



Specializing in High Performance Solid Carbide End Mills.



Made in the U.S.A. 

|                          |       |
|--------------------------|-------|
| Technical Information    | pg. 4 |
| Policies and Precautions | pg. 5 |

## PROMAX Premier

### Universal

|                        |       |
|------------------------|-------|
| US451 4 Flute Variable | pg. 6 |
|------------------------|-------|

### Hardened Steel

|                        |       |
|------------------------|-------|
| US453 4 Flute Variable | pg. 7 |
| US367 6 Flute Variable | pg. 8 |

### Stainless Steel

|                        |        |
|------------------------|--------|
| US340 3 Flute Variable | pg. 9  |
| US445 4 Flute Variable | pg. 10 |

### Titanium

|                                      |           |
|--------------------------------------|-----------|
| US456 4 Flute Variable               | pg. 11    |
| US457 4 Flute Variable Corner Radius | pg. 12-13 |
| US556 5 Flute Variable               | pg. 14    |

### Aluminum

|                        |        |
|------------------------|--------|
| US220 2 Flute          | pg. 15 |
| US360 3 Flute Variable | pg. 16 |
| US376 6 Flute Variable | pg. 17 |

### PREMIER Style Feeds & Speeds **pg. 18 - 23**

## PROMAX Premium

### Aluminum

|                              |        |
|------------------------------|--------|
| 109 3 Flute                  | pg. 24 |
| 119 3 Flute Rougher-Finisher | pg. 25 |
| 102 3 Flute Rougher          | pg. 26 |

### Universal

|                                      |             |
|--------------------------------------|-------------|
| 160 7 Flute                          | pg. 27      |
| 161 7 Flute Corner Radius            | pg. 28      |
| 112 5 Flute                          | pg. 29      |
| 158 5 Flute Var-A-Tech               | pg. 30      |
| 159 5 Flute Var-A-Tech Corner Radius | pg. 31 - 32 |
| 121 5 Flute Rougher-Finisher         | pg. 33      |
| 111 4 Flute                          | pg. 34      |
| 155 4 Flute Var-A-Tech               | pg. 35      |
| 156 4 Flute Var-A-Tech Corner Radius | pg. 36 - 37 |
| 157 4 Flute Ball                     | pg. 38      |
| 190 4 Flute PRO-4                    | pg. 39      |
| 191 4 Flute PRO-4 Corner Radius      | pg. 40      |
| 120 4 Flute Rougher-Finisher         | pg. 41      |
| 100 4 Flute Rougher                  | pg. 42      |
| 106 3 Flute                          | pg. 43      |
| 113 3 Flute Ball                     | pg. 44      |
| 117 3 Flute Rougher-Finisher         | pg. 45      |

### Titanium

|                     |        |
|---------------------|--------|
| 101 4 Flute Rougher | pg. 46 |
|---------------------|--------|

### Die & Mold Tools

|                     |        |
|---------------------|--------|
| 250 2 Flute 0° Ball | pg. 47 |
| 251 2 Flute 1° Ball | pg. 48 |
| 252 2 Flute 3° Ball | pg. 49 |
| 253 2 Flute 5° Ball | pg. 50 |
| 254 2 Flute 8° Ball | pg. 51 |

### Corner Rounders

|             |        |
|-------------|--------|
| 137 2 Flute | pg. 52 |
| 139 4 Flute | pg. 53 |

### Chamfer Spotting Tools

|                  |        |
|------------------|--------|
| 132 2 Flute 60°  | pg. 54 |
| 133 4 Flute 60°  | pg. 54 |
| 134 2 Flute 90°  | pg. 55 |
| 135 4 Flute 90°  | pg. 55 |
| 130 2 Flute 120° | pg. 56 |
| 131 4 Flute 120° | pg. 56 |

### PREMIUM Style Feeds & Speeds **pg. 57 - 69**

## Design-Rite XL

































### General Purpose Aluminum

|      |              |        |
|------|--------------|--------|
| D142 | 2 Flute      | pg. 70 |
| D162 | 2 Flute Ball | pg. 71 |

### General Purpose Universal

|        |                           |               |
|--------|---------------------------|---------------|
| D442   | 2 Flute                   | pg. 72        |
| D642   | 2 Flute                   | pg. 73 - 75   |
| D642M  | 2 Flute Metric            | pg. 76        |
| D842   | 2 Flute Double End        | pg. 77        |
| D642CR | 2 Flute Corner Radius     | pg. 78 - 79   |
| D662   | 2 Flute Ball              | pg. 80 - 82   |
| D662M  | 2 Flute Ball Metric       | pg. 83        |
| D862   | 2 Flute Ball Double End   | pg. 84        |
| D643   | 3 Flute                   | pg. 85 - 87   |
| D643CR | 3 Flute Corner Radius     | pg. 88 - 89   |
| D663   | 3 Flute Ball              | pg. 90 - 91   |
| D701   | 4 Flute Rougher-Finisher  | pg. 92        |
| D644   | 4 Flute                   | pg. 93 - 95   |
| D644M  | 4 Flute Metric            | pg. 96        |
| D844   | 4 Flute Double End        | pg. 97        |
| D844M  | 4 Flute Double End Metric | pg. 98        |
| D644CR | 4 Flute Corner Radius     | pg. 99 - 106  |
| D664   | 4 Flute Ball              | pg. 107 - 109 |
| D664M  | 4 Flute Ball Metric       | pg. 110       |
| D864   | 4 Flute Ball Double End   | pg. 111       |
| D645   | 5 Flute                   | pg. 112       |
| D845   | 5 Flute Double End        | pg. 113       |
| D646   | 6 Flute                   | pg. 114       |

### Design-Rite XL Feeds & Speeds **pg. 115**

|                                    |  |
|------------------------------------|--|
| <b>Best Used In Material</b>       |       |
| <b>Number Of Flutes</b>            |        |
| <b>End Mill Corner / End Style</b> |      |
| <b>Application Uses</b>            |     <br>    |
| <b>Geometry Information</b>        |      <br>    |

## PROMAX COATINGS

All materials are not alike, that's why PROMAX Tools developed 3 lines of carbide end mills. Using the latest in carbide tool technology and various grades of carbide, PROMAX engineered the right geometries to produce maximum metal removal for all of your applications.

**TiCN**  
(Titanium Carbonitride)



This multipurpose gradient coating is used for milling in general purpose applications in which interrupted cutting is encountered as it has a higher edge stability than TiCN-grey. It is also ideal where high feed and speed rates are desirable.

**AlTiN**  
(Aluminum Titanium Nitride)



Our AlTiN is a monoblock and gradient, multilayer coating designed specifically for use on carbide end mills. Use when machining Cast Iron and Steel work pieces as it has excellent oxidation resistance allowing for high speeds in semi-dry or dry machining operations where increased heat is generated.

**ZrN**  
(Zirconium Nitride)



This monolayer coating effectively reduces built-up edges when machining aluminum and titanium alloys. Recommended when machining medical grade materials and in other high heat resistant applications. Also for use in machining Steels, Alloyed Steels, Superalloys, Aluminium > 12% Si, Aluminium < 12% Si, Copper, Bronze and Brass Plastics.

**nACRo®**  
(Aluminum-Chromium-Silicon)



The latest generation in tool coatings, nACRo®, has a nanocomposite structure that has increased hardness for scratch and higher heat resistance. Add to these qualities increased tool life and decreased tool changes, this coating will maximize machine time in "tough" difficult to cut materials including Steels, Hardened Steels, Alloyed Steels, and Superalloys. nACRo® coated tools have been proven to reduce production time by up to 30%.

## "FEEL THE EDGE"

PROMAX's EDGE PREP is standard on many of our End Mills. This process allows you to forgo the tedious and long break-in periods needed on most tools in order to receive the most production out of your tool. Combining our edge prep with our superior coatings and the results are clear – longer running tools with fewer tool changes per run equaling significant cost effectiveness.

## PROMAX CUSTOMER SERVICE

At PROMAX, we will provide the highest quality cutting tools to best suit your application. In addition, our customers receive both an excellent tool and the knowledge and assistance of our Technical Support and other departments. PROMAX Tools is built on the foundation that customer service is just as important as the product being sold. Our customers receive the answers they seek and the information they need in a more timely manner. You can feel comfortable knowing that quality products and customer satisfaction are at the center of every decision PROMAX Tools makes.

**Call the knowledgeable PROMAX Tech Line at 800-878-0502 for all of your cutting tool needs and questions.**

## LIMITED WARRANTY

PROMAX Tools warrants each new product manufactured and sold by PROMAX or one of our authorized dealers against defects in workmanship and/or materials. Our obligation is limited to the repair or replacement of defective products. At our discretion, we may refund the purchase price of a defective product. This warranty does not cover products that are damaged as a result of negligence or misuse including improper operating conditions and machine set up or any items that have been repaired or altered. This warranty excludes all other warranties, expressed or implied, including any implied warranties of merchant ability or fitness for a particular purpose. In no event will PROMAX be liable for any incidental, special or consequential damages of any nature.

## RETURN POLICY

Returned products must be accompanied by a PROMAX Tools authorized Returned Goods Authorization number (RGA). Warranty claims should be made through the distributor from whom the product was purchased. Distributors may call PROMAX at 1-800-878-0502 to receive an RGA number. Returned goods may be subject to a restocking fee. Special, modified, non-catalog or altered tools are not acceptable for return.

## TEST TOOL POLICY

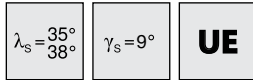
Take the PROMAX Challenge: Throw it on the spindle and prove it to yourself. Higher production rates and longer tool life are your goals and ours. PROMAX Tools will authorize a test tool credit only when the proper procedures of the existing GUARANTEED TEST TOOL ORDER (GTO) are followed. For details on this program, please call our TECH LINE at 1-800-878-0502.

## SAFETY PRECAUTIONS

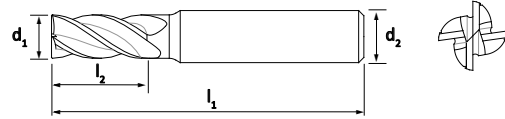
Carbide cutting tools can break or shatter under improper or severe use. Always wear the proper personal protective equipment when performing metal cutting operations. Carbide cutting tools have sharp edges. Use caution while handling cutting tools to avoid injury.



\*For more information on our Policies and Precautions, please visit our website at [www.promaxtools.com](http://www.promaxtools.com)

**Tolerances**

Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Chamfer: 1/8" - 1" = +/- .002

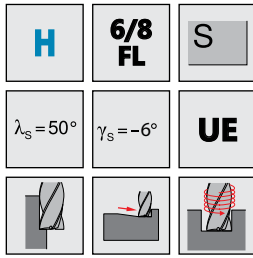


| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | C<br>Chamfer | Flute | AlTiN    | nACRo®   |
|-----------------------|-------------------------|-----------------------|-----------------------|--------------|-------|----------|----------|
| 1/8                   | 1/8                     | 3/8                   | 1 - 1/2               | 0.006        | 4     | US451002 | US451003 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 0.006        | 4     | US451005 | US451006 |
| 5/32                  | 3/16                    | 3/8                   | 2                     | 0.006        | 4     | US451008 | US451009 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.006        | 4     | US451011 | US451012 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.006        | 4     | US451014 | US451015 |
| 7/32                  | 1/4                     | 3/4                   | 2 - 1/2               | 0.006        | 4     | US451017 | US451018 |
| 7/32                  | 1/4                     | 3/8                   | 2                     | 0.006        | 4     | US451020 | US451021 |
| 1/4                   | 1/4                     | 3/4                   | 2 - 1/2               | 0.010        | 4     | US451023 | US451024 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.010        | 4     | US451026 | US451027 |
| 1/4                   | 1/4                     | 1 - 1/4               | 3                     | 0.010        | 4     | US451029 | US451030 |
| 5/16                  | 5/16                    | 3/4                   | 2 - 1/2               | 0.010        | 4     | US451032 | US451033 |
| 5/16                  | 5/16                    | 1/2                   | 2 - 1/2               | 0.010        | 4     | US451035 | US451036 |
| 3/8                   | 3/8                     | 7/8                   | 3                     | 0.010        | 4     | US451038 | US451039 |
| 3/8                   | 3/8                     | 5/8                   | 2 - 1/2               | 0.010        | 4     | US451041 | US451042 |
| 3/8                   | 3/8                     | 1 - 1/2               | 4                     | 0.010        | 4     | US451044 | US451045 |
| 7/16                  | 7/16                    | 1                     | 2 - 3/4               | 0.014        | 4     | US451047 | US451048 |
| 1/2                   | 1/2                     | 1 - 1/4               | 3 - 1/2               | 0.014        | 4     | US451050 | US451051 |
| 1/2                   | 1/2                     | 5/8                   | 2 - 1/2               | 0.014        | 4     | US451053 | US451054 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.014        | 4     | US451056 | US451057 |
| 5/8                   | 5/8                     | 1 - 1/4               | 3 - 1/2               | 0.014        | 4     | US451059 | US451060 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 0.014        | 4     | US451062 | US451063 |
| 5/8                   | 5/8                     | 2 - 1/2               | 5                     | 0.014        | 4     | US451065 | US451066 |
| 3/4                   | 3/4                     | 1 - 5/8               | 4                     | 0.014        | 4     | US451068 | US451069 |
| 3/4                   | 3/4                     | 2 - 1/2               | 5                     | 0.014        | 4     | US451071 | US451072 |
| 1                     | 1                       | 1 - 1/2               | 4                     | 0.014        | 4     | US451074 | US451075 |
| 1                     | 1                       | 2 - 3/4               | 6                     | 0.014        | 4     | US451077 | US451078 |

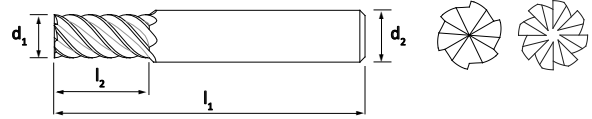
**Feeds & Speeds Available on Page 18**
**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        | •             |                     |



**Tolerances**

Shank:  $1/8'' - 3/4'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 3/4'' = +.000/-0.002$



| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flute | nACRo®   |
|--------------|----------------|--------------|--------------|-------|----------|
| 1/8          | 1/8            | 3/8          | 2            | 6     | US367002 |
| 3/16         | 3/16           | 7/16         | 2            | 6     | US367004 |
| 3/16         | 3/16           | 5/8          | 2 - 1/2      | 6     | US367006 |
| 1/4          | 1/4            | 1/2          | 2            | 6     | US367008 |
| 1/4          | 1/4            | 11/16        | 2 - 1/2      | 6     | US367010 |
| 5/16         | 5/16           | 3/4          | 2 - 1/2      | 6     | US367012 |
| 5/16         | 5/16           | 1            | 3            | 6     | US367014 |
| 3/8          | 3/8            | 7/8          | 3            | 6     | US367016 |
| 3/8          | 3/8            | 1 - 1/8      | 3 - 1/2      | 6     | US367018 |
| 1/2          | 1/2            | 1 - 1/4      | 3 - 1/2      | 6     | US367020 |
| 1/2          | 1/2            | 4            | 1 - 1/2      | 6     | US367022 |
| 5/8          | 5/8            | 1 - 1/4      | 3 - 1/2      | 8     | US367024 |
| 5/8          | 5/8            | 1 - 7/8      | 5            | 8     | US367026 |
| 3/4          | 3/4            | 1 - 1/2      | 4            | 8     | US367028 |
| 3/4          | 3/4            | 2 - 1/4      | 5            | 8     | US367030 |

Feeds & Speeds Available on Page 19

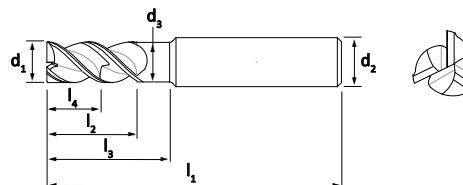
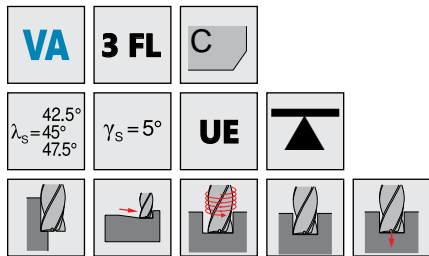
**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              |                 |          |                  |           |          |                        |               |                     |



# Series US340

## 3 Flute Stainless Steel



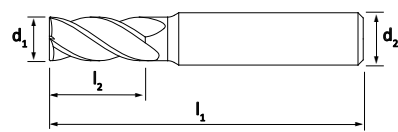
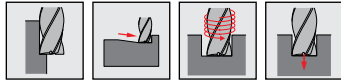
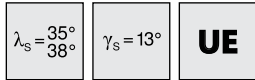
**Tolerances**  
 Shank: 1/8" - 3/4" = -.0001/- .0004  
 Cutting Dia: 1/8" - 3/4" = +.000/- .002  
 Chamfer: 1/8" - 3/4" = +/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>4</sub><br>TCL | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | C<br>Chamfer | Flute | AlTiN    | nACRo®   |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------------|--------------|-------|----------|----------|
| 1/8                   | 1/8                     | 3/8                   | 0.163                 | 2 - 1/4               | 1/2                   | 0.120                      | 0.006        | 3     | US340002 | US340003 |
| 3/16                  | 3/16                    | 7/16                  | 0.243                 | 2 - 1/2               | 11/16                 | 0.180                      | 0.006        | 3     | US340012 | US340014 |
| 3/16                  | 3/16                    | 5/8                   | 0.243                 | 2 - 1/2               | 1                     | 0.180                      | 0.006        | 3     | US340007 | US340009 |
| 3/16                  | 3/16                    | 3/8                   | 0.206                 | 2 - 1/2               | 5/8                   | 0.180                      | 0.006        | 3     | US340013 | US340015 |
| 3/16                  | 3/16                    | 5/8                   | 0.243                 | 2 - 1/2               |                       |                            | 0.006        | 3     | US340006 | US340008 |
| 1/4                   | 1/4                     | 1/2                   | 0.325                 | 2 - 1/2               | 3/4                   | 0.240                      | 0.010        | 3     | US340024 | US340026 |
| 1/4                   | 1/4                     | 3/4                   | 0.325                 | 2 - 1/2               | 1                     | 0.240                      | 0.010        | 3     | US340019 | US340021 |
| 1/4                   | 1/4                     | 3/8                   | 0.275                 | 2 - 1/2               | 5/8                   | 0.240                      | 0.010        | 3     | US340025 | US340027 |
| 1/4                   | 1/4                     | 3/4                   | 0.325                 | 2 - 1/2               |                       |                            | 0.010        | 3     | US340018 | US340020 |
| 5/16                  | 5/16                    | 3/4                   | 0.406                 | 2 - 1/2               | 1                     | 0.300                      | 0.010        | 3     | US340030 | US340032 |
| 5/16                  | 5/16                    | 1/2                   | 0.343                 | 2 - 1/2               | 3/4                   | 0.300                      | 0.010        | 3     | US340035 | US340036 |
| 5/16                  | 5/16                    | 15/16                 | 0.406                 | 2 - 1/2               |                       |                            | 0.010        | 3     | US340031 | US340033 |
| 3/8                   | 3/8                     | 7/8                   | 0.487                 | 2 - 1/2               | 1 - 1/8               | 0.360                      | 0.010        | 3     | US340045 | US340047 |
| 3/8                   | 3/8                     | 1 - 3/16              | 0.487                 | 3                     | 1 - 1/2               | 0.360                      | 0.010        | 3     | US340040 | US340042 |
| 3/8                   | 3/8                     | 1/2                   | 0.412                 | 2 - 1/2               | 7/8                   | 0.360                      | 0.010        | 3     | US340046 | US340048 |
| 3/8                   | 3/8                     | 1 - 3/16              | 0.487                 | 3                     |                       |                            | 0.010        | 3     | US340039 | US340041 |
| 1/2                   | 1/2                     | 1                     | 0.650                 | 3                     | 1 - 3/8               | 0.480                      | 0.010        | 3     | US340057 | US340059 |
| 1/2                   | 1/2                     | 1 - 1/2               | 0.650                 | 4                     | 1 - 7/8               | 0.480                      | 0.010        | 3     | US340052 | US340054 |
| 1/2                   | 1/2                     | 5/8                   | 0.550                 | 3                     | 1                     | 0.480                      | 0.010        | 3     | US340058 | US340060 |
| 1/2                   | 1/2                     | 1 - 1/2               | 0.650                 | 4                     |                       |                            | 0.010        | 3     | US340051 | US340053 |
| 5/8                   | 5/8                     | 1 - 1/4               | 0.812                 | 3 - 1/2               | 1 - 5/8               | 0.600                      | 0.010        | 3     | US340069 | US340071 |
| 5/8                   | 5/8                     | 1 - 5/8               | 0.812                 | 4                     | 2 - 1/4               | 0.600                      | 0.010        | 3     | US340064 | US340066 |
| 5/8                   | 5/8                     | 7/8                   | 0.687                 | 3 - 1/2               | 1 - 1/4               | 0.600                      | 0.010        | 3     | US340070 | US340072 |
| 5/8                   | 5/8                     | 1 - 5/8               | 0.812                 | 4                     |                       |                            | 0.010        | 3     | US340063 | US340065 |
| 3/4                   | 3/4                     | 1 - 1/2               | 0.975                 | 4                     | 1                     | 0.720                      | 0.010        | 3     | US340081 | US340083 |
| 3/4                   | 3/4                     | 2 - 3/8               | 0.975                 | 6                     | 2 - 7/8               | 0.720                      | 0.010        | 3     | US340076 | US340078 |
| 3/4                   | 3/4                     | 1                     | 0.825                 | 4                     | 1 - 1/2               | 0.720                      | 0.010        | 3     | US340082 | US340084 |
| 3/4                   | 3/4                     | 2 - 3/8               | 0.975                 | 6                     |                       |                            | 0.010        | 3     | US340075 | US340077 |

Feeds & Speeds Available on Page 21

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                | •               | •        | •                | •         |          |                        | •             |                     |

**Tolerances**

Shank: 3/16" - 3/4" = -.0001/- .0004  
 Cutting Dia: 3/16" - 3/4" = +.000/- .002  
 Chamfer: 3/16" - 3/4" = +/- .002

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | C<br>Chamfer | Flute | AlTiN    | nACRo®   |
|--------------|----------------|--------------|--------------|--------------|-------|----------|----------|
| 3/16         | 3/16           | 7/16         | 2            | 0.006        | 4     | US445002 | US445003 |
| 1/4          | 1/4            | 1/2          | 2 - 1/2      | 0.010        | 4     | US445005 | US445006 |
| 5/16         | 5/16           | 3/4          | 2 - 1/2      | 0.010        | 4     | US445008 | US445009 |
| 3/8          | 3/8            | 7/8          | 3            | 0.010        | 4     | US445011 | US445012 |
| 7/16         | 7/16           | 1            | 2 - 3/4      | 0.014        | 4     | US445014 | US445015 |
| 1/2          | 1/2            | 1 - 1/4      | 3 - 1/2      | 0.014        | 4     | US445017 | US445018 |
| 5/8          | 5/8            | 1 - 1/2      | 4            | 0.014        | 4     | US445020 | US445021 |
| 3/4          | 3/4            | 1 - 5/8      | 4            | 0.014        | 4     | US445023 | US445024 |

**Feeds & Speeds Available on Page 20**
**Application Range:**

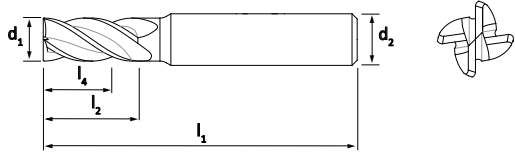
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  | •         |          |                        |               |                     |

# Series US456

## 4 Flute Titanium



|                                      |                       |           |
|--------------------------------------|-----------------------|-----------|
| <b>TI</b>                            | <b>4 FL</b>           | <b>R</b>  |
| $\lambda_s = 35^\circ$<br>$38^\circ$ | $\gamma_s = 13^\circ$ | <b>UE</b> |
|                                      |                       |           |
|                                      |                       |           |



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Radius: 1/8" - 1" = +/- .001

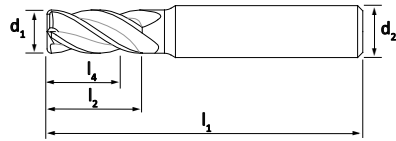
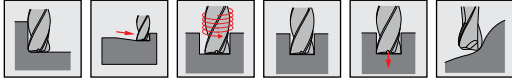
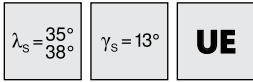
| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>4</sub><br>TCL | l <sub>1</sub><br>OAL | R<br>Radius | Flute | nACRo®   | ZrN      |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|-------------|-------|----------|----------|
| 1/8                   | 1/8                     | 3/8                   | 0.300                 | 1 - 1/2               | 0.004       | 4     | US456002 | US456003 |
| 3/16                  | 3/16                    | 5/8                   | 0.512                 | 2                     | 0.004       | 4     | US456005 | US456006 |
| 1/4                   | 1/4                     | 3/4                   | 0.600                 | 2 - 1/2               | 0.008       | 4     | US456008 | US456009 |
| 1/4                   | 1/4                     | 3/8                   | 0.275                 | 2                     | 0.008       | 4     | US456011 | US456012 |
| 1/4                   | 1/4                     | 1 - 1/4               | 1.100                 | 3                     | 0.008       | 4     | US456014 | US456015 |
| 5/16                  | 5/16                    | 3/4                   | 0.562                 | 2 - 1/2               | 0.008       | 4     | US456017 | US456018 |
| 3/8                   | 3/8                     | 7/8                   | 0.650                 | 3                     | 0.008       | 4     | US456020 | US456021 |
| 3/8                   | 3/8                     | 5/8                   | 0.412                 | 2 - 1/2               | 0.008       | 4     | US456023 | US456024 |
| 3/8                   | 3/8                     | 1 - 1/2               | 1.275                 | 4                     | 0.008       | 4     | US456026 | US456027 |
| 7/16                  | 7/16                    | 1                     | 0.737                 | 2 - 3/4               | 0.008       | 4     | US456029 | US456030 |
| 1/2                   | 1/2                     | 1 - 1/4               | 0.950                 | 3 - 1/2               | 0.012       | 4     | US456032 | US456033 |
| 1/2                   | 1/2                     | 5/8                   | 0.550                 | 2 - 1/2               | 0.012       | 4     | US456035 | US456036 |
| 1/2                   | 1/2                     | 2                     | 1.700                 | 4                     | 0.012       | 4     | US456038 | US456039 |
| 5/8                   | 5/8                     | 1 - 1/4               | 0.687                 | 3 - 1/2               | 0.012       | 4     | US456041 | US456042 |
| 5/8                   | 5/8                     | 2 - 1/2               | 2.125                 | 5                     | 0.012       | 4     | US456044 | US456045 |
| 3/4                   | 3/4                     | 1 - 5/8               | 0.825                 | 4                     | 0.012       | 4     | US456047 | US456048 |
| 3/4                   | 3/4                     | 2 - 1/2               | 2.050                 | 5                     | 0.012       | 4     | US456050 | US456051 |
| 1                     | 1                       | 1 - 1/2               | 1.100                 | 4                     | 0.012       | 4     | US456053 | US456054 |

Feeds & Speeds Available on Page 22

PROMAX PREMIER

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 | •        | •                |           |          |                        |               |                     |



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Radius: Radius < 0.060 = +/- .001  
 Radius ≥ 0.060 = +/- .0015

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>4</sub><br>TCL | l <sub>1</sub><br>OAL | R<br>Radius | Flute | nACRo®   | ZrN      |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|-------------|-------|----------|----------|
| 1/8                   | 1/8                     | 3/8                   | 0.300                 | 1 - 1/2               | 0.010       | 4     | US457002 | US457003 |
| 1/8                   | 1/8                     | 3/8                   | 0.300                 | 1 - 1/2               | 0.015       | 4     | US457035 | US457036 |
| 1/8                   | 1/8                     | 3/8                   | 0.300                 | 1 - 1/2               | 0.020       | 4     | US457071 | US457072 |
| 3/16                  | 3/16                    | 3/8                   | 0.206                 | 2                     | 0.010       | 4     | US457008 | US457009 |
| 3/16                  | 3/16                    | 3/8                   | 0.206                 | 2                     | 0.015       | 4     | US457041 | US457042 |
| 3/16                  | 3/16                    | 3/8                   | 0.206                 | 2                     | 0.020       | 4     | US457077 | US457078 |
| 3/16                  | 3/16                    | 5/8                   | 0.512                 | 2                     | 0.010       | 4     | US457005 | US457006 |
| 3/16                  | 3/16                    | 5/8                   | 0.512                 | 2                     | 0.015       | 4     | US457038 | US457039 |
| 3/16                  | 3/16                    | 5/8                   | 0.512                 | 2                     | 0.020       | 4     | US457074 | US457075 |
| 1/4                   | 1/4                     | 3/8                   | 0.275                 | 2                     | 0.010       | 4     | US457014 | US457015 |
| 1/4                   | 1/4                     | 3/8                   | 0.275                 | 2                     | 0.015       | 4     | US457047 | US457048 |
| 1/4                   | 1/4                     | 3/8                   | 0.275                 | 2                     | 0.020       | 4     | US457083 | US457084 |
| 1/4                   | 1/4                     | 3/8                   | 0.275                 | 2                     | 0.030       | 4     | US457113 | US457114 |
| 1/4                   | 1/4                     | 3/4                   | 0.600                 | 2 - 1/2               | 0.010       | 4     | US457011 | US457012 |
| 1/4                   | 1/4                     | 3/4                   | 0.600                 | 2 - 1/2               | 0.015       | 4     | US457044 | US457045 |
| 1/4                   | 1/4                     | 3/4                   | 0.600                 | 2 - 1/2               | 0.020       | 4     | US457080 | US457081 |
| 1/4                   | 1/4                     | 3/4                   | 0.600                 | 2 - 1/2               | 0.030       | 4     | US457110 | US457111 |
| 1/4                   | 1/4                     | 1 - 1/4               | 1.100                 | 3                     | 0.010       | 4     | US457017 | US457018 |
| 1/4                   | 1/4                     | 1 - 1/4               | 1.100                 | 3                     | 0.015       | 4     | US457050 | US457051 |
| 1/4                   | 1/4                     | 1 - 1/4               | 1.100                 | 3                     | 0.020       | 4     | US457086 | US457087 |
| 1/4                   | 1/4                     | 1 - 1/4               | 1.100                 | 3                     | 0.030       | 4     | US457116 | US457117 |
| 5/16                  | 5/16                    | 3/4                   | 0.562                 | 2 - 1/2               | 0.015       | 4     | US457053 | US457054 |
| 5/16                  | 5/16                    | 3/4                   | 0.562                 | 2 - 1/2               | 0.020       | 4     | US457089 | US457090 |
| 5/16                  | 5/16                    | 3/4                   | 0.562                 | 2 - 1/2               | 0.030       | 4     | US457119 | US457120 |
| 3/8                   | 3/8                     | 5/8                   | 0.412                 | 2 - 1/2               | 0.010       | 4     | US457023 | US457024 |
| 3/8                   | 3/8                     | 5/8                   | 0.412                 | 2 - 1/2               | 0.015       | 4     | US457059 | US457060 |
| 3/8                   | 3/8                     | 5/8                   | 0.412                 | 2 - 1/2               | 0.020       | 4     | US457095 | US457096 |
| 3/8                   | 3/8                     | 5/8                   | 0.412                 | 2 - 1/2               | 0.030       | 4     | US457125 | US457126 |
| 3/8                   | 3/8                     | 7/8                   | 0.650                 | 3                     | 0.010       | 4     | US457020 | US457021 |
| 3/8                   | 3/8                     | 7/8                   | 0.650                 | 3                     | 0.015       | 4     | US457056 | US457057 |
| 3/8                   | 3/8                     | 7/8                   | 0.650                 | 3                     | 0.020       | 4     | US457092 | US457093 |
| 3/8                   | 3/8                     | 7/8                   | 0.650                 | 3                     | 0.030       | 4     | US457122 | US457123 |

Additional Sizes On Page 13

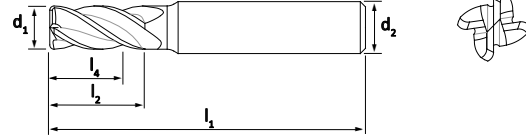
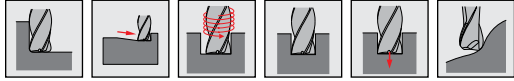
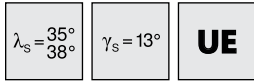
Feeds & Speeds Available on Page 22

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 | •        | •                |           |          |                        |               |                     |

# Series US457

## 4 Flute Titanium Corner Radius



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: Radius < 0.060 = +/-0.001  
 Radius ≥ 0.060 = +/-0.0015

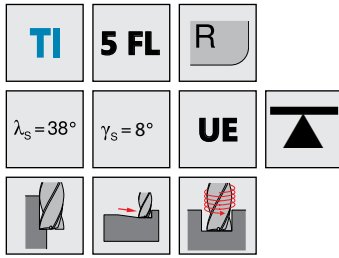
| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>4</sub><br>TCL | l <sub>1</sub><br>OAL | R<br>Radius | Flute | nACRo®   | ZrN      |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|-------------|-------|----------|----------|
| 3/8                   | 3/8                     | 1 - 1/2               | 1.275                 | 4                     | 0.010       | 4     | US457026 | US457027 |
| 3/8                   | 3/8                     | 1 - 1/2               | 1.275                 | 4                     | 0.015       | 4     | US457062 | US457063 |
| 3/8                   | 3/8                     | 1 - 1/2               | 1.275                 | 4                     | 0.020       | 4     | US457098 | US457099 |
| 3/8                   | 3/8                     | 1 - 1/2               | 1.275                 | 4                     | 0.030       | 4     | US457128 | US457129 |
| 7/16                  | 7/16                    | 1                     | 0.737                 | 2 - 3/4               | 0.020       | 4     | US457101 | US457102 |
| 1/2                   | 1/2                     | 5/8                   | 0.550                 | 2 - 1/2               | 0.010       | 4     | US457032 | US457033 |
| 1/2                   | 1/2                     | 5/8                   | 0.550                 | 2 - 1/2               | 0.015       | 4     | US457068 | US457069 |
| 1/2                   | 1/2                     | 5/8                   | 0.550                 | 2 - 1/2               | 0.020       | 4     | US457107 | US457108 |
| 1/2                   | 1/2                     | 5/8                   | 0.550                 | 2 - 1/2               | 0.030       | 4     | US457134 | US457135 |
| 1/2                   | 1/2                     | 5/8                   | 0.550                 | 2 - 1/2               | 0.060       | 4     | US457161 | US457162 |
| 1/2                   | 1/2                     | 1 - 1/4               | 0.950                 | 3 - 1/2               | 0.010       | 4     | US457029 | US457030 |
| 1/2                   | 1/2                     | 1 - 1/4               | 0.950                 | 3 - 1/2               | 0.015       | 4     | US457065 | US457066 |
| 1/2                   | 1/2                     | 1 - 1/4               | 0.950                 | 3 - 1/2               | 0.020       | 4     | US457104 | US457105 |
| 1/2                   | 1/2                     | 1 - 1/4               | 0.950                 | 3 - 1/2               | 0.030       | 4     | US457131 | US457132 |
| 1/2                   | 1/2                     | 1 - 1/4               | 0.950                 | 3 - 1/2               | 0.060       | 4     | US457158 | US457159 |
| 5/8                   | 5/8                     | 7/8                   | 0.687                 | 3                     | 0.030       | 4     | US457140 | US457141 |
| 5/8                   | 5/8                     | 7/8                   | 0.687                 | 3                     | 0.060       | 4     | US457167 | US457168 |
| 5/8                   | 5/8                     | 1 - 1/4               | 0.687                 | 3 - 1/2               | 0.030       | 4     | US457137 | US457138 |
| 5/8                   | 5/8                     | 1 - 1/4               | 0.687                 | 3 - 1/2               | 0.060       | 4     | US457164 | US457165 |
| 5/8                   | 5/8                     | 2 - 1/2               | 2.125                 | 5                     | 0.030       | 4     | US457143 | US457144 |
| 5/8                   | 5/8                     | 2 - 1/2               | 2.125                 | 5                     | 0.060       | 4     | US457170 | US457171 |
| 3/4                   | 3/4                     | 1 - 5/8               | 0.825                 | 4                     | 0.030       | 4     | US457146 | US457147 |
| 3/4                   | 3/4                     | 1 - 5/8               | 0.825                 | 4                     | 0.060       | 4     | US457173 | US457174 |
| 3/4                   | 3/4                     | 1 - 5/8               | 0.825                 | 4                     | 0.125       | 4     | US457185 | US457186 |
| 3/4                   | 3/4                     | 2 - 1/2               | 2.050                 | 5                     | 0.030       | 4     | US457149 | US457150 |
| 3/4                   | 3/4                     | 2 - 1/2               | 2.050                 | 5                     | 0.060       | 4     | US457176 | US457177 |
| 1                     | 1                       | 1 - 1/2               | 1.100                 | 4                     | 0.030       | 4     | US457152 | US457153 |
| 1                     | 1                       | 1 - 1/2               | 1.100                 | 4                     | 0.060       | 4     | US457179 | US457180 |
| 1                     | 1                       | 1 - 1/2               | 1.100                 | 4                     | 0.125       | 4     | US457188 | US457189 |
| 1                     | 1                       | 2 - 3/4               | 2.150                 | 6                     | 0.030       | 4     | US457155 | US457156 |
| 1                     | 1                       | 2 - 3/4               | 2.150                 | 6                     | 0.060       | 4     | US457182 | US457183 |
| 1                     | 1                       | 2 - 3/4               | 2.150                 | 6                     | 0.125       | 4     | US457191 | US457192 |

Additional Sizes On Page 12

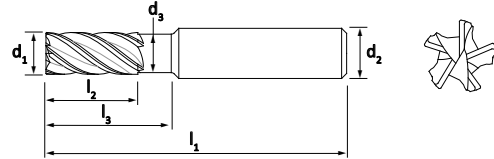
Feeds & Speeds Available on Page 22

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 | •        | •                |           |          |                        |               |                     |

**Tolerances**

Shank: 1/8" - 3/4" = -.0001/- .0004  
 Cutting Dia: 1/8" - 3/4" = +.000/- .002  
 Radius: 1/8" - 3/4" = +/- .002



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flute | nACRo®   |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|-------|----------|
| 1/8                   | 1/8                     | 3/8                   | 2                     | 1/2                   | 0.120                      | 0.004       | 5     | US556002 |
| 3/16                  | 3/16                    | 7/16                  | 2                     | 5/8                   | 0.180                      | 0.004       | 5     | US556004 |
| 1/4                   | 1/4                     | 1/2                   | 2 - 1/2               | 3/4                   | 0.240                      | 0.008       | 5     | US556006 |
| 5/16                  | 5/16                    | 3/4                   | 2 - 1/2               | 1                     | 0.300                      | 0.008       | 5     | US556008 |
| 3/8                   | 3/8                     | 7/8                   | 3                     | 1 - 1/8               | 0.360                      | 0.008       | 5     | US556010 |
| 7/16                  | 7/16                    | 1                     | 2 - 3/4               | 1 - 3/8               | 0.420                      | 0.008       | 5     | US556012 |
| 1/2                   | 1/2                     | 1 - 1/4               | 3 - 1/2               | 1 - 1/2               | 0.480                      | 0.012       | 5     | US556014 |
| 5/8                   | 5/8                     | 1 - 1/4               | 3 - 1/2               | 1 - 5/8               | 0.600                      | 0.012       | 5     | US556016 |
| 3/4                   | 3/4                     | 1 - 5/8               | 4                     | 2                     | 0.720                      | 0.012       | 5     | US556018 |

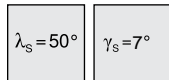
Feeds & Speeds Available on Page 22

**Application Range:**

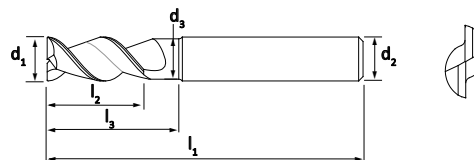
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                | •               | •        | •                |           |          |                        |               |                     |

# Series US220

## 2 Flute Aluminum



**Tolerances**  
 Shank: 1/8" - 3/4" = -.0001/- .0004  
 Cutting Dia: 1/8" - 3/4" = +.000/- .002  
 Chamfer: 1/8" - 3/4" = +/- .002

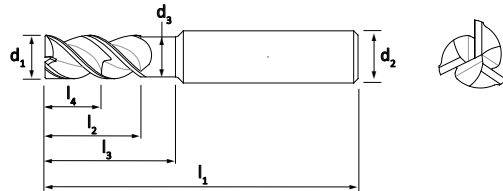
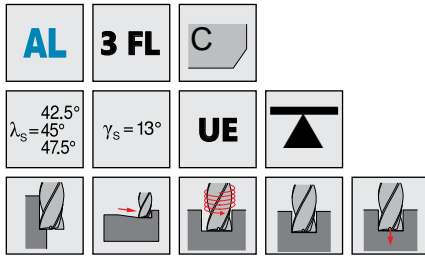


| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | C<br>Chamfer | Flute | Uncoated |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|--------------|-------|----------|
| 1/8                   | 1/8                     | 3/8                   | 2                     | 3/4                   | 0.120                      | 0.006        | 2     | US220001 |
| 3/16                  | 3/16                    | 7/16                  | 2                     | 3/4                   | 0.180                      | 0.006        | 2     | US220002 |
| 1/4                   | 1/4                     | 1/2                   | 2 - 1/2               | 13/16                 | 0.240                      | 0.006        | 2     | US220003 |
| 5/16                  | 5/16                    | 3/4                   | 3                     | 1                     | 0.300                      | 0.006        | 2     | US220004 |
| 3/8                   | 3/8                     | 7/8                   | 3                     | 1 - 1/8               | 0.360                      | 0.006        | 2     | US220005 |
| 1/2                   | 1/2                     | 1 - 1/4               | 3 - 1/2               | 1 - 5/8               | 0.480                      | 0.006        | 2     | US220006 |
| 5/8                   | 5/8                     | 1 - 1/4               | 4                     | 1 - 7/8               | 0.600                      | 0.006        | 2     | US220007 |
| 3/4                   | 3/4                     | 1 - 1/2               | 5                     | 2 - 1/4               | 0.720                      | 0.006        | 2     | US220008 |

Feeds & Speeds Available on Page 23

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | •        | •                      | •             |                     |



**Tolerances**  
 Shank: 1/8" - 3/4" = -.0001/- .0004  
 Cutting Dia: 1/8" - 3/4" = +.000/- .002  
 Chamfer: 1/8" - 3/4" = +/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>4</sub><br>TCL | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | C<br>Chamfer | Flute | Uncoated | ZrN      |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------------|--------------|-------|----------|----------|
| 1/8                   | 1/8                     | 5/16                  | 0.406                 | 2 - 1/4               | 1/2                   | 0.120                      | 0.006        | 3     | US360001 | US360002 |
| 1/8                   | 1/8                     | 1/4                   |                       | 3                     | 3/4                   | 0.120                      | 0.006        | 3     | US360003 | US360004 |
| 5/32                  | 3/16                    | 7/16                  | 0.568                 | 2 - 1/2               | 3/4                   | 0.150                      | 0.006        | 3     | US360005 | US360006 |
| 5/32                  | 3/16                    | 1/4                   |                       | 3                     | 1                     | 0.150                      | 0.006        | 3     | US360007 | US360008 |
| 3/16                  | 3/16                    | 1/2                   | 0.650                 | 2 - 1/2               | 3/4                   | 0.180                      | 0.006        | 3     | US360009 | US360010 |
| 3/16                  | 3/16                    | 5/16                  |                       | 3                     | 1 - 1/4               | 0.180                      | 0.006        | 3     | US360011 | US360012 |
| 1/4                   | 1/4                     | 1/2                   | 0.650                 | 2 - 1/2               | 3/4                   | 0.240                      | 0.010        | 3     | US360013 | US360014 |
| 1/4                   | 1/4                     | 1/2                   | 0.650                 | 3                     | 1 - 5/8               | 0.240                      | 0.010        | 3     | US360017 | US360018 |
| 1/4                   | 1/4                     | 3/8                   |                       | 3                     | 1 - 5/8               | 0.240                      | 0.010        | 3     | US360015 | US360016 |
| 5/16                  | 5/16                    | 3/4                   | 0.975                 | 2 - 1/2               | 1                     | 0.300                      | 0.010        | 3     | US360019 | US360020 |
| 5/16                  | 5/16                    | 3/4                   | 0.975                 | 4                     | 2 - 1/2               | 0.300                      | 0.010        | 3     | US360023 | US360024 |
| 5/16                  | 5/16                    | 1/2                   |                       | 4                     | 2 - 1/2               | 0.300                      | 0.010        | 3     | US360021 | US360022 |
| 3/8                   | 3/8                     | 7/8                   | 1.137                 | 3                     | 1 - 1/8               | 0.360                      | 0.010        | 3     | US360025 | US360026 |
| 3/8                   | 3/8                     | 7/8                   | 1.137                 | 4                     | 2 - 1/4               | 0.360                      | 0.010        | 3     | US360029 | US360030 |
| 3/8                   | 3/8                     | 5/8                   |                       | 4                     | 2 - 1/4               | 0.360                      | 0.010        | 3     | US360027 | US360028 |
| 7/16                  | 7/16                    | 1                     | 1.300                 | 2 - 3/4               | 1 - 1/4               | 0.420                      | 0.010        | 3     | US360031 | US360032 |
| 1/2                   | 1/2                     | 1                     | 1.300                 | 3 - 1/2               | 1 - 3/8               | 0.480                      | 0.010        | 3     | US360033 | US360034 |
| 1/2                   | 1/2                     | 1                     | 1.300                 | 5                     | 2 - 7/8               | 0.480                      | 0.010        | 3     | US360037 | US360038 |
| 1/2                   | 1/2                     | 3/4                   |                       | 5                     | 2 - 7/8               | 0.480                      | 0.010        | 3     | US360035 | US360036 |
| 5/8                   | 5/8                     | 1 - 1/4               | 1.625                 | 3 - 1/2               | 1 - 5/8               | 0.600                      | 0.010        | 3     | US360039 | US360040 |
| 5/8                   | 5/8                     | 1 - 1/4               | 1.625                 | 6                     | 4                     | 0.600                      | 0.010        | 3     | US360043 | US360044 |
| 5/8                   | 5/8                     | 1                     |                       | 6                     | 4                     | 0.600                      | 0.010        | 3     | US360041 | US360042 |
| 3/4                   | 3/4                     | 1 - 5/8               | 2.112                 | 4                     | 2 - 1/8               | 0.720                      | 0.010        | 3     | US360045 | US360046 |
| 3/4                   | 3/4                     | 1 - 1/4               |                       | 6                     | 4                     | 0.720                      | 0.010        | 3     | US360047 | US360048 |

Feeds & Speeds Available on Page 22

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | •        | •                      | •             |                     |

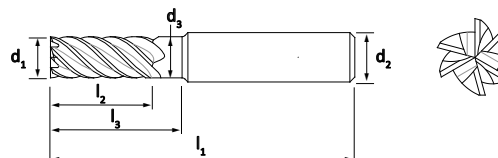


# Series US376

## 6 Flute Aluminum



|  |                       |           |
|--|-----------------------|-----------|
| <b>AL</b>                                | <b>6 FL</b>           | <b>S</b>  |
| $\lambda_s = 43.5^\circ$<br>$46.5^\circ$ | $\gamma_s = 21^\circ$ | <b>UE</b> |
|  |                       |           |



**Tolerances**  
 Shank:  $1/4'' - 1'' = -.0001/- .0004$   
 Cutting Dia:  $1/4'' - 1'' = +.000/- .002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | $l_3$<br>LOR | $d_3$<br>Neck Dia | Flute | Uncoated | ZrN      |
|--------------|----------------|--------------|--------------|--------------|-------------------|-------|----------|----------|
| 1/4          | 1/4            | 5/8          | 2 - 1/2      | 7/8          | 0.240             | 6     | US376001 | US376002 |
| 1/4          | 1/4            | 5/8          | 3            | 1 - 5/8      | 0.240             | 6     | US376003 | US376004 |
| 5/16         | 4/93           | 3/4          | 2 - 1/2      | 1            | 0.300             | 6     | US376005 | US376006 |
| 5/16         | 5/16           | 3/4          | 4            | 2 - 3/8      | 0.300             | 6     | US376007 | US376008 |
| 3/8          | 3/8            | 1            | 3            | 1 - 1/4      | 0.360             | 6     | US376009 | US376010 |
| 3/8          | 3/8            | 1            | 4            | 2 - 1/4      | 0.360             | 6     | US376011 | US376012 |
| 1/2          | 1/2            | 1 - 1/4      | 3 - 1/2      | 1 - 1/2      | 0.480             | 6     | US376013 | US376014 |
| 1/2          | 1/2            | 1 - 1/4      | 5            | 3            | 0.480             | 6     | US376015 | US376016 |
| 1/2          | 1/2            | 1 - 7/8      | 5            |              |                   | 6     | US376017 | US376018 |
| 5/8          | 5/8            | 1 - 1/4      | 3 - 1/2      | 1 - 1/2      | 0.600             | 6     | US376019 | US376020 |
| 5/8          | 5/8            | 1 - 1/4      | 6            | 3 - 5/8      | 0.600             | 6     | US376021 | US376022 |
| 5/8          | 5/8            | 2 - 1/2      | 6            |              |                   | 6     | US376023 | US376024 |
| 3/4          | 3/4            | 1 - 5/8      | 4            | 2            | 0.720             | 6     | US376025 | US376026 |
| 3/4          | 3/4            | 1 - 5/8      | 6            | 3 - 5/8      | 0.720             | 6     | US376027 | US376028 |
| 1            | 1              | 2            | 6            | 3 - 7/8      | 0.960             | 6     | US376029 | US376030 |

Feeds & Speeds Available on Page 23

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | •        | •                      | •             |                     |

| Universal - US451                |  |                 |                  |                  |                            |                        |               |              |        |        |
|----------------------------------|--|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |  | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                                  |  |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>                      | 853             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | > 500 N/mm <sup>2</sup>                      | 787             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>            | 820             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>            | 755             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy  | 722             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Cementation Steel                | < 150 HB                                     | 689             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | 150-200 HB                                   | 656             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 200 HB                                     | 623             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>                     | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 1000 N/mm <sup>2</sup>                     | 558             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>            | 656             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy < 800 N/mm <sup>2</sup>                | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>             | 591             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>            | 558             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
|                                  | Alloy 1300-1600 N/mm <sup>2</sup>            | 492             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
| Non-Alloy Tool Steel             | General                                      | 607             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Tool Steel for Cold Processing   | Low Alloy < 1000 N/mm <sup>2</sup>           | 591             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Low Alloy < 1200 N/mm <sup>2</sup>           | 558             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 492             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 459             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Tool Steel for Warm Processing   | Low Alloy < 1200 N/mm <sup>2</sup>           | 656             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 591             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 492             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 459             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 427             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
| Stainless Steel                  | Ferric                                       | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Martensitic                                  | 262             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Austenitic A5 < 40%                          | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Austenitic A5 > 40%                          | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Sulphured                                    | 361             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
| High Temperature Alloy           | Fe-Alloy                                     | 98              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                  | Ni-Alloy not hardened                        | 98              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                  | Ni-Alloy hardened                            | 98              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                  | Co-Alloy                                     | 98              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
| Cast Iron                        | Non-Alloy                                    | 656             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Low-Alloy                                    | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | High-Alloy                                   | 394             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Stainless Cast Steel             | Ferric/Martensitic                           | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Austentic                                    | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                           | 656             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Non-Alloy > 180 HB                           | 591             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Alloy  | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Spheroidal Cast Iron             | High Alloy                                   | 394             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Non-Alloy < 180 HB                           | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Non-Alloy > 180 HB                           | 558             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| White Malleable Cast Iron        | < 180 HB                                     | 492             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 180 HB                                     | 591             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Black Malleable Cast Iron        | < 180 HB                                     | 591             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 180 HB                                     | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Copper                           | Non-Alloy                                    | 919             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Wrought Alloy Non-Hardened                   | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Wrought Alloy Hardened                       | 656             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | CuNi-Alloy                                   | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | CuNiZn-Alloy Long-Chipping                   | 656             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | CuNiZn-Alloy Short-Chipping                  | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| CuZn (Brass)                     | Long-Chipping                                | 984             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Short-Chipping                               | 1148            | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| CuSn (Bronze)                    | Long-Chipping                                | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Short-Chipping                               | 919             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| CuAlFe (Ampco)                   | Long-Chipping                                | 459             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Short-Chipping                               | 525             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| Titanium                         | Non-Alloy                                    | 295             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloyed-Annealed                             | 262             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
|                                  | Alloyed-Hardened                             | 164             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |

| Hardened Steel - US367         |  |                 |                  |                  |                            |                        |               |              |        |        |
|--------------------------------|--|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation           |  | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                                |  |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Spring Steel                   | Annealed < 250 HB                            | 427             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | Natural Hard 250-350 HB                      | 394             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | Feader Hard 1200-1600 N/mm <sup>2</sup>      | 377             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
| Nitriding Steel                | > 1000 N/mm <sup>2</sup>                     | 394             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
| Quenched & Tempered Steel      | Alloy 1000-1300 N/mm <sup>2</sup>            | 394             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | Alloy 1300-1600 N/mm <sup>2</sup>            | 361             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
| Non-Alloy Tool Steel           | General                                      | 443             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
| Tool Steel for Cold Processing | Low Alloy < 1000 N/mm <sup>2</sup>           | 427             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | Low Alloy < 1200 N/mm <sup>2</sup>           | 394             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 361             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 328             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 295             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
| Tool Steel for Warm Processing | Low Alloy < 1200 N/mm <sup>2</sup>           | 394             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 361             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 328             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 295             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 279             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
| Hardened Tool Steel            | < 55 HRC                                     | 262             | 0.05x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | 55-58 HRC                                    | 230             | 0.03x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | 58-60 HRC                                    | 197             | 0.03x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | 60-62 HRC                                    | 148             | 0.03x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |
|                                | 62-64 HRC                                    | 115             | 0.03x $\phi$     | 1.5x $\phi$      | 0.0016                     | 0.0018                 | 0.0024        | 0.0028       | 0.0039 | 0.0049 |

| Hardened Steel - US453         |  |                 |                  |                  |                            |                        |               |              |        |        |
|--------------------------------|--|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation           |  | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                                |  |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Spring Steel                   | Annealed < 250 HB                            | 525             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | Natural Hard 250-350 HB                      | 443             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | Feader Hard 1200-1600 N/mm <sup>2</sup>      | 328             | 1x $\phi$        | 1x $\phi$        | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
| Nitriding Steel                | > 1000 N/mm <sup>2</sup>                     | 525             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
| Quenched & Tempered Steel      | Alloy 800-1000 N/mm <sup>2</sup>             | 525             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | Alloy 1000-1300 N/mm <sup>2</sup>            | 443             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | Alloy 1300-1600 N/mm <sup>2</sup>            | 377             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
| Tool Steel for Cold Processing | Low Alloy < 1000 N/mm <sup>2</sup>           | 525             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | Low Alloy < 1200 N/mm <sup>2</sup>           | 377             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 295             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 443             | 1x $\phi$        | 1x $\phi$        | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 427             | 1x $\phi$        | 1x $\phi$        | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
| Tool Steel for Warm Processing | Low Alloy < 1200 N/mm <sup>2</sup>           | 410             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 377             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 443             | 1x $\phi$        | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0016        | 0.0020       | 0.0024 | 0.0030 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 410             | 1x $\phi$        | 1x $\phi$        | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 377             | 1x $\phi$        | 1x $\phi$        | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
| Hardened Tool Steel            | < 55 HRC                                     | 164             | 1x $\phi$        | 1x $\phi$        | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                | 55-58 HRC                                    | 115             | 1x $\phi$        | 0.5x $\phi$      | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                | 58-60 HRC                                    | 82              | 1x $\phi$        | 0.5x $\phi$      | 0.0003                     | 0.0004                 | 0.0008        | 0.0012       | 0.0016 | 0.0020 |
|                                | 60-62 HRC                                    | 66              | 1x $\phi$        | 0.5x $\phi$      | 0.0003                     | 0.0004                 | 0.0008        | 0.0012       | 0.0016 | 0.0020 |
|                                | 62-64 HRC                                    | 49              | 1x $\phi$        | 0.5x $\phi$      | 0.0003                     | 0.0004                 | 0.0008        | 0.0012       | 0.0016 | 0.0020 |

\* Feeds and Speeds are starting points for Overall Lengths of 3" and shorter.  
For End Mills with Overall Lengths over 3" decrease the Feeds and Speeds.

| Stainless Steel - US445          |  |                  |                  |                            |                        |               |              |        |        |        |
|----------------------------------|--|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|--------|
| Material Designation             | SFM<br>[ft/min]                              | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |        |
|                                  |  |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |        |
| Machining Steel                  | > 500 N/mm <sup>2</sup>                      | 787              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>            | 820              | 0.8x $\phi$      | 1x $\phi$                  | 0.0008                 | 0.0016        | 0.0024       | 0.0031 | 0.0039 | 0.0047 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>            | 755              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Cementation Steel                | Alloy  | 722              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | < 150 HB                                     | 689              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | 150-200 HB                                   | 656              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Nitriding Steel                  | > 200 HB                                     | 623              | 0.8x $\phi$      | 1x $\phi$                  | 0.0005                 | 0.0010        | 0.0016       | 0.0020 | 0.0028 | 0.0035 |
|                                  | < 1000 N/mm <sup>2</sup>                     | 623              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| > 1000 N/mm <sup>2</sup>         |  | 558              | 0.8x $\phi$      | 1x $\phi$                  | 0.0005                 | 0.0010        | 0.0016       | 0.0020 | 0.0028 | 0.0035 |
|                                  |  | 656              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>            | 656              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 623              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Alloy < 800 N/mm <sup>2</sup>                | 623              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>             | 591              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>            | 558              | 0.8x $\phi$      | 1x $\phi$                  | 0.0005                 | 0.0010        | 0.0016       | 0.0020 | 0.0028 | 0.0035 |
|                                  | Alloy 1300-1600 N/mm <sup>2</sup>            | 492              | 0.8x $\phi$      | 1x $\phi$                  | 0.0005                 | 0.0010        | 0.0016       | 0.0020 | 0.0028 | 0.0035 |
| Non-Alloy Tool Steel             | General                                      | 607              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Tool Steel for Cold Processing   | Low Alloy < 1000 N/mm <sup>2</sup>           | 591              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Low Alloy < 1200 N/mm <sup>2</sup>           | 558              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 492              | 0.8x $\phi$      | 1x $\phi$                  | 0.0005                 | 0.0010        | 0.0016       | 0.0020 | 0.0028 | 0.0035 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 525              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 459              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Tool Steel for Warm Processing   | Low Alloy < 1200 N/mm <sup>2</sup>           | 656              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 591              | 0.8x $\phi$      | 1x $\phi$                  | 0.0005                 | 0.0010        | 0.0016       | 0.0020 | 0.0028 | 0.0035 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 492              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 459              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 427              | 0.8x $\phi$      | 1x $\phi$                  | 0.0005                 | 0.0010        | 0.0016       | 0.0020 | 0.0028 | 0.0035 |
| Stainless Steel                  | Ferric                                       | 328              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0008        | 0.0012       | 0.0020 | 0.0024 | 0.0028 |
|                                  | Martensitic                                  | 262              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0008        | 0.0012       | 0.0020 | 0.0024 | 0.0028 |
|                                  | Austenitic A5 < 40%                          | 328              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0008        | 0.0012       | 0.0020 | 0.0024 | 0.0028 |
|                                  | Austenitic A5 > 40%                          | 328              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0008        | 0.0012       | 0.0020 | 0.0024 | 0.0028 |
|                                  | Sulphured                                    | 361              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0008        | 0.0012       | 0.0020 | 0.0024 | 0.0028 |
| Cast Iron                        | Non-Alloy                                    | 656              | 0.8x $\phi$      | 1x $\phi$                  | 0.0008                 | 0.0016        | 0.0024       | 0.0031 | 0.0039 | 0.0047 |
|                                  | Low-Alloy                                    | 525              | 0.8x $\phi$      | 1x $\phi$                  | 0.0008                 | 0.0016        | 0.0024       | 0.0031 | 0.0039 | 0.0047 |
|                                  | High-Alloy                                   | 394              | 0.8x $\phi$      | 1x $\phi$                  | 0.0008                 | 0.0016        | 0.0024       | 0.0031 | 0.0039 | 0.0047 |
| Stainless Cast Steel             | Ferric/Martensitic                           | 328              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0008        | 0.0012       | 0.0020 | 0.0024 | 0.0028 |
|                                  | Austenitic                                   | 328              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0008        | 0.0012       | 0.0020 | 0.0024 | 0.0028 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                           | 656              | 0.8x $\phi$      | 1x $\phi$                  | 0.0008                 | 0.0016        | 0.0024       | 0.0031 | 0.0039 | 0.0047 |
|                                  | Non-Alloy > 180 HB                           | 591              | 0.8x $\phi$      | 1x $\phi$                  | 0.0008                 | 0.0016        | 0.0024       | 0.0031 | 0.0039 | 0.0047 |
|                                  | Alloy  | 525              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | High Alloy                                   | 394              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                           | 623              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Non-Alloy > 180 HB                           | 558              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | Alloy  | 492              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| White Malleable Cast Iron        | < 180 HB                                     | 591              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | > 180 HB                                     | 525              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
| Black Malleable Cast Iron        | < 180 HB                                     | 591              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |
|                                  | > 180 HB                                     | 525              | 0.8x $\phi$      | 1x $\phi$                  | 0.0006                 | 0.0012        | 0.0020       | 0.0024 | 0.0031 | 0.0039 |

\* Feeds and Speeds are starting points for Overall Lengths of 3" and shorter.  
For End Mills with Overall Lengths over 3" decrease the Feeds and Speeds.

| Stainless Steel - US340          |                                      |                 |                  |                  |                            |                        |               |              |        |        |
|----------------------------------|--------------------------------------|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |                                      | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                                  |                                      |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>              | 853             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | > 500 N/mm <sup>2</sup>              | 787             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>    | 820             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>    | 755             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy                                | 722             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Cementation Steel                | < 150 HB                             | 689             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | 150-200 HB                           | 656             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 200 HB                             | 623             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>             | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 1000 N/mm <sup>2</sup>             | 558             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>    | 656             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup> | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy < 800 N/mm <sup>2</sup>        | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>     | 591             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>    | 558             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
| Stainless Steel                  | Ferric                               | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Martensitic                          | 262             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Austenitic A5 < 40%                  | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Austenitic A5 > 40%                  | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Sulphured                            | 361             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
| High Temperature Alloy           | Fe-Alloy                             | 82              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                  | Ni-Alloy not hardened                | 82              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                  | Ni-Alloy hardened                    | 82              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
|                                  | Co-Alloy                             | 82              | 1xØ              | 0.5xØ            | 0.0004                     | 0.0008                 | 0.0012        | 0.0016       | 0.0020 | 0.0024 |
| Cast Iron                        | Non-Alloy                            | 656             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Low-Alloy                            | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | High-Alloy                           | 394             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Stainless Cast Steel             | Ferric/Martensitic                   | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
|                                  | Austentic                            | 328             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |
| Cast iron with Lamellar Graphite | Non-Alloy < 180 HB                   | 656             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Non-Alloy > 180 HB                   | 591             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Alloy                                | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | High Alloy                           | 394             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                   | 623             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Non-Alloy > 180 HB                   | 558             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloy                                | 492             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| White Malleable Cast Iron        | < 180 HB                             | 591             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 180 HB                             | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Black Malleable Cast Iron        | < 180 HB                             | 591             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | > 180 HB                             | 525             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
| Copper                           | Non-Alloy                            | 919             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Wrought Alloy Non-Hardened           | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Wrought Alloy Hardened               | 656             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | CuNi-Alloy                           | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | CuNiZn-Alloy Long-Chipping           | 656             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | CuNiZn-Alloy Short-Chipping          | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| CuZn (Brass)                     | Long-Chipping                        | 984             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Short-Chipping                       | 1148            | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| CuSn (Bronze)                    | Long-Chipping                        | 787             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Short-Chipping                       | 919             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| CuAlFe (Ampco)                   | Long-Chipping                        | 459             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                                  | Short-Chipping                       | 525             | 1xØ              | 1xØ              | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
| Titanium                         | Non-Alloy                            | 295             | 1xØ              | 1xØ              | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                                  | Alloyed-Annealed                     | 262             | 1xØ              | 1xØ              | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |
|                                  | Alloyed-Hardened                     | 164             | 1xØ              | 1xØ              | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 | 0.0035 |

\* Feeds and Speeds are starting points for Overall Lengths of 3" and shorter.  
For End Mills with Overall Lengths over 3" decrease the Feeds and Speeds.

| Titanium - US456 / US457 |                       |                 |                  |                  |                            |                        |               |              |        |        |
|--------------------------|-----------------------|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation     |                       | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                          |                       |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| High Temperature Alloy   | Fe-Alloy              | 180             | 1x $\phi$        | 0.5x $\phi$      | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
|                          | Ni-Alloy not hardened | 180             | 1x $\phi$        | 0.5x $\phi$      | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
|                          | Ni-Alloy hardened     | 180             | 1x $\phi$        | 0.5x $\phi$      | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
|                          | Co-Alloy              | 180             | 1x $\phi$        | 0.5x $\phi$      | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
| Titanium                 | Non-Alloy             | 394             | 1x $\phi$        | 0.5x $\phi$      | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 | 0.0055 |
|                          | Alloyed-Annealed      | 328             | 1x $\phi$        | 0.5x $\phi$      | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 | 0.0047 |
|                          | Alloyed-Hardened      | 262             | 1x $\phi$        | 0.5x $\phi$      | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 | 0.0039 |

| Titanium - US556       |                       |                 |                  |                  |                            |                        |               |              |        |
|------------------------|-----------------------|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|
| Material Designation   |                       | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |
|                        |                       |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   |
| Stainless Steel        | Ferric                | 328             | 0.5x $\phi$      | 1x $\phi$        | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 |
|                        | Martensitic           | 262             | 0.5x $\phi$      | 1x $\phi$        | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 |
|                        | Austenitic A5 < 40%   | 328             | 0.5x $\phi$      | 1x $\phi$        | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 |
|                        | Austenitic A5 > 40%   | 328             | 0.5x $\phi$      | 1x $\phi$        | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 |
|                        | Sulphured             | 361             | 0.5x $\phi$      | 1x $\phi$        | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 |
| High Temperature Alloy | Fe-Alloy              | 180             | 0.5x $\phi$      | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 |
|                        | Ni-Alloy not hardened | 180             | 0.5x $\phi$      | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 |
|                        | Ni-Alloy hardened     | 180             | 0.5x $\phi$      | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 |
|                        | Co-Alloy              | 180             | 0.5x $\phi$      | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 |
| Stainless Cast Steel   | Ferric/Martensitic    | 328             | 0.5x $\phi$      | 1x $\phi$        | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 |
|                        | Austentic             | 328             | 0.5x $\phi$      | 1x $\phi$        | 0.0005                     | 0.0010                 | 0.0016        | 0.0020       | 0.0028 |
| Titanium               | Non-Alloy             | 394             | 0.5x $\phi$      | 1x $\phi$        | 0.0010                     | 0.0018                 | 0.0028        | 0.0039       | 0.0047 |
|                        | Alloyed-Annealed      | 328             | 0.5x $\phi$      | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0039 |
|                        | Alloyed-Hardened      | 262             | 0.5x $\phi$      | 1x $\phi$        | 0.0006                     | 0.0012                 | 0.0020        | 0.0024       | 0.0031 |

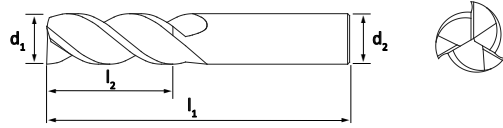
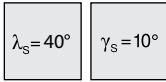
| Aluminum - US360     |                             |                 |                  |                  |                            |                        |               |              |        |        |
|----------------------|-----------------------------|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation |                             | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                      |                             |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Aluminium            | Non-Alloy                   | 1968            | 1x $\phi$        | 1x $\phi$        | 0.0014                     | 0.0024                 | 0.0028        | 0.0035       | 0.0047 | 0.0055 |
|                      | Wrought Alloy Non-Hardened  | 1968            | 1x $\phi$        | 1x $\phi$        | 0.0014                     | 0.0024                 | 0.0028        | 0.0035       | 0.0047 | 0.0055 |
|                      | Wrought Alloy Hardened      | 1968            | 1x $\phi$        | 1x $\phi$        | 0.0014                     | 0.0024                 | 0.0028        | 0.0035       | 0.0047 | 0.0055 |
|                      | Casting Alloy < 6% Si       | 1575            | 1x $\phi$        | 1x $\phi$        | 0.0014                     | 0.0024                 | 0.0028        | 0.0035       | 0.0047 | 0.0055 |
|                      | Casting Alloy 6-12% Si      | 1181            | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
|                      | Casting Alloy > 6% Si       | 787             | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
| Magnesium            | Wrought Alloy               | 722             | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
|                      | Casting Alloy               | 656             | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
| Copper               | Non-Alloy                   | 558             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Wrought Alloy Non-Hardened  | 509             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Wrought Alloy Hardened      | 394             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | CuNi-Alloy                  | 492             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | CuNiZn-Alloy Long-Chipping  | 394             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | CuNiZn-Alloy Short-Chipping | 492             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
| CuZn (Brass)         | Long-Chipping               | 591             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Short-Chipping              | 787             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
| CuSn (Bronze)        | Long-Chipping               | 492             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Short-Chipping              | 558             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
| CuAlFe (Ampco)       | Long-Chipping               | 180             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Short-Chipping              | 230             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |

\* Feeds and Speeds are starting points for Overall Lengths of 3" and shorter.  
For End Mills with Overall Lengths over 3" decrease the Feeds and Speeds.

| Aluminum - US376     |                             |                 |                  |                  |                            |                        |               |              |        |        |
|----------------------|-----------------------------|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation |                             | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                      |                             |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Aluminium            | Non-Alloy                   | 1640            | 0.05x $\phi$     | 2x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
|                      | Wrought Alloy Non-Hardened  | 1640            | 0.05x $\phi$     | 2x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
|                      | Wrought Alloy Hardened      | 1640            | 0.05x $\phi$     | 2x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
|                      | Casting Alloy < 6% Si       | 1312            | 0.05x $\phi$     | 2x $\phi$        | 0.0008                     | 0.0016                 | 0.0020        | 0.0024       | 0.0028 | 0.0031 |
|                      | Casting Alloy 6-12% Si      | 984             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | Casting Alloy > 6% Si       | 689             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
| Magnesium            | Wrought Alloy               | 656             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | Casting Alloy               | 558             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
| Copper               | Non-Alloy                   | 492             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | Wrought Alloy Non-Hardened  | 459             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | Wrought Alloy Hardened      | 361             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | CuNi-Alloy                  | 427             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | CuNiZn-Alloy Long-Chipping  | 361             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | CuNiZn-Alloy Short-Chipping | 427             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
| CuZn (Brass)         | Long-Chipping               | 492             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | Short-Chipping              | 689             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
| CuSn (Bronze)        | Long-Chipping               | 427             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | Short-Chipping              | 459             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
| CuAlFe (Ampco)       | Long-Chipping               | 197             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |
|                      | Short-Chipping              | 230             | 0.05x $\phi$     | 2x $\phi$        | 0.0006                     | 0.0008                 | 0.0012        | 0.0020       | 0.0024 | 0.0028 |

| Aluminum - US220     |                             |                 |                  |                  |                            |                        |               |              |        |        |
|----------------------|-----------------------------|-----------------|------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation |                             | SFM<br>[ft/min] | ae max<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [Inch] |                        |               |              |        |        |
|                      |                             |                 |                  |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Aluminium            | Non-Alloy                   | 1968            | 1x $\phi$        | 1x $\phi$        | 0.0016                     | 0.0024                 | 0.0031        | 0.0059       | 0.0079 | 0.0089 |
|                      | Wrought Alloy Non-Hardened  | 1968            | 1x $\phi$        | 1x $\phi$        | 0.0016                     | 0.0024                 | 0.0031        | 0.0059       | 0.0079 | 0.0089 |
|                      | Wrought Alloy Hardened      | 1968            | 1x $\phi$        | 1x $\phi$        | 0.0016                     | 0.0024                 | 0.0031        | 0.0059       | 0.0079 | 0.0089 |
|                      | Casting Alloy < 6% Si       | 1575            | 1x $\phi$        | 1x $\phi$        | 0.0016                     | 0.0024                 | 0.0031        | 0.0059       | 0.0079 | 0.0089 |
|                      | Casting Alloy 6-12% Si      | 1181            | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
|                      | Casting Alloy > 6% Si       | 787             | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
| Magnesium            | Wrought Alloy               | 722             | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
|                      | Casting Alloy               | 656             | 1x $\phi$        | 1x $\phi$        | 0.0012                     | 0.0020                 | 0.0028        | 0.0047       | 0.0067 | 0.0083 |
| Copper               | Non-Alloy                   | 558             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Wrought Alloy Non-Hardened  | 509             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Wrought Alloy Hardened      | 394             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | CuNi-Alloy                  | 492             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | CuNiZn-Alloy Long-Chipping  | 394             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | CuNiZn-Alloy Short-Chipping | 492             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
| CuZn (Brass)         | Long-Chipping               | 591             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Short-Chipping              | 787             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
| CuSn (Bronze)        | Long-Chipping               | 492             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Short-Chipping              | 558             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
| CuAlFe (Ampco)       | Long-Chipping               | 180             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |
|                      | Short-Chipping              | 230             | 1x $\phi$        | 1x $\phi$        | 0.0008                     | 0.0016                 | 0.0024        | 0.0031       | 0.0047 | 0.0055 |

\* Feeds and Speeds are starting points for Overall Lengths of 3" and shorter.  
For End Mills with Overall Lengths over 3" decrease the Feeds and Speeds.



**Tolerances**

Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | Flutes | AlTiN     | ZrN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 |                       |                            | 3      | 109-00824 | 109-00826 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 3      | 109-00814 | 109-00816 |
| 5/32                  | 3/16                    | 1/2                   | 2                     |                       |                            | 3      | 109-01014 | 109-01016 |
| 5/32                  | 3/16                    | 3/8                   | 2                     |                       |                            | 3      | 109-01024 | 109-01026 |
| 3/16                  | 3/16                    | 3/8                   | 2                     |                       |                            | 3      | 109-01224 | 109-01226 |
| 3/16                  | 3/16                    | 5/8                   | 2                     |                       |                            | 3      | 109-01214 | 109-01216 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 3      | 109-01414 | 109-01416 |
| 7/32                  | 1/4                     | 3/8                   | 2                     |                       |                            | 3      | 109-01424 | 109-01426 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 3      | 109-01624 | 109-01626 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 3      | 109-01614 | 109-01616 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     |                       |                            | 3      | 109-01634 | 109-01636 |
| 1/4                   | 1/4                     | 1-1/2                 | 3-1/2                 |                       |                            | 3      | 109-01644 | 109-01646 |
| 1/4                   | 1/4                     | 3/4                   | 4                     | 2-1/8                 | 0.240                      | 3      | 109-01664 | 109-01666 |
| 9/32                  | 5/16                    | 1/2                   | 2-1/2                 |                       |                            | 3      | 109-01824 | 109-01826 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 |                       |                            | 3      | 109-01814 | 109-01816 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 |                       |                            | 3      | 109-02024 | 109-02026 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 |                       |                            | 3      | 109-02014 | 109-02016 |
| 3/8                   | 3/8                     | 5/8                   | 2                     |                       |                            | 3      | 109-02424 | 109-02426 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 3      | 109-02414 | 109-02416 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 |                       |                            | 3      | 109-02434 | 109-02436 |
| 3/8                   | 3/8                     | 2                     | 4                     |                       |                            | 3      | 109-02444 | 109-02446 |
| 3/8                   | 3/8                     | 1                     | 6                     | 2-3/8                 | 0.360                      | 3      | 109-02464 | 109-02466 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 |                       |                            | 3      | 109-02814 | 109-02816 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 3      | 109-03224 | 109-03226 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 3      | 109-03214 | 109-03216 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 |                       |                            | 3      | 109-03234 | 109-03236 |
| 1/2                   | 1/2                     | 2                     | 4                     |                       |                            | 3      | 109-03244 | 109-03246 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 |                       |                            | 3      | 109-03614 | 109-03616 |
| 5/8                   | 5/8                     | 7/8                   | 3                     |                       |                            | 3      | 109-04024 | 109-04026 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 |                       |                            | 3      | 109-04014 | 109-04016 |
| 5/8                   | 5/8                     | 1-3/4                 | 4                     |                       |                            | 3      | 109-04034 | 109-04036 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     |                       |                            | 3      | 109-04044 | 109-04046 |
| 3/4                   | 3/4                     | 1                     | 3                     |                       |                            | 3      | 109-04824 | 109-04826 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 3      | 109-04814 | 109-04816 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     |                       |                            | 3      | 109-04834 | 109-04836 |
| 3/4                   | 3/4                     | 3-1/4                 | 6                     |                       |                            | 3      | 109-04844 | 109-04846 |
| 1                     | 1                       | 1-3/4                 | 4                     |                       |                            | 3      | 109-06414 | 109-06416 |
| 1                     | 1                       | 2-3/4                 | 5                     |                       |                            | 3      | 109-06434 | 109-06436 |
| 1                     | 1                       | 3-3/8                 | 6                     |                       |                            | 3      | 109-06444 | 109-06446 |

Feeds & Speeds Available on Page 57

**Application Range:**

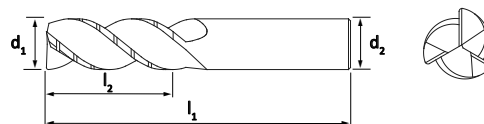
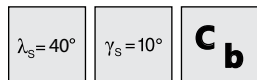
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | ●        | ●                      | ●             |                     |



# Series 119

## 3 Flute Aluminum Rougher Finisher

**PROMAX**  
TOOLS



**Tolerances**

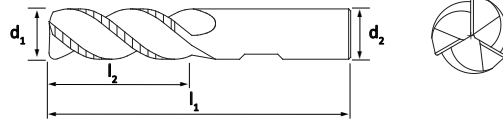
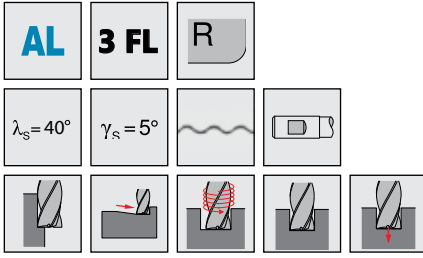
Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +.002/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | AlTiN     | ZrN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 0.010       | 3      | 119-00824 | 119-00826 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.010       | 3      | 119-00814 | 119-00816 |
| 5/32                  | 3/16                    | 3/8                   | 2                     | 0.010       | 3      | 119-01024 | 119-01026 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 0.010       | 3      | 119-01014 | 119-01016 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.010       | 3      | 119-01224 | 119-01226 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.010       | 3      | 119-01214 | 119-01216 |
| 7/32                  | 1/4                     | 3/8                   | 2                     | 0.020       | 3      | 119-01424 | 119-01426 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 | 0.020       | 3      | 119-01414 | 119-01416 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.020       | 3      | 119-01624 | 119-01626 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.020       | 3      | 119-01614 | 119-01616 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     | 0.020       | 3      | 119-01634 | 119-01636 |
| 1/4                   | 1/4                     | 1-1/2                 | 3-1/2                 | 0.020       | 3      | 119-01644 | 119-01646 |
| 9/32                  | 5/16                    | 1/2                   | 2-1/2                 | 0.020       | 3      | 119-01824 | 119-01826 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 | 0.020       | 3      | 119-01814 | 119-01816 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 | 0.020       | 3      | 119-02024 | 119-02026 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.020       | 3      | 119-02014 | 119-02016 |
| 11/32                 | 3/8                     | 5/8                   | 2                     | 0.020       | 3      | 119-02224 | 119-02226 |
| 11/32                 | 3/8                     | 7/8                   | 2-1/2                 | 0.020       | 3      | 119-02214 | 119-02216 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.020       | 3      | 119-02424 | 119-02426 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.020       | 3      | 119-02414 | 119-02416 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 | 0.020       | 3      | 119-02434 | 119-02436 |
| 3/8                   | 3/8                     | 2                     | 4                     | 0.020       | 3      | 119-02444 | 119-02446 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 0.020       | 3      | 119-02814 | 119-02816 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.020       | 3      | 119-03224 | 119-03226 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.020       | 3      | 119-03214 | 119-03216 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 | 0.020       | 3      | 119-03234 | 119-03236 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.020       | 3      | 119-03244 | 119-03246 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 0.030       | 3      | 119-03614 | 119-03616 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 0.030       | 3      | 119-04024 | 119-04026 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.030       | 3      | 119-04014 | 119-04016 |
| 5/8                   | 5/8                     | 1-3/4                 | 4                     | 0.030       | 3      | 119-04034 | 119-04036 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     | 0.030       | 3      | 119-04044 | 119-04046 |
| 3/4                   | 3/4                     | 1                     | 3                     | 0.030       | 3      | 119-04824 | 119-04826 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 0.030       | 3      | 119-04814 | 119-04816 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     | 0.030       | 3      | 119-04834 | 119-04836 |
| 3/4                   | 3/4                     | 3-1/4                 | 6                     | 0.030       | 3      | 119-04844 | 119-04846 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.030       | 3      | 119-06414 | 119-06416 |
| 1                     | 1                       | 2-3/4                 | 5                     | 0.030       | 3      | 119-06434 | 119-06436 |
| 1                     | 1                       | 3-3/8                 | 6                     | 0.030       | 3      | 119-06444 | 119-06446 |

Feeds & Speeds Available on Page 57

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | •        | •                      | •             |                     |



**Tolerances**

Shank: 3/16" - 1" = -.0001/-0.0004  
 Cutting Dia: 3/16" - 1" = +.000/-0.002  
 Radius: 3/16" - 1" = +/-0.005

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | AlTiN     | ZrN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-----------|-----------|
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.030       | 3      | 102-01224 | 102-01226 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.030       | 3      | 102-01214 | 102-01216 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.045       | 3      | 102-01624 | 102-01626 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.045       | 3      | 102-01614 | 102-01616 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 | 0.045       | 3      | 102-02024 | 102-02026 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.045       | 3      | 102-02014 | 102-02016 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.060       | 3      | 102-02424 | 102-02426 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.060       | 3      | 102-02414 | 102-02416 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 0.060       | 3      | 102-02814 | 102-02816 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.060       | 3      | 102-03224 | 102-03226 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.060       | 3      | 102-03214 | 102-03216 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 | 0.060       | 3      | 102-03234 | 102-03236 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 0.060       | 3      | 102-03614 | 102-03616 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.060       | 3      | 102-04014 | 102-04016 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 0.060       | 3      | 102-04814 | 102-04816 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.060       | 3      | 102-04834 | 102-04836 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.060       | 3      | 102-06414 | 102-06416 |
| 1                     | 1                       | 2-5/8                 | 5                     | 0.060       | 3      | 102-06434 | 102-06436 |

Feeds & Speeds Available on Page 57

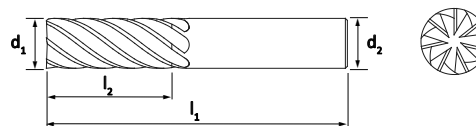
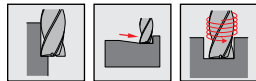
**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | •        | •                      | •             |                     |

# Series 160 7 Flute Universal



$\lambda_s = 37.5^\circ$      $\gamma_s = 10^\circ$



Tolerances  
Shank:  $1/4'' - 1'' = -.0001/-0.0004$   
Cutting Dia:  $1/4'' - 1'' = +.000/-0.002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | $l_3$<br>LOR | $d_3$<br>Neck Dia | Flutes | nACRo®    |
|--------------|----------------|--------------|--------------|--------------|-------------------|--------|-----------|
| 1/4          | 1/4            | 3/4          | 2-1/2        |              |                   | 7      | 160-01615 |
| 3/8          | 3/8            | 7/8          | 2-1/2        |              |                   | 7      | 160-02415 |
| 3/8          | 3/8            | 1-1/4        | 3            |              |                   | 7      | 160-02445 |
| 3/8          | 3/8            | 1/2          | 6            | 3-1/8        | 0.360             | 7      | 160-02485 |
| 1/2          | 1/2            | 1-1/4        | 3            |              |                   | 7      | 160-03215 |
| 1/2          | 1/2            | 1-5/8        | 4            |              |                   | 7      | 160-03245 |
| 1/2          | 1/2            | 5/8          | 6            | 3-1/8        | 0.480             | 7      | 160-03275 |
| 5/8          | 5/8            | 1-5/8        | 3-1/2        |              |                   | 7      | 160-04015 |
| 5/8          | 5/8            | 2-1/8        | 4            |              |                   | 7      | 160-04045 |
| 5/8          | 5/8            | 3/4          | 6            | 3 1/8        | 0.600             | 7      | 160-04075 |
| 3/4          | 3/4            | 1-5/8        | 4            |              |                   | 7      | 160-04815 |
| 3/4          | 3/4            | 2-1/4        | 5            |              |                   | 7      | 160-04845 |
| 3/4          | 3/4            | 1            | 6            | 3-1/8        | 0.720             | 7      | 160-04875 |
| 1            | 1              | 2            | 4            |              |                   | 7      | 160-06415 |
| 1            | 1              | 2-5/8        | 5            |              |                   | 7      | 160-06445 |

Feeds & Speeds Available on Page 58

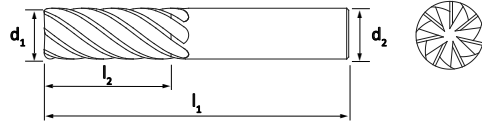
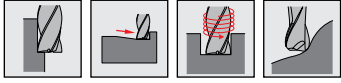
PROMAX PREMIUM

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |



$\lambda_s = 37.5^\circ$     $\gamma_s = 10^\circ$



**Tolerances**

Shank: 1/4" - 1" = -.0001/- .0004  
 Cutting Dia: 1/4" - 1" = +.000/- .002  
 Radius: 1/4" - 1" = +/- .001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flutes | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|--------|-----------|
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 7      | 161-31615 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.030       | 7      | 161-41615 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     |                       |                            | 0.020       | 7      | 161-31645 |
| 1/4                   | 1/4                     | 3/8                   | 4                     | 2-1/2                 | 0.240                      | 0.020       | 7      | 161-31675 |
| 1/4                   | 1/4                     | 3/8                   | 4                     | 2-1/2                 | 0.240                      | 0.030       | 7      | 161-41675 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.020       | 7      | 161-32415 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.030       | 7      | 161-42415 |
| 3/8                   | 3/8                     | 1-1/4                 | 3                     |                       |                            | 0.020       | 7      | 161-32445 |
| 3/8                   | 3/8                     | 1-1/4                 | 3                     |                       |                            | 0.030       | 7      | 161-42445 |
| 3/8                   | 3/8                     | 1/2                   | 6                     | 3-1/8                 | 0.360                      | 0.020       | 7      | 161-32485 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.020       | 7      | 161-33215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.030       | 7      | 161-43215 |
| 1/2                   | 1/2                     | 1-5/8                 | 4                     |                       |                            | 0.020       | 7      | 161-33245 |
| 1/2                   | 1/2                     | 1-5/8                 | 4                     |                       |                            | 0.030       | 7      | 161-43245 |
| 1/2                   | 1/2                     | 5/8                   | 6                     | 3-1/8                 | 0.480                      | 0.020       | 7      | 161-33275 |
| 1/2                   | 1/2                     | 5/8                   | 6                     | 3-1/8                 | 0.480                      | 0.030       | 7      | 161-43275 |
| 5/8                   | 5/8                     | 1-5/8                 | 3-1/2                 |                       |                            | 0.030       | 7      | 161-44015 |
| 5/8                   | 5/8                     | 2-1/8                 | 4                     |                       |                            | 0.030       | 7      | 161-44045 |
| 5/8                   | 5/8                     | 3/4                   | 6                     | 3-1/8                 | 0.600                      | 0.030       | 7      | 161-44075 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.030       | 7      | 161-44815 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     |                       |                            | 0.030       | 7      | 161-44845 |
| 3/4                   | 3/4                     | 1                     | 6                     | 3-1/8                 | 0.720                      | 0.030       | 7      | 161-44875 |
| 1                     | 1                       | 2-5/8                 | 5                     |                       |                            | 0.030       | 7      | 161-46445 |

Feeds & Speeds Available on Page 58

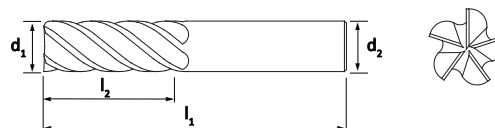
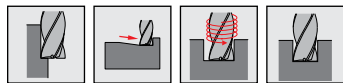
**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |

# Series 112 5 Flute Universal



$\lambda_s = 40^\circ$      $\gamma_s = 10^\circ$



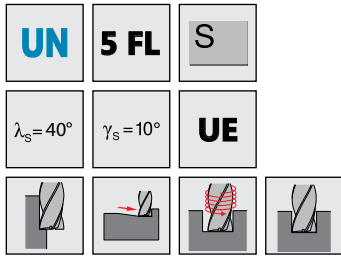
Tolerances  
Shank:  $1/8'' - 1'' = -.0001/-0.0004$   
Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | TiCN      | AlTiN     | nACRo®    |
|--------------|----------------|--------------|--------------|--------|-----------|-----------|-----------|
| 1/8          | 1/8            | 1/4          | 1-1/2        | 5      | 112-00822 | 112-00824 | 112-00825 |
| 1/8          | 1/8            | 1/2          | 1-1/2        | 5      | 112-00812 | 112-00814 | 112-00815 |
| 5/32         | 3/16           | 3/8          | 2            | 5      | 112-01022 | 112-01024 | 112-01025 |
| 5/32         | 3/16           | 1/2          | 2            | 5      | 112-01012 | 112-01014 | 112-01015 |
| 3/16         | 3/16           | 3/8          | 2            | 5      | 112-01222 | 112-01224 | 112-01225 |
| 3/16         | 3/16           | 5/8          | 2            | 5      | 112-01212 | 112-01214 | 112-01215 |
| 7/32         | 1/4            | 3/4          | 2-1/2        | 5      | 112-01412 | 112-01414 | 112-01415 |
| 1/4          | 1/4            | 3/8          | 2            | 5      | 112-01622 | 112-01624 | 112-01625 |
| 1/4          | 1/4            | 3/4          | 2-1/2        | 5      | 112-01612 | 112-01614 | 112-01615 |
| 5/16         | 5/16           | 1/2          | 2-1/2        | 5      | 112-02022 | 112-02024 | 112-02025 |
| 5/16         | 5/16           | 3/4          | 2-1/2        | 5      | 112-02012 | 112-02014 | 112-02015 |
| 3/8          | 3/8            | 5/8          | 2            | 5      | 112-02422 | 112-02424 | 112-02425 |
| 3/8          | 3/8            | 7/8          | 2-1/2        | 5      | 112-02412 | 112-02414 | 112-02415 |
| 3/8          | 3/8            | 1-1/2        | 3-1/2        | 5      | 112-02432 | 112-02434 | 112-02435 |
| 7/16         | 7/16           | 1            | 2-3/4        | 5      | 112-02812 | 112-02814 | 112-02815 |
| 1/2          | 1/2            | 5/8          | 2-1/2        | 5      | 112-03222 | 112-03224 | 112-03225 |
| 1/2          | 1/2            | 1-1/4        | 3            | 5      | 112-03212 | 112-03214 | 112-03215 |
| 1/2          | 1/2            | 1-1/2        | 3-1/2        | 5      | 112-03232 | 112-03234 | 112-03235 |
| 1/2          | 1/2            | 2            | 4            | 5      | 112-03242 | 112-03244 | 112-03245 |
| 9/16         | 9/16           | 1-1/4        | 3-1/2        | 5      | 112-03612 | 112-03614 | 112-03615 |
| 5/8          | 5/8            | 7/8          | 3            | 5      | 112-04022 | 112-04024 | 112-04025 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        | 5      | 112-04012 | 112-04014 | 112-04015 |
| 5/8          | 5/8            | 1-3/4        | 4            | 5      | 112-04032 | 112-04034 | 112-04035 |
| 3/4          | 3/4            | 1            | 3            | 5      | 112-04822 | 112-04824 | 112-04825 |
| 3/4          | 3/4            | 1-5/8        | 4            | 5      | 112-04812 | 112-04814 | 112-04815 |
| 3/4          | 3/4            | 2-1/2        | 5            | 5      | 112-04832 | 112-04834 | 112-04835 |
| 3/4          | 3/4            | 3-1/4        | 6            | 5      | 112-04842 | 112-04844 | 112-04845 |
| 1            | 1              | 1-3/4        | 4            | 5      | 112-06412 | 112-06414 | 112-06415 |
| 1            | 1              | 2-3/4        | 5            | 5      | 112-06432 | 112-06434 | 112-06435 |
| 1            | 1              | 3-3/8        | 6            | 5      | 112-06442 | 112-06444 | 112-06445 |

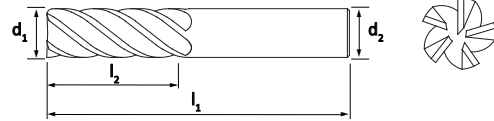
Feeds & Speeds Available on Page 59

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |

**Tolerances**

Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | AlTiN     | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 5      | 158-00814 | 158-00815 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 5      | 158-01014 | 158-01015 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 5      | 158-01224 | 158-01225 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 5      | 158-01214 | 158-01215 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 | 5      | 158-01414 | 158-01415 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 5      | 158-01624 | 158-01625 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 5      | 158-01614 | 158-01615 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     | 5      | 158-01634 | 158-01635 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 5      | 158-02014 | 158-02015 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 5      | 158-02424 | 158-02425 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 5      | 158-02414 | 158-02415 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 | 5      | 158-02434 | 158-02435 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 5      | 158-02814 | 158-02815 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 5      | 158-03224 | 158-03225 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 5      | 158-03214 | 158-03215 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 | 5      | 158-03234 | 158-03235 |
| 1/2                   | 1/2                     | 2                     | 4                     | 5      | 158-03244 | 158-03245 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 5      | 158-03614 | 158-03615 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 5      | 158-04024 | 158-04025 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 5      | 158-04014 | 158-04015 |
| 5/8                   | 5/8                     | 1-3/4                 | 4                     | 5      | 158-04034 | 158-04035 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     | 5      | 158-04044 | 158-04045 |
| 3/4                   | 3/4                     | 1                     | 3                     | 5      | 158-04824 | 158-04825 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 5      | 158-04814 | 158-04815 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     | 5      | 158-04834 | 158-04835 |
| 3/4                   | 3/4                     | 3-1/4                 | 6                     | 5      | 158-04844 | 158-04845 |
| 1                     | 1                       | 1-3/4                 | 4                     | 5      | 158-06414 | 158-06415 |
| 1                     | 1                       | 2-3/4                 | 5                     | 5      | 158-06434 | 158-06435 |
| 1                     | 1                       | 3-3/8                 | 6                     | 5      | 158-06444 | 158-06445 |

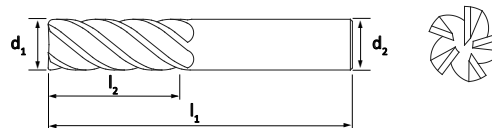
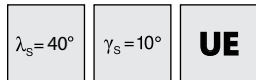
Feeds & Speeds Available on Page 60

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |

# Series 159

## 5 Flute Universal Corner Radius



Tolerances  
 Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Radius: 1/8" - 1" = +/- .001

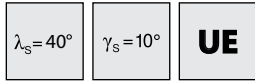
| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-----------|
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.010       | 5      | 159-10815 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.015       | 5      | 159-20815 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 0.010       | 5      | 159-11015 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.010       | 5      | 159-11225 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.020       | 5      | 159-31225 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.010       | 5      | 159-11215 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.020       | 5      | 159-31215 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 | 0.015       | 5      | 159-21415 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.010       | 5      | 159-11625 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.015       | 5      | 159-21625 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.020       | 5      | 159-31625 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.030       | 5      | 159-41625 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.010       | 5      | 159-11615 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.015       | 5      | 159-21615 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.020       | 5      | 159-31615 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.030       | 5      | 159-41615 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     | 0.030       | 5      | 159-41635 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.015       | 5      | 159-22015 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.010       | 5      | 159-12425 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.015       | 5      | 159-22425 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.020       | 5      | 159-32425 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.030       | 5      | 159-42425 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.010       | 5      | 159-12415 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.015       | 5      | 159-22415 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.020       | 5      | 159-32415 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.030       | 5      | 159-42415 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 | 0.010       | 5      | 159-12435 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 | 0.015       | 5      | 159-22435 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 | 0.030       | 5      | 159-42435 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.010       | 5      | 159-13225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.015       | 5      | 159-23225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.020       | 5      | 159-33225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.030       | 5      | 159-43225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.060       | 5      | 159-63225 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.010       | 5      | 159-13215 |

Additional Sizes On Page 32

Feeds & Speeds Available on Page 60

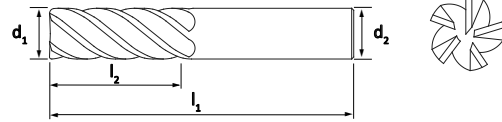
Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |



## Tolerances

Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Radius: 1/8" - 1" = +/- .001



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-----------|
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.015       | 5      | 159-23215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.020       | 5      | 159-33215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.030       | 5      | 159-43215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.060       | 5      | 159-63215 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.030       | 5      | 159-43245 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.060       | 5      | 159-63245 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 0.030       | 5      | 159-44025 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 0.060       | 5      | 159-64025 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.030       | 5      | 159-44015 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     | 0.030       | 5      | 159-44045 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     | 0.060       | 5      | 159-64045 |
| 3/4                   | 3/4                     | 1                     | 3                     | 0.030       | 5      | 159-44825 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 0.030       | 5      | 159-44815 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     | 0.030       | 5      | 159-44835 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     | 0.060       | 5      | 159-64835 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.030       | 5      | 159-46415 |
| 1                     | 1                       | 2-3/4                 | 5                     | 0.030       | 5      | 159-46435 |
| 1                     | 1                       | 2-3/4                 | 5                     | 0.060       | 5      | 159-66435 |
| 1                     | 1                       | 3-3/8                 | 6                     | 0.030       | 5      | 159-46445 |

Additional Sizes On Page 31

Feeds & Speeds Available on Page 60

## Application Range:

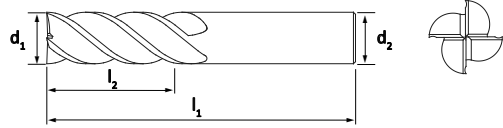
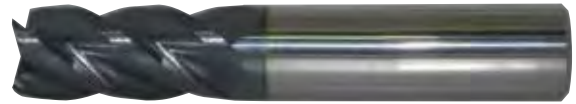
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |







$\lambda_s = 40^\circ$      $\gamma_s = 10^\circ$



**Tolerances**  
 Shank: 1/32" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/32" - 7/64" = +/- .0005  
 1/8" - 1" = +.000/-0.002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|-----------|-----------|
| 1/32                  | 1/8                     | 3/32                  | 1-1/2                 | 4      | 111-00212 | 111-00214 |
| 3/64                  | 1/8                     | 9/64                  | 1-1/2                 | 4      | 111-00312 | 111-00314 |
| 1/16                  | 1/8                     | 1/8                   | 1-1/2                 | 4      | 111-00422 | 111-00424 |
| 1/16                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | 111-00412 | 111-00414 |
| 5/64                  | 1/8                     | 1/4                   | 1-1/2                 | 4      | 111-00512 | 111-00514 |
| 3/32                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | 111-00622 | 111-00624 |
| 3/32                  | 1/8                     | 9/32                  | 1-1/2                 | 4      | 111-00612 | 111-00614 |
| 7/64                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | 111-00722 | 111-00724 |
| 7/64                  | 1/8                     | 3/8                   | 1-1/2                 | 4      | 111-00712 | 111-00714 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 4      | 111-00822 | 111-00824 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 4      | 111-00812 | 111-00814 |
| 5/32                  | 3/16                    | 3/8                   | 2                     | 4      | 111-01022 | 111-01024 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 4      | 111-01012 | 111-01014 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 4      | 111-01222 | 111-01224 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 4      | 111-01212 | 111-01214 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 | 4      | 111-01412 | 111-01414 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 4      | 111-01622 | 111-01624 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 4      | 111-01612 | 111-01614 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     | 4      | 111-01632 | 111-01634 |
| 1/4                   | 1/4                     | 1-1/2                 | 3-1/2                 | 4      | 111-01642 | 111-01644 |
| 1/4                   | 1/4                     | 3/8                   | 4                     | 4      | 111-01662 | 111-01664 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 | 4      | 111-02022 | 111-02024 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 4      | 111-02012 | 111-02014 |
| 5/16                  | 5/16                    | 7/16                  | 4                     | 4      | 111-02062 | 111-02064 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 4      | 111-02422 | 111-02424 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 4      | 111-02412 | 111-02414 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 | 4      | 111-02432 | 111-02434 |
| 3/8                   | 3/8                     | 2                     | 4                     | 4      | 111-02442 | 111-02444 |
| 3/8                   | 3/8                     | 1/2                   | 6                     | 4      | 111-02472 | 111-02474 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 4      | 111-02812 | 111-02814 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 4      | 111-03222 | 111-03224 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 4      | 111-03212 | 111-03214 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 | 4      | 111-03232 | 111-03234 |
| 1/2                   | 1/2                     | 2                     | 4                     | 4      | 111-03242 | 111-03244 |
| 1/2                   | 1/2                     | 5/8                   | 6                     | 4      | 111-03272 | 111-03274 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 4      | 111-03612 | 111-03614 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 4      | 111-04022 | 111-04024 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 4      | 111-04012 | 111-04014 |
| 5/8                   | 5/8                     | 1-3/4                 | 4                     | 4      | 111-04032 | 111-04034 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     | 4      | 111-04042 | 111-04044 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 4      | 111-04812 | 111-04814 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     | 4      | 111-04832 | 111-04834 |
| 3/4                   | 3/4                     | 3-1/4                 | 6                     | 4      | 111-04842 | 111-04844 |
| 1                     | 1                       | 1-3/4                 | 4                     | 4      | 111-06412 | 111-06414 |
| 1                     | 1                       | 2-3/4                 | 5                     | 4      | 111-06432 | 111-06434 |

**Application Range:**

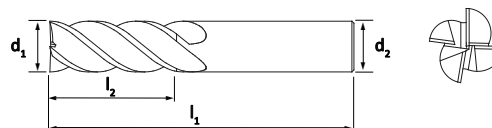
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                | ●               | ●        | ●                | ●         |          |                        | ●             |                     |

# Series 155 4 Flute Universal

**PROMAX  
TOOLS**

**UN** **4 FL** **S**

$\lambda_s = 40^\circ$   $\gamma_s = 10^\circ$  **UE**



**Tolerances**

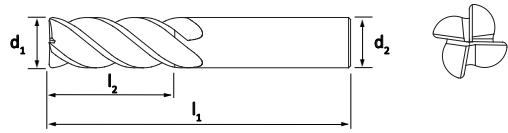
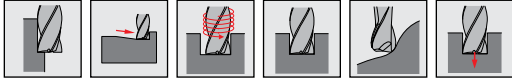
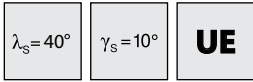
Shank:  $1/8'' - 1'' = -.0001/-0.0004$   
Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | $l_3$<br>LOR | $d_3$<br>Neck Dia | Flutes | AlTiN     | nACRo®    |
|--------------|----------------|--------------|--------------|--------------|-------------------|--------|-----------|-----------|
| 1/8          | 1/8            | 1/4          | 1-1/2        |              |                   | 4      | 155-00824 | 155-00825 |
| 1/8          | 1/8            | 1/2          | 1-1/2        |              |                   | 4      | 155-00814 | 155-00815 |
| 5/32         | 3/16           | 3/8          | 2            |              |                   | 4      | 155-01024 | 155-01025 |
| 5/32         | 3/16           | 1/2          | 2            |              |                   | 4      | 155-01014 | 155-01015 |
| 3/16         | 3/16           | 3/8          | 2            |              |                   | 4      | 155-01224 | 155-01225 |
| 3/16         | 3/16           | 5/8          | 2            |              |                   | 4      | 155-01214 | 155-01215 |
| 7/32         | 1/4            | 3/8          | 2            |              |                   | 4      | 155-01424 | 155-01425 |
| 7/32         | 1/4            | 3/4          | 2-1/2        |              |                   | 4      | 155-01414 | 155-01415 |
| 1/4          | 1/4            | 3/8          | 2            |              |                   | 4      | 155-01624 | 155-01625 |
| 1/4          | 1/4            | 3/4          | 2-1/2        |              |                   | 4      | 155-01614 | 155-01615 |
| 1/4          | 1/4            | 3/4          | 4            | 2-1/8        | 0.240             | 4      | 155-01664 | 155-01665 |
| 1/4          | 1/4            | 1-1/4        | 5            |              |                   | 4      | 155-01634 | 155-01635 |
| 5/16         | 5/16           | 1/2          | 2-1/2        |              |                   | 4      | 155-02024 | 155-02025 |
| 5/16         | 5/16           | 3/4          | 2-1/2        |              |                   | 4      | 155-02014 | 155-02015 |
| 3/8          | 3/8            | 5/8          | 2            |              |                   | 4      | 155-02424 | 155-02425 |
| 3/8          | 3/8            | 7/8          | 2-1/2        |              |                   | 4      | 155-02414 | 155-02415 |
| 3/8          | 3/8            | 1-1/2        | 3-1/2        |              |                   | 4      | 155-02434 | 155-02435 |
| 3/8          | 3/8            | 7/8          | 4            | 2-3/8        | 0.360             | 4      | 155-02464 | 155-02465 |
| 3/8          | 3/8            | 7/8          | 6            | 3-3/8        | 0.360             | 4      | 155-02474 | 155-02475 |
| 7/16         | 7/16           | 1            | 2-3/4        |              |                   | 4      | 155-02814 | 155-02815 |
| 1/2          | 1/2            | 5/8          | 2-1/2        |              |                   | 4      | 155-03224 | 155-03225 |
| 1/2          | 1/2            | 1-1/4        | 3            |              |                   | 4      | 155-03214 | 155-03215 |
| 1/2          | 1/2            | 2            | 4            |              |                   | 4      | 155-03244 | 155-03245 |
| 1/2          | 1/2            | 1            | 6            | 2-3/8        | 0.480             | 4      | 155-03264 | 155-03265 |
| 1/2          | 1/2            | 1            | 6            | 3-3/8        | 0.480             | 4      | 155-03274 | 155-03275 |
| 9/16         | 9/16           | 1-1/4        | 3-1/2        |              |                   | 4      | 155-03614 | 155-03615 |
| 5/8          | 5/8            | 7/8          | 3            |              |                   | 4      | 155-04024 | 155-04025 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        |              |                   | 4      | 155-04014 | 155-04015 |
| 5/8          | 5/8            | 2-1/2        | 5            |              |                   | 4      | 155-04044 | 155-04045 |
| 3/4          | 3/4            | 1            | 3            |              |                   | 4      | 155-04824 | 155-04825 |
| 3/4          | 3/4            | 1-5/8        | 4            |              |                   | 4      | 155-04814 | 155-04815 |
| 3/4          | 3/4            | 2-1/2        | 5            |              |                   | 4      | 155-04834 | 155-04835 |
| 1            | 1              | 1-3/4        | 4            |              |                   | 4      | 155-06414 | 155-06415 |
| 1            | 1              | 2-3/4        | 5            |              |                   | 4      | 155-06434 | 155-06435 |
| 1            | 1              | 3-3/8        | 6            |              |                   | 4      | 155-06444 | 155-06445 |

Feeds & Speeds Available on Page 62 - 63

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          |                | ●               | ●        | ●                | ●         |          |                        |               |                     |



**Tolerances**

Shank: 1/8" - 1" = -.0001/-.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/- .001

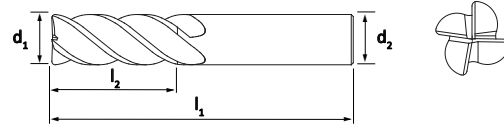
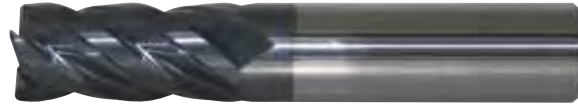
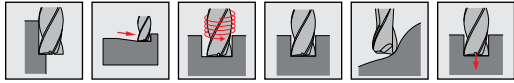
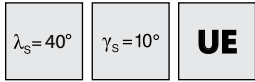
| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flutes | AlTiN     | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 |                       |                            | 0.010       | 4      | 156-10824 | 156-10825 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 |                       |                            | 0.020       | 4      | 156-30824 | 156-30825 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 0.010       | 4      | 156-10814 | 156-10815 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 0.015       | 4      | 156-20814 | 156-20815 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 0.020       | 4      | 156-30814 | 156-30815 |
| 5/32                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.010       | 4      | 156-11024 | 156-11025 |
| 5/32                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.015       | 4      | 156-21024 | 156-21025 |
| 5/32                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.020       | 4      | 156-31024 | 156-31025 |
| 5/32                  | 3/16                    | 1/2                   | 2                     |                       |                            | 0.010       | 4      | 156-11014 | 156-11015 |
| 5/32                  | 3/16                    | 1/2                   | 2                     |                       |                            | 0.015       | 4      | 156-21014 | 156-21015 |
| 5/32                  | 3/16                    | 1/2                   | 2                     |                       |                            | 0.020       | 4      | 156-31014 | 156-31015 |
| 3/16                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.010       | 4      | 156-11224 | 156-11225 |
| 3/16                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.020       | 4      | 156-31224 | 156-31225 |
| 3/16                  | 3/16                    | 5/8                   | 2                     |                       |                            | 0.010       | 4      | 156-11214 | 156-11215 |
| 3/16                  | 3/16                    | 5/8                   | 2                     |                       |                            | 0.020       | 4      | 156-31214 | 156-31215 |
| 7/32                  | 1/4                     | 3/8                   | 2                     |                       |                            | 0.020       | 4      | 156-31424 | 156-31425 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.015       | 4      | 156-21414 | 156-21415 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 4      | 156-31414 | 156-31415 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 0.010       | 4      | 156-11624 | 156-11625 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 0.015       | 4      | 156-21624 | 156-21625 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 0.020       | 4      | 156-31624 | 156-31625 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 0.030       | 4      | 156-41624 | 156-41625 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.010       | 4      | 156-11614 | 156-11615 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.015       | 4      | 156-21614 | 156-21615 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 4      | 156-31614 | 156-31615 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.030       | 4      | 156-41614 | 156-41615 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     |                       |                            | 0.010       | 4      | 156-11634 | 156-11635 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     |                       |                            | 0.015       | 4      | 156-21634 | 156-21635 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     |                       |                            | 0.020       | 4      | 156-31634 | 156-31635 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     |                       |                            | 0.030       | 4      | 156-41634 | 156-41635 |
| 1/4                   | 1/4                     | 3/4                   | 4                     | 2 1/8                 | 0.240                      | 0.015       | 4      | 156-21664 | 156-21665 |
| 1/4                   | 1/4                     | 3/4                   | 4                     | 2 1/8                 | 0.240                      | 0.020       | 4      | 156-31664 | 156-31665 |
| 1/4                   | 1/4                     | 3/4                   | 4                     | 2 1/8                 | 0.240                      | 0.030       | 4      | 156-41664 | 156-41665 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 4      | 156-31814 | 156-31815 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 |                       |                            | 0.020       | 4      | 156-32024 | 156-32025 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 |                       |                            | 0.030       | 4      | 156-42014 | 156-42015 |
| 3/8                   | 3/8                     | 5/8                   | 2                     |                       |                            | 0.010       | 4      | 156-12424 | 156-12425 |
| 3/8                   | 3/8                     | 5/8                   | 2                     |                       |                            | 0.015       | 4      | 156-22424 | 156-22425 |
| 3/8                   | 3/8                     | 5/8                   | 2                     |                       |                            | 0.020       | 4      | 156-32424 | 156-32425 |
| 3/8                   | 3/8                     | 5/8                   | 2                     |                       |                            | 0.030       | 4      | 156-42424 | 156-42425 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.010       | 4      | 156-12414 | 156-12415 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.020       | 4      | 156-32414 | 156-32415 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.030       | 4      | 156-42414 | 156-42415 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 |                       |                            | 0.010       | 4      | 156-12434 | 156-12435 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 |                       |                            | 0.020       | 4      | 156-32434 | 156-32435 |

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |

# Series 156

## 4 Flute Universal Corner Radius



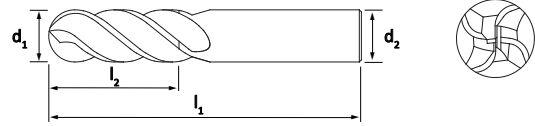
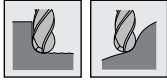
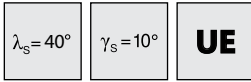
**Tolerances**  
 Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Radius: 1/8" - 1" = +/- .001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flutes | AlTiN     | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|--------|-----------|-----------|
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 |                       |                            | 0.030       | 4      | 156-42434 | 156-42435 |
| 3/8                   | 3/8                     | 7/8                   | 4                     | 2 3/8                 | 0.360                      | 0.030       | 4      | 156-42464 | 156-42465 |
| 7/16                  | 7/16                    | 5/8                   | 2-3/4                 |                       |                            | 0.020       | 4      | 156-32824 | 156-32825 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 |                       |                            | 0.020       | 4      | 156-32814 | 156-32815 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.010       | 4      | 156-13224 | 156-13225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.015       | 4      | 156-23224 | 156-23225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.020       | 4      | 156-33224 | 156-33225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.030       | 4      | 156-43224 | 156-43225 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.060       | 4      | 156-63224 | 156-63225 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.010       | 4      | 156-13214 | 156-13215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.015       | 4      | 156-23214 | 156-23215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.020       | 4      | 156-33214 | 156-33215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.030       | 4      | 156-43214 | 156-43215 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.060       | 4      | 156-63214 | 156-63215 |
| 1/2                   | 1/2                     | 2                     | 4                     |                       |                            | 0.020       | 4      | 156-33244 | 156-33245 |
| 1/2                   | 1/2                     | 2                     | 4                     |                       |                            | 0.030       | 4      | 156-43244 | 156-43245 |
| 1/2                   | 1/2                     | 2                     | 4                     |                       |                            | 0.060       | 4      | 156-63244 | 156-63245 |
| 1/2                   | 1/2                     | 1                     | 6                     | 2 3/8                 | 0.480                      | 0.030       | 4      | 156-43264 | 156-43265 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 |                       |                            | 0.030       | 4      | 156-43614 | 156-43615 |
| 5/8                   | 5/8                     | 7/8                   | 3                     |                       |                            | 0.030       | 4      | 156-44024 | 156-44025 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 |                       |                            | 0.010       | 4      | 156-14014 | 156-14015 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 |                       |                            | 0.030       | 4      | 156-44014 | 156-44015 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 |                       |                            | 0.060       | 4      | 156-64014 | 156-64015 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     |                       |                            | 0.030       | 4      | 156-44044 | 156-44045 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     |                       |                            | 0.060       | 4      | 156-64044 | 156-64045 |
| 5/8                   | 5/8                     | 1-1/4                 | 6                     | 2 3/8                 | 0.600                      | 0.030       | 4      | 156-44064 | 156-44065 |
| 3/4                   | 3/4                     | 1                     | 3                     |                       |                            | 0.010       | 4      | 156-14824 | 156-14825 |
| 3/4                   | 3/4                     | 1                     | 3                     |                       |                            | 0.030       | 4      | 156-44824 | 156-44825 |
| 3/4                   | 3/4                     | 1                     | 3                     |                       |                            | 0.060       | 4      | 156-64824 | 156-64825 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.010       | 4      | 156-14814 | 156-14815 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.020       | 4      | 156-34814 | 156-34815 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.030       | 4      | 156-44814 | 156-44815 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.060       | 4      | 156-64814 | 156-64815 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.125       | 4      | 156-84814 | 156-84815 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     |                       |                            | 0.030       | 4      | 156-44834 | 156-44835 |
| 3/4                   | 3/4                     | 2-1/2                 | 5                     |                       |                            | 0.060       | 4      | 156-64834 | 156-64835 |
| 3/4                   | 3/4                     | 1-5/8                 | 6                     | 2 1/2                 | 0.720                      | 0.030       | 4      | 156-44864 | 156-44865 |
| 1                     | 1                       | 1-3/4                 | 4                     |                       |                            | 0.030       | 4      | 156-46414 | 156-46415 |
| 1                     | 1                       | 1-3/4                 | 4                     |                       |                            | 0.060       | 4      | 156-66414 | 156-66415 |
| 1                     | 1                       | 2-3/4                 | 5                     |                       |                            | 0.030       | 4      | 156-46434 | 156-46435 |
| 1                     | 1                       | 2-3/4                 | 5                     |                       |                            | 0.060       | 4      | 156-66434 | 156-66435 |
| 1                     | 1                       | 3-3/8                 | 6                     |                       |                            | 0.030       | 4      | 156-46444 | 156-46445 |
| 1                     | 1                       | 3-3/8                 | 6                     |                       |                            | 0.060       | 4      | 156-66444 | 156-66445 |

Feeds & Speeds Available on Page 62 - 63

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          |                | ●               | ●        | ●                | ●         |          |                        |               |                     |

**Tolerances**

Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Ball Radius: 1/8" - 1" = +/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flutes | AlTiN     | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 |                       |                            | 0.063       | 4      | 157-00824 | 157-00825 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 0.063       | 4      | 157-00814 | 157-00815 |
| 5/32                  | 3/16                    | 1/2                   | 2                     |                       |                            | 0.078       | 4      | 157-01014 | 157-01015 |
| 3/16                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.094       | 4      | 157-01224 | 157-01225 |
| 3/16                  | 3/16                    | 5/8                   | 2                     |                       |                            | 0.094       | 4      | 157-01214 | 157-01215 |
| 7/32                  | 1/4                     | 3/8                   | 2                     |                       |                            | 0.109       | 4      | 157-01424 | 157-01425 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.109       | 4      | 157-01414 | 157-01415 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 0.125       | 4      | 157-01624 | 157-01625 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.125       | 4      | 157-01614 | 157-01615 |
| 1/4                   | 1/4                     | 3/4                   | 4                     | 2-1/8                 | 0.240                      | 0.125       | 4      | 157-01664 | 157-01665 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 |                       |                            | 0.156       | 4      | 157-02024 | 157-02025 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 |                       |                            | 0.156       | 4      | 157-02014 | 157-02015 |
| 3/8                   | 3/8                     | 5/8                   | 2                     |                       |                            | 0.188       | 4      | 157-02424 | 157-02425 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.188       | 4      | 157-02414 | 157-02415 |
| 3/8                   | 3/8                     | 7/8                   | 4                     | 2-3/8                 | 0.360                      | 0.188       | 4      | 157-02464 | 157-02465 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.250       | 4      | 157-03224 | 157-03225 |
| 1/2                   | 1/2                     | 1                     | 3                     |                       |                            | 0.250       | 4      | 157-03214 | 157-03215 |
| 1/2                   | 1/2                     | 1                     | 6                     | 2-3/8                 | 0.480                      | 0.250       | 4      | 157-03264 | 157-03265 |
| 1/2                   | 1/2                     | 1                     | 6                     | 3-3/8                 | 0.480                      | 0.250       | 4      | 157-03274 | 157-03275 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 |                       |                            | 0.281       | 4      | 157-03614 | 157-03615 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 |                       |                            | 0.313       | 4      | 157-04014 | 157-04015 |
| 5/8                   | 5/8                     | 1-1/4                 | 6                     | 3-3/8                 | 0.600                      | 0.313       | 4      | 157-04074 | 157-04075 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.375       | 4      | 157-04814 | 157-04815 |
| 1                     | 1                       | 1-3/4                 | 4                     |                       |                            | 0.500       | 4      | 157-06414 | 157-06415 |
| 1                     | 1                       | 2-3/4                 | 5                     |                       |                            | 0.500       | 4      | 157-06434 | 157-06435 |
| 1                     | 1                       | 1-7/8                 | 6                     | 3-3/8                 | 0.960                      | 0.500       | 4      | 157-06474 | 157-06475 |

Feeds & Speeds Available on Page 63 - 64

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               | •        | •                | •         |          |                        |               |                     |

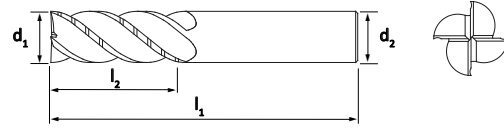
# Series 190

## 4 Flute Universal Multi-Geometry



**UN** **4 FL** **S**

$\lambda_s = 40^\circ$   $\gamma_s = 10^\circ$  **Cb**



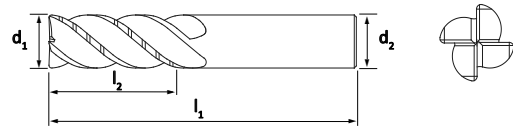
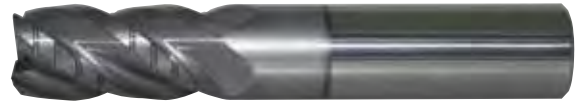
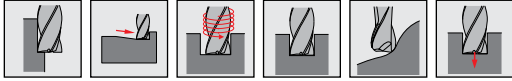
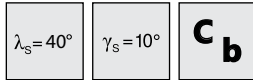
**Tolerances**  
 Shank:  $3/16'' - 1'' = -.0001/- .0004$   
 Cutting Dia:  $3/16'' - 1'' = +.000/- .002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | $l_3$<br>LOR | $d_3$<br>Neck Dia | Flutes | AlTiN     | nACRo®    |
|--------------|----------------|--------------|--------------|--------------|-------------------|--------|-----------|-----------|
| 3/16         | 3/16           | 5/8          | 2            |              |                   | 4      | 190-01214 | 190-01215 |
| 1/4          | 1/4            | 3/8          | 2            |              |                   | 4      | 190-01624 | 190-01625 |
| 1/4          | 1/4            | 3/4          | 2-1/2        |              |                   | 4      | 190-01614 | 190-01615 |
| 5/16         | 5/16           | 3/4          | 2-1/2        |              |                   | 4      | 190-02014 | 190-02015 |
| 3/8          | 3/8            | 5/8          | 2            |              |                   | 4      | 190-02424 | 190-02425 |
| 3/8          | 3/8            | 7/8          | 2-1/2        |              |                   | 4      | 190-02414 | 190-02415 |
| 3/8          | 3/8            | 7/8          | 4            | 2-1/8        | 0.360             | 4      | 190-02464 | 190-02465 |
| 1/2          | 1/2            | 5/8          | 2-1/2        |              |                   | 4      | 190-03224 | 190-03225 |
| 1/2          | 1/2            | 1-1/4        | 3            |              |                   | 4      | 190-03214 | 190-03215 |
| 1/2          | 1/2            | 2            | 4            |              |                   | 4      | 190-03234 | 190-03235 |
| 1/2          | 1/2            | 1            | 6            | 2-3/8        | 0.480             | 4      | 190-03264 | 190-03265 |
| 5/8          | 5/8            | 7/8          | 3            |              |                   | 4      | 190-04024 | 190-04025 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        |              |                   | 4      | 190-04014 | 190-04015 |
| 3/4          | 3/4            | 1            | 3            |              |                   | 4      | 190-04824 | 190-04825 |
| 3/4          | 3/4            | 1-5/8        | 4            |              |                   | 4      | 190-04814 | 190-04815 |
| 1            | 1              | 1-3/4        | 4            |              |                   | 4      | 190-06414 | 190-06415 |

Feeds & Speeds Available on Page 64

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                | •               | •        | •                | •         |          |                        |               |                     |

**Tolerances**

Shank: 3/16" - 1" = -.0001/-0.0004  
 Cutting Dia: 3/16" - 1" = +.000/-0.002  
 Radius: 3/16" - 1" = +.002/-0.001

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | R<br>Radius | Flutes | AlTiN     | nACRo®    |
|--------------|----------------|--------------|--------------|-------------|--------|-----------|-----------|
| 3/16         | 3/16           | 5/8          | 2            | 0.010       | 4      | 191-11214 | 191-11215 |
| 1/4          | 1/4            | 3/4          | 2-1/2        | 0.020       | 4      | 191-31614 | 191-31615 |
| 5/16         | 5/16           | 3/4          | 2-1/2        | 0.020       | 4      | 191-32014 | 191-32015 |
| 5/16         | 5/16           | 3/4          | 2-1/2        | 0.030       | 4      | 191-42014 | 191-42015 |
| 3/8          | 3/8            | 7/8          | 2-1/2        | 0.020       | 4      | 191-32414 | 191-32415 |
| 3/8          | 3/8            | 7/8          | 2-1/2        | 0.030       | 4      | 191-42414 | 191-42415 |
| 1/2          | 1/2            | 5/8          | 2-1/2        | 0.020       | 4      | 191-33224 | 191-33225 |
| 1/2          | 1/2            | 5/8          | 2-1/2        | 0.030       | 4      | 191-43224 | 191-43225 |
| 1/2          | 1/2            | 1-1/4        | 3            | 0.020       | 4      | 191-33214 | 191-33215 |
| 1/2          | 1/2            | 1-1/4        | 3            | 0.030       | 4      | 191-43214 | 191-43215 |
| 1/2          | 1/2            | 2            | 4            | 0.020       | 4      | 191-33234 | 191-33235 |
| 1/2          | 1/2            | 2            | 4            | 0.030       | 4      | 191-43234 | 191-43235 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        | 0.030       | 4      | 191-44014 | 191-44015 |
| 3/4          | 3/4            | 1-5/8        | 4            | 0.030       | 4      | 191-44814 | 191-44815 |
| 1            | 1              | 1-3/4        | 4            | 0.030       | 4      | 191-46414 | 191-46415 |

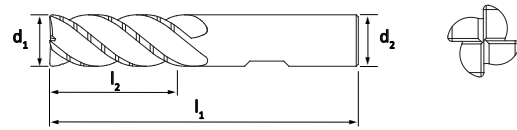
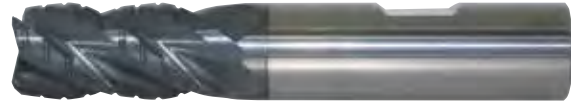
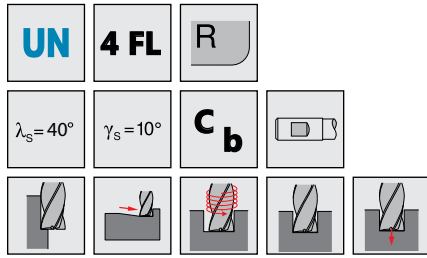
**Feeds & Speeds Available on Page 64**
**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                | •               | •        | •                | •         |          |                        |               |                     |



# Series 120

## 4 Flute Universal Rougher-Finisher



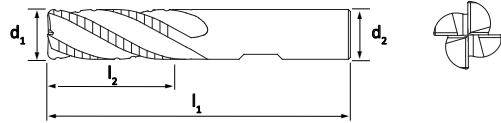
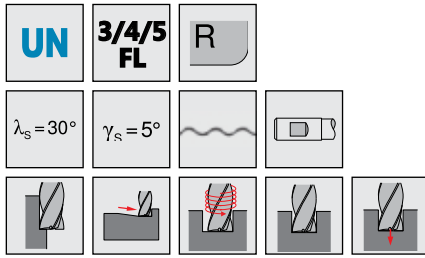
**Tolerances**  
 Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.003  
 Radius: 1/8" - 1" = +.002/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flutes | TiCN      | AlTiN     | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|--------|-----------|-----------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 |                       |                            | 0.010       | 4      | 120-00822 | 120-00824 | 120-00825 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 0.010       | 4      | 120-00812 | 120-00814 | 120-00815 |
| 5/32                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.010       | 4      | 120-01022 | 120-01024 | 120-01025 |
| 5/32                  | 3/16                    | 1/2                   | 2                     |                       |                            | 0.010       | 4      | 120-01012 | 120-01014 | 120-01015 |
| 3/16                  | 3/16                    | 3/8                   | 2                     |                       |                            | 0.010       | 4      | 120-01222 | 120-01224 | 120-01225 |
| 3/16                  | 3/16                    | 5/8                   | 2                     |                       |                            | 0.010       | 4      | 120-01212 | 120-01214 | 120-01215 |
| 7/32                  | 1/4                     | 3/8                   | 2                     |                       |                            | 0.020       | 4      | 120-01422 | 120-01424 | 120-01425 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-01412 | 120-01414 | 120-01415 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 0.020       | 4      | 120-01622 | 120-01624 | 120-01625 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-01612 | 120-01614 | 120-01615 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     |                       |                            | 0.020       | 4      | 120-01632 | 120-01634 | 120-01635 |
| 1/4                   | 1/4                     | 1-1/2                 | 3-1/2                 |                       |                            | 0.020       | 4      | 120-01642 | 120-01644 | 120-01645 |
| 1/4                   | 1/4                     | 3/4                   | 4                     | 2-1/8                 | 0.240                      | 0.020       | 4      | 120-01662 | 120-01664 | 120-01665 |
| 9/32                  | 5/16                    | 1/2                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-01822 | 120-01824 | 120-01825 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-01812 | 120-01814 | 120-01815 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-02022 | 120-02024 | 120-02025 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-02012 | 120-02014 | 120-02015 |
| 11/32                 | 3/8                     | 5/8                   | 2                     |                       |                            | 0.020       | 4      | 120-02222 | 120-02224 | 120-02225 |
| 11/32                 | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-02212 | 120-02214 | 120-02215 |
| 3/8                   | 3/8                     | 5/8                   | 2                     |                       |                            | 0.020       | 4      | 120-02422 | 120-02424 | 120-02425 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-02412 | 120-02414 | 120-02415 |
| 3/8                   | 3/8                     | 1-1/2                 | 3-1/2                 |                       |                            | 0.020       | 4      | 120-02432 | 120-02434 | 120-02435 |
| 3/8                   | 3/8                     | 7/8                   | 4                     | 2-1/8                 | 0.360                      | 0.020       | 4      | 120-02462 | 120-02464 | 120-02465 |
| 3/8                   | 3/8                     | 2                     | 4                     |                       |                            | 0.020       | 4      | 120-02442 | 120-02444 | 120-02445 |
| 3/8                   | 3/8                     | 7/8                   | 6                     | 3-3/8                 | 0.360                      | 0.020       | 4      | 120-02472 | 120-02474 | 120-02475 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 |                       |                            | 0.020       | 4      | 120-02812 | 120-02814 | 120-02815 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.020       | 4      | 120-03222 | 120-03224 | 120-03225 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.020       | 4      | 120-03212 | 120-03214 | 120-03215 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 |                       |                            | 0.020       | 4      | 120-03232 | 120-03234 | 120-03235 |
| 1/2                   | 1/2                     | 2                     | 4                     |                       |                            | 0.020       | 4      | 120-03242 | 120-03244 | 120-03245 |
| 1/2                   | 1/2                     | 1                     | 6                     | 2-3/8                 | 0.480                      | 0.020       | 4      | 120-03262 | 120-03264 | 120-03265 |
| 1/2                   | 1/2                     | 1                     | 6                     | 3-3/8                 | 0.480                      | 0.020       | 4      | 120-03272 | 120-03274 | 120-03275 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 |                       |                            | 0.030       | 4      | 120-03612 | 120-03614 | 120-03615 |
| 5/8                   | 5/8                     | 7/8                   | 3                     |                       |                            | 0.030       | 4      | 120-04022 | 120-04024 | 120-04025 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 |                       |                            | 0.030       | 4      | 120-04012 | 120-04014 | 120-04015 |
| 5/8                   | 5/8                     | 1-3/4                 | 4                     |                       |                            | 0.030       | 4      | 120-04032 | 120-04034 | 120-04035 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     |                       |                            | 0.030       | 4      | 120-04042 | 120-04044 | 120-04045 |
| 3/4                   | 3/4                     | 1                     | 3                     |                       |                            | 0.030       | 4      | 120-04822 | 120-04824 | 120-04825 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.030       | 4      | 120-04812 | 120-04814 | 120-04815 |
| 3/4                   | 3/4                     | 1-5/8                 | 6                     | 2-1/2                 | 0.720                      | 0.030       | 4      | 120-04862 | 120-04864 | 120-04865 |
| 1                     | 1                       | 1-3/4                 | 4                     |                       |                            | 0.030       | 4      | 120-06412 | 120-06414 | 120-06415 |

Feeds & Speeds Available on Page 65

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          |                | ●               | ●        | ●                | ●         |          |                        |               |                     |



**Tolerances**  
 Shank: 3/16" - 1" = -.0001/-0.0004  
 Cutting Dia: 3/16" - 1" = +.000/-0.005  
 Radius: 3/16" - 1" = +/-0.005

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-----------|-----------|
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.030       | 3      | 100-01222 | 100-01224 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.030       | 3      | 100-01212 | 100-01214 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.045       | 4      | 100-01622 | 100-01624 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.045       | 4      | 100-01612 | 100-01614 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 | 0.045       | 4      | 100-02022 | 100-02024 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.045       | 4      | 100-02012 | 100-02014 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.060       | 4      | 100-02422 | 100-02424 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.060       | 4      | 100-02412 | 100-02414 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 0.060       | 4      | 100-02812 | 100-02814 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.060       | 4      | 100-03222 | 100-03224 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.060       | 4      | 100-03212 | 100-03214 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 | 0.060       | 4      | 100-03232 | 100-03234 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 0.060       | 4      | 100-03612 | 100-03614 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 0.060       | 4      | 100-04022 | 100-04024 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.060       | 4      | 100-04012 | 100-04014 |
| 5/8                   | 5/8                     | 2                     | 4                     | 0.060       | 4      | 100-04032 | 100-04034 |
| 3/4                   | 3/4                     | 1                     | 3                     | 0.060       | 4      | 100-04822 | 100-04824 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 0.060       | 4      | 100-04812 | 100-04814 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.060       | 4      | 100-04832 | 100-04834 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.060       | 5      | 100-06412 | 100-06414 |
| 1                     | 1                       | 2-5/8                 | 5                     | 0.060       | 5      | 100-06432 | 100-06434 |

Feeds & Speeds Available on Page 65 - 66

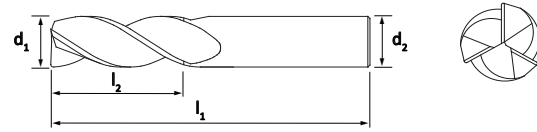
**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                | ●               |          |                  | ●         |          |                        |               |                     |

# Series 106 3 Flute Universal



$\lambda_s = 35^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 3/4'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 3/4'' = +.000/-0.002$   
 Radius:  $1/8'' - 3/4'' = +/-0.001$

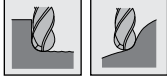
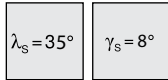
| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flutes | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 |                       |                            | 0.010       | 3      | 106-00822 | 106-00824 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 0.010       | 3      | 106-00812 | 106-00814 |
| 5/32                  | 3/16                    | 5/16                  | 2                     |                       |                            | 0.010       | 3      | 106-01022 | 106-01024 |
| 3/16                  | 3/16                    | 5/16                  | 2                     |                       |                            | 0.010       | 3      | 106-01222 | 106-01224 |
| 3/16                  | 3/16                    | 5/8                   | 2                     |                       |                            | 0.010       | 3      | 106-01212 | 106-01214 |
| 1/4                   | 1/4                     | 3/8                   | 2                     |                       |                            | 0.020       | 3      | 106-01622 | 106-01624 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.020       | 3      | 106-01612 | 106-01614 |
| 1/4                   | 1/4                     | 3/8                   | 4                     | 2-1/8                 | 0.240                      | 0.020       | 3      | 106-01662 | 106-01664 |
| 5/16                  | 5/16                    | 13/16                 | 2-1/2                 |                       |                            | 0.020       | 3      | 106-02012 | 106-02014 |
| 3/8                   | 3/8                     | 1/2                   | 2                     |                       |                            | 0.020       | 3      | 106-02422 | 106-02424 |
| 3/8                   | 3/8                     | 1                     | 2-1/2                 |                       |                            | 0.020       | 3      | 106-02412 | 106-02414 |
| 3/8                   | 3/8                     | 1/2                   | 6                     | 2-1/8                 | 0.360                      | 0.020       | 3      | 106-02462 | 106-02464 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 |                       |                            | 0.020       | 3      | 106-02812 | 106-02814 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 |                       |                            | 0.020       | 3      | 106-03222 | 106-03224 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.020       | 3      | 106-03212 | 106-03214 |
| 1/2                   | 1/2                     | 5/8                   | 6                     | 2-3/8                 | 0.480                      | 0.020       | 3      | 106-03262 | 106-03264 |
| 5/8                   | 5/8                     | 1-5/8                 | 3-1/2                 |                       |                            | 0.030       | 3      | 106-04012 | 106-04014 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.030       | 3      | 106-04812 | 106-04814 |

Feeds & Speeds Available on Page 66

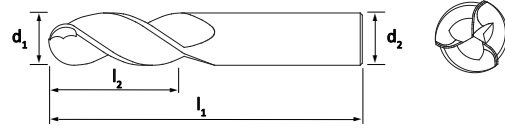
PROMAX PREMIUM

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          |                        |               |                     |

**Tolerances**

Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Ball Radius: 1/8" - 1" = +/- .001



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | R<br>Radius | Flutes | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|-------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 |                       |                            | 0.063       | 3      | 113-00822 | 113-00824 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 |                       |                            | 0.063       | 3      | 113-00812 | 113-00814 |
| 3/16                  | 3/16                    | 5/8                   | 2                     |                       |                            | 0.094       | 3      | 113-01212 | 113-01214 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 |                       |                            | 0.125       | 3      | 113-01612 | 113-01614 |
| 1/4                   | 1/4                     | 3/8                   | 4                     | 2-1/8                 | 0.240                      | 0.125       | 3      | 113-01662 | 113-01664 |
| 5/16                  | 5/16                    | 13/16                 | 2-1/2                 |                       |                            | 0.156       | 3      | 113-02012 | 113-02014 |
| 5/16                  | 5/16                    | 7/16                  | 4                     | 2-1/8                 | 0.300                      | 0.156       | 3      | 113-02062 | 113-02064 |
| 3/8                   | 3/8                     | 1                     | 2-1/2                 |                       |                            | 0.188       | 3      | 113-02412 | 113-02414 |
| 3/8                   | 3/8                     | 1/2                   | 6                     | 2-1/8                 | 0.360                      | 0.188       | 3      | 113-02462 | 113-02464 |
| 3/8                   | 3/8                     | 1/2                   | 6                     | 3-3/8                 | 0.360                      | 0.188       | 3      | 113-02472 | 113-02474 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     |                       |                            | 0.250       | 3      | 113-03212 | 113-03214 |
| 1/2                   | 1/2                     | 5/8                   | 6                     | 2-3/8                 | 0.480                      | 0.250       | 3      | 113-03262 | 113-03264 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 |                       |                            | 0.313       | 3      | 113-04012 | 113-04014 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     |                       |                            | 0.375       | 3      | 113-04812 | 113-04814 |
| 1                     | 1                       | 1-3/4                 | 4                     |                       |                            | 0.500       | 3      | 113-06412 | 113-06414 |

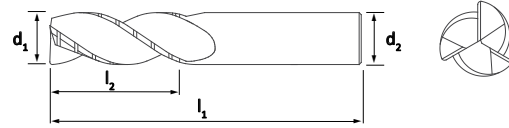
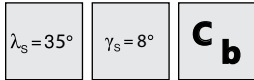
Feeds & Speeds Available on Page 67

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          |                        |               |                     |

# Series 117

## 3 Flute Universal Rougher-Finisher



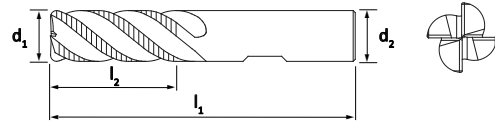
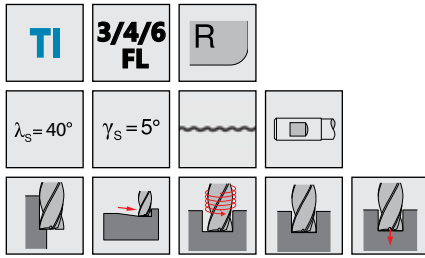
**Tolerances**  
 Shank: 1/8" - 3/4" = -.0001/- .0004  
 Cutting Dia: 1/8" - 3/4" = +.000/- .002  
 Radius: 1/8" - 3/4" = +.002/- .001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-----------|-----------|
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.010       | 3      | 117-00812 | 117-00814 |
| 3/16                  | 3/16                    | 5/16                  | 2                     | 0.010       | 3      | 117-01222 | 117-01224 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.010       | 3      | 117-01212 | 117-01214 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.020       | 3      | 117-01622 | 117-01624 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.020       | 3      | 117-01612 | 117-01614 |
| 5/16                  | 5/16                    | 13/16                 | 2-1/2                 | 0.020       | 3      | 117-02012 | 117-02014 |
| 3/8                   | 3/8                     | 1                     | 2-1/2                 | 0.020       | 3      | 117-02412 | 117-02414 |
| 7/16                  | 7/16                    | 5/8                   | 2-3/4                 | 0.020       | 3      | 117-02822 | 117-02824 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 0.020       | 3      | 117-02812 | 117-02814 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.020       | 3      | 117-03222 | 117-03224 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.020       | 3      | 117-03212 | 117-03214 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.030       | 3      | 117-04012 | 117-04014 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 0.030       | 3      | 117-04812 | 117-04814 |

Feeds & Speeds Available on Page 67

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          |                        |               |                     |



**Tolerances**  
 Shank: 3/16" - 1" = -.0001/-0.0004  
 Cutting Dia: 3/16" - 1" = +.000/-0.005  
 Radius: 3/16" - 1" = +/-0.005

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | TiCN      | AlTiN     | nACRo®    |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-----------|-----------|-----------|
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.030       | 3      | 101-01222 | 101-01224 | 101-01225 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.030       | 3      | 101-01212 | 101-01214 | 101-01215 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.045       | 4      | 101-01622 | 101-01624 | 101-01625 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.045       | 4      | 101-01612 | 101-01614 | 101-01615 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 | 0.045       | 4      | 101-02022 | 101-02024 | 101-02025 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.045       | 4      | 101-02012 | 101-02014 | 101-02015 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.060       | 4      | 101-02422 | 101-02424 | 101-02425 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.060       | 4      | 101-02412 | 101-02414 | 101-02415 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 0.060       | 4      | 101-02812 | 101-02814 | 101-02815 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.060       | 4      | 101-03222 | 101-03224 | 101-03225 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 0.060       | 4      | 101-03212 | 101-03214 | 101-03215 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 | 0.060       | 4      | 101-03232 | 101-03234 | 101-03235 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 0.060       | 4      | 101-03612 | 101-03614 | 101-03615 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 0.060       | 4      | 101-04022 | 101-04024 | 101-04025 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.060       | 4      | 101-04012 | 101-04014 | 101-04015 |
| 5/8                   | 5/8                     | 2                     | 4                     | 0.060       | 4      | 101-04032 | 101-04034 | 101-04035 |
| 3/4                   | 3/4                     | 1                     | 3                     | 0.060       | 4      | 101-04822 | 101-04824 | 101-04825 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 0.060       | 4      | 101-04812 | 101-04814 | 101-04815 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.060       | 4      | 101-04832 | 101-04834 | 101-04835 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.060       | 6      | 101-06412 | 101-06414 | 101-06415 |
| 1                     | 1                       | 2-5/8                 | 5                     | 0.060       | 6      | 101-06432 | 101-06434 | 101-06435 |

Feeds & Speeds Available on Page 68

**Application Range:**

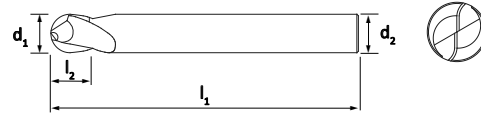
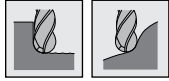
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       | •          |                | •               | •        | •                |           |          |                        |               |                     |

# Series 250

## 2 Flute 0° Die and Mold Tool



$\lambda_s = 30^\circ$       $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 1/2'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 1/2'' = +.000/-0.0008$   
 Radius:  $1/8'' - 1/2'' = +.000/-0.0004$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | R<br>Radius | Flutes | AITiN     |
|--------------|----------------|--------------|--------------|-------------|--------|-----------|
| 1/8          | 1/8            | 1/8          | 3            | 0.063       | 2      | 250-00814 |
| 3/16         | 3/16           | 3/16         | 3            | 0.094       | 2      | 250-01214 |
| 1/4          | 1/4            | 1/4          | 4            | 0.125       | 2      | 250-01614 |
| 3/8          | 3/8            | 3/8          | 4            | 0.188       | 2      | 250-02414 |
| 3/8          | 3/8            | 3/8          | 6            | 0.188       | 2      | 250-02444 |
| 1/2          | 1/2            | 1/2          | 4            | 0.250       | 2      | 250-03214 |
| 1/2          | 1/2            | 1/2          | 6            | 0.250       | 2      | 250-03244 |

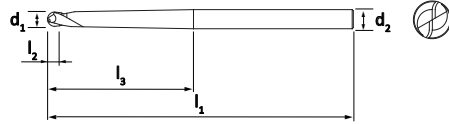
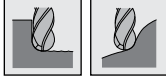
Feeds & Speeds Available on Page 68

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  |           |          |                        |               |                     |



$\lambda_s = 30^\circ$       $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/32" - 3/16" = -.0001/-0.0004  
 Cutting Dia: 1/32" - 3/16" = +.000/-0.0008  
 Radius: 1/32" - 3/16" = +.000/-0.0004

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | R<br>Radius | Flutes | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|-------------|--------|-----------|
| 1/32                  | 1/4                     | 1/32                  | 4                     | 0.625                 | 0.016       | 2      | 251-00214 |
| 0.06                  | 1/4                     | .060                  | 4                     | 1.250                 | 0.030       | 2      | 251-00414 |
| 0.06                  | 1/4                     | .080                  | 4                     | 1.625                 | 0.040       | 2      | 251-00514 |
| 3/32                  | 1/4                     | 3/32                  | 4                     | 1.875                 | 0.047       | 2      | 251-00614 |
| 1/8                   | 1/4                     | 1/8                   | 4                     | 2.500                 | 0.063       | 2      | 251-00814 |
| 3/16                  | 1/4                     | 3/16                  | 4                     | 2.265                 | 0.094       | 2      | 251-01214 |

Feeds & Speeds Available on Page 69

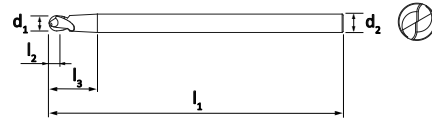
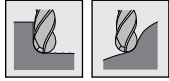
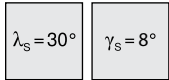
**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  |           |          |                        |               |                     |



# Series 252

## 2 Flute 3° Die and Mold Tool



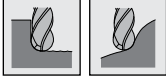
**Tolerances**  
 Shank: 1/32" - 3/16" = -.0001/- .0004  
 Cutting Dia: 1/32" - 3/16" = +.000/- .0008  
 Radius: 1/32" - 3/16" = +.000/- .0004

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | R<br>Radius | Flutes | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|-------------|--------|-----------|
| 1/32                  | 1/4                     | 1/32                  | 4                     | 2.112                 | 0.016       | 2      | 252-00214 |
| 0.06                  | 1/4                     | .060                  | 4                     | 1.875                 | 0.030       | 2      | 252-00414 |
| 0.06                  | 1/4                     | .080                  | 4                     | 1.704                 | 0.040       | 2      | 252-00514 |
| 3/32                  | 1/4                     | 3/32                  | 4                     | 1.584                 | 0.047       | 2      | 252-00614 |
| 1/8                   | 1/4                     | 1/8                   | 4                     | 1.324                 | 0.063       | 2      | 252-00814 |
| 3/16                  | 1/4                     | 3/16                  | 4                     | 0.786                 | 0.094       | 2      | 252-01214 |

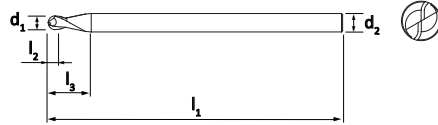
Feeds & Speeds Available on Page 69

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  |           |          |                        |               |                     |


 $\lambda_s = 30^\circ$      $\gamma_s = 8^\circ$ 
**Tolerances**

Shank: 1/32" - 3/16" = -.0001/- .0004  
 Cutting Dia: 1/32" - 3/16" = +.000/- .0008  
 Radius: 1/32" - 3/16" = +.000/- .0004



| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | $l_3$<br>LOR | R<br>Radius | Flutes | AlTiN     |
|--------------|----------------|--------------|--------------|--------------|-------------|--------|-----------|
| 1/32         | 1/4            | 1/32         | 4            | 1.282        | 0.016       | 2      | 253-00214 |
| 0.06         | 1/4            | .060         | 4            | 1.175        | 0.030       | 2      | 253-00414 |
| 0.06         | 1/4            | .080         | 4            | 1.084        | 0.040       | 2      | 253-00514 |
| 3/32         | 1/4            | 3/32         | 4            | 1.018        | 0.047       | 2      | 253-00614 |
| 1/8          | 1/4            | 1/8          | 4            | 0.897        | 0.063       | 2      | 253-00814 |
| 3/16         | 1/4            | 3/16         | 4            | 0.680        | 0.094       | 2      | 253-01214 |

**Feeds & Speeds Available on Page 69**
**Application Range:**

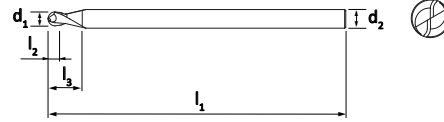
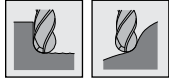
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  |           |          |                        |               |                     |

# Series 254

## 2 Flute 8° Die and Mold Tool



$\lambda_s = 30^\circ$       $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/32'' - 3/16'' = -.0001/-0.0004$   
 Cutting Dia:  $1/32'' - 3/16'' = +.000/-0.0008$   
 Radius:  $1/32'' - 3/16'' = +.000/-0.0004$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | $l_3$<br>LOR | R<br>Radius | Flutes | AlTiN     |
|--------------|----------------|--------------|--------------|--------------|-------------|--------|-----------|
| 1/32         | 1/4            | 1/32         | 4            | 0.851        | 0.016       | 2      | 254-00214 |
| 0.06         | 1/4            | .060         | 4            | 0.773        | 0.030       | 2      | 254-00414 |
| 0.06         | 1/4            | .080         | 4            | 0.726        | 0.040       | 2      | 254-00514 |
| 3/32         | 1/4            | 3/32         | 4            | 0.690        | 0.047       | 2      | 254-00614 |
| 1/8          | 1/4            | 1/8          | 4            | 0.636        | 0.063       | 2      | 254-00814 |
| 3/16         | 1/4            | 3/16         | 4            | 0.454        | 0.094       | 2      | 254-01214 |

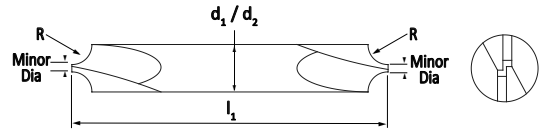
Feeds & Speeds Available on Page 69

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  |           |          |                        |               |                     |

**Tolerances**

Shank:  $1/8'' - 3/8'' = -.0001/-0.0004$   
 Radius:  $1/8'' - 3/8'' = +/- .001$



| $d_1$<br>Dia | $d_2$<br>Shank | $L_1$<br>OAL | Minor Dia | R<br>Radius | Flutes | Uncoated  | TiCN      | AlTiN     |
|--------------|----------------|--------------|-----------|-------------|--------|-----------|-----------|-----------|
| 1/8          | 1/8            | 1-1/2        | 0.105     | 0.010       | 2      | 137-00810 | 137-00812 | 137-00814 |
| 1/8          | 1/8            | 1-1/2        | 0.095     | 0.010       | 2      | 137-00820 | 137-00822 | 137-00824 |
| 1/8          | 1/8            | 1-1/2        | 0.085     | 0.020       | 2      | 137-00830 | 137-00832 | 137-00834 |
| 1/8          | 1/8            | 1-1/2        | 0.075     | 0.020       | 2      | 137-00840 | 137-00842 | 137-00844 |
| 1/8          | 1/8            | 1-1/2        | 0.063     | 0.031       | 2      | 137-00850 | 137-00852 | 137-00854 |
| 1/8          | 1/8            | 1-1/2        | 0.055     | 0.031       | 2      | 137-00860 | 137-00862 | 137-00864 |
| 1/8          | 1/8            | 1-1/2        | 0.045     | 0.040       | 2      | 137-00870 | 137-00872 | 137-00874 |
| 1/8          | 1/8            | 1-1/2        | 0.095     | 0.040       | 2      | 137-01210 | 137-01212 | 137-01214 |
| 3/16         | 3/16           | 2            | 0.087     | 0.050       | 2      | 137-01220 | 137-01222 | 137-01224 |
| 3/16         | 3/16           | 2            | 0.077     | 0.050       | 2      | 137-01230 | 137-01232 | 137-01234 |
| 3/16         | 3/16           | 2            | 0.058     | 0.062       | 2      | 137-01240 | 137-01242 | 137-01244 |
| 1/4          | 1/4            | 2-1/2        | 0.106     | 0.072       | 2      | 137-01610 | 137-01612 | 137-01614 |
| 1/4          | 1/4            | 2-1/2        | 0.094     | 0.072       | 2      | 137-01620 | 137-01622 | 137-01624 |
| 1/4          | 1/4            | 2-1/2        | 0.080     | 0.085       | 2      | 137-01630 | 137-01632 | 137-01634 |
| 1/4          | 1/4            | 2-1/2        | 0.062     | 0.094       | 2      | 137-01640 | 137-01642 | 137-01644 |
| 1/4          | 1/4            | 2-1/2        | 0.050     | 0.100       | 2      | 137-01650 | 137-01652 | 137-01654 |
| 1/4          | 1/4            | 2-1/2        | 0.094     | 0.100       | 2      | 137-02010 | 137-02012 | 137-02014 |
| 5/16         | 5/16           | 2-1/2        | 0.076     | 0.118       | 2      | 137-02020 | 137-02022 | 137-02024 |
| 5/16         | 5/16           | 2-1/2        | 0.063     | 0.125       | 2      | 137-02030 | 137-02032 | 137-02034 |
| 3/8          | 3/8            | 2-1/2        | 0.095     | 0.140       | 2      | 137-02410 | 137-02412 | 137-02414 |
| 3/8          | 3/8            | 2-1/2        | 0.063     | 0.156       | 2      | 137-02420 | 137-02422 | 137-02424 |

**Application Range:**

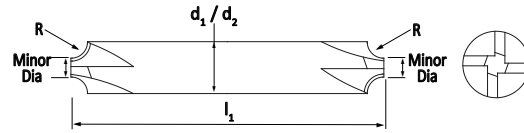
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  |           |          |                        |               |                     |

# Series 139

## 4 Flute Corner Rounder



$\gamma_s = 3.5^\circ$



**Tolerances**  
 Shank:  $3/16'' - 1/2'' = -.0001/-0.0004$   
 Radius:  $3/16'' - 1/2'' = +/-0.001$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_1$<br>OAL | Minor Dia | R<br>Radius | Flutes | Uncoated  | TiCN      | AlTiN     |
|--------------|----------------|--------------|-----------|-------------|--------|-----------|-----------|-----------|
| 3/16         | 3/16           | 2            | 0.162     | 0.010       | 4      | 139-01200 | 139-01202 | 139-01204 |
| 3/16         | 3/16           | 2            | 0.152     | 0.015       | 4      | 139-01210 | 139-01212 | 139-01214 |
| 3/16         | 3/16           | 2            | 0.142     | 0.020       | 4      | 139-01220 | 139-01222 | 139-01224 |
| 3/16         | 3/16           | 2            | 0.132     | 0.025       | 4      | 139-01230 | 139-01232 | 139-01234 |
| 3/16         | 3/16           | 2            | 0.120     | 0.031       | 4      | 139-01240 | 139-01242 | 139-01244 |
| 3/16         | 3/16           | 2            | 0.112     | 0.035       | 4      | 139-01250 | 139-01252 | 139-01254 |
| 1/4          | 1/4            | 2-1/2        | 0.165     | 0.040       | 4      | 139-01600 | 139-01602 | 139-01604 |
| 1/4          | 1/4            | 2-1/2        | 0.153     | 0.046       | 4      | 139-01610 | 139-01612 | 139-01614 |
| 1/4          | 1/4            | 2-1/2        | 0.145     | 0.050       | 4      | 139-01620 | 139-01622 | 139-01624 |
| 1/4          | 1/4            | 2-1/2        | 0.135     | 0.055       | 4      | 139-01640 | 139-01642 | 139-01644 |
| 1/4          | 1/4            | 2-1/2        | 0.121     | 0.062       | 4      | 139-01630 | 139-01632 | 139-01634 |
| 3/8          | 3/8            | 2-1/2        | 0.214     | 0.078       | 4      | 139-02400 | 139-02402 | 139-02404 |
| 3/8          | 3/8            | 2-1/2        | 0.182     | 0.094       | 4      | 139-02410 | 139-02412 | 139-02414 |
| 3/8          | 3/8            | 2-1/2        | 0.170     | 0.100       | 4      | 139-02420 | 139-02422 | 139-02424 |
| 3/8          | 3/8            | 2-1/2        | 0.134     | 0.118       | 4      | 139-02430 | 139-02432 | 139-02434 |
| 3/8          | 3/8            | 2-1/2        | 0.120     | 0.125       | 4      | 139-02440 | 139-02442 | 139-02444 |
| 1/2          | 1/2            | 3            | 0.183     | 0.156       | 4      | 139-03200 | 139-03202 | 139-03204 |

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          |                | •               |          |                  |           |          |                        |               |                     |

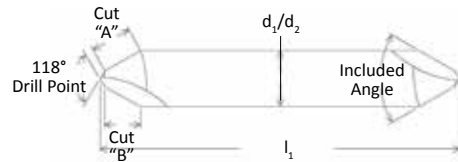
UN

2 FL

4 FL



Standard with 118° Drill Point

**Tolerances**Shank:  $1/8'' - 1/2'' = -.0001/- .0004$ 

| $d_1$<br>Dia | $d_2$<br>Shank | $l_1$<br>OAL | Included<br>Angle | Cut "A" | Cut "B" | Flutes | Uncoated  | TiCN      | AlTiN     |
|--------------|----------------|--------------|-------------------|---------|---------|--------|-----------|-----------|-----------|
| * 1/8        | 1/8            | 1-1/2        | 60°               | 0.098   | 0.085   | 2      | 132-00820 | 132-00822 | 132-00824 |
| * 3/16       | 3/16           | 2            | 60°               | 0.147   | 0.127   | 2      | 132-01220 | 132-01222 | 132-01224 |
| 1/4          | 1/4            | 2-1/2        | 60°               | 0.200   | 0.173   | 2      | 132-01520 | 132-01522 | 132-01524 |
| 3/8          | 3/8            | 2-1/2        | 60°               | 0.313   | 0.271   | 2      | 132-02420 | 132-02422 | 132-02424 |
| 1/2          | 1/2            | 3            | 60°               | 0.430   | 0.372   | 2      | 132-03220 | 132-03222 | 132-03224 |

\* No Drill Point



Standard with 118° Drill Point

| $d_1$<br>Dia | $d_2$<br>Shank | $l_1$<br>OAL | Included<br>Angle | Cut "A" | Cut "B" | Flutes | Uncoated  | TiCN      | AlTiN     |
|--------------|----------------|--------------|-------------------|---------|---------|--------|-----------|-----------|-----------|
| 1/4          | 1/4            | 2-1/2        | 60°               | 0.200   | 0.173   | 4      | 133-01520 | 133-01522 | 133-01524 |
| 3/8          | 3/8            | 2-1/2        | 60°               | 0.313   | 0.271   | 4      | 133-02420 | 133-02422 | 133-02424 |
| 1/2          | 1/2            | 3            | 60°               | 0.430   | 0.372   | 4      | 133-03220 | 133-03222 | 133-03224 |

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         | •        | •                      | •             | •                   |

# Series 134 & 135

## 2 & 4 Flute 90° Chamfer-Spot

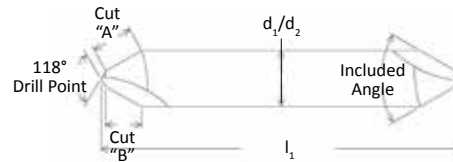
**UN**   **2 FL**   **4 FL**



Standard with 118° Drill Point



**Tolerances**  
Shank:  $1/8'' - 1/2'' = -.0001/- .0004$



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>1</sub><br>OAL | Included<br>Angle | Cut "A" | Cut "B" | Flutes | Uncoated  | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-------------------|---------|---------|--------|-----------|-----------|-----------|
| * 1/8                 | 1/8                     | 1-1/2                 | 90°               | 0.071   | 0.050   | 2      | 134-00830 | 134-00832 | 134-00834 |
| * 3/16                | 3/16                    | 2                     | 90°               | 0.107   | 0.076   | 2      | 134-01230 | 134-01232 | 134-01234 |
| 1/4                   | 1/4                     | 2-1/2                 | 90°               | 0.141   | 0.100   | 2      | 134-01530 | 134-01532 | 134-01534 |
| 3/8                   | 3/8                     | 2-1/2                 | 90°               | 0.221   | 0.157   | 2      | 134-02430 | 134-02432 | 134-02434 |
| 1/2                   | 1/2                     | 3                     | 90°               | 0.304   | 0.215   | 2      | 134-03230 | 134-03232 | 134-03234 |

\* No Drill Point



Standard with 118° Drill Point

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>1</sub><br>OAL | Included<br>Angle | Cut "A" | Cut "B" | Flutes | Uncoated  | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-------------------|---------|---------|--------|-----------|-----------|-----------|
| 1/4                   | 1/4                     | 2-1/2                 | 90°               | 0.141   | 0.100   | 4      | 135-01530 | 135-01532 | 135-01534 |
| 3/8                   | 3/8                     | 2-1/2                 | 90°               | 0.221   | 0.157   | 4      | 135-02430 | 135-02432 | 135-02434 |
| 1/2                   | 1/2                     | 3                     | 90°               | 0.304   | 0.215   | 4      | 135-03230 | 135-03232 | 135-03234 |

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         | •        | •                      | •             | •                   |

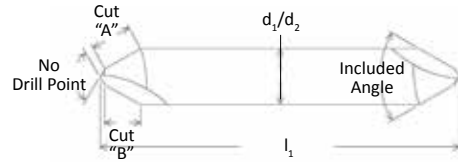
UN

2 FL

4 FL



No Drill Point

**Tolerances**Shank:  $1/4" - 1/2" = -.0001/-0.0004$ 

| $d_1$<br>Dia | $d_2$<br>Shank | $l_1$<br>OAL | Included<br>Angle | Cut "A" | Cut "B" | Cut "B" | Uncoated  | TiCN      | AlTiN     |
|--------------|----------------|--------------|-------------------|---------|---------|---------|-----------|-----------|-----------|
| * 1/4        | 1/4            | 2-1/2        | 120°              | 0.124   | 0.062   | 2       | 130-01510 | 130-01512 | 130-01514 |
| * 3/8        | 3/8            | 2-1/2        | 120°              | 0.199   | 0.100   | 2       | 130-02410 | 130-02412 | 130-02414 |
| * 1/2        | 1/2            | 3            | 120°              | 0.266   | 0.133   | 2       | 130-03210 | 130-03212 | 130-03214 |

\* No Drill Point



No Drill Point

| $d_1$<br>Dia | $d_2$<br>Shank | $l_1$<br>OAL | Included<br>Angle | Cut "A" | Cut "B" | Cut "B" | Uncoated  | TiCN      | AlTiN     |
|--------------|----------------|--------------|-------------------|---------|---------|---------|-----------|-----------|-----------|
| * 1/4        | 1/4            | 2-1/2        | 120°              | 0.144   | 0.072   | 4       | 131-01510 | 131-01512 | 131-01514 |
| * 3/8        | 3/8            | 2-1/2        | 120°              | 0.217   | 0.108   | 4       | 131-02410 | 131-02412 | 131-02414 |
| * 1/2        | 1/2            | 3            | 120°              | 0.289   | 0.144   | 4       | 131-03210 | 131-03212 | 131-03214 |

\* No Drill Point

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         | •        | •                      | •             | •                   |



| Aluminum - 109 / 102 |                             |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------|-----------------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation |                             | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                      |                             |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Aluminium            | Non-Alloy                   | 410             | 1xø               | 0.7xø            | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                      | Wrought Alloy Non-Hardened  | 410             | 1xø               | 0.7xø            | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                      | Wrought Alloy Hardened      | 410             | 1xø               | 0.7xø            | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                      | Casting Alloy < 6% Si       | 328             | 1xø               | 0.7xø            | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                      | Casting Alloy 6-12% Si      | 295             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
|                      | Casting Alloy > 6% Si       | 246             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
| Magnesium            | Wrought Alloy               | 295             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
|                      | Casting Alloy               | 262             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
| Copper               | Non-Alloy                   | 230             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Wrought Alloy Non-Hardened  | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Wrought Alloy Hardened      | 164             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | CuNi-Alloy                  | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | CuNiZn-Alloy Long-Chipping  | 164             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | CuNiZn-Alloy Short-Chipping | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
| CuZn (Brass)         | Long-Chipping               | 246             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Short-Chipping              | 328             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
| CuSn (Bronze)        | Long-Chipping               | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Short-Chipping              | 230             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
| CuAlFe (Ampco)       | Long-Chipping               | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Short-Chipping              | 230             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
| Titanium             | Non-Alloy                   | 82              | 1xø               | 0.7xø            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                      | Alloyed-Annealed            | 57              | 1xø               | 0.7xø            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                      | Alloyed-Hardened            | 33              | 1xø               | 0.7xø            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |

| Aluminum - 119       |                             |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------|-----------------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation |                             | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                      |                             |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Aluminium            | Non-Alloy                   | 984             | 1xø               | 0.7xø            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                      | Wrought Alloy Non-Hardened  | 984             | 1xø               | 0.7xø            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                      | Wrought Alloy Hardened      | 984             | 1xø               | 0.7xø            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                      | Casting Alloy < 6% Si       | 787             | 1xø               | 0.7xø            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                      | Casting Alloy 6-12% Si      | 591             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
|                      | Casting Alloy > 6% Si       | 394             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
| Magnesium            | Wrought Alloy               | 361             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
|                      | Casting Alloy               | 328             | 1xø               | 0.7xø            | 0.0008                     | 0.0014                 | 0.0019        | 0.0033       | 0.0047 | 0.0058 |
| Copper               | Non-Alloy                   | 279             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Wrought Alloy Non-Hardened  | 254             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Wrought Alloy Hardened      | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | CuNi-Alloy                  | 246             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | CuNiZn-Alloy Long-Chipping  | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | CuNiZn-Alloy Short-Chipping | 246             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
| CuZn (Brass)         | Long-Chipping               | 295             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Short-Chipping              | 394             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
| CuSn (Bronze)        | Long-Chipping               | 246             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Short-Chipping              | 279             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
| CuAlFe (Ampco)       | Long-Chipping               | 90              | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |
|                      | Short-Chipping              | 115             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0033 | 0.0039 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Universal - 160 / 161            |  |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                  |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>                      | 533             | 0.05xø            | 1.4xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | > 500 N/mm <sup>2</sup>                      | 492             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>            | 509             | 0.05xø            | 1.4xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>            | 476             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy  | 459             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spring Steel                     | Annealed < 250 HB                            | 262             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | Natural Hard 250-350 HB                      | 246             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | Feeder Hard 1200-1600 N/mm <sup>2</sup>      | 230             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cementation Steel                | < 150 HB                                     | 427             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | 150-200 HB                                   | 410             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 200 HB                                     | 377             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>                     | 377             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 1000 N/mm <sup>2</sup>                     | 344             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>            | 410             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 377             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy < 800 N/mm <sup>2</sup>                | 377             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>             | 361             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>            | 344             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | Alloy 1300-1600 N/mm <sup>2</sup>            | 312             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Non-Alloy Tool Steel             | General                                      | 377             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Cold Processing   | Low Alloy < 1000 N/mm <sup>2</sup>           | 361             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1200 N/mm <sup>2</sup>           | 344             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 303             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 328             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 287             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Warm Processing   | Low Alloy < 1200 N/mm <sup>2</sup>           | 336             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 303             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 303             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 287             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 262             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Stainless Steel                  | Ferric                                       | 197             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Martensitic                                  | 164             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic A5 < 40%                          | 197             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic A5 > 40%                          | 197             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Sulphured                                    | 213             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| High Temperature Alloy           | Fe-Alloy                                     | 66              | 0.05xø            | 1.4xø            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Ni-Alloy not hardened                        | 66              | 0.05xø            | 1.4xø            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Ni-Alloy hardened                            | 66              | 0.05xø            | 1.4xø            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Co-Alloy                                     | 66              | 0.05xø            | 1.4xø            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Cast Iron                                    | Non-Alloy       | 410               | 0.05xø           | 1.4xø                      | 0.0006                 | 0.0011        | 0.0017       | 0.0022 | 0.0028 |
| Stainless Cast Steel             | Low-Alloy                                    | 328             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High-Alloy                                   | 246             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Ferric/Martensitic                           | 197             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cast Iron with Lamellar Graphite | Austentic                                    | 197             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Non-Alloy < 180 HB                           | 410             | 0.05xø            | 1.4xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                           | 361             | 0.05xø            | 1.4xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloy  | 328             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spheroidal Cast Iron             | High Alloy                                   | 246             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy < 180 HB                           | 377             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy > 180 HB                           | 344             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| White Malleable Cast Iron        | Alloy  | 303             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | < 180 HB                                     | 361             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Black Malleable Cast Iron        | > 180 HB                                     | 328             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | < 180 HB                                     | 361             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Titanium                         | > 180 HB                                     | 328             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy                                    | 328             | 0.05xø            | 1.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloyed-Annealed                             | 287             | 0.05xø            | 1.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | Alloyed-Hardened                             | 205             | 0.05xø            | 1.4xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Material Designation             |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|----------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
|                                  |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>                      | 427             | 1xø               | 0.7xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | > 500 N/mm <sup>2</sup>                      | 394             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>            | 410             | 1xø               | 0.7xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>            | 377             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy  | 361             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Cementation Steel                | < 150 HB                                     | 344             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | 150-200 HB                                   | 328             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 200 HB                                     | 312             | 1xø               | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>                     | 312             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 1000 N/mm <sup>2</sup>                     | 279             | 1xø               | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>            | 328             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 312             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy < 800 N/mm <sup>2</sup>                | 312             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>             | 295             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>            | 279             | 1xø               | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | Alloy 1300-1600 N/mm <sup>2</sup>            | 246             | 1xø               | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Non-Alloy Tool Steel             | General                                      | 303             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Cold Processing   | Low Alloy < 1000 N/mm <sup>2</sup>           | 295             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1200 N/mm <sup>2</sup>           | 279             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 246             | 1xø               | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 262             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Warm Processing   | Low Alloy < 1200 N/mm <sup>2</sup>           | 328             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 295             | 1xø               | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 246             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 213             | 1xø               | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Stainless Steel                  | Ferric                                       | 164             | 1xø               | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Martensitic                                  | 131             | 1xø               | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic A5 < 40%                          | 164             | 1xø               | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic A5 > 40%                          | 164             | 1xø               | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Sulphured                                    | 180             | 1xø               | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| High Temperature Alloy           | Fe-Alloy                                     | 90              | 0.5xø             | 0.7xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Ni-Alloy not hardened                        | 90              | 0.5xø             | 0.7xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Ni-Alloy hardened                            | 90              | 0.5xø             | 0.7xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Co-Alloy                                     | 90              | 0.5xø             | 0.7xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Cast Iron                        | Non-Alloy                                    | 328             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low-Alloy                                    | 262             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High-Alloy                                   | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Stainless Cast Steel             | Ferric/Martensitic                           | 164             | 1xø               | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic                                   | 164             | 1xø               | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                           | 328             | 1xø               | 0.7xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                           | 295             | 1xø               | 0.7xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloy  | 262             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy                                   | 197             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                           | 312             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy > 180 HB                           | 279             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy  | 246             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| White Malleable Cast Iron        | < 180 HB                                     | 295             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB                                     | 262             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Black Malleable Cast Iron        | < 180 HB                                     | 295             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB                                     | 262             | 1xø               | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Titanium                         | Non-Alloy                                    | 197             | 0.5xø             | 0.7xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloyed-Annealed                             | 164             | 0.5xø             | 0.7xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloyed-Hardened                             | 131             | 0.5xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Universal - 158 / 159            |  |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip load per tooth [inch] |                        |               |              |        |        |
|                                  |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>                      | 427             | 1x $\phi$         | 0.7x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | > 500 N/mm <sup>2</sup>                      | 394             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>            | 410             | 1x $\phi$         | 0.7x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>            | 377             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy  | 361             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Cementation Steel                | < 150 HB                                     | 344             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | 150-200 HB                                   | 328             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 200 HB                                     | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>                     | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 1000 N/mm <sup>2</sup>                     | 279             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>            | 328             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy < 800 N/mm <sup>2</sup>                | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>             | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>            | 279             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | Alloy 1300-1600 N/mm <sup>2</sup>            | 246             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Non-Alloy Tool Steel             | General                                      | 303             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Cold Processing   | Low Alloy < 1000 N/mm <sup>2</sup>           | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1200 N/mm <sup>2</sup>           | 279             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 246             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Warm Processing   | Low Alloy < 1200 N/mm <sup>2</sup>           | 328             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low Alloy < 1500 N/mm <sup>2</sup>           | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 246             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Stainless Steel                  | Ferric                                       | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Martensitic                                  | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic A5 < 40%                          | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic A5 > 40%                          | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Sulphured                                    | 180             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| High Temperature Alloy           | Fe-Alloy                                     | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Ni-Alloy not hardened                        | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Ni-Alloy hardened                            | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Co-Alloy                                     | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Cast Iron                        | Non-Alloy                                    | 328             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low-Alloy                                    | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High-Alloy                                   | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Stainless Cast Steel             | Ferric/Martensitic                           | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austentic                                    | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                           | 328             | 1x $\phi$         | 0.7x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                           | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloy  | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy                                   | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                           | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy > 180 HB                           | 279             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy  | 246             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| White Malleable Cast Iron        | < 180 HB                                     | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB                                     | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Black Malleable Cast Iron        | < 180 HB                                     | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB                                     | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy  | 246             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Titanium                         | Non-Alloy                                    | 197             | 1x $\phi$         | 0.4x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloyed-Annealed                             | 164             | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloyed-Hardened                             | 131             | 1x $\phi$         | 0.4x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Universal - 121                |  |                 |                   |                  |                            |                        |               |              |        |        |
|--------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation           |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                | < 500 N/mm <sup>2</sup>                      | 287             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | > 500 N/mm <sup>2</sup>                      | 246             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Construction Steel             | Non-Alloy < 500 N/mm <sup>2</sup>            | 287             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                | Non-Alloy > 500 N/mm <sup>2</sup>            | 246             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                | Alloy  | 246             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Spring Steel                   | Annealed < 250 HB                            | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Cementation Steel              | < 150 HB                                     | 287             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | 150-200 HB                                   | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | > 200 HB                                     | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Nitriding Steel                | < 1000 N/mm <sup>2</sup>                     | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | > 1000 N/mm <sup>2</sup>                     | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Quenched & Tempered Steel      | Non-Alloy < 800 N/mm <sup>2</sup>            | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | Alloy < 800 N/mm <sup>2</sup>                | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | Alloy 800-1000 N/mm <sup>2</sup>             | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | Alloy 1000-1300 N/mm <sup>2</sup>            | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Non-Alloy Tool Steel           | General                                      | 246             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Tool Steel for Cold Processing | Low Alloy < 1000 N/mm <sup>2</sup>           | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | Low Alloy < 1200 N/mm <sup>2</sup>           | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Tool Steel for Warm Processing | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |

| Universal - 111           |   |                 |                   |                  |                            |                        |               |              |        |        |
|---------------------------|---|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation      |   | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                           |   |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel           | < 500 N/mm <sup>2</sup>                 | 427             | 1xØ               | 1.1xØ            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                           | > 500 N/mm <sup>2</sup>                 | 394             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Construction Steel        | Non-Alloy < 500 N/mm <sup>2</sup>       | 410             | 1xØ               | 1.1xØ            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                           | Non-Alloy > 500 N/mm <sup>2</sup>       | 377             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | Alloy                                   | 361             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spring Steel              | Annealed < 250 HB                       | 213             | 1xØ               | 1.1xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                           | Natural Hard 250-350 HB                 | 197             | 1xØ               | 1.1xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                           | Feader Hard 1200-1600 N/mm <sup>2</sup> | 180             | 1xØ               | 1.1xØ            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cementation Steel         | < 150 HB                                | 344             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | 150-200 HB                              | 328             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | > 200 HB                                | 312             | 1xØ               | 1.1xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Nitriding Steel           | < 1000 N/mm <sup>2</sup>                | 312             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | > 1000 N/mm <sup>2</sup>                | 279             | 1xØ               | 1.1xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Quenched & Tempered Steel | Non-Alloy < 800 N/mm <sup>2</sup>       | 328             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | Non-Alloy 800-1000 N/mm <sup>2</sup>    | 312             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | Alloy < 800 N/mm <sup>2</sup>           | 312             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | Alloy 800-1000 N/mm <sup>2</sup>        | 295             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | Alloy 1000-1300 N/mm <sup>2</sup>       | 279             | 1xØ               | 1.1xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                           | Alloy 1300-1600 N/mm <sup>2</sup>       | 246             | 1xØ               | 1.1xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Non-Alloy Tool Steel      | General                                 | 303             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Stainless Steel           | Ferric                                  | 164             | 0.8xØ             | 0.7xØ            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                           | Martensitic                             | 131             | 0.8xØ             | 0.7xØ            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                           | Austenitic A5 < 40%                     | 164             | 0.8xØ             | 0.7xØ            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                           | Austenitic A5 > 40%                     | 164             | 0.8xØ             | 0.7xØ            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                           | Sulphured                               | 180             | 0.8xØ             | 0.7xØ            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
| High Temperature Alloy    | Fe-Alloy                                | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                           | Ni-Alloy not hardened                   | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                           | Ni-Alloy hardened                       | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                           | Co-Alloy                                | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Cast Iron                 | Non-Alloy                               | 328             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | Low-Alloy                               | 262             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                           | High-Alloy                              | 197             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Stainless Cast Steel      | Ferric/Martensitic                      | 197             | 1xØ               | 1.1xØ            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                           | Austentic                               | 197             | 1xØ               | 1.1xØ            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Universal - 111 (Continued)      |                    |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|--------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |                    | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                  |                    |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB | 328             | 1x $\phi$         | 1.1x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB | 295             | 1x $\phi$         | 1.1x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloy              | 262             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy         | 197             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB | 312             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy > 180 HB | 279             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy              | 246             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| White Malleable Cast Iron        | < 180 HB           | 295             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB           | 262             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Black Malleable Cast Iron        | < 180 HB           | 295             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB           | 262             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Titanium                         | Non-Alloy          | 197             | 1x $\phi$         | 0.4x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloyed-Annealed   | 164             | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloyed-Hardened   | 131             | 1x $\phi$         | 0.4x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |

| Universal - 155 / 156          |  |                 |                   |                  |                            |                        |               |              |        |        |
|--------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation           |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                | < 500 N/mm <sup>2</sup>                      | 427             | 1x $\phi$         | 1.1x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                | > 500 N/mm <sup>2</sup>                      | 394             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Construction Steel             | Non-Alloy < 500 N/mm <sup>2</sup>            | 410             | 1x $\phi$         | 1.1x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                | Non-Alloy > 500 N/mm <sup>2</sup>            | 377             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Alloy  | 361             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spring Steel                   | Annealed < 250 HB                            | 213             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | Natural Hard 250-350 HB                      | 197             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | Feader Hard 1200-1600 N/mm <sup>2</sup>      | 180             | 1x $\phi$         | 1.1x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cementation Steel              | < 150 HB                                     | 344             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | 150-200 HB                                   | 328             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | > 200 HB                                     | 312             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Nitriding Steel                | < 1000 N/mm <sup>2</sup>                     | 312             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | > 1000 N/mm <sup>2</sup>                     | 279             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Quenched & Tempered Steel      | Non-Alloy < 800 N/mm <sup>2</sup>            | 328             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 312             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Alloy < 800 N/mm <sup>2</sup>                | 312             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Alloy 800-1000 N/mm <sup>2</sup>             | 295             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Alloy 1000-1300 N/mm <sup>2</sup>            | 279             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | Alloy 1300-1600 N/mm <sup>2</sup>            | 246             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Non-Alloy Tool Steel           | General                                      | 303             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Cold Processing | Low Alloy < 1000 N/mm <sup>2</sup>           | 295             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Low Alloy < 1200 N/mm <sup>2</sup>           | 279             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 246             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 262             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Tool Steel for Warm Processing | Low Alloy < 1200 N/mm <sup>2</sup>           | 328             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 295             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 246             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 213             | 1x $\phi$         | 1.1x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Stainless Steel                | Ferric                                       | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                | Martensitic                                  | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                | Austenitic A5 < 40%                          | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                | Austenitic A5 > 40%                          | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                | Sulphured                                    | 180             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| High Temperature Alloy         | Fe-Alloy                                     | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Ni-Alloy not hardened                        | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Ni-Alloy hardened                            | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Co-Alloy                                     | 90              | 1x $\phi$         | 0.4x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Cast Iron                      | Non-Alloy                                    | 328             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Low-Alloy                                    | 262             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | High-Alloy                                   | 197             | 1x $\phi$         | 1.1x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Universal - 155 / 156 (Continued) |                    |                 |                   |                  |                            |                        |               |              |        |        |
|-----------------------------------|--------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation              |                    | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                   |                    |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Stainless Cast Steel              | Ferric/Martensitic | 197             | 1xØ               | 1.1xØ            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                   | Austenitic         | 197             | 1xØ               | 1.1xØ            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cast Iron with Lamellar Graphite  | Non-Alloy < 180 HB | 328             | 1xØ               | 1.1xØ            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                   | Non-Alloy > 180 HB | 295             | 1xØ               | 1.1xØ            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                   | Alloy              | 262             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                   | High Alloy         | 197             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spheroidal Cast Iron              | Non-Alloy < 180 HB | 312             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                   | Non-Alloy > 180 HB | 279             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                   | Alloy              | 246             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| White Malleable Cast Iron         | < 180 HB           | 295             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                   | > 180 HB           | 262             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Black Malleable Cast Iron         | < 180 HB           | 295             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                   | > 180 HB           | 262             | 1xØ               | 1.1xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Titanium                          | Non-Alloy          | 197             | 1xØ               | 0.4xØ            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                   | Alloyed-Annealed   | 164             | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                   | Alloyed-Hardened   | 131             | 1xØ               | 0.4xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |

| Universal - 157                |  |                 |                   |                  |                            |                        |               |              |        |        |
|--------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation           |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load Per Tooth [inch] |                        |               |              |        |        |
|                                |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                | < 500 N/mm <sup>2</sup>                      | 968             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | > 500 N/mm <sup>2</sup>                      | 755             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
| Construction Steel             | Non-Alloy < 500 N/mm <sup>2</sup>            | 968             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Non-Alloy > 500 N/mm <sup>2</sup>            | 755             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Alloy  | 640             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Spring Steel                   | Annealed < 250 HB                            | 853             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Natural Hard 250-350 HB                      | 755             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                | Feeder Hard 1200-1600 N/mm <sup>2</sup>      | 509             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Cementation Steel              | < 150 HB                                     | 919             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | 150-200 HB                                   | 853             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | > 200 HB                                     | 656             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Nitriding Steel                | < 1000 N/mm <sup>2</sup>                     | 771             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | > 1000 N/mm <sup>2</sup>                     | 574             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Quenched & Tempered Steel      | Non-Alloy < 800 N/mm <sup>2</sup>            | 853             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 689             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Alloy < 800 N/mm <sup>2</sup>                | 574             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Alloy 800-1000 N/mm <sup>2</sup>             | 640             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Alloy 1000-1300 N/mm <sup>2</sup>            | 574             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                | Alloy 1300-1600 N/mm <sup>2</sup>            | 476             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Non-Alloy Tool Steel           | General                                      | 755             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
| Tool Steel for Cold Processing | Low Alloy < 1000 N/mm <sup>2</sup>           | 640             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Low Alloy < 1200 N/mm <sup>2</sup>           | 541             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 427             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 541             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 377             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Tool Steel for Warm Processing | Low Alloy < 1200 N/mm <sup>2</sup>           | 543             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 427             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 541             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 377             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 344             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                | Stainless Steel                              | Ferric          | 82                | 0.05xØ           | 0.08xØ                     | 0.0003                 | 0.0006        | 0.0008       | 0.0011 | 0.0014 |
| Stainless Steel                | Martensitic                                  | 66              | 0.05xØ            | 0.08xØ           | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                | Austenitic A5 < 40%                          | 82              | 0.05xØ            | 0.08xØ           | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                | Austenitic A5 > 40%                          | 66              | 0.05xØ            | 0.08xØ           | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                | Sulphured                                    | 98              | 0.05xØ            | 0.08xØ           | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                | High Temperature Alloy                       | Fe-Alloy        | 90                | 1xØ              | 0.4xØ                      | 0.0006                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| High Temperature Alloy         | Ni-Alloy not hardened                        | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Ni-Alloy hardened                            | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Co-Alloy                                     | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Co-Alloy                                     | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Universal - 157 (Continued)      |                            |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|----------------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |                            | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                  |                            |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Cast Iron                        | Non-Alloy                  | 755             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Low-Alloy                  | 541             | 0.04x $\phi$      | 0.05x $\phi$     | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                  | High-Alloy                 | 377             | 0.04x $\phi$      | 0.05x $\phi$     | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB         | 1001            | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Non-Alloy > 180 HB         | 853             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Alloy                      | 755             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                  | High Alloy                 | 541             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB         | 1001            | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Non-Alloy > 180 HB         | 853             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                  | Alloy                      | 705             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| White Malleable Cast Iron        | < 180 HB                   | 1001            | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | > 180 HB                   | 853             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Black Malleable Cast Iron        | < 180 HB                   | 1001            | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | > 180 HB                   | 853             | 0.05x $\phi$      | 0.08x $\phi$     | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Copper                           | Non-Alloy                  | 1394            | 0.1x $\phi$       | 0.15x $\phi$     | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Wrought Alloy Non-Hardened | 1181            | 0.1x $\phi$       | 0.15x $\phi$     | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Wrought Alloy Hardened     | 968             | 0.1x $\phi$       | 0.15x $\phi$     | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |

| Universal - 190 / 191            |                                      |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|--------------------------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |                                      | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                  |                                      |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>             | 98              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | > 1000 N/mm <sup>2</sup>             | 74              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>    | 115             | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup> | 98              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy < 800 N/mm <sup>2</sup>        | 98              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>     | 82              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>    | 74              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 1300-1600 N/mm <sup>2</sup>    | 66              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Stainless Steel                  | Ferric                               | 82              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Martensitic                          | 66              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austenitic A5 < 40%                  | 57              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austenitic A5 > 40%                  | 82              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Sulphured                            | 98              | 0.5x $\phi$       | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| High Temperature Alloy           | Fe-Alloy                             | 49              | 1x $\phi$         | 0.4x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Ni-Alloy not hardened                | 49              | 1x $\phi$         | 0.4x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Ni-Alloy hardened                    | 49              | 1x $\phi$         | 0.4x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Co-Alloy                             | 49              | 1x $\phi$         | 0.4x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| Cast Iron                        | Non-Alloy                            | 328             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low-Alloy                            | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High-Alloy                           | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Stainless Cast Steel             | Ferric/Martensitic                   | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                  | Austenitic                           | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                   | 328             | 1x $\phi$         | 0.7x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                   | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloy                                | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High Alloy                           | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                   | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Non-Alloy > 180 HB                   | 279             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloy                                | 246             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| White Malleable Cast Iron        | < 180 HB                             | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB                             | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Black Malleable Cast Iron        | < 180 HB                             | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | > 180 HB                             | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Titanium                         | Non-Alloy                            | 148             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloyed-Annealed                     | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                  | Alloyed-Hardened                     | 82              | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.



| Universal - 120                  |  |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                  |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>                      | 295             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | > 500 N/mm <sup>2</sup>                      | 213             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>            | 295             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>            | 213             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Alloy  | 180             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Spring Steel                     | Annealed < 250 HB                            | 180             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Cementation Steel                | < 150 HB                                     | 279             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | 150-200 HB                                   | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | > 200 HB                                     | 180             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>                     | 213             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | > 1000 N/mm <sup>2</sup>                     | 164             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>            | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 213             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy < 800 N/mm <sup>2</sup>                | 213             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>             | 180             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>            | 148             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Non-Alloy Tool Steel             | General                                      | 180             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Tool Steel for Cold Processing   | Low Alloy < 1000 N/mm <sup>2</sup>           | 164             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Low Alloy < 1200 N/mm <sup>2</sup>           | 131             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 131             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Tool Steel for Warm Processing   | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 131             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Stainless Steel                  | Ferric                                       | 164             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Martensitic                                  | 131             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austenitic A5 < 40%                          | 164             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austenitic A5 > 40%                          | 164             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Sulphured                                    | 180             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| High Temperature Alloy           | Fe-Alloy                                     | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Ni-Alloy not hardened                        | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Ni-Alloy hardened                            | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Co-Alloy                                     | 90              | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Cast Iron                        | Non-Alloy                                    | 295             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Low-Alloy                                    | 213             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Stainless Cast Steel             | Ferric/Martensitic                           | 131             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austentic                                    | 164             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                           | 361             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                           | 312             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Alloy  | 262             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | High Alloy                                   | 213             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                           | 361             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Non-Alloy > 180 HB                           | 312             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Alloy  | 262             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| White Malleable Cast Iron        | < 180 HB                                     | 361             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                                     | 312             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Black Malleable Cast Iron        | < 180 HB                                     | 361             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                                     | 312             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Titanium                         | Non-Alloy                                    | 197             | 1xØ               | 0.4xØ            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                  | Alloyed-Annealed                             | 164             | 1xØ               | 0.4xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Alloyed-Hardened                             | 131             | 1xØ               | 0.4xØ            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |

| Universal - 100      |                                   |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------|-----------------------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation |                                   | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                      |                                   |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel      | < 500 N/mm <sup>2</sup>           | 295             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                      | > 500 N/mm <sup>2</sup>           | 213             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Construction Steel   | Non-Alloy < 500 N/mm <sup>2</sup> | 295             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                      | Non-Alloy > 500 N/mm <sup>2</sup> | 213             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                      | Alloy                             | 180             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Spring Steel         | Annealed < 250 HB                 | 180             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Cementation Steel    | < 150 HB                          | 279             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                      | 150-200 HB                        | 230             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                      | > 200 HB                          | 180             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Nitriding Steel      | < 1000 N/mm <sup>2</sup>          | 213             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                      | > 1000 N/mm <sup>2</sup>          | 164             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

| Universal - 100 (Continued)      |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|----------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>            | 230             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy < 800 N/mm <sup>2</sup>                | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>             | 180             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>            | 148             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Non-Alloy Tool Steel             | General                                      | 180             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Tool Steel for Cold Processing   | Low Alloy < 1000 N/mm <sup>2</sup>           | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Low Alloy < 1200 N/mm <sup>2</sup>           | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Tool Steel for Warm Processing   | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Stainless Steel                  | Ferric                                       | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Martensitic                                  | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austenitic A5 < 40%                          | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austenitic A5 > 40%                          | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Sulphured                                    | 180             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| Cast Iron                        | Non-Alloy                                    | 295             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | Low-Alloy                                    | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Stainless Cast Steel             | Ferric/Martensitic                           | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austentic                                    | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                           | 361             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                           | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Alloy  | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | High Alloy                                   | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                           | 361             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Non-Alloy > 180 HB                           | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Alloy  | 262             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| White Malleable Cast Iron        | < 180 HB                                     | 361             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                                     | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Black Malleable Cast Iron        | < 180 HB                                     | 361             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                                     | 312             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |

| Universal - 106                  |                                      | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|----------------------------------|--------------------------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |                                      |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>              | 230             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | > 500 N/mm <sup>2</sup>              | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>    | 230             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>    | 164             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Alloy                                | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Cementation Steel                | < 150 HB                             | 180             | 1x $\phi$         | 0.7x $\phi$      | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | 150-200 HB                           | 148             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | > 200 HB                             | 115             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>             | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | > 1000 N/mm <sup>2</sup>             | 90              | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>    | 148             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup> | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy < 800 N/mm <sup>2</sup>        | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>     | 115             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>    | 90              | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Cast Iron                        | Non-Alloy                            | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Low-Alloy                            | 148             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | High-Alloy                           | 115             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
| Stainless Cast Steel             | Ferric/Martensitic                   | 98              | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
|                                  | Austentic                            | 98              | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                   | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                   | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Alloy                                | 148             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | High Alloy                           | 131             | 1x $\phi$         | 0.7x $\phi$      | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                   | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Non-Alloy > 180 HB                   | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Alloy                                | 148             | 1x $\phi$         | 0.7x $\phi$      | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| White Malleable Cast Iron        | < 180 HB                             | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                             | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Black Malleable Cast Iron        | < 180 HB                             | 213             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                             | 197             | 1x $\phi$         | 0.7x $\phi$      | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |

| <b>Universal - 113</b>           |   |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|---|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |   | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                  |   |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>                 | 968             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | > 500 N/mm <sup>2</sup>                 | 755             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>       | 968             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>       | 755             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Alloy                                   | 640             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Spring Steel                     | Annealed < 250 HB                       | 853             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Natural Hard 250-350 HB                 | 755             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                  | Feeder Hard 1200-1600 N/mm <sup>2</sup> | 509             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Cementation Steel                | < 150 HB                                | 919             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | 150-200 HB                              | 853             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | > 200 HB                                | 656             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>                | 771             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | > 1000 N/mm <sup>2</sup>                | 574             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>       | 853             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup>    | 689             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Alloy < 800 N/mm <sup>2</sup>           | 574             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>        | 640             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>       | 574             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Cast Iron                        | Non-Alloy                               | 755             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Low-Alloy                               | 541             | 0.04xØ            | 0.05xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                  | High-Alloy                              | 377             | 0.04xØ            | 0.05xØ           | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                      | 1001            | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Non-Alloy > 180 HB                      | 853             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Alloy                                   | 755             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                  | High Alloy                              | 541             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                      | 1001            | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | Non-Alloy > 180 HB                      | 853             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
| White Malleable Cast Iron        | < 180 HB                                | 705             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |
|                                  | > 180 HB                                | 1001            | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
| Black Malleable Cast Iron        | < 180 HB                                | 1001            | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0022                 | 0.0033        | 0.0055       | 0.0069 | 0.0083 |
|                                  | > 180 HB                                | 853             | 0.05xØ            | 0.08xØ           | 0.0011                     | 0.0017                 | 0.0022        | 0.0041       | 0.0055 | 0.0062 |

| <b>Universal - 117</b>           |                                      |                 |                   |                  |                            |                        |               |              |        |        |
|----------------------------------|--------------------------------------|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation             |                                      | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                  |                                      |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Machining Steel                  | < 500 N/mm <sup>2</sup>              | 164             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | > 500 N/mm <sup>2</sup>              | 115             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Construction Steel               | Non-Alloy < 500 N/mm <sup>2</sup>    | 164             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Non-Alloy > 500 N/mm <sup>2</sup>    | 115             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Alloy                                | 98              | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Spring Steel                     | Annealed < 250 HB                    | 98              | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Cementation Steel                | < 150 HB                             | 156             | 1xØ               | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                  | 150-200 HB                           | 123             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | > 200 HB                             | 98              | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Nitriding Steel                  | < 1000 N/mm <sup>2</sup>             | 115             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | > 1000 N/mm <sup>2</sup>             | 90              | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Quenched & Tempered Steel        | Non-Alloy < 800 N/mm <sup>2</sup>    | 131             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Non-Alloy 800-1000 N/mm <sup>2</sup> | 115             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy < 800 N/mm <sup>2</sup>        | 115             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 800-1000 N/mm <sup>2</sup>     | 98              | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | Alloy 1000-1300 N/mm <sup>2</sup>    | 90              | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Cast Iron                        | Non-Alloy                            | 328             | 0.8xØ             | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | Low-Alloy                            | 262             | 0.8xØ             | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                  | High-Alloy                           | 197             | 0.8xØ             | 0.7xØ            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
| Cast Iron with Lamellar Graphite | Non-Alloy < 180 HB                   | 197             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Non-Alloy > 180 HB                   | 164             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | Alloy                                | 131             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
|                                  | High Alloy                           | 115             | 1xØ               | 0.7xØ            | 0.0004                     | 0.0008                 | 0.0011        | 0.0014       | 0.0017 | 0.0019 |
| Spheroidal Cast Iron             | Non-Alloy < 180 HB                   | 197             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Non-Alloy > 180 HB                   | 164             | 1xØ               | 0.7xØ            | 0.0008                     | 0.0012                 | 0.0014        | 0.0019       | 0.0022 | 0.0025 |
|                                  | Alloy                                | 131             | 1xØ               | 0.7xØ            | 0.0003                     | 0.0006                 | 0.0008        | 0.0011       | 0.0014 | 0.0017 |
| White Malleable Cast Iron        | < 180 HB                             | 197             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                             | 164             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
| Black Malleable Cast Iron        | < 180 HB                             | 197             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |
|                                  | > 180 HB                             | 164             | 1xØ               | 0.7xØ            | 0.0010                     | 0.0017                 | 0.0019        | 0.0025       | 0.0033 | 0.0039 |

| Titanium - 101                 |  |                 |                   |                  |                            |                        |               |              |        |        |
|--------------------------------|--|-----------------|-------------------|------------------|----------------------------|------------------------|---------------|--------------|--------|--------|
| Material Designation           |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |                        |               |              |        |        |
|                                |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4"<br>5/16" | 3/8"<br>7/16" | 1/2"<br>5/8" | 3/4"   | 1"     |
| Non-Alloy Tool Steel           | General                                      | 303             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Tool Steel for Cold Processing | Low Alloy < 1000 N/mm <sup>2</sup>           | 295             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | Low Alloy < 1200 N/mm <sup>2</sup>           | 279             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 246             | 0.8xø             | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 262             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
| Tool Steel for Warm Processing | Low Alloy < 1200 N/mm <sup>2</sup>           | 328             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 295             | 0.8xø             | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 246             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 230             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |
|                                | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 213             | 0.8xø             | 0.7xø            | 0.0003                     | 0.0007                 | 0.0011        | 0.0014       | 0.0019 | 0.0025 |
| Stainless Steel                | Ferric                                       | 164             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                                | Martensitic                                  | 131             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                                | Austenitic A5 < 40%                          | 164             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                                | Austenitic A5 > 40%                          | 164             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
|                                | Sulphured                                    | 180             | 0.8xø             | 0.7xø            | 0.0004                     | 0.0006                 | 0.0008        | 0.0014       | 0.0017 | 0.0019 |
| High Temperature Alloy         | Fe-Alloy                                     | 90              | 1xø               | 0.4xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Ni-Alloy not hardened                        | 90              | 1xø               | 0.4xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Ni-Alloy hardened                            | 90              | 1xø               | 0.4xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
|                                | Co-Alloy                                     | 90              | 1xø               | 0.4xø            | 0.0006                     | 0.0011                 | 0.0014        | 0.0017       | 0.0019 | 0.0022 |
| Titanium                       | Non-Alloy                                    | 197             | 1xø               | 0.4xø            | 0.0007                     | 0.0012                 | 0.0019        | 0.0028       | 0.0033 | 0.0039 |
|                                | Alloyed-Annealed                             | 164             | 1xø               | 0.4xø            | 0.0006                     | 0.0011                 | 0.0017        | 0.0022       | 0.0028 | 0.0033 |
|                                | Alloyed-Hardened                             | 131             | 1xø               | 0.4xø            | 0.0004                     | 0.0008                 | 0.0014        | 0.0017       | 0.0022 | 0.0028 |

| Steel - 250                    |  |                 |                   |                  |                            |               |        |        |  |
|--------------------------------|--|-----------------|-------------------|------------------|----------------------------|---------------|--------|--------|--|
| Material Designation           |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per Tooth [inch] |               |        |        |  |
|                                |  |                 |                   |                  | 1/8"                       | 3/16"<br>1/4" | 3/8"   | 1/2"   |  |
| Machining Steel                | < 500 N/mm <sup>2</sup>                      | 968             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | > 500 N/mm <sup>2</sup>                      | 755             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
| Construction Steel             | Non-Alloy < 500 N/mm <sup>2</sup>            | 968             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Non-Alloy > 500 N/mm <sup>2</sup>            | 755             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Alloy  | 640             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
| Spring Steel                   | Annealed < 250 HB                            | 853             | 0.04xø            | 0.05xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Natural Hard 250-350 HB                      | 755             | 0.04xø            | 0.05xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
|                                | Feader Hard 1200-1600 N/mm <sup>2</sup>      | 509             | 0.04xø            | 0.05xø           | 0.0010                     | 0.0017        | 0.0019 | 0.0025 |  |
| Cementation Steel              | < 150 HB                                     | 919             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | 150-200 HB                                   | 853             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | > 200 HB                                     | 656             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
| Nitriding Steel                | < 1000 N/mm <sup>2</sup>                     | 771             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | > 1000 N/mm <sup>2</sup>                     | 574             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
| Quenched & Tempered Steel      | Non-Alloy < 800 N/mm <sup>2</sup>            | 853             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 689             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Alloy < 800 N/mm <sup>2</sup>                | 574             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Alloy 800-1000 N/mm <sup>2</sup>             | 640             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Alloy 1000-1300 N/mm <sup>2</sup>            | 574             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
|                                | Alloy 1300-1600 N/mm <sup>2</sup>            | 476             | 0.04xø            | 0.05xø           | 0.0010                     | 0.0017        | 0.0019 | 0.0025 |  |
| Non-Alloy Tool Steel           | General                                      | 755             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
| Tool Steel for Cold Processing | Low Alloy < 1000 N/mm <sup>2</sup>           | 640             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Low Alloy < 1200 N/mm <sup>2</sup>           | 541             | 0.04xø            | 0.05xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 427             | 0.04xø            | 0.05xø           | 0.0010                     | 0.0017        | 0.0019 | 0.0025 |  |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 541             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 377             | 0.04xø            | 0.05xø           | 0.0010                     | 0.0017        | 0.0019 | 0.0025 |  |
| Tool Steel for Warm Processing | Low Alloy < 1200 N/mm <sup>2</sup>           | 541             | 0.04xø            | 0.05xø           | 0.0011                     | 0.0022        | 0.0033 | 0.0055 |  |
|                                | Low Alloy < 1500 N/mm <sup>2</sup>           | 427             | 0.04xø            | 0.05xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
|                                | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 541             | 0.05xø            | 0.08xø           | 0.0011                     | 0.0017        | 0.0022 | 0.0041 |  |
|                                | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 377             | 0.04xø            | 0.05xø           | 0.0010                     | 0.0017        | 0.0019 | 0.0025 |  |
|                                | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 344             | 0.04xø            | 0.05xø           | 0.0010                     | 0.0017        | 0.0019 | 0.0025 |  |
| Stainless Steel                | Ferric                                       | 82              | 0.05xø            | 0.08xø           | 0.0003                     | 0.0006        | 0.0008 | 0.0011 |  |
|                                | Martensitic                                  | 66              | 0.05xø            | 0.08xø           | 0.0003                     | 0.0006        | 0.0008 | 0.0011 |  |
|                                | Austenitic A5 < 40%                          | 82              | 0.05xø            | 0.08xø           | 0.0003                     | 0.0006        | 0.0008 | 0.0011 |  |
|                                | Austenitic A5 > 40%                          | 66              | 0.05xø            | 0.08xø           | 0.0003                     | 0.0006        | 0.0008 | 0.0011 |  |
|                                | Sulphured                                    | 98              | 0.05xø            | 0.08xø           | 0.0003                     | 0.0006        | 0.0008 | 0.0011 |  |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

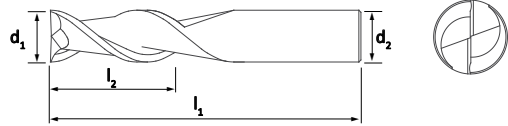
| Steel - 251 / 252 / 253 / 254     |  |                 |                   |                  |                               |        |
|-----------------------------------|--|-----------------|-------------------|------------------|-------------------------------|--------|
| Material Designation              |  | SFM<br>[ft/min] | ae max.<br>[inch] | ap max<br>[inch] | Chip Load per<br>Tooth [inch] |        |
|                                   |  |                 |                   |                  | 1/32"<br>3/32"<br>1/8"        | 3/16"  |
| Machining Steel                   | < 500 N/mm <sup>2</sup>                      | 213             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | > 500 N/mm <sup>2</sup>                      | 189             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
| Construction Steel                | Non-Alloy < 500 N/mm <sup>2</sup>            | 213             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Non-Alloy > 500 N/mm <sup>2</sup>            | 189             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Alloy  | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
| Spring Steel                      | Annealed < 250 HB                            | 189             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Natural Hard 250-350 HB                      | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Feeder Hard 1200-1600 N/mm <sup>2</sup>      | 115             | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
| Cementation Steel                 | < 150 HB                                     | 213             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | 150-200 HB                                   | 189             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | > 200 HB                                     | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
| Nitriding Steel                   | < 1000 N/mm <sup>2</sup>                     | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | > 1000 N/mm <sup>2</sup>                     | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
| Quenched & Tempered Steel         | Non-Alloy < 800 N/mm <sup>2</sup>            | 189             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Non-Alloy 800-1000 N/mm <sup>2</sup>         | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Alloy < 800 N/mm <sup>2</sup>                | 189             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Alloy 800-1000 N/mm <sup>2</sup>             | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Alloy 1000-1300 N/mm <sup>2</sup>            | 115             | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
| Alloy 1300-1600 N/mm <sup>2</sup> | 98   | 1x∅             | 0.03x∅            | 0.0010           | 0.0017                        |        |
| Non-Alloy Tool Steel              | General                                      | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
| Tool Steel for Cold Processing    | Low Alloy < 1000 N/mm <sup>2</sup>           | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | Low Alloy < 1200 N/mm <sup>2</sup>           | 115             | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
|                                   | Low Alloy < 1500 N/mm <sup>2</sup>           | 98              | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
|                                   | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 115             | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
| Tool Steel for Warm Processing    | Low Alloy < 1200 N/mm <sup>2</sup>           | 115             | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
|                                   | Low Alloy < 1500 N/mm <sup>2</sup>           | 98              | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
|                                   | High Alloy Annealed < 1000 N/mm <sup>2</sup> | 148             | 1x∅               | 0.04x∅           | 0.0011                        | 0.0017 |
|                                   | High Alloy Hardened < 1300 N/mm <sup>2</sup> | 115             | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
|                                   | High Alloy Hardened < 1600 N/mm <sup>2</sup> | 98              | 1x∅               | 0.03x∅           | 0.0010                        | 0.0017 |
| Stainless Steel                   | Ferric                                       | 82              | 0.05x∅            | 0.08x∅           | 0.0003                        | 0.0006 |
|                                   | Martensitic                                  | 66              | 0.05x∅            | 0.08x∅           | 0.0003                        | 0.0006 |
|                                   | Austenitic A5 < 40%                          | 82              | 0.05x∅            | 0.08x∅           | 0.0003                        | 0.0006 |
|                                   | Austenitic A5 > 40%                          | 66              | 0.05x∅            | 0.08x∅           | 0.0003                        | 0.0006 |
|                                   | Sulphured                                    | 98              | 0.05x∅            | 0.08x∅           | 0.0003                        | 0.0006 |

\* Feeds and Speeds are starting points for Overall Lengths of 4" and shorter.  
For End Mills with Overall Lengths over 4" decrease the Feeds and Speeds.

# DESIGN-RITE XL Series D142 2 Flute Aluminum



$\lambda_s = 40^\circ$      $\gamma_s = 12^\circ$



**Tolerances**  
 Shank: 1/8" - 1" = +.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | ZrN      |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 2      | D1422120 | D1422126 |
| 1/8                   | 1/8                     | 3/8                   | 1-1/2                 | 2      | D1421120 | D1421126 |
| 5/32                  | 3/16                    | 5/16                  | 2                     | 2      | D1422150 | D1422156 |
| 5/32                  | 3/16                    | 9/16                  | 2                     | 2      | D1421150 | D1421156 |
| 3/16                  | 3/16                    | 5/16                  | 2                     | 2      | D1422180 | D1422186 |
| 3/16                  | 3/16                    | 9/16                  | 2                     | 2      | D1421180 | D1421186 |
| 7/32                  | 1/4                     | 3/8                   | 2                     | 2      | D1422210 | D1422216 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 2      | D1422250 | D1422256 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 2      | D1421250 | D1421256 |
| 1/4                   | 1/4                     | 1-1/4                 | 3-1/2                 | 2      | D1423250 | D1423256 |
| 9/32                  | 5/16                    | 13/16                 | 2-1/2                 | 2      | D1421280 | D1421286 |
| 5/16                  | 5/16                    | 13/16                 | 2-1/2                 | 2      | D1421310 | D1421316 |
| 5/16                  | 5/16                    | 1-1/4                 | 4                     | 2      | D1423310 | D1423316 |
| 5/16                  | 5/16                    | 2-1/8                 | 4                     | 2      | D1424310 | D1424316 |
| 11/32                 | 3/8                     | 1                     | 2-1/2                 | 2      | D1421340 | D1421346 |
| 3/8                   | 3/8                     | 1/2                   | 2-1/2                 | 2      | D1422370 | D1422376 |
| 3/8                   | 3/8                     | 1                     | 2-1/2                 | 2      | D1421370 | D1421376 |
| 3/8                   | 3/8                     | 1-1/2                 | 4                     | 2      | D1423370 | D1423376 |
| 3/8                   | 3/8                     | 2-1/2                 | 6                     | 2      | D1424370 | D1424376 |
| 13/32                 | 7/16                    | 1                     | 2-3/4                 | 2      | D1421400 | D1421406 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 2      | D1422500 | D1422506 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 2      | D1421500 | D1421506 |
| 1/2                   | 1/2                     | 2                     | 4                     | 2      | D1423500 | D1423506 |
| 1/2                   | 1/2                     | 3                     | 6                     | 2      | D1424500 | D1424506 |
| 5/8                   | 5/8                     | 1-5/8                 | 3-1/2                 | 2      | D1421620 | D1421626 |
| 3/4                   | 3/4                     | 1                     | 4                     | 2      | D1422750 | D1422756 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 2      | D1421750 | D1421756 |
| 3/4                   | 3/4                     | 3                     | 6                     | 2      | D1423750 | D1423756 |
| 3/4                   | 3/4                     | 4                     | 7                     | 2      | D1424750 | D1424756 |
| 1                     | 1                       | 2                     | 5                     | 2      | D1421100 | D1421106 |
| 1                     | 1                       | 3                     | 6                     | 2      | D1423100 | D1423106 |

Feeds & Speeds Available on Page 115

**Application Range:**

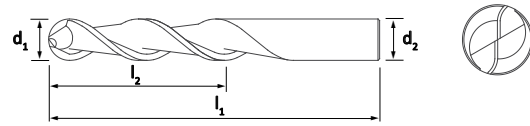
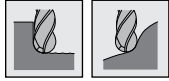
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | ●        | ●                      | ●             |                     |

# Series D162

## 2 Flute Aluminum Ball



$\lambda_s = 40^\circ$      $\gamma_s = 12^\circ$



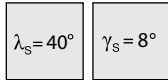
**Tolerances**  
 Shank:  $1/4'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/4'' - 1'' = +.000/-0.002$   
 Ball:  $1/4'' - 1'' = +/-0.001$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | ZrN      |
|--------------|----------------|--------------|--------------|--------|----------|----------|
| 1/4          | 1/4            | 3/8          | 2            | 2      | D1622250 | D1622256 |
| 1/4          | 1/4            | 3/4          | 2-1/2        | 2      | D1621250 | D1621256 |
| 1/4          | 1/4            | 1-1/4        | 3-1/2        | 2      | D1623250 | D1623256 |
| 5/16         | 5/16           | 7/16         | 2-1/2        | 2      | D1622310 | D1622316 |
| 5/16         | 5/16           | 13/16        | 2-1/2        | 2      | D1621310 | D1621316 |
| 5/16         | 5/16           | 1-1/4        | 4            | 2      | D1623310 | D1623316 |
| 3/8          | 3/8            | 1/2          | 2-1/2        | 2      | D1622370 | D1622376 |
| 3/8          | 3/8            | 1            | 2-1/2        | 2      | D1621370 | D1621376 |
| 3/8          | 3/8            | 1-1/2        | 4            | 2      | D1623370 | D1623376 |
| 7/16         | 7/16           | 9/16         | 2-3/4        | 2      | D1622430 | D1622436 |
| 7/16         | 7/16           | 1            | 2-3/4        | 2      | D1621430 | D1621436 |
| 1/2          | 1/2            | 5/8          | 2-1/2        | 2      | D1622500 | D1622506 |
| 1/2          | 1/2            | 1-1/4        | 3            | 2      | D1621500 | D1621506 |
| 1/2          | 1/2            | 2            | 4            | 2      | D1623500 | D1623506 |
| 5/8          | 5/8            | 3/4          | 3            | 2      | D1622620 | D1622626 |
| 5/8          | 5/8            | 1-5/8        | 3-1/2        | 2      | D1621620 | D1621626 |
| 3/4          | 3/4            | 1            | 4            | 2      | D1622750 | D1622756 |
| 3/4          | 3/4            | 1-5/8        | 4            | 2      | D1621750 | D1621756 |
| 1            | 1              | 1-1/4        | 4            | 2      | D1622100 | D1622106 |
| 1            | 1              | 3            | 6            | 2      | D1623100 | D1623106 |

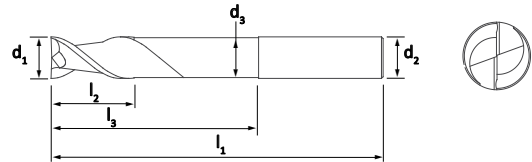
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
|       |            |                |                 |          |                  |           | •        | •                      | •             |                     |

**Tolerances**

Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | l <sub>3</sub><br>LOR | d <sub>3</sub><br>Neck Dia | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|----------------------------|--------|----------|----------|----------|
| 1/8                   | 1/8                     | 1/2                   | 3                     | 2 1/2                 | 0.120                      | 2      | D4424120 | D4424122 | D4424124 |
| 3/16                  | 3/16                    | 1/2                   | 3                     | 4 1/4                 | 0.180                      | 2      | D4424180 | D4424182 | D4424184 |
| 1/4                   | 1/4                     | 3/4                   | 4                     | 2                     | 0.240                      | 2      | D4424250 | D4424252 | D4424254 |
| 5/16                  | 5/16                    | 3/4                   | 4                     | 2                     | 0.300                      | 2      | D4424310 | D4424312 | D4424314 |
| 3/8                   | 3/8                     | 3/4                   | 4                     | 2 1/2                 | 0.360                      | 2      | D4424370 | D4424372 | D4424374 |
| 1/2                   | 1/2                     | 1                     | 4                     | 2 1/2                 | 0.480                      | 2      | D4423500 | D4423502 | D4423504 |
| 1/2                   | 1/2                     | 1-1/8                 | 6                     | 2 1/2                 | 0.480                      | 2      | D4424500 | D4424502 | D4424504 |
| 5/8                   | 5/8                     | 1-1/4                 | 6                     | 4 1/8                 | 0.600                      | 2      | D4424620 | D4424622 | D4424624 |
| 3/4                   | 3/4                     | 1-1/2                 | 6                     | 4 1/8                 | 0.720                      | 2      | D4424750 | D4424752 | D4424754 |
| 1                     | 1                       | 1-1/2                 | 6                     | 4 1/8                 | 0.960                      | 2      | D4424100 | D4424102 | D4424104 |

Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         | •        | •                      | •             |                     |

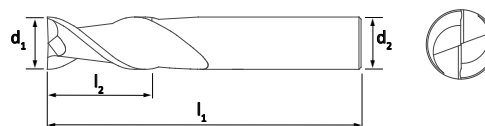


# Series D642

## 2 Flute Universal



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/32'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/-0.0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/32         | 1/8            | 3/32         | 1-1/2        | 2      | D6421030 | D6421032 | D6421034 |
| 3/64         | 1/8            | 9/64         | 1-1/2        | 2      | D6421040 | D6421042 | D6421044 |
| 1/16         | 1/8            | 1/8          | 1-1/2        | 2      | D6422060 | D6422062 | D6422064 |
| 1/16         | 1/8            | 3/16         | 1-1/2        | 2      | D6421060 | D6421062 | D6421064 |
| 5/64         | 1/8            | 1/4          | 1-1/2        | 2      | D6421070 | D6421072 | D6421074 |
| 3/32         | 1/8            | 3/16         | 1-1/2        | 2      | D6422090 | D6422092 | D6422094 |
| 3/32         | 1/8            | 9/32         | 1-1/2        | 2      | D6421090 | D6421092 | D6421094 |
| 7/64         | 1/8            | 3/16         | 1-1/2        | 2      | D6422190 | D6422192 | D6422194 |
| 7/64         | 1/8            | 3/8          | 1-1/2        | 2      | D6421190 | D6421192 | D6421194 |
| 1/8          | 1/8            | 1/4          | 1-1/2        | 2      | D6422120 | D6422122 | D6422124 |
| 1/8          | 1/8            | 1/2          | 1-1/2        | 2      | D6421120 | D6421122 | D6421124 |
| 1/8          | 1/8            | 3/4          | 2-1/4        | 2      | D6423120 | D6423122 | D6423124 |
| 1/8          | 1/8            | 3/4          | 3            | 2      | D6426120 | D6426122 | D6426124 |
| 1/8          | 1/8            | 1            | 3            | 2      | D6424120 | D6424122 | D6424124 |
| 9/64         | 3/16           | 3/8          | 2            | 2      | D6422140 | D6422142 | D6422144 |
| 9/64         | 3/16           | 1/2          | 2            | 2      | D6421140 | D6421142 | D6421144 |
| 5/32         | 3/16           | 3/8          | 2            | 2      | D6422150 | D6422152 | D6422154 |
| 5/32         | 3/16           | 1/2          | 2            | 2      | D6421150 | D6421152 | D6421154 |
| 5/32         | 3/16           | 3/4          | 2-1/2        | 2      | D6425150 | D6425152 | D6425154 |
| 11/64        | 3/16           | 3/8          | 2            | 2      | D6422170 | D6422172 | D6422174 |
| 11/64        | 3/16           | 5/8          | 2            | 2      | D6421170 | D6421172 | D6421174 |
| 3/16         | 3/16           | 3/8          | 2            | 2      | D6422180 | D6422182 | D6422184 |
| 3/16         | 3/16           | 5/8          | 2            | 2      | D6421180 | D6421182 | D6421184 |
| 3/16         | 3/16           | 3/4          | 2-1/2        | 2      | D6423180 | D6423182 | D6423184 |
| 3/16         | 3/16           | 1            | 2-1/2        | 2      | D6425180 | D6425182 | D6425184 |
| 3/16         | 3/16           | 1            | 4            | 2      | D6426180 | D6426182 | D6426184 |
| 3/16         | 3/16           | 1-1/8        | 3            | 2      | D6424180 | D6424182 | D6424184 |
| 13/64        | 1/4            | 3/8          | 2            | 2      | D6422200 | D6422202 | D6422204 |
| 13/64        | 1/4            | 5/8          | 2-1/2        | 2      | D6421200 | D6421202 | D6421204 |
| 7/32         | 1/4            | 3/8          | 2            | 2      | D6422210 | D6422212 | D6422214 |
| 7/32         | 1/4            | 5/8          | 2-1/2        | 2      | D6421210 | D6421212 | D6421214 |
| 7/32         | 1/4            | 1            | 3            | 2      | D6425210 | D6425212 | D6425214 |
| 15/64        | 1/4            | 3/8          | 2            | 2      | D6422230 | D6422232 | D6422234 |
| 15/64        | 1/4            | 3/4          | 2-1/2        | 2      | D6421230 | D6421232 | D6421234 |
| 1/4          | 1/4            | 3/8          | 2            | 2      | D6422250 | D6422252 | D6422254 |
| 1/4          | 1/4            | 3/4          | 2-1/2        | 2      | D6421250 | D6421252 | D6421254 |
| 1/4          | 1/4            | 1            | 4            | 2      | D6426250 | D6426252 | D6426254 |
| 1/4          | 1/4            | 1-1/8        | 3            | 2      | D6423250 | D6423252 | D6423254 |
| 1/4          | 1/4            | 1-1/4        | 3            | 2      | D6425250 | D6425252 | D6425254 |
| 1/4          | 1/4            | 1-1/2        | 4            | 2      | D6424250 | D6424252 | D6424254 |
| 1/4          | 1/4            | 1-1/2        | 6            | 2      | D6427250 | D6427252 | D6427254 |
| 17/64        | 5/16           | 1/2          | 2            | 2      | D6422260 | D6422262 | D6422264 |

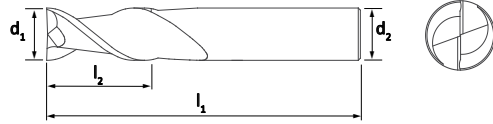
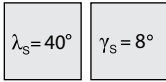
Additional Sizes On Pages 74 - 75

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         |          | •                      | •             |                     |

# DESIGN-RITE XL Series D642 2 Flute Universal



**Tolerances**  
 Shank: 1/32" - 1" = -.0001/- .0004  
 Cutting Dia: 1/32" - 7/64" = +/- .0005  
 Cutting Dia: 1/8" - 1" = +.000/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 17/64                 | 5/16                    | 3/4                   | 2-1/2                 | 2      | D6421260 | D6421262 | D6421264 |
| 9/32                  | 5/16                    | 1/2                   | 2                     | 2      | D6422280 | D6422282 | D6422284 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 | 2      | D6421280 | D6421282 | D6421284 |
| 9/32                  | 5/16                    | 1-1/4                 | 3                     | 2      | D6425280 | D6425282 | D6425284 |
| 19/64                 | 5/16                    | 1/2                   | 2                     | 2      | D6422290 | D6422292 | D6422294 |
| 19/64                 | 5/16                    | 3/4                   | 2-1/2                 | 2      | D6421290 | D6421292 | D6421294 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 2      | D6422310 | D6422312 | D6422314 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 2      | D6421310 | D6421312 | D6421314 |
| 5/16                  | 5/16                    | 1                     | 4                     | 2      | D6426310 | D6426312 | D6426314 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 2      | D6423310 | D6423312 | D6423314 |
| 5/16                  | 5/16                    | 1-3/8                 | 3                     | 2      | D6425310 | D6425312 | D6425314 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 2      | D6427310 | D6427312 | D6427314 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 2      | D6424310 | D6424312 | D6424314 |
| 21/64                 | 3/8                     | 5/8                   | 2                     | 2      | D6422320 | D6422322 | D6422324 |
| 21/64                 | 3/8                     | 7/8                   | 2-1/2                 | 2      | D6421320 | D6421322 | D6421324 |
| 11/32                 | 3/8                     | 5/8                   | 2                     | 2      | D6422340 | D6422342 | D6422344 |
| 11/32                 | 3/8                     | 7/8                   | 2-1/2                 | 2      | D6421340 | D6421342 | D6421344 |
| 23/64                 | 3/8                     | 5/8                   | 2                     | 2      | D6422350 | D6422352 | D6422354 |
| 23/64                 | 3/8                     | 7/8                   | 2-1/2                 | 2      | D6421350 | D6421352 | D6421354 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 2      | D6422370 | D6422372 | D6422374 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 2      | D6421370 | D6421372 | D6421374 |
| 3/8                   | 3/8                     | 1                     | 4                     | 2      | D6426370 | D6426372 | D6426374 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 2      | D6423370 | D6423372 | D6423374 |
| 3/8                   | 3/8                     | 1-3/8                 | 3                     | 2      | D6425370 | D6425372 | D6425374 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 2      | D6427370 | D6427372 | D6427374 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 2      | D6424370 | D6424372 | D6424374 |
| 3/8                   | 3/8                     | 3                     | 6                     | 2      | D6428370 | D6428372 | D6428374 |
| 25/64                 | 7/16                    | 5/8                   | 2                     | 2      | D6422390 | D6422392 | D6422394 |
| 25/64                 | 7/16                    | 1                     | 2-3/4                 | 2      | D6421390 | D6421392 | D6421394 |
| 13/32                 | 7/16                    | 5/8                   | 2                     | 2      | D6422400 | D6422402 | D6422404 |
| 13/32                 | 7/16                    | 1                     | 2-3/4                 | 2      | D6421400 | D6421402 | D6421404 |
| 27/64                 | 7/16                    | 5/8                   | 2                     | 2      | D6422420 | D6422422 | D6422424 |
| 27/64                 | 7/16                    | 1                     | 2-3/4                 | 2      | D6421420 | D6421422 | D6421424 |
| 7/16                  | 7/16                    | 5/8                   | 2                     | 2      | D6422430 | D6422432 | D6422434 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 2      | D6421430 | D6421432 | D6421434 |
| 7/16                  | 7/16                    | 1                     | 4                     | 2      | D6426430 | D6426432 | D6426434 |
| 7/16                  | 7/16                    | 1-3/8                 | 4                     | 2      | D6425430 | D6425432 | D6425434 |
| 7/16                  | 7/16                    | 1-1/2                 | 6                     | 2      | D6427430 | D6427432 | D6427434 |
| 7/16                  | 7/16                    | 2                     | 4                     | 2      | D6423430 | D6423432 | D6423434 |
| 7/16                  | 7/16                    | 3                     | 6                     | 2      | D6424430 | D6424432 | D6424434 |
| 29/64                 | 1/2                     | 5/8                   | 2-1/2                 | 2      | D6422450 | D6422452 | D6422454 |
| 29/64                 | 1/2                     | 1                     | 3                     | 2      | D6421450 | D6421452 | D6421454 |

Additional Sizes On Pages 73 & 75

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          | ●                      | ●             |                     |

# Series D642

## 2 Flute Universal

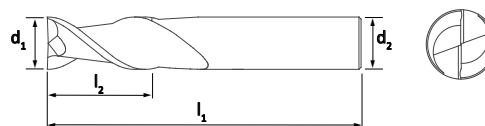


$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



### Tolerances

Shank:  $1/32'' - 1'' = -.0001/- .0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/- .002$



| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 15/32        | 1/2            | 5/8          | 2-1/2        | 2      | D6422460 | D6422462 | D6422464 |
| 15/32        | 1/2            | 1            | 3            | 2      | D6421460 | D6421462 | D6421464 |
| 31/64        | 1/2            | 5/8          | 2-1/2        | 2      | D6422480 | D6422482 | D6422484 |
| 31/64        | 1/2            | 1            | 3            | 2      | D6421480 | D6421482 | D6421484 |
| 1/2          | 1/2            | 5/8          | 2-1/2        | 2      | D6422500 | D6422502 | D6422504 |
| 1/2          | 1/2            | 1            | 3            | 2      | D6421500 | D6421502 | D6421504 |
| 1/2          | 1/2            | 1            | 4            | 2      | D6426500 | D6426502 | D6426504 |
| 1/2          | 1/2            | 1-1/2        | 3-1/2        | 2      | D6425500 | D6425502 | D6425504 |
| 1/2          | 1/2            | 1-1/2        | 6            | 2      | D6427500 | D6427502 | D6427504 |
| 1/2          | 1/2            | 2            | 4            | 2      | D6423500 | D6423502 | D6423504 |
| 1/2          | 1/2            | 3            | 6            | 2      | D6424500 | D6424502 | D6424504 |
| 9/16         | 9/16           | 7/8          | 3            | 2      | D6422560 | D6422562 | D6422564 |
| 9/16         | 9/16           | 1-1/4        | 3-1/2        | 2      | D6421560 | D6421562 | D6421564 |
| 9/16         | 9/16           | 2            | 6            | 2      | D6426560 | D6426562 | D6426564 |
| 9/16         | 9/16           | 3            | 6            | 2      | D6424560 | D6424562 | D6424564 |
| 5/8          | 5/8            | 7/8          | 3            | 2      | D6422620 | D6422622 | D6422624 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        | 2      | D6421620 | D6421622 | D6421624 |
| 5/8          | 5/8            | 2            | 6            | 2      | D6426620 | D6426622 | D6426624 |
| 5/8          | 5/8            | 2-1/8        | 4-5/8        | 2      | D6423620 | D6423622 | D6423624 |
| 5/8          | 5/8            | 3            | 6            | 2      | D6424620 | D6424622 | D6424624 |
| 11/16        | 3/4            | 1            | 3            | 2      | D6422680 | D6422682 | D6422684 |
| 11/16        | 3/4            | 1-1/2        | 4            | 2      | D6421680 | D6421682 | D6421684 |
| 3/4          | 3/4            | 1            | 3            | 2      | D6422750 | D6422752 | D6422754 |
| 3/4          | 3/4            | 1-1/2        | 4            | 2      | D6421750 | D6421752 | D6421754 |
| 3/4          | 3/4            | 2            | 6            | 2      | D6426750 | D6426752 | D6426754 |
| 3/4          | 3/4            | 2-1/4        | 5            | 2      | D6423750 | D6423752 | D6423754 |
| 3/4          | 3/4            | 3            | 6            | 2      | D6424750 | D6424752 | D6424754 |
| 7/8          | 7/8            | 1-3/4        | 4            | 2      | D6421870 | D6421872 | D6421874 |
| 1            | 1              | 1-3/4        | 4            | 2      | D6421100 | D6421102 | D6421104 |
| 1            | 1              | 2            | 6            | 2      | D6426100 | D6426102 | D6426104 |
| 1            | 1              | 2-1/4        | 5            | 2      | D6423100 | D6423102 | D6423104 |
| 1            | 1              | 3            | 6            | 2      | D6424100 | D6424102 | D6424104 |

Additional Sizes On Pages 73 - 74

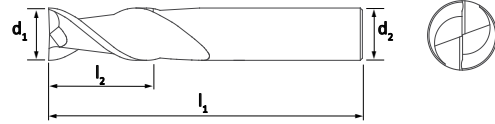
Feeds & Speeds Available on Page 115

### Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         |          | •                      | •             |                     |



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$

**Tolerances**

Shank: 1mm - 25mm = -.0025/-.0102  
 Cutting Dia: 1mm - 2.5mm = +/- .0127  
 Cutting Dia: 3mm - 25mm = +.000/- .0508

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated  | TiCN      | AlTiN     |
|--------------|----------------|--------------|--------------|--------|-----------|-----------|-----------|
| 1.0mm        | 3.0mm          | 2.0mm        | 38.0mm       | 2      | D64220390 | D64220392 | D64220394 |
| 1.0mm        | 3.0mm          | 4.0mm        | 38.0mm       | 2      | D64210390 | D64210392 | D64210394 |
| 1.5mm        | 3.0mm          | 3.0mm        | 38.0mm       | 2      | D64220590 | D64220592 | D64220594 |
| 1.5mm        | 3.0mm          | 5.0mm        | 38.0mm       | 2      | D64210590 | D64210592 | D64210594 |
| 2.0mm        | 3.0mm          | 4.0mm        | 38.0mm       | 2      | D64220780 | D64220782 | D64220784 |
| 2.0mm        | 3.0mm          | 8.0mm        | 38.0mm       | 2      | D64210780 | D64210782 | D64210784 |
| 2.5mm        | 3.0mm          | 5.0mm        | 38.0mm       | 2      | D64220980 | D64220982 | D64220984 |
| 2.5mm        | 3.0mm          | 9.5mm        | 38.0mm       | 2      | D64210980 | D64210982 | D64210984 |
| 3.0mm        | 3.0mm          | 6.0mm        | 38.0mm       | 2      | D64221180 | D64221182 | D64221184 |
| 3.0mm        | 3.0mm          | 12.0mm       | 38.0mm       | 2      | D64211180 | D64211182 | D64211184 |
| 3.5mm        | 4.0mm          | 7.0mm        | 50.0mm       | 2      | D64221370 | D64221372 | D64221374 |
| 3.5mm        | 4.0mm          | 12.0mm       | 50.0mm       | 2      | D64211370 | D64211372 | D64211374 |
| 4.0mm        | 4.0mm          | 8.0mm        | 50.0mm       | 2      | D64221570 | D64221572 | D64221574 |
| 4.0mm        | 4.0mm          | 14.0mm       | 50.0mm       | 2      | D64211570 | D64211572 | D64211574 |
| 4.5mm        | 6.0mm          | 9.5mm        | 63.0mm       | 2      | D64221770 | D64221772 | D64221774 |
| 4.5mm        | 6.0mm          | 16.0mm       | 63.0mm       | 2      | D64211770 | D64211772 | D64211774 |
| 5.0mm        | 6.0mm          | 10.0mm       | 63.0mm       | 2      | D64221960 | D64221962 | D64221964 |
| 5.0mm        | 6.0mm          | 16.0mm       | 63.0mm       | 2      | D64211960 | D64211962 | D64211964 |
| 6.0mm        | 6.0mm          | 12.0mm       | 63.0mm       | 2      | D64222360 | D64222362 | D64222364 |
| 6.0mm        | 6.0mm          | 19.0mm       | 63.0mm       | 2      | D64212360 | D64212362 | D64212364 |
| 7.0mm        | 8.0mm          | 12.0mm       | 63.0mm       | 2      | D64222750 | D64222752 | D64222754 |
| 7.0mm        | 8.0mm          | 19.0mm       | 63.0mm       | 2      | D64212750 | D64212752 | D64212754 |
| 8.0mm        | 8.0mm          | 12.0mm       | 63.0mm       | 2      | D64223150 | D64223152 | D64223154 |
| 8.0mm        | 8.0mm          | 20.0mm       | 63.0mm       | 2      | D64213150 | D64213152 | D64213154 |
| 9.0mm        | 10.0mm         | 14.0mm       | 70.0mm       | 2      | D64223540 | D64223542 | D64223544 |
| 9.0mm        | 10.0mm         | 25.0mm       | 70.0mm       | 2      | D64213540 | D64213542 | D64213544 |
| 10.0mm       | 10.0mm         | 14.0mm       | 70.0mm       | 2      | D64223930 | D64223932 | D64223934 |
| 10.0mm       | 10.0mm         | 25.0mm       | 70.0mm       | 2      | D64213930 | D64213932 | D64213934 |
| 11.0mm       | 12.0mm         | 14.0mm       | 76.0mm       | 2      | D64224330 | D64224332 | D64224334 |
| 11.0mm       | 12.0mm         | 25.0mm       | 76.0mm       | 2      | D64214330 | D64214332 | D64214334 |
| 12.0mm       | 12.0mm         | 16.0mm       | 76.0mm       | 2      | D64224720 | D64224722 | D64224724 |
| 12.0mm       | 12.0mm         | 25.0mm       | 76.0mm       | 2      | D64214720 | D64214722 | D64214724 |
| 14.0mm       | 14.0mm         | 32.0mm       | 89.0mm       | 2      | D64215510 | D64215512 | D64215514 |
| 16.0mm       | 16.0mm         | 32.0mm       | 89.0mm       | 2      | D64216290 | D64216292 | D64216294 |
| 18.0mm       | 18.0mm         | 38.0mm       | 100.0mm      | 2      | D64217080 | D64217082 | D64217084 |
| 20.0mm       | 20.0mm         | 38.0mm       | 100.0mm      | 2      | D64217870 | D64217872 | D64217874 |
| 25.0mm       | 25.0mm         | 38.0mm       | 100.0mm      | 2      | D64219840 | D64219842 | D64219844 |

Feeds & Speeds Available on Page 115

**Application Range:**

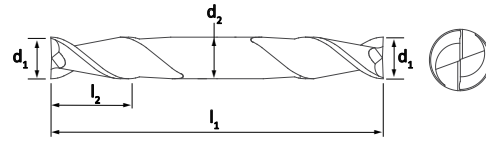
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          | ●                      | ●             |                     |

# Series D842

## 2 Flute Universal



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/32'' - 1/2'' = -.0001/-0.0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1/2'' = +.000/-0.002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/32         | 1/8            | 1/16         | 1-1/2        | 2      | D8422030 | D8422032 | D8422034 |
| 3/64         | 1/8            | 3/32         | 1-1/2        | 2      | D8422040 | D8422042 | D8422044 |
| 1/16         | 1/8            | 1/8          | 1-1/2        | 2      | D8422060 | D8422062 | D8422064 |
| 5/64         | 1/8            | 5/32         | 1-1/2        | 2      | D8422070 | D8422072 | D8422074 |
| 3/32         | 1/8            | 3/16         | 1-1/2        | 2      | D8422090 | D8422092 | D8422094 |
| 7/64         | 1/8            | 3/16         | 1-1/2        | 2      | D8422190 | D8422192 | D8422194 |
| 1/8          | 1/8            | 1/4          | 1-1/2        | 2      | D8422120 | D8422122 | D8422124 |
| 1/8          | 3/8            | 3/8          | 3            | 2      | D8421120 | D8421122 | D8421124 |
| 9/64         | 3/16           | 5/16         | 2            | 2      | D8422140 | D8422142 | D8422144 |
| 5/32         | 3/16           | 5/16         | 2            | 2      | D8422150 | D8422152 | D8422154 |
| 5/32         | 3/8            | 7/16         | 3            | 2      | D8421150 | D8421152 | D8421154 |
| 11/64        | 3/16           | 5/16         | 2            | 2      | D8422170 | D8422172 | D8422174 |
| 3/16         | 3/16           | 3/8          | 2            | 2      | D8422180 | D8422182 | D8422184 |
| 3/16         | 3/8            | 1/2          | 3            | 2      | D8421180 | D8421182 | D8421184 |
| 13/64        | 1/4            | 1/2          | 2-1/2        | 2      | D8422200 | D8422202 | D8422204 |
| 7/32         | 1/4            | 7/16         | 2-1/2        | 2      | D8422210 | D8422212 | D8422214 |
| 7/32         | 3/8            | 9/16         | 3            | 2      | D8421210 | D8421212 | D8421214 |
| 15/64        | 1/4            | 1/2          | 2-1/2        | 2      | D8422230 | D8422232 | D8422234 |
| 1/4          | 1/4            | 1/2          | 2-1/2        | 2      | D8422250 | D8422252 | D8422254 |
| 1/4          | 3/8            | 5/8          | 3            | 2      | D8421250 | D8421252 | D8421254 |
| 9/32         | 5/16           | 1/2          | 2-1/2        | 2      | D8422280 | D8422282 | D8422284 |
| 9/32         | 3/8            | 11/16        | 3-1/2        | 2      | D8421280 | D8421282 | D8421284 |
| 5/16         | 5/16           | 1/2          | 2-1/2        | 2      | D8422310 | D8422312 | D8422314 |
| 5/16         | 3/8            | 3/4          | 3-1/2        | 2      | D8421310 | D8421312 | D8421314 |
| 11/32        | 3/8            | 3/4          | 3-1/2        | 2      | D8421340 | D8421342 | D8421344 |
| 3/8          | 3/8            | 1/2          | 2-1/2        | 2      | D8422370 | D8422372 | D8422374 |
| 3/8          | 3/8            | 3/4          | 3-1/2        | 2      | D8421370 | D8421372 | D8421374 |
| 7/16         | 7/16           | 9/16         | 2-3/4        | 2      | D8422430 | D8422432 | D8422434 |
| 7/16         | 1/2            | 7/8          | 4            | 2      | D8421430 | D8421432 | D8421434 |
| 1/2          | 1/2            | 5/8          | 3            | 2      | D8422500 | D8422502 | D8422504 |
| 1/2          | 1/2            | 1            | 4            | 2      | D8421500 | D8421502 | D8421504 |

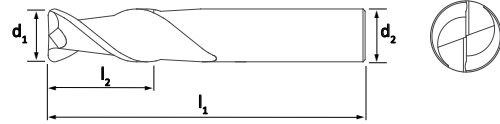
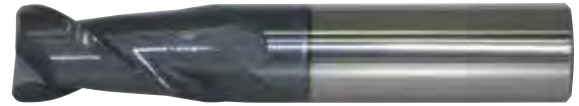
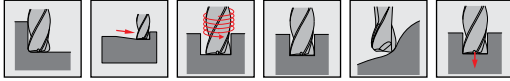
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         |          | •                      | •             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 3/4'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 3/4'' = +.000/-0.002$   
 Radius:  $1/8'' - 3/4'' = +/- .001$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.010       | 2      | D6421120/10 | D6421122/10 | D6421124/10 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.015       | 2      | D6421120/15 | D6421122/15 | D6421124/15 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.020       | 2      | D6421120/20 | D6421122/20 | D6421124/20 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.030       | 2      | D6421120/30 | D6421122/30 | D6421124/30 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.045       | 2      | D6421120/45 | D6421122/45 | D6421124/45 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.010       | 2      | D6421180/10 | D6421182/10 | D6421184/10 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.015       | 2      | D6421180/15 | D6421182/15 | D6421184/15 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.020       | 2      | D6421180/20 | D6421182/20 | D6421184/20 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.030       | 2      | D6421180/30 | D6421182/30 | D6421184/30 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.045       | 2      | D6421180/45 | D6421182/45 | D6421184/45 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.060       | 2      | D6421180/60 | D6421182/60 | D6421184/60 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.010       | 2      | D6421250/10 | D6421252/10 | D6421254/10 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.015       | 2      | D6421250/15 | D6421252/15 | D6421254/15 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.020       | 2      | D6421250/20 | D6421252/20 | D6421254/20 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.030       | 2      | D6421250/30 | D6421252/30 | D6421254/30 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.045       | 2      | D6421250/45 | D6421252/45 | D6421254/45 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.060       | 2      | D6421250/60 | D6421252/60 | D6421254/60 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.090       | 2      | D6421250/90 | D6421252/90 | D6421254/90 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.010       | 2      | D6421310/10 | D6421312/10 | D6421314/10 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.015       | 2      | D6421310/15 | D6421312/15 | D6421314/15 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.020       | 2      | D6421310/20 | D6421312/20 | D6421314/20 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.030       | 2      | D6421310/30 | D6421312/30 | D6421314/30 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.045       | 2      | D6421310/45 | D6421312/45 | D6421314/45 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.060       | 2      | D6421310/60 | D6421312/60 | D6421314/60 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.090       | 2      | D6421310/90 | D6421312/90 | D6421314/90 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.010       | 2      | D6421370/10 | D6421372/10 | D6421374/10 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.015       | 2      | D6421370/15 | D6421372/15 | D6421374/15 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.020       | 2      | D6421370/20 | D6421372/20 | D6421374/20 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.030       | 2      | D6421370/30 | D6421372/30 | D6421374/30 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.045       | 2      | D6421370/45 | D6421372/45 | D6421374/45 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.060       | 2      | D6421370/60 | D6421372/60 | D6421374/60 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.090       | 2      | D6421370/90 | D6421372/90 | D6421374/90 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.125       | 2      | D6421370/12 | D6421372/12 | D6421374/12 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.010       | 2      | D6421500/10 | D6421502/10 | D6421504/10 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.015       | 2      | D6421500/15 | D6421502/15 | D6421504/15 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.020       | 2      | D6421500/20 | D6421502/20 | D6421504/20 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.030       | 2      | D6421500/30 | D6421502/30 | D6421504/30 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.045       | 2      | D6421500/45 | D6421502/45 | D6421504/45 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.060       | 2      | D6421500/60 | D6421502/60 | D6421504/60 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.090       | 2      | D6421500/90 | D6421502/90 | D6421504/90 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.125       | 2      | D6421500/12 | D6421502/12 | D6421504/12 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.010       | 2      | D6421620/10 | D6421622/10 | D6421624/10 |

Additional Sizes On Pages 79  
 Feeds & Speeds Available on Page 115

Application Range:

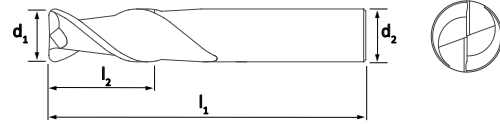
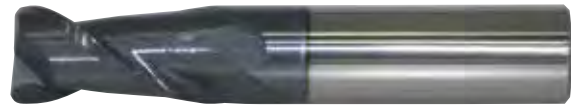
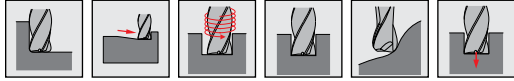
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          | ●                      | ●             |                     |

# Series D642CR

## 2 Flute Universal Corner Radius



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 3/4'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 3/4'' = +.000/-0.002$   
 Radius:  $1/8'' - 3/4'' = +/-0.001$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.015       | 2      | D6421620/15 | D6421622/15 | D6421624/15 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.020       | 2      | D6421620/20 | D6421622/20 | D6421624/20 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.030       | 2      | D6421620/30 | D6421622/30 | D6421624/30 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.045       | 2      | D6421620/45 | D6421622/45 | D6421624/45 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.060       | 2      | D6421620/60 | D6421622/60 | D6421624/60 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.090       | 2      | D6421620/90 | D6421622/90 | D6421624/90 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.125       | 2      | D6421620/12 | D6421622/12 | D6421624/12 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.010       | 2      | D6421750/10 | D6421752/10 | D6421754/10 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.015       | 2      | D6421750/15 | D6421752/15 | D6421754/15 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.020       | 2      | D6421750/20 | D6421752/20 | D6421754/20 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.030       | 2      | D6421750/30 | D6421752/30 | D6421754/30 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.045       | 2      | D6421750/45 | D6421752/45 | D6421754/45 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.060       | 2      | D6421750/60 | D6421752/60 | D6421754/60 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.090       | 2      | D6421750/90 | D6421752/90 | D6421754/90 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.125       | 2      | D6421750/12 | D6421752/12 | D6421754/12 |

Additional Sizes On Pages 78

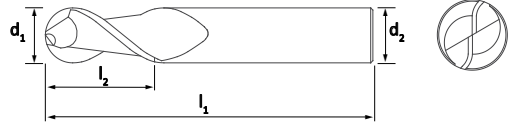
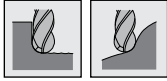
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         |          | •                      | •             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/32'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$   
 Ball:  $1/32'' - 1'' = +/- .001$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/32         | 1/8            | 3/32         | 1-1/2        | 2      | D6621030 | D6621032 | D6621034 |
| 3/64         | 1/8            | 9/64         | 1-1/2        | 2      | D6621040 | D6621042 | D6621044 |
| 1/16         | 1/8            | 1/8          | 1-1/2        | 2      | D6622060 | D6622062 | D6622064 |
| 1/16         | 1/8            | 3/16         | 1-1/2        | 2      | D6621060 | D6621062 | D6621064 |
| 5/64         | 1/8            | 1/4          | 1-1/2        | 2      | D6621070 | D6621072 | D6621074 |
| 3/32         | 1/8            | 3/16         | 1-1/2        | 2      | D6622090 | D6622092 | D6622094 |
| 3/32         | 1/8            | 9/32         | 1-1/2        | 2      | D6621090 | D6621092 | D6621094 |
| 7/64         | 1/8            | 3/16         | 1-1/2        | 2      | D6622190 | D6622192 | D6622194 |
| 7/64         | 1/8            | 3/8          | 1-1/2        | 2      | D6621190 | D6621192 | D6621194 |
| 1/8          | 1/8            | 1/4          | 1-1/2        | 2      | D6622120 | D6622122 | D6622124 |
| 1/8          | 1/8            | 1/2          | 1-1/2        | 2      | D6621120 | D6621122 | D6621124 |
| 1/8          | 1/8            | 3/4          | 2-1/4        | 2      | D6623120 | D6623122 | D6623124 |
| 1/8          | 1/8            | 3/4          | 3            | 2      | D6626120 | D6626122 | D6626124 |
| 1/8          | 1/8            | 1            | 3            | 2      | D6624120 | D6624122 | D6624124 |
| 9/64         | 3/16           | 3/8          | 2            | 2      | D6622140 | D6622142 | D6622144 |
| 9/64         | 3/16           | 1/2          | 2            | 2      | D6621140 | D6621142 | D6621144 |
| 5/32         | 3/16           | 3/8          | 2            | 2      | D6622150 | D6622152 | D6622154 |
| 5/32         | 3/16           | 1/2          | 2            | 2      | D6621150 | D6621152 | D6621154 |
| 11/64        | 3/16           | 3/8          | 2            | 2      | D6622170 | D6622172 | D6622174 |
| 11/64        | 3/16           | 5/8          | 2            | 2      | D6621170 | D6621172 | D6621174 |
| 3/16         | 3/16           | 3/8          | 2            | 2      | D6622180 | D6622182 | D6622184 |
| 3/16         | 3/16           | 5/8          | 2            | 2      | D6621180 | D6621182 | D6621184 |
| 3/16         | 3/16           | 3/4          | 2-1/2        | 2      | D6623180 | D6623182 | D6623184 |
| 3/16         | 3/16           | 1            | 4            | 2      | D6626180 | D6626182 | D6626184 |
| 3/16         | 3/16           | 1-1/8        | 3            | 2      | D6624180 | D6624182 | D6624184 |
| 13/64        | 1/4            | 3/8          | 2            | 2      | D6622200 | D6622202 | D6622204 |
| 13/64        | 1/4            | 5/8          | 2-1/2        | 2      | D6621200 | D6621202 | D6621204 |
| 7/32         | 1/4            | 3/8          | 2            | 2      | D6622210 | D6622212 | D6622214 |
| 7/32         | 1/4            | 5/8          | 2-1/2        | 2      | D6621210 | D6621212 | D6621214 |
| 15/64        | 1/4            | 3/8          | 2            | 2      | D6622230 | D6622232 | D6622234 |
| 15/64        | 1/4            | 3/4          | 2-1/2        | 2      | D6621230 | D6621232 | D6621234 |
| 1/4          | 1/4            | 3/8          | 2            | 2      | D6622250 | D6622252 | D6622254 |
| 1/4          | 1/4            | 3/4          | 2-1/2        | 2      | D6621250 | D6621252 | D6621254 |
| 1/4          | 1/4            | 1            | 4            | 2      | D6626250 | D6626252 | D6626254 |
| 1/4          | 1/4            | 1-1/8        | 3            | 2      | D6623250 | D6623252 | D6623254 |
| 1/4          | 1/4            | 1-1/2        | 4            | 2      | D6624250 | D6624252 | D6624254 |
| 1/4          | 1/4            | 1-1/2        | 6            | 2      | D6627250 | D6627252 | D6627254 |
| 17/64        | 5/16           | 1/2          | 2            | 2      | D6622260 | D6622262 | D6622264 |
| 17/64        | 5/16           | 3/4          | 2-1/2        | 2      | D6621260 | D6621262 | D6621264 |
| 9/32         | 5/16           | 1/2          | 2            | 2      | D6622280 | D6622282 | D6622284 |
| 9/32         | 5/16           | 3/4          | 2-1/2        | 2      | D6621280 | D6621282 | D6621284 |
| 19/64        | 5/16           | 1/2          | 2            | 2      | D6622290 | D6622292 | D6622294 |

Additional Sizes On Pages 81 - 82

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          | ●                      | ●             |                     |

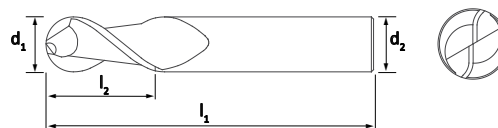
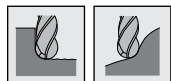


# Series D662

## 2 Flute Universal Ball



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/32'' - 1'' = -.0001/- .0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/- .002$   
 Ball:  $1/32'' - 1'' = +/- .001$

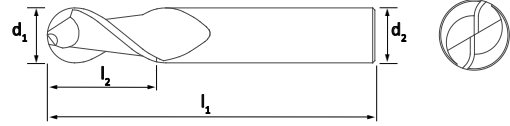
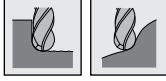
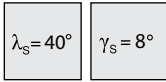
| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 19/64        | 5/16           | 3/4          | 2-1/2        | 2      | D6621290 | D6621292 | D6621294 |
| 5/16         | 5/16           | 1/2          | 2            | 2      | D6622310 | D6622312 | D6622314 |
| 5/16         | 5/16           | 3/4          | 2-1/2        | 2      | D6621310 | D6621312 | D6621314 |
| 5/16         | 5/16           | 1            | 4            | 2      | D6626310 | D6626312 | D6626314 |
| 5/16         | 5/16           | 1-1/8        | 3            | 2      | D6623310 | D6623312 | D6623314 |
| 5/16         | 5/16           | 1-1/2        | 6            | 2      | D6627310 | D6627312 | D6627314 |
| 5/16         | 5/16           | 1-5/8        | 4            | 2      | D6624310 | D6624312 | D6624314 |
| 21/64        | 3/8            | 5/8          | 2            | 2      | D6622320 | D6622322 | D6622324 |
| 21/64        | 3/8            | 7/8          | 2-1/2        | 2      | D6621320 | D6621322 | D6621324 |
| 11/32        | 3/8            | 5/8          | 2            | 2      | D6622340 | D6622342 | D6622344 |
| 11/32        | 3/8            | 7/8          | 2-1/2        | 2      | D6621340 | D6621342 | D6621344 |
| 23/64        | 3/8            | 5/8          | 2            | 2      | D6622350 | D6622352 | D6622354 |
| 23/64        | 3/8            | 7/8          | 2-1/2        | 2      | D6621350 | D6621352 | D6621354 |
| 3/8          | 3/8            | 5/8          | 2            | 2      | D6622370 | D6622372 | D6622374 |
| 3/8          | 3/8            | 7/8          | 2-1/2        | 2      | D6621370 | D6621372 | D6621374 |
| 3/8          | 3/8            | 1            | 4            | 2      | D6626370 | D6626372 | D6626374 |
| 3/8          | 3/8            | 1-1/8        | 3            | 2      | D6623370 | D6623372 | D6623374 |
| 3/8          | 3/8            | 1-1/2        | 6            | 2      | D6627370 | D6627372 | D6627374 |
| 3/8          | 3/8            | 1-3/4        | 4            | 2      | D6624370 | D6624372 | D6624374 |
| 3/8          | 3/8            | 3            | 6            | 2      | D6628370 | D6628372 | D6628374 |
| 25/64        | 7/16           | 5/8          | 2            | 2      | D6622390 | D6622392 | D6622394 |
| 25/64        | 7/16           | 1            | 2-3/4        | 2      | D6621390 | D6621392 | D6621394 |
| 13/32        | 7/16           | 5/8          | 2            | 2      | D6622400 | D6622402 | D6622404 |
| 13/32        | 7/16           | 1            | 2-3/4        | 2      | D6621400 | D6621402 | D6621404 |
| 27/64        | 7/16           | 5/8          | 2            | 2      | D6622420 | D6622422 | D6622424 |
| 27/64        | 7/16           | 1            | 2-3/4        | 2      | D6621420 | D6621422 | D6621424 |
| 7/16         | 7/16           | 5/8          | 2            | 2      | D6622430 | D6622432 | D6622434 |
| 7/16         | 7/16           | 1            | 2-3/4        | 2      | D6621430 | D6621432 | D6621434 |
| 7/16         | 7/16           | 1            | 4            | 2      | D6626430 | D6626432 | D6626434 |
| 7/16         | 7/16           | 1-1/2        | 6            | 2      | D6627430 | D6627432 | D6627434 |
| 7/16         | 7/16           | 2            | 4            | 2      | D6623430 | D6623432 | D6623434 |
| 7/16         | 7/16           | 3            | 6            | 2      | D6624430 | D6624432 | D6624434 |
| 29/64        | 1/2            | 5/8          | 2-1/2        | 2      | D6622450 | D6622452 | D6622454 |
| 29/64        | 1/2            | 1            | 3            | 2      | D6621450 | D6621452 | D6621454 |
| 15/32        | 1/2            | 5/8          | 2-1/2        | 2      | D6622460 | D6622462 | D6622464 |
| 15/32        | 1/2            | 1            | 3            | 2      | D6621460 | D6621462 | D6621464 |
| 31/64        | 1/2            | 5/8          | 2-1/2        | 2      | D6622480 | D6622482 | D6622484 |
| 31/64        | 1/2            | 1            | 3            | 2      | D6621480 | D6621482 | D6621484 |
| 1/2          | 1/2            | 5/8          | 2-1/2        | 2      | D6622500 | D6622502 | D6622504 |
| 1/2          | 1/2            | 1            | 3            | 2      | D6621500 | D6621502 | D6621504 |
| 1/2          | 1/2            | 1            | 4            | 2      | D6626500 | D6626502 | D6626504 |
| 1/2          | 1/2            | 1-1/2        | 6            | 2      | D6627500 | D6627502 | D6627504 |

Additional Sizes On Pages 80 & 82

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          | ●                      | ●             |                     |

**Tolerances**

Shank: 1/32" - 1" = -.0001/-.0004  
 Cutting Dia: 1/32" - 7/64" = +/- .0005  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Ball: 1/32" - 1" = +/- .001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 1/2                   | 1/2                     | 2                     | 4                     | 2      | D6623500 | D6623502 | D6623504 |
| 1/2                   | 1/2                     | 3                     | 6                     | 2      | D6624500 | D6624502 | D6624504 |
| 9/16                  | 9/16                    | 7/8                   | 3                     | 2      | D6622560 | D6622562 | D6622564 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 2      | D6621560 | D6621562 | D6621564 |
| 9/16                  | 9/16                    | 2                     | 6                     | 2      | D6626560 | D6626562 | D6626564 |
| 9/16                  | 9/16                    | 3                     | 6                     | 2      | D6624560 | D6624562 | D6624564 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 2      | D6622620 | D6622622 | D6622624 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 2      | D6621620 | D6621622 | D6621624 |
| 5/8                   | 5/8                     | 2                     | 6                     | 2      | D6626620 | D6626622 | D6626624 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 2      | D6623620 | D6623622 | D6623624 |
| 5/8                   | 5/8                     | 3                     | 6                     | 2      | D6624620 | D6624622 | D6624624 |
| 11/16                 | 3/4                     | 1                     | 3                     | 2      | D6622680 | D6622682 | D6622684 |
| 11/16                 | 3/4                     | 1-1/2                 | 4                     | 2      | D6621680 | D6621682 | D6621684 |
| 3/4                   | 3/4                     | 1                     | 3                     | 2      | D6622750 | D6622752 | D6622754 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 2      | D6621750 | D6621752 | D6621754 |
| 3/4                   | 3/4                     | 2                     | 6                     | 2      | D6626750 | D6626752 | D6626754 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 2      | D6623750 | D6623752 | D6623754 |
| 3/4                   | 3/4                     | 3                     | 6                     | 2      | D6624750 | D6624752 | D6624754 |
| 7/8                   | 7/8                     | 1-3/4                 | 4                     | 2      | D6621870 | D6621872 | D6621874 |
| 1                     | 1                       | 1-3/4                 | 4                     | 2      | D6621100 | D6621102 | D6621104 |
| 1                     | 1                       | 2                     | 6                     | 2      | D6626100 | D6626102 | D6626104 |
| 1                     | 1                       | 2-1/4                 | 5                     | 2      | D6623100 | D6623102 | D6623104 |
| 1                     | 1                       | 3                     | 6                     | 2      | D6624100 | D6624102 | D6624104 |

Additional Sizes On Pages 80 - 81

Feeds & Speeds Available on Page 115

**Application Range:**

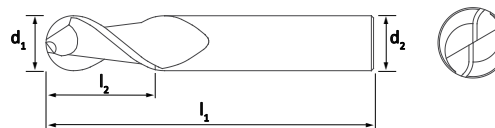
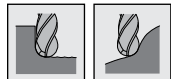
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         |          | •                      | •             |                     |

# Series D662M

## 2 Flute Universal Ball



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



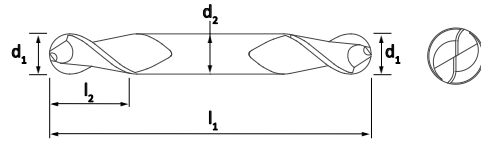
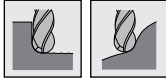
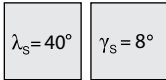
**Tolerances**  
 Shank: 1mm - 25mm =  $-.0025/-0.0102$   
 Cutting Dia: 1mm - 2.5mm =  $+/-0.0127$   
 Cutting Dia: 3mm - 25mm =  $+0.000/-0.0508$   
 Ball: 1mm - 25mm =  $+/-0.0254$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated  | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|-----------|-----------|-----------|
| 1.0mm                 | 3.0mm                   | 2.0mm                 | 38.0mm                | 2      | D66220390 | D66220392 | D66220394 |
| 1.0mm                 | 3.0mm                   | 4.0mm                 | 38.0mm                | 2      | D66210390 | D66210392 | D66210394 |
| 1.5mm                 | 3.0mm                   | 3.0mm                 | 38.0mm                | 2      | D66220590 | D66220592 | D66220594 |
| 1.5mm                 | 3.0mm                   | 6.0mm                 | 38.0mm                | 2      | D66210590 | D66210592 | D66210594 |
| 2.0mm                 | 3.0mm                   | 4.0mm                 | 38.0mm                | 2      | D66220780 | D66220782 | D66220784 |
| 2.0mm                 | 3.0mm                   | 8.0mm                 | 38.0mm                | 2      | D66210780 | D66210782 | D66210784 |
| 2.5mm                 | 3.0mm                   | 10.0mm                | 38.0mm                | 2      | D66210980 | D66210982 | D66210984 |
| 2.5mm                 | 3.0mm                   | 5.0mm                 | 38.0mm                | 2      | D66220980 | D66220982 | D66220984 |
| 3.0mm                 | 3.0mm                   | 6.0mm                 | 38.0mm                | 2      | D66221180 | D66221182 | D66221184 |
| 3.0mm                 | 3.0mm                   | 12.0mm                | 38.0mm                | 2      | D66211180 | D66211182 | D66211184 |
| 3.5mm                 | 4.0mm                   | 7.0mm                 | 50.0mm                | 2      | D66221370 | D66221372 | D66221374 |
| 3.5mm                 | 4.0mm                   | 12.0mm                | 50.0mm                | 2      | D66211370 | D66211372 | D66211374 |
| 4.0mm                 | 4.0mm                   | 8.0mm                 | 50.0mm                | 2      | D66221570 | D66221572 | D66221574 |
| 4.0mm                 | 4.0mm                   | 14.0mm                | 50.0mm                | 2      | D66211570 | D66211572 | D66211574 |
| 4.5mm                 | 6.0mm                   | 9.5mm                 | 63.0mm                | 2      | D66221770 | D66221772 | D66221774 |
| 4.5mm                 | 6.0mm                   | 16.0mm                | 63.0mm                | 2      | D66211770 | D66211772 | D66211774 |
| 5.0mm                 | 6.0mm                   | 10.0mm                | 63.0mm                | 2      | D66221960 | D66221962 | D66221964 |
| 5.0mm                 | 6.0mm                   | 16.0mm                | 63.0mm                | 2      | D66211960 | D66211962 | D66211964 |
| 6.0mm                 | 6.0mm                   | 12.0mm                | 63.0mm                | 2      | D66222360 | D66222362 | D66222364 |
| 6.0mm                 | 6.0mm                   | 19.0mm                | 63.0mm                | 2      | D66212360 | D66212362 | D66212364 |
| 7.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 2      | D66222750 | D66222752 | D66222754 |
| 7.0mm                 | 8.0mm                   | 19.0mm                | 63.0mm                | 2      | D66212750 | D66212752 | D66212754 |
| 8.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 2      | D66223150 | D66223152 | D66223154 |
| 8.0mm                 | 8.0mm                   | 20.0mm                | 63.0mm                | 2      | D66213150 | D66213152 | D66213154 |
| 9.0mm                 | 10.0mm                  | 14.0mm                | 70.0mm                | 2      | D66223540 | D66223542 | D66223544 |
| 9.0mm                 | 10.0mm                  | 25.0mm                | 70.0mm                | 2      | D66213540 | D66213542 | D66213544 |
| 10.0mm                | 10.0mm                  | 14.0mm                | 70.0mm                | 2      | D66223930 | D66223932 | D66223934 |
| 10.0mm                | 10.0mm                  | 25.0mm                | 70.0mm                | 2      | D66213930 | D66213932 | D66213934 |
| 11.0mm                | 12.0mm                  | 14.0mm                | 76.0mm                | 2      | D66224330 | D66224332 | D66224334 |
| 11.0mm                | 12.0mm                  | 25.0mm                | 76.0mm                | 2      | D66214330 | D66214332 | D66214334 |
| 12.0mm                | 12.0mm                  | 16.0mm                | 76.0mm                | 2      | D66224720 | D66224722 | D66224724 |
| 12.0mm                | 12.0mm                  | 25.0mm                | 76.0mm                | 2      | D66214720 | D66214722 | D66214724 |
| 14.0mm                | 14.0mm                  | 32.0mm                | 89.0mm                | 2      | D66215510 | D66215512 | D66215514 |
| 16.0mm                | 16.0mm                  | 32.0mm                | 89.0mm                | 2      | D66216290 | D66216292 | D66216294 |
| 18.0mm                | 18.0mm                  | 38.0mm                | 100.0mm               | 2      | D66217080 | D66217082 | D66217084 |
| 20.0mm                | 20.0mm                  | 38.0mm                | 100.0mm               | 2      | D66217870 | D66217872 | D66217874 |
| 25.0mm                | 25.0mm                  | 38.0mm                | 100.0mm               | 2      | D66219840 | D66219842 | D66219844 |

Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         |          | ●                      | ●             |                     |

**Tolerances**

Shank:  $1/32'' - 3/8'' = -.0001/- .0004$   
 Cutting Dia:  $1/32'' - 3/32'' = +/- .0005$   
 Ball:  $1/8'' - 3/8'' = +/- .001$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/32         | 1/8            | 1/16         | 1-1/2        | 2      | D8622030 | D8622032 | D8622034 |
| 3/64         | 1/8            | 3/32         | 1-1/2        | 2      | D8622040 | D8622042 | D8622044 |
| 1/16         | 1/8            | 1/8          | 1-1/2        | 2      | D8622060 | D8622062 | D8622064 |
| 5/64         | 1/8            | 5/32         | 1-1/2        | 2      | D8622070 | D8622072 | D8622074 |
| 3/32         | 1/8            | 3/16         | 1-1/2        | 2      | D8622090 | D8622092 | D8622094 |
| 1/8          | 1/8            | 1/4          | 1-1/2        | 2      | D8622120 | D8622122 | D8622124 |
| 5/32         | 3/16           | 5/16         | 2            | 2      | D8622150 | D8622152 | D8622154 |
| 3/16         | 3/16           | 3/8          | 2            | 2      | D8622180 | D8622182 | D8622184 |
| 7/32         | 1/4            | 7/16         | 2-1/2        | 2      | D8622210 | D8622212 | D8622214 |
| 1/4          | 1/4            | 1/2          | 2-1/2        | 2      | D8622250 | D8622252 | D8622254 |
| 5/16         | 5/16           | 1/2          | 2-1/2        | 2      | D8622310 | D8622312 | D8622314 |
| 3/8          | 3/8            | 1/2          | 2-1/2        | 2      | D8622370 | D8622372 | D8622374 |

Feeds &amp; Speeds Available on Page 115

**Application Range:**

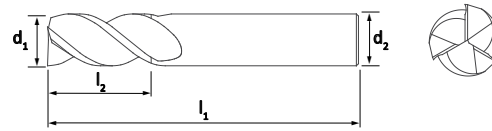
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         |          | •                      | •             |                     |

# Series D643

## 3 Flute Universal



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/16'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/16'' - 7/64'' = +/-0.0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$

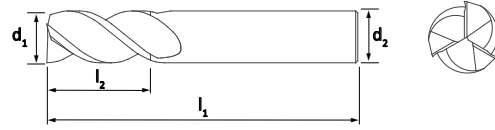
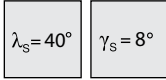
| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/16         | 1/8            | 1/8          | 1-1/2        | 3      | D6432060 | D6432062 | D6432064 |
| 1/16         | 1/8            | 3/16         | 1-1/2        | 3      | D6431060 | D6431062 | D6431064 |
| 5/64         | 1/8            | 1/4          | 1-1/2        | 3      | D6431070 | D6431072 | D6431074 |
| 3/32         | 1/8            | 3/16         | 1-1/2        | 3      | D6432090 | D6432092 | D6432094 |
| 3/32         | 1/8            | 9/32         | 1-1/2        | 3      | D6431090 | D6431092 | D6431094 |
| 7/64         | 1/8            | 3/8          | 1-1/2        | 3      | D6431190 | D6431192 | D6431194 |
| 1/8          | 1/8            | 1/4          | 1-1/2        | 3      | D6432120 | D6432122 | D6432124 |
| 1/8          | 1/8            | 1/2          | 1-1/2        | 3      | D6431120 | D6431122 | D6431124 |
| 1/8          | 1/8            | 3/4          | 2-1/4        | 3      | D6433120 | D6433122 | D6433124 |
| 1/8          | 1/8            | 3/4          | 3            | 3      | D6436120 | D6436122 | D6436124 |
| 1/8          | 1/8            | 1            | 3            | 3      | D6434120 | D6434122 | D6434124 |
| 9/64         | 3/16           | 1/2          | 2            | 3      | D6431140 | D6431142 | D6431144 |
| 5/32         | 3/16           | 3/8          | 2            | 3      | D6432150 | D6432152 | D6432154 |
| 5/32         | 3/16           | 1/2          | 2            | 3      | D6431150 | D6431152 | D6431154 |
| 11/64        | 3/16           | 5/8          | 2            | 3      | D6431170 | D6431172 | D6431174 |
| 3/16         | 3/16           | 3/8          | 2            | 3      | D6432180 | D6432182 | D6432184 |
| 3/16         | 3/16           | 5/8          | 2            | 3      | D6431180 | D6431182 | D6431184 |
| 3/16         | 3/16           | 3/4          | 2-1/2        | 3      | D6433180 | D6433182 | D6433184 |
| 3/16         | 3/16           | 1            | 2-1/2        | 3      | D6435180 | D6435182 | D6435184 |
| 3/16         | 3/16           | 1            | 4            | 3      | D6436180 | D6436182 | D6436184 |
| 3/16         | 3/16           | 1-1/8        | 3            | 3      | D6434180 | D6434182 | D6434184 |
| 13/64        | 1/4            | 5/8          | 2-1/2        | 3      | D6431200 | D6431202 | D6431204 |
| 7/32         | 1/4            | 3/8          | 2            | 3      | D6432210 | D6432212 | D6432214 |
| 7/32         | 1/4            | 5/8          | 2-1/2        | 3      | D6431210 | D6431212 | D6431214 |
| 15/64        | 1/4            | 3/4          | 2-1/2        | 3      | D6431230 | D6431232 | D6431234 |
| 1/4          | 1/4            | 3/8          | 2            | 3      | D6432250 | D6432252 | D6432254 |
| 1/4          | 1/4            | 3/4          | 2-1/2        | 3      | D6431250 | D6431252 | D6431254 |
| 1/4          | 1/4            | 1            | 4            | 3      | D6436250 | D6436252 | D6436254 |
| 1/4          | 1/4            | 1-1/8        | 3            | 3      | D6433250 | D6433252 | D6433254 |
| 1/4          | 1/4            | 1-1/2        | 4            | 3      | D6434250 | D6434252 | D6434254 |
| 1/4          | 1/4            | 1-1/2        | 6            | 3      | D6437250 | D6437252 | D6437254 |
| 17/64        | 5/16           | 3/4          | 2-1/2        | 3      | D6431260 | D6431262 | D6431264 |
| 9/32         | 5/16           | 1/2          | 2            | 3      | D6432280 | D6432282 | D6432284 |
| 9/32         | 5/16           | 3/4          | 2-1/2        | 3      | D6431280 | D6431282 | D6431284 |
| 19/64        | 5/16           | 3/4          | 2-1/2        | 3      | D6431290 | D6431292 | D6431294 |
| 5/16         | 5/16           | 1/2          | 2            | 3      | D6432310 | D6432312 | D6432314 |
| 5/16         | 5/16           | 3/4          | 2-1/2        | 3      | D6431310 | D6431312 | D6431314 |
| 5/16         | 5/16           | 1            | 4            | 3      | D6436310 | D6436312 | D6436314 |
| 5/16         | 5/16           | 1-1/8        | 3            | 3      | D6433310 | D6433312 | D6433314 |
| 5/16         | 5/16           | 1-1/2        | 6            | 3      | D6437310 | D6437312 | D6437314 |
| 5/16         | 5/16           | 1-5/8        | 4            | 3      | D6434310 | D6434312 | D6434314 |
| 21/64        | 3/8            | 7/8          | 2-1/2        | 3      | D6431320 | D6431322 | D6431324 |

Additional Sizes On Pages 86 - 87

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         | •        | •                      | •             |                     |



**Tolerances**

Shank: 1/16" - 1" = -.0001/-.0004  
 Cutting Dia: 1/16" - 7/64" = +/- .0005  
 Cutting Dia: 1/8" - 1" = +.000/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 11/32                 | 3/8                     | 5/8                   | 2                     | 3      | D6432340 | D6432342 | D6432344 |
| 11/32                 | 3/8                     | 7/8                   | 2-1/2                 | 3      | D6431340 | D6431342 | D6431344 |
| 23/64                 | 3/8                     | 7/8                   | 2-1/2                 | 3      | D6431350 | D6431352 | D6431354 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 3      | D6432370 | D6432372 | D6432374 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 3      | D6431370 | D6431372 | D6431374 |
| 3/8                   | 3/8                     | 1                     | 4                     | 3      | D6436370 | D6436372 | D6436374 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 3      | D6433370 | D6433372 | D6433374 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 3      | D6437370 | D6437372 | D6437374 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 3      | D6434370 | D6434372 | D6434374 |
| 3/8                   | 3/8                     | 3                     | 6                     | 3      | D6438370 | D6438372 | D6438374 |
| 25/64                 | 7/16                    | 1                     | 2-3/4                 | 3      | D6431390 | D6431392 | D6431394 |
| 13/32                 | 7/16                    | 1                     | 2-3/4                 | 3      | D6431400 | D6431402 | D6431404 |
| 27/64                 | 7/16                    | 1                     | 2-3/4                 | 3      | D6431420 | D6431422 | D6431424 |
| 7/16                  | 7/16                    | 5/8                   | 2                     | 3      | D6432430 | D6432432 | D6432434 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 3      | D6431430 | D6431432 | D6431434 |
| 7/16                  | 7/16                    | 1                     | 4                     | 3      | D6436430 | D6436432 | D6436434 |
| 7/16                  | 7/16                    | 1-1/2                 | 6                     | 3      | D6437430 | D6437432 | D6437434 |
| 7/16                  | 7/16                    | 2                     | 4                     | 3      | D6433430 | D6433432 | D6433434 |
| 7/16                  | 7/16                    | 3                     | 6                     | 3      | D6434430 | D6434432 | D6434434 |
| 29/64                 | 1/2                     | 1                     | 3                     | 3      | D6431450 | D6431452 | D6431454 |
| 15/32                 | 1/2                     | 1                     | 3                     | 3      | D6431460 | D6431462 | D6431464 |
| 31/64                 | 1/2                     | 1                     | 3                     | 3      | D6431480 | D6431482 | D6431484 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 3      | D6432500 | D6432502 | D6432504 |
| 1/2                   | 1/2                     | 1                     | 3                     | 3      | D6431500 | D6431502 | D6431504 |
| 1/2                   | 1/2                     | 1                     | 4                     | 3      | D6436500 | D6436502 | D6436504 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 3      | D6437500 | D6437502 | D6437504 |
| 1/2                   | 1/2                     | 2                     | 4                     | 3      | D6433500 | D6433502 | D6433504 |
| 1/2                   | 1/2                     | 3                     | 6                     | 3      | D6434500 | D6434502 | D6434504 |
| 9/16                  | 9/16                    | 7/8                   | 3                     | 3      | D6432560 | D6432562 | D6432564 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 3      | D6431560 | D6431562 | D6431564 |
| 9/16                  | 9/16                    | 2                     | 6                     | 3      | D6436560 | D6436562 | D6436564 |
| 9/16                  | 9/16                    | 3                     | 6                     | 3      | D6434560 | D6434562 | D6434564 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 3      | D6432620 | D6432622 | D6432624 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 3      | D6431620 | D6431622 | D6431624 |
| 5/8                   | 5/8                     | 2                     | 6                     | 3      | D6436620 | D6436622 | D6436624 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 3      | D6433620 | D6433622 | D6433624 |
| 5/8                   | 5/8                     | 3                     | 6                     | 3      | D6434620 | D6434622 | D6434624 |
| 11/16                 | 3/4                     | 1                     | 3                     | 3      | D6432680 | D6432682 | D6432684 |
| 11/16                 | 3/4                     | 1-1/2                 | 4                     | 3      | D6431680 | D6431682 | D6431684 |
| 3/4                   | 3/4                     | 1                     | 3                     | 3      | D6432750 | D6432752 | D6432754 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 3      | D6431750 | D6431752 | D6431754 |
| 3/4                   | 3/4                     | 2                     | 6                     | 3      | D6436750 | D6436752 | D6436754 |

Additional Sizes On Pages 85 & 87

Feeds & Speeds Available on Page 115

Application Range:

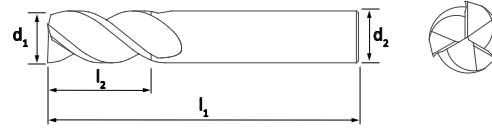
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         | ●        | ●                      | ●             |                     |

# Series D643

## 3 Flute Universal



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/16'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/16'' - 7/64'' = +/-0.0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 3/4          | 3/4            | 2-1/4        | 5            | 3      | D6433750 | D6433752 | D6433754 |
| 3/4          | 3/4            | 3            | 6            | 3      | D6434750 | D6434752 | D6434754 |
| 7/8          | 7/8            | 1-3/4        | 4            | 3      | D6431870 | D6431872 | D6431874 |
| 1            | 1              | 1-3/4        | 4            | 3      | D6431100 | D6431102 | D6431104 |
| 1            | 1              | 2            | 6            | 3      | D6436100 | D6436102 | D6436104 |
| 1            | 1              | 2-1/4        | 5            | 3      | D6433100 | D6433102 | D6433104 |
| 1            | 1              | 3            | 6            | 3      | D6434100 | D6434102 | D6434104 |

Additional Sizes On Pages 85 - 86

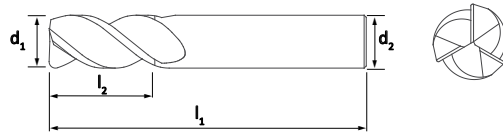
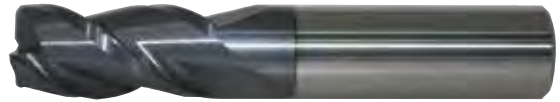
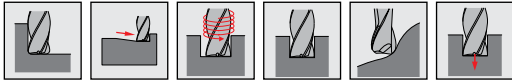
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         | •        | •                      | •             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.010       | 3      | D6431120/10 | D6431122/10 | D6431124/10 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.015       | 3      | D6431120/15 | D6431122/15 | D6431124/15 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.020       | 3      | D6431120/20 | D6431122/20 | D6431124/20 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.030       | 3      | D6431120/30 | D6431122/30 | D6431124/30 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.045       | 3      | D6431120/45 | D6431122/45 | D6431124/45 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.010       | 3      | D6431180/10 | D6431182/10 | D6431184/10 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.015       | 3      | D6431180/15 | D6431182/15 | D6431184/15 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.020       | 3      | D6431180/20 | D6431182/20 | D6431184/20 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.030       | 3      | D6431180/30 | D6431182/30 | D6431184/30 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.045       | 3      | D6431180/45 | D6431182/45 | D6431184/45 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.060       | 3      | D6431180/60 | D6431182/60 | D6431184/60 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.010       | 3      | D6431250/10 | D6431252/10 | D6431254/10 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.015       | 3      | D6431250/15 | D6431252/15 | D6431254/15 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.020       | 3      | D6431250/20 | D6431252/20 | D6431254/20 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.030       | 3      | D6431250/30 | D6431252/30 | D6431254/30 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.045       | 3      | D6431250/45 | D6431252/45 | D6431254/45 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.060       | 3      | D6431250/60 | D6431252/60 | D6431254/60 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.090       | 3      | D6431250/90 | D6431252/90 | D6431254/90 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.010       | 3      | D6431310/10 | D6431312/10 | D6431314/10 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.015       | 3      | D6431310/15 | D6431312/15 | D6431314/15 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.020       | 3      | D6431310/20 | D6431312/20 | D6431314/20 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.030       | 3      | D6431310/30 | D6431312/30 | D6431314/30 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.045       | 3      | D6431310/45 | D6431312/45 | D6431314/45 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.060       | 3      | D6431310/60 | D6431312/60 | D6431314/60 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.090       | 3      | D6431310/90 | D6431312/90 | D6431314/90 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.010       | 3      | D6431370/10 | D6431372/10 | D6431374/10 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.015       | 3      | D6431370/15 | D6431372/15 | D6431374/15 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.020       | 3      | D6431370/20 | D6431372/20 | D6431374/20 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.030       | 3      | D6431370/30 | D6431372/30 | D6431374/30 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.045       | 3      | D6431370/45 | D6431372/45 | D6431374/45 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.060       | 3      | D6431370/60 | D6431372/60 | D6431374/60 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.090       | 3      | D6431370/90 | D6431372/90 | D6431374/90 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.125       | 3      | D6431370/12 | D6431372/12 | D6431374/12 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.010       | 3      | D6431500/10 | D6431502/10 | D6431504/10 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.015       | 3      | D6431500/15 | D6431502/15 | D6431504/15 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.020       | 3      | D6431500/20 | D6431502/20 | D6431504/20 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.030       | 3      | D6431500/30 | D6431502/30 | D6431504/30 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.045       | 3      | D6431500/45 | D6431502/45 | D6431504/45 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.060       | 3      | D6431500/60 | D6431502/60 | D6431504/60 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.090       | 3      | D6431500/90 | D6431502/90 | D6431504/90 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.125       | 3      | D6431500/12 | D6431502/12 | D6431504/12 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.010       | 3      | D6431620/10 | D6431622/10 | D6431624/10 |

Additional Sizes On Pages 89

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         | ●        | ●                      | ●             |                     |

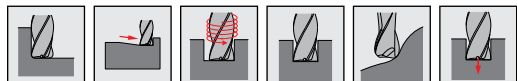


# Series D643CR

## 3 Flute Universal Corner Radius

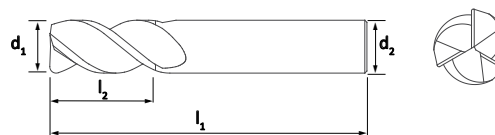


$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



### Tolerances

Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/-0.001



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.015       | 3      | D6431620/15 | D6431622/15 | D6431624/15 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.020       | 3      | D6431620/20 | D6431622/20 | D6431624/20 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.030       | 3      | D6431620/30 | D6431622/30 | D6431624/30 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.045       | 3      | D6431620/45 | D6431622/45 | D6431624/45 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.060       | 3      | D6431620/60 | D6431622/60 | D6431624/60 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.090       | 3      | D6431620/90 | D6431622/90 | D6431624/90 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.125       | 3      | D6431620/12 | D6431622/12 | D6431624/12 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.010       | 3      | D6431750/10 | D6431752/10 | D6431754/10 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.015       | 3      | D6431750/15 | D6431752/15 | D6431754/15 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.020       | 3      | D6431750/20 | D6431752/20 | D6431754/20 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.030       | 3      | D6431750/30 | D6431752/30 | D6431754/30 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.045       | 3      | D6431750/45 | D6431752/45 | D6431754/45 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.060       | 3      | D6431750/60 | D6431752/60 | D6431754/60 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.090       | 3      | D6431750/90 | D6431752/90 | D6431754/90 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.125       | 3      | D6431750/12 | D6431752/12 | D6431754/12 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.010       | 3      | D6431100/10 | D6431102/10 | D6431104/10 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.015       | 3      | D6431100/15 | D6431102/15 | D6431104/15 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.020       | 3      | D6431100/20 | D6431102/20 | D6431104/20 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.030       | 3      | D6431100/30 | D6431102/30 | D6431104/30 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.045       | 3      | D6431100/45 | D6431102/45 | D6431104/45 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.060       | 3      | D6431100/60 | D6431102/60 | D6431104/60 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.090       | 3      | D6431100/90 | D6431102/90 | D6431104/90 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.125       | 3      | D6431100/12 | D6431102/12 | D6431104/12 |

Additional Sizes On Pages 88

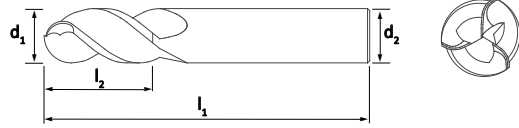
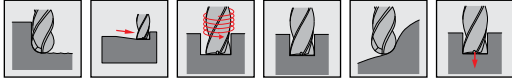
Feeds & Speeds Available on Page 115

### Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         | •        | •                      | •             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 3      | D6632120 | D6632122 | D6632124 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 3      | D6631120 | D6631122 | D6631124 |
| 1/8                   | 1/8                     | 3/4                   | 2-1/4                 | 3      | D6633120 | D6633122 | D6633124 |
| 1/8                   | 1/8                     | 3/4                   | 3                     | 3      | D6636120 | D6636122 | D6636124 |
| 1/8                   | 1/8                     | 1                     | 3                     | 3      | D6634120 | D6634122 | D6634124 |
| 9/64                  | 3/16                    | 1/2                   | 2                     | 3      | D6631140 | D6631142 | D6631144 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 3      | D6631150 | D6631152 | D6631154 |
| 11/64                 | 3/16                    | 5/8                   | 2                     | 3      | D6631170 | D6631172 | D6631174 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 3      | D6632180 | D6632182 | D6632184 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 3      | D6631180 | D6631182 | D6631184 |
| 3/16                  | 3/16                    | 3/4                   | 2-1/2                 | 3      | D6633180 | D6633182 | D6633184 |
| 3/16                  | 3/16                    | 1                     | 2-1/2                 | 3      | D6635180 | D6635182 | D6635184 |
| 3/16                  | 3/16                    | 1                     | 4                     | 3      | D6636180 | D6636182 | D6636184 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 3      | D6634180 | D6634182 | D6634184 |
| 13/64                 | 1/4                     | 5/8                   | 2-1/2                 | 3      | D6631200 | D6631202 | D6631204 |
| 7/32                  | 1/4                     | 5/8                   | 2-1/2                 | 3      | D6631210 | D6631212 | D6631214 |
| 15/64                 | 1/4                     | 3/4                   | 2-1/2                 | 3      | D6631230 | D6631232 | D6631234 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 3      | D6632250 | D6632252 | D6632254 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 3      | D6631250 | D6631252 | D6631254 |
| 1/4                   | 1/4                     | 1                     | 4                     | 3      | D6636250 | D6636252 | D6636254 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 3      | D6633250 | D6633252 | D6633254 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 3      | D6634250 | D6634252 | D6634254 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 3      | D6637250 | D6637252 | D6637254 |
| 17/64                 | 5/16                    | 3/4                   | 2-1/2                 | 3      | D6631260 | D6631262 | D6631264 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 | 3      | D6631280 | D6631282 | D6631284 |
| 19/64                 | 5/16                    | 3/4                   | 2-1/2                 | 3      | D6631290 | D6631292 | D6631294 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 3      | D6631310 | D6631312 | D6631314 |
| 5/16                  | 5/16                    | 1                     | 4                     | 3      | D6636310 | D6636312 | D6636314 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 3      | D6637310 | D6637312 | D6637314 |
| 21/64                 | 3/8                     | 7/8                   | 2-1/2                 | 3      | D6631320 | D6631322 | D6631324 |
| 11/32                 | 3/8                     | 7/8                   | 2-1/2                 | 3      | D6631340 | D6631342 | D6631344 |
| 23/64                 | 3/8                     | 7/8                   | 2-1/2                 | 3      | D6631350 | D6631352 | D6631354 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 3      | D6632370 | D6632372 | D6632374 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 3      | D6631370 | D6631372 | D6631374 |
| 3/8                   | 3/8                     | 1                     | 4                     | 3      | D6636370 | D6636372 | D6636374 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 3      | D6633370 | D6633372 | D6633374 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 3      | D6637370 | D6637372 | D6637374 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 3      | D6634370 | D6634372 | D6634374 |
| 3/8                   | 3/8                     | 3                     | 6                     | 3      | D6638370 | D6638372 | D6638374 |
| 25/64                 | 7/16                    | 1                     | 2-3/4                 | 3      | D6631390 | D6631392 | D6631394 |
| 13/32                 | 7/16                    | 1                     | 2-3/4                 | 3      | D6631400 | D6631402 | D6631404 |
| 27/64                 | 7/16                    | 1                     | 2-3/4                 | 3      | D6631420 | D6631422 | D6631424 |

Additional Sizes On Pages 91

Feeds & Speeds Available on Page 115

Application Range:

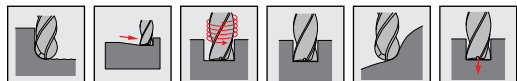
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     |            |                |                 |          |                  | ●         | ●        | ●                      | ●             |                     |

# Series D663

## 3 Flute Universal Ball

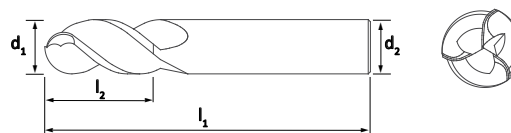


$\lambda_s = 40^\circ$     $\gamma_s = 8^\circ$



**Tolerances**

Shank:  $1/8'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$   
 Radius:  $1/8'' - 1'' = +/-0.001$



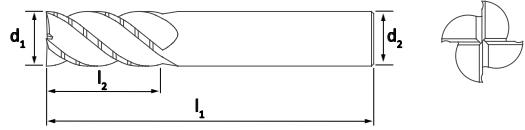
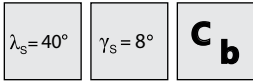
| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 7/16         | 7/16           | 1            | 2-3/4        | 3      | D6631430 | D6631432 | D6631434 |
| 7/16         | 7/16           | 1            | 4            | 3      | D6636430 | D6636432 | D6636434 |
| 7/16         | 7/16           | 1-1/2        | 6            | 3      | D6637430 | D6637432 | D6637434 |
| 7/16         | 7/16           | 2            | 4            | 3      | D6633430 | D6633432 | D6633434 |
| 7/16         | 7/16           | 3            | 6            | 3      | D6634430 | D6634432 | D6634434 |
| 29/64        | 1/2            | 1            | 3            | 3      | D6631450 | D6631452 | D6631454 |
| 15/32        | 1/2            | 1            | 3            | 3      | D6631460 | D6631462 | D6631464 |
| 31/64        | 1/2            | 1            | 3            | 3      | D6631480 | D6631482 | D6631484 |
| 1/2          | 1/2            | 5/8          | 2-1/2        | 3      | D6632500 | D6632502 | D6632504 |
| 1/2          | 1/2            | 1            | 3            | 3      | D6631500 | D6631502 | D6631504 |
| 1/2          | 1/2            | 1            | 4            | 3      | D6636500 | D6636502 | D6636504 |
| 1/2          | 1/2            | 1-1/2        | 6            | 3      | D6637500 | D6637502 | D6637504 |
| 1/2          | 1/2            | 2            | 4            | 3      | D6633500 | D6633502 | D6633504 |
| 1/2          | 1/2            | 3            | 6            | 3      | D6634500 | D6634502 | D6634504 |
| 9/16         | 9/16           | 1-1/4        | 3-1/2        | 3      | D6631560 | D6631562 | D6631564 |
| 9/16         | 9/16           | 2            | 6            | 3      | D6636560 | D6636562 | D6636564 |
| 9/16         | 9/16           | 3            | 6            | 3      | D6634560 | D6634562 | D6634564 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        | 3      | D6631620 | D6631622 | D6631624 |
| 5/8          | 5/8            | 2            | 6            | 3      | D6636620 | D6636622 | D6636624 |
| 5/8          | 5/8            | 2-1/8        | 4-5/8        | 3      | D6633620 | D6633622 | D6633624 |
| 5/8          | 5/8            | 3            | 6            | 3      | D6634620 | D6634622 | D6634624 |
| 11/16        | 3/4            | 1-1/2        | 4            | 3      | D6631680 | D6631682 | D6631684 |
| 3/4          | 3/4            | 1-1/2        | 4            | 3      | D6631750 | D6631752 | D6631754 |
| 3/4          | 3/4            | 2            | 6            | 3      | D6636750 | D6636752 | D6636754 |
| 3/4          | 3/4            | 2-1/4        | 5            | 3      | D6633750 | D6633752 | D6633754 |
| 3/4          | 3/4            | 3            | 6            | 3      | D6634750 | D6634752 | D6634754 |
| 7/8          | 7/8            | 1-3/4        | 4            | 3      | D6631870 | D6631872 | D6631874 |
| 1            | 1              | 1-3/4        | 4            | 3      | D6631100 | D6631102 | D6631104 |
| 1            | 1              | 2            | 6            | 3      | D6636100 | D6636102 | D6636104 |
| 1            | 1              | 2-1/4        | 5            | 3      | D6633100 | D6633102 | D6633104 |
| 1            | 1              | 3            | 6            | 3      | D6634100 | D6634102 | D6634104 |

Additional Sizes On Pages 90

Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     |            |                |                 |          |                  | •         | •        | •                      | •             |                     |



**Tolerances**  
Shank: 1/8" - 1" = -.0001/- .0004  
Cutting Dia: 1/8" - 1" = +.000/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|-----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 4      | D70100824 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 4      | D70100814 |
| 1/8                   | 1/8                     | 3/4                   | 2-1/4                 | 4      | D70100834 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 4      | D70101224 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 4      | D70101214 |
| 3/16                  | 3/16                    | 3/4                   | 2-1/2                 | 4      | D70101234 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 4      | D70101244 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 4      | D70101624 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 4      | D70101614 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 4      | D70101634 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 4      | D70102024 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 4      | D70102014 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 4      | D70102034 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 4      | D70102424 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 4      | D70102414 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 4      | D70102434 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 4      | D70102444 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 4      | D70102814 |
| 7/16                  | 7/16                    | 2                     | 4                     | 4      | D70102834 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 4      | D70103224 |
| 1/2                   | 1/2                     | 1                     | 3                     | 4      | D70103214 |
| 1/2                   | 1/2                     | 2                     | 4                     | 4      | D70103234 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 4      | D70104024 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 4      | D70104014 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 4      | D70104814 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 4      | D70104834 |
| 3/4                   | 3/4                     | 3                     | 6                     | 4      | D70104844 |
| 1                     | 1                       | 1-3/4                 | 4                     | 4      | D70106414 |
| 1                     | 1                       | 2-1/4                 | 5                     | 4      | D70106434 |

Feeds & Speeds Available on Page 115

Application Range:

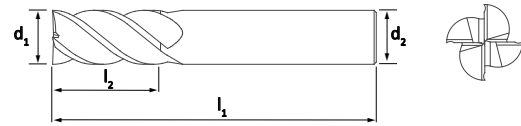
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      |               |                     |

# Series D644

## 4 Flute Universal



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**

Shank: 1/32" - 1" = -.0001/- .0004  
 Cutting Dia: 1/32" - 7/64" = +/- .0005  
 Cutting Dia: 1/8" - 1" = +.000/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 1/32                  | 1/8                     | 1/16                  | 1-1/2                 | 4      | D6442030 | D6442032 | D6442034 |
| 1/32                  | 1/8                     | 3/32                  | 1-1/2                 | 4      | D6441030 | D6441032 | D6441034 |
| 3/64                  | 1/8                     | 3/32                  | 1-1/2                 | 4      | D6442040 | D6442042 | D6442044 |
| 3/64                  | 1/8                     | 9/64                  | 1-1/2                 | 4      | D6441040 | D6441042 | D6441044 |
| 1/16                  | 1/8                     | 1/8                   | 1-1/2                 | 4      | D6442060 | D6442062 | D6442064 |
| 1/16                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D6441060 | D6441062 | D6441064 |
| 5/64                  | 1/8                     | 1/4                   | 1-1/2                 | 4      | D6441070 | D6441072 | D6441074 |
| 3/32                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D6442090 | D6442092 | D6442094 |
| 3/32                  | 1/8                     | 9/32                  | 1-1/2                 | 4      | D6441090 | D6441092 | D6441094 |
| 7/64                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D6442190 | D6442192 | D6442194 |
| 7/64                  | 1/8                     | 3/8                   | 1-1/2                 | 4      | D6441190 | D6441192 | D6441194 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 4      | D6442120 | D6442122 | D6442124 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 4      | D6441120 | D6441122 | D6441124 |
| 1/8                   | 1/8                     | 3/4                   | 2-1/4                 | 4      | D6445120 | D6445122 | D6445124 |
| 1/8                   | 1/8                     | 3/4                   | 3                     | 4      | D6446120 | D6446122 | D6446124 |
| 1/8                   | 1/8                     | 1                     | 3                     | 4      | D6444120 | D6444122 | D6444124 |
| 9/64                  | 3/16                    | 3/8                   | 2                     | 4      | D6442140 | D6442142 | D6442144 |
| 9/64                  | 3/16                    | 1/2                   | 2                     | 4      | D6441140 | D6441142 | D6441144 |
| 5/32                  | 3/16                    | 3/8                   | 2                     | 4      | D6442150 | D6442152 | D6442154 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 4      | D6441150 | D6441152 | D6441154 |
| 5/32                  | 3/16                    | 3/4                   | 2-1/2                 | 4      | D6445150 | D6445152 | D6445154 |
| 11/64                 | 3/16                    | 3/8                   | 2                     | 4      | D6442170 | D6442172 | D6442174 |
| 11/64                 | 3/16                    | 5/8                   | 2                     | 4      | D6441170 | D6441172 | D6441174 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 4      | D6442180 | D6442182 | D6442184 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 4      | D6441180 | D6441182 | D6441184 |
| 3/16                  | 3/16                    | 3/4                   | 2-1/2                 | 4      | D6443180 | D6443182 | D6443184 |
| 3/16                  | 3/16                    | 1                     | 2-1/2                 | 4      | D6445180 | D6445182 | D6445184 |
| 3/16                  | 3/16                    | 1                     | 4                     | 4      | D6446180 | D6446182 | D6446184 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 4      | D6444180 | D6444182 | D6444184 |
| 13/64                 | 1/4                     | 3/8                   | 2                     | 4      | D6442200 | D6442202 | D6442204 |
| 13/64                 | 1/4                     | 5/8                   | 2-1/2                 | 4      | D6441200 | D6441202 | D6441204 |
| 7/32                  | 1/4                     | 3/8                   | 2                     | 4      | D6442210 | D6442212 | D6442214 |
| 7/32                  | 1/4                     | 5/8                   | 2-1/2                 | 4      | D6441210 | D6441212 | D6441214 |
| 7/32                  | 1/4                     | 1                     | 3                     | 4      | D6445210 | D6445212 | D6445214 |
| 15/64                 | 1/4                     | 3/8                   | 2                     | 4      | D6442230 | D6442232 | D6442234 |
| 15/64                 | 1/4                     | 3/4                   | 2-1/2                 | 4      | D6441230 | D6441232 | D6441234 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 4      | D6442250 | D6442252 | D6442254 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 4      | D6441250 | D6441252 | D6441254 |
| 1/4                   | 1/4                     | 1                     | 4                     | 4      | D6446250 | D6446252 | D6446254 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 4      | D6443250 | D6443252 | D6443254 |
| 1/4                   | 1/4                     | 1-1/4                 | 3                     | 4      | D6445250 | D6445252 | D6445254 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 4      | D6444250 | D6444252 | D6444254 |

Additional Sizes On Pages 94 - 95

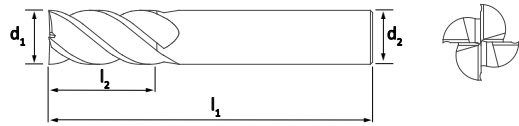
Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/32" - 1" = -.0001/-.0004  
 Cutting Dia: 1/32" - 7/64" = +/- .0005  
 Cutting Dia: 1/8" - 1" = +.000/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 4      | D6447250 | D6447252 | D6447254 |
| 17/64                 | 5/16                    | 1/2                   | 2                     | 4      | D6442260 | D6442262 | D6442264 |
| 17/64                 | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6441260 | D6441262 | D6441264 |
| 9/32                  | 5/16                    | 1/2                   | 2                     | 4      | D6442280 | D6442282 | D6442284 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6441280 | D6441282 | D6441284 |
| 9/32                  | 5/16                    | 1-1/4                 | 3                     | 4      | D6445280 | D6445282 | D6445284 |
| 19/64                 | 5/16                    | 1/2                   | 2                     | 4      | D6442290 | D6442292 | D6442294 |
| 19/64                 | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6441290 | D6441292 | D6441294 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 4      | D6442310 | D6442312 | D6442314 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6441310 | D6441312 | D6441314 |
| 5/16                  | 5/16                    | 1                     | 4                     | 4      | D6446310 | D6446312 | D6446314 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 4      | D6443310 | D6443312 | D6443314 |
| 5/16                  | 5/16                    | 1-3/8                 | 3                     | 4      | D6445310 | D6445312 | D6445314 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 4      | D6447310 | D6447312 | D6447314 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 4      | D6444310 | D6444312 | D6444314 |
| 21/64                 | 3/8                     | 5/8                   | 2                     | 4      | D6442320 | D6442322 | D6442324 |
| 21/64                 | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6441320 | D6441322 | D6441324 |
| 11/32                 | 3/8                     | 5/8                   | 2                     | 4      | D6442340 | D6442342 | D6442344 |
| 11/32                 | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6441340 | D6441342 | D6441344 |
| 23/64                 | 3/8                     | 5/8                   | 2                     | 4      | D6442350 | D6442352 | D6442354 |
| 23/64                 | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6441350 | D6441352 | D6441354 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 4      | D6442370 | D6442372 | D6442374 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6441370 | D6441372 | D6441374 |
| 3/8                   | 3/8                     | 1                     | 4                     | 4      | D6446370 | D6446372 | D6446374 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 4      | D6443370 | D6443372 | D6443374 |
| 3/8                   | 3/8                     | 1-3/8                 | 3                     | 4      | D6445370 | D6445372 | D6445374 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 4      | D6447370 | D6447372 | D6447374 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 4      | D6444370 | D6444372 | D6444374 |
| 3/8                   | 3/8                     | 3                     | 6                     | 4      | D6448370 | D6448372 | D6448374 |
| 25/64                 | 7/16                    | 5/8                   | 2                     | 4      | D6442390 | D6442392 | D6442394 |
| 25/64                 | 7/16                    | 1                     | 2-3/4                 | 4      | D6441390 | D6441392 | D6441394 |
| 13/32                 | 7/16                    | 5/8                   | 2                     | 4      | D6442400 | D6442402 | D6442404 |
| 13/32                 | 7/16                    | 1                     | 2-3/4                 | 4      | D6441400 | D6441402 | D6441404 |
| 27/64                 | 7/16                    | 5/8                   | 2                     | 4      | D6442420 | D6442422 | D6442424 |
| 27/64                 | 7/16                    | 1                     | 2-3/4                 | 4      | D6441420 | D6441422 | D6441424 |
| 7/16                  | 7/16                    | 5/8                   | 2                     | 4      | D6442430 | D6442432 | D6442434 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 4      | D6441430 | D6441432 | D6441434 |
| 7/16                  | 7/16                    | 1                     | 4                     | 4      | D6446430 | D6446432 | D6446434 |
| 7/16                  | 7/16                    | 1-3/8                 | 4                     | 4      | D6445430 | D6445432 | D6445434 |
| 7/16                  | 7/16                    | 1-1/2                 | 6                     | 4      | D6447430 | D6447432 | D6447434 |
| 7/16                  | 7/16                    | 2                     | 4                     | 4      | D6443430 | D6443432 | D6443434 |
| 7/16                  | 7/16                    | 3                     | 6                     | 4      | D6444430 | D6444432 | D6444434 |

Additional Sizes On Pages 93 & 95

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |

# Series D644

## 4 Flute Universal



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**

Shank:  $1/32'' - 1'' = -.0001/- .0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/- .002$



| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 29/64                 | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6442450 | D6442452 | D6442454 |
| 29/64                 | 1/2                     | 1                     | 3                     | 4      | D6441450 | D6441452 | D6441454 |
| 15/32                 | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6442460 | D6442462 | D6442464 |
| 15/32                 | 1/2                     | 1                     | 3                     | 4      | D6441460 | D6441462 | D6441464 |
| 31/64                 | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6442480 | D6442482 | D6442484 |
| 31/64                 | 1/2                     | 1                     | 3                     | 4      | D6441480 | D6441482 | D6441484 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6442500 | D6442502 | D6442504 |
| 1/2                   | 1/2                     | 1                     | 3                     | 4      | D6441500 | D6441502 | D6441504 |
| 1/2                   | 1/2                     | 1                     | 4                     | 4      | D6446500 | D6446502 | D6446504 |
| 1/2                   | 1/2                     | 1-1/2                 | 3-1/2                 | 4      | D6445500 | D6445502 | D6445504 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 4      | D6447500 | D6447502 | D6447504 |
| 1/2                   | 1/2                     | 2                     | 4                     | 4      | D6443500 | D6443502 | D6443504 |
| 1/2                   | 1/2                     | 3                     | 6                     | 4      | D6444500 | D6444502 | D6444504 |
| 9/16                  | 9/16                    | 7/8                   | 3                     | 4      | D6442560 | D6442562 | D6442564 |
| 9/16                  | 9/16                    | 1-1/4                 | 3-1/2                 | 4      | D6441560 | D6441562 | D6441564 |
| 9/16                  | 9/16                    | 2                     | 6                     | 4      | D6446560 | D6446562 | D6446564 |
| 9/16                  | 9/16                    | 3                     | 6                     | 4      | D6444560 | D6444562 | D6444564 |
| 5/8                   | 5/8                     | 7/8                   | 3                     | 4      | D6442620 | D6442622 | D6442624 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 4      | D6441620 | D6441622 | D6441624 |
| 5/8                   | 5/8                     | 2                     | 6                     | 4      | D6446620 | D6446622 | D6446624 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 4      | D6443620 | D6443622 | D6443624 |
| 5/8                   | 5/8                     | 3                     | 6                     | 4      | D6444620 | D6444622 | D6444624 |
| 11/16                 | 3/4                     | 1                     | 3                     | 4      | D6442680 | D6442682 | D6442684 |
| 11/16                 | 3/4                     | 1-1/2                 | 4                     | 4      | D6441680 | D6441682 | D6441684 |
| 3/4                   | 3/4                     | 1                     | 3                     | 4      | D6442750 | D6442752 | D6442754 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 4      | D6441750 | D6441752 | D6441754 |
| 3/4                   | 3/4                     | 2                     | 6                     | 4      | D6446750 | D6446752 | D6446754 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 4      | D6443750 | D6443752 | D6443754 |
| 3/4                   | 3/4                     | 3                     | 6                     | 4      | D6444750 | D6444752 | D6444754 |
| 7/8                   | 7/8                     | 1-3/4                 | 4                     | 4      | D6441870 | D6441872 | D6441874 |
| 1                     | 1                       | 1-3/4                 | 4                     | 4      | D6441100 | D6441102 | D6441104 |
| 1                     | 1                       | 2                     | 6                     | 4      | D6446100 | D6446102 | D6446104 |
| 1                     | 1                       | 2-1/4                 | 5                     | 4      | D6443100 | D6443102 | D6443104 |
| 1                     | 1                       | 3                     | 6                     | 4      | D6444100 | D6444102 | D6444104 |

Additional Sizes On Pages 93 - 94

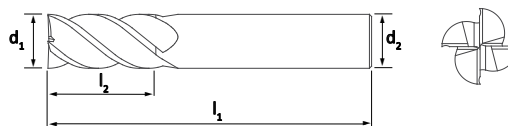
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**

Shank: 1mm - 25mm = -.0025/-.0102  
 Cutting Dia: 1mm - 2.5mm = +/- .0127  
 Cutting Dia: 3mm - 25mm = +.000/- .0508

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated  | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|-----------|-----------|-----------|
| 1.0mm                 | 3.0mm                   | 2.0mm                 | 38.0mm                | 4      | D64420390 | D64420392 | D64420394 |
| 1.0mm                 | 3.0mm                   | 4.0mm                 | 38.0mm                | 4      | D64410390 | D64410392 | D64410394 |
| 1.5mm                 | 3.0mm                   | 3.0mm                 | 38.0mm                | 4      | D64420590 | D64420592 | D64420594 |
| 1.5mm                 | 3.0mm                   | 5.0mm                 | 38.0mm                | 4      | D64410590 | D64410592 | D64410594 |
| 2.0mm                 | 3.0mm                   | 4.0mm                 | 38.0mm                | 4      | D64420780 | D64420782 | D64420784 |
| 2.0mm                 | 3.0mm                   | 8.0mm                 | 38.0mm                | 4      | D64410780 | D64410782 | D64410784 |
| 2.5mm                 | 3.0mm                   | 10.0mm                | 38.0mm                | 4      | D64410980 | D64410982 | D64410984 |
| 3.0mm                 | 3.0mm                   | 6.0mm                 | 38.0mm                | 4      | D64421180 | D64421182 | D64421184 |
| 3.0mm                 | 3.0mm                   | 12.0mm                | 38.0mm                | 4      | D64411180 | D64411182 | D64411184 |
| 3.5mm                 | 4.0mm                   | 7.0mm                 | 50.0mm                | 4      | D64421370 | D64421372 | D64421374 |
| 3.5mm                 | 4.0mm                   | 12.0mm                | 50.0mm                | 4      | D64411370 | D64411372 | D64411374 |
| 4.0mm                 | 4.0mm                   | 8.0mm                 | 50.0mm                | 4      | D64421570 | D64421572 | D64421574 |
| 4.0mm                 | 4.0mm                   | 14.0mm                | 50.0mm                | 4      | D64411570 | D64411572 | D64411574 |
| 4.5mm                 | 6.0mm                   | 9.5mm                 | 63.0mm                | 4      | D64421770 | D64421772 | D64421774 |
| 4.5mm                 | 6.0mm                   | 16.0mm                | 63.0mm                | 4      | D64411770 | D64411772 | D64411774 |
| 5.0mm                 | 6.0mm                   | 10.0mm                | 63.0mm                | 4      | D64421960 | D64421962 | D64421964 |
| 5.0mm                 | 6.0mm                   | 16.0mm                | 63.0mm                | 4      | D64411960 | D64411962 | D64411964 |
| 5.0mm                 | 6.0mm                   | 16.0mm                | 63.0mm                | 4      | D64412360 | D64412362 | D64412364 |
| 6.0mm                 | 6.0mm                   | 12.0mm                | 63.0mm                | 4      | D64422360 | D64422362 | D64422364 |
| 7.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 4      | D64422750 | D64422752 | D64422754 |
| 7.0mm                 | 8.0mm                   | 19.0mm                | 63.0mm                | 4      | D64412750 | D64412752 | D64412754 |
| 8.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 4      | D64423150 | D64423152 | D64423154 |
| 8.0mm                 | 8.0mm                   | 20.0mm                | 63.0mm                | 4      | D64413150 | D64413152 | D64413154 |
| 9.0mm                 | 10.0mm                  | 14.0mm                | 70.0mm                | 4      | D64423540 | D64423542 | D64423544 |
| 9.0mm                 | 10.0mm                  | 25.0mm                | 70.0mm                | 4      | D64413540 | D64413542 | D64413544 |
| 10.0mm                | 10.0mm                  | 14.0mm                | 70.0mm                | 4      | D64423930 | D64423932 | D64423934 |
| 10.0mm                | 10.0mm                  | 25.0mm                | 70.0mm                | 4      | D64413930 | D64413932 | D64413934 |
| 11.0mm                | 12.0mm                  | 14.0mm                | 76.0mm                | 4      | D64424330 | D64424332 | D64424334 |
| 11.0mm                | 12.0mm                  | 25.0mm                | 76.0mm                | 4      | D64414330 | D64414332 | D64414334 |
| 12.0mm                | 12.0mm                  | 16.0mm                | 76.0mm                | 4      | D64424720 | D64424722 | D64424724 |
| 12.0mm                | 12.0mm                  | 25.0mm                | 76.0mm                | 4      | D64414720 | D64414722 | D64414724 |
| 14mm                  | 14.0mm                  | 32.0mm                | 89.0mm                | 4      | D64415510 | D64415512 | D64415514 |
| 16.0mm                | 16.0mm                  | 32.0mm                | 89.0mm                | 4      | D64416290 | D64416292 | D64416294 |
| 18.0mm                | 18.0mm                  | 38.0mm                | 100.0mm               | 4      | D64417080 | D64417082 | D64417084 |
| 20.0mm                | 20.0mm                  | 38.0mm                | 100.0mm               | 4      | D64417870 | D64417872 | D64417874 |
| 20.0mm                | 20.0mm                  | 38.0mm                | 100.0mm               | 4      | D64420980 | D64420982 | D64420984 |
| 25.0mm                | 25.0mm                  | 38.0mm                | 100.0mm               | 4      | D64419840 | D64419842 | D64419844 |

Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |

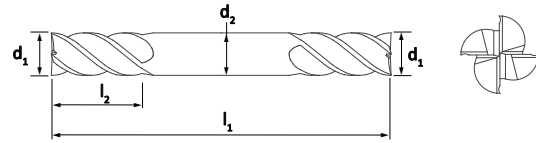


# Series D844

## 4 Flute Universal



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**

Shank: 1/32" - 1/2" = -.0001/-0.0004  
 Cutting Dia: 1/32" - 7/64" = +/- .0005  
 Cutting Dia: 1/8" - 1/2" = +.000/-0.002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 1/32                  | 1/8                     | 1/16                  | 1-1/2                 | 4      | D8442030 | D8442032 | D8442034 |
| 3/64                  | 1/8                     | 3/32                  | 1-1/2                 | 4      | D8442040 | D8442042 | D8442044 |
| 1/16                  | 1/8                     | 1/8                   | 1-1/2                 | 4      | D8442060 | D8442062 | D8442064 |
| 5/64                  | 1/8                     | 5/32                  | 1-1/2                 | 4      | D8442070 | D8442072 | D8442074 |
| 3/32                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D8442090 | D8442092 | D8442094 |
| 7/64                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D8442190 | D8442192 | D8442194 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 4      | D8442120 | D8442122 | D8442124 |
| 1/8                   | 3/8                     | 3/8                   | 3                     | 4      | D8441120 | D8441122 | D8441124 |
| 9/64                  | 3/16                    | 5/16                  | 2                     | 4      | D8442140 | D8442142 | D8442144 |
| 5/32                  | 3/16                    | 5/16                  | 2                     | 4      | D8442150 | D8442152 | D8442154 |
| 5/32                  | 3/8                     | 7/16                  | 3                     | 4      | D8441150 | D8441152 | D8441154 |
| 11/64                 | 3/16                    | 5/16                  | 2                     | 4      | D8442170 | D8442172 | D8442174 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 4      | D8442180 | D8442182 | D8442184 |
| 3/16                  | 3/8                     | 1/2                   | 3                     | 4      | D8441180 | D8441182 | D8441184 |
| 13/64                 | 1/4                     | 1/2                   | 2-1/2                 | 4      | D8442200 | D8442202 | D8442204 |
| 7/32                  | 1/4                     | 7/16                  | 2-1/2                 | 4      | D8442210 | D8442212 | D8442214 |
| 7/32                  | 3/8                     | 9/16                  | 3                     | 4      | D8441210 | D8441212 | D8441214 |
| 15/64                 | 1/4                     | 1/2                   | 2-1/2                 | 4      | D8442230 | D8442232 | D8442234 |
| 1/4                   | 1/4                     | 1/2                   | 2-1/2                 | 4      | D8442250 | D8442252 | D8442254 |
| 1/4                   | 3/8                     | 5/8                   | 3                     | 4      | D8441250 | D8441252 | D8441254 |
| 9/32                  | 5/16                    | 1/2                   | 2-1/2                 | 4      | D8442280 | D8442282 | D8442284 |
| 9/32                  | 3/8                     | 11/16                 | 3-1/2                 | 4      | D8441280 | D8441282 | D8441284 |
| 5/16                  | 5/16                    | 1/2                   | 2-1/2                 | 4      | D8442310 | D8442312 | D8442314 |
| 5/16                  | 3/8                     | 3/4                   | 3-1/2                 | 4      | D8441310 | D8441312 | D8441314 |
| 11/32                 | 3/8                     | 3/4                   | 3-1/2                 | 4      | D8441340 | D8441342 | D8441344 |
| 3/8                   | 3/8                     | 1/2                   | 2-1/2                 | 4      | D8442370 | D8442372 | D8442374 |
| 3/8                   | 3/8                     | 3/4                   | 3-1/2                 | 4      | D8441370 | D8441372 | D8441374 |
| 7/16                  | 7/16                    | 9/16                  | 2-3/4                 | 4      | D8442430 | D8442432 | D8442434 |
| 7/16                  | 1/2                     | 7/8                   | 4                     | 4      | D8441430 | D8441432 | D8441434 |
| 1/2                   | 1/2                     | 5/8                   | 3                     | 4      | D8442500 | D8442502 | D8442504 |
| 1/2                   | 1/2                     | 1                     | 4                     | 4      | D8441500 | D8441502 | D8441504 |

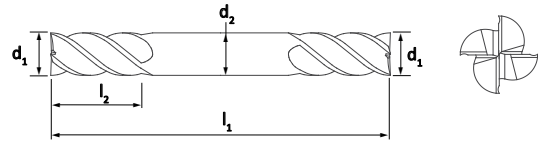
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1mm - 12mm = -.0025/-.0102  
 Cutting Dia: 1mm - 2.5mm = +/- .0127  
 Cutting Dia: 3mm - 12mm = +.000/-.0508

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated  | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|-----------|-----------|-----------|
| 1.0mm                 | 3.0mm                   | 2.0mm                 | 38.0mm                | 4      | D84420390 | D84420392 | D84420394 |
| 1.5mm                 | 3.0mm                   | 3.0mm                 | 38.0mm                | 4      | D84420590 | D84420592 | D84420594 |
| 2.0mm                 | 3.0mm                   | 4.0mm                 | 38.0mm                | 4      | D84420780 | D84420782 | D84420784 |
| 2.5mm                 | 3.0mm                   | 5.0mm                 | 38.0mm                | 4      | D84420980 | D84420982 | D84420984 |
| 3.0mm                 | 3.0mm                   | 6.0mm                 | 38.0mm                | 4      | D84421180 | D84421182 | D84421184 |
| 3.5mm                 | 4.0mm                   | 7.0mm                 | 38.0mm                | 4      | D84421370 | D84421372 | D84421374 |
| 4.0mm                 | 4.0mm                   | 8.0mm                 | 50.0mm                | 4      | D84421570 | D84421572 | D84421574 |
| 4.5mm                 | 6.0mm                   | 9.5mm                 | 63.0mm                | 4      | D84421770 | D84421772 | D84421774 |
| 5.0mm                 | 6.0mm                   | 10.0mm                | 63.0mm                | 4      | D84421960 | D84421962 | D84421964 |
| 6.0mm                 | 6.0mm                   | 12.0mm                | 63.0mm                | 4      | D84422360 | D84422362 | D84422364 |
| 7.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 4      | D84422750 | D84422752 | D84422754 |
| 8.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 4      | D84423150 | D84423152 | D84423154 |
| 9.0mm                 | 10.0mm                  | 14.0mm                | 70.0mm                | 4      | D84423540 | D84423542 | D84423544 |
| 10.0mm                | 10.0mm                  | 14.0mm                | 70.0mm                | 4      | D84423930 | D84423932 | D84423934 |
| 11.0mm                | 12.0mm                  | 14.0mm                | 76.0mm                | 4      | D84424330 | D84424332 | D84424334 |
| 12.0mm                | 12.0mm                  | 16.0mm                | 76.0mm                | 4      | D84424720 | D84424722 | D84424724 |

Feeds & Speeds Available on Page 115

Application Range:

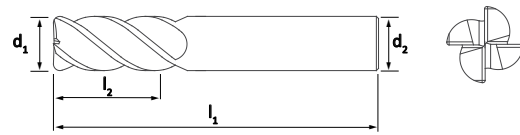
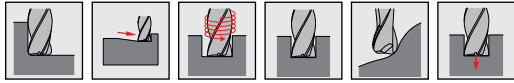
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |

# Series D644CR

## 4 Flute Universal Corner Radius



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 0.010       | 4      | D6442120/10 | D6442122/10 | D6442124/10 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 0.015       | 4      | D6442120/15 | D6442122/15 | D6442124/15 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 0.020       | 4      | D6442120/20 | D6442122/20 | D6442124/20 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 0.030       | 4      | D6442120/30 | D6442122/30 | D6442124/30 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 0.045       | 4      | D6442120/45 | D6442122/45 | D6442124/45 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.010       | 4      | D6441120/10 | D6441122/10 | D6441124/10 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.015       | 4      | D6441120/15 | D6441122/15 | D6441124/15 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.020       | 4      | D6441120/20 | D6441122/20 | D6441124/20 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.030       | 4      | D6441120/30 | D6441122/30 | D6441124/30 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 0.045       | 4      | D6441120/45 | D6441122/45 | D6441124/45 |
| 1/8                   | 1/8                     | 1                     | 3                     | 0.010       | 4      | D6444120/10 | D6444122/10 | D6444124/10 |
| 1/8                   | 1/8                     | 1                     | 3                     | 0.015       | 4      | D6444120/15 | D6444122/15 | D6444124/15 |
| 1/8                   | 1/8                     | 1                     | 3                     | 0.020       | 4      | D6444120/20 | D6444122/20 | D6444124/20 |
| 1/8                   | 1/8                     | 1                     | 3                     | 0.030       | 4      | D6444120/30 | D6444122/30 | D6444124/30 |
| 1/8                   | 1/8                     | 1                     | 3                     | 0.045       | 4      | D6444120/45 | D6444122/45 | D6444124/45 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.010       | 4      | D6442180/10 | D6442182/10 | D6442184/10 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.015       | 4      | D6442180/15 | D6442182/15 | D6442184/15 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.020       | 4      | D6442180/20 | D6442182/20 | D6442184/20 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.030       | 4      | D6442180/30 | D6442182/30 | D6442184/30 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.045       | 4      | D6442180/45 | D6442182/45 | D6442184/45 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 0.060       | 4      | D6442180/60 | D6442182/60 | D6442184/60 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.010       | 4      | D6441180/10 | D6441182/10 | D6441184/10 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.015       | 4      | D6441180/15 | D6441182/15 | D6441184/15 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.020       | 4      | D6441180/20 | D6441182/20 | D6441184/20 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.030       | 4      | D6441180/30 | D6441182/30 | D6441184/30 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.045       | 4      | D6441180/45 | D6441182/45 | D6441184/45 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 0.060       | 4      | D6441180/60 | D6441182/60 | D6441184/60 |
| 3/16                  | 3/16                    | 1                     | 4                     | 0.010       | 4      | D6446180/10 | D6446182/10 | D6446184/10 |
| 3/16                  | 3/16                    | 1                     | 4                     | 0.015       | 4      | D6446180/15 | D6446182/15 | D6446184/15 |
| 3/16                  | 3/16                    | 1                     | 4                     | 0.020       | 4      | D6446180/20 | D6446182/20 | D6446184/20 |
| 3/16                  | 3/16                    | 1                     | 4                     | 0.030       | 4      | D6446180/30 | D6446182/30 | D6446184/30 |
| 3/16                  | 3/16                    | 1                     | 4                     | 0.045       | 4      | D6446180/45 | D6446182/45 | D6446184/45 |
| 3/16                  | 3/16                    | 1                     | 4                     | 0.060       | 4      | D6446180/60 | D6446182/60 | D6446184/60 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 0.010       | 4      | D6444180/10 | D6444182/10 | D6444184/10 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 0.015       | 4      | D6444180/15 | D6444182/15 | D6444184/15 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 0.020       | 4      | D6444180/20 | D6444182/20 | D6444184/20 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 0.030       | 4      | D6444180/30 | D6444182/30 | D6444184/30 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 0.045       | 4      | D6444180/45 | D6444182/45 | D6444184/45 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 0.060       | 4      | D6444180/60 | D6444182/60 | D6444184/60 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.010       | 4      | D6442250/10 | D6442252/10 | D6442254/10 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.015       | 4      | D6442250/15 | D6442252/15 | D6442254/15 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.020       | 4      | D6442250/20 | D6442252/20 | D6442254/20 |

Additional Sizes On Pages 100 - 106

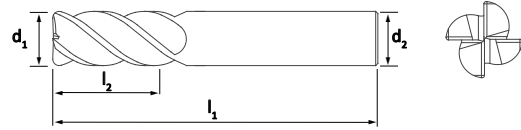
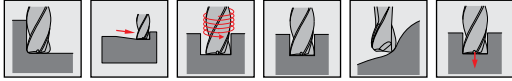
Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.030       | 4      | D6442250/30 | D6442252/30 | D6442254/30 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.045       | 4      | D6442250/45 | D6442252/45 | D6442254/45 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.060       | 4      | D6442250/60 | D6442252/60 | D6442254/60 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 0.090       | 4      | D6442250/90 | D6442252/90 | D6442254/90 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.010       | 4      | D6441250/10 | D6441252/10 | D6441254/10 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.015       | 4      | D6441250/15 | D6441252/15 | D6441254/15 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.020       | 4      | D6441250/20 | D6441252/20 | D6441254/20 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.030       | 4      | D6441250/30 | D6441252/30 | D6441254/30 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.045       | 4      | D6441250/45 | D6441252/45 | D6441254/45 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.060       | 4      | D6441250/60 | D6441252/60 | D6441254/60 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 0.090       | 4      | D6441250/90 | D6441252/90 | D6441254/90 |
| 1/4                   | 1/4                     | 1                     | 4                     | 0.010       | 4      | D6446250/10 | D6446252/10 | D6446254/10 |
| 1/4                   | 1/4                     | 1                     | 4                     | 0.015       | 4      | D6446250/15 | D6446252/15 | D6446254/15 |
| 1/4                   | 1/4                     | 1                     | 4                     | 0.020       | 4      | D6446250/20 | D6446252/20 | D6446254/20 |
| 1/4                   | 1/4                     | 1                     | 4                     | 0.030       | 4      | D6446250/30 | D6446252/30 | D6446254/30 |
| 1/4                   | 1/4                     | 1                     | 4                     | 0.045       | 4      | D6446250/45 | D6446252/45 | D6446254/45 |
| 1/4                   | 1/4                     | 1                     | 4                     | 0.060       | 4      | D6446250/60 | D6446252/60 | D6446254/60 |
| 1/4                   | 1/4                     | 1                     | 4                     | 0.090       | 4      | D6446250/90 | D6446252/90 | D6446254/90 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 0.010       | 4      | D6443250/10 | D6443252/10 | D6443254/10 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 0.015       | 4      | D6443250/15 | D6443252/15 | D6443254/15 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 0.020       | 4      | D6443250/20 | D6443252/20 | D6443254/20 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 0.030       | 4      | D6443250/30 | D6443252/30 | D6443254/30 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 0.045       | 4      | D6443250/45 | D6443252/45 | D6443254/45 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 0.060       | 4      | D6443250/60 | D6443252/60 | D6443254/60 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 0.090       | 4      | D6443250/90 | D6443252/90 | D6443254/90 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 0.010       | 4      | D6444250/10 | D6444252/10 | D6444254/10 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 0.010       | 4      | D6447250/10 | D6447252/10 | D6447254/10 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 0.015       | 4      | D6444250/15 | D6444252/15 | D6444254/15 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 0.015       | 4      | D6447250/15 | D6447252/15 | D6447254/15 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 0.020       | 4      | D6444250/20 | D6444252/20 | D6444254/20 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 0.020       | 4      | D6447250/20 | D6447252/20 | D6447254/20 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 0.030       | 4      | D6444250/30 | D6444252/30 | D6444254/30 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 0.030       | 4      | D6447250/30 | D6447252/30 | D6447254/30 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 0.045       | 4      | D6444250/45 | D6444252/45 | D6444254/45 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 0.045       | 4      | D6447250/45 | D6447252/45 | D6447254/45 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 0.060       | 4      | D6444250/60 | D6444252/60 | D6444254/60 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 0.060       | 4      | D6447250/60 | D6447252/60 | D6447254/60 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 0.090       | 4      | D6444250/90 | D6444252/90 | D6444254/90 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 0.090       | 4      | D6447250/90 | D6447252/90 | D6447254/90 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.010       | 4      | D6442310/10 | D6442312/10 | D6442314/10 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.015       | 4      | D6442310/15 | D6442312/15 | D6442314/15 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.020       | 4      | D6442310/20 | D6442312/20 | D6442314/20 |

Additional Sizes On Pages 99, 101 - 106

Feeds & Speeds Available on Page 115

Application Range:

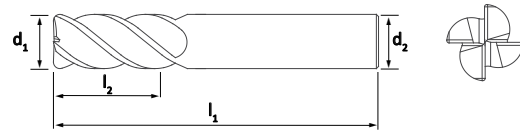
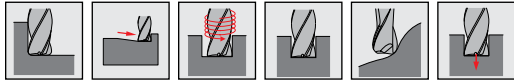
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |

# Series D644CR

## 4 Flute Universal Corner Radius



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$   
 Radius:  $1/8'' - 1'' = +/-0.001$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.030       | 4      | D6442310/30 | D6442312/30 | D6442314/30 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.045       | 4      | D6442310/45 | D6442312/45 | D6442314/45 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.060       | 4      | D6442310/60 | D6442312/60 | D6442314/60 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.090       | 4      | D6442310/90 | D6442312/90 | D6442314/90 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 0.125       | 4      | D6442310/12 | D6442312/12 | D6442314/12 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.010       | 4      | D6441310/10 | D6441312/10 | D6441314/10 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.015       | 4      | D6441310/15 | D6441312/15 | D6441314/15 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.020       | 4      | D6441310/20 | D6441312/20 | D6441314/20 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.030       | 4      | D6441310/30 | D6441312/30 | D6441314/30 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.045       | 4      | D6441310/45 | D6441312/45 | D6441314/45 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.060       | 4      | D6441310/60 | D6441312/60 | D6441314/60 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.090       | 4      | D6441310/90 | D6441312/90 | D6441314/90 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 0.125       | 4      | D6441310/12 | D6441312/12 | D6441314/12 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.010       | 4      | D6446310/10 | D6446312/10 | D6446314/10 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.015       | 4      | D6446310/15 | D6446312/15 | D6446314/15 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.020       | 4      | D6446310/20 | D6446312/20 | D6446314/20 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.030       | 4      | D6446310/30 | D6446312/30 | D6446314/30 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.045       | 4      | D6446310/45 | D6446312/45 | D6446314/45 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.060       | 4      | D6446310/60 | D6446312/60 | D6446314/60 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.090       | 4      | D6446310/90 | D6446312/90 | D6446314/90 |
| 5/16                  | 5/16                    | 1                     | 4                     | 0.125       | 4      | D6446310/12 | D6446312/12 | D6446314/12 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.010       | 4      | D6443310/10 | D6443312/10 | D6443314/10 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.015       | 4      | D6443310/15 | D6443312/15 | D6443314/15 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.020       | 4      | D6443310/20 | D6443312/20 | D6443314/20 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.030       | 4      | D6443310/30 | D6443312/30 | D6443314/30 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.045       | 4      | D6443310/45 | D6443312/45 | D6443314/45 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.060       | 4      | D6443310/60 | D6443312/60 | D6443314/60 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.090       | 4      | D6443310/90 | D6443312/90 | D6443314/90 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 0.125       | 4      | D6443310/12 | D6443312/12 | D6443314/12 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.010       | 4      | D6447310/10 | D6447312/10 | D6447314/10 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.015       | 4      | D6447310/15 | D6447312/15 | D6447314/15 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.020       | 4      | D6447310/20 | D6447312/20 | D6447314/20 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.030       | 4      | D6447310/30 | D6447312/30 | D6447314/30 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.045       | 4      | D6447310/45 | D6447312/45 | D6447314/45 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.060       | 4      | D6447310/60 | D6447312/60 | D6447314/60 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.090       | 4      | D6447310/90 | D6447312/90 | D6447314/90 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 0.125       | 4      | D6447310/12 | D6447312/12 | D6447314/12 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.010       | 4      | D6444310/10 | D6444312/10 | D6444314/10 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.015       | 4      | D6444310/15 | D6444312/15 | D6444314/15 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.020       | 4      | D6444310/20 | D6444312/20 | D6444314/20 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.030       | 4      | D6444310/30 | D6444312/30 | D6444314/30 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.045       | 4      | D6444310/45 | D6444312/45 | D6444314/45 |

Additional Sizes On Pages 99 - 100 & 102 - 106

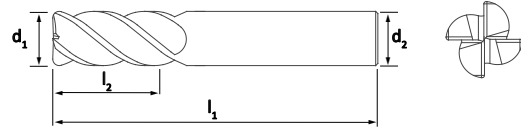
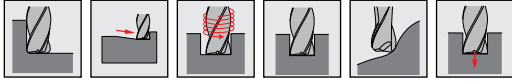
Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002  
 Radius: 1/8" - 1" = +/- .001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.060       | 4      | D6444310/60 | D6444312/60 | D6444314/60 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.090       | 4      | D6444310/90 | D6444312/90 | D6444314/90 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 0.125       | 4      | D6444310/12 | D6444312/12 | D6444314/12 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.010       | 4      | D6442370/10 | D6442372/10 | D6442374/10 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.015       | 4      | D6442370/15 | D6442372/15 | D6442374/15 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.020       | 4      | D6442370/20 | D6442372/20 | D6442374/20 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.030       | 4      | D6442370/30 | D6442372/30 | D6442374/30 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.045       | 4      | D6442370/45 | D6442372/45 | D6442374/45 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.060       | 4      | D6442370/60 | D6442372/60 | D6442374/60 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.090       | 4      | D6442370/90 | D6442372/90 | D6442374/90 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 0.125       | 4      | D6442370/12 | D6442372/12 | D6442374/12 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.010       | 4      | D6441370/10 | D6441372/10 | D6441374/10 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.015       | 4      | D6441370/15 | D6441372/15 | D6441374/15 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.020       | 4      | D6441370/20 | D6441372/20 | D6441374/20 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.030       | 4      | D6441370/30 | D6441372/30 | D6441374/30 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.045       | 4      | D6441370/45 | D6441372/45 | D6441374/45 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.060       | 4      | D6441370/60 | D6441372/60 | D6441374/60 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.090       | 4      | D6441370/90 | D6441372/90 | D6441374/90 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 0.125       | 4      | D6441370/12 | D6441372/12 | D6441374/12 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.010       | 4      | D6446370/10 | D6446372/10 | D6446374/10 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.015       | 4      | D6446370/15 | D6446372/15 | D6446374/15 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.020       | 4      | D6446370/20 | D6446372/20 | D6446374/20 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.030       | 4      | D6446370/30 | D6446372/30 | D6446374/30 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.045       | 4      | D6446370/45 | D6446372/45 | D6446374/45 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.060       | 4      | D6446370/60 | D6446372/60 | D6446374/60 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.090       | 4      | D6446370/90 | D6446372/90 | D6446374/90 |
| 3/8                   | 3/8                     | 1                     | 4                     | 0.125       | 4      | D6446370/12 | D6446372/12 | D6446374/12 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.010       | 4      | D6443370/10 | D6443372/10 | D6443374/10 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.015       | 4      | D6443370/15 | D6443372/15 | D6443374/15 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.020       | 4      | D6443370/20 | D6443372/20 | D6443374/20 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.030       | 4      | D6443370/30 | D6443372/30 | D6443374/30 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.045       | 4      | D6443370/45 | D6443372/45 | D6443374/45 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.060       | 4      | D6443370/60 | D6443372/60 | D6443374/60 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.090       | 4      | D6443370/90 | D6443372/90 | D6443374/90 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 0.125       | 4      | D6443370/12 | D6443372/12 | D6443374/12 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.010       | 4      | D6447370/10 | D6447372/10 | D6447374/10 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.015       | 4      | D6447370/15 | D6447372/15 | D6447374/15 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.020       | 4      | D6447370/20 | D6447372/20 | D6447374/20 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.030       | 4      | D6447370/30 | D6447372/30 | D6447374/30 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.045       | 4      | D6447370/45 | D6447372/45 | D6447374/45 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.060       | 4      | D6447370/60 | D6447372/60 | D6447374/60 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.090       | 4      | D6447370/90 | D6447372/90 | D6447374/90 |

Additional Sizes On Pages 99 - 101 & 103 - 106

Feeds & Speeds Available on Page 115

Application Range:

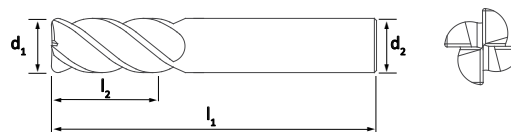
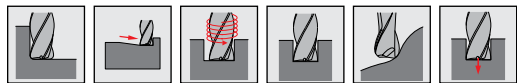
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |

# Series D644CR

## 4 Flute Universal Corner Radius



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$   
 Radius:  $1/8'' - 1'' = +/-0.001$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 0.125       | 4      | D6447370/12 | D6447372/12 | D6447374/12 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.010       | 4      | D6444370/10 | D6444372/10 | D6444374/10 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.015       | 4      | D6444370/15 | D6444372/15 | D6444374/15 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.020       | 4      | D6444370/20 | D6444372/20 | D6444374/20 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.030       | 4      | D6444370/30 | D6444372/30 | D6444374/30 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.045       | 4      | D6444370/45 | D6444372/45 | D6444374/45 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.060       | 4      | D6444370/60 | D6444372/60 | D6444374/60 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.090       | 4      | D6444370/90 | D6444372/90 | D6444374/90 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 0.125       | 4      | D6444370/12 | D6444372/12 | D6444374/12 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.010       | 4      | D6448370/10 | D6448372/10 | D6448374/10 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.015       | 4      | D6448370/15 | D6448372/15 | D6448374/15 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.020       | 4      | D6448370/20 | D6448372/20 | D6448374/20 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.030       | 4      | D6448370/30 | D6448372/30 | D6448374/30 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.045       | 4      | D6448370/45 | D6448372/45 | D6448374/45 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.060       | 4      | D6448370/60 | D6448372/60 | D6448374/60 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.090       | 4      | D6448370/90 | D6448372/90 | D6448374/90 |
| 3/8                   | 3/8                     | 3                     | 6                     | 0.125       | 4      | D6448370/12 | D6448372/12 | D6448374/12 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.010       | 4      | D6442500/10 | D6442502/10 | D6442504/10 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.015       | 4      | D6442500/15 | D6442502/15 | D6442504/15 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.020       | 4      | D6442500/20 | D6442502/20 | D6442504/20 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.030       | 4      | D6442500/30 | D6442502/30 | D6442504/30 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.045       | 4      | D6442500/45 | D6442502/45 | D6442504/45 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.060       | 4      | D6442500/60 | D6442502/60 | D6442504/60 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.090       | 4      | D6442500/90 | D6442502/90 | D6442504/90 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 0.125       | 4      | D6442500/12 | D6442502/12 | D6442504/12 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.010       | 4      | D6441500/10 | D6441502/10 | D6441504/10 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.010       | 4      | D6446500/10 | D6446502/10 | D6446504/10 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.015       | 4      | D6441500/15 | D6441502/15 | D6441504/15 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.015       | 4      | D6446500/15 | D6446502/15 | D6446504/15 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.020       | 4      | D6441500/20 | D6441502/20 | D6441504/20 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.020       | 4      | D6446500/20 | D6446502/20 | D6446504/20 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.030       | 4      | D6441500/30 | D6441502/30 | D6441504/30 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.030       | 4      | D6446500/30 | D6446502/30 | D6446504/30 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.045       | 4      | D6441500/45 | D6441502/45 | D6441504/45 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.045       | 4      | D6446500/45 | D6446502/45 | D6446504/45 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.060       | 4      | D6441500/60 | D6441502/60 | D6441504/60 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.060       | 4      | D6446500/60 | D6446502/60 | D6446504/60 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.090       | 4      | D6441500/90 | D6441502/90 | D6441504/90 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.090       | 4      | D6446500/90 | D6446502/90 | D6446504/90 |
| 1/2                   | 1/2                     | 1                     | 3                     | 0.125       | 4      | D6441500/12 | D6441502/12 | D6441504/12 |
| 1/2                   | 1/2                     | 1                     | 4                     | 0.125       | 4      | D6446500/12 | D6446502/12 | D6446504/12 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.010       | 4      | D6447500/10 | D6447502/10 | D6447504/10 |

Additional Sizes On Pages 99 - 102 & 104 - 106

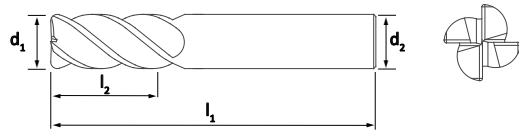
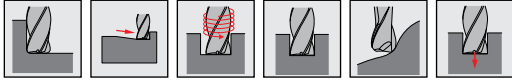
Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.015       | 4      | D6447500/15 | D6447502/15 | D6447504/15 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.020       | 4      | D6447500/20 | D6447502/20 | D6447504/20 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.030       | 4      | D6447500/30 | D6447502/30 | D6447504/30 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.045       | 4      | D6447500/45 | D6447502/45 | D6447504/45 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.060       | 4      | D6447500/60 | D6447502/60 | D6447504/60 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.090       | 4      | D6447500/90 | D6447502/90 | D6447504/90 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 0.125       | 4      | D6447500/12 | D6447502/12 | D6447504/12 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.010       | 4      | D6443500/10 | D6443502/10 | D6443504/10 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.015       | 4      | D6443500/15 | D6443502/15 | D6443504/15 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.020       | 4      | D6443500/20 | D6443502/20 | D6443504/20 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.030       | 4      | D6443500/30 | D6443502/30 | D6443504/30 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.045       | 4      | D6443500/45 | D6443502/45 | D6443504/45 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.060       | 4      | D6443500/60 | D6443502/60 | D6443504/60 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.090       | 4      | D6443500/90 | D6443502/90 | D6443504/90 |
| 1/2                   | 1/2                     | 2                     | 4                     | 0.125       | 4      | D6443500/12 | D6443502/12 | D6443504/12 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.010       | 4      | D6444500/10 | D6444502/10 | D6444504/10 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.015       | 4      | D6444500/15 | D6444502/15 | D6444504/15 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.020       | 4      | D6444500/20 | D6444502/20 | D6444504/20 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.030       | 4      | D6444500/30 | D6444502/30 | D6444504/30 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.045       | 4      | D6444500/45 | D6444502/45 | D6444504/45 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.060       | 4      | D6444500/60 | D6444502/60 | D6444504/60 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.090       | 4      | D6444500/90 | D6444502/90 | D6444504/90 |
| 1/2                   | 1/2                     | 3                     | 6                     | 0.125       | 4      | D6444500/12 | D6444502/12 | D6444504/12 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.010       | 4      | D6441620/10 | D6441622/10 | D6441624/10 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.015       | 4      | D6441620/15 | D6441622/15 | D6441624/15 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.020       | 4      | D6441620/20 | D6441622/20 | D6441624/20 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.030       | 4      | D6441620/30 | D6441622/30 | D6441624/30 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.045       | 4      | D6441620/45 | D6441622/45 | D6441624/45 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.060       | 4      | D6441620/60 | D6441622/60 | D6441624/60 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.090       | 4      | D6441620/90 | D6441622/90 | D6441624/90 |
| 5/8                   | 5/8                     | 1-1/4                 | 3-1/2                 | 0.125       | 4      | D6441620/12 | D6441622/12 | D6441624/12 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.010       | 4      | D6446620/10 | D6446622/10 | D6446624/10 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.015       | 4      | D6446620/15 | D6446622/15 | D6446624/15 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.020       | 4      | D6446620/20 | D6446622/20 | D6446624/20 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.030       | 4      | D6446620/30 | D6446622/30 | D6446624/30 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.045       | 4      | D6446620/45 | D6446622/45 | D6446624/45 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.060       | 4      | D6446620/60 | D6446622/60 | D6446624/60 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.090       | 4      | D6446620/90 | D6446622/90 | D6446624/90 |
| 5/8                   | 5/8                     | 2                     | 6                     | 0.125       | 4      | D6446620/12 | D6446622/12 | D6446624/12 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.010       | 4      | D6443620/10 | D6443622/10 | D6443624/10 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.015       | 4      | D6443620/15 | D6443622/15 | D6443624/15 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.020       | 4      | D6443620/20 | D6443622/20 | D6443624/20 |

Additional Sizes On Pages 99 - 103 & 105 - 106

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |

DESIGN-RITE XL

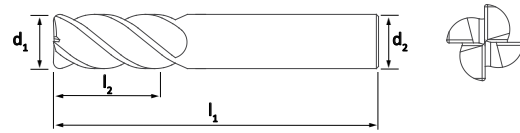
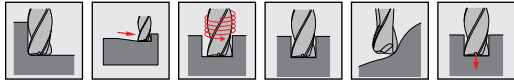


# Series D644CR

## 4 Flute Universal Corner Radius



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 1'' = -.0001/-0.0004$   
 Cutting Dia:  $1/8'' - 1'' = +.000/-0.002$   
 Radius:  $1/8'' - 1'' = +/-0.001$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.030       | 4      | D6443620/30 | D6443622/30 | D6443624/30 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.045       | 4      | D6443620/45 | D6443622/45 | D6443624/45 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.060       | 4      | D6443620/60 | D6443622/60 | D6443624/60 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.090       | 4      | D6443620/90 | D6443622/90 | D6443624/90 |
| 5/8                   | 5/8                     | 2-1/8                 | 4-5/8                 | 0.125       | 4      | D6443620/12 | D6443622/12 | D6443624/12 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.010       | 4      | D6444620/10 | D6444622/10 | D6444624/10 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.015       | 4      | D6444620/15 | D6444622/15 | D6444624/15 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.020       | 4      | D6444620/20 | D6444622/20 | D6444624/20 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.030       | 4      | D6444620/30 | D6444622/30 | D6444624/30 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.045       | 4      | D6444620/45 | D6444622/45 | D6444624/45 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.060       | 4      | D6444620/60 | D6444622/60 | D6444624/60 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.090       | 4      | D6444620/90 | D6444622/90 | D6444624/90 |
| 5/8                   | 5/8                     | 3                     | 6                     | 0.125       | 4      | D6444620/12 | D6444622/12 | D6444624/12 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.010       | 4      | D6441750/10 | D6441752/10 | D6441754/10 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.015       | 4      | D6441750/15 | D6441752/15 | D6441754/15 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.020       | 4      | D6441750/20 | D6441752/20 | D6441754/20 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.030       | 4      | D6441750/30 | D6441752/30 | D6441754/30 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.045       | 4      | D6441750/45 | D6441752/45 | D6441754/45 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.060       | 4      | D6441750/60 | D6441752/60 | D6441754/60 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.090       | 4      | D6441750/90 | D6441752/90 | D6441754/90 |
| 3/4                   | 3/4                     | 1-1/2                 | 4                     | 0.125       | 4      | D6441750/12 | D6441752/12 | D6441754/12 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.010       | 4      | D6446750/10 | D6446752/10 | D6446754/10 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.015       | 4      | D6446750/15 | D6446752/15 | D6446754/15 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.020       | 4      | D6446750/20 | D6446752/20 | D6446754/20 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.030       | 4      | D6446750/30 | D6446752/30 | D6446754/30 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.045       | 4      | D6446750/45 | D6446752/45 | D6446754/45 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.060       | 4      | D6446750/60 | D6446752/60 | D6446754/60 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.090       | 4      | D6446750/90 | D6446752/90 | D6446754/90 |
| 3/4                   | 3/4                     | 2                     | 6                     | 0.125       | 4      | D6446750/12 | D6446752/12 | D6446754/12 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.010       | 4      | D6443750/10 | D6443752/10 | D6443754/10 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.015       | 4      | D6443750/15 | D6443752/15 | D6443754/15 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.020       | 4      | D6443750/20 | D6443752/20 | D6443754/20 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.030       | 4      | D6443750/30 | D6443752/30 | D6443754/30 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.045       | 4      | D6443750/45 | D6443752/45 | D6443754/45 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.060       | 4      | D6443750/60 | D6443752/60 | D6443754/60 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.090       | 4      | D6443750/90 | D6443752/90 | D6443754/90 |
| 3/4                   | 3/4                     | 2-1/4                 | 5                     | 0.125       | 4      | D6443750/12 | D6443752/12 | D6443754/12 |
| 3/4                   | 3/4                     | 3                     | 6                     | 0.010       | 4      | D6444750/10 | D6444752/10 | D6444754/10 |
| 3/4                   | 3/4                     | 3                     | 6                     | 0.015       | 4      | D6444750/15 | D6444752/15 | D6444754/15 |
| 3/4                   | 3/4                     | 3                     | 6                     | 0.020       | 4      | D6444750/20 | D6444752/20 | D6444754/20 |
| 3/4                   | 3/4                     | 3                     | 6                     | 0.030       | 4      | D6444750/30 | D6444752/30 | D6444754/30 |
| 3/4                   | 3/4                     | 3                     | 6                     | 0.045       | 4      | D6444750/45 | D6444752/45 | D6444754/45 |

Additional Sizes On Pages 99 - 104 & 106

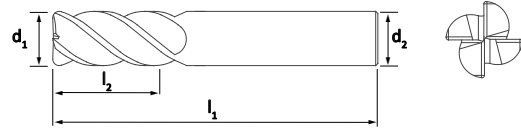
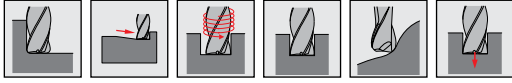
Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**

Shank: 1/8" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Radius: 1/8" - 1" = +/-0.001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | R<br>Radius | Flutes | Uncoated    | TiCN        | AlTiN       |
|-----------------------|-------------------------|-----------------------|-----------------------|-------------|--------|-------------|-------------|-------------|
| 3/4                   | 3/4                     | 3                     | 6                     | 0.060       | 4      | D6444750/60 | D6444752/60 | D6444754/60 |
| 3/4                   | 3/4                     | 3                     | 6                     | 0.090       | 4      | D6444750/90 | D6444752/90 | D6444754/90 |
| 3/4                   | 3/4                     | 3                     | 6                     | 0.125       | 4      | D6444750/12 | D6444752/12 | D6444754/12 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.010       | 4      | D6441100/10 | D6441102/10 | D6441104/10 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.015       | 4      | D6441100/15 | D6441102/15 | D6441104/15 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.020       | 4      | D6441100/20 | D6441102/20 | D6441104/20 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.030       | 4      | D6441100/30 | D6441102/30 | D6441104/30 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.045       | 4      | D6441100/45 | D6441102/45 | D6441104/45 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.060       | 4      | D6441100/60 | D6441102/60 | D6441104/60 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.090       | 4      | D6441100/90 | D6441102/90 | D6441104/90 |
| 1                     | 1                       | 1-3/4                 | 4                     | 0.125       | 4      | D6441100/12 | D6441102/12 | D6441104/12 |
| 1                     | 1                       | 2                     | 6                     | 0.010       | 4      | D6446100/10 | D6446102/10 | D6446104/10 |
| 1                     | 1                       | 2                     | 6                     | 0.015       | 4      | D6446100/15 | D6446102/15 | D6446104/15 |
| 1                     | 1                       | 2                     | 6                     | 0.020       | 4      | D6446100/20 | D6446102/20 | D6446104/20 |
| 1                     | 1                       | 2                     | 6                     | 0.030       | 4      | D6446100/30 | D6446102/30 | D6446104/30 |
| 1                     | 1                       | 2                     | 6                     | 0.045       | 4      | D6446100/45 | D6446102/45 | D6446104/45 |
| 1                     | 1                       | 2                     | 6                     | 0.060       | 4      | D6446100/60 | D6446102/60 | D6446104/60 |
| 1                     | 1                       | 2                     | 6                     | 0.090       | 4      | D6446100/90 | D6446102/90 | D6446104/90 |
| 1                     | 1                       | 2                     | 6                     | 0.125       | 4      | D6446100/12 | D6446102/12 | D6446104/12 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.010       | 4      | D6443100/10 | D6443102/10 | D6443104/10 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.015       | 4      | D6443100/15 | D6443102/15 | D6443104/15 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.020       | 4      | D6443100/20 | D6443102/20 | D6443104/20 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.030       | 4      | D6443100/30 | D6443102/30 | D6443104/30 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.045       | 4      | D6443100/45 | D6443102/45 | D6443104/45 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.060       | 4      | D6443100/60 | D6443102/60 | D6443104/60 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.090       | 4      | D6443100/90 | D6443102/90 | D6443104/90 |
| 1                     | 1                       | 2-1/4                 | 5                     | 0.125       | 4      | D6443100/12 | D6443102/12 | D6443104/12 |
| 1                     | 1                       | 3                     | 6                     | 0.010       | 4      | D6444100/10 | D6444102/10 | D6444104/10 |
| 1                     | 1                       | 3                     | 6                     | 0.015       | 4      | D6444100/15 | D6444102/15 | D6444104/15 |
| 1                     | 1                       | 3                     | 6                     | 0.020       | 4      | D6444100/20 | D6444102/20 | D6444104/20 |
| 1                     | 1                       | 3                     | 6                     | 0.030       | 4      | D6444100/30 | D6444102/30 | D6444104/30 |
| 1                     | 1                       | 3                     | 6                     | 0.045       | 4      | D6444100/45 | D6444102/45 | D6444104/45 |
| 1                     | 1                       | 3                     | 6                     | 0.060       | 4      | D6444100/60 | D6444102/60 | D6444104/60 |
| 1                     | 1                       | 3                     | 6                     | 0.090       | 4      | D6444100/90 | D6444102/90 | D6444104/90 |
| 1                     | 1                       | 3                     | 6                     | 0.125       | 4      | D6444100/12 | D6444102/12 | D6444104/12 |

Additional Sizes On Pages 99 - 105

Feeds & Speeds Available on Page 115

**Application Range:**

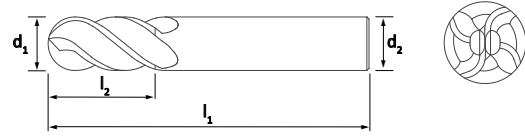
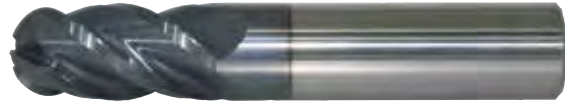
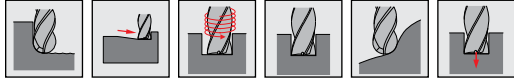
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |

# Series D664

## 4 Flute Universal Ball



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/32'' - 1'' = -.0001/- .0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/- .002$   
 Ball:  $1/32'' - 1'' = +/- .001$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 1/32                  | 1/8                     | 3/32                  | 1-1/2                 | 4      | D6641030 | D6641032 | D6641034 |
| 3/64                  | 1/8                     | 9/64                  | 1-1/2                 | 4      | D6641040 | D6641042 | D6641044 |
| 1/16                  | 1/8                     | 1/8                   | 1-1/2                 | 4      | D6642060 | D6642062 | D6642064 |
| 1/16                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D6641060 | D6641062 | D6641064 |
| 5/64                  | 1/8                     | 1/4                   | 1-1/2                 | 4      | D6641070 | D6641072 | D6641074 |
| 3/32                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D6642090 | D6642092 | D6642094 |
| 3/32                  | 1/8                     | 9/32                  | 1-1/2                 | 4      | D6641090 | D6641092 | D6641094 |
| 7/64                  | 1/8                     | 3/16                  | 1-1/2                 | 4      | D6642190 | D6642192 | D6642194 |
| 7/64                  | 1/8                     | 3/8                   | 1-1/2                 | 4      | D6641190 | D6641192 | D6641194 |
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 4      | D6642120 | D6642122 | D6642124 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 4      | D6641120 | D6641122 | D6641124 |
| 1/8                   | 1/8                     | 3/4                   | 2-1/4                 | 4      | D6643120 | D6643122 | D6643124 |
| 1/8                   | 1/8                     | 3/4                   | 3                     | 4      | D6646120 | D6646122 | D6646124 |
| 1/8                   | 1/8                     | 1                     | 3                     | 4      | D6644120 | D6644122 | D6644124 |
| 9/64                  | 3/16                    | 3/8                   | 2                     | 4      | D6642140 | D6642142 | D6642144 |
| 9/64                  | 3/16                    | 1/2                   | 2                     | 4      | D6641140 | D6641142 | D6641144 |
| 5/32                  | 3/16                    | 3/8                   | 2                     | 4      | D6642150 | D6642152 | D6642154 |
| 5/32                  | 3/16                    | 1/2                   | 2                     | 4      | D6641150 | D6641152 | D6641154 |
| 11/64                 | 3/16                    | 3/8                   | 2                     | 4      | D6642170 | D6642172 | D6642174 |
| 11/64                 | 3/16                    | 5/8                   | 2                     | 4      | D6641170 | D6641172 | D6641174 |
| 3/16                  | 3/16                    | 3/8                   | 2                     | 4      | D6642180 | D6642182 | D6642184 |
| 3/16                  | 3/16                    | 5/8                   | 2                     | 4      | D6641180 | D6641182 | D6641184 |
| 3/16                  | 3/16                    | 3/4                   | 2-1/2                 | 4      | D6643180 | D6643182 | D6643184 |
| 3/16                  | 3/16                    | 1                     | 4                     | 4      | D6646180 | D6646182 | D6646184 |
| 3/16                  | 3/16                    | 1-1/8                 | 3                     | 4      | D6644180 | D6644182 | D6644184 |
| 13/64                 | 1/4                     | 3/8                   | 2                     | 4      | D6642200 | D6642202 | D6642204 |
| 13/64                 | 1/4                     | 5/8                   | 2-1/2                 | 4      | D6641200 | D6641202 | D6641204 |
| 7/32                  | 1/4                     | 3/8                   | 2                     | 4      | D6642210 | D6642212 | D6642214 |
| 7/32                  | 1/4                     | 5/8                   | 2-1/2                 | 4      | D6641210 | D6641212 | D6641214 |
| 15/64                 | 1/4                     | 3/8                   | 2                     | 4      | D6642230 | D6642232 | D6642234 |
| 15/64                 | 1/4                     | 3/4                   | 2-1/2                 | 4      | D6641230 | D6641232 | D6641234 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 4      | D6642250 | D6642252 | D6642254 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 4      | D6641250 | D6641252 | D6641254 |
| 1/4                   | 1/4                     | 1                     | 4                     | 4      | D6646250 | D6646252 | D6646254 |
| 1/4                   | 1/4                     | 1-1/8                 | 3                     | 4      | D6643250 | D6643252 | D6643254 |
| 1/4                   | 1/4                     | 1-1/2                 | 4                     | 4      | D6644250 | D6644252 | D6644254 |
| 1/4                   | 1/4                     | 1-1/2                 | 6                     | 4      | D6647250 | D6647252 | D6647254 |
| 17/64                 | 5/16                    | 1/2                   | 2                     | 4      | D6642260 | D6642262 | D6642264 |
| 17/64                 | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6641260 | D6641262 | D6641264 |
| 9/32                  | 5/16                    | 1/2                   | 2                     | 4      | D6642280 | D6642282 | D6642284 |
| 9/32                  | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6641280 | D6641282 | D6641284 |
| 19/64                 | 5/16                    | 1/2                   | 2                     | 4      | D6642290 | D6642292 | D6642294 |

Additional Sizes On Pages 108 - 109

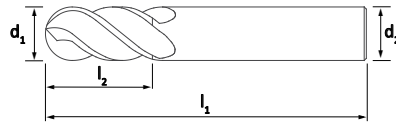
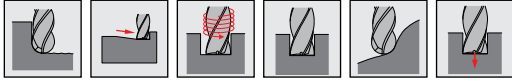
Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1/32" - 1" = -.0001/-0.0004  
 Cutting Dia: 1/32" - 7/64" = +/- .0005  
 Cutting Dia: 1/8" - 1" = +.000/-0.002  
 Ball: 1/32" - 1" = +/- .001

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|----------|
| 19/64                 | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6641290 | D6641292 | D6641294 |
| 5/16                  | 5/16                    | 1/2                   | 2                     | 4      | D6642310 | D6642312 | D6642314 |
| 5/16                  | 5/16                    | 3/4                   | 2-1/2                 | 4      | D6641310 | D6641312 | D6641314 |
| 5/16                  | 5/16                    | 1                     | 4                     | 4      | D6646310 | D6646312 | D6646314 |
| 5/16                  | 5/16                    | 1-1/8                 | 3                     | 4      | D6643310 | D6643312 | D6643314 |
| 5/16                  | 5/16                    | 1-1/2                 | 6                     | 4      | D6647310 | D6647312 | D6647314 |
| 5/16                  | 5/16                    | 1-5/8                 | 4                     | 4      | D6644310 | D6644312 | D6644314 |
| 21/64                 | 3/8                     | 5/8                   | 2                     | 4      | D6642320 | D6642322 | D6642324 |
| 21/64                 | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6641320 | D6641322 | D6641324 |
| 11/32                 | 3/8                     | 5/8                   | 2                     | 4      | D6642340 | D6642342 | D6642344 |
| 11/32                 | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6641340 | D6641342 | D6641344 |
| 23/64                 | 3/8                     | 5/8                   | 2                     | 4      | D6642350 | D6642352 | D6642354 |
| 23/64                 | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6641350 | D6641352 | D6641354 |
| 3/8                   | 3/8                     | 5/8                   | 2                     | 4      | D6642370 | D6642372 | D6642374 |
| 3/8                   | 3/8                     | 7/8                   | 2-1/2                 | 4      | D6641370 | D6641372 | D6641374 |
| 3/8                   | 3/8                     | 1                     | 4                     | 4      | D6646370 | D6646372 | D6646374 |
| 3/8                   | 3/8                     | 1-1/8                 | 3                     | 4      | D6643370 | D6643372 | D6643374 |
| 3/8                   | 3/8                     | 1-1/2                 | 6                     | 4      | D6647370 | D6647372 | D6647374 |
| 3/8                   | 3/8                     | 1-3/4                 | 4                     | 4      | D6644370 | D6644372 | D6644374 |
| 3/8                   | 3/8                     | 3                     | 6                     | 4      | D6648370 | D6648372 | D6648374 |
| 25/64                 | 7/16                    | 5/8                   | 2                     | 4      | D6642390 | D6642392 | D6642394 |
| 25/64                 | 7/16                    | 1                     | 2-3/4                 | 4      | D6641390 | D6641392 | D6641394 |
| 13/32                 | 7/16                    | 5/8                   | 2                     | 4      | D6642400 | D6642402 | D6642404 |
| 13/32                 | 7/16                    | 1                     | 2-3/4                 | 4      | D6641400 | D6641402 | D6641404 |
| 27/64                 | 7/16                    | 5/8                   | 2                     | 4      | D6642420 | D6642422 | D6642424 |
| 27/64                 | 7/16                    | 1                     | 2-3/4                 | 4      | D6641420 | D6641422 | D6641424 |
| 7/16                  | 7/16                    | 5/8                   | 2                     | 4      | D6642430 | D6642432 | D6642434 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 4      | D6641430 | D6641432 | D6641434 |
| 7/16                  | 7/16                    | 1                     | 4                     | 4      | D6646430 | D6646432 | D6646434 |
| 7/16                  | 7/16                    | 1-1/2                 | 6                     | 4      | D6647430 | D6647432 | D6647434 |
| 7/16                  | 7/16                    | 2                     | 4                     | 4      | D6643430 | D6643432 | D6643434 |
| 7/16                  | 7/16                    | 3                     | 6                     | 4      | D6644430 | D6644432 | D6644434 |
| 29/64                 | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6642450 | D6642452 | D6642454 |
| 29/64                 | 1/2                     | 1                     | 3                     | 4      | D6641450 | D6641452 | D6641454 |
| 15/32                 | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6642460 | D6642462 | D6642464 |
| 15/32                 | 1/2                     | 1                     | 3                     | 4      | D6641460 | D6641462 | D6641464 |
| 31/64                 | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6642480 | D6642482 | D6642484 |
| 31/64                 | 1/2                     | 1                     | 3                     | 4      | D6641480 | D6641482 | D6641484 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 4      | D6642500 | D6642502 | D6642504 |
| 1/2                   | 1/2                     | 1                     | 3                     | 4      | D6641500 | D6641502 | D6641504 |
| 1/2                   | 1/2                     | 1                     | 4                     | 4      | D6646500 | D6646502 | D6646504 |
| 1/2                   | 1/2                     | 1-1/2                 | 6                     | 4      | D6647500 | D6647502 | D6647504 |

Additional Sizes On Pages 107 & 109

Feeds & Speeds Available on Page 115

Application Range:

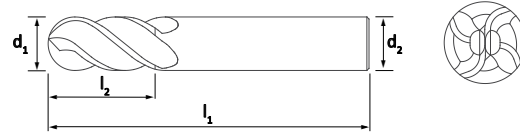
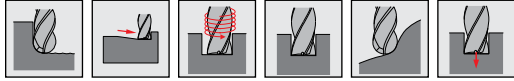
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |

# Series D664

## 4 Flute Universal Ball



$\lambda_s = 40^\circ$     $\gamma_s = 8^\circ$



**Tolerances**

Shank:  $1/32'' - 1'' = -.0001/- .0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1'' = +.000/- .002$   
 Ball:  $1/32'' - 1'' = +/- .001$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/2          | 1/2            | 2            | 4            | 4      | D6643500 | D6643502 | D6643504 |
| 1/2          | 1/2            | 3            | 6            | 4      | D6644500 | D6644502 | D6644504 |
| 9/16         | 9/16           | 7/8          | 3            | 4      | D6642560 | D6642562 | D6642564 |
| 9/16         | 9/16           | 1-1/4        | 3-1/2        | 4      | D6641560 | D6641562 | D6641564 |
| 9/16         | 9/16           | 2            | 6            | 4      | D6646560 | D6646562 | D6646564 |
| 9/16         | 9/16           | 3            | 6            | 4      | D6644560 | D6644562 | D6644564 |
| 5/8          | 5/8            | 7/8          | 3            | 4      | D6642620 | D6642622 | D6642624 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        | 4      | D6641620 | D6641622 | D6641624 |
| 5/8          | 5/8            | 2            | 6            | 4      | D6646620 | D6646622 | D6646624 |
| 5/8          | 5/8            | 2-1/8        | 4-5/8        | 4      | D6643620 | D6643622 | D6643624 |
| 5/8          | 5/8            | 3            | 6            | 4      | D6644620 | D6644622 | D6644624 |
| 11/16        | 3/4            | 1            | 3            | 4      | D6642680 | D6642682 | D6642684 |
| 11/16        | 3/4            | 1-1/2        | 4            | 4      | D6641680 | D6641682 | D6641684 |
| 3/4          | 3/4            | 1            | 3            | 4      | D6642750 | D6642752 | D6642754 |
| 3/4          | 3/4            | 1-1/2        | 4            | 4      | D6641750 | D6641752 | D6641754 |
| 3/4          | 3/4            | 2            | 6            | 4      | D6646750 | D6646752 | D6646754 |
| 3/4          | 3/4            | 2-1/4        | 5            | 4      | D6643750 | D6643752 | D6643754 |
| 3/4          | 3/4            | 3            | 6            | 4      | D6644750 | D6644752 | D6644754 |
| 7/8          | 7/8            | 1-3/4        | 4            | 4      | D6641870 | D6641872 | D6641874 |
| 1            | 1              | 1-3/4        | 4            | 4      | D6641100 | D6641102 | D6641104 |
| 1            | 1              | 2            | 6            | 4      | D6646100 | D6646102 | D6646104 |
| 1            | 1              | 2-1/4        | 5            | 4      | D6643100 | D6643102 | D6643104 |
| 1            | 1              | 3            | 6            | 4      | D6644100 | D6644102 | D6644104 |

Additional Sizes On Pages 107 & 108

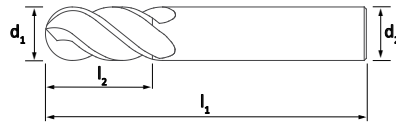
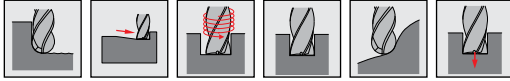
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank: 1mm - 25mm =  $-.0025/-0.102$   
 Cutting Dia: 1mm - 2.5mm =  $\pm 0.0127$   
 Cutting Dia: 3mm - 25mm =  $\pm 0.000/-0.0508$   
 Ball: 1mm - 25mm =  $\pm 0.0254$

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated  | TiCN      | AlTiN     |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|-----------|-----------|-----------|
| 1.0mm                 | 3.0mm                   | 2.0mm                 | 38.0mm                | 4      | D66420390 | D66420392 | D66420394 |
| 1.0mm                 | 3.0mm                   | 4.0mm                 | 38.0mm                | 4      | D66410390 | D66410392 | D66410394 |
| 1.5mm                 | 3.0mm                   | 3.0mm                 | 38.0mm                | 4      | D66420590 | D66420592 | D66420594 |
| 1.5mm                 | 3.0mm                   | 6.0mm                 | 38.0mm                | 4      | D66410590 | D66410592 | D66410594 |
| 2.0mm                 | 3.0mm                   | 4.0mm                 | 38.0mm                | 4      | D66420780 | D66420782 | D66420784 |
| 2.0mm                 | 3.0mm                   | 8.0mm                 | 38.0mm                | 4      | D66410780 | D66410782 | D66410784 |
| 2.5mm                 | 3.0mm                   | 5.0mm                 | 38.0mm                | 4      | D66420980 | D66420982 | D66420984 |
| 2.5mm                 | 3.0mm                   | 9.5mm                 | 38.0mm                | 4      | D66410980 | D66410982 | D66410984 |
| 3.0mm                 | 3.0mm                   | 6.0mm                 | 38.0mm                | 4      | D66421180 | D66421182 | D66421184 |
| 3.0mm                 | 3.0mm                   | 12.0mm                | 38.0mm                | 4      | D66411180 | D66411182 | D66411184 |
| 3.5mm                 | 4.0mm                   | 7.0mm                 | 50.0mm                | 4      | D66421370 | D66421372 | D66421374 |
| 3.5mm                 | 4.0mm                   | 12.0mm                | 50.0mm                | 4      | D66411370 | D66411372 | D66411374 |
| 4.0mm                 | 4.0mm                   | 8.0mm                 | 50.0mm                | 4      | D66421570 | D66421572 | D66421574 |
| 4.0mm                 | 4.0mm                   | 14.0mm                | 50.0mm                | 4      | D66411570 | D66411572 | D66411574 |
| 4.5mm                 | 6.0mm                   | 9.5mm                 | 63.0mm                | 4      | D66421770 | D66421772 | D66421774 |
| 4.5mm                 | 6.0mm                   | 16.0mm                | 63.0mm                | 4      | D66411770 | D66411772 | D66411774 |
| 5.0mm                 | 6.0mm                   | 10.0mm                | 63.0mm                | 4      | D66421960 | D66421962 | D66421964 |
| 5.0mm                 | 6.0mm                   | 16.0mm                | 63.0mm                | 4      | D66411960 | D66411962 | D66411964 |
| 6.0mm                 | 6.0mm                   | 12.0mm                | 63.0mm                | 4      | D66422360 | D66422362 | D66422364 |
| 6.0mm                 | 6.0mm                   | 19.0mm                | 63.0mm                | 4      | D66412360 | D66412362 | D66412364 |
| 7.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 4      | D66422750 | D66422752 | D66422754 |
| 7.0mm                 | 8.0mm                   | 19.0mm                | 63.0mm                | 4      | D66412750 | D66412752 | D66412754 |
| 8.0mm                 | 8.0mm                   | 12.0mm                | 63.0mm                | 4      | D66423150 | D66423152 | D66423154 |
| 8.0mm                 | 8.0mm                   | 20.0mm                | 63.0mm                | 4      | D66413150 | D66413152 | D66413154 |
| 9.0mm                 | 10.0mm                  | 14.0mm                | 70.0mm                | 4      | D66423540 | D66423542 | D66423544 |
| 9.0mm                 | 10.0mm                  | 25.0mm                | 70.0mm                | 4      | D66413540 | D66413542 | D66413544 |
| 10.0mm                | 10.0mm                  | 14.0mm                | 70.0mm                | 4      | D66423930 | D66423932 | D66423934 |
| 10.0mm                | 10.0mm                  | 25.0mm                | 70.0mm                | 4      | D66413930 | D66413932 | D66413934 |
| 11.0mm                | 12.0mm                  | 14.0mm                | 76.0mm                | 4      | D66424330 | D66424332 | D66424334 |
| 11.0mm                | 12.0mm                  | 25.0mm                | 76.0mm                | 4      | D66414330 | D66414332 | D66414334 |
| 12.0mm                | 12.0mm                  | 16.0mm                | 76.0mm                | 4      | D66424720 | D66424722 | D66424724 |
| 12.0mm                | 12.0mm                  | 25.0mm                | 76.0mm                | 4      | D66414720 | D66414722 | D66414724 |
| 14.0mm                | 14.0mm                  | 32.0mm                | 89.0mm                | 4      | D66415510 | D66415512 | D66415514 |
| 16.0mm                | 16.0mm                  | 32.0mm                | 89.0mm                | 4      | D66416290 | D66416292 | D66416294 |
| 18.0mm                | 18.0mm                  | 38.0mm                | 100.0mm               | 4      | D66417080 | D66417082 | D66417084 |
| 20.0mm                | 20.0mm                  | 38.0mm                | 100.0mm               | 4      | D66417870 | D66417872 | D66417874 |
| 25.0mm                | 25.0mm                  | 38.0mm                | 100.0mm               | 4      | D66419840 | D66419842 | D66419844 |

Feeds & Speeds Available on Page 115

Application Range:

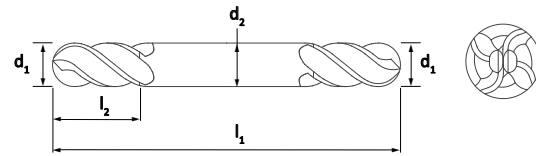
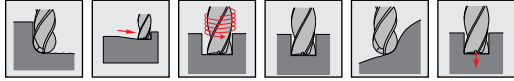
| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          | ●                      | ●             |                     |

# Series D864

## 4 Flute Universal Ball



$\lambda_s = 40^\circ$   $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/32'' - 1/2'' = -.0001/-0.0004$   
 Cutting Dia:  $1/32'' - 7/64'' = +/- .0005$   
 Cutting Dia:  $1/8'' - 1/2'' = +.000/-0.002$   
 Ball:  $1/32'' - 1/2'' = +/- .001$

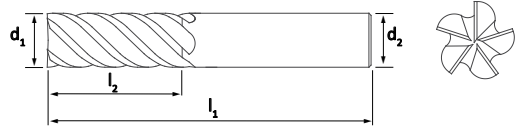
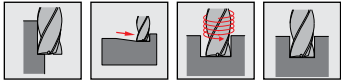
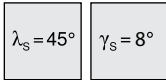
| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/32         | 1/8            | 1/16         | 1-1/2        | 4      | D8642030 | D8642032 | D8642034 |
| 3/64         | 1/8            | 3/32         | 1-1/2        | 4      | D8642040 | D8642042 | D8642044 |
| 1/16         | 1/8            | 1/8          | 1-1/2        | 4      | D8642060 | D8642062 | D8642064 |
| 5/64         | 1/8            | 5/32         | 1-1/2        | 4      | D8642070 | D8642072 | D8642074 |
| 3/32         | 1/8            | 3/16         | 1-1/2        | 4      | D8642090 | D8642092 | D8642094 |
| 7/64         | 1/8            | 3/16         | 1-1/2        | 4      | D8642190 | D8642192 | D8642194 |
| 1/8          | 1/8            | 1/4          | 1-1/2        | 4      | D8642120 | D8642122 | D8642124 |
| 1/8          | 3/8            | 3/8          | 3            | 4      | D8641120 | D8641122 | D8641124 |
| 9/64         | 3/16           | 5/16         | 2            | 4      | D8642140 | D8642142 | D8642144 |
| 5/32         | 3/16           | 5/16         | 2            | 4      | D8642150 | D8642152 | D8642154 |
| 5/32         | 3/8            | 7/16         | 3            | 4      | D8641150 | D8641152 | D8641154 |
| 11/64        | 3/16           | 5/16         | 2            | 4      | D8642170 | D8642172 | D8642174 |
| 3/16         | 3/16           | 3/8          | 2            | 4      | D8642180 | D8642182 | D8642184 |
| 3/16         | 3/8            | 1/2          | 3            | 4      | D8641180 | D8641182 | D8641184 |
| 13/64        | 1/4            | 1/2          | 2-1/2        | 4      | D8642200 | D8642202 | D8642204 |
| 7/32         | 1/4            | 7/16         | 2-1/2        | 4      | D8642210 | D8642212 | D8642214 |
| 15/64        | 1/4            | 1/2          | 2-1/2        | 4      | D8642230 | D8642232 | D8642234 |
| 1/4          | 1/4            | 1/2          | 2-1/2        | 4      | D8642250 | D8642252 | D8642254 |
| 1/4          | 3/8            | 5/8          | 3            | 4      | D8641250 | D8641252 | D8641254 |
| 9/32         | 5/16           | 1/2          | 2-1/2        | 4      | D8642280 | D8642282 | D8642284 |
| 5/16         | 5/16           | 1/2          | 2-1/2        | 4      | D8642310 | D8642312 | D8642314 |
| 5/16         | 3/8            | 3/4          | 3-1/2        | 4      | D8641310 | D8641312 | D8641314 |
| 3/8          | 3/8            | 1/2          | 2-1/2        | 4      | D8642370 | D8642372 | D8642374 |
| 3/8          | 3/8            | 3/4          | 3-1/2        | 4      | D8641370 | D8641372 | D8641374 |
| 7/16         | 7/16           | 9/16         | 2-3/4        | 4      | D8642430 | D8642432 | D8642434 |
| 1/2          | 1/2            | 5/8          | 3            | 4      | D8642500 | D8642502 | D8642504 |
| 1/2          | 1/2            | 1            | 4            | 4      | D8641500 | D8641502 | D8641504 |

Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          | •                      | •             |                     |

# DESIGN-RITE XL Series D645 5 Flute Universal



**Tolerances**  
 Shank: 1/8" - 1" = -.0001/- .0004  
 Cutting Dia: 1/8" - 1" = +.000/- .002

| d <sub>1</sub><br>Dia | d <sub>2</sub><br>Shank | l <sub>2</sub><br>LOC | l <sub>1</sub><br>OAL | Flutes | Uncoated | AlTiN    |
|-----------------------|-------------------------|-----------------------|-----------------------|--------|----------|----------|
| 1/8                   | 1/8                     | 1/4                   | 1-1/2                 | 5      | D6452120 | D6452124 |
| 1/8                   | 1/8                     | 1/2                   | 1-1/2                 | 5      | D6451120 | D6451124 |
| 5/32                  | 3/16                    | 5/16                  | 2                     | 5      | D6452150 | D6452154 |
| 5/32                  | 3/16                    | 9/16                  | 2                     | 5      | D6451150 | D6451154 |
| 3/16                  | 3/16                    | 5/16                  | 2                     | 5      | D6452180 | D6452184 |
| 3/16                  | 3/16                    | 9/16                  | 2                     | 5      | D6451180 | D6451184 |
| 7/32                  | 1/4                     | 3/8                   | 2                     | 5      | D6452210 | D6452214 |
| 7/32                  | 1/4                     | 3/4                   | 2-1/2                 | 5      | D6451210 | D6451214 |
| 1/4                   | 1/4                     | 3/8                   | 2                     | 5      | D6452250 | D6452254 |
| 1/4                   | 1/4                     | 3/4                   | 2-1/2                 | 5      | D6451250 | D6451254 |
| 1/4                   | 1/4                     | 1-1/4                 | 4                     | 5      | D6454250 | D6454254 |
| 9/32                  | 5/16                    | 7/16                  | 2                     | 5      | D6452280 | D6452284 |
| 9/32                  | 5/16                    | 13/16                 | 2-1/2                 | 5      | D6451280 | D6451284 |
| 5/16                  | 5/16                    | 7/16                  | 2                     | 5      | D6452310 | D6452314 |
| 5/16                  | 5/16                    | 13/16                 | 2-1/2                 | 5      | D6451310 | D6451314 |
| 11/32                 | 3/8                     | 1/2                   | 2                     | 5      | D6452340 | D6452344 |
| 11/32                 | 3/8                     | 1                     | 2-1/2                 | 5      | D6451340 | D6451344 |
| 3/8                   | 3/8                     | 1/2                   | 2                     | 5      | D6452370 | D6452374 |
| 3/8                   | 3/8                     | 1                     | 2-1/2                 | 5      | D6451370 | D6451374 |
| 3/8                   | 3/8                     | 1-1/2                 | 4                     | 5      | D6454370 | D6454374 |
| 13/32                 | 7/16                    | 1                     | 2-3/4                 | 5      | D6451400 | D6451404 |
| 7/16                  | 7/16                    | 1                     | 2-3/4                 | 5      | D6451430 | D6451434 |
| 15/32                 | 1/2                     | 1-1/4                 | 3                     | 5      | D6451460 | D6451464 |
| 1/2                   | 1/2                     | 5/8                   | 2-1/2                 | 5      | D6452500 | D6452504 |
| 1/2                   | 1/2                     | 1-1/4                 | 3                     | 5      | D6451500 | D6451504 |
| 1/2                   | 1/2                     | 2                     | 4                     | 5      | D6453500 | D6453504 |
| 9/16                  | 9/16                    | 1-1/2                 | 3-1/2                 | 5      | D6451560 | D6451564 |
| 5/8                   | 5/8                     | 3/4                   | 3                     | 5      | D6452620 | D6452624 |
| 5/8                   | 5/8                     | 1-5/8                 | 3-1/2                 | 5      | D6451620 | D6451624 |
| 5/8                   | 5/8                     | 2-1/2                 | 5                     | 5      | D6453620 | D6453624 |
| 3/4                   | 3/4                     | 1                     | 3                     | 5      | D6452750 | D6452754 |
| 3/4                   | 3/4                     | 1-5/8                 | 4                     | 5      | D6451750 | D6451754 |
| 3/4                   | 3/4                     | 3-1/4                 | 6                     | 5      | D6454750 | D6454754 |
| 7/8                   | 7/8                     | 2                     | 4                     | 5      | D6451870 | D6451874 |
| 1                     | 1                       | 1-1/4                 | 3                     | 5      | D6452100 | D6452104 |
| 1                     | 1                       | 2                     | 4                     | 5      | D6451100 | D6451104 |
| 1                     | 1                       | 3-1/4                 | 6                     | 5      | D6454100 | D6454104 |

Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| ●     | ●          | ●              | ●               | ●        | ●                | ●         |          |                        |               |                     |

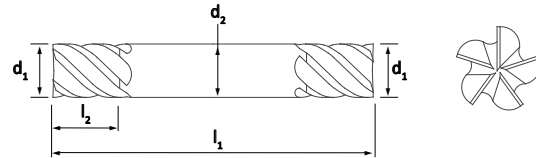
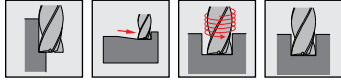
DESIGN-RITE XL



# Series D845 5 Flute Universal



$\lambda_s = 45^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
 Shank:  $1/8'' - 1/2'' = -.0001/- .0004$   
 Cutting Dia:  $1/8'' - 1/2'' = +.000/- .002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 1/8          | 1/8            | 1/4          | 1-1/2        | 5      | D8452120 | D8452122 | D8452124 |
| 3/16         | 3/16           | 5/16         | 2            | 5      | D8452180 | D8452182 | D8452184 |
| 1/4          | 1/4            | 3/8          | 2-1/2        | 5      | D8452250 | D8452252 | D8452254 |
| 5/16         | 5/16           | 7/16         | 2-1/2        | 5      | D8452310 | D8452312 | D8452314 |
| 3/8          | 3/8            | 1/2          | 2-1/2        | 5      | D8452370 | D8452372 | D8452374 |
| 7/16         | 7/16           | 9/16         | 2-3/4        | 5      | D8452430 | D8452432 | D8452434 |
| 1/2          | 1/2            | 5/8          | 3            | 5      | D8452500 | D8452502 | D8452504 |

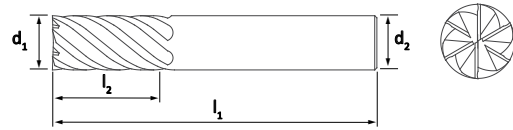
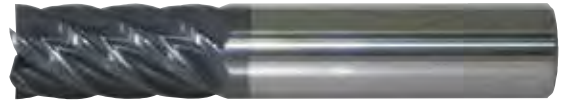
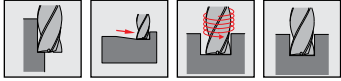
Feeds & Speeds Available on Page 115

**Application Range:**

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          |                        |               |                     |



$\lambda_s = 40^\circ$      $\gamma_s = 8^\circ$



**Tolerances**  
Shank:  $3/16'' - 1'' = -.0001/-0.0004$   
Cutting Dia:  $3/16'' - 1'' = +.000/-0.002$

| $d_1$<br>Dia | $d_2$<br>Shank | $l_2$<br>LOC | $l_1$<br>OAL | Flutes | Uncoated | TiCN     | AlTiN    |
|--------------|----------------|--------------|--------------|--------|----------|----------|----------|
| 3/16         | 3/16           | 5/8          | 2            | 6      | D6461180 | D6461182 | D6461184 |
| 1/4          | 1/4            | 3/4          | 2-1/2        | 6      | D6461250 | D6461252 | D6461254 |
| 1/4          | 1/4            | 1-1/8        | 3            | 6      | D6463250 | D6463252 | D6463254 |
| 5/16         | 5/16           | 7/8          | 2-1/2        | 6      | D6461310 | D6461312 | D6461314 |
| 3/8          | 3/8            | 7/8          | 2-1/2        | 6      | D6461370 | D6461372 | D6461374 |
| 3/8          | 3/8            | 1-1/8        | 3            | 6      | D6463370 | D6463372 | D6463374 |
| 7/16         | 7/16           | 1            | 2-3/4        | 6      | D6461430 | D6461432 | D6461434 |
| 1/2          | 1/2            | 1            | 3            | 6      | D6461500 | D6461502 | D6461504 |
| 1/2          | 1/2            | 2            | 4            | 6      | D6463500 | D6463502 | D6463504 |
| 5/8          | 5/8            | 1-1/4        | 3-1/2        | 6      | D6461620 | D6461622 | D6461624 |
| 5/8          | 5/8            | 2-1/8        | 4-5/8        | 6      | D6463620 | D6463622 | D6463624 |
| 3/4          | 3/4            | 1-1/2        | 4            | 6      | D6461750 | D6461752 | D6461754 |
| 3/4          | 3/4            | 2-1/4        | 5            | 6      | D6463750 | D6463752 | D6463754 |
| 1            | 1              | 1-3/4        | 4            | 6      | D6461100 | D6461102 | D6461104 |
| 1            | 1              | 2-1/4        | 5            | 6      | D6463100 | D6463102 | D6463104 |

Feeds & Speeds Available on Page 115

Application Range:

| Steel | Tool Steel | Hardened Steel | Stainless Steel | Titanium | High Temp Alloys | Cast Iron | Aluminum | Aluminum High Silicone | Copper, Brass | Plastic, Composites |
|-------|------------|----------------|-----------------|----------|------------------|-----------|----------|------------------------|---------------|---------------------|
| •     | •          | •              | •               | •        | •                | •         |          |                        |               |                     |

| MATERIAL                   | SPEED<br>(S.M.F.) | END MILL DIAMETER |             |             |
|----------------------------|-------------------|-------------------|-------------|-------------|
|                            |                   | UP TO 1/4"        | UP TO 1/2"  | UP TO 1"    |
| FEED PER TOOTH (INCHES)    |                   |                   |             |             |
| Aluminum/Aluminum Alloys   | 600-1200          | .0002-.0020       | .0020-.0040 | .0060-.0100 |
| Brass/Bronze               | 200-350           | .0005-.0020       | .0020-.0030 | .0040-.0080 |
| Copper/Copper Alloys       | 350-900           | .0005-.0020       | .0020       | .0020-.0060 |
| Iron-Cast (soft)           | 200-500           | .0005-.0020       | .0020-.0030 | .0030-.0080 |
| Iron-Cast (hard)           | 80-350            | .0003-.0008       | .0008-.0020 | .0020-.0040 |
| Iron-Ductile               | 80-400            | .0002-.0010       | .0010-.0020 | .0020-.0060 |
| Iron-Malleable             | 200-600           | .0002-.0010       | .0010-.0030 | .0030-.0070 |
| Magnesium/Magnesium Alloys | 800-1400          | .0005-.0020       | .0020-.0060 | .0040-.0100 |
| Monel/High Nickel Steel    | 150-300           | .0002-.0010       | .0010-.0020 | .0020-.0040 |
| Plastics                   | 600-1200          | .0006-.0030       | .0030-.0060 | .0060-.0150 |
| Plastic-Glass Filled       | 300-800           | .0006-.0030       | .0030-.0040 | .0040-.0120 |
| Refractory Alloys          | 80-400            | .0002-.0010       | .0010       | .0010-.0020 |
| Steel-Low Carbon           | 200-500           | .0002-.0010       | .0010-.0030 | .0030-.0070 |
| Steel-Medium Carbon        | 100-250           | .0004-.0015       | .0015-.0020 | .0020-.0050 |
| Steel-Hardened             | 25-120            | .0002-.0005       | .0005-.0010 | .0010-.0030 |
| Steel-Mold                 | 200-350           | .0002-.0010       | .0010-.0020 | .0020-.0060 |
| Steel-Tool                 | 100-300           | .0002-.0010       | .0010-.0020 | .0020-.0060 |

**ALL DESIGN-RITE END MILLS ARE CENTER CUTTING**

- Lower Radial Width of Cut – Higher range of recommended surface speeds should be used
- Greater Radial Width of Cut – Lower range of recommended surface speeds should be used
- For Slotting Applications – Speeds should be reduced by approximately 20% of lowest range value
- For Peripheral Applications – Axial depth of cut not to exceed 1-1/2 times the cutter diameter
  - Long & X-Long End Mills – Reduce feed per tooth by 50%
  - TiCN & AlTiN Coating – Increase S.F.M. by 25% to 40%

| S.F.M. | DIAMETER |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|--------|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|        | 1/16     | 3/32   | 1/8    | 5/32   | 3/16   | 7/32   | 1/4    | 5/16   | 3/8    | 7/16   | 1/2    | 5/8    | 3/4    | 7/8    | 1      |
| 50     | 3,050    | 2,040  | 1,530  | 1,220  | 1,020  | 875    | 765    | 610    | 510    | 440    | 380    | 310    | 250    | 220    | 190    |
| 75     | 4,580    | 3,060  | 2,290  | 1,830  | 1,530  | 1,310  | 1,150  | 920    | 760    | 660    | 570    | 460    | 380    | 330    | 285    |
| 100    | 6,100    | 4,080  | 3,050  | 2,450  | 2,040  | 1,750  | 1,530  | 1,220  | 1,020  | 870    | 760    | 610    | 510    | 440    | 385    |
| 125    | 7,630    | 5,100  | 3,820  | 3,050  | 2,550  | 2,180  | 1,920  | 1,530  | 1,270  | 1,100  | 950    | 770    | 630    | 550    | 475    |
| 150    | 9,150    | 6,120  | 4,570  | 3,670  | 3,060  | 2,620  | 2,290  | 1,830  | 1,530  | 1,310  | 1,140  | 920    | 760    | 660    | 575    |
| 175    | 10,680   | 7,140  | 5,350  | 4,270  | 3,570  | 3,060  | 2,680  | 2,140  | 1,780  | 1,540  | 1,330  | 1,080  | 880    | 770    | 665    |
| 200    | 12,200   | 8,150  | 6,100  | 4,900  | 4,070  | 3,500  | 3,100  | 2,450  | 2,000  | 1,750  | 1,500  | 1,200  | 1,000  | 875    | 750    |
| 300    | 18,500   | 12,200 | 9,200  | 7,300  | 6,100  | 5,250  | 4,600  | 3,700  | 3,100  | 2,600  | 2,300  | 1,800  | 1,500  | 1,300  | 1,100  |
| 400    | 24,500   | 16,300 | 12,200 | 9,800  | 8,150  | 7,000  | 6,100  | 4,900  | 4,100  | 3,500  | 3,050  | 2,450  | 2,050  | 1,750  | 1,525  |
| 500    | 30,500   | 20,400 | 15,300 | 12,200 | 10,200 | 8,700  | 7,600  | 6,100  | 5,100  | 4,400  | 3,800  | 3,100  | 2,500  | 2,200  | 1,900  |
| 750    | 45,800   | 36,700 | 22,900 | 18,300 | 15,300 | 13,100 | 11,500 | 9,200  | 7,600  | 6,550  | 5,700  | 4,600  | 3,800  | 3,770  | 2,850  |
| 1,000  | -        | 40,800 | 30,600 | 24,500 | 20,400 | 17,500 | 15,300 | 12,200 | 10,200 | 8,750  | 7,650  | 6,100  | 5,100  | 4,400  | 3,800  |
| 1,500  | -        | -      | 45,900 | 36,700 | 30,600 | 26,200 | 22,900 | 18,300 | 15,300 | 13,150 | 11,300 | 9,200  | 7,600  | 6,500  | 5,700  |
| 2,000  | -        | -      | -      | 49,000 | 40,800 | 35,000 | 30,600 | 24,400 | 20,400 | 17,500 | 15,300 | 12,200 | 10,200 | 8,700  | 7,600  |
| 3,000  | -        | -      | -      | -      | -      | 52,500 | 45,900 | 36,600 | 30,600 | 26,250 | 22,900 | 18,300 | 15,300 | 13,100 | 11,400 |
| 4,000  | -        | -      | -      | -      | -      | -      | -      | 48,800 | 40,800 | 35,000 | 30,600 | 24,400 | 20,400 | 17,500 | 15,200 |
| 5,000  | -        | -      | -      | -      | -      | -      | -      | -      | -      | 43,700 | 38,200 | 30,600 | 25,500 | 21,800 | 19,000 |



## PROMAX TOOLS

11312 Sunrise Gold Circle  
Rancho Cordova, CA 95742  
United States

T. +1 800 878 0502  
+1 916 638 0501  
F. +1 916 638 0512  
E. [sales@promaxtools.com](mailto:sales@promaxtools.com)

[www.promaxtools.com](http://www.promaxtools.com)

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