

# Proto-Cutter, Inc.

Precision Cutting Tools



Made in the U.S.A.

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



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## WELCOME, FROM THE PRESIDENT!

*We are excited to launch our new catalog. In doing so, we hope to inform all of our customers of what is "new and innovative" here at Proto-Cutter, Inc. Our Commitment to Quality includes producing the best tools in the industry and delivering defect-free products and services on time, every time. We work with special applications you may have and currently serve customers in the Aerospace, Agriculture, Automotive, and Medical fields.*

***We look forward to working with you and meeting your requirements.***

*Sincerely,  
Pete Alber*

## USING STATE-OF-THE-ART TECHNOLOGY AND HIGHLY SKILLED OPERATORS, PROTO-CUTTER PROVIDES SOLUTIONS FOR TOUGH TOOLING PROBLEMS.

**In 1991, Proto-Cutter, Inc. was established to offer cutting tool resharpener. Since that time, we have increased in size and now manufacture several types of precision cutting tools.**

At Proto-Cutter, our business philosophy is simple and straightforward: Provide the highest quality coolant-fed reamers and the best customer service anywhere in the industry to maximize your productivity and achieve your lowest cost per hole.

We specialize in manufacturing carbide tipped, solid carbide, and high-speed steel coolant-fed reamers in standard and special designs for precision hole finishing.

Standard cutting diameter tolerances are maintained within  $+.00015"/-.00015"$  unless otherwise specified.

In addition to our standard design right-hand spiral/right-hand cut reamers, we offer the following special flute configurations:

- Straight flute
- Left-hand spiral/right-hand cut
- Left-hand spiral/left-hand cut
- Right-hand spiral/left-hand cut

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Our experienced sales engineers will work with you to determine the flute configuration that best meets your production requirements.

All of our reamers are manufactured to provide ease of set-up and operation. We can provide you with reamers capable of extended life, reamers that will produce an exceptionally high finish (minimizing the need for secondary operations), or a reamer that will give you a quality finish and provide you with long tool life. In addition, Proto-Cutter reamers eliminate chatter and other problems associated with conventional reamers.

**Proto-Cutter has become a trusted name in hole finishing tools because of our high quality standards, unmatched customer service, and fast lead times, which are qualities we also apply to our special made-to-print items. We are committed to providing high quality tools at affordable prices and look forward to serving all your cutting tool needs.**

# SEVEN IMPORTANT REASONS WHY PROTO-CUTTER SHOULD BE YOUR SOURCE FOR COOLANT-FED REAMERS

## 1. OUR "TOTAL COMMITMENT" ASSURES YOUR COMPLETE AND CONSISTENT SATISFACTION

At Proto-Cutter, "Total Commitment" serves as the foundation for everything we do. There are four areas of our business relationship with you where a commitment to quality is continually stressed.

**A commitment to product excellence:** At Proto-Cutter, we consistently utilize only the latest mechanical and computerized inspection equipment, which is applied at every facet of the manufacturing process. This investment in quality control results in tooling that is second to none.

**A commitment to superior performance combined with cost efficiency:** We understand that you want the best cutting tool your money can buy, but at a reasonable cost. Proto-Cutter provides the highest quality tools at competitive prices.

**A commitment to our responsibility to meet all your needs:** At Proto-Cutter, we do much more than just take orders. We take responsibility by meeting all of your needs in the areas of product design, quality, price and delivery.

**A commitment to professionalism:** Professionalism at Proto-Cutter means servicing our customers' needs quickly and conscientiously, and staying on the cutting edge of technology to consistently produce the finest reamers in the industry. By maintaining our "Total Commitment," we provide a competitive advantage that will aid you in your marketplace.

## 2. CUSTOM SHARPENING RESULTS IN PRECISE ACCURACY AND EXCEPTIONAL FINISH

Because we custom sharpen each and every reamer to its exact specified profile and tolerance, you are able to achieve hole size to within .0005". Hole straightness can be maintained to within .0002", depending on the hole's depth and prior operation. With Proto-Cutter reamers, you can achieve a surface finish of 32 RMs, or even better in some circumstances. By achieving this high level of finish, our reamers eliminate the need for time-consuming grinding, honing or burnishing operations. That means more holes reamed per year, increasing your productivity and dramatically reducing your cost per hole.

## 3. EXTENDED TOOL LIFE MEANS LESS MACHINE DOWNTIME

The unique design of Proto-Cutter reamers extends reamer life significantly over that of conventional reamers, giving you increased tool repeatability and less downtime for more holes reamed per year and increased productivity. *Proto-Cutter reamers give you "The Most Value For Your Hole Dollar."*

## 4. QUICK AND CONSISTENT ON-TIME DELIVERY MEANS LESS DOWNTIME FOR YOU

Our excellent on-time delivery record is consistently better than any of our competitors and means less downtime for you. When you're in a bind, don't get behind, pick up the phone and call us.

## 5. ENGINEERING ASSISTANCE AT NO COST MAKES TOOL SELECTION EASY

Our sales engineers have a broad working knowledge of materials, hardness, feeds, speeds and many other factors that contribute to the performance of the reamer. They will help you choose a reamer and a sharpening profile that will accomplish your hole finishing requirements and productivity goals. Their experience is available without cost or obligation. Just call us.

## 6. RECONDITIONING SERVICES MEAN SINGLE-SOURCING AND COST-EFFICIENCY

Reconditioning your reamers provides maximum tool life and results in decreased tool costs overall. As your single-source for both new reamers and reconditioning, Proto-Cutter will maximize your tool cost efficiency. In reamer conditioning, we precisely restore the controlled cutting edges through lead sharpening, resizing or replacing carbide tips and sharpening them to the original specifications.

## 7. COMPUTER DATA BASE MEANS QUICK AND ACCURATE RE-ORDERING

We maintain an extensive computer data base file for each customer, recording information such as your tool numbers, reamer sizes, profile selections, and more. With this information readily accessible, each new order you place can be quickly and accurately duplicated.





# Coolant-Fed Reamers

Coolant-fed reamers lubricate and cool the cutting edges and provide exceptional chip disposal, resulting in increased productivity, longer tool life and lower tool costs.



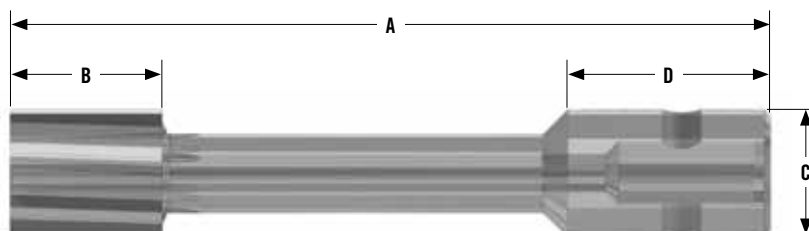
## CARBIDE-TIPPED & SOLID CARBIDE

Carbide-tipped and solid carbide coolant-fed reamers offer many significant advantages for hole finishing:

- These reamers work well for almost all materials.
- Operation at higher speeds and feed rates increases tool life and decreases cycle time.
- Depending on the application, they can outlast high-speed steel reamers by as much as 10-to-1.

Part No.	Diameter Range	A	B	C	D	No. of Flutes
PSC-0125*	.0935-.1300	2.500	.375	.375	.750	4
PSC-0157*	.1301-.1600	2.500	.375	.375	.750	4
PSC-0175*	.1601-.1800	2.500	.375	.375	.750	4
PC-0210	.1801-.2200	2.500	.500	.375	.750	4
PSC-0210*	.1801-.2200	2.500	.500	.375	.750	6
PC-0255	.2201-.2600	2.500	.500	.375	.750	4
PSC-0255*	.2201-.2600	2.500	.500	.375	.750	6
PC-0286	.2601-.2920	2.500	.500	.375	.750	4
PSC-0286*	.2601-.2920	2.500	.500	.375	.750	6
PC-0318	.2921-.3250	2.500	.500	.375	.750	6
PSC-0318*	.2921-.3250	2.500	.500	.375	.750	6
PC-0380	.3251-.3900	2.500	.500	.375	.750	6
PSC-0380*	.3251-.3900	2.500	.500	.375	.750	6
PC-0436	.3901-.4450	2.625	.500	.375	.750	6
PSC-0436*	.3901-.4450	2.625	.500	.375	.750	6
PC-0505	.4451-.5150	3.500	.625	.625	1.000	6
PC-0630	.5151-.6400	3.750	.750	.625	1.000	6
PC-0755	.6401-.7650	4.250	.750	.625	1.000	6
PC-0880	.7651-.8900	4.750	.875	.625	1.000	6
PC-1005	.8901-1.0150	5.500	1.000	1.000	1.500	8
PC-1130	1.0151-1.1400	6.000	1.250	1.000	1.500	8
PC-1255	1.1401-1.2650	6.000	1.250	1.000	1.500	8
PC-1380	1.2651-1.3900	6.000	1.250	1.000	1.500	8
PC-1505	1.3901-1.5150	6.000	1.250	1.000	1.500	8
PC-1630	1.5151-1.6400	6.000	1.250	1.000	1.500	10
PC-1755	1.6401-1.7650	6.000	1.250	1.000	1.500	10
PC-1880	1.7651-1.8900	6.000	1.250	1.000	1.500	10
PC-2015	1.8901-2.0250	6.000	1.250	1.000	1.500	10

\*PSC indicates solid carbide



The coolant-fed feature of Proto-Cutter reamers produces maximum chip-flushing action and is designed for use in blind hole and through hole reaming. In blind hole reaming, chip flushing and cooling are achieved simultaneously. The coolant is fed through the reamer body, hits the end of the blind hole and is forced back through the flutes.

# REAMERS



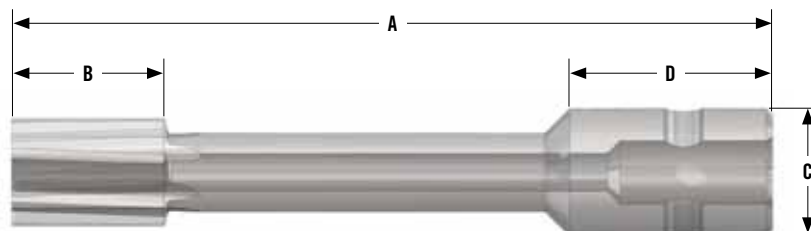
## HIGH-SPEED STEEL

High-speed steel (HSS) reamers are an excellent choice for low cost production jobs:

- They work well with a variety of materials.
- HSS reamers are cost efficient.
- They are great for smaller quantity production runs.

Part No.	Diameter Range	A	B	C	D	No. of Flutes
PH-0125*	.0935-.1300	2.500	.375	.375	.750	4
PH-0157*	.1301-.1600	2.500	.375	.375	.750	4
PH-0175*	.1601-.1800	2.500	.375	.375	.750	4
PH-0210	.1801-.2150	2.500	.500	.375	.750	6
PH-0254	.2151-.2600	2.500	.500	.375	.750	6
PH-0284	.2601-.2900	2.500	.500	.375	.750	6
PH-0318	.2901-.3250	2.500	.500	.375	.750	6
PH-0344	.3251-.3500	2.500	.500	.375	.750	6
PH-0407	.3501-.4100	2.625	.500	.375	.750	6
PH-0439	.4101-.4450	2.625	.500	.375	.750	6
PH-0505	.4451-.5100	3.500	.625	.625	1.000	6
PH-0567	.5101-.5700	3.500	.625	.625	1.000	6
PH-0630	.5701-.6350	3.750	.625	.625	1.000	8
PH-0692	.6351-.6950	4.250	.750	.625	1.000	8
PH-0755	.6951-.7600	4.250	.750	.625	1.000	8
PH-0817	.7601-.8200	4.500	.875	.625	1.000	8
PH-0884	.8201-.8900	4.750	.875	.625	1.000	8
PH-1015	.8901-1.0200	5.500	1.000	1.000	1.500	8
PH-1137	1.0201-1.1400	6.000	1.000	1.000	1.500	8
PH-1323	1.1401-1.3300	6.000	1.250	1.000	1.500	8
PH-1505	1.3301-1.5100	6.000	1.250	1.000	1.500	8
PH-1656	1.5101-1.6600	6.000	1.250	1.000	1.500	10
PH-1813	1.6601-1.8200	6.000	1.250	1.000	1.500	10
PH-2015	1.8201-2.0200	6.000	1.250	1.000	1.500	10

\*Does not contain coolant through hole



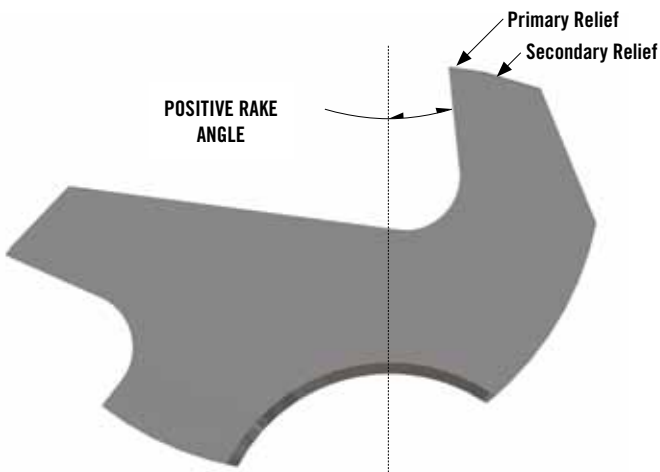
# Product Design and Performance

## SUPERIOR PRODUCT DESIGN FEATURES PRODUCE UNSURPASSED PERFORMANCE

Our reamers include established design features that minimize friction, harmonic chatter and galling to increase the performance and extend the life of your reamers.

These design features include:

- **Irregularly spaced flutes:** This type of spacing provides superior cutting action and reduces harmonic chatter. The design of the spacing, in conjunction with the coolant-fed feature, allows the reamers to produce finishes that were formerly unattainable without secondary finishing operations.
- **Special designed profile:** The profile design on the reamer is important for obtaining optimum finish and maximum tool life. Our applications engineers will select the profile best suited for your material, finish requirements and work piece configuration.
- **Positive rake angle:** This design feature enhances reamer performance and extends tool life, thereby reducing friction and permitting the reamer to cut more freely.



## RECONDITIONING TO ORIGINAL SPECIFICATIONS RESULTS IN SUPERIOR PERFORMANCE

Proto-Cutter restores original sharpening design features to extend the life of your reamers.

### Don't throw away your dull cutting tools

Proto-Cutter specializes in reconditioning "Barber-Colman" style coolant-fed reamers. We will restore the precisely controlled cutting edges on a variety of this type of reamer through lead sharpening, resizing or replacing carbide tips and sharpening them to your original specifications. We will accurately and properly recondition your reamers, delivering them to you quickly so they can be put back on the production line, and servicing them effectively again when they need it.

### We provide three basic reconditioning services:

- **Retipping** for carbide-tipped reamers. We can replace the carbide and precisely sharpen the reamer to its original diameter and tolerances. Many reamers, if properly used, can be retipped up to 50 times or more to achieve the absolute lowest cost per hole.
- **Resizing** for carbide-tipped and high-speed steel reamers. If you use a reamer blank for more than one hole size, we can resize the reamer to a smaller diameter with controlled and precise accuracy (minimum stock required of .003).
- **Lead sharpening** for carbide-tipped and high-speed steel reamers. Chamfer and/or lead angles can be ground to remove wear and extend tool life. However, this is not guaranteed to restore the reamer to the performance level of a retipped or resized tool.

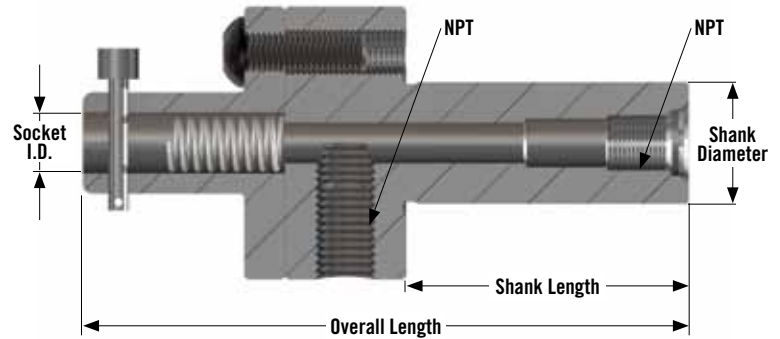
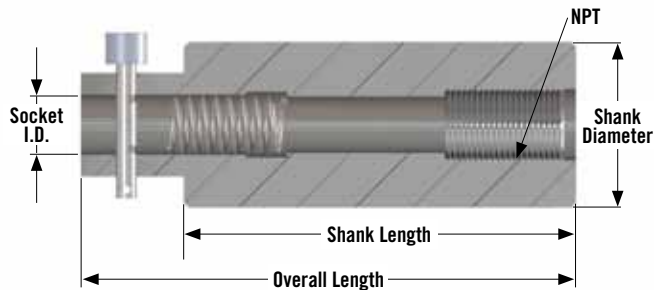
## SAME DAY SERVICE, 24 OR 48 HOUR

In addition to conventional coolant flooding for through hole reaming, we offer coolant dispersion by placing coolant holes between the flutes.

For both blind hole and through hole reaming, the coolant action flushes the chips from the cutting area, while lubricating and cooling the cutting edges. This action increases productivity by reducing frictional heat, improving the finish and extending tool life.



## FOR COOLANT-FED REAMERS – TOOL STATIONARY



### FIXED CENTER

Part Number	Reamer Shank Diameter	Shank Diameter	Shank Length	Overall Length
PF-05	.375	.625	2.375	3.000
PF-10	.375	.750	2.375	3.000
PF-15	.375	1.000	2.375	3.000
PF-20	.625	.750	1.750	3.000
PF-25	.625	1.000	2.125	3.000
PF-30	.625	1.250	2.125	3.000
PF-35	.625	1.500	2.125	3.000
PF-40	.625	1.500	4.000	5.000
PF-45	.625	1.750	4.000	5.000
PF-50	.625	2.000	4.000	5.000
PF-55	1.000	1.000	1.437	5.000
PF-57	1.000	1.250	4.000	5.500
PF-60	1.000	1.500	4.000	5.500
PF-65	1.000	1.750	4.000	5.500
PF-70	1.000	2.000	4.000	5.500

### ADJUSTABLE

Part Number	Reamer Shank Diameter	Shank Diameter	Shank Length	Overall Length
PAF-05	.375	.625	1.500	3.500
PAF-10*	.375	.625	1.250	2.250
PAF-15	.375	.750	1.750	3.750
PAF-20	.375	1.000	1.750	3.750
PAF-25*	.375	1.000	2.125	3.125
PAF-30	.625	.750	2.125	4.000
PAF-35	.625	1.000	2.125	4.000
PAF-40	.625	1.250	2.125	4.000
PAF-45	.625	1.500	2.125	4.000
PAF-50	.625	1.500	3.625	5.500
PAF-55	.625	1.750	3.625	5.500
PAF-60	.625	2.000	3.625	5.500
PAF-65	1.000	1.000	2.000	5.000
PAF-67	1.000	1.250	3.625	6.000
PAF-70	1.000	1.500	3.625	6.000
PAF-75	1.000	1.750	3.625	6.000
PAF-80	1.000	2.000	3.625	6.000

\*Does not contain coolant flange on side of holder

### REPLACEMENT HEAD

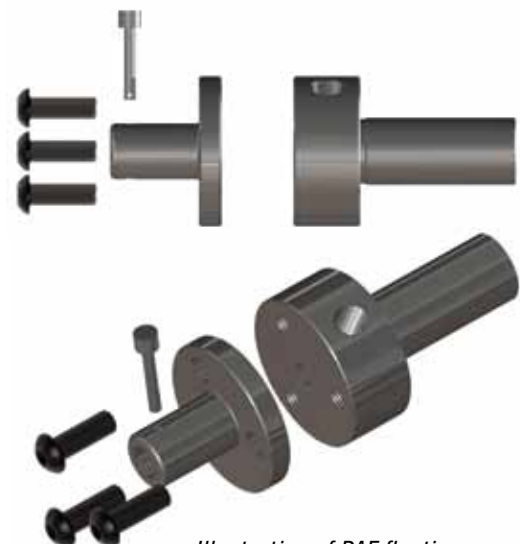
Part Number	Overall Length	Diameter
HD-0	.750	Fits PAF-10 & PAF-25
HD-1	1.25	Fits PAF-05, PAF-15, PAF-20
HD-2	1.125	Fits PAF-30 thru PAF-60
HD-3	1.625	Fits PAF-65 thru PAF-80

### REPLACEMENT PINS

Part Number	Description
PIN-1	Fits PF-05 thru PF-15 & PAF-05 thru PAF-25
PIN-2	Fits PF-20 thru PF-50 & PAF-30 thru PAF-60
PIN-3	Fits PF-55 thru PF-70 & PAF-65 thru PAF-80

### REPLACEMENT SPRINGS

Part Number	Description
SP-1	Fits PF-05 thru PF-15 & PAF-05 thru PAF-25
SP-2	Fits PF-20 thru PF-50 & PAF-30 thru PAF-60
SP-3	Fits PF-55 thru PF-70 & PAF-65 thru PAF-80



*Illustration of PAF floating reamer holder. Please contact Proto-Cutter for holder instructions.*

# Precision Reaming System

Proto-Cutter XR Reamers are designed for tight hole tolerances, concentric holes and superior micro finishes. One replaceable cutting blade is supported by guide pads to guide the reamer in a predrilled, bored, or cored hole. Reamers are made for through or blind hole reaming. Proto-Cutter can custom design an XR Reamer beyond our standard dimensions.

## XR XTREME REAMER

Reamer Size	Diameter Range	Working Length	Shank Diameter	Overall Length	Shank Length
XR-0390	.370-.400	2.5	5/8 (16.00 mm)	4.5	2
XR-0420	.401-.430	2.5	5/8 (16.00 mm)	4.5	2
XR-0450	.431-.460	2.5	5/8 (16.00 mm)	4.5	2
XR-0480	.461-.490	2.5	5/8 (16.00 mm)	4.5	2
XR-0510	.491-.520	3.0	5/8 (16.00 mm)	5.0	2
XR-0540	.521-.550	3.0	5/8 (16.00 mm)	5.0	2
XR-0570	.551-.580	3.0	5/8 (16.00 mm)	5.0	2
XR-0600	.581-.610	3.0	5/8 (16.00 mm)	5.0	2
XR-0630	.611-.640	3.0	5/8 (16.00 mm)	5.0	2
XR-0660	.641-.670	3.0	3/4 (20.00 mm)	5.0	2
XR-0690	.671-.700	3.0	3/4 (20.00 mm)	5.0	2
XR-0720	.701-.730	3.0	3/4 (20.00 mm)	5.0	2
XR-0750	.731-.760	3.5	3/4 (20.00 mm)	5.5	2
XR-0780	.761-.790	3.5	3/4 (20.00 mm)	5.5	2
XR-0810	.791-.820	3.5	3/4 (20.00 mm)	5.5	2
XR-0840	.821-.850	3.5	3/4 (20.00 mm)	5.5	2
XR-0870	.851-.880	3.5	3/4 (20.00 mm)	5.5	2
XR-0900	.881-.910	3.5	3/4 (20.00 mm)	5.5	2
XR-0930	.911-.940	3.5	3/4 (20.00 mm)	5.5	2
XR-0960	.941-.970	3.5	3/4 (20.00 mm)	5.5	2
XR-0990	.971-1.000	3.5	3/4 (20.00 mm)	5.5	2
XR-1020	1.001-1.03	4.0	1 (24.00 mm)	6.0	2
XR-1080	1.031-1.090	4.0	1 (24.00 mm)	6.0	2
XR-1140	1.091-1.150	4.0	1 (24.00 mm)	6.0	2
XR-1200	1.151-1.210	4.0	1 (24.00 mm)	6.0	2
XR-1260	1.211-1.270	4.0	1 (24.00 mm)	6.0	2
XR-1320	1.271-1.330	4.0	1 (24.00 mm)	6.0	2
XR-1380	1.331-1.390	4.0	1 (24.00 mm)	6.0	2
XR-1440	1.391-1.450	4.0	1 (24.00 mm)	6.0	2
XR-1500	1.451-1.510	4.0	1 (24.00 mm)	6.0	2





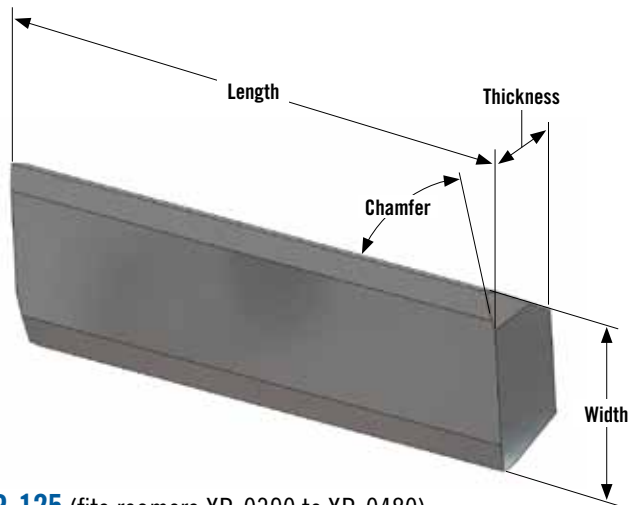
## XR REAMER BLADES

Proto-Cutter XR Reamer blades are manufactured from high quality micro-grain polished carbide. Edge honing is applied to the blades for certain applications to reduce micro chipping. Blades are double ended to minimize cost.

Lead and rake angles are determined by our sales engineers to maximize micro finish and concentric holes. Please consult Proto-Cutter sales engineers for lead angle geometries to suit your application.

Reamer blades can be coated with TIN, TICN or TIALN. Other coatings are available depending on the material and application.

Proto-Cutter also makes replacement blades for reamer bodies made by other manufacturers.



**XR-125** (fits reamers XR-0390 to XR-0480)

**XR-185** (fits reamers XR-0510 to XR-1500)



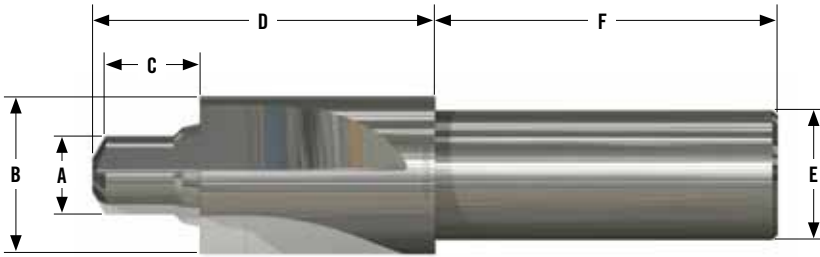
## XR TOOL SETTER

**XR Tool Setter-1** is a bench center that measures tools up to 4" in diameter and 12" long and comes with a spring-loaded center. Two Mahr Federal gages reading in .00005" increments come with the tool setter.

**XR Tool Setter-2** is a bench center that measures tools up to 4" in diameter and 24" long and comes with a spring-loaded center. Two Mahr Federal gages reading in .00005" increments come with the tool setter.

# Port Contour Cutters

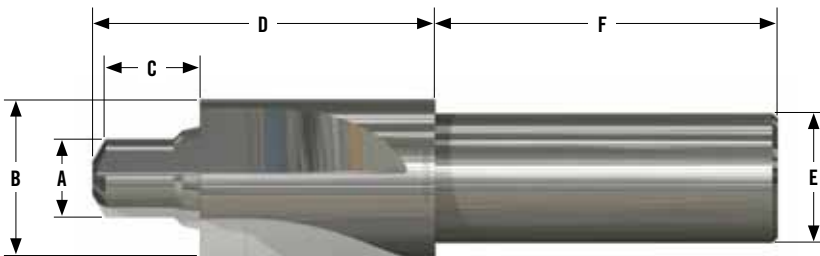
At Proto-Cutter we understand customer requirements for precision holes, which is why our porting tools are all ground between centers to ensure tool concentricity. They are form relieved so a simple face grind for resharpener can be done.



## TUNGSTEN CARBIDE TIPPED, STRAIGHT SHANK – STANDARD

SAE J1926, MS 16142

Thread Size	Tube		Part Number	A Small Diameter	B Spotface Diameter	C Bore Length	D Head Length	E Shank Diameter	F Shank Length	Pre-Drill Diameter/Length
	No.	O.D.								
5/16-24	2	.125	PTCS-0312	.272	.682	.473	1.500	.500	3.125	F x .688
3/8-24	3	.187	PTCS-0375	.335	.760	.473	1.500	.500	3.125	O x .688
7/16-20	4	.250	PTCS-0437	.389	.838	.552	1.500	.500	3.125	U x .812
1/2-20	5	.312	PTCS-0500	.452	.916	.552	1.500	.500	3.125	.44 x .812
9/16-18	6	.375	PTCS-0562	.509	.994	.614	1.500	.500	3.125	.48 x .875
3/4-16	8	.500	PTCS-0750	.689	1.198	.693	1.750	.750	3.875	.67 x .937
7/8-14	10	.625	PTCS-0875	.806	1.354	.786	1.750	.750	3.875	.78 x 1.062
1-1/16-12	12	.750	PTCS-1062	.981	1.635	.911	2.000	.750	3.875	.95 x 1.250
1-3/16-12	14	.875	PTCS-1187	1.106	1.775	.911	2.000	.750	3.875	1.09 x 1.250
1-5/16-12	16	1.000	PTCS-1312	1.231	1.920	.911	2.000	.750	3.875	1.21 x 1.250
1-5/8-12	20	1.250	PTCS-1625	1.544	2.280	.911	2.000	1.000	4.875	1.53 x 1.250
1-7/8-12	24	1.500	PTCS-1875	1.794	2.570	.911	2.000	1.000	4.875	1.78 x 1.250
2-1/2-12	32	2.000	PTCS-2500	2.419	3.490	.911	2.000	1.000	4.875	2.41 x 1.250



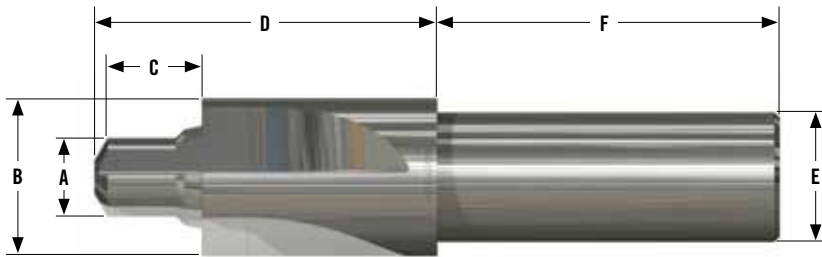
## TUNGSTEN CARBIDE TIPPED, STRAIGHT SHANK – METRIC

ISO 6149, SAE J2244/1

Thread Size	Part Number	A Small Diameter	B Spotface Diameter	C Bore Length	D Head Length	E Shank Diameter	Pre-Drill Diameter/Length
M 8 x 1	PTCM-8	7.035 (.277)	14 (.5512)	11.5 (.4528)	41.28 (1.625)	12.7 (.500)	D x .589
M 10 x 1	PTCM-10	9.042 (.356)	16 (.6299)	11.5 (.4528)	41.28 (1.625)	19.05 (.750)	P x .589
M 12 x 1.5	PTCM-12	10.541 (.415)	19 (.748)	14 (.5512)	41.28 (1.625)	19.05 (.750)	W x .681
M 14 x 1.5	PTCM-14	12.522 (.493)	21 (.8268)	14 (.5512)	41.28 (1.625)	19.05 (.750)	.45 x .681
M 16 x 1.5	PTCM-16	14.528 (.572)	24 (.9449)	15.5 (.6102)	47.63 (1.875)	19.05 (.750)	.54 x .740
M 18 x 1.5	PTCM-18	16.535 (.651)	26 (1.0236)	17 (.6693)	47.63 (1.875)	19.05 (.750)	.62 x .809
M 22 x 1.5	PTCM-22	20.523 (.808)	29 (1.1417)	18 (.7087)	47.63 (1.875)	19.05 (.750)	.78 x .849
M 27 x 2	PTCM-27	25.019 (.985)	34 (1.3386)	22 (.8661)	53.98 (2.125)	25.4 (1.00)	.95 x 1.01
M 33 x 2	PTCM-33	31.013 (1.221)	43 (1.6929)	22 (.8661)	53.98 (2.125)	25.4 (1.00)	1.17 x 1.01
M 42 x 2	PTCM-42	40.030 (1.576)	52 (2.0472)	22.5 (.8858)	53.98 (2.125)	31.75 (1.25)	1.54 x 1.03
M 48 x 2	PTCM-48	46.025 (1.812)	57 (2.2441)	25 (.9843)	53.98 (2.125)	31.75 (1.25)	1.78 x 1.13
M 60 x 2	PTCM-60	58.013 (2.284)	67 (2.6378)	27.5 (1.0827)	53.98 (2.125)	38.1 (1.50)	2.25 x 1.22

Port tools are carbide tipped or high-speed steel. Our port tools can be altered to meet special ports. If a standard cannot be altered, a special port tool can be made. Coolant holes can be added in the flutes as an option.

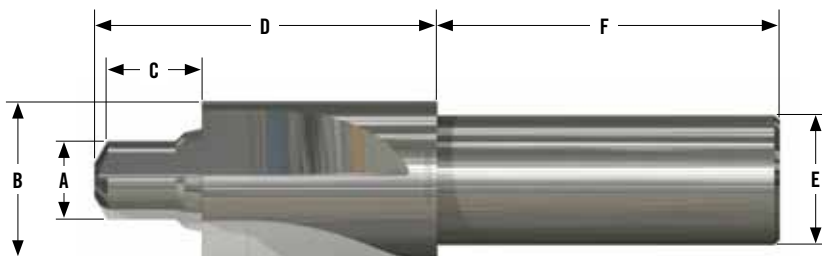
## PORTING TOOLS



### HIGH-SPEED STEEL, STRAIGHT SHANK – STANDARD

### SAE J1926, MS 16142

Thread Size	Tube		Part Number	A Small Diameter	B Spotface Diameter	C Bore Length	D Head Length	E Shank Diameter	F Shank Length	Pre-Drill Diameter/Length
	No.	O.D.								
5/16-24	2	.125	PTHS-0312	.272	.682	.473	1.500	.500	3.125	F x .688
3/8-24	3	.187	PTHS-0375	.335	.760	.473	1.500	.500	3.125	O x .688
7/16-20	4	.250	PTHS-0437	.389	.838	.552	1.500	.500	3.125	U x .812
1/2-20	5	.312	PTHS-0500	.452	.916	.552	1.500	.500	3.125	.44 x .812
9/16-18	6	.375	PTHS-0562	.509	.994	.614	1.500	.500	3.125	.48 x .875
3/4-16	8	.500	PTHS-0750	.689	1.198	.693	1.750	.750	3.875	.67 x .937
7/8-14	10	.625	PTHS-0875	.806	1.354	.786	1.750	.750	3.875	.78 x 1.062
1-1/16-12	12	.750	PTHS-1062	.981	1.635	.911	2.000	.750	3.875	.95 x 1.250
1-3/16-12	14	.875	PTHS-1187	1.106	1.775	.911	2.000	.750	3.875	1.09 x 1.250
1-5/16-12	16	1.000	PTHS-1312	1.231	1.939	.911	2.000	.750	3.875	1.21 x 1.250
1-5/8-12	20	1.250	PTHS-1625	1.544	2.280	.911	2.250	1.000	4.875	1.53 x 1.250
1-7/8-12	24	1.500	PTHS-1875	1.794	2.570	.911	2.250	1.000	4.875	1.78 x 1.250
2-1/2-12	32	2.000	PTHS-2500	2.419	3.490	.911	2.250	1.000	4.875	2.41 x 1.250



### HIGH-SPEED STEEL, STRAIGHT SHANK – METRIC

### ISO 6149-1, SAE J2244/1

Thread Size	Part Number	A Small Diameter	B Spotface Diameter	C Bore Length	D Head Length	E Shank Diameter	Pre-Drill Diameter/Length
M 8 x 1	PTHM-8	7.035 (.277)	14 (.5512)	11.5 (.4528)	41.28 (1.625)	12.7 (.500)	D x .589
M 10 x 1	PTHM-10	9.042 (.356)	16 (.6299)	11.5 (.4528)	41.28 (1.625)	19.05 (.750)	P x .589
M 12 x 1.5	PTHM-12	10.541 (.415)	19 (.748)	14 (.5512)	41.28 (1.625)	19.05 (.750)	W x .681
M 14 x 1.5	PTHM-14	12.522 (.493)	21 (.8268)	14 (.5512)	41.28 (1.625)	19.05 (.750)	.45 x .681
M 16 x 1.5	PTHM-16	14.528 (.572)	24 (.9449)	15.5 (.6102)	47.63 (1.875)	19.05 (.750)	.54 x .740
M 18 x 1.5	PTHM-18	16.535 (.651)	26 (1.0236)	17 (.6693)	47.63 (1.875)	19.05 (.750)	.62 x .809
M 22 x 1.5	PTHM-22	20.523 (.808)	29 (1.1417)	18 (.7087)	47.63 (1.875)	19.05 (.750)	.78 x .849
M 27 x 2	PTHM-27	25.019 (.985)	34 (1.3386)	22 (.8661)	53.98 (2.125)	25.4 (1.00)	.95 x 1.01
M 33 x 2	PTHM-33	31.013 (1.221)	43 (1.6929)	22 (.8661)	53.98 (2.125)	25.4 (1.00)	1.17 x 1.01
M 42 x 2	PTHM-42	40.030 (1.576)	52 (2.0475)	22.5 (.8858)	53.98 (2.125)	31.75 (1.25)	1.54 x 1.03
M 48 x 2	PTHM-48	46.025 (1.812)	57 (2.2441)	25 (.9843)	53.98 (2.125)	31.75 (1.25)	1.78 x 1.13
M 60 x 2	PTHM-60	58.013 (2.284)	67 (2.6378)	27.5 (1.0827)	53.98 (2.125)	38.1 (1.50)	2.25 x 1.22

# End Mills

**Proto-Cutter Tough Cut End Mills have an eccentric grind excellent for tough-to-machine materials and hardened steel.**

They are TiCN coated for maximum wear resistance with staggered, serrated edges to break chips and allow for finish applications, outperforming conventional rougher/finisher end mills.

## TOUGH CUT END MILLS

Part Number	Flute Diameter	Length of Cut	Shank Diameter	Overall Length
ACEM-4250	1/4	3/4	1/4	2 1/2
ACEM-4313	5/16	7/8	5/16	2 1/2
ACEM-4375	3/8	7/8	3/8	2 1/2
ACEM-4500	1/2	1	1/2	3
ACEM-4625	5/8	1 1/4	5/8	3 1/2
ACEM-4750	3/4	1 1/2	3/4	4
ACEM-4100	1	1 1/2	1	4





## SOLID CARBIDE END MILLS – SQUARE NOSE

2 Flute	4 Flute	Flute Diameter	Length of Cut	Shank Diameter	Overall Length
CEMS2125	CEMS4125	1/8	1/2	1/8	1 1/2
CEMS2156	CEMS4156	5/32	9/16	3/16	2
CEMS2188	CEMS4188	3/16	5/8	3/16	2
CEMS2218	CEMS4218	7/32	5/8	1/4	2 1/2
CEMS2250	CEMS4250	1/4	3/4	1/4	2 1/2
CEMS2281	CEMS4281	9/32	7/8	5/16	2 1/2
CEMS2312	CEMS4312	5/16	7/8	5/16	2 1/2
CEMS2343	CEMS4343	11/32	7/8	3/8	2 1/2
CEMS2375	CEMS4375	3/8	7/8	3/8	2 1/2
CEMS2406	CEMS4406	13/32	7/8	7/16	2 1/2
CEMS2437	CEMS4437	7/16	1	7/16	2 1/2
CEMS2468	CEMS4468	15/32	1	1/2	3
CEMS2500	CEMS4500	1/2	1	1/2	3
CEMS2562	CEMS4562	9/16	1 1/4	9/16	3 1/2
CEMS2625	CEMS4625	5/8	1 1/4	5/8	3 1/2
CEMS2750	CEMS4750	3/4	1 1/2	3/4	4
CEMS2875	CEMS4875	7/8	1 1/2	7/8	4
CEMS2100	CEMS4100	1	1 1/2	1	4



## SOLID CARBIDE END MILLS – BALL NOSE

2 Flute	4 Flute	Flute Diameter	Length of Cut	Shank Diameter	Overall Length
CEMB2125	CEMB4125	1/8	1/2	1/8	1 1/2
CEMB2156	CEMB4156	5/32	9/16	3/16	2
CEMB2188	CEMB4188	3/16	5/8	3/16	2
CEMB2218	CEMB4218	7/32	5/8	1/4	2 1/2
CEMB2250	CEMB4250	1/4	3/4	1/4	2 1/2
CEMB2281	CEMB4281	9/32	7/8	5/16	2 1/2
CEMB2312	CEMB4312	5/16	7/8	5/16	2 1/2
CEMB2343	CEMB4343	11/32	7/8	3/8	2 1/2
CEMB2375	CEMB4375	3/8	7/8	3/8	2 1/2
CEMB2406	CEMB4406	13/32	7/8	7/16	2 1/2
CEMB2437	CEMB4437	7/16	1	7/16	2 1/2
CEMB2468	CEMB4468	15/32	1	1/2	3
CEMB2500	CEMB4500	1/2	1	1/2	3
CEMB2562	CEMB4562	9/16	1 1/4	9/16	3 1/2
CEMB2625	CEMB4625	5/8	1 1/4	5/8	3 1/2
CEMB2750	CEMB4750	3/4	1 1/2	3/4	4
CEMB2875	CEMB4875	7/8	1 1/2	7/8	4
CEMB2100	CEMB4100	1	1 1/2	1	4



## Resharpener Services

Proto-Cutter has full in-house resharpener services using state-of-the-art CNC sharpeners. We specialize in solid carbide or HSS reamers, end mills, drills and milling cutters.

# Custom Tooling

All Proto-Cutter custom tools can be made from carbide or high-speed steel and can be coolant fed. We can make custom tooling from your tool print or part print. Material is kept in inventory for occasions when rush service is required.



## CUSTOM CHUCKING & PIN-FLOAT REAMERS

Chucking and pin-float coolant-fed reamers can be used on all materials. Our custom pin-float reamers are like our standard reamers, but can be made longer or shorter. Chucking reamers are a cost-effective way to finish a hole. Lead angles on our reamers can be made with specific angles, which are important for micro finishes and sizing. Reamers can be made left-hand helix for through holes (coolant holes in the flutes) or right-hand helix for blind holes (coolant hole through the center of the tool).



## CUSTOM STEP REAMERS

Step reamers are good for multiple hole sizing and chamfering all in one step. Reamers can be made left-hand helix for through holes (coolant holes in the flutes) or right-hand helix for blind holes (coolant hole through the center of the tool).



## CUSTOM FORM TOOLS

Form tools are used for producing radii and other geometric forms on the O.D. or I.D. of a part.



## CUSTOM DOUBLE MARGIN DRILLS

Double margin drills are used for tight hole tolerances and stability when cutting non-ferrous materials and irons.



## CUSTOM PORTING TOOLS

Porting tools can be made for SAE, metric, MS ports and cartridge valves with straight or Morse tapered shanks. Porting tools can be made profile sharpened or cam relieved.



## CUSTOM KEY CUTTERS

Key cutters are good for plunging, slotting or making an internal groove in a part. Key cutters can be made with corner chamfer/radii.



## CUSTOM PROFILE CUTTERS

Profile cutters are used for profiling areas where many tangential positions must be met; for example, turbine roots and blades.



## CUSTOM END MILLS

End mills can be used for all materials. End mills can be made to circle interpolate (multitask) where one or many diameters must be produced and with serrations for roughing and chamfer/radii.



## CUSTOM STEP DRILLS

Step drills work well for roughing out multiple holes.



## CUSTOM SAWS & MILLING CUTTERS

Custom saws and milling cutters are good for use on all materials and are used for slotting, circle interpolating and grooving. They can be made with corner chamfer/radii and with equally or unequally spaced flutes (reduced harmonic chatter).



## CUSTOM TAPERED & RADIUS TOOLING

Tapered and radius tools produce radii and other geometric forms in and on the outside of a part. Tooling includes reamers, end mills and spherical cutters.



## SPOT WELD DRILLS

**Designed by Proto-Cutter for the automotive industry** with special drill point geometry to more easily remove spot welds and prevent walking better than conventional spot weld drills. No pilot hole needed.

- Speed: 600-670 rpm
- 850 rpm maximum

# Feed Rates

## RECOMMENDATIONS AND CONVERSIONS



### Recommended material for REAMING

Hole Diameter	Material Left (Diameter)
.090-.170	.005-.010
.171-.280	.008-.012
.281-.880	.010-.016
.881-2.50	.015-.030

### Metric-to-Standard Conversion Formula (millimeters to inches)

$$\text{mm} \div 25.4 = \text{inches}$$

Example:

$$12.70 \text{ mm} \div 25.4 = .500 \text{ inches}$$

### Calculating Revolutions Per Minute (RPM) from Surface Footage (SFPM) Diameter

$$\frac{12 \times \text{SFPM}}{\pi \times \text{diameter}} = \text{RPM}$$

### Speeds and Feeds

.002 - .003 per flute per revolution

.0025 x number of flutes = inches per revolution (IPR)

.0025 x number of flutes x RPM = inches per minute (IPM)



### Feeds for DRILLING

Feeds	Diameter
.001-.003 IPR	.1250 or less
.002-.006 IPR	.1250-.250
.004-.010 IPR	.250-.500
.007-.015 IPR	.500-1.00
.010-.025 IPR	1.00 and up

## RECOMMENDED CUTTING SPEEDS IN FEET PER MINUTE FOR DRILLING AND REAMING FERROUS CAST METALS

Material Ferrous Cast Metals	Hardness, HB*	Material Condition*	Cutting Speed, fpm		
			Drilling	Reaming	
			HSS	HSS	Carbide
<b>GRAY CAST IRON</b>					
ASTM Class 20	120-150	A	100	65	300
ASTM Class 25	160-200	AC	90	60	225
ASTM Class 30, 35, and 40	190-220	AC	80	55	180
ASTM Class 45 and 50	220-260	AC	60	40	125
ASTM Class 55 and 60	250-320	AC, HT	30	20	80
ASTM Type 1, 1b, 5 (Ni-Resist)	100-215	AC	50	30	150
ASTM Type 2, 3, 6 (Ni-Resist)	120-175	AC	40	25	140
ASTM Type 2b, 4 (Ni-Resist)	150-250	AC	30	20	125
<b>MALLEABLE IRON</b>					
Ferritic 32510, 35018	110-160	MHT	110	75	325
Pearlitic 40010, 43010, 45006, 45008, 48005, 50005	160-200 200-240	MHT MHT	80 70	55 45	250 180
Martensitic 53004, 60003, 60004	200-255	MHT	55	35	160
Martensitic 70002, 70003	220-260	MHT	50	30	150
Martensitic 80002	240-280	MHT	45	30	100
Martensitic 90001	250-320	MHT	25	15	80
<b>NODULAR (DUCTILE) IRON</b>					
Ferritic 60-40-18, 65-45-12	140-190	A	100	65	300
Ferritic-Pearlitic 80-55-06	190-225 225-260	AC AC	70 50	45 30	225 140
Pearlitic-Martensitic 100-70-03	240-300	HT	40	25	115
Martensitic 120-90-02	270-330 330-400	HT HT	25 10	15 5	65 30
<b>CAST STEELS</b>					
Low Carbon 1010, 1020	100-150 125-175	AC, A, N AC, A, N	100 90	65 60	250 240
Medium Carbon 1030, 1040, 1050	175-225 225-300	AC, A, N AC, HT	70 55	45 35	220 200
Low Carbon Alloy 1320, 2315, 2320, 4110, 4120, 4320, 8020, 8620	150-200 200-250 250-300	AC, A, N AC, A, N AC, HT	75 65 50	50 40 30	220 200 150
Medium Carbon Alloy 1330, 1340, 2325, 2330, 4125, 4130, 4140, 4330, 4340, 80B30, 8040, 8430, 8440, 8630, 8640, 9525, 9530, 9535	175-225 225-250 250-300 300-350 350-400	AC, A, N AC, A, N AC, HT AC, HT HT	70 60 45 30 20	45 35 30 20 10	200 180 150 140 100

\*Abbreviations designate: A, annealed; AC, as cast; N, normalized; HT, heat treated; MHT, Malleablizing heat treatment; and HB, Brinell hardness number.

## RECOMMENDED CUTTING SPEEDS IN FEET PER MINUTE FOR DRILLING AND REAMING LIGHT METALS

Material Light Metals	Material Condition*	Cutting Speed, fpm		
		Drilling	Reaming	
		HSS	HSS	Carbide
All Wrought Aluminum Alloys	CD	400	400	800
	ST and A	350	350	750
All Aluminum Sand and Permanent Mold Casting Alloys	AC	500	500	900
	ST and A	350	350	750
All Aluminum Die Casting Alloys	AC	300	300	500
	ST and A	70	70	200
<i>Except Alloys 390.0 and 392.0</i>	AC	125	100	250
	ST and A	45	40	200
All Wrought Magnesium Alloys	A, CD, ST and A	500	500	1000
All Cast Magnesium Alloys	A, CD, ST and A	450	450	1000

\*Abbreviations designate: A, annealed; AC, as cast; CD, cold drawn; and ST and A, solution treated and aged.



# Feed Rates

## RECOMMENDATIONS AND CONVERSIONS



### Recommended material for REAMING

Hole Diameter	Material Left (Diameter)
.090-.170	.005-.010
.171-.280	.008-.012
.281-.880	.010-.016
.881-2.50	.015-.030

### Metric-to-Standard Conversion Formula (millimeters to inches)

$$\text{mm} \div 25.4 = \text{inches}$$

Example:

$$12.70 \text{ mm} \div 25.4 = .500 \text{ inches}$$

### Calculating Revolutions Per Minute (RPM) from Surface Footage (SFPM) Diameter

$$\frac{12 \times \text{SFPM}}{\pi \times \text{diameter}} = \text{RPM}$$

### Speeds and Feeds

.002 - .003 per flute per revolution

.0025 x number of flutes = inches per revolution (IPR)

.0025 x number of flutes x RPM = inches per minute (IPM)



### Feeds for DRILLING

Feeds	Diameter
.001-.003 IPR	.1250 or less
.002-.006 IPR	.1250-.250
.004-.010 IPR	.250-.500
.007-.015 IPR	.500-1.00
.010-.025 IPR	1.00 and up

# RECOMMENDED CUTTING SPEEDS IN FEET PER MINUTE FOR DRILLING AND REAMING PLAIN CARBON AND ALLOY STEELS

Material AISI and SAE Steels	Hardness, HB*	Material Condition*	Cutting Speed, fpm		
			Drilling	Reaming	
			HSS	HSS	Carbide
<b>FREE MACHINING PLAIN CARBON STEELS (RESULPHURIZED)</b>					
1212, 1213, 1214	100-150	HR,A	120	80	400
	150-200	CD	125	80	350
1108, 1109, 1115, 1117, 1118, 1120, 1126, 1211	100-150	HR,A	110	75	375
	150-200	CD	120	80	350
	175-225	HR, A, N, CD	100	65	350
1132, 1137, 1139, 1140, 1144, 1146, 1151	275-325	Q and T	70	45	250
	325-375	Q and T	45	30	175
	375-425	Q and T	35	20	100
<b>FREE MACHINING PLAIN CARBON STEELS (LEADED)</b>					
11L17, 11L18, 12L13, 12L14	100-150	HR, A, N, CD	130	85	400
	150-200	HR, A, N, CD	120	80	375
	200-250	N, CD	90	60	275
<b>PLAIN CARBON STEELS</b>					
1006, 1008, 1009, 1010, 1012, 1015, 1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1513, 1514	100-125	HR, A, N, CD	100	65	300
	125-175	HR, A, N, CD	90	60	275
	175-225	HR, N, CD	70	45	200
	225-275	CD	60	40	175
	125-175	HR, A, N, CD	90	60	250
1027, 1030, 1033, 1035, 1036, 1037, 1038, 1039, 1040, 1041, 1042, 1043, 1045, 1046, 1048, 1049, 1050, 1052, 1524, 1526, 1527, 1541	175-225	HR, A, N, CD	75	50	200
	225-275	N, CD, Q and T	60	40	150
	275-325	Q and T	50	30	120
	325-375	Q and T	35	20	100
	375-425	Q and T	25	15	80
	125-175	HR, A, N, CD	85	55	250
1055, 1060, 1064, 1065, 1070, 1074, 1078, 1080, 1084, 1086, 1090, 1095, 1548, 1551, 1552, 1561, 1566	175-225	HR, A, N, CD	70	45	200
	225-275	N, CD, Q and T	50	30	140
	275-325	Q and T	40	25	110
	325-375	Q and T	30	20	90
	375-425	Q and T	15	10	70
<b>FREE MACHINING ALLOY STEELS (RESULPHURIZED)</b>					
4140, 4150	175-200	HR, A, N, CD	90	60	250
	200-250	HR, N, CD	80	50	225
	250-300	Q and T	55	30	200
	300-375	Q and T	40	25	150
	375-425	Q and T	30	15	100
<b>FREE MACHINING ALLOY STEELS (LEADED)</b>					
41L30, 41L40, 41L47, 41L50, 43L47, 51L32, 52L100, 86L20, 86L40	150-200	HR, A, N, CD	100	65	285
	200-250	HR, N, CD	90	60	250
	250-300	Q and T	65	40	200
	300-375	Q and T	45	30	150
	375-425	Q and T	30	15	110
<b>ALLOY STEELS</b>					
4012, 4023, 4024, 4028, 4118, 4120, 4419, 4422, 4427, 4615, 4620, 4621, 4626, 4718, 4720, 4815, 4817, 4820, 5015, 5017, 5020, 6118, 8115, 8615, 8617, 8620, 8622, 8625, 8627, 8620, 8822, 94B17	125-175	HR, A, N, CD	85	55	250
	175-225	HR, N, CD	70	45	225
	225-275	CD, N, Q and T	55	35	200
	275-325	Q and T	50	30	150
	325-375	Q and T	35	25	125
	375-425	Q and T	25	15	90
1330, 1335, 1340, 1345, 4032, 4037, 4042, 4047, 4130, 4135, 4137, 4140, 4142, 4145, 4147, 4150, 4160, 4337, 4340, 50B44, 50B46, 50B50, 50B60, 5130, 5132, 5140, 5145, 5147, 5150, 5160, 51B60, 6150, 81B45, 8630, 8635, 8637, 8640, 8642, 8645, 8650, 8655, 8660, 8740, 9254, 9255, 9260, 9262, 94B30	175-225	HR, A, N, CD	75	50	200
	225-275	N, CD, Q and T	60	40	175
	275-325	N, Q and T	45	30	150
	325-375	N, Q and T	30	15	100
	375-425	Q and T	20	15	80
E51100, E52100	175-225	HR, A, CD	60	40	200
	225-275	N, CD, Q and T	50	30	125
	275-325	N, Q and T	35	25	100
	325-375	N, Q and T	30	20	80
	375-425	Q and T	20	10	50
<b>ULTRA HIGH STRENGTH STEELS (NOT AISI)</b>					
AMS6424, AMS6421 (98B37 Mod.), AMS6422 (98BV40), AMS6427, AMS6428, AMS6430, AMS6432, AMS6433, AMS6434, AMS6436, AMS6442, 300M, D6ac	220-300	A	50	30	180
	300-350	N	35	20	125
	350-400	N	20	10	90
<b>MARAGING STEELS (NOT AISI)</b>					
18% Nickel Grade 200, 18% Nickel Grade 250, 18% Nickel Grade 300, 18% Nickel Grade 350	250-225	A	50	30	175
<b>NITRIDING STEELS</b>					
Nitralloy 125, Nitralloy 135, Nitralloy 135 (Mod.), Nitralloy 225, Nitralloy 230, Nitralloy N, Nitralloy EZ, Nitralloy I	200-250	A	60	40	175
	250-300	N, Q and T	35	20	125

\*Abbreviations designate: A, annealed; HR, hot rolled; CD, cold drawn; N, normalized; Q and T, quenched and tempered; and HB, Brinell hardness number.

# Feed Rates

## RECOMMENDATIONS AND CONVERSIONS



### Recommended material for REAMING

Hole Diameter	Material Left (Diameter)
.090-.170	.005-.010
.171-.280	.008-.012
.281-.880	.010-.016
.881-2.50	.015-.030

### Metric-to-Standard Conversion Formula (millimeters to inches)

$$\text{mm} \div 25.4 = \text{inches}$$

Example:

$$12.70 \text{ mm} \div 25.4 = .500 \text{ inches}$$

### Calculating Revolutions Per Minute (RPM) from Surface Footage (SFPM) Diameter

$$\frac{12 \times \text{SFPM}}{\pi \times \text{diameter}} = \text{RPM}$$

### Speeds and Feeds

.002 - .003 per flute per revolution

.0025 x number of flutes = inches per revolution (IPR)

.0025 x number of flutes x RPM = inches per minute (IPM)



### Feeds for DRILLING

Feeds	Diameter
.001-.003 IPR	.1250 or less
.002-.006 IPR	.1250-.250
.004-.010 IPR	.250-.500
.007-.015 IPR	.500-1.00
.010-.025 IPR	1.00 and up

## RECOMMENDED CUTTING SPEEDS IN FEET PER MINUTE FOR DRILLING AND REAMING TOOL STEELS

Material Tool Steels	Hardness, HB*	Material Condition*	Cutting Speed, fpm		
			Drilling	Reaming	
			HSS	HSS	Carbide
<b>WATER HARDENING</b>					
W1, W2, W5	150-209	A	85	55	200
<b>SHOCK RESISTING</b>					
S1, S2, S5, S6, S7	175-225	A	50	35	175
<b>COLD WORK, OIL HARDENING</b>					
O1, O2, O6, O7	175-225	A	45	30	150
<b>COLD WORK, HIGH CARBON HIGH</b>					
Chromium, D2, D3, D4, D5, D7	200-250	A	30	20	80
<b>COLD WORK, AIR HARDENING</b>					
A2, A3, A8, A9, A10	210-250	A	50	35	150
A4, A6	200-250	A	45	30	125
A7	225-275	A	30	20	100
<b>HOT WORK, CHROMIUM TYPE</b>					
H10, H11, H12, H13, H14, H19	150-200	A	60	40	200
	200-250	A	50	30	150
	325-375	Q and T	30	20	100
<b>HOT WORK, TUNGSTEN TYPE</b>					
H21, H22, H23, H24, H25, H26	150-200	A	55	35	150
	200-250	A	40	25	125
<b>HOT WORK, MOLYBDENUM TYPE</b>					
H41, H42, H43	150-200	A	45	30	150
	200-250	A	35	20	125
<b>SPECIAL PURPOSE, LOW ALLOY</b>					
L2, L3, L6	150-200	A	60	40	200
<b>MOLD</b>					
P2, P3, P4, P5, P6	100-150	A	75	50	225
	150-200	A	60	40	200
<b>HIGH-SPEED STEEL</b>					
M1, M2, M6, M10, T1, T2, T6	200-250	A	45	30	150
	M3-1, M4, M7, M30, M33, M34, M36, M41, M42, M43, M44, M46, M47, T5, T8	225-275	A	35	20
225-275		A	25	15	80

\*Abbreviations designate: A, annealed; Q and T, quenched and tempered; and HB, Brinell hardness number.

## RECOMMENDED CUTTING SPEEDS IN FEET PER MINUTE FOR DRILLING AND REAMING STAINLESS STEELS

Material Stainless Steels	Hardness, HB*	Material Condition*	Cutting Speed, fpm		
			Drilling	Reaming	
			HSS	HSS	Carbide
<b>FREE MACHINING STAINLESS STEEL</b>					
Ferritic 430F, 430F Se	135-185	A	90	60	250
Austenitic 203EZ, 303, 303 Se, 303 MA, 303 Pb, 303 Cu, 303 Plus X	135-185	A	85	55	225
	225-275	CD	70	45	200
Martensitic 416, 416 Se, 416 Plus X, 420F, 420F Se, 440F, 440F Se	135-185	A	90	60	250
	185-240	CD	70	45	200
	275-325	Q and T	40	25	150
	375-425	Q and T	20	10	80
<b>STAINLESS STEELS</b>					
Ferritic 405, 409, 429, 430, 434, 436, 442, 445, 502	135-185	A	65	45	200
Austenitic 201, 202, 301, 302, 304, 304L, 305, 308, 321, 347, 348	135-185	A	55	35	150
	225-275	CD	50	30	125
Austenitic 302B, 309, 309S, 310, 310S, 314, 316, 316L, 317, 330	135-185	A	50	30	150
	135-175	A	75	50	225
Martensitic 403, 410, 420, 501	175-225	A	65	45	200
	275-325	Q and T	40	25	125
	375-425	Q and T	25	15	80
	225-275	A	50	30	150
Martensitic 414, 431 Greek Ascoloy	275-325	Q and T	40	25	125
	375-425	Q and T	25	15	80
	225-275	A	45	30	125
Martensitic, 440A, 440B, 440C	275-325	Q and T	40	25	100
	375-425	Q and T	20	10	75
	150-200	A	50	30	150
Precipitation Hardening 15-5PH, 17-4PH, 17-7PH, 17-14Cu Mo, AF-71, AFC-77, AM-350, AM-355, AM-362, Custom 455, HNM, PH13-8, PH14-8Mo, PH15-7Mo, Stainless W	275-325	H	45	25	125
	325-375	H	35	20	75
	375-425	H	20	10	50

\*Abbreviations designate: A, annealed; CD, cold drawn; Q and T, quenched and tempered; H, precipitation hardened; and HB, Brinell hardness number.

# Feed Rates

## RECOMMENDATIONS AND CONVERSIONS



### Recommended material for REAMING

Hole Diameter	Material Left (Diameter)
.090-.170	.005-.010
.171-.280	.008-.012
.281-.880	.010-.016
.881-2.50	.015-.030

### Metric-to-Standard Conversion Formula (millimeters to inches)

$$\text{mm} \div 25.4 = \text{inches}$$

Example:

$$12.70 \text{ mm} \div 25.4 = .500 \text{ inches}$$

### Calculating Revolutions Per Minute (RPM) from Surface Footage (SFPM) Diameter

$$\frac{12 \times \text{SFPM}}{\pi \times \text{diameter}} = \text{RPM}$$

### Speeds and Feeds

.002 - .003 per flute per revolution

.0025 x number of flutes = inches per revolution (IPR)

.0025 x number of flutes x RPM = inches per minute (IPM)



### Feeds for DRILLING

Feeds	Diameter
.001-.003 IPR	.1250 or less
.002-.006 IPR	.1250-.250
.004-.010 IPR	.250-.500
.007-.015 IPR	.500-1.00
.010-.025 IPR	1.00 and up

# RECOMMENDED CUTTING SPEEDS IN FEET PER MINUTE FOR DRILLING AND REAMING COPPER ALLOYS

Material Copper Alloys (Copper Alloy Nos. as per the Copper Development Assn. Inc.)	Material Condition*	Cutting Speed, fpm		
		Drilling	Reaming	
		HSS	HSS	Carbide
314 Leaded Commercial Bronze	A CD	160 175	160 175	320 360
332 High Leaded Brass				
340 Medium Leaded Brass				
342 High Leaded Brass				
353 High Leaded Brass				
356 Extra High Leaded Brass				
360 Free Cutting Brass				
370 Free Cutting Muntz Metal				
377 Forging Brass				
385 Architectural Bronze				
485 Leaded Naval Brass	A CD	120 140	110 120	250 275
544 Free Cutting Phosphor Bronze				
226 Jewelry Bronze				
230 Red Brass				
240 Low Brass				
260 Cartridge Brass 70%				
268 Yellow Brass				
280 Muntz Metal				
335 Low Leaded Brass				
365 Leaded Muntz Metal				
368 Leaded Muntz Metal	A CD	60 65	50 60	180 200
443 Admiralty Brass (inhibited)				
445 Admiralty Brass (inhibited)				
651 Low Silicon Bronze				
655 High Silicon Bronze				
675 Manganese Bronze				
687 Aluminum Brass				
770 Nickel Silver				
796 Leaded Nickel Silver				
102 Oxygen Free Copper				
110 Electrolytic Tough Pitch Copper				
122 Phosphorus Deoxidized Copper				
170 Beryllium Copper				
172 Beryllium Copper				
175 Beryllium Copper				
210 Guilding 95%				
220 Commercial Bronze				
502 Phosphor Bronze 1.25%				
510 Phosphor Bronze 5%				
521 Phosphor Bronze 8%				
524 Phosphor Bronze 10%				
614 Aluminum Bronze				
706 Copper Nickel 10%				
715 Copper Nickel 30%				
745 Nickel Silver				
752 Nickel Silver				
754 Nickel Silver				
757 Nickel Silver				

\*Abbreviations designate: A, annealed; CD, cold drawn

## SPEEDS AND FEEDS FOR CARBIDE END MILLS

Material	SFM	1/8	1/4	1/2	3/4	1
Aluminum/Aluminum Alloy	400-1200	.005	.0020	.0040	.0060	.0080
Brass/Bronze	250-500	.0010	.0020	.0030	.0040	.0050
Plastics	500-1500	.0015	.0030	.0060	.0100	.0120
Cast/Malleable Iron	100-500	.0005	.0010	.0030	.0050	.0070
Nickel Alloys	50-150	.0005	.008	.0010	.0013	.0020
Monel	100-200	.0005	.0010	.0015	.0030	.0040
Leaded Steels	150-400	.0005	.0013	.0030	.0040	.0065
Hardened Steels	25-100	.0002	.0005	.0010	.0020	.0030
Tool Steels	30-150	.0002	.0008	.0015	.0020	.0030
Ductile Iron	100-375	.0005	.0010	.0020	.0030	.0050
Stainless Steels up to 40 Rc	200-400	.0005	.0010	.0030	.0040	.0060
Stainless Steels 40 Rc & Up	50-250	.0003	.0005	.0012	.0030	.0050
Low Carbon Steels	150-400	.0005	.0010	.0030	.0045	.0065
Medium Carbon Steels	125-300	.0005	.0010	.0020	.0040	.0050
Titanium (soft)	100-400	.0004	.0010	.0020	.0030	.0050
Titanium (hard)	50-150	.0003	.0005	.0010	.0020	.0035

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