)

## Nylon Brush Razor Cutting



*Nylon Brush for Localized Web Support*

Razor slitting  can be set-up in either  a "web  supported" or "unsupported" arrangement. Typically web supported rolls are grooved to allow the razor edge to ride in a slot. Unsupported razor slitting allows for oscillation to continually present a new cutting surface and extend time between blade changes. With razor slitting even the softest or materials can rather quickly dull a razor's edge.

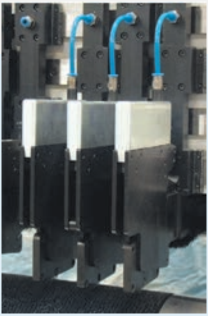
Burst cutting; one variation of razor slitting available is to provide a very sharp rotary shear knife that operates in a grooved roll. Longer blade life with clean edges can be realized for some materials.

# Razor Slitting (continued)

### Razor Blade Holders

- Pneumatic Operation
- Dovetail or Linear Bearing Mount
- Ratchet Clamp
- 360° Guard
- Quik-Clamp™
- Pneumatic Operation
- Dovetail or Linear Bearing

Pneumatic blade holders offer flexibility and some performance advantages.

## Razor8 Dienes Razor Slitting Holder with Automatic Blade Rotation

- Eight (8) blade capacity
- Powered sequencing (programmable or operator initiated) with non-stop slitting
- Designed for new machinery or existing slitter system upgrades
- Micrometer web entry depth setting
- Full guarding with minimum operating blade exposure



# Crush Cut Trouble Shooting

### Knife Chipping

- Knife radius too small to handle load?
- Web material type?
- Correct knife material?

### Knife Wears Prematurely

- Groove in roll, 0.002″ maximum depth!
- Hardness 63/65 Rc
- Excessive air pressure
- Knife setting hard to anvil, no flow control
- Anvil dimensional run out? 0.004″ maximum
- Knife material poor quality

### Groove in Anvil Roll

- Check knife hardness; should be 60 to 62.5 Rc
- Anvil roll should be 63 to 65 Rc
- Is knife chipped and work hardened?

### Varying Slit Widths

- Clearance in holders
- Holder not square to anvil
- Radius not centered on blade
- Worn side plates

# Glossary of Terms

**Anvil sleeves:** A through (or near through) hardened anvil to slide over a bottom shaft.

**Austenite:** A non-magnetic solid solution of ferric carbide or carbon in iron, used in making corrosion-resistant steel.

**Bevel:** Angle(s) machined into a crush blade to support cutting forces.

**Blade radius:** The cutting edge shape or size.

**Case hardened anvil:** A bottom shaft with a smooth hardened outer surface to serve as an anvil. Hardness is relative to depth of regrinding.

**Crush cut:** A blade is pushed through the web... backed up by a hardened roll.

**Fatigue failure:** Destruction of components due to constant bending forces.

**Force analysis:** The understanding of metals under stress during crush cutting.

**Heat cutting:** Using temperature elevated blades to minimize glue buildup when cutting adhesive webs or sealing laminates.

**Included angle:** The amount of blade support material for the radius.

**Martensite:** A solid solution of iron and up to one percent carbon, the chief constituent of hardened carbon tool steels.

**Overspeed:** Bottom anvils running faster than web speed. Used with tangential slitting only.

**Perf cut:** An irregular cut pattern used to weaken but not separate material when cut.

**Radial run out:** A condition describing the up-and-down movement of the blade cutting edge.

**Score cut:** A blade is partially pushed through a web...as in cutting a single layer of a two-web laminate.

**Shock/impact failure:** Destruction of components, usually the knife-edge, due to rapid acceleration of the knife into the hardened anvil surface.

**Surface shear pitting:** Destruction of the surface of the anvil roll at the point of contact with the knife-edge. Cause of fatigue failure emanating from beneath the anvil surface.

**Tangential slitting:** The web path is tangential to the bottom anvil.

**Torsion:** Twisting force around the centerline of a knife holder shaft.

**Web:** The material being cut.

**Wrap slit:** The web is wrapped around the hardened anvil roll.

**Work hardening:** Excessive hardening of the knife-edge as a result of blade chipping from shock/impact loading and continued operation.

**Yield strength:** Innate characteristics of all materials to resist deformation.

# DIENES REGRINDING SERVICE

- **3-day Turnaround on Request**
- **Blade Life Evaluation**
- **Custom Shipping Containers at Cost**
- **Damage Diagnostics and Reporting**
- **Professional Workmanship**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