Introduction

Mate Precision Tooling is the world’s leading manufacturer of NC punch press tooling. Our only business is punch press tooling. Our five decades of specialization and expertise have earned us a worldwide reputation of top quality products, fast delivery, competitive prices and customer satisfaction.

Purpose

The purpose of this tooling manual is to explain in detail the processes involved in making holes and making forms in sheet metal. It was designed to accompany the Mate Precision Tooling ULTRA® Tooling Catalog. This manual explains methods for producing higher quality sheet metal products.

Mate Precision Tooling

mate.com
1295 Lund Boulevard
Anoka, Minnesota 55303 USA
Phone 800-328-4492 • 763-421-0230
Fax 800-541-0285 • 763-421-0285

Tooling Manual for
Punch Presses Using
Thick Turret Style Tooling
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I. The Perforation Process

Hole Punching Process

Punching holes on a CNC punch press is a very productive and efficient way to produce holes in sheet metal. It appears to be a simple process, although many variables greatly affect the quality of the piece part and the life of the tooling.

ULTRA TEC® 1 1/4" B Station Assembly

The following sequence visually describes the process of the punch impacting the sheet metal and the slug passing through the Slug Free® die.

Material held securely by stripper before punch makes contact.
Punch penetrates the material. Slug fractures away from sheet.
Pressure point constricts slug. Punch stroke bottoms out as slug squeezes past pressure point.
Punch retracts and slug is free to fall down and away through exit taper of the Slug Free® die.

Dimensions in inches (millimeters)  5  © 2001 Mate Precision Tooling
What Do Your Slugs Tell You?

The slug is essentially a mirror image of the hole with the same parts in reverse order. By examining your slugs, you can tell if punch-to-die clearance is correct, if tool angularity is correct, or if tooling is dull.

An **ideal slug** is created when the fracture planes coming from the top and bottom of the material have the same angle and form in alignment with each other. This keeps punching force to a minimum and forms a clean hole with little burr. When clearance is proper, tool life is extended.

If the **clearance is too large**, the slug will show a rough fracture plane (C) and a small burnish zone (B). The larger the clearance, the greater the angle between the fracture plane (C) and the burnish zone (B). Excess clearance makes a hole with large rollover (A) and fracture (C) so that the profile is somewhat pointed with a thin burr (D). When clearance is too large, tool life is reduced.

If **clearance is too small**, the slug will show a fracture plane (C) with little angle, and a large burnish zone (B). Inadequate clearance makes a hole with small rollover (A) and steep fracture (C) so that the profile is more or less perpendicular to the surface of the material. When clearance is too small, tool life is reduced.

### Anatomy of a Punched Hole

1. Punch  
2. Stripper  
3. Material  
4. Slug Free® Die  
5. Slug  
6. Grind life  
7. Entry - Constricting taper  
8. Pressure point  
9. Exit - Relief taper

### Hole/Slug Geometry

A. Rollover  
B. Burnish  
C. Fracture  
D. Burr

See Die Clearance on page 10 for percent comparisons of slug characteristics.
M. Material held securely by stripper before punch makes contact
A. Penetration / yield point / compressive forces
B. Maximum compressive and shear force
C. Fracture / "pure shear"
D. Secondary shear break point
E. Secondary shearing
F. Slug movement
G. Completed
H. Stripping force
Proper vs. Tight Clearance

Why use proper die clearance?

Optimum clearance –
Shear cracks join, balancing punching force, piece part quality and tool life.

Clearance too small –
Secondary shear cracks are created, raising punching force and shortening tool life.
Die Clearance

Die clearance is the difference in size between the punch dimensions and the die dimensions. Mate always refers to total die clearance rather than die clearance per side.

**Benefits of PROPER Die Clearance:**

- Longer tool life.
- Better stripping.
- Smaller average burr height.
- Smaller average burr thickness.
- Cleaner, more uniform holes.
- Little or no shavings.
- Reduced galling.
- Flatter work pieces.
- More accurate hole locations.
- Lowest force required to pierce the material.
Die Clearance

<table>
<thead>
<tr>
<th>INSUFFICIENT Die Clearance:</th>
<th>EXCESSIVE Die Clearance:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Galling</td>
<td>• Increased slug pulling</td>
</tr>
<tr>
<td>• Work piece shavings</td>
<td>• Work piece shavings</td>
</tr>
<tr>
<td>• Shortened tool life</td>
<td>• Poor hole quality</td>
</tr>
<tr>
<td>• Slow/erratic stripping</td>
<td>• Increased work piece distortion</td>
</tr>
<tr>
<td>• Poor hole quality</td>
<td>• Increased burr</td>
</tr>
<tr>
<td>• Excessive heat</td>
<td>• Increased rollover</td>
</tr>
<tr>
<td>• Warped sheets</td>
<td>• Increased breakaway area</td>
</tr>
<tr>
<td>• Smaller initial burr</td>
<td>• Rounded slugs</td>
</tr>
<tr>
<td>• Larger, thicker running burr</td>
<td>• Work hardened burrs</td>
</tr>
<tr>
<td>• Quieter punching</td>
<td></td>
</tr>
<tr>
<td>• Reduced rollover</td>
<td></td>
</tr>
<tr>
<td>• Reduced break-away area</td>
<td></td>
</tr>
<tr>
<td>• Reduced slug pulling</td>
<td></td>
</tr>
<tr>
<td>• Work hardened burrs</td>
<td></td>
</tr>
</tbody>
</table>

ANATOMY OF A PUNCHED HOLE

Total Clearance - (TC)

- Rollover Depth - (RD)
- Rollover Width - (RW)
- Material Thickness (%)
- Burr Height - (BH)
- Burnish Land - (BL)

EFFECT OF TOTAL CLEARANCE AS A PERCENT (%) OF MATERIAL THICKNESS

<table>
<thead>
<tr>
<th>TC</th>
<th>RD</th>
<th>RW</th>
<th>BH</th>
<th>BL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>10%</td>
<td>50%</td>
<td>15%</td>
<td>75%</td>
</tr>
<tr>
<td>15%</td>
<td>12%</td>
<td>40%</td>
<td>10%</td>
<td>55%</td>
</tr>
<tr>
<td>25%</td>
<td>16%</td>
<td>45%</td>
<td>6%</td>
<td>50%</td>
</tr>
<tr>
<td>35%</td>
<td>20%</td>
<td>50%</td>
<td>6%</td>
<td>45%</td>
</tr>
</tbody>
</table>
## Die Clearance Chart

The information in this chart is a detailed version of general clearance charts that are published in Mate Precision Tooling catalogs and in other industry publications.

The chart is also based on experiences from Mate customers who achieve superior piece part quality and the longest possible tool life.

Blanking tools are generally assigned with less clearance than piercing tools so that the burnished area of the piece part (slug) is greater. This leads to a higher quality piece part. Due to the smaller clearances, blanking tools may become dull more quickly.

<table>
<thead>
<tr>
<th>Material Type (typical shear strength)</th>
<th>Material Thickness (T)</th>
<th>Total Die Clearance (% of T)</th>
<th>Piercing</th>
<th>Blanking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum 25K psi (.1724kN/mm²)</td>
<td>Less than .098 (2.50)</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.098 (2.50) through .197 (5.00)</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greater than .197 (5.00)</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild Steel 50K psi (.3447kN/mm²)</td>
<td>Less than .118 (3.00)</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.118 (3.00) through .236 (6.00)</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greater than .236 (6.00)</td>
<td>30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stainless Steel 75K psi (.5171kN/mm²)</td>
<td>Less than .059 (1.50)</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.059 (1.50) through .109 (2.77)</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.110 (2.77) through .158 (4.00)</td>
<td>30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greater than .158 (4.00)</td>
<td>35%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dimensions in inches (millimeters) 11 © 2001 Mate Precision Tooling
II. Tonnage

When punching thick materials or when punching materials with a high tensile strength, caution must be observed not to exceed the recommended machine tonnage. Damage to the machine or the tooling could be the result in this situation.

**Note:** Some amount of tonnage is required for compressing the springs in any spring tooling system. The amount is greater in the larger stations than in the smaller stations. When nearing press capacity, contact your local Mate representative or Mate customer service for recommendations.

**Tonnage Calculation**

**Tonnage Formula:**

\[
\text{Tonnage} = \text{Punch Perimeter} \times \text{Material Thickness} \times \text{Material Tonnage Value} \times \text{Material Multiplier}
\]

See example on following page.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum (soft sheet)</td>
<td>0.3</td>
</tr>
<tr>
<td>Aluminum (1/2 hard)</td>
<td>0.38</td>
</tr>
<tr>
<td>Aluminum (full hard)</td>
<td>0.5</td>
</tr>
<tr>
<td>Copper (rolled)</td>
<td>0.57</td>
</tr>
<tr>
<td>Brass (soft sheet)</td>
<td>0.6</td>
</tr>
<tr>
<td>Brass (1/2 hard)</td>
<td>0.7</td>
</tr>
<tr>
<td>Mild Steel</td>
<td>1.0</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Dimensions in inches (millimeters)
Tonnage

Directions for Calculation:
Calculate the tonnage using the Tonnage Formula. Equations for calculating the outside Punch Perimeter ("L" dimension) are found in the "Dimension Chart" on the following page. For the Material Tonnage Value (Table 1) and the Material Multiplier Value (Table 2), please reference the previous page.

Example of Tonnage Calculation for a Square:

<table>
<thead>
<tr>
<th>.787 (20.00) square, .118 (3.00) mild steel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tonnage Formula:</strong>&lt;br&gt;Punch Perimeter x Material Thickness x Material Tonnage Value x Material Multiplier</td>
</tr>
<tr>
<td><img src="image" alt="Diagram of a Square Punch" /></td>
</tr>
<tr>
<td>.787 x .787 (20.00 x 20.00) Square</td>
</tr>
<tr>
<td>118 (3.00) Mild Steel</td>
</tr>
<tr>
<td>Tonnage = (4 x .787) x .118 x 25 x 1 = 9.28 Tons</td>
</tr>
<tr>
<td>Tonnage = (4 x 20) x 3 x .0352 x 1 = 8.45 Metric Tons</td>
</tr>
</tbody>
</table>

Example of Tonnage Calculation for a Round:

<table>
<thead>
<tr>
<th>1.18 (30.00) diameter, .118 (3.00) aluminum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tonnage Formula:</strong>&lt;br&gt;Punch Perimeter x Material Thickness x Material Tonnage Value x Material Multiplier</td>
</tr>
<tr>
<td><img src="image" alt="Diagram of a Round Punch" /></td>
</tr>
<tr>
<td>1.18 (30.00) diameter</td>
</tr>
<tr>
<td>118 (3.00) Aluminum</td>
</tr>
<tr>
<td>Tonnage = (3.14 x 1.18) x .118 x 25 x 0.5 = 5.47 Tons</td>
</tr>
<tr>
<td>Tonnage = (3.14 x 30) x 3 x .0352 x 0.5 = 4.97 Metric Tons</td>
</tr>
</tbody>
</table>
### Dimension Chart for Tonnage Calculation

<table>
<thead>
<tr>
<th>Shape</th>
<th>‘A’ Dimension Dictates Station Size</th>
<th>‘L’ Dimension Outside Perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>A = Diameter</td>
<td>L = 3.14 x A</td>
</tr>
<tr>
<td>Square</td>
<td>A = B x 1.414</td>
<td>L = 4 x B</td>
</tr>
<tr>
<td>Rectangle</td>
<td>$A = \sqrt{(B^2 + C^2)}$</td>
<td>L = 2 x (B + C)</td>
</tr>
<tr>
<td>Oval</td>
<td>A = C</td>
<td>L = 2C + 1.14B</td>
</tr>
<tr>
<td>Rect / Oval</td>
<td>$A = \sqrt{(B^2 + C^2)}$</td>
<td>L = 2C + 1.57B</td>
</tr>
<tr>
<td>Equilateral Triangle</td>
<td>A = 1.334 x C</td>
<td>L = 3 x B</td>
</tr>
<tr>
<td>Quad ‘D’</td>
<td>A = Diameter</td>
<td>L = (approx.) 3.14 x A</td>
</tr>
<tr>
<td>Hexagon</td>
<td>A = 1.155 x B</td>
<td>L = 3 x A</td>
</tr>
</tbody>
</table>

Dimensions in inches (millimeters)
III. ULTRA TEC® Tooling System

ULTRA TEC® is a premium tooling system for thick turret style machines. It is a full line system available for 1/2" A through 4 1/2" E stations.

<table>
<thead>
<tr>
<th>ULTRA TEC® Station Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
</tbody>
</table>
**Standard Shapes**

In the ULTRA TEC® Tooling System, standard shapes include round, rectangle, oval, square, single D and double D.

<table>
<thead>
<tr>
<th>Round</th>
<th>Rectangle</th>
<th>Oval</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Round" /></td>
<td><img src="image" alt="Rectangle" /></td>
<td><img src="image" alt="Oval" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Square</th>
<th>Single ‘D’</th>
<th>Double ‘D’</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Square" /></td>
<td><img src="image" alt="Single ‘D’" /></td>
<td><img src="image" alt="Double ‘D’" /></td>
</tr>
</tbody>
</table>

When ordering tooling, customers should indicate the following:

- Tool style
- Material type and thickness
- Tool dimensions
- Tool shape
- Piercing or blanking
- Non-standard features (if desired)
- Special tolerances (if application is appropriate)
ULTRA TEC® Tooling System

ULTRA TEC® is a complete system for both piercing and forming. The many features include premium high speed steel (HSS) punches, Slug Free® dies, hardened guides with multiple angle settings, interchangeability with other styles of thick turret tooling, extra grind life, quick length adjustment, and quick tool change capability. The ULTRAFORM® system for forming tools offers a standard holder design where forming inserts are quickly interchanged, and length adjustment is done in .002 (0.05) increments.

Some ULTRA TEC® highlights include:

**Canister**
The 1/2" A station canister is designed with high pressure Belleville disc springs. The 1 1/4" B station canister is designed with a special trapezoidal coil spring that assures even pressure and long cycle life. The 2" C, 3 1/2" D, and 4 1/2" E station guides also use high pressure Belleville disc springs.

The 1/2" A station punch length is adjustable in .006 (0.15) increments. The 1 1/4" B station punch length is adjustable in .008 (0.20) increments. The 2" C, 3 1/2" D and 4 1/2" E station guides punch lengths can be adjusted in .008 (0.20) increments.

**Punch**
Punches are made from premium high speed tool steel (HSS). Standard back taper on original thick turret and ULTRA TEC® punches is 1/8° per side, 1/4° total. Lubrication grooves are standard on 1/2" A and 1 1/4" B ULTRA TEC® punches.
Guide
The ULTRA TEC® hardened polished guide is designed with fluid through holes and external spiral lubrication grooves for even and consistent lubrication between the tool and the turret bore. Mate hardened guides are resistant to picking up small particles which cause marks on the guide and can be abrasive in the turret bore or tool holder.

The 1/2" A station shape guide has one external slot at 270° and three internal slots at 90°, 180° and 315°.

The 1/2" A station round guide has one internal and one external slot designed to accept diameter punches.

The 1 1/4” B station shape guide has one external slot at 270° and five internal slots at 0°, 90°, 180°, 225° and 270°.

The 1 1/4” B station round guide has one internal and one external slot designed to accept diameter punches.

Stripper
The slide-in stripper has .008 (0.20) total clearance to punch point (.002 [0.05] when any punch dimension is smaller than .125 [3.18]).

The .118 (3.00) relief in the A and B station strippers, .078 (2.00) in the C, D and E station, increases grind life.

Die
Dies are made from hardened tool steel for maximum edge wear without breakage. The uniform clearance in the corners of squares and rectangles makes dies stronger and improves piece part quality. The Stress Free Relief™ redistributes punching stresses to increase die strength up to 50%. The Slug Free® design clears the slug every cycle, eliminating slug pulling, improving piece part quality and reducing scrap.

Recommended Stripper Lead

<table>
<thead>
<tr>
<th>Station</th>
<th>Recommended Stripper Lead</th>
<th>Number of Clicks on ULTRA Guide or Canister</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current Production</td>
</tr>
<tr>
<td>A</td>
<td>.048 (1.22)</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>.048 (1.22)</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>.033 (0.84)</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>.073 (1.85)</td>
<td>8</td>
</tr>
<tr>
<td>E</td>
<td>.033 (0.84)</td>
<td>4</td>
</tr>
</tbody>
</table>

Maximum Die Inside Diameter Dimensions

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.560 (14.22)</td>
<td>1.310 (33.27)</td>
<td>2.060 (52.32)</td>
<td>3.560 (90.42)</td>
<td>4.560 (115.82)</td>
</tr>
</tbody>
</table>

Note: Regardless of sheet thickness, the recommended penetration of the punch into a Slug Free® die is .118 (3.00).
Angle Settings

The charts that follow explain the angle settings that the ULTRA TEC® tooling system provides as standard. The zero degree reference point is on the X-axis (horizontal). Angles are referenced counter-clockwise from that point. This is also known as the Cartesian coordinate system.

The precision interior and exterior angle slots in the ULTRA TEC® guides provide exceptional angular alignment. The precision slots allow versatility and flexibility of multiple angle settings as standard.

<table>
<thead>
<tr>
<th>Station</th>
<th>Punch</th>
<th>Stripper</th>
<th>Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; A</td>
<td>1 pin at 180°</td>
<td>Follows punch point</td>
<td>270° exterior slot</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>90°, 180°, 315° interior slots</td>
</tr>
<tr>
<td>1 1/4&quot; B</td>
<td>1 pin at 180°</td>
<td>Follows punch point</td>
<td>270° exterior slot</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0°, 90°, 180°, 225°,270° interior slots</td>
</tr>
</tbody>
</table>

The precision interior and exterior angle slots in the ULTRA TEC® guides provide exceptional angular alignment. The precision slots allow versatility and flexibility of multiple angle settings as standard.
ULTRA TEC® 1/2" A Station Angle Settings
Three internal angle slots in the ULTRA TEC® 1/2" A station shape guide allow all A station tools, any shape, to be capable of angle settings at 90°, 180°, and 315°. The unit is easily disassembled (see the assembly and installation instructions in the "ULTRA TEC® Tooling" chapter) and the punch can be reinserted into the guide at another angle. The 315° internal slot is designed into the tool mainly to accommodate a 45° angle setting for squares. Since all of the angle setting decision making occurs when the tool is being assembled correct tool installation is guaranteed.

ULTRA TEC® 1 1/4" B Station Angle Settings
The size of the ULTRA TEC® 1 1/4" B station shape guide allows for five precision internal angle slots at 0°, 90°, 180°, 225°, and 270°. This allows any punch to be set at any of the (5) angle settings. The one key slot on the outer diameter of the guide assures ease and accuracy when installing the assembly into the turret. Since all of the angle setting decision making occurs when the tool is being assembled correct tool installation is guaranteed.
** Also available with 3 exterior slots (to accommodate a 45˚ setting)

**ULTRA TEC® 2" C Station Angle Settings**
The combination of one key slot on the punch and two slots on the guide allows standard rectangle and oval C station thick turret and ULTRA TEC® punch assemblies to be set 180˚ and 270˚. Square punches have an additional key slot at 45˚. The combination of two key slots on the punch and two external slots on the guide gives non-symmetrical shapes, such as single D, the capability of four angle settings: 0˚, 90˚, 180˚ and 270˚.

**ULTRA TEC® 3 1/2" D and 4 1/2" E Station Angle Settings**
Standard rectangles and ovals in the D and E stations are also capable of setting 180˚ and 270˚ (0˚ and 90˚). Square punches have the additional key slot at 135˚ in the D range and 315˚ in the E range. The combination of two key slots on the punch and two external slots on the guide gives non-symmetrical shapes, such as single D, the capability of four angle settings: 0˚, 90˚, 180˚ and 270˚.

---

<table>
<thead>
<tr>
<th>Station</th>
<th>Punch</th>
<th>Guides (Standard and Fully Guided)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2&quot; C</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>180˚ key slot</td>
<td>180˚, 270˚ exterior slots 180˚ interior slot</td>
</tr>
<tr>
<td>Rectangle</td>
<td>180˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Oval, Double D</td>
<td>180˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Square</td>
<td>45˚, 180˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Single D</td>
<td>0˚, 180˚ key slot</td>
<td></td>
</tr>
<tr>
<td><strong>3 1/2&quot; D</strong></td>
<td></td>
<td>180˚, 270˚ exterior slots** 270˚ interior slots</td>
</tr>
<tr>
<td>Diameter</td>
<td>270˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Rectangle</td>
<td>270˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Oval, Double D</td>
<td>270˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Square</td>
<td>135˚, 270˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Single D</td>
<td>90˚, 270˚ key slot</td>
<td></td>
</tr>
<tr>
<td><strong>4 1/2&quot; E</strong></td>
<td></td>
<td>0˚, 90˚ exterior slot 90˚ interior slots</td>
</tr>
<tr>
<td>Diameter</td>
<td>90˚ key slot</td>
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</tr>
<tr>
<td>Rectangle</td>
<td>90˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Oval, Double D</td>
<td>90˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Square</td>
<td>90˚, 315˚ key slot</td>
<td></td>
</tr>
<tr>
<td>Single D</td>
<td>90˚, 270˚ key slot</td>
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</table>
## Die Angle Settings

<table>
<thead>
<tr>
<th>Station</th>
<th>Rectangle and Oval</th>
<th>Square</th>
<th>Single D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; A and 1 1/4&quot; B</td>
<td>180° pinhole</td>
<td>180° or 135° pinhole (must specify one). This is standard. <strong>OR</strong> 180° and 135° pinholes (by request)</td>
<td>180° pinhole</td>
</tr>
<tr>
<td>2&quot; C and 3 1/2&quot; D</td>
<td>180° and 270° slots</td>
<td>225° and 270° slots</td>
<td>0°, 90°, 180°, 270° slots</td>
</tr>
<tr>
<td>4 1/2&quot; E</td>
<td>0° and 90° slots</td>
<td>45° and 90° slots</td>
<td>0°, 90°, 180°, 270° slots</td>
</tr>
</tbody>
</table>

### Die Angle Settings – 1/2" A and 1 1/4" B Stations
Rectangle and oval dies have one pin at 180°. The die holder in the machine will accommodate rotating the shape 90° so the long dimension runs parallel to the Y-axis. A square die comes standard with either a pin at 180° or 135°. By request, the die can be made with pinholes in both positions. Non-symmetrical shapes, such as single D, also come with just one pin. The die can be placed in a different slot in the die holder to allow for 0°, 90°, 180° and 270°.

![Image](image1.png)

1/2" A station die O.D. = 1.000 (25.40) 1 1/4" B station die O.D. = 1.875 (47.62)

### Die Angle Settings – 2" C, 3 1/2" D and 4 1/2" E Stations
Rectangle and oval dies have two slots to allow 180° and 270° orientation (0° and 90° in the E station). Squares have two slots at 225° and 270° (45° and 90° E station). All non-symmetrical shapes in the C, D and E stations are made standard with four slots at 0°, 90°, 180° and 270°.

![Image](image2.png)

2" C station die O.D. = 3.500 (88.90) 3 1/2" D station die O.D. = 4.937 (125.40) 4 1/2" E station die O.D. = 6.250 (158.75)
**Grind Life**

*Grind life* is the maximum usable length that can be removed from a punch by sharpening. The size of the punch and the thickness of the material being punched are factors that affect grind life. The formula for grind life is:

\[
\text{Grind Life} = \text{Straight Before Radius (SBR)} - (\text{Material Thickness} + \text{Die Penetration} + \text{Stripper Thickness})
\]

The example below illustrates the grind life of an ULTRA TEC® 1 1/4" B station punch in .250 (6.35) thick material. Material thickness of .250 (6.35), die penetration of .118 (3.00) and stripper thickness of .157 (4.00) are all subtracted from the Straight Before Radius (SBR) of .742 (18.85). The resulting grind life is .217 (5.50).

\[
\begin{align*}
\text{.742 (18.85)} & \quad - \quad \text{.250 (6.35)} & \quad - \quad \text{.118 (3.00)} & \quad - \quad \text{.157 (4.00)} & \quad = \quad \text{.217 (5.50)} \\
\text{Straight Before Radius (SBR)} & & \text{Material Thickness} & & \text{Die Penetration} & & \text{Stripper Thickness} & & \text{Grind Life}
\end{align*}
\]
ULTRA TEC® 1/2" A Station
Installation/Length Adjustment

ITEMS...

1. ULTRA CANISTER

2. PUNCH

3. PUNCH GUIDE

4. STRIPPER PLATE

.118(3.00) Relief in ULTRA Stripper

ULTRA Stripper (Face View)

TO ASSEMBLE...

• STEP 1
ATTACH ① TO ②...

• STEP 2
SELECT ANGLE SETTING...
NOTE: ROUNDS ONLY CANISTER
One interior slot for diameter punches

• STEP 3
INSERT ① AND ② PARTIALLY INTO ③. DO NOT SNAP TOGETHER...

• STEP 4
INSERT ④ INTO ③. LINE UP ④ WITH ② AND SNAP TOGETHER...

• STEP 5
PUSH UP LOCK BUTTON TO ENABLE THE CANISTER TO ROTATE...

• STEP 6
ADJUST PUNCH LENGTH...
While pushing up lock button to disengage pin, rotate canister and set punch face flush with stripper. Turn canister eight 'clicks' clockwise to retract punch by .048(1.22), to provide proper stripper lead. Each 'click' equals .006(0.15) length adjustment.

TO DISASSEMBLE...

• STEP 1
TURN KNURLED PORTION OF CANISTER UNTIL PIN ENGAGES DETENT...

• STEP 2
PULL ASSEMBLY APART...

NOTE: ROUNDS ONLY CANISTER
One interior slot for diameter punches
ULTRA TEC® 1 1/4" B Station
Installation/Length Adjustment

ITEMS...

1. ULTRA CANISTER
2. PUNCH
3. PUNCH GUIDE
4. STRIPPER PLATE

TO ASSEMBLE...

• STEP 1
ATTACH ① TO ② …

• STEP 2
SELECT ANGLE SETTING…
NOTE: ROUNDS ONLY CANISTER
One interior slot for diameter punches

• STEP 3
INSERT ① AND ② PARTIALLY INTO ③. DO NOT SNAP TOGETHER…

• STEP 4
INSERT ④ INTO ③. LINE UP ④ WITH ② AND SNAP TOGETHER…

• STEP 5
PUSHING DOWN LOCK BUTTON WILL ALLOW THE CANISTER TO ROTATE…

• STEP 6
ADJUST PUNCH LENGTH…
While pushing down lock button, set punch face flush with stripper. Turn canister six ‘clicks’ clock-wise to retract punch .048(1.22), to provide proper stripper lead. Each ‘click’ equals .008(0.20) length adjustment.

TO DISASSEMBLE…

• STEP 1
ALIGN CANISTER…
Turn canister assembly until index mark is aligned with the push buttons on the punch guide.

• STEP 2
DEPRESS BUTTONS AND PULL ASSEMBLY APART…
Hint: The best way to overcome button spring pressure when disassembling is to fully depress your index finger button and then your thumb button. Following this sequence will make disassembly faster and easier.
ULTRA TEC® Guides
Mate ULTRA TEC® and Original Style Thick Turret Tooling

2" C STATION  3 1/2" D STATION  4 1/2" E STATION

Ease-Out Design
The Quick Length Adjustment System for ULTRA 2" C, 3 1/2" D and 4 1/2" E station holders uses the Ease-Out design to make the installation and removal of punches easier. This exclusive MATE design eliminates the need for shoulder holes in the punch as a method of punch removal.

The Quick Length Adjustment Assembly includes punch head, length adjustment thread, punch driver and drawbolt.

Installation:
The punch is fitted inside the guide and pushed lightly until it contacts the drawbolt. Turning the drawbolt engages the punch. The punch is guided to where the key engages the keyway as the bolt is tightened. Turning the drawbolt further pulls the punch into the guide in the correct keyed position, secure and ready for punching. Rapid stripper installation (press-click) is provided by the ULTRA punch guide’s spring loaded locking system—no wrenches needed.

In 2" C station assemblies, the key is engaged BEFORE the drawbolt can be threaded into the punch. In 3 1/2" D and 4 1/2" E station assemblies, the key is engaged AFTER the drawbolt is threaded into the punch.

Removal:
Refer to small cutaway views at right. Remove stripper before removing punch. Rapid stripper removal (twist-click) is provided by the ULTRA punch guide’s spring loaded locking system—no wrenches needed. ① To remove the punch, simply unscrew the drawbolt. ② With the Ease-Out design the drawbolt is supported internally by the Quick Length Adjustment Assembly. ③ As the drawbolt is unscrewed, the punch moves out of the guide until it can be firmly grabbed and removed. Bolt holes in the punch shoulder are unnecessary. Punch removal resistance is overcome by unscrewing the drawbolt.

To adjust the length of the punch with the Quick Length Adjustment System, press the Quick Length Adjustment button and rotate the Quick Length Adjustment guide counterclockwise for punch length extension or clockwise for punch length retraction until the button ‘clicks’ into the next stop. Each ‘click’ adjust the punch .008(.20). To provide proper stripper lead for each station, set punch face flush with stripper and retract punch as follows: four ‘clicks’ or .032(.81) for 2" C station, eight ‘clicks’ or .064(1.62) for 3 1/2" D station, four ‘clicks’ or .032(.81) for 4 1/2" E station. 16 stops or ‘clicks’ completes one revolution of the Quick Length Adjustment punch head. No tools are required and no need to loosen the drawbolt.
# Material Thickness Recommendations

## Ultra and Thick Turret Maximum Material Thickness Chart

<table>
<thead>
<tr>
<th>Station</th>
<th>Style</th>
<th>Aluminum</th>
<th>Mild Steel</th>
<th>Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Recommended Maximum</td>
<td>* Extreme Maximum</td>
<td>Recommended Maximum</td>
</tr>
<tr>
<td>1 1/2&quot; A</td>
<td>Ultra</td>
<td>.159 (4.00)</td>
<td>.159 (4.00)</td>
<td>.159 (4.00)</td>
</tr>
<tr>
<td></td>
<td>Ultra Heavy Duty</td>
<td>.250 (6.35)</td>
<td>.250 (6.35)</td>
<td>.180 (4.50)</td>
</tr>
<tr>
<td></td>
<td>Original Style</td>
<td>.159 (4.00)</td>
<td>.159 (4.00)</td>
<td>.159 (4.00)</td>
</tr>
<tr>
<td>1 1/4&quot; B</td>
<td>Ultra</td>
<td>.159 (4.00)</td>
<td>.250 (6.35)</td>
<td>.159 (4.00)</td>
</tr>
<tr>
<td></td>
<td>Ultra Heavy Duty</td>
<td>.315 (8.00)</td>
<td>.315 (8.00)</td>
<td>.250 (6.35)</td>
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<tr>
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<td>Ultra Fully Guided</td>
<td>.159 (4.00)</td>
<td>.250 (6.35)</td>
<td>.159 (4.00)</td>
</tr>
<tr>
<td></td>
<td>Original Style</td>
<td>.159 (4.00)</td>
<td>.250 (6.35)</td>
<td>.159 (4.00)</td>
</tr>
<tr>
<td>2&quot; C</td>
<td>Ultra</td>
<td>.159 (4.00)</td>
<td>.375 (9.50)</td>
<td>.159 (4.00)</td>
</tr>
<tr>
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<td>Ultra Heavy Duty</td>
<td>.315 (8.00)</td>
<td>.500 (12.70)</td>
<td>.250 (6.35)</td>
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<td>.159 (4.00)</td>
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<td>Original Style</td>
<td>.159 (4.00)</td>
<td>.375 (9.50)</td>
<td>.159 (4.00)</td>
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<tr>
<td>3 1/2&quot; D</td>
<td>Ultra</td>
<td>.159 (4.00)</td>
<td>.375 (9.50)</td>
<td>.159 (4.00)</td>
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<td>Ultra Heavy Duty</td>
<td>.315 (8.00)</td>
<td>.500 (12.70)</td>
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<td>.159 (4.00)</td>
</tr>
<tr>
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<td>Original Style</td>
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<td>.375 (9.50)</td>
<td>.159 (4.00)</td>
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<tr>
<td>4 1/2&quot; E</td>
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<td>.159 (4.00)</td>
<td>.375 (9.50)</td>
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<td>Ultra Heavy Duty</td>
<td>.315 (8.00)</td>
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<td>Original Style</td>
<td>.159 (4.00)</td>
<td>.375 (9.50)</td>
<td>.159 (4.00)</td>
</tr>
</tbody>
</table>

*NOTES:

1. The maximum material recommendations identified in this chart should be adjusted when the punch diameter or width dimension approaches the material thickness. Reference Chapter 7 "Special Applications". All recommendations assume tooling is properly sharpened and maintained.

2. Many customers exceed these recommendations without machine or tooling complications. In these cases each user considers their application, their machine and their tooling before exceeding these recommendations.

3. The "Extreme Maximums" listed are theoretical only and are not practical in real punching applications.
IV. ULTRA TEC® Fully Guided

What does Fully Guided mean?
Fully guided means that the punch is held securely in at least two extreme points – the punch point and the back of the punch. The objective of punch point guiding is to prevent lateral movement of the punch point to assure accurate hole punching and long tool life.

The punch tip is supported by the stripper, which is manufactured with .0016 (0.04) clearance between the punch and the stripper. This guiding keeps the punch from twisting when side loads are present.

Stations
Fully guided guide assemblies are available for 1 1/4" B, 2" C, 3 1/2" D and 4 1/2" E stations. The guided stripper improves stripping and increases hole accuracy under every condition, for the full range of each station. The Slug Free® die clears the slug every cycle, eliminating slug pulling problems and reducing scrap.

Features
The Ultra fully guided line of tooling offers all the standard advantages found in the ULTRA tooling system. Hardened guides, quick punch length adjustment without shims, interchangeability with competitor tooling systems and extra grind life are all standard. Interior and exterior spiral grease grooves allow for even and consistent tool lubrication, which increases tool life.
ULTRA® Fully Guided Clamp Clearing
The ULTRA® Fully Guided line also includes a clamp clearing model. It is designed with a relief to allow work holders to travel between the stripper and the die, saving material by providing the ability to work close to the edge of the sheet.

Slitting Tools
The slitting process requires the tool to pierce material cleanly and accurately while overcoming various side loads. Parting a sheet includes an amount of punch overlap in each hit where sheet resistance is partially absent. This causes the punch to try and move towards the space where material is absent. The greater the area where material is absent, the greater the side load on the punch. In extreme cases where sheet thickness is thin, the material may even be folded into the die rather than fracturing and falling away. Any of these problems can reduce sheet quality and tool life.

Mate ULTRA TEC® fully guided holders are designed to overcome problems associated with partial hits and side loading.

NOTCHING OR NIBBLING LESS THAN 2 1/2 TIMES SHEET THICKNESS IS NOT RECOMMENDED.

On excessively thin cuts, metal tends to bend down into the die opening instead of shearing cleanly. It will wedge the punch sideways. This causes the punch and die to dull quickly. This is likely to happen when trying to square a sheet edge to zero at one end of the cut as shown here.
V. Special Shapes

A special shape tool is any two dimensional (2D) shape tool other than a round, square, rectangle, oval, single D or double D. Illustrations of Mate’s special shapes are found on the following pages. When ordering a special shape tool, there are some things to keep in mind.

- Is the drawing complete?
- Are there any missing dimensions?
- Do any of the dimensions have special tolerances?
- What material type and thickness will the tool be punching?
- What is the machine brand and model?
- Are any non-standard features requested?
- Will the tool be used in an auto-index station?
- Is this a piercing or blanking application?

Drawings saved as CAD files can be e-mailed to Mate in many standard formats, including .dxf and .igs. Orders can be e-mailed directly to a customer service representative or to orders@mate.com.

Information

All of the above considerations are important when ordering a special shape tool. Knowing the material type and thickness is necessary information to insure the proper tooling is supplied for the specific application. It is critical to know whether the tool will be used to pierce a hole in the sheet – piercing, or if the application is to save the slugs – blanking. In a piercing operation, the punch size is the hole size in the sheet metal. When blanking, the die size is the size of the slug that will fall through the material.

Tips and Helpful Hints

For shapes C2, C3, and C4, one of the points of these triangles may be a 45° angle or less. Special consideration must be given to that size. Corners with included angles of 45° or less require a radius equal to 1/2 the total clearance, or .012 (0.30) minimum, on the punch.
A keyway, shape C6, requires special attention regarding the size of the tab. The depth of the tab (Z) (into the diameter) cannot be any greater than half of the width across (Y). If the depth (Z) is greater than half of the width across (Y), the tab is likely to break.

By programming a small gap of .008 (0.20) between hits with this special D6 tab tool, tabs are formed between the parts. These tabs keep the sheet and parts intact until removed from the press and shaken loose.

Shake-and-break is a popular name for this easy method of separating multiple parts from a sheet of material.
Special shapes E1, E2, and E3, are generally used for adding a radius to the corner of a part that is being saved.

Using a punch, stripper and die with an arc, such as shapes E7, E9, E11, or E12, an auto index station can nibble a smooth edged large round hole. The tools can be made with any custom radii required. Tools such as these are also used when large holes can exceed press capacities if attempted in one hit.

A single 9-way corner rounding tool provides nine popular radii in one tool. Auto indexing selects and rotates the desired radius to round off all corners of a piece part.

The inside/outside radius tool is for use in presses with an auto index station. One tool can be programmed to punch holes with slugs, or when saving blanks larger than press capacity. Small tabs, .016(0.40), programmed between hits permit the slugs and blanks to remain intact while being punched, and to break away easily off the press.
Mate Special Shapes

<table>
<thead>
<tr>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>B1</th>
<th>B2</th>
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</thead>
<tbody>
<tr>
<td>SINGLE D</td>
<td>DOUBLE D</td>
<td>SQUARE WITH RADIUS CORNERS</td>
<td>SQUARE WITH CHAMFERED CORNERS</td>
<td>RECTANGLE WITH RADIUS CORNERS</td>
<td>RECTANGLE WITH CHAMFERED CORNERS</td>
</tr>
<tr>
<td>B3</td>
<td>B4</td>
<td>B5</td>
<td>C1</td>
<td>C2</td>
<td>C3</td>
</tr>
<tr>
<td>RECT/oval</td>
<td>HEXAGON</td>
<td>OCTAGON</td>
<td>EQUILATERAL TRIANGLE</td>
<td>45° RIGHT TRIANGLE</td>
<td>TRIANGLE</td>
</tr>
<tr>
<td>C4</td>
<td>C5</td>
<td>C6</td>
<td>D1</td>
<td>D2</td>
<td>D3</td>
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<td>RIGHT TRIANGLE</td>
<td>RADIUS KEYWAY</td>
<td>SQUARE KEYWAY</td>
<td>RADIUS KEYHOLE</td>
<td>SQUARE KEYHOLE</td>
<td>LONG RADIUS KEYHOLE</td>
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<td>D4</td>
<td>D5</td>
<td>D6</td>
<td>E1</td>
<td>E2</td>
<td>E3</td>
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<td>LONG SQUARE KEYHOLE</td>
<td>DOUBLE KEYWAY</td>
<td>SHAKE AND BREAK</td>
<td>4-WAY RADIUS</td>
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<tr>
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<td>2-WAY RADIUS</td>
<td>2-WAY RADIUS</td>
<td>CABLE OPENING</td>
<td>ARC OVAL</td>
<td>ARC OVAL</td>
<td>FOOTBALL</td>
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<td>E11</td>
<td>E12</td>
<td>F1</td>
<td>F2</td>
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<td>TRI-RADIUS</td>
<td>QUAD-RADIUS</td>
<td>DOUBLE KEYHOLE RADIUS TABS</td>
<td>DOUBLE KEYHOLE RECTANGLE TABS</td>
<td>RECTANGLE WITH ONE NOTCH</td>
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<tr>
<td>F4</td>
<td>G1</td>
<td>G2</td>
<td>G3</td>
<td>G4</td>
<td>G5</td>
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<tr>
<td>RECTANGLE WITH TWO NOTCHES</td>
<td>4-WAY SQUARE KEYHOLE</td>
<td>RECTANGLE WITH TABS</td>
<td>DOUBLE RECTANGLE</td>
<td>CABLE OPENING WITH TABS</td>
<td>9 WAY CORNER ROUNDERING</td>
</tr>
</tbody>
</table>

Maximum Station Ranges

<table>
<thead>
<tr>
<th>1/2&quot; A</th>
<th>1 1/4&quot; B</th>
<th>2&quot; C</th>
<th>3 1/2&quot; D</th>
<th>4 1/2&quot; E</th>
</tr>
</thead>
<tbody>
<tr>
<td>.500 (12.70)</td>
<td>1.250 (31.75)</td>
<td>2.000 (50.80)</td>
<td>3.500 (88.90)</td>
<td>4.500 (114.30)</td>
</tr>
</tbody>
</table>

Dimensions in inches (millimeters)
VI. Special Assemblies

Special assemblies are forming tools such as card guides, centerpoints, countersinks, embosses, extrusions, knockouts, lance and forms, louvers, stamping tools, thread forms and clusters.

Ordering Information
When ordering a special assembly, it is important to keep the following in mind:

- Is the drawing complete?
- Are there any dimensions missing?
- Do any of the dimensions have special tolerances?
- What material type and thickness will the forming tool will be used on?
- What is the machine brand and model?
- Are any non-standard features requested?
- Will the tool be used in an auto-index station?
- Drawings saved in CAD files can be e-mailed to Mate in many standard formats, including .dx and .igs. Orders can be e-mailed directly to a customer service representative or to orders@mate.com.

General Considerations
When forming sheet metal, the following considerations should be practiced:

- Forming tools should be run at a lower punching speed. Most inverted assemblies are built with stripping springs that require additional time for the material to separate from the tool.
- Forming should be the last hit on the sheet whenever possible.
- Adjacent stations to the forming tool should not be used. It is, however, necessary to have a die in the lower turret die holder in the adjacent stations. Roller dies are recommended (available for 1 1/4" B station -- see Mate Precision Tooling ULTRA® Tooling Catalog).
- Form down operations should generally be avoided. During the sheet advance process, the formed material can drop into dies, get caught and pull the work piece out of the work holders. If a form down operation is the only solution for a particular piece part, make it the last operation on the sheet.
- Lubrication to the top of the work piece is recommended.
- Periodically remove the tool from the turret and check the sharpness of any cutting edges.
- For first time set-up, form tools should be set at their shortest length, and adjusted after trial hits to shortest length that produces a satisfactory form.
ULTRAFORM® Assemblies

Ultraform holders have four external slots in the 1 1/4" B, 2" C, 3 1/2" D and 4 1/2" E stations. The Ultraform inserts have four pin holes and one pin, allowing the form unit to be set at 0°, 90°, 180° and 270°. One adjustable length Ultraform holder can be used with a variety of forming inserts – reducing tooling costs. The length adjustment is made by depressing the length adjustment button on the top of the holder and turning it clockwise to reduce length (counterclockwise to increase length) until the button 'clicks' into the next stop. Ultraform holders have 20 stops per revolution. Each stop adjusts assembly length by .002 (0.05). For more information on the ULTRAFORM® system, see the Mate Precision Tooling ULTRA® Tooling Catalog.

Note:
The Ultraform holder design has two configurations. They are identified by the number of external slots. The current design (April 1999 and newer), is with four external slots which enables the holder to be installed into the turret bore in any one of four positions. The previous design had one external slot where angle settings were made by positioning the insert in any one of four positions. There are no more and no fewer angle setting capabilities in either design. All inserts manufactured prior to the current design are usable in the current holder design. All current inserts are also usable in the previous design holders. The current design Ultraform holder is available as a response to customer requests.
Clusters

Cluster assemblies are 2 or more holes in a single unit. Some of the benefits of using cluster tools are time savings, cost savings, evenly punched holes and flatter surfaces. Clusters are especially helpful when hole to hole tolerances are critical. Most styles are offered with replaceable inserts to reduce tooling costs. After sharpening or replacing inserts in a cluster assembly, the stripper lead must be reset to .020 -.040 (0.51-1.02).

It is NOT recommended to re-enter a punched hole with a cluster assembly. This would cause a side load on the punch assembly. Use a single hole punch to complete a pattern. **Tonnage (punching force) for a cluster assembly should not exceed 75% of press capacity.**

An ULTRA TEC® **fully guided cluster assembly** uses the ULTRA TEC® fully guided holder combined with a fully guided stripper. The stripper opening guides the punch point with .0016 (0.04) total clearance to accurately locate and support the punches. The unit has interior and exterior spiral lubrication grooves. The Slug Free® die clears the slug every cycle.
Special Assemblies

Helpful Hints:

The form height of a card guide is determined by the web width. Consult Mate Precision Tooling ULTRA® Tooling Catalog for in-depth explanations for recommended pre-pierce widths and lengths, form heights and web widths.

CARD GUIDE TOOL...
Card Guides for Printed Circuit Boards

The dedicated countersink is designed specifically for one material thickness and one screw size. The depth of the taper can be from 60% of material thickness to a maximum of 85%. The depth of the form may not exceed 60% of material thickness when using a universal style countersink tool.

COUNTERSINK TOOL...
Forms a taper to accept a flathead screw or rivet.

CENTERPOINT TOOLS...
Make Top or Bottom Centerpoints

The centerpoint assembly is designed for penetration into material without leaving a ‘lip’ or burr.
**Embossing** involves two processes. One, the metal bends, and two, the metal in the sidewall stretches, flowing and thinning as it lengthens. When an emboss stresses a metal beyond forming capacity, failure usually occurs at the base or top of the emboss as a tear or fracture. The more ductile the metal, the more it will stretch before it fails. Gentle angles (45° or less) and generous radii (.030 [.76]) are conditions for good embosses with minimal distortion. Generally, formed embosses require less punching force than a hole of the same size.

---

Screws not holding? Try tapping **extrusions**. Screws in extruded holes develop nearly twice the holding strength as non-extruded holes. To develop an extrusion two-and-a-half times as high as material thickness, the diameter of the pre-pierced hole will be about 65% of the diameter of the finished extrusion. Minimum distance between extrusions and metal edge should be at least three times material thickness. Minimum distance between extruded holes should be a minimum of six times the material thickness.

---

**Knockouts** are commonly used in the manufacture of electrical boxes. The size of a knockout is usually related to a conduit or connector. The stripper plate in the lower assembly bottoms out at the die line. When the stripper is bottomed out, the lower insert should lead the stripper by 1.1 x material thickness. If the punching force for a double knockout is over press capacity, the form can be made in two hits. The first hit is a knockout down and the second is a knockout up with relief. The same can be done for triples and quads. The minimum web between knockouts is .562 (14.27). A knockout assembly accommodates a ± .016 (0.41) range in material thickness.

---

A **planishing** punch pushes a knockout back to 75% material thickness, leaving 25% still raised. This is important when painting or sealing the enclosure.
The lower unit using an inverted punch normally performs the ‘lance’ part of a lance and form operation. The ‘form’ takes place as the work piece is squeezed between the lower unit and an inverted die in the upper unit. A 5˚ minimum draft angle on the sides of the form improves stripping and piece part quality.

Lance and form assemblies can be any size and shape.

The primary purpose for louvers is to permit the passage of air from one side of a panel to the other. A panel with louvers should be programmed to move through the press with the louver openings away from the direction of material movement. A .500 (12.70) radius is recommended on the ends of a closed end louver for stainless and cold rolled steel under .060 (1.52) to prevent corners from tearing. A 10˚ draft angle is standard on the ends of an open end louver. To ensure flatness between louvers, a minimum spacing between the cutting edge of the first louver and the back edge of the second louver should be three material thicknesses. For spacing between rows (end to end spacing) a .314 (8.00) minimum is recommended.

A shearbutton is a special purpose tool for placing locating tabs in sheet metal for further fabrication such as shearing and spot welding.

SHEARBUTTON TOOLS...
Easy Shear Guides, Programmable

Screw holding threads are pierced and formed in one operation with a thread form assembly. The domed shape with a screw thread acts like a locknut as a screw tightens it down.
Mate Sheetmarker™
Mate Sheetmarker™ Tool is used to "mark" or scribe the top surface of the sheet metal. The assembly uses a diamond point insert in an Ultraform® holder to create the etchings. The marking is the result of programs created in the punch press programming system. The Sheetmarker tool can be used on all material types and thicknesses. A variety of results can be produced, ranging from very light etching to fairly deep grooves in the sheet. The press must be capable of holding the ram down while the sheet is moved on the x or y axis.

Mate Rollerball®
Mate Rollerball® assembly is used to make a continuous bead emboss on a piece of sheet metal. The Mate Rollerball is used in an auto index station. The tool can make forms not possible with single hit forming tools. The Mate Rollerball can form ribs, flanges or offsets across the entire work surface. The press must be capable of holding the ram down while the sheet is moved on the x or y axis.
VII. Special Applications

A standard application is punching and nibbling within 80% of the press capacity. Standard material thicknesses are mild steel and aluminum that are .020 to .157 (0.51 to 4.00) thick. 85% of the work done on turret presses falls into this category.

Special applications, are applications that are outside these parameters.

- Material less than .020 (0.51) thick
- Material greater than .157 (4.00) thick
- Special aluminum alloys
- Stainless steel greater than .078 (2.00) thick
- "Exotic" materials (inconel, hastalloy, plastics, etc.)
- "Special" special shape
- "Special" special assembly
- Many hits and/or nibbling
- Wall thicknesses of less than 2 1/2 material thickness
- Special tolerances or hole cross-sections
- Large holes (greater than 3.0 [76.20])
- Small holes (less than 1 material thickness)
- Tonnage greater than 80% of press capacity

Any one of the above existing conditions should be a warning to be alert to this particular job. Any two in combination will probably require special design and/or instructions.
Special Applications

Punching Thick Material (over .157 [4.00])

- Use sharp punches and dies – sharpen when cutting edge has a .003 -.005 (.07-.13) radius – proper sharpening is critical
- Clearance of 25-30% of material thickness (reference die clearance chart)
- Heavy duty back taper on punches
- Minimum punch size (width or diameter) of .250 (6.35)
- .020 (.51) radius on all punch corners
- Inspect tools frequently for wear
- Lubricate the sheet, punch, guide
- Run machine on slow cycle
- Special care should be taken NOT to exceed press capacity (tonnage) when punching large shapes – for best results, use 80% of press capacity
- Bridge hitting is recommended – this will keep a balanced load on the punch
- Nibbling is NOT recommended – if you must nibble, use 70% minimum of punch length – DO NOT nibble with width of punch
- ULTRA TEC® Heavy Duty Tooling is recommended

ULTRA TEC® Heavy Duty Tooling Advantages:

- 1° back taper (per side) on punches
- Heavy duty Slug Free® die design
- Heavy duty springs in ULTRA TEC® canister, 1 1/4" B station
- Rooftop shear – B station and larger
- Radius on all 90° corners to improve corner strength
- Premium High Speed Steel (HSS) tool steel
- Quick length adjust
- Quick tool change
- Maxima™ coating option

Punching Non-Metallic Material

- Use sharp punches and dies
- Reduce die clearance by 5%-8%
- Run the machine on slow cycle
- Lubricate hard plastic if possible
- Use Maxima™ coated punches
- If marking occurs use urethane pads
- Support thin material when possible
Special Applications

Blanking Operations

Blanking is when the slug, normally the scrap part, becomes the saved or good part. The following recommendations will assist in making good quality blanks.

- Determine what blank dimensions are critical and inform Mate upon ordering that the tools are to be used for blanking. When blanking, the die size is the blank size. Punch dimensions are calculated from the die dimensions.

- Use only sharp punches and dies. This increases the straight or burnished portion of the blank to provide straighter walls on the required parts.

- Reduce the die clearance by 5%. Reference die clearance chart in "The Perforation Process" chapter for proper clearance based on material type and thickness. This also helps increase the burnish area and minimizes the dimensional difference between the top and bottom of the blank.

- Punches should be flat-faced.

- Use straight taper dies.

- Inspect tools frequently for wear. We recommend more frequent inspection of the tools, since tools will require sharpening more frequently when using reduced die clearances.
Special Applications

Small Diameter or Narrow Holes

When punching small diameter or narrow holes, check that tools are properly sharpened and maintained. The following recommendations are provided as guidelines to eliminate machine or tooling complications. In each situation, the user must consider their application, their machine, and their tooling before exceeding these recommendations.

**Ratio of Punch to Material Thickness**

<table>
<thead>
<tr>
<th>Material</th>
<th>Punch to Material Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>.75 to 1</td>
</tr>
<tr>
<td>Mild Steel</td>
<td>1 to 1</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>2 to 1</td>
</tr>
</tbody>
</table>

This means that if the material being punched is .078 (2.00) thick aluminum, it is reasonable to punch a .060 (1.50) diameter hole with the above listed styles of tooling. If the material being punched is .078 (2.00) thick mild steel the smallest punch that is recommended is .078 (2.00) diameter (or wide shape). If the material being punched is .078 (2.00) stainless steel, the smallest punch recommended is .157 (4.00) diameter (or wide shape).

<table>
<thead>
<tr>
<th>Material</th>
<th>Punch to Material Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>.5 to 1</td>
</tr>
<tr>
<td>Mild Steel</td>
<td>.75 to 1</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>1 to 1</td>
</tr>
</tbody>
</table>

This means that if the material being punched is .078 (2.00) aluminum, it is possible to punch a .039 (1.00) diameter hole using a Mate fully guided product. In mild steel that tool would need to be a minimum of .060 (1.50), and in stainless a minimum of .078 (2.00) diameter (or wide shape).
Special Applications

**Recommended Minimum Distances:**

- Between holes
- Between forms
- From edges of sheet

If holes and forms are placed any closer to each other or to the edge of a sheet than shown below, they will distort each other and/or the material. This is because material flows when it is punched or formed.

<table>
<thead>
<tr>
<th>Recommended Minimum Distances</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Between holes</td>
<td>Minimum 2 times material thickness</td>
</tr>
<tr>
<td>Between hole and edge of sheet</td>
<td>Minimum 2 1/2 times material thickness</td>
</tr>
<tr>
<td>From form to edge of sheet</td>
<td>Minimum 3 times material thickness</td>
</tr>
<tr>
<td>Between forms</td>
<td>Minimum 6 times material thickness</td>
</tr>
</tbody>
</table>

Dimensions in inches (millimeters)
VIII. Treatments and Coatings

Nitride Treatment

Nitriding is an optional heat treatment feature for high speed steel (HSS) punches. It is a surface treatment, which becomes an integral component of the structure of the material itself. Nitrided punches are recommended for punching abrasive materials such as fiberglass or materials that cause galling such as stainless steel, galvanized steel, or aluminum. It is also recommended for high speed nibbling applications. It is not recommended for punches smaller than .078 (2.00) in diameter or width, or for material thicker than .250 (6.35).

Maxima™ Coating

Maxima is a premium tool steel coating that has been specially formulated for turret punch press tooling applications. Maxima is a hard, wear resistant, multilayer Zirconium Titanium Nitride (ZrTiN) coating. It acts as a barrier between the punch and the sheet metal being punched and because of its exceptional lubricity, greatly improves stripping.

Maxima is applied to the precision ground surface of Mate’s premium high speed steel (HSS) punches. Since Maxima is an extremely hard, wear resistant, slippery material which reduces the friction that occurs during the stripping portion of the punching cycle, it is particularly good for abrasive tooling applications. Less friction means less heat build up, less galling and longer tool life.

<table>
<thead>
<tr>
<th>ULTRA TEC® Tools That Can be Maxima coated:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rounds</strong></td>
</tr>
<tr>
<td><strong>Squares</strong></td>
</tr>
<tr>
<td><strong>Rectangles and ovals</strong></td>
</tr>
<tr>
<td><strong>Cluster Insert</strong></td>
</tr>
<tr>
<td><strong>MT™ Punches</strong></td>
</tr>
</tbody>
</table>
IX. Punch Shear

Punch "shear" is the geometry of the punch face. The standard shear for 1/2" A station through 3 1/2" D station ULTRA TEC® punches is flat – without shear. The standard shear for 4 1/2" E station is rooftop shear. Other shear types are available upon request. Shear helps reduce tonnage because the punch is not hitting with the full face on the material.

Advantages of Shear

- Tonnage reduction
- Noise reduction
- Slug control
- Reduced shock loads
- Improved stripping

Common Types of Shear

- Rooftop shear is the best shear for minimizing tonnage in thicker materials.
- Concave shear is a good alternative shear for nibbling. Without shear is recommended for nibbling.
- One way shear is best for minimizing tonnage when blanking.
- Four way shear is a good alternative shear used on square tools.
Punching Force Considerations

Punches with Shear - Consideration
Punch shear tends to lessen punching force. The degree to which this happens is the SHEAR FACTOR. Shear factor does change as the punch becomes less sharp. Note that the factory does not recommend using shear to bring punching force within press capacity, because dulling tool edges quickly raise punching force, and press capacity may be exceeded.

Material Thickness -
Material thickness is the width of the workpiece or sheet that the punch must penetrate in making a hole. Generally the thicker the material the more difficult it is to punch, but this isn't the only factor.

Material Shear Strength -
Material shear strength is a measure of maximum internal stress before a given material begins to shear. This property is determined by metallurgical science and expressed as a numerical factor. Popular materials like aluminum, brass, mild steel and stainless steel have approximate shear strengths of:

<table>
<thead>
<tr>
<th>MATERIAL:</th>
<th>SHEAR Strength-lbs/in² (kN/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum 5052 H32</td>
<td>25000 (0.1724)</td>
</tr>
<tr>
<td>Brass</td>
<td>35000 (0.2413)</td>
</tr>
<tr>
<td>Mild Steel</td>
<td>50000 (0.3447)</td>
</tr>
<tr>
<td>Stainless</td>
<td>80000 (0.5516)</td>
</tr>
</tbody>
</table>
X. Maintenance

To protect your tooling investment, knowing and practicing proper maintenance is essential.

Tools that are maintained and lubricated properly will produce quality holes and more piece parts at a lower cost per hole. See Mate’s full line ULTRA® Tooling Catalog for complete punch and die maintenance instructions.

Benefits of Proper Tool Maintenance

- Improved Piece Part Quality
- Flatter Sheets
- Cleaner Holes
- Longer Tool Life
- Less Stress on Tools and Machine

Torque Recommendations

Punches in ULTRA TEC® 2" C, 3 1/2" D, and 4 1/2" E punch guides should be tightened to 75 ft. lbs. (102 Nm).

Sharpening Rules

- Sharpen frequently – in small amounts.
- Tools last longer if sharpened in small amounts --- .001-.002 (0.03-0.05) should be removed in one pass.
- Repeat until tool is sharp, normally .005 -.012 (0.13-0.30) total.
- Apply coolant with as much force and as close to the tool and wheel as is practical.
- Use the proper grinding wheel and dress the wheel often, using a rigid single or multi-point diamond.
- After sharpening, lightly stone the sharp cutting edges to remove any grinding burrs and to leave a .001 -.002 (0.03-0.05) radius.
- Provide proper face geometry.
- Observe proper set-up practices.

ESTABLISH WRITTEN MAINTENANCE PROCEDURES.
When to Sharpen Punches

As a punch is used, the cutting edge begins to break down and form a radius on that cutting edge. This radius grows larger with continued use. As it grows, hole quality is compromised and punching efficiency deteriorates. This growth rate varies with hole size, material type and material thickness being punched. Typically, hole quality begins to deteriorate when the radius reaches .005 (0.13).

At this point, the punch should be ground to remove .005 (0.13) radius, restoring the sharp cutting edge.

Die Maintenance

Keep dies clean and watch for wear. Use the same wheel and feed rates sharpening procedures as punches, holding die on surface grinder's magnetic chuck. Check die thickness after each sharpening and add shims as necessary. Remachining of chamfer and radius may be required to facilitate sheet lead in.

Importance of Frequent Tool Maintenance

It is very important that punches and dies be sharpened when the cutting edge radius reaches .005 (0.13).

More Than DOUBLE Tool Life When Sharpened Frequently!
Tool Maintenance Tips

• Proper die clearance is critical.

• When punches get dull too fast, clearance may be too tight.

• Keep tools clean and watch for wear.

• Sharpen tools frequently – in small amounts.

• Always use coolant when sharpening.

• After sharpening, lightly stone the sharp cutting edges to remove any grinding burrs and to leave .001-.002 (0.03-0.05) radius.

• Demagnetize the punch and spray on a light oil.

• Establish written maintenance procedures.

• Remove galling by rubbing with a fine stone parallel to the direction of the punching motion.

• If a piece-part is starting to show too much rollover, perhaps a tool is dull.

• If the punch press is making more noise than you think it should, perhaps a tool is dull.

• If the press is working harder than it used to, perhaps a tool is dull.

• Maintain press alignment.

• Check machine level and adjust if necessary.

• Examine punch and die holder for wear. Replace if necessary.

• Examine turret bores and die holder seats. Restore if they are damaged. Fix damaged keyways.

• Proper lubrication of tools extends tool life.

• Proper lubrication of sheet extends tool life.

• Use of Maxima™ increases tool life.

• Use Slug Free® dies.

• Recommended die penetration is .118 (3.00).
Factors Affecting Tool Wear

**Hole Size** – Small punches will wear faster than larger punches.

**Hole Configuration** – Sharp corners will show wear much more quickly than straight or curved edges, particularly on punches. Narrow sections will wear faster than heavier sections.

**Shear Face on Punch** – The portion of the punch that strikes first does most of the work and will, therefore, wear faster.

**Clearance** – Proper clearance will yield longer tool life.

**Punching Conditions** – Reducing the hitting shock and holding the sheet flat allows the punch to cut cleanly and will give better life to the punch.

**Stripping Conditions** – Stripping the work piece from the punch evenly contributes to easy stripping.

**Turret Alignment** – Mechanical damage of punches and dies is often misinterpreted as wear. Tight clearance on one side of a punch and die will accelerate wear at that point. It is critical to regularly check turret alignment in order to prevent problems such as unacceptable part quality and turret wear.

**Tool Material** – To develop toughness and hardness required for long life, high speed steel (HSS) undergoes several heat treatments. The punches are double tempered to C 62 Rockwell hardness. Hardened (59 Rockwell C) tool steel is the optimum material for dies. It correctly balances the need for maximum edge wear without breakage.

**Punching Speed** – High punching speeds can, under certain conditions, generate enough frictional heat to soften a punch. A softer punch will wear much faster.

**Lubrication** – A lubricant will increase tool life significantly.

**Work Piece Thickness** – Thicker material will cause faster punch wear.

**Work Piece Properties** – Physical and mechanical properties of the work piece will greatly affect tool life.

**Punch/Die Wear** – Punches will generally wear faster than dies. Dies are less affected by the factors described above than punches.

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Maintenance

Minimum Punch Lengths

Original Thick Turret Punch in ULTRA TEC® Guide Assembly

<table>
<thead>
<tr>
<th>Station</th>
<th>Minimum Punch Lengths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Station Overall Length</td>
</tr>
<tr>
<td>A</td>
<td>8.169(207.50)</td>
</tr>
<tr>
<td>B</td>
<td>8.169(207.50)</td>
</tr>
<tr>
<td>C</td>
<td>3.786(96.16)</td>
</tr>
<tr>
<td>D</td>
<td>3.313(84.15)</td>
</tr>
<tr>
<td>E</td>
<td>3.353(85.17)</td>
</tr>
</tbody>
</table>

ULTRA TEC® Punch in ULTRA TEC® Guide Assembly

<table>
<thead>
<tr>
<th>Station</th>
<th>Minimum Punch Lengths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Station Overall Length</td>
</tr>
<tr>
<td>A</td>
<td>4.246(107.85)</td>
</tr>
<tr>
<td>B</td>
<td>3.957(100.50)</td>
</tr>
<tr>
<td>C</td>
<td>3.786(96.16)</td>
</tr>
<tr>
<td>D</td>
<td>3.313(84.15)</td>
</tr>
<tr>
<td>E</td>
<td>3.353(85.17)</td>
</tr>
</tbody>
</table>

Minimum Die Height

Die height of stations 1/2" A through 4 1/2" E is 1.187 (30.15).

.125 (3.18) Grind Life. Dies may be sharpened 10 to 20 times at .005 -.010 (0.13-0.25) per sharpening. After sharpening, remachining of chamfer and radius may be required to maintain sheet lead in.

The maximum die sharpening of thick turret Slug Free® dies is .125 (3.18)
# XI. Troubleshooting

## Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Solution Suggested</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excessive Burrs</strong></td>
<td>Incorrect die clearance</td>
<td>• Adjust to proper</td>
</tr>
<tr>
<td></td>
<td>Differing material hardness although gage</td>
<td>• Adjust clearance</td>
</tr>
<tr>
<td></td>
<td>is the same</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dull punches and dies</td>
<td>• Sharpen tooling</td>
</tr>
<tr>
<td></td>
<td>Slug pileup or packing</td>
<td>• Check dies and clear</td>
</tr>
<tr>
<td></td>
<td>Holder or station misaligned</td>
<td>• Check alignment</td>
</tr>
<tr>
<td><strong>Poor Hole Quality</strong></td>
<td>Dull punches and dies</td>
<td>• Sharpen tooling</td>
</tr>
<tr>
<td></td>
<td>Improper clearance</td>
<td>• Adjust to proper</td>
</tr>
<tr>
<td></td>
<td>Die not properly seating</td>
<td>• Check dies</td>
</tr>
<tr>
<td></td>
<td>Holder or station out of alignment</td>
<td>• Check alignment</td>
</tr>
<tr>
<td></td>
<td>Punching thin material</td>
<td>• Use guided tooling</td>
</tr>
<tr>
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<td>• Adjust to proper</td>
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<td>• Ensure tools are properly loaded in turret</td>
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<td>Size of punch less than one</td>
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<td><strong>Punch Does Not Strip</strong></td>
<td>Dull punches or dies</td>
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<td>.039 to .078 (1.00 to 2.00) thick material, with</td>
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<td>sharp tools, using optimum clearance, and minimum</td>
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<td>penetration on oiled material. The solutions</td>
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<td>suggested are to:</td>
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<td>• Maximize die penetration</td>
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XII. Tips and Techniques

The Do’s and Don’ts of Punching

**DO**
1. Keep tooling sharp.
2. Use proper die clearance.
3. Clean tooling on a regular schedule and use lubrication when possible.
4. Order dies by punch size + clearance (for uniform corner clearance).
5. Sharpen punches and dies correctly at proper time – edge breakdown of .005 -.010 (0.13-0.25), .001 -.002 (0.03-0.05) per grinding wheel pass.
6. Program correctly – bridge hit, use 75% of parting tool, nibble 2.5 material thickness’, cut large cut-outs along the same axis.
7. Recommendation: Holes be a minimum of 2 1/2 times material thickness from the edge of sheet being punched.
8. Check turret bores.
9. Check punch and die holders for wear.
11. Check and level press.
12. When nibbling large holes use 2 tools of the same size. Tool change frequently between them to avoid overheating.

**DON’T**
1. "Nibble" when you can "punch".
2. Have unnecessary punch shear.
3. Use tool with an offset centerline.
4. Re-enter a punched hole (using a cluster assembly to complete pattern).
I/O Radius Tool cuts both inside and outside radii
Small, precise tabs keep slugs and blanks intact while being punched, yet permit them to break away from each other easily off the machine. The recommended width for the tab is .015 (0.38) gap between hits. The tool is for use in an auto index station. Inside radius must be larger than outside radius. Programming requirements are included with the tooling.

Placing the form on the sheet with the grain running perpendicular to the form can reduce tearing or splitting of over stressed metal forms. Corners of high louvers, high extrusions, complex lance and forms, and card guides are typically vulnerable to this effect. Liberal application of a forming lubricant is also recommended to let the metal slide more freely over the forming surface of the tool, especially in stainless steel.

Parts to be welded can be positioned precisely, when shearbuttons are programmed into surfaces to be joined. Layers of material come together with NC accuracy.

Costs for bolts and lockwashers can be eliminated, if thread forms can be programmed into a part. This domed shape with a screw thread acts like a lock nut as a screw tightens it down. Mate’s special thread form tools make both the screw hole and the raised dome in one hit.

Inscribe parts on a punch press to reduce costly separate operations. Inscribing numbers, words, or any combination thereof can be programmed into your punch press with Mate stamping tools. Produce one or two lines with one hit. The characters line up straight and depth of impression is uniform.

Mate Sheetmarker™ tool can be used to inscribe or mark sheetmetal. Mate Sheetmarker™ assembly is available for presses that can hold the ram down while the sheet is allowed to move.

If stainless steel extrusions are distorted, apply a good forming lubricant to the material before making the extrusion. Not only will the material release from the die better, it slides over the die surface smoothly when being formed. This gives the material a better opportunity to distribute the forces of bending and stretching, preventing distortion in the formed wall and tearing at the base of the extrusion.
Galling is an adhesion to the punch tip by the metal being punched, caused by pressure and heat. The best technique for removing galling is to rub it off with a fine stone. The rubbing should be done parallel to the direction of the punching motion. This will polish the surface that contacts the material, decreasing any chance of future galling. Do not sandblast, belt sand or use other harsh abrasive methods. These create a coarse surface finish to which material adheres more easily.

Shake-and-break is a popular name for this easy method of separating multiple parts from a sheet of material. The method is based on small, interconnecting tabs between the parts created by programming spacing of the shearing or slitting punch. These tabs keep the sheet and parts intact while being punched, yet are easy to separate off the machine. The tabs should be .008 (0.20) wide. Straight, curved, or corner shaped tools are available.

Combating material warp.
If you are punching a large number of holes in a sheet and the sheet does not stay flat, it could be caused by the cumulative effect of punching. Each time a hole is punched, material surrounding the hole is stretched downward, placing the top of the sheet in tension. The downward movement causes a corresponding compression at the bottom of the sheet. One way to counteract this effect is to punch every other hole first and then come back and punch the remaining holes. This places the same amount of force on the sheet, but it disrupts tension/compression accumulation that occurs when punching operations follow one another in close succession and in the same direction.

Use Mate’s urethane stripper pads to punch painted surfaces without marring. These self-stick pads can be applied to ULTRA TEC® stripper faces. Pads are available for all stations A through E.
Notch a variety of angles with one set of 3-way corner notching tools. This is another application for an auto index station. A 3-way corner notching tool can cut any angle larger than the smallest point by programming single or multiple hits. 15° is the smallest angle available.

Clearance corners in dies control corner burrs. A radius in the corners of rectangular and square dies with clearance greater than .020 (0.51) keeps clearance uniform around the corner of the punch. If the die is sharp cornered too, then distance between punch and die corners would be greater than side clearance, resulting in large burrs.

Mate Rollerball® assembly is used to make a continuous bead emboss on a piece of sheetmetal. The Mate Rollerball® is also capable of offset forming. The assembly is available for presses that can hold the ram down while the sheet is allowed to move.

Shaving makes straight-walled holes without drilling.
When you need a smooth, straight-walled hole, shaving can save the time and trouble of performing a second operation on another machine. To do this, you need to punch the hole twice. First use a punch with total clearance taken off equal to 20% of material thickness, and a die with total clearance .004 (0.10) over the desired finished shaved hole size. Then, program a second hit in the same place using the same size die, and a punch the size of the desired finished hole. The second operation will shave the sides of the hole, removing most of the rollover and fracture effects caused in the first step, and enlarge the burnished area. This operation works best on mild steel and other materials that shear well. The example shown is a finished shaved hole of 1.000 (25.40) diameter in .187 (4.75) thick material.

Form down last. When using forming tools, form down operations are generally avoided because they take up so much vertical room and any additional operations tend to flatten them out or bend the sheet. They can also drop into dies, get caught and pull out of work holders. However, if a form down operation is the only solution for a particular piece part, make it the last operation on the sheet.
Bridge hitting reduces tool wear.
By alternating hits when performing shearing/slitting operations, forces upon the tool remain balanced from side to side and end to end. As a result, the punch operates square to the material and die. Over the long run, this will reduce the frequency of sharpening and generally longer tool service. This practice is called "bridge" hitting because the full hits leave a "bridge" of material between them that is removed by the next sequence of hits.

If punches overheat:
• Use a lubricant. This will decrease friction.
• Use more than one punch of the same size in the sequence. By alternating the punches, there will be a longer time for each punch to cool down before it is used again.
• Simply give the tool a rest. Program tool changes to interrupt long repeated operations.
• Slow the press down.
• Use Maxima™ coating.

What do your slugs tell you?
The slug is essentially a mirror image of the hole, with the same parts in reverse order. By examining your slugs you can tell if punch-to-die clearance is correct. If clearance is too large, the slug will show a rough fracture plane and a small burnish zone. The larger the clearance, the greater the angle between the fracture plane and the burnish zone. If clearance is too small, the slug will show a fracture plane with little angle, and a large burnish zone. An ideal slug is created when the fracture planes coming from the top and the bottom of the material have the same angle and form in alignment with each other. This keeps punching force to a minimum and forms a clean hole with little burr. At this point, any extension in tool life gained by increasing clearance comes at the sacrifice of hole quality.
**Recommended minimum distance between holes, between forms and from edges of sheets.** If holes and forms are placed any closer to each other or to edges of sheets than is given below, they may distort each other or the material.

- Minimum 2 times material thickness between holes.
- Minimum 2 1/2 times material thickness between hole and edge of sheet.
- Minimum 3 times material thickness from form to edge of sheet.
- Minimum 6 times material thickness between forms.

**Recommended die penetration is .118 (3.00).**

**How to punch large holes without exceeding press tonnage.**

Although tooling is available for round holes up to station maximums for the largest station, such holes can exceed press capacities, especially in high shear strength materials. Creating the hole with more than one hit may solve the problem. Using smaller tools to break long perimeters on large tools can cut tonnage by a half or more, without resorting to nibbling the entire periphery. The diagrams use rounds, double D’s, a quad radius and a biconvex radius. In all three, slugs fall away through the die, leaving no scrap on the punch press table.

**Start continuous louvers in the center.**

Continuous louver tools are now designed to produce smooth-edged, level-topped louvers when recommended procedures are followed. Start in the center and form to one side and then the other in .030 (0.80) increments. If needed, complete the process by rehitting the center for ultimate flatness.
XIII. Glossary

**A2 Tool Steel.** A2 tool steel has a higher toughness/hardness ratio, with minimum movement in hardening and a greater wear resistance than oil hardened tool steels.

**Actual Size.** The measured size of the die with the total clearance included.

**Alpha Numeric Stamping Assembly.** A special assembly that stamps letters or numbers into sheet metal using replaceable character inserts.

**Beading Tool.** An embossing assembly that can hit continuously along the sheet to form a long, strengthening rib.

**Blank.** Any part cut from a sheet of metal that is not scrap.

**Blanking.** When saving the slug as the finished product. The punch is made without shear. The die size determines the blank size.

**Bridge Hitting.** Programming a wide section of material between each hit during the first punching sequence and then removing that entire section (or bridge) during another sequence of hits.

**Burnished Land.** The shiny, sheared portion of the hole in the sheet metal in between the rollover and the burr.

**Burr.** The rough edge that protrudes out of the bottom side of the sheet after punching.

**Burr Height.** The visible part of the burr hanging below the sheet. With optimum clearance, the burr height is approximately 10% of the material thickness.

**Cable Opening.** A special shape (see E6 in "Special Shapes" chapter).

**Cantilever.** A projected area in a special shape die that is likely to break. A keyway is a good example.

**Card Guide.** A special assembly tool that forms the material up into a channel.

**Cartesian Coordinates.** This angle setting method sets 0 degrees at 3 o’clock, and the following angle settings are set counterclockwise from there. The system is named for the French philosopher and scientist René Descartes.

**Centerline Drawing.** A drawing furnished for all special shape punches and dies used for programming and reordering.
**Centerpoint.** A special assembly that puts cone-shaped indentations, used for locating, into the sheet.

**Cluster.** A special assembly that produces multiple holes in one hit.

**Concave shear.** The concave shear arches into the center of the punch face, with the center striking the metal last.

**Convex or "Rooftop" Shear.** This punch face angles to a point, with the center of the punch striking the metal first. This shear should not be used in any notching operations because it will push the punch away from the cutting operation which may result in an unsatisfactory hole.

**Countersink (Universal).** A tool used to form a taper in a prepierced hole to accept a flathead screw or rivet. The depth of form may not exceed 60% of material thickness.

**Dedicated Countersink.** This tool is similar to a universal countersink, except it is used specifically for one material thickness and one screw size, and the depth is up to 85% of the material thickness. It is used with a blank die.

**Deviation Clause (DC).** Indicates that the tool deviates from or exceeds the press manufacturer’s standards or recommendations. Tools ordered with this clause are not guaranteed.

**Die.** A tool that supports the sheet metal as the punch penetrates through it. The die hole must be larger than the punch. The die size is determined by the thickness and type of material being punched.

**Die Clearance.** The difference in size between the punch dimensions and the die dimensions which allows for the proper shearing of the material being punched. Based on the thickness and type of material being punched.

**Die Holder.** Holds the die into the lower turret.

**Die Land.** The usable cutting edge of the top surface of the die.

**Die Line.** The plane at which the top of all standard dies sit, when properly installed.

**Die Pin.** A pin in the die for locating in the die holder.

**Double D.** A special shape (see A2 in "Special Shapes" chapter).

**Double Keyhole.** A special shape (see F1 in "Special Shapes" chapter).

**Double Keyway.** A special shape (see D5 in "Special Shapes" chapter).

**Ellipse.** A special shape (see E10 in "Special Shapes" chapter).
**Emboss.** A special assembly that forms without cutting, producing raised or sunken designs in sheet metal.

**Engraved Punch.** A punch, used with a blank die, to stamp characters .005 - .008 (0.13-0.20) deep in sheet metal. Some examples are numbers, letters, and logos.

**Equilateral Triangle.** A special shape (see C1 in "Special Shapes" chapter).

**Etch.** The engraving of a number, letter, or combination thereof, on a tool used for identification purposes. Etch numbers are always assigned to special shapes and special assemblies.

**Extrusion.** The forming of material upward, usually in a round shape. It is normally prepierced, then formed. Usually designed to accept self tapping screws.

**Feed Gap (Turret Gap).** The distance between the upper turret and the top of the lower die.

**Forming.** An operation that shapes the material.

**Four-way Corner.** A special shape punch and die used for rounding corners of parts (see E1, E2, E3 in "Special Shapes" chapter).

**Four Way Shear.** A shear ground in four different quadrants that meet in the center.

**Fully Guided.** Guiding at punch point supports punch. Accurate and close tolerances between guide and stripper hold punch rigid. Increases hole accuracy, improves stripping, controls against hole distortion and saw toothing.

**Galling.** Metal depositing on the sides of the punch point.

**Gage.** A system of measurement for the thickness of sheet metal.

**Grind Life.** The maximum useable length that can be removed from a punch or die by sharpening.

**HSS.** High Speed Steel. A tool steel used for making punches and punch inserts. The hardness is 60-62 Rockwell C scale.

**Hardening.** Any process of increasing hardness of metal by suitable treatment, usually involving heating and cooling.

**Heavy Duty.** Style of tooling designed for thick material applications .157 (4.00) and over.

**Hinge Tools, 1 and 2.** A pair of special assemblies that form hinge knuckles directly on the edge of the part. Hinge tool 1 lifts the tab tips and orients the tab centers. Hinge tool 2 rolls the tabs all the way over. Inserting a hinge pin joins the hinged parts together.
Indexing. Any time you rotate a punch and die to an angle within a 360 degree range.

Inside/Outside Radius Tool. A tool designed for use in auto indexing stations that cuts both inside and outside radii without stopping the machine to remove the slug or blank.

Internal Key. A key attached to the inside of a guide that locates the punch in the guide.

Jumper. A tool ordered out of station range.

Key. A device used to locate or align something. One example is a key to position tooling in a holder, or the holder in a turret.

Keyhole. A special shape (see D1-D4 in "Special Shapes" chapter).

Keyway. A special shape (see C5, C6 in "Special Shapes" chapter).

Knockout. The process of cutting and forming material, except the slug is held into the sheet metal by a tab or tabs.

Lance and Form. A tool that slits and forms an opening in a part in just one hit.

Line-up Tools. Tools used to align the upper turret with the lower turret.

Louver. A special assembly tool that forms the material up for an air opening. It cuts and forms the material in one hit.

Lubricant. A substance capable of reducing friction, heat, and wear during punching and forming operations when introduced as a film between solid surfaces.

Maxima™ Coating. A premium tool steel coating. Maxima is a hard, wear resistant, multilayer Zirconium Titanium Nitride (ZrTiN) coating (see "Treatments and Coatings" chapter).

Maximum Tonnage. The rated force that a press is designed to exert at a predetermined distance above the bottom of the stroke of the slide.

Multi-Tool. An assembly that holds more than one punch. A "turret within a turret".

Nibbling. Nibbling is a process where the sheet advance is less than the size of the punch being used to make a hole. Doing this in a series causes an elongated hole to be created. Commonly used with round punches to create an oval opening or circular cut out.

Nine-Way Corner Rounding. A special shape tool that provides nine external radii.

Nitride Treatment. A gas heat-treating process used to produce a hard, wear-resistant case on steels. It can be used advantageously only on tool steels that do not temper back excessively at the nitriding temperature, 975° C (see "Treatments and Coatings" chapter).
Notching. To cut or make an indentation in something. This involves removing the material from the corner of the sheet, often at an angle, to allow bending.

Octagon. A special shape (see B5 in "Special Shapes" chapter).

Off-Center Punching. When the entire periphery of the punch is not engaged with the material being punched.

Oil Canning. Warpage or bending caused by punching or forming the sheet metal.

One way Shear. A one way sloped shear that angles to a longer point on one side of the punch.

Parting. An operation usually performed to produce two or more parts from one common stamping.

Perforating. The process of punching a number of uniformly spaced holes in a piece of metal. The holes may be any shape, and they usually cover a large portion of the entire sheet.

Pierce After Emboss. A punch and die used to pierce a hole into a piece of formed sheet metal.

Pierce and Emboss. A special assembly that pierces and forms sheet metal in one hit.

Pierce and Extrude. A special assembly that pierces and extrudes sheet metal in one hit.

Piercing. The general term for cutting, shearing or punching openings, such as holes and slots in sheet material, plate, or parts.

Planishing. A flat punch used with a blank die to push a knockout back into the sheet (75% maximum).

Punch. A tool used to pierce through sheet metal.

Punch Tip. The point of the punch that actually pierces through the sheet metal.

Punching. The process of using a punch and die to pierce a hole or opening, or to form a shape, or stamp a surface.

Quad Radius. A special shape with a different radius on each of the four sides designed to nibble large holes with smoother edges in fewer hits than a round nibbling punch.

Radius Corner. A corner on a punch and die that has been rounded.

Rect/Oval. A special shape with sharp 90° corners on one end and a full radius on the other end (see B3 in "Special Shapes" chapter).

Relief. Clearance obtained by removing metal, either behind or beyond the cutting edge of a punch or die.
Roller Ball Die. Die used in stations adjacent to forming stations. It is a solid die with a spring loaded ball bearing installed which supports the work piece and allows it to clear the feed gap for easy travel.

Rollerball®. Mate Rollerball assembly is a forming assembly used to make a continuous bead emboss on a piece of sheet metal. The press must be capable of holding the ram down while the sheet is moved on the x or y axis.

Rollover. The top part of the sheet that is drawn and formed into the hole being punched.

Rooftop Shear. See "convex" shear.

S7 Shock Steel. A more shock-resistant steel than the A2 steel, that dies are made from. This steel contains less carbon and has increased toughness. It is employed where heavy cutting or forming operations are required and where breakage is a problem.

ScissorTool™ Assembly. A shearing assembly used for parting, slitting and sheet squaring. The ScissorTool™ Assembly is designed for use in auto indexing stations which permit programmed cutting at any angle.

Set-Up Instructions. A set of instructions included with all special assemblies, used to assist in setting up tools.

Shake-and-Break. A special shape piercing tool that leaves retaining tabs in between parts for easy separation of multiple hit parts.

Shank. The main body of the tool.

Shape. The physical appearance; any shape other than round.

Shear. The geometry of the punch face, other than flat. It helps reduce tonnage because it is not hitting with the full face of the punch.

Sheetmarker™. Mate Sheetmarker assembly uses a diamond point insert to scribe or "mark" the top of the piece of sheet metal. The press must be capable of holding the ram down while the sheet is moved on the x or y axis.

Shim. A thin piece of metal used to fill in space between items.

Single D. A special shape (see A1 in "Special Shapes" chapter).

Slug. The pieces of material (usually scrap) which are produced when punching holes in sheet metal.

Slug Free®. Refers to dies, which have an hourglass taper to prevent slugs from pulling back up with the punch. Slug Free® is a registered trademark of Mate Precision Tooling.
**Slug Shedder.** Small urethane in the shape of a cylinder used to aid stripping of the slug away from the punch. The two sizes for thick turret tooling are .118 (3.00) and .236 (6.00) diameter.

**Slug Shedder Hole.** A hole in the face of the punch for urethane slug shedders to be inserted.

**Special Assembly.** A special punch and die tool assembly that will shape and/or form the material.

**Special Shape.** A shape other than a round, square, oval, rectangle, single D or double D.

**Station.** A position in the turret of variable sizes for various punch and die ranges.

**Stripper Plate.** A metal plate designed to surround the punch. Its purpose is to strip the sheet metal from the face of the punch.

**Stripping.** The process of removing the punch from the sheet metal.

**Thread Forming Assembly.** An assembly that pierces and forms an inverted thread configuration that will accept a wide variety of sheet metal screws with various thread sizes. The dome shape acts as a spring lock washer when the screw is tightened providing extra strength. The assembly will pierce a through-hole and form the dome in one hit.

**Three-way Notching Tool.** A triangle shaped punch and die for use in creating a variety of angled notches. Two popular configurations are 30°-60°-90° and 45°-60°-75°.

**Tonnage.** The measurable force needed for punching or forming sheet metal.

**Torque.** A measurement of a twisting force. For example, a measurement of how much to tighten a screw.

**Total Clearance (TC).** The size difference between the punch and the die that allows the punch to fit through the die and make a clean break in the sheet metal.

**Triangle.** A special shape (see C1-C4 in "Special Shapes" chapter).

**Turret.** A pivoted and revolvable holder in a machine. The name is derived from the manner in which tools are mounted in the press. An upper turret holds the punch holders (punches), and a lower turret holds the respective die holders (dies).

**Two-way Corner.** This special shape is a four-way corner cut in half.

**ULTRA TEC®.** ULTRA TEC® is a premium tooling system for thick turret style machines (see "ULTRA TEC® Tooling System" chapter).

**ULTRA ABS®.** ULTRA ABS is a premium tooling system for use only in Amada brand thick turret machines configured with ABS. Ultra ABS is licensed by Amada Inc.
**Without Shear.** When the punch face is completely flat. The entire face of the punch has contact with the material being cut. This is used for blanking, as it does not distort the slug (blank).

**Work Piece.** Any material part or piece that is being processed or handled to or from a processing operation.