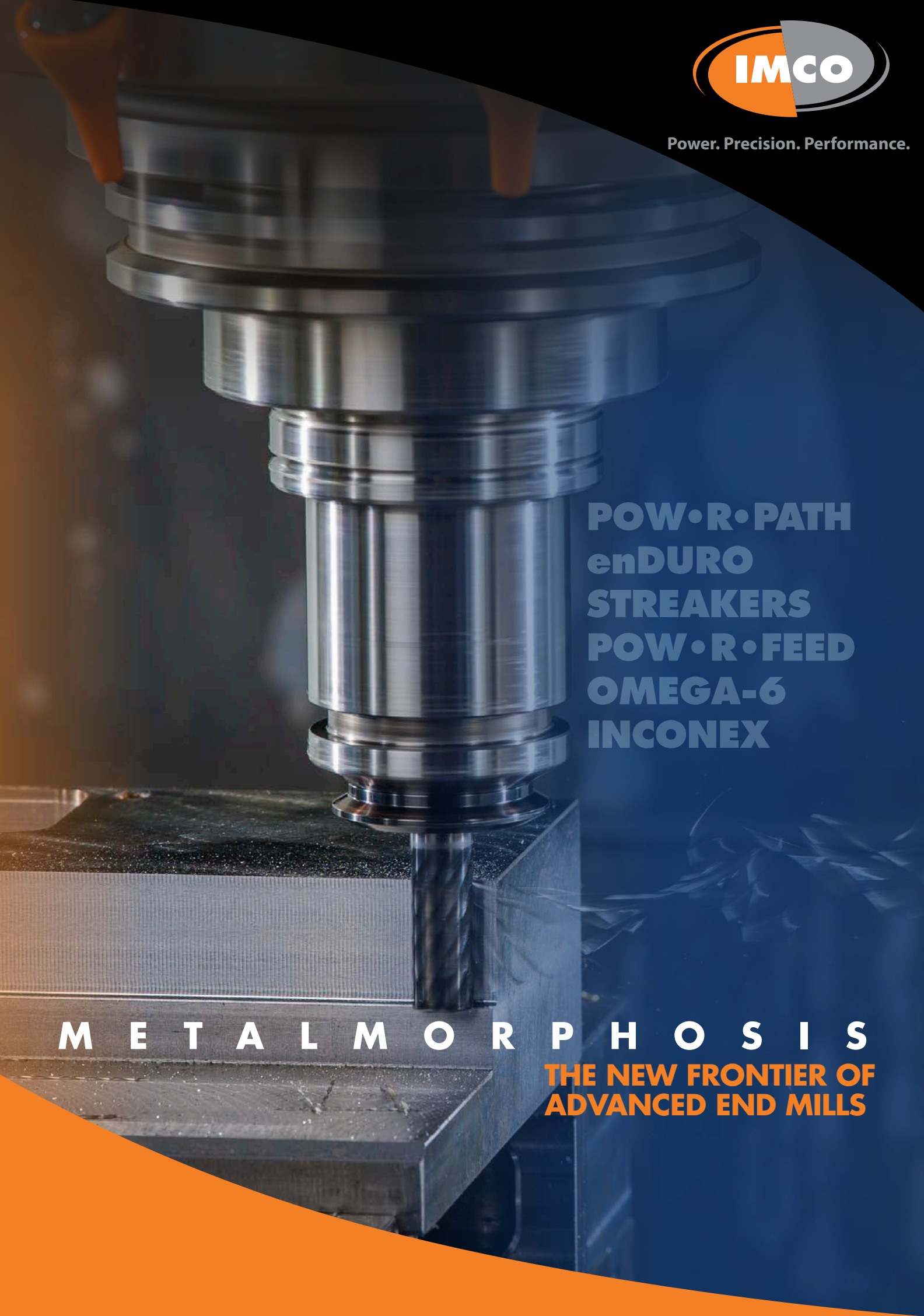
IMCO

Power. Precision. Performance.



POW•R•PATH
enDURO
STREAKERS
POW•R•FEED
OMEGA-6
INCONEX

METALMORPHOSIS

THE NEW FRONTIER OF ADVANCED END MILLS

METALMORPHOSIS

THE NEW FRONTIER OF ADVANCED END MILLS.

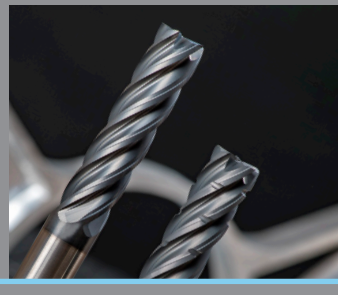
The tools in this catalogue are made for a new age in metalworking, unique designs that run smarter, smoother and with incredible precision. Every innovation in each end mill series is the result of IMCO's advanced technology and our continuous drive for greater productivity. And the changes keep coming.

We're pushing boundaries and exploring technology to its outer edges. This is the new frontier, and the new age in metalworking — a metalmorphosis — is just ahead.

What's new?

INTRODUCING AP5

Our new AP5 POW•R•PATH series end mills bring the benefits of HEM tool paths to machining aluminum. The advanced design plus taC coating means these tools are built for speed.



INTRODUCING M223/M233

Introducing new designs in the M2 STREAKERS series end mills that cover the spectrum for machining aluminum — new grinds for better surface finishes and a new line of roughing end mills for better chip control. Both styles offered with ZrN coating for maximum tool life.

UPDATE TO THE IP PRODUCT LINE

Take metal removal rates to a higher level with the new IP11 and IP13 POW•R•PATH end mills for HEM tool paths in ferrous materials and hi-temp alloys. More flutes on our advanced tool design for higher feed rates and longer tool life.

ABOUT IMCO

Strategic cutting solutions for 21st-century machining.

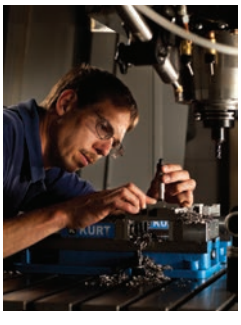
Since 1977 IMCO Carbide Tool Inc. has been an industry leader in the world of solid carbide tooling. Based in the Midwestern region of the United States, IMCO develops cutting edge products for the aerospace, automotive, medical, and energy generation industries. IMCO tools are built on a foundation of innovation and consistency which drives the design, development, and manufacturing decisions that go into our products.

Substrates

IMCO uses only premium grades of carbide materials in all of our end mills – both the high performance and general purpose series – for high quality and repeatable performance.

Coatings

IMCO chooses the most advanced coatings for each end mill design by matching the hardness, heat resistance, and lubricity of the coating with the intended application of the tools.



Design

IMCO develops unique end mill geometries through both our own extensive in house research and development and field testing in the most demanding applications. The results are tools made specifically for maximizing output in a broad range of materials and applications.

This catalogue is an overview of our 'best in class' solutions for milling. Each high performance model is a tested and proven solution for today's increasingly tougher machining challenges. They are products of our hands-on machining expertise, advanced technology, and an entrepreneurial approach to problem solving.

IMCO's High-Performance End Mill Families

DRIVEN TO MEET YOUR CUTTING TOOL NEEDS.

It's not just what you're machining, it's how you're machining it.

The team at IMCO helps our customers meet those demands and turn them into opportunities. Our innovative designs create families of tools made to maximize performance in a wide range of materials by utilizing high quality substrates, coatings, and grinds. In house development and testing with both traditional and high-efficiency CAM tool paths ensure that all IMCO tools excel in a wide variety of applications.

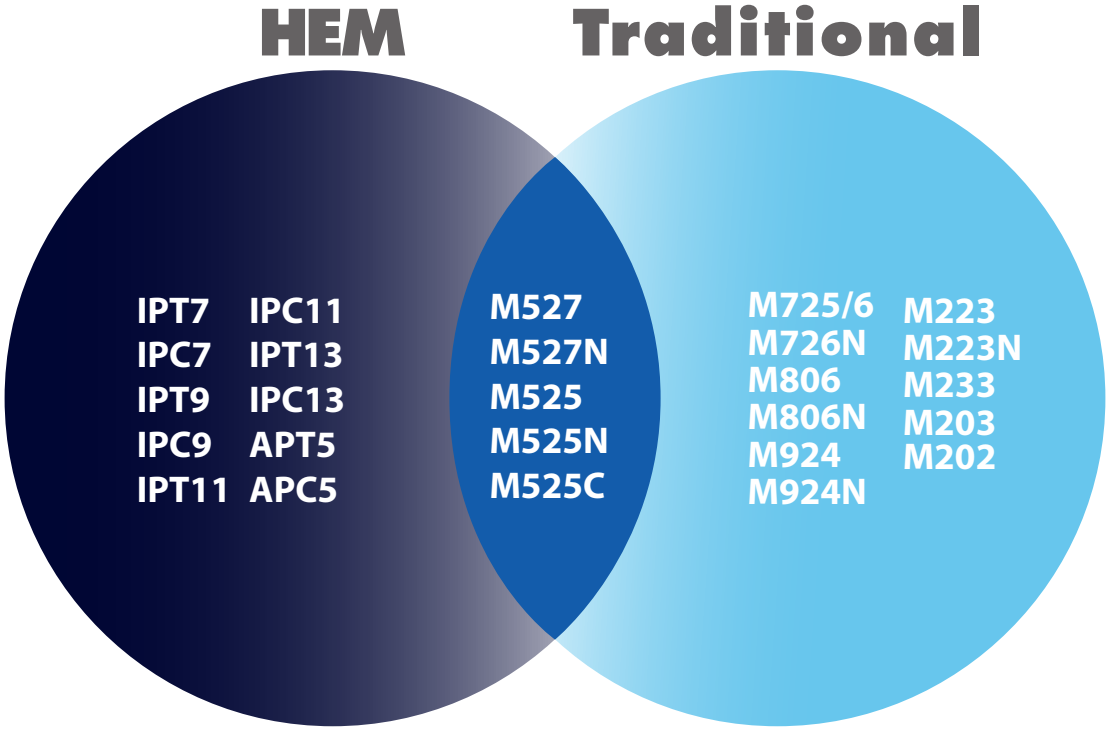
IMCO has an entire family of tools dedicated to milling using High Efficiency Machining (HEM). HEM, also called trochoidal milling, utilizes light radial tool engagements and elliptical tool paths to reduce cutting pressure and maximize tool output. IMCO's POW•R•PATH line of end mills includes 5, 7, 9, 11, and 13-flute end mills to mill everything from aluminium to hi-temp alloys.

IMCO also offers many high-performance end mill styles for maximum tool performance in a variety of materials using traditional tool paths.

Bridging the gap between HEM and traditional machining techniques is the enDURO line of end mills that offer maximum flexibility in tool choice.

Find more detailed info on HEM on pages 8 and 9 and in our tool selection on pages 10 and 11.

Use the following graph to determine the proper end mill series that will work best for your machining applications.



PICTORIAL INDEX

POW•R•PATH

enDURO

OMEGA-6

INCONEX

POW • R • FEED

STREAKERS

Information on tips and adjustments for the following milling operations can be found in our Technical Resources section.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

WWW.IMCOUSA.COM

Don't see what you need here? Check out our website at www.imcousa.com.

User-focused navigation – Start with machining type then you choose how you want to look further – by tool family, by application or by end type, whatever works best for you.

Complete tool info – Dimensions and drawings, flutes, coatings, end cuts, sizes ... everything you need to know. Downloadable catalogues, too.

Real-time data for distributors – Password-protected access 24/7 for secure online ordering, real-time inventory checks, order tracking and more. With 24/7 access to real-time information, you can respond to customer needs on the spot, anytime. When priorities shift from minute to minute, **speed and flexibility** are game changers.

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@IMCO Carbide Tool

Follow us on Instagram
@imcousa

HIGH-EFFICIENCY MACHINING

Choose the right tool for your job.

Deciding which end mill to use in an application now goes beyond matching the end mill to the material. The programming style – high-efficiency machining or traditional – plays a key role in determining which tool will decrease cycle time and maximize tool life.

Our tool selection charts on pages 10-11 can help you pick the best tool for the material and the programming you use. Detailed speed, feed and tool engagement information can be found at the end of each product section.

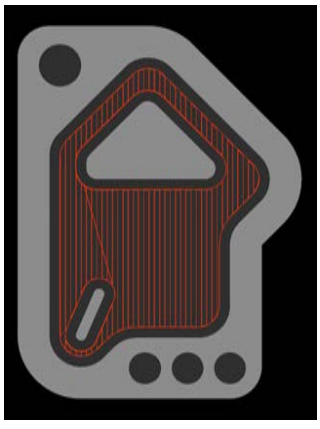
HEM vs. Traditional: Which is best?

HEM Tool Path

High-Efficiency Machining (HEM), also known as trochoidal tool paths, can greatly reduce the cycle time of a job AND improve tool life. HEM uses advanced tool paths that maintain consistent pressure on cutting tools and the machine spindle. Common characteristics of these tool paths are:

- Light radial cuts (step-overs)
- Deep axial cuts
- Elliptical tool paths when slotting and pocketing

Traditional tool paths use straight-line moves that generate heavy tool engagement, intense pressure in the corners, and the potential for the tool to break. That means the machine "looks ahead" and slows down the tool or requires programming speeds and feeds that allow the end mill to survive sharp turns.



Traditional Tool Path

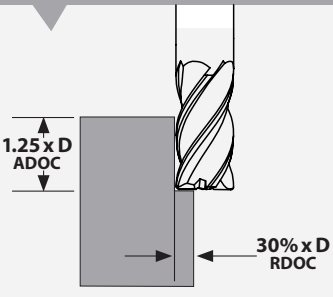
With HEM, the potential for reduced costs through faster cycle times and increased tool life is *huge.*

See example in sidebar at right:

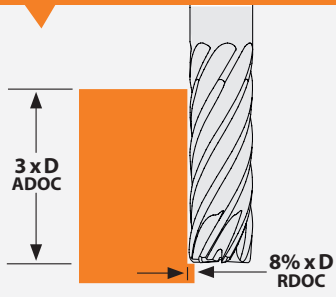
MACHINING 316 STAINLESS STEEL

Must remove 3.6 mm from a wall 36 mm tall.

Traditional method using IMCO M924 Series 12mm OD 4-flute end mill, taking a radial DOC of 30% of the diameter and an axial DOC of 1.25 x D (15 mm in this example).



HEM method roughing out the same part using the IPT 7-flute end mill, taking a radial DOC of 8% of the diameter and an axial DOC of 3 x D (the full 36 mm of the wall in this example).



SPEED

99 M/min	134 M/min
2483 RPM	3361 RPM

CHIP LOAD

.0838 mm. per tooth	.147 mm. per tooth

FEED RATE

832.3 mm. per minute	3466 mm. per minute
2483 rpm x [.0838 mm per tooth x 4 flutes]	3361 rpm x [.1473 mm per tooth x 7 flutes]

METAL REMOVAL RATE

44.95 cm^3	119.37 cm^3
832.4 mm/min x 3.6 RDOC per pass x 15mm ADOC per pass	3454 mm/min x 96 RDOC per pass x 36mm ADOC per pass

In this example, material is removed 2.5 x faster using the HEM IPT end mill versus a traditional path. The metal removal rate is measured in cubic centimeters: at IMCO, "It's all about the cubes."

Do all end mills run well in HEM tool paths?

All end mills are **not** created equal when it comes to HEM. End mills with multiple flutes, thick cores, and strong corner radii are much more effective than traditional 4-flute tools. IMCO has created end mills specifically for HEM tool paths and others that can run both HEM and traditional cuts. It's all indicated in our tool selection guide.

Is HEM the best method to run on every job?

No. In general, **HEM does show significant savings** in most applications, but it really shines when you can run an axial depth of cut that is 1.25 x the tool diameter or greater. Traditional tool paths run well on very short runs and simple, shallow cuts.

An easy way to check if HEM will run a job faster is to calculate the metal removal rate, or MRR. The MRR takes the tool feed rate and multiplies that by the tool engagement to determine how many cubic inches or centimeters the tool removes in one minute.

MRR = Feed rate of the tool x width of cut x depth of cut

OR

MRR = (RPM x (MMPT x # of flutes) x Radial DOC x Axial DOC

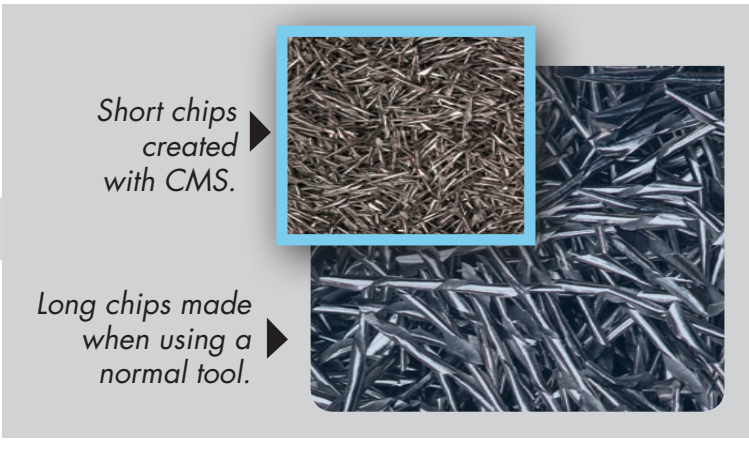
Plug in the numbers for the feed rate, step-over (RDOC) and the axial depth of cut (ADOC) the tool manufacturer recommends to compare MRRs between the programming techniques. **On parts that require cutting at least 1.25 x the tool diameter deep, you will find that HEM shines.** Use the chart below to determine the best tool and path to use based on the axial depths (ADOC).

MRR Ranking	1.25 x D axial depths	1.5 - 2 x D axial depths	2.5 x D axial depths	3 x D axial depths
1	IP13 - HEM	IP13 - HEM	IP9 - HEM	IP9 - HEM
2	IP9 - HEM	IP9 - HEM	IP11 - HEM	IP7 - HEM
3	IP11 - HEM	IP11 - HEM	IP7 - HEM	M527 - HEM
4	M525 - Traditional	IP7 - HEM	IP13 - HEM	IP13 - HEM
5	M527 - Traditional	M527 - HEM	M527 - HEM	M525 - HEM
6	IP7 - HEM	M525 - HEM	M525 - HEM	IP11 - HEM
7	M527 - HEM	-	-	-
8	M525 - HEM	-	-	-

1=highest MRR, 8=lowest MRR
Chart assumes adequate coolant and no chip pollution in the cut. Chart is typical for most ferrous materials and hi-temp alloys.

Will the deep cuts used in HEM create chip pollution?

Yes, HEM can generate long chips based on the light step-over and deep cuts. The chips of some materials tend to break easily, and the coolant is effective in taking them out of the cutting zone. Other materials can cause issues. IMCO has developed special grinds that break the chips for easy removal without reducing tool life. Our ***Chip Management System (CMS)*** is available as a standard feature on many of our high-performance end mill designs. Look for the "C" in the series number to find them.



Tool Selection Guide

Pick the right tool for your material and application.

ISO Code	Work Material	Type of Cut	POW•R•PATH									
			IPT7	IPC7	IPT9	IPC9	IPT11	IPC11	IPT13	IPC13	APT5	APC5
												
K	Cast Iron - Gray	Traditional Roughing										
		Traditional Finishing										
		HEM	●●●●	●●●	●●●●	●●●	●●●●	●●●	●●●●	●●●		
	Cast Iron - Malleable	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
P	Low Carbon Steels < 48 HRC	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
	Medium Carbon Steels < 48 HRC	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
	Tool & Die Steels < 48 HRC	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
H	Tool & Die Steels 48 - 62 HRC	Traditional Roughing										
		Traditional Finishing										
M	Austenitic Stainless Steels	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
	Martensitic Stainless Steels	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
	PH Stainless Steels	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
S	Titanium Alloys	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●		
	Hi-Temperature Alloys	Traditional Roughing										
		Traditional Finishing	●●●		●●●							
		HEM	●●●●		●●●		●●		●			
N	Aluminium Alloys	Traditional Roughing									●●●	●●●
		Traditional Finishing									●●●●	
		HEM									●●●●	●●●●
	Copper Alloys, Brass, Bronze	Traditional Roughing										
		Traditional Finishing										
	Composites, Plastics, Fiberglass	Traditional Roughing										
		Traditional Finishing										

Maximum Performance: ●●●● Superior Performance: ●●● Excellent Performance: ●● Good Performance: ●

enDURO			OMEGA-6	INCONEX	POW•R•FEED	STREAKERS			
M525	M525C	M527	M725/6	M806	M924	M223	M233	M203	M202
									
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Maximum Performance: •••• Superior Performance: ••• Excellent Performance: •• Good Performance: •

POW•R•PATH

MACHINING REBOOTED. PRODUCTIVITY RELOADED.

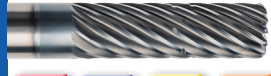
Push your productivity to the max with IMCO's POW•R•PATH IP/AP series end mills, designed specifically for High-Efficiency Machining (HEM). This dynamic combination of unique tool design features along with HEM tool paths increase your metal removal rates while decreasing wear of your tool. The proof is in the savings!

IP/AP Series Features

NEW TOOLS FOR THE NEW AGE OF MACHINING.

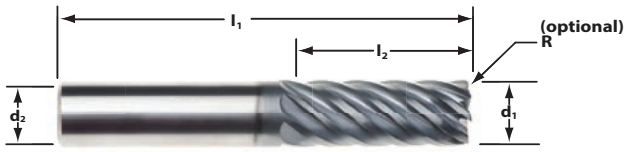
Amplify the benefits of high-efficiency machining with POW•R•PATH IP / AP series cutting tools. Every aspect of POW•R•PATH end mills is optimized specifically for HEM methods to make sure you get every advantage this modern machining system can provide.

The POW•R•PATH line is the most complete offering of end mills dedicated to HEM tool paths in the market, ranging from 7 to 13-flutes for steels and hi-temp alloys, and a 5-flute design for aluminium – all available with or without the unique Chip Management System (CMS).

	NUMBER OF FLUTES	END TYPES	HELIX ANGLE	COATING	SHANK TYPES	APPLICATION(S)
IPT7  K P M S	Z7	SQ CR	40°	AlCrNX	PLAIN WELDON	HEM FINISH
IPC7  K P M S	Z7	CR	40°	AlCrNX	PLAIN WELDON	HEM FINISH
IPT9  **IPC9**  K P M S	Z9	CR	36°	AlCrNX	PLAIN	HEM FINISH
IPT11  **IPC11**  K P M S	Z11	CR	34°	AlCrNX	PLAIN	HEM
IPT13  **IPC13**  K P M S	Z13	CR	30°	AlCrNX	PLAIN	HEM
APT5  **APC5**  N	Z5	SQ CR	35°	taC	PLAIN	HEM FINISH ROUGH

IPT7
POW•R•PATH

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. The IPT7 is the most versatile of the POW•R•PATH end mills. Engineered specifically for HEM tool paths, the IPT7's unique design runs up to 4.5 x the tool diameter deep at elevated feed and metal removal rates.



mm: *d1: +0.000 / -0.050* *d2: -0.0025 / -0.0100*

K P M S

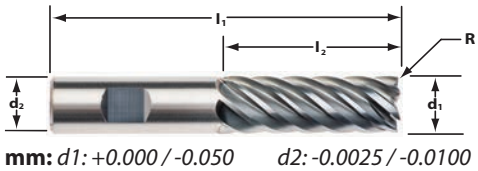
Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR
6	6	2	12	57	63670	63671	-	-	-	-
		3	18	63	63672	63673	-	-	-	-
		4	24	75	63674	63675	-	-	-	-
8	8	2	16	58	64007	64008	-	-	-	-
		3	24	63	63678	63679	-	-	-	-
		4	32	75	63680	63681	-	-	-	-
10	10	2	20	66	63682	63683	63684	-	-	-
		2.5	25	72	63685	63686	63687	-	-	-
		3	30	75	63688	63689	63690	-	-	-
		4	40	88	63691	63692	63693	-	-	-
12	12	2	24	75	64015	-	64016	64023	64024	64029
		2.5	30	83	63699	-	63700	63701	63702	63703
		3	36	88	64036	-	64037	64043	64050	64051
		3.5	42	93	64057	-	64058	64064	64070	64071
		4	48	100	63714	-	63715	63716	63717	63718
16	16	2	32	92	64075	-	64076	64081	64085	64086
		2.5	40	100	64087	-	64088	64090	64091	64092
		3	48	110	64093	-	64094	64096	64097	64098
		3.5	56	110	63734	-	63735	63736	63737	63738
		4	64	125	63739	-	63740	63741	63742	63743
20	20	2	40	104	63744	-	63745	63746	63747	63748
		2.5	50	115	64099	-	64100	64108	64115	64116
		3	60	125	63754	-	63755	63756	63757	63758
		3.5	70	135	64123	-	64124	64136	64137	64142
		4	80	150	63764	-	63765	63766	63767	63768
25	25	2	50	120	63769	-	63770	63771	63772	63773
		2.5	63	135	63399	-	63451	63453	63454	63627
		3	75	150	63779	-	63780	63781	63782	63783
		3.5	88	165	63628	-	63629	63810	63811	63812

D = Tool Diameter

Inch sizes available upon request.

IPT7 w/WELDON

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 1.0 CR	1.5 CR	3.0 CR
12	12	3	36	88	63002	-	63008
		3.5	42	93	63009	-	63015
		4	48	100	63017	-	63019
16	16	3	48	110	-	63021	63023
		3.5	56	110	-	63031	63033
		4	64	125	-	63035	63037
20	20	3	60	125	-	63039	63041
		3.5	70	135	-	63042	63053
		4	80	150	-	63055	63057



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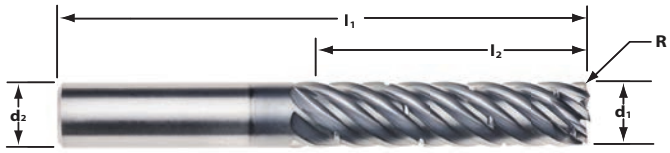
Speed and Feed charts can be found on page 18.

IPC7
POW•R•PATH

Z7 | CR | 40° | CMS | AlCrNX | PLAIN | WELDON

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. Adds the benefits of the unique **Chip Management System (CMS)** to the versatility of the IPT7 design. Breaks up long stringy chips, which eliminates recutting chips and chip packing and allows for deep, free cutting tool movement in a variety of materials.



mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

K P M S

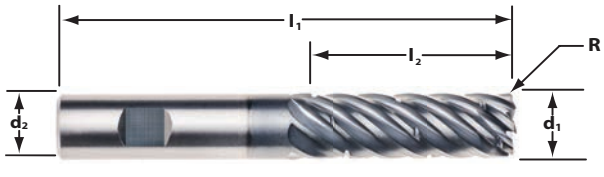
Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code 1.0 CR
10	10	3	30	75	63790
		4	40	88	63791
12	12	2.5	30	83	63792
		3	36	88	64042
		3.5	42	93	64063
		4	48	100	63795
16	16	2	32	92	64080
		2.5	40	100	64089
		3	48	110	64095
		3.5	56	110	63799
		4	64	125	63800
20	20	2	40	104	63801
		2.5	50	115	64107
		3	60	125	63803
		3.5	70	135	64129
		4	80	150	63805
25	25	2	50	120	63806
		2.5	63	135	63452
		3	75	150	63808
		3.5	88	165	63789

D = Tool Diameter

Inch sizes available upon request.

IPC7 w/WELDON

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code 1.0 CR
12	12	3	36	88	63339
		3.5	42	93	63341
		4	48	100	63352
16	16	3	48	110	63353
		3.5	56	110	63355
		4	64	125	63366
20	20	3	60	125	63367
		3.5	70	135	63368
		4	80	150	63369

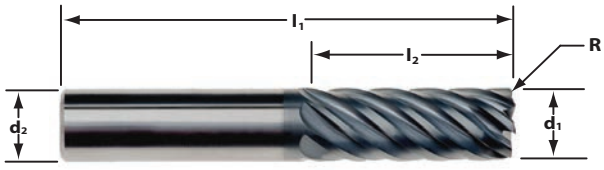


mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

Speed and Feed charts can be found on page 18.

IPT9
POW•R•PATH

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. The IPT9 POW•R•PATH end mill is engineered specifically for HEM tool paths with great core strength and 9-flutes for increased feed rates and excellent surface finishes. The unique design runs up to 3.5 x the tool diameter deep, generating high metal removal rates.



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K P M S

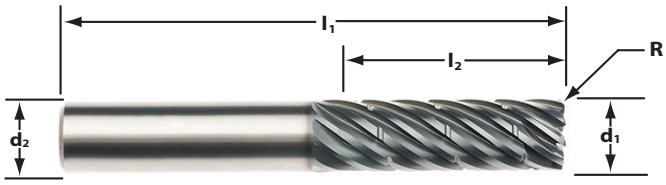
Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	3.0 CR
6	6	2	12	57	64357	64358	-	-
		2.5	15	57	64359	64360	-	-
		3	18	63	64361	64362	-	-
		3.5	21	75	64363	64364	-	-
8	8	2.5	20	63	64365	64366	-	-
		3	24	63	64367	64368	-	-
		3.5	28	75	64369	64370	-	-
10	10	2	20	66	64371	64372	-	-
		2.5	25	72	64373	64374	-	-
		3	30	75	64375	64376	-	-
		3.5	35	88	64377	64378	-	-
12	12	2	24	75	-	64379	64380	-
		2.5	30	83	-	64381	64382	-
		3	36	88	-	64383	64384	-
		3.5	42	93	-	64385	64386	-
16	16	2	32	92	-	64387	64388	-
		2.5	40	100	-	64389	64390	-
		3	48	110	-	64391	64392	-
		3.5	56	110	-	64393	64394	-
20	20	2	40	104	-	64395	64396	64397
		2.5	50	115	-	64398	64399	64400
		3	60	125	-	64401	64402	64403
		3.5	70	135	-	64404	64405	64406
25	25	2	50	120	-	64407	-	64408
		2.5	63	135	-	64409	-	64410
		3	75	150	-	64411	-	64412
		3.5	88	165	-	64413	-	64414

D = Tool Diameter

Inch sizes available upon request.

IPC9
POW•R•PATH

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. Adds the benefits of the unique **Chip Management System (CMS)** to the versatility of the IPT9 design. Breaks up long stringy chips, which eliminates recutting chips and chip packing, and allows for deep, free cutting tool movement in a variety of materials.



mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

K P M S

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 1.0 CR	1.5 CR	3.0 CR
12	12	2	24	75	64143	-	-
		2.5	30	83	63889	-	-
		3	36	88	64150	64415	-
		3.5	42	93	64151	64416	-
16	16	2	32	92	64157	-	-
		2.5	40	100	64158	64417	-
		3	48	110	64163	64418	-
		3.5	56	110	63901	64419	-
20	20	2	40	104	63903	64420	63904
		2.5	50	115	64164	64421	64170
		3	60	125	63907	64422	63908
		3.5	70	135	64171	64423	64175
25	25	2	50	120	63911	-	63912
		2.5	63	135	63813	-	63814
		3	75	150	63915	-	63916
		3.5	88	165	63863	-	63864

D = Tool Diameter

Inch sizes available upon request.

TOOL TIP

HEM Tool Holder Recommendations.

HEM tool paths reduce the amount of radial cutting forces that are exerted on the end mill, allowing for more aggressive speeds and feeds and longer tool life. The axial cutting forces, however, are increased and work to pull the end mill out of the holder and into the part. Using a holder with a high level of gripping power is critical for successful machining in HEM tool paths. It is also important to choose a holder that minimizes the run-out of the end mill.

Holder Type	Use in HEM Programming?
Press Fit	Recommended
Shrink Fit	Recommended
Mechanical Chuck	Recommended
Hydraulic Chuck	Only if ADOC < 3 x D
Advanced ER Collet	Only if ADOC < 3 x D
Standard ER Collet	Not recommended
Side Lock Holder	MUST keep run-out minimized

IPT7/IPC7 Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 6.0	10.0	12.0	16.0	20.0	25.0
K	Gray ASTM-A48 Class 20, 25, 30, 35 & 40	Peripheral - HEM	≤ 3 x D	.1 x D	7	122	.0864	.1434	.1728	.2298	.2868	.3456
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	122	.0778	.1291	.1555	.2068	.2581	.3110
		Peripheral - HEM	> 4 - 5 x D	.08 x D	7	119	.0691	.1147	.1382	.1838	.2295	.2765
		Finish	3 x D	.015 x D	7	137	.0312	.0518	.0624	.0830	.1036	.1248
	Cast Iron Malleable	Peripheral - HEM	≤ 3 x D	.08 x D	7	119	.0696	.1155	.1392	.1851	.2311	.2784
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	119	.0626	.1040	.1253	.1666	.2079	.2505
		Peripheral - HEM	> 4 - 5 x D	.08 x D	7	114	.0557	.0924	.1114	.1481	.1848	.2227
		Finish	3 x D	.015 x D	7	107	.0252	.0418	.0504	.0670	.0837	.1008
P	Low Carbon Steels ≤ 38 Rc 1018, 1020, 12L14, 5120, 8620	Peripheral - HEM	≤ 3 x D	.08 x D	7	148	.0900	.1494	.1800	.2394	.2988	.3600
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	148	.0810	.1344	.1620	.2154	.2689	.3240
		Peripheral - HEM	> 4 - 5 x D	.08 x D	7	142	.0720	.1195	.1440	.1915	.2390	.2880
		Finish	3 x D	.015 x D	7	128	.0336	.0558	.0672	.0894	.1115	.1344
	Medium Carbon Steels ≤ 48 HRC 1045, 4140, 4340, 5140	Peripheral - HEM	≤ 3 x D	.08 x D	7	137	.0852	.1414	.1704	.2266	.2828	.3408
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	137	.0767	.1273	.1533	.2040	.2546	.3067
		Peripheral - HEM	> 4 - 5 x D	.08 x D	7	130	.0682	.1131	.1363	.1813	.2263	.2726
		Finish	3 x D	.015 x D	7	119	.0300	.0498	.0600	.0798	.0996	.1200
	Tool and Die Steels ≤ 48 Rc A2, D2, O1, S7, P20, H13	Peripheral - HEM	≤ 3 x D	.08 x D	7	128	.0768	.1275	.1536	.2043	.2550	.3072
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	128	.0691	.1147	.1382	.1838	.2295	.2765
		Peripheral - HEM	> 4 - 5 x D	.08 x D	7	120	.0614	.1020	.1229	.1634	.2040	.2457
		Finish	3 x D	.015 x D	7	111	.0252	.0418	.0504	.0670	.0837	.1008
M	Martensitic & Ferritic Stainless Steels 410, 416, 440	Peripheral - HEM	≤ 3 x D	.08 x D	7	137	.0900	.1494	.1800	.2394	.2988	.3600
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	137	.0810	.1344	.1620	.2154	.2689	.3240
		Peripheral - HEM	> 4 - 5 x D	.08 x D	7	130	.0720	.1195	.1440	.1915	.2390	.2880
		Finish	3 x D	.015 x D	7	119	.0300	.0498	.0600	.0798	.0996	.1200
	Austenitic Stainless Steels, FeNi Alloys 303, 304, 316, Invar, Kovar	Peripheral - HEM	≤ 3 x D	.08 x D	7	137	.0768	.1275	.1536	.2043	.2550	.3072
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	134	.0691	.1147	.1382	.1838	.2295	.2765
		Peripheral - HEM	> 4 - 5 x D	.07 x D	7	130	.0614	.1020	.1229	.1634	.2040	.2457
		Finish	3 x D	.015 x D	7	119	.0288	.0478	.0576	.0766	.0956	.1152
	Precipitation Hardening Stainless Steels 17-4, 15-5	Peripheral - HEM	≤ 3 x D	.08 x D	7	134	.0744	.1235	.1488	.1979	.2470	.2976
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	134	.0670	.1111	.1339	.1781	.2223	.2678
		Peripheral - HEM	> 4 - 5 x D	.07 x D	7	126	.0595	.0988	.1190	.1583	.1976	.2381
		Finish	3 x D	.015 x D	7	116	.0240	.0398	.0480	.0638	.0797	.0960
S	Titanium Alloys 6Al-4V, 6-2-4	Peripheral - HEM	≤ 3 x D	.1 x D	7	123	.0492	.0817	.0984	.1309	.1633	.1968
		Peripheral - HEM	> 3 - 4 x D	.08 x D	7	123	.0443	.0735	.0886	.1178	.1470	.1771
		Peripheral - HEM	> 4 - 5 x D	.08 x D	7	119	.0394	.0653	.0787	.1047	.1307	.1574
		Finish	3 x D	.015 x D	7	107	.0192	.0319	.0384	.0511	.0637	.0768
	Difficult-to-Machine Titanium Alloys 10-2-3 Precipitation Hardening Stainless Steel M 13-8	Peripheral - HEM	≤ 2.5 x D	.08 x D	7	102	.0480	.0797	.0960	.1277	.1593	.1920
		Peripheral - HEM	> 2.5 - 3.5 x D	.07 x D	7	99	.0432	.0717	.0864	.1149	.1434	.1728
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	7	93	.0384	.0637	.0768	.1021	.1275	.1536
		Finish	3 x D	.01 x D	7	88	.0168	.0279	.0336	.0447	.0558	.0672
	Hastalloy, Waspalloy	Peripheral - HEM	≤ 1.5 x D	.08 x D	7	30	.1128	.1872	.2256	.3000	.3745	.4512
		Peripheral - HEM	> 1.5 - 2.5 x D	.08 x D	7	29	.1015	.1685	.2030	.2700	.3370	.4060
		Peripheral - HEM	> 2.5 - 3.5 x D	.06 x D	7	26	.0902	.1498	.1805	.2400	.2996	.3609
		Finish	2 x D	.01 x D	7	27	.0600	.0996	.1200	.1596	.1992	.2400
	Inconel 718, Rene 88	Peripheral - HEM	≤ 1.5 x D	.07 x D	7	29	.1116	.1852	.2232	.2968	.3705	.4464
		Peripheral - HEM	> 1.5 - 2.5 x D	.06 x D	7	27	.1004	.1667	.2009	.2671	.3334	.4017
		Peripheral - HEM	> 2.5 - 3 x D	.06 x D	7	26	.0893	.1482	.1785	.2375	.2964	.3571
		Finish	2 x D	.01 x D	7	26	.0576	.0956	.1152	.1532	.1912	.2304

D = Tool Diameter HEM = High-efficiency machining

≈ Approximately Equals < Less Than
≤ Less Than or Equal To > Greater Than
≥ Greater Than or Equal To = Equals
× Multiply

Common Machining Formulas

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

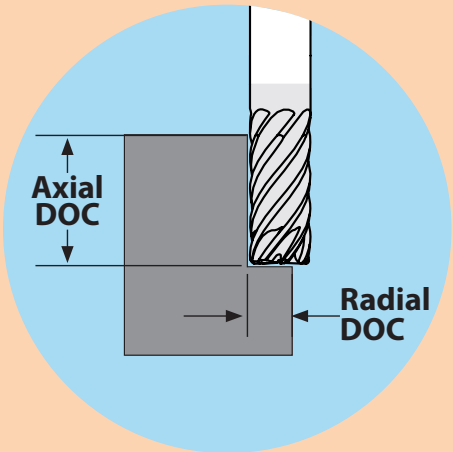
$$MRR = RDOC \times ADOC \times MMPM$$

D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

IPT9/IPC9 Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 6.0	10.0	12.0	16.0	20.0	25.0
K	Gray ASTM-A48 Class 20, 25, 30, 35 & 40	Peripheral - HEM	≤ 3 x D	.1 x D	9	122	.0864	.1434	.1728	.2298	.2868	.3456
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	122	.0778	.1291	.1555	.2068	.2581	.3110
		Peripheral - HEM	> 4 - 5 x D	.08 x D	9	119	.0691	.1147	.1382	.1838	.2295	.2765
		Finish	3 x D	.015 x D	9	137	.0312	.0518	.0624	.0830	.1036	.1248
	Cast Iron Malleable	Peripheral - HEM	≤ 3 x D	.08 x D	9	119	.0696	.1155	.1392	.1851	.2311	.2784
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	119	.0626	.1040	.1253	.1666	.2079	.2505
		Peripheral - HEM	> 4 - 5 x D	.08 x D	9	114	.0557	.0924	.1114	.1481	.1848	.2227
		Finish	3 x D	.015 x D	9	107	.0252	.0418	.0504	.0670	.0837	.1008
P	Low Carbon Steels ≤ 38 Rc 1018, 1020, 12L14, 5120, 8620	Peripheral - HEM	≤ 3 x D	.08 x D	9	148	.0900	.1494	.1800	.2394	.2988	.3600
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	148	.0810	.1344	.1620	.2154	.2689	.3240
		Peripheral - HEM	> 4 - 5 x D	.08 x D	9	142	.0720	.1195	.1440	.1915	.2390	.2880
		Finish	3 x D	.015 x D	9	128	.0336	.0558	.0672	.0894	.1115	.1344
	Medium Carbon Steels ≤ 48 HRC 1045, 4140, 4340, 5140	Peripheral - HEM	≤ 3 x D	.08 x D	9	137	.0852	.1414	.1704	.2266	.2828	.3408
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	137	.0767	.1273	.1533	.2040	.2546	.3067
		Peripheral - HEM	> 4 - 5 x D	.08 x D	9	130	.0682	.1131	.1363	.1813	.2263	.2726
		Finish	3 x D	.015 x D	9	119	.0300	.0498	.0600	.0798	.0996	.1200
	Tool and Die Steels ≤ 48 Rc A2, D2, O1, S7, P20, H13	Peripheral - HEM	≤ 3 x D	.08 x D	9	128	.0768	.1275	.1536	.2043	.2550	.3072
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	128	.0691	.1147	.1382	.1838	.2295	.2765
		Peripheral - HEM	> 4 - 5 x D	.08 x D	9	120	.0614	.1020	.1229	.1634	.2040	.2457
		Finish	3 x D	.015 x D	9	111	.0252	.0418	.0504	.0670	.0837	.1008
M	Martensitic & Ferritic Stainless Steels 410, 416, 440	Peripheral - HEM	≤ 3 x D	.08 x D	9	137	.0900	.1494	.1800	.2394	.2988	.3750
		Peripheral - HEM	>3 - 4 x D	.08 x D	9	134	.0810	.1344	.1620	.2154	.2689	.3375
		Peripheral - HEM	> 4 - 5 x D	.07 x D	9	130	.0720	.1195	.1440	.1915	.2390	.3000
		Finish	3 x D	.015 x D	9	119	.0300	.0498	.0600	.0798	.0996	.1250
	Austenitic Stainless Steels, FeNi Alloys 303, 304, 316, Invar, Kovar	Peripheral - HEM	≤ 3 x D	.08 x D	9	137	.0768	.1275	.1536	.2043	.2550	.3200
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	137	.0691	.1147	.1382	.1838	.2295	.2880
		Peripheral - HEM	> 4 - 5 x D	.08 x D	9	130	.0614	.1020	.1229	.1634	.2040	.2560
		Finish	3 x D	.015 x D	9	119	.0288	.0478	.0576	.0766	.0956	.1200
	Precipitation Hardening Stainless Steels 17-4, 15-5	Peripheral - HEM	≤ 3 x D	.08 x D	9	134	.0744	.1235	.1488	.1979	.2470	.2976
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	134	.0670	.1111	.1339	.1781	.2223	.2678
		Peripheral - HEM	> 4 - 5 x D	.07 x D	9	126	.0595	.0988	.1190	.1583	.1976	.2381
		Finish	3 x D	.015 x D	9	116	.0240	.0398	.0480	.0638	.0797	.0960
S	Titanium Alloys 6Al-4V, 6-2-4	Peripheral - HEM	≤ 3 x D	.1 x D	9	123	.0492	.0817	.0984	.1309	.1633	.1968
		Peripheral - HEM	> 3 - 4 x D	.08 x D	9	123	.0443	.0735	.0886	.1178	.1470	.1771
		Peripheral - HEM	> 4 - 5 x D	.08 x D	9	119	.0394	.0653	.0787	.1047	.1307	.1574
		Finish	3 x D	.015 x D	9	107	.0192	.0319	.0384	.0511	.0637	.0768
	Difficult-to-Machine Titanium Alloys 10-2-3	Peripheral - HEM	≤ 2.5 x D	.08 x D	9	102	.0480	.0797	.0960	.1277	.1593	.1920
		Peripheral - HEM	> 2.5 - 3.5 x D	.07 x D	9	99	.0432	.0717	.0864	.1149	.1434	.1728
	Precipitation Hardening Stainless Steel M 13-8	Peripheral - HEM	> 3.5 - 4 x D	.06 x D	9	93	.0384	.0637	.0768	.1021	.1275	.1536
		Finish	3 x D	.01 x D	9	88	.0168	.0279	.0336	.0447	.0558	.0672
	Hastalloy, Waspalloy	Peripheral - HEM	≤ 1.5 x D	.08 x D	9	30	.1080	.1793	.2160	.2873	.3585	.4320
		Peripheral - HEM	> 1.5 - 2.5 x D	.08 x D	9	29	.0972	.1613	.1944	.2585	.3227	.3888
		Peripheral - HEM	> 2.5 - 3.5 x D	.06 x D	9	26	.0864	.1434	.1728	.2298	.2868	.3456
		Finish	2 x D	.01 x D	9	27	.0576	.0956	.1152	.1532	.1912	.2304
	Inconel 718, Rene 88	Peripheral - HEM	≤ 1.5 x D	.07 x D	9	29	.1092	.1813	.2184	.2904	.3625	.4368
		Peripheral - HEM	> 1.5 - 2.5 x D	.06 x D	9	27	.0983	.1631	.1965	.2614	.3263	.3931
		Peripheral - HEM	> 2.5 - 3 x D	.06 x D	9	26	.0874	.1450	.1747	.2324	.2900	.3494
		Finish	2 x D	.01 x D	9	26	.0552	.0916	.1104	.1468	.1832	.2208

D = Tool Diameter HEM = High-efficiency machining



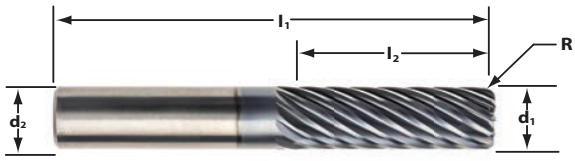
Technical Resources

Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

IPT11
POW•R•PATH

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. Built for results with 11 cutting edges to yield incredible feed rates. Engineered specifically for HEM tool paths, the IPT11 has a very thick core for extra stability when machining materials up to 3.5 x the tool diameter deep.



mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

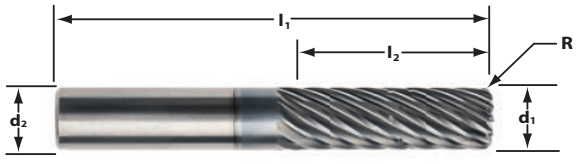
K P M S

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 1.0 CR	1.5 CR	3.0 CR
12	12	2	24	75	64424	64425	-
		2.5	30	83	64426	64427	-
		3	36	88	64428	64429	-
		3.5	42	93	64430	64431	-
16	16	2	32	92	64432	64433	-
		2.5	40	100	64434	64435	-
		3	48	110	64436	64437	-
		3.5	56	110	64438	64439	-
20	20	2	40	104	64440	64441	64442
		2.5	50	115	64443	64444	64445
		3	60	125	64446	64447	64448
		3.5	70	135	64449	64450	64451

Note that the IPT11 is not designed for light-duty machines and should only be run in machines with adequate spindle torque and horsepower.

IPC11

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. Adds the benefits of the unique **Chip Management System (CMS)** to the versatility of the IPT11 design. Breaks up long stringy chips, which eliminates recutting chips and chip packing, and allows for deep, free cutting tool movement in a variety of materials. The results are great chip control and very high metal removal rates.



mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

K P M S

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 1.0 CR	1.5 CR	3.0 CR
12	12	3	36	88	64452	64453	-
		3.5	42	93	64454	64455	-
16	16	2.5	40	100	64456	64457	-
		3	48	110	64458	64459	-
		3.5	56	110	64460	64461	-
20	20	2	40	104	64462	64463	64464
		2.5	50	115	64465	64466	64467
		3	60	125	64468	64469	64470
		3.5	70	135	64471	64472	64473

Note that the IPC11 is not designed for light-duty machines and should only be run in machines with adequate spindle torque and horsepower.

D = Tool Diameter

Inch sizes available upon request.

IPT11/IPC11 Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 12.0	16.0	20.0
K	Gray ASTM-A48 Class 20, 25, 30, 35 & 40	Peripheral - HEM	≤ 2 x D	.08 x D	11	111	.1272	.1692	.2111
		Peripheral - HEM	> 2 - 3 x D	.07 x D	11	111	.1104	.1468	.1832
		Peripheral - HEM	> 3 - 3.5 x D	.07 x D	11	107	.0960	.1277	.1593
		Peripheral - HEM	> 3.5 - 4 x D	.065 x D	11	107	.0816	.1085	.1354
		Finish	3 x D	.01 x D	11	113	.0528	.0702	.0876
	Cast Iron Malleable	Peripheral - HEM	≤ 2 x D	.07 x D	11	114	.1512	.2011	.2510
		Peripheral - HEM	> 2 - 3 x D	.07 x D	11	114	.1344	.1787	.2231
		Peripheral - HEM	> 3 - 3.5 x D	.07 x D	11	110	.1152	.1532	.1912
		Peripheral - HEM	> 3.5 - 4 x D	.07 x D	11	110	.0960	.1277	.1593
		Finish	3 x D	.01 x D	11	102	.0552	.0734	.0916
P	Low Carbon Steels ≤ 38 Rc 1018, 1020, 12L14, 5120, 8620	Peripheral - HEM	≤ 2 x D	.07 x D	11	168	.1320	.1755	.2191
		Peripheral - HEM	> 2 - 3 x D	.07 x D	11	162	.1152	.1532	.1912
		Peripheral - HEM	> 3 - 3.5 x D	.07 x D	11	157	.1008	.1341	.1673
		Peripheral - HEM	> 3.5 - 4 x D	.07 x D	11	154	.0864	.1149	.1434
		Finish	3 x D	.01 x D	11	145	.0480	.0638	.0797
	Medium Carbon Steels ≤ 48 HRC 1045, 4140, 4340, 5140	Peripheral - HEM	≤ 2 x D	.07 x D	11	162	.1296	.1724	.2151
		Peripheral - HEM	> 2 - 3 x D	.07 x D	11	157	.1128	.1500	.1872
		Peripheral - HEM	> 3 - 3.5 x D	.07 x D	11	152	.0984	.1309	.1633
		Peripheral - HEM	> 3.5 - 4 x D	.07 x D	11	149	.0840	.1117	.1394
		Finish	3 x D	.01 x D	11	139	.0456	.0606	.0757
	Tool and Die Steels ≤ 48 Rc A2, D2, O1, S7, P20, H13	Peripheral - HEM	≤ 2 x D	.06 x D	11	136	.1512	.2011	.2510
		Peripheral - HEM	> 2 - 3 x D	.06 x D	11	131	.1320	.1755	.2191
		Peripheral - HEM	> 3 - 3.5 x D	.06 x D	11	126	.1152	.1532	.1912
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	11	125	.0984	.1309	.1633
		Finish	3 x D	.01 x D	11	117	.0480	.0638	.0797
M	Martensitic & Ferritic Stainless Steels 410, 416, 440	Peripheral - HEM	≤ 2 x D	.06 x D	11	137	.1608	.2138	.2669
		Peripheral - HEM	> 2 - 3 x D	.06 x D	11	137	.1416	.1883	.2350
		Peripheral - HEM	> 3 - 3.5 x D	.06 x D	11	130	.1248	.1660	.2072
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	11	130	.1032	.1372	.1713
		Finish	3 x D	.01 x D	11	119	.0600	.0798	.0996
	Austenitic Stainless Steels, FeNi Alloys 303, 304, 316, Invar, Kovar	Peripheral - HEM	≤ 2 x D	.06 x D	11	136	.1632	.2170	.2709
		Peripheral - HEM	> 2 - 3 x D	.06 x D	11	131	.1440	.1915	.2390
		Peripheral - HEM	> 3 - 3.5 x D	.06 x D	11	126	.1296	.1724	.2151
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	11	125	.1056	.1404	.1753
		Finish	3 x D	.01 x D	11	117	.0552	.0734	.0916
	Precipitation Hardening Stainless Steels 17-4, 15-5	Peripheral - HEM	≤ 2 x D	.06 x D	11	133	.1632	.2170	.2709
		Peripheral - HEM	> 2 - 3 x D	.06 x D	11	128	.1440	.1915	.2390
		Peripheral - HEM	> 3 - 3.5 x D	.06 x D	11	123	.1248	.1660	.2072
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	11	122	.1032	.1372	.1713
		Finish	3 x D	.01 x D	11	114	.0528	.0702	.0876
S	Titanium Alloys 6Al-4V, 6-2-4	Peripheral - HEM	≤ 2 x D	.06 x D	11	130	.1440	.1915	.2390
		Peripheral - HEM	> 2 - 3 x D	.06 x D	11	126	.1032	.1372	.1713
		Peripheral - HEM	> 3 - 3.5 x D	.06 x D	11	120	.1008	.1341	.1673
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	11	120	.0936	.1245	.1554
		Finish	3 x D	.015 x D	11	113	.0552	.0734	.0916
	Difficult-to-Machine Titanium Alloys 10-2-3 Precipitation Hardening Stainless Steel M 13-8	Peripheral - HEM	≤ 2 x D	0.06	11	107	.1416	.1883	.2350
		Peripheral - HEM	> 2 - 3 x D	0.06	11	101	.1008	.1341	.1673
		Peripheral - HEM	> 3 - 3.5 x D	0.055	11	96	.0984	.1309	.1633
		Peripheral - HEM	> 3.5 - 4 x D	0.05	11	94	.0912	.1213	.1514
		Finish	3 x D	.01 x D	11	91	.0480	.0638	.0797
	Hastalloy, Waspalloy	Peripheral - HEM	≤ 2 x D	.07 X D	11	32	.2160	.2873	.3585
		Peripheral - HEM	> 2 - 3 x D	.065 x D	11	30	.1944	.2585	.3227
		Peripheral - HEM	> 3 - 3.5 x D	.055 x D	11	27	.1728	.2298	.2868
		Peripheral - HEM	> 3.5 - 4 x D	.055 x D	11	27	.1555	.2068	.2581
		Finish	3 x D	.01 x D	11	27	.1128	.1500	.1872
	Inconel 718, Rene 88	Peripheral - HEM	≤ 2 x D	.065 x D	11	30	.1488	.1979	.2470
		Peripheral - HEM	> 2 - 3 x D	.06 x D	11	29	.1440	.1915	.2390
		Peripheral - HEM	> 3 - 3.5 x D	.05 x D	11	29	.1440	.1915	.2390
		Peripheral - HEM	> 3.5 - 4 x D	.05 x D	11	29	.1248	.1660	.2072
		Finish	3 x D	.01 x D	11	27	.0768	.1021	.1275

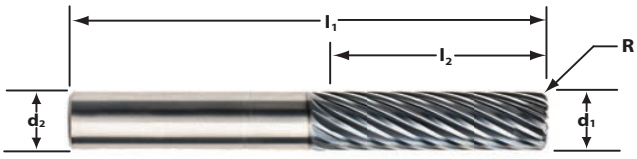
D = Tool Diameter HEM = High-efficiency machining

≈ Approximately Equals < Less Than
≤ Less Than or Equal To > Greater Than
≥ Greater Than or Equal To = Equals
× Multiply

IPT13
POW•R•PATH

Z13 | CR | 30° | AlCrNX | PLAIN

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. The IPT13 offers the most cutting edges available in the POW•R•PATH line. The 13-flutes yield incredible metal removal rates and tool life. Engineered specifically for HEM tool paths, the IPT13 has a very thick core for extra stability when machining materials up to 3.5 x the tool diameter deep.



mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

K P M S

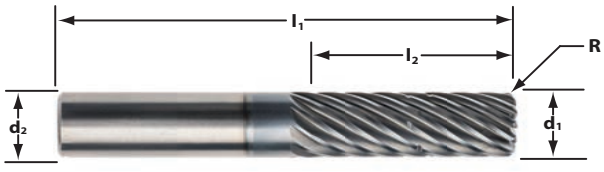
Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 1.0 CR	1.5 CR	3.0 CR
12	12	2	24	75	64474	64475	-
		2.5	30	83	64476	64477	-
		3	36	88	64478	64479	-
		3.5	42	93	64480	64481	-
16	16	2	32	92	64482	64483	-
		2.5	40	100	64484	64485	-
		3	48	110	64486	64487	-
		3.5	56	110	64488	64489	-
20	20	2	40	104	64490	64491	64492
		2.5	50	115	64493	64494	64495
		3	60	125	64496	64497	64498
		3.5	70	135	64499	64500	64501

Note that the IPT13 is not designed for light-duty machines and should only be run in machines with adequate spindle torque and horsepower.

IPC13

CMS

For high-efficiency machining (HEM) in materials ranging from low carbon steels to hi-temp alloys. Adds the benefits of the unique **Chip Management System (CMS)** to the versatility of the IPT13 design. Breaks up long stringy chips, which eliminates recutting chips and chip packing, and allows for deep, free cutting tool movement in a variety of materials. The results are great chip control and very high metal removal rates.



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K P M S

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 1.0 CR	1.5 CR	3.0 CR
12	12	3	36	88	64502	64503	-
		3.5	42	93	64504	64505	-
16	16	2.5	40	100	64506	64507	-
		3	48	110	64508	64509	-
		3.5	56	110	64510	64511	-
20	20	2	40	104	64512	64513	64514
		2.5	50	115	64515	64516	64517
		3	60	125	64518	64519	64520
		3.5	70	135	64521	64522	64523

Note that the IPC13 is not designed for light-duty machines and should only be run in machines with adequate spindle torque and horsepower.

D = Tool Diameter

Inch sizes available upon request.

IPT13/IPC13 Application Guide - Speed & Feed

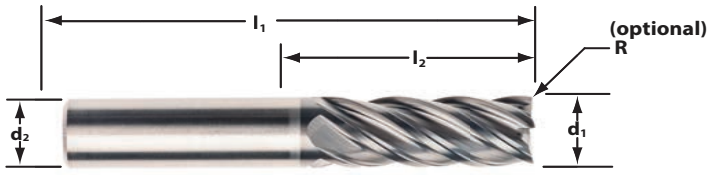
ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 12.0	16.0	20.0	25.0	32.0
K	Gray ASTM-A48 Class 20, 25, 30, 35 & 40	Peripheral - HEM	≤ 2 x D	.07 x D	13	113	.1080	.1436	.1793	.2160	.2808
		Peripheral - HEM	> 2 - 3 x D	.07 x D	13	113	.0960	.1277	.1593	.1920	.2496
		Peripheral - HEM	> 3 - 3.5 x D	.07 x D	13	110	.0816	.1085	.1354	.1632	.2121
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	13	110	.0720	.0958	.1195	.1440	.1872
		Finish	3 x D	.01 x D	13	111	.0480	.0638	.0797	.0960	.1248
	Cast Iron Malleable	Peripheral - HEM	≤ 2 x D	.07 x D	13	116	.1152	.1532	.1912	.2304	.2995
		Peripheral - HEM	> 2 - 3 x D	.07 x D	13	116	.1008	.1341	.1673	.2016	.2621
		Peripheral - HEM	> 3 - 3.5 x D	.07 x D	13	111	.0936	.1245	.1554	.1872	.2433
		Peripheral - HEM	> 3.5 - 4 x D	.07 x D	13	111	.0864	.1149	.1434	.1728	.2246
		Finish	3 x D	.01 x D	13	104	.0408	.0543	.0677	.0816	.1061
P	Low Carbon Steels ≤ 38 Rc 1018, 1020, 12L14, 5120, 8620	Peripheral - HEM	≤ 2 x D	.07 x D	13	137	.1056	.1404	.1753	.2112	.2745
		Peripheral - HEM	> 2 - 3 x D	.07 x D	13	131	.0936	.1245	.1554	.1872	.2433
		Peripheral - HEM	> 3 - 3.5 x D	.07 x D	13	128	.0864	.1149	.1434	.1728	.2246
		Peripheral - HEM	> 3.5 - 4 x D	.07 x D	13	125	.0816	.1085	.1354	.1632	.2121
		Finish	3 x D	.01 x D	13	120	.0408	.0543	.0677	.0816	.1061
	Medium Carbon Steels ≤ 48 HRC 1045, 4140, 4340, 5140	Peripheral - HEM	≤ 2 x D	.06 x D	13	123	.1056	.1404	.1753	.2112	.2745
		Peripheral - HEM	> 2 - 3 x D	.06 x D	13	123	.0984	.1309	.1633	.1968	.2558
		Peripheral - HEM	> 3 - 3.5 x D	.05 x D	13	123	.0936	.1245	.1554	.1872	.2433
		Peripheral - HEM	> 3.5 - 4 x D	.05 x D	13	123	.0864	.1149	.1434	.1728	.2246
		Finish	3 x D	.01 x D	13	113	.0408	.0543	.0677	.0816	.1061
	Tool and Die Steels ≤ 48 Rc A2, D2, O1, S7, P20, H13	Peripheral - HEM	≤ 2 x D	.06 x D	13	128	.1080	.1436	.1793	.2160	.2808
		Peripheral - HEM	> 2 - 3 x D	.06 x D	13	128	.0960	.1277	.1593	.1920	.2496
		Peripheral - HEM	> 3 - 3.5 x D	.05 x D	13	126	.0888	.1181	.1474	.1776	.2309
		Peripheral - HEM	> 3.5 - 4 x D	.05 x D	13	126	.0840	.1117	.1394	.1680	.2184
		Finish	3 x D	.01 x D	13	117	.0360	.0479	.0598	.0720	.0936
M	Martensitic & Ferritic Stainless Steels 410, 416, 440	Peripheral - HEM	≤ 2 x D	.06 x D	13	140	.0984	.1309	.1633	.1968	.2558
		Peripheral - HEM	> 2 - 3 x D	.06 x D	13	140	.0960	.1277	.1593	.1920	.2496
		Peripheral - HEM	> 3 - 3.5 x D	.06 x D	13	137	.0888	.1181	.1474	.1776	.2309
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	13	136	.0840	.1117	.1394	.1680	.2184
		Finish	3 x D	.01 x D	13	119	.0360	.0479	.0598	.0720	.0936
	Austenitic Stainless Steels, FeNi Alloys 303, 304, 316, Invar, Kovar	Peripheral - HEM	≤ 2 x D	.06 x D	13	137	.1200	.1596	.1992	.2400	.3120
		Peripheral - HEM	> 2 - 3 x D	.06 x D	13	137	.1152	.1532	.1912	.2304	.2995
		Peripheral - HEM	> 3 - 3.5 x D	.05 x D	13	137	.0960	.1277	.1593	.1920	.2496
		Peripheral - HEM	> 3.5 - 4 x D	.05 x D	13	136	.0840	.1117	.1394	.1680	.2184
		Finish	3 x D	.01 x D	13	126	.0432	.0575	.0717	.0864	.1123
	Precipitation Hardening Stainless Steels 17-4, 15-5	Peripheral - HEM	≤ 2 x D	.06 x D	13	134	.1080	.1436	.1793	.2160	.2808
		Peripheral - HEM	> 2 - 3 x D	.06 x D	13	134	.0984	.1309	.1633	.1968	.2558
		Peripheral - HEM	> 3 - 3.5 x D	.05 x D	13	133	.0912	.1213	.1514	.1824	.2371
		Peripheral - HEM	> 3.5 - 4 x D	.05 x D	13	133	.0816	.1085	.1354	.1632	.2121
		Finish	3 x D	.01 x D	13	122	.0408	.0543	.0677	.0816	.1061
S	Titanium Alloys 6Al-4V, 6-2-4	Peripheral - HEM	≤ 2 x D	.08 x D	13	120	.1200	.1596	.1992	.2400	.3120
		Peripheral - HEM	> 2 - 3 x D	.07 x D	13	119	.1080	.1436	.1793	.2160	.2808
		Peripheral - HEM	> 3 - 3.5 x D	.06 x D	13	116	.0984	.1309	.1633	.1968	.2558
		Peripheral - HEM	> 3.5 - 4 x D	.06 x D	13	116	.0816	.1085	.1354	.1632	.2121
		Finish	3 x D	.015 x D	13	108	.0528	.0702	.0876	.1056	.1373
	Difficult-to-Machine Titanium Alloys 10-2-3	Peripheral - HEM	≤ 2 x D	0.06	13	107	.1200	.1596	.1992	.2400	.3120
		Peripheral - HEM	> 2 - 3 x D	0.06	13	101	.0864	.1149	.1434	.1728	.2246
	Precipitation Hardening Stainless Steel M 13-8	Peripheral - HEM	> 3 - 3.5 x D	0.055	13	96	.0840	.1117	.1394	.1680	.2184
		Peripheral - HEM	> 3.5 - 4 x D	0.05	13	94	.0768	.1021	.1275	.1536	.1997
		Finish	3 x D	.01 x D	13	91	.0408	.0543	.0677	.0816	.1061
	Hastalloy, Waspalloy	Peripheral - HEM	≤ 2 x D	.07 X D	13	32	.1704	.2266	.2828	.3408	.4430
		Peripheral - HEM	> 2 - 3 x D	.065 x D	13	30	.1536	.2043	.2550	.3072	.3993
		Peripheral - HEM	> 3 - 3.5 x D	.055 x D	13	27	.1488	.1979	.2470	.2976	.3868
		Peripheral - HEM	> 3.5 - 4 x D	.05 x D	13	27	.1368	.1819	.2271	.2736	.3556
		Finish	3 x D	.01 x D	13	27	.1056	.1404	.1753	.2112	.2745
	Inconel 718, Rene 88	Peripheral - HEM	≤ 2 x D	.06 x D	13	30	.1248	.1660	.2072	.2496	.3245
		Peripheral - HEM	> 2 - 3 x D	.05 x D	13	29	.1248	.1660	.2072	.2496	.3245
		Peripheral - HEM	> 3 - 3.5 x D	.05 x D	13	29	.1152	.1532	.1912	.2304	.2995
		Peripheral - HEM	> 3.5 - 4 x D	.04 x D	13	29	.1152	.1532	.1912	.2304	.2995
		Finish	3 x D	.01 x D	13	27	.0552	.0734	.0916	.1104	.1435

D = Tool Diameter HEM = High-efficiency machining

≈ Approximately Equals
≤ Less Than or Equal To
≥ Greater Than or Equal To
× Multiply
< Less Than
> Greater Than
= Equals

APT5
POW•R•PATH

For high-efficiency machining (HEM) in aluminium alloys. The APT5 is the POW•R•PATH tool that takes the HEM tool paths that work very well in ferrous materials and applies them to aluminium alloys. Engineered with both a solid core for stability and chip evacuation space for high feed rates. The unique cutting edge design combined with 5-flutes and the extra durable coating generate incredibly high metal removal rates.



mm: *d1: -0.0025 / -0.0100 d2: -0.0025 / -0.0100*

N

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	2.0 CR	2.5 CR	3.0 CR	4.0 CR
6	6	2	12	57	61700	61701	61702	61703	-	-	-	-
		3	18	63	61704	61705	61706	61707	-	-	-	-
		4	24	75	61708	61709	61710	61711	-	-	-	-
8	8	2	16	58	61712	61713	61714	61715	-	-	-	-
		3	24	63	61716	61717	61718	61719	-	-	-	-
		4	32	75	61720	61721	61722	61723	-	-	-	-
10	10	2	20	66	61724	61725	61726	61727	61728	-	-	-
		3	30	75	61729	61730	61731	61732	61733	-	-	-
		4	40	88	61734	61735	61736	61737	61738	-	-	-
12	12	2	24	75	61739	61740	61741	61742	61743	61744	61745	-
		2.5	30	83	61746	61747	61748	61749	61750	61751	61752	-
		3	36	88	61753	61754	61755	61756	61757	61758	61759	-
		3.5	42	93	61760	61761	61762	61763	-	-	61764	-
		4	48	100	61765	61766	61767	61768	61769	61770	61771	-
16	16	2	32	92	61772	-	61773	61774	61775	61776	61777	61778
		3	48	110	61779	-	61780	61781	61782	61783	61784	-
		4	64	125	61785	-	61786	61787	61788	61789	61790	61791
20	20	2	40	104	61792	-	61793	61794	61795	61796	61797	61798
		2.5	50	115	61799	-	61800	61801	-	-	61802	-
		3	60	125	61803	-	61804	61805	61806	61807	61808	61809
		3.5	70	135	61810	-	61811	61812	-	-	61813	-
		4	80	150	61814	-	61815	61816	61817	61818	61819	61820

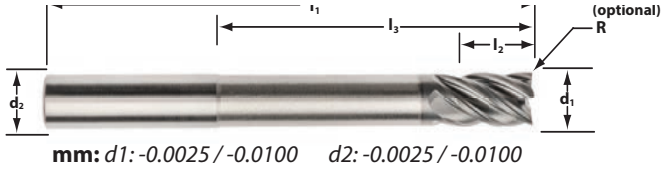
D = Tool Diameter

Inch sizes available upon request.

APT5N
POW•R•PATH

Z5 | SQ | CR | 35° | NECK | taC | PLAIN

For high-efficiency machining (HEM) in aluminium alloys. Adding a necked shank to the APT5 design offers a high-performance tool that permits clearance in deeper cavities and easier machining against tight walls. Neck relief and short to standard flute length combine to increase end mill stability in the cut for more precise tolerances. Great for work in pockets.



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N

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Reach LBS l3	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	2.0 CR	2.5 CR	3.0 CR	4.0 CR
6	6	9	26	63	61821	61822	61823	61824	-	-	-	-
			32	75	61825	61826	61827	61828	-	-	-	-
8	8	12	34	75	61829	61830	61831	61832	-	-	-	-
10	10	15	32	75	62211	62214	62215	62219	62223	-	-	-
			42	88	61833	61834	61835	61836	61837	-	-	-
			52	100	61838	61839	61840	61841	61842	-	-	-
12	12	18	38	88	61843	61844	61845	61846	61847	61848	61849	-
			50	100	61850	61851	61852	61853	61854	61855	61856	-
			62	125	62228	62229	62230	62231	62239	62244	62245	-
16	16	24	50	110	61857	-	61858	61859	61860	61861	61862	-
			66	125	61863	-	61864	61865	61866	61867	61868	-
			82	150	62246	-	62247	62251	62252	62253	62254	-
20	20	30	62	125	61869	-	61870	61871	61872	61873	61874	61875
			82	135	62255	-	62258	62259	62281	62286	62295	62298
			102	150	61876	-	61877	61878	61879	61880	61881	61882

Inch sizes available upon request.

TOOL TIP

AP5 - Pushing the limits of productivity.

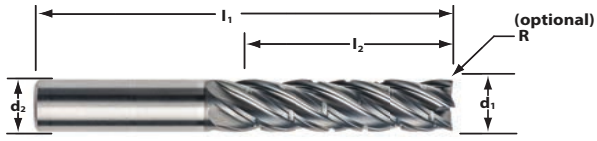
The APT5 and APC5 POW•R•PATH end mills bring the concept of HEM tool paths to machining aluminium alloys. The unique AP design cleaves through aluminium at very high metal removal rates without needing a lot of horsepower - making the AP end mills extremely versatile. Adding to the AP's versatility are:

- 5-flutes for excellent surface finishes.
- The taC coating that protects the cutting edges to ensure long tool life - even in high silicon aluminiums.
- Many corner radius options.
- The Chip Management System that stops chip pollution by breaking the aluminium chips into manageable lengths, eliminating chip packing and re-cutting chips.

APC5
POW•R•PATH

Z5 | SQ | CR | 35° | CMS | taC | PLAIN

For high-efficiency machining (HEM) in aluminium alloys. Adds the benefits of the unique **Chip Management System (CMS)** to the versatility of the APT5 design. Breaks up long stringy chips, which eliminates re-cutting chips and chip packing, and allows for deep, free cutting tool movement in aluminium. The results are great chip control and very high metal removal rates.



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N

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.5 CR	1.0 CR
10	10	3	30	75	61452	61453	-
		4	40	88	61454	61455	-
12	12	2.5	30	83	61456	-	61457
		3	36	88	61458	-	61459
		3.5	42	93	61460	-	61461
		4	48	100	61462	-	61463
16	16	2	32	92	61464	-	61465
		3	48	110	61466	-	61467
		4	64	125	61468	-	61469
20	20	2	40	104	61470	-	61471
		2.5	50	115	61472	-	61473
		3	60	125	61474	-	61475
		3.5	70	135	61476	-	61477
		4	80	150	61478	-	61479

D = Tool Diameter

Inch sizes available upon request.

APT5/APC5 Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 10.0	12.0	16.0	20.0
N	Aluminium Alloys 6061, 7075, 2024	Slotting	1 x D	1 x D	5	183	.0598	.0720	.0958	.1195
		Peripheral - HEM	≤ 2 x D	.25 x D	5	259	.1992	.2400	.3192	.3984
		Peripheral - HEM	> 2 - 2.5 x D	.25 x D	5	244	.1992	.2400	.3192	.3984
		Peripheral - HEM	> 2.5 - 3 x D	.25 x D	5	244	.1992	.2400	.3192	.3984
		Peripheral - HEM	> 3 - 3.5 x D	.25 x D	5	244	.1892	.2280	.3032	.3784
		Peripheral - HEM	> 3.5 - 4 x D	.20 x D	5	238	.1892	.2280	.3032	.3784
		Peripheral - Rough	≤ 2 x D	.45 x D	5	305	.0956	.1152	.1532	.1912
		Peripheral - Rough	> 2 - 3 x D	.375 x D	5	274	.0916	.1104	.1468	.1832
		Peripheral - Rough	> 3 - 4 x D	.35 x D	5	244	.0896	.1080	.1436	.1793
		Finish	≤ 4 x D	.01 x D	5	198	.0598	.0720	.0958	.1195

D = Tool Diameter

Common Machining Formulas

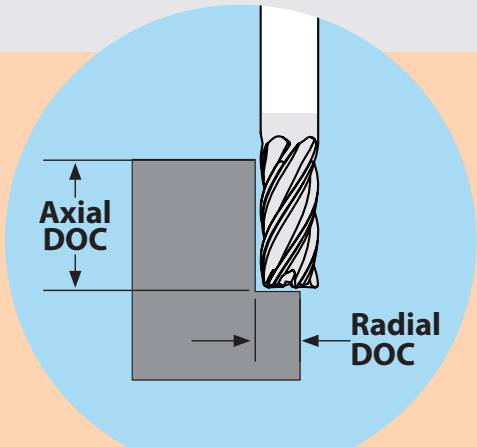
$$RPM = \frac{M/min \times 318.3}{D}$$

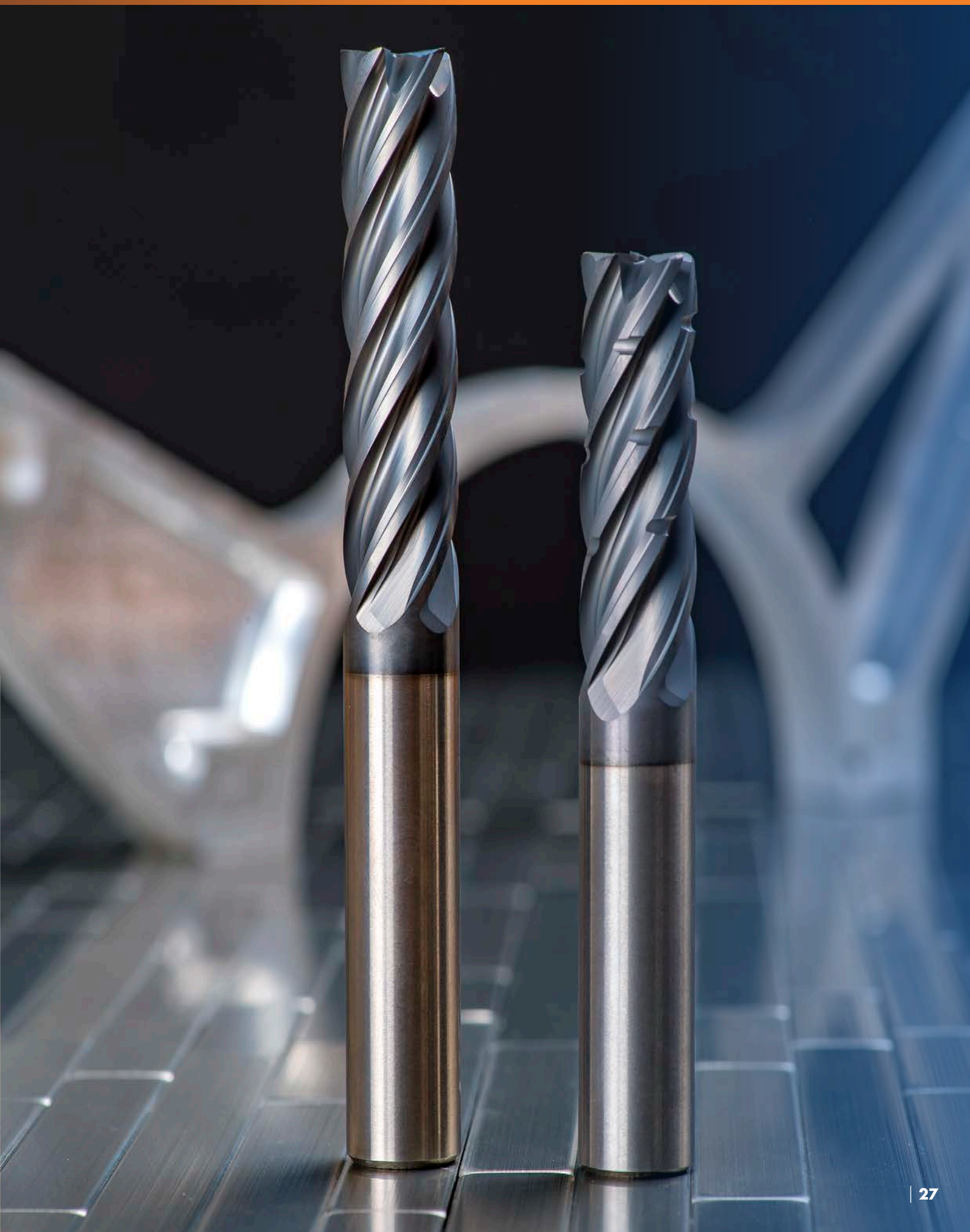
$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$

D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut





enDURO

MUSCLE TO HUSTLE IN TITANIUM AND STAINLESS STEELS

Advanced high-shear cutting edges and amazing corner strength make enDURO end mills the best choice for milling hard-to-machine materials, whether you use high-efficiency machining or traditional techniques.

M5 Series Features

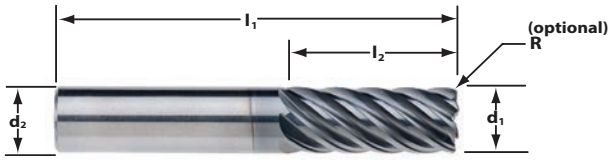
MUSCLE TO THE HUSTLE.

Truly a "go-to" tool for a wide range of applications, the enDURO is the ultimate combination of strength and flexibility. A solid core, reinforced cutting edges, variable indexed flutes, and an advanced coating all come together in the M525 and M527 series to create an "everyday" high-performance end mill that excels in both traditional and high-efficiency milling tool paths.

		NUMBER OF FLUTES	END TYPES	HELIX ANGLE	COATING	SHANK TYPES	APPLICATION(S)
M527	 K P M S	Z7	SQ CR	40°	AlCrNX	PLAIN	HEM ROUGH FINISH
M527N	 K P M S	Z7	CR	40°	AlCrNX	PLAIN NECK	HEM ROUGH FINISH
M525	 K P M S	Z5	SQ CR	40°	AlCrNX	PLAIN	HEM ROUGH FINISH
M525C	 K P M S	Z5	SQ CR	40°	AlCrNX	PLAIN	HEM ROUGH
M525N	 K P M S	Z5	SQ CR BN	40°	AlCrNX	PLAIN NECK	HEM FINISH

M527 enDURO

For high-performance machining in materials ranging from low carbon steels to titanium. The M527 takes the best features of the M525 and adds two cutting edges to improve metal removal rates – especially in HEM tool paths – without losing any versatility. The seven cutting edges also makes the M527 an excellent choice for finishing applications.



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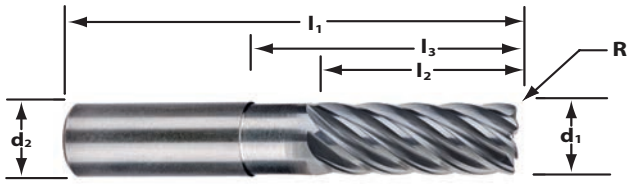
K P M S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR	4.0 CR
10	10	22	72	66440	66441	66442	66443			
12	12	26	83	66448	66449	66450	66451			
		32	83		66575	66576	66577	66578	66579	66580
16	16	34	92	66460	66461	66462	66463			
		42	92		66581	66582		66583	66584	66585
20	20	42	104	66472	66473	66474	66475			
		52	104		66586	66587		66588	66589	66590

Inch sizes available upon request.

M527N

For high-performance machining in materials ranging from low carbon steels to titanium. Adding a necked shank to the M527 design offers a high performance tool that permits clearance in deeper cavities and easier machining against tight walls. Neck relief and short to standard flute length combine to increase end mill stability in the cut for more precise tolerances. Great for work in pockets.



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K P M S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Reach LBS	Overall Length l1	Order Code by Corner Radius 0.5 CR	1.0 CR	3.0 CR
12	12	26	55	100	66591	66592	66593
16	16	34	75	125	66594	66595	66596
20	20	42	100	150	66597	66598	66599

Inch sizes available upon request.

M527 Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 10.0	12.0	16.0	20.0	25.0
K	Cast Iron Gray	Slotting	.5 x D	1 x D	7	91	.0353	.0425	.0566	.0706	.0850
		Peripheral - Rough	1.25 x D	.3 x D	7	114	.0467	.0563	.0749	.0935	.1126
		Finish	2 x D	.015 x D	7	137	.0476	.0573	.0762	.0951	.1146
	Cast Iron	Slotting	.5 x D	1 x D	7	84	.0285	.0343	.0456	.0569	.0686
		Peripheral - Rough	1.25 x D	.3 x D	7	107	.0388	.0468	.0622	.0776	.0935
		Peripheral - HEM*	3 x D	.05 x D	7	119	.1133	.1365	.1816	.2266	.2730
		Finish	2 x D	.015 x D	7	107	.0395	.0476	.0633	.0790	.0952
P	Low Carbon Steels ≤ 38 Rc 1018, 1020, 12L14, 5120, 8620	Slotting	.5 x D	1 x D	7	99	.0398	.0480	.0638	.0797	.0960
		Peripheral - Rough	1.25 x D	.3 x D	7	122	.0543	.0655	.0871	.1087	.1309
		Peripheral - HEM*	3 x D	.05 x D	7	137	.1743	.2100	.2793	.3486	.4200
		Finish	2 x	.015 x D	7	122	.0553	.0666	.0886	.1106	.1333
	Medium Carbon Steels ≤ 48 HRC 1045, 4140, 4340, 5140	Slotting	.5 x D	1 x D	7	91	.0364	.0439	.0584	.0729	.0878
		Peripheral - Rough	1.25 x D	.3 x D	7	114	.0497	.0599	.0796	.0994	.1197
		Peripheral - HEM*	3 x D	.05 x D	7	126	.1708	.2058	.2737	.3417	.4116
		Finish	2 x D	.015 x D	7	114	.0506	.0609	.0810	.1011	.1219
	Tool and Die Steels ≤ 48 Rc A2, D2, O1, S7, P20, H13	Slotting	.5 x D	1 x D	7	84	.0307	.0370	.0493	.0615	.0741
		Peripheral - Rough	1.25 x D	.3 x D	7	107	.0419	.0505	.0672	.0838	.1010
		Peripheral - HEM*	3 x D	.05 x D	7	119	.1464	.1764	.2346	.2929	.3528
		Finish	2 x D	.015 x D	7	107	.0427	.0514	.0684	.0853	.1028
M	Martensitic & Ferritic Stainless Steels 410, 416, 440	Slotting	.5 x D	1 x D	7	91	.0364	.0439	.0584	.0729	.0878
		Peripheral - Rough	1.25 x D	.3 x D	7	114	.0497	.0599	.0796	.0994	.1197
		Peripheral - HEM*	3 x D	.05 x D	7	126	.1708	.2058	.2737	.3417	.4116
		Finish	2 x D	.015 x D	7	114	.0506	.0609	.0810	.1011	.1219
	Austenitic Stainless Steels, FeNi Alloys 303, 304, 316, Invar, Kovar	Slotting	.5 x D	1 x D	7	84	.0341	.0411	.0547	.0683	.0823
		Peripheral - Rough	1.25 x D	.3 x D	7	107	.0466	.0561	.0746	.0931	.1122
		Peripheral - HEM*	3 x D	.05 x D	7	119	.1660	.2000	.2660	.3320	.4000
		Finish	2 x D	.015 x D	7	107	.0474	.0571	.0760	.0948	.1142
	Precipitation Hardening Stainless Steels 17-4, 15-5	Slotting	.5 x D	1 x D	7	76	.0285	.0343	.0456	.0569	.0686
		Peripheral - Rough	1.25 x D	.3 x D	7	99	.0388	.0468	.0622	.0776	.0935
		Peripheral - HEM*	3 x D	.05 x D	7	110	.1328	.1600	.2128	.2656	.3200
		Finish	1.5 x D	.015 x D	7	99	.0395	.0476	.0633	.0790	.0952
S	Titanium Alloys 6Al-4V, 6-2-4	Slotting	.5 x D	1 x D	7	76	.0262	.0315	.0420	.0524	.0631
		Peripheral - Rough	1 x D	.3 x D	7	91	.0357	.0430	.0572	.0714	.0860
		Peripheral - HEM*	3 x D	.05 x D	7	101	.1257	.1515	.2015	.2515	.3030
		Finish	1.5 x D	.015 x D	7	91	.0363	.0438	.0582	.0727	.0876
	Difficult-to-Machine Titanium Alloys 10-2-3 Precipitation Hardening Stainless Steels M 13-8	Slotting	.25 x D	1 x D	7	61	.0193	.0233	.0310	.0387	.0466
		Peripheral - Rough	1 x D	.25 x D	7	76	.0279	.0336	.0447	.0558	.0673
		Peripheral - HEM*	3 x D	.05 x D	7	84	.0975	.1175	.1563	.1950	.2350
		Finish	1.5 x D	.01 x D	7	76	.0328	.0395	.0526	.0656	.0791

D = Tool Diameter *HEM = High-efficiency machining (chip thinning calculations have already been applied to HEM parameters shown)

≈ Approximately Equals
≤ Less Than or Equal To
≥ Greater Than or Equal To
× Multiply
< Less Than
> Greater Than
= Equals

Common Machining Formulas

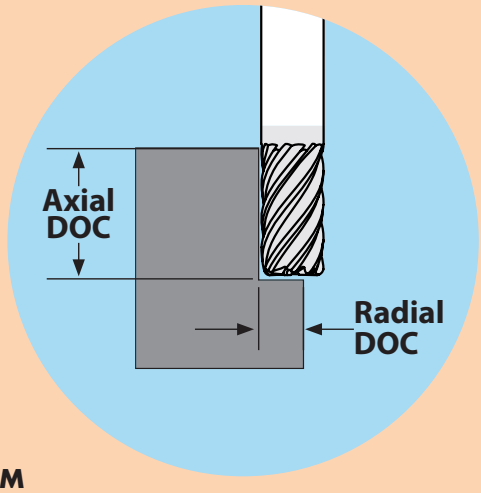
D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$



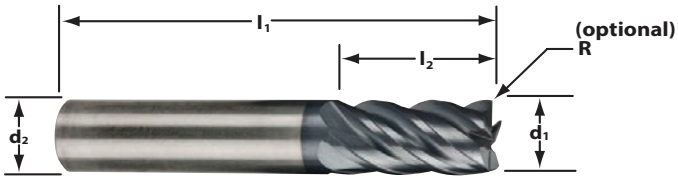
Technical Resources

Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

M525 enDURO

For high-performance machining in materials ranging from low carbon steels to titanium. Engineered for both speed and tool life, the M525 series is extremely versatile – it optimizes tool performance in many materials and in many application environments – from short runs in job shops to long production runs.



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K P M S

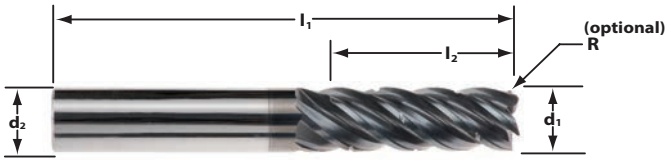
Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.5 CR	0.75 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR	4.0 CR	5.0 CR
6	6	10	54	-	66825	-	-	-	-	-	-	-
		13	57	66655	66656	-	66658	66659	-	-	-	-
		25	75	66826	66828	-	66829	-	-	-	-	-
8	8	12	58	-	66830	-	-	-	-	-	-	-
		19	63	66660	66661	-	66663	66664	-	-	-	-
		32	75	66831	66832	-	66833	-	-	-	-	-
10	10	14	66	-	-	-	66834	-	-	-	-	-
		22	72	66665	66666	-	66668	66669	66670	-	-	-
		40	88	66836	66837	-	66838	66839	66840	-	-	-
12	12	16	73	-	-	-	66841	-	-	-	-	-
		26	83	66671	66672	66673	66674	66675	66676	66677	-	-
		50	100	66870	-	66871	66872	66873	66844	66845	-	-
		75	150	66874	-	66875	66876	66877	-	-	-	-
16	16	22	82	-	-	-	66846	-	-	-	-	-
		32	92	66678	-	66679	66680	66681	66682	66683	66684	-
		55	110	66878	-	66879	66880	66881	66847	66848	-	-
		75	150	66882	-	66883	66884	66885	-	-	-	-
20	20	26	92	-	-	-	66849	-	-	-	-	-
		38	104	66685	-	-	66687	66688	66689	66690	66691	66692
		65	125	66886	-	-	66888	66889	66850	66852	-	-
		85	150	66890	-	-	66892	66893	66853	66854	-	-
25	25	45	120	66693	-	-	66695	66696	66697	66698	66699	66700
		85	150	66894	-	-	66896	66897	66855	66856	66857	-

Inch sizes available upon request.

M525C enDURO

Z5 | SQ | CR | 40° | CMS | AlCrNX | PLAIN

For high-performance machining in materials ranging from low carbon steels to titanium. Adds the benefits of the unique **Chip Management System (CMS)** to the versatility of the M525 design. Breaks up long stringy chips, which eliminates recutting chips and chip packing, and allows for free cutting tool movement in a variety of materials.



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K P M S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.75 CR	1.0 CR	1.5 CR
12	12	50	100	66900	66901	66902	66903
		75	150	66904	66905	66906	66907
16	16	55	110	66908	66909	66910	66911
		75	150	66912	66913	66914	66915
20	20	65	125	66916	-	66918	66919
		85	150	66920	-	66922	66923
25	25	55	120	66924	-	66926	66927
		85	150	66928	-	66930	66931

Inch sizes available upon request.

TOOL TIP

Chip Management System: Stop Chip Pollution

Controlling chip size and clearing the chips from the cutting zone is important when machining in all tool paths, but it becomes critical in traditional slotting and when using HEM paths. IMCO's Chip Management System (CMS) is a unique design of edge treatment that breaks materials into smaller, more manageable chips. CMS helps improve the effectiveness of the coolant or air blasts in evacuating the chips from the cutting zone, preventing chip packing and recutting – improving tool life and performance.

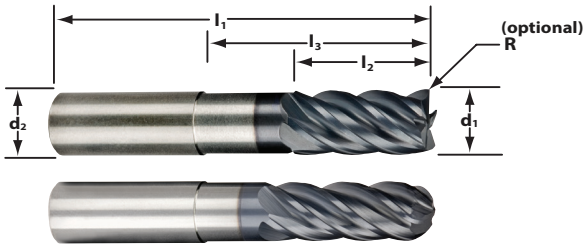
Chip pollution caused by a non-CMS tool. ▶

M525N enDURO

Z5 | SQ | CR | BN | 40° | NECK | AlCrNX | PLAIN

For high-performance machining in materials ranging from low carbon steels to titanium. Adding a necked shank to the M525 design offers a high performance tool that permits clearance in deeper cavities and easier machining against tight walls. Neck relief and short to standard flute length combine to increase end mill stability in the cut for more precise tolerances. Great for work in pockets.

K P M S



mm: *d1: +0.000 / -0.050* *d2: -0.0025 / -0.0100*

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Reach LBS l3	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR	Order Code BN
6	6	8	27	63	66701	66835	66843	66851	-	-	66802
			39	75	66706	66859	66867	66702	-	-	66804
			64	100	66711	66703	66704	66705	-	-	66805
8	8	10	27	63	66716	66707	66708	66709	-	-	66806
			39	75	66721	66710	66712	66713	-	-	66807
			64	100	66727	66714	66715	66717	-	-	66808
10	10	12	32	72	66733	66718	66719	66720	-	-	66809
			60	100	66740	66723	66724	66725	-	-	66810
12	12	15	38	83	66754	66732	66734	66735	66736	66737	66813
			55	100	66761	66738	66739	66741	66742	66743	66814
			80	125	66768	66744	66745	66746	66748	66749	66815
			105	150	66775	66750	66751	66752	66753	66755	66816
16	16	20	62	110	66782	-	66756	66757	66758	66759	66817
			102	150	66789	-	66762	66763	66764	66765	66818
20	20	25	75	125	66803	-	66774	66776	66777	66778	66821
			100	150	66811	-	66781	66783	66784	66785	66822
25	25	32	64	120	66819	-	66788	66790	66791	66792	-
			94	150	66827	-	66795	66797	66798	66799	-

Inch sizes available upon request.

M525 Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 6,0	8,0	10,0	12,0	16,0	20,0	25,0
K	Cast Iron Gray ASTM-A48 Class 20, 25, 30, 35 & 40	Slotting	.5 x D	1 x D	5	91	.0288	.0384	.0478	.0576	.0766	.0956	.1152
		Peripheral - Rough	1.25 x D	.3 x D	5	114	.0393	.0524	.0652	.0786	.1045	.1304	.1571
		Finish	2 x D	.015 x D	5	114	.0400	.0533	.0664	.0800	.1063	.1327	.1599
	Cast Iron Malleable	Slotting	.5 x D	1 x D	5	84	.0240	.0320	.0398	.0480	.0638	.0797	.0960
		Peripheral - Rough	1.25 x D	.3 x D	5	107	.0327	.0436	.0543	.0655	.0871	.1087	.1309
		Peripheral - HEM*	3 x D	.05 x D	5	119	.0966	.1288	.1604	.1932	.2570	.3207	.3864
		Finish	2 x D	.015 x D	5	107	.0333	.0444	.0553	.0666	.0886	.1106	.1333
P	Low Carbon Steels ≤ 38 Rc 1018, 1020, 12L14, 5120, 8620	Slotting	.5 x D	1 x D	5	99	.0336	.0448	.0558	.0672	.0894	.1115	.1344
		Peripheral - Rough	1.25 x D	.3 x D	5	122	.0458	.0611	.0761	.0916	.1219	.1521	.1833
		Peripheral - HEM*	3 x D	.07 x D	5	137	.1344	.1792	.2231	.2688	.3575	.4463	.5377
		Finish	2 x	.015 x D	5	122	.0466	.0622	.0774	.0933	.1241	.1549	.1866
	Medium Carbon Steels ≤ 48 HRC 1045, 4140, 4340, 5140	Slotting	.5 x D	1 x D	5	91	.0307	.0410	.0510	.0614	.0817	.1020	.1229
		Peripheral - Rough	1.25 x D	.3 x D	5	114	.0419	.0559	.0695	.0838	.1114	.1391	.1676
		Peripheral - HEM*	3 x D	.05 x D	5	126	.1239	.1652	.2057	.2478	.3296	.4114	.4957
		Finish	2 x D	.015 x D	5	114	.0426	.0569	.0708	.0853	.1134	.1416	.1706
	Tool and Die Steels ≤ 48 Rc A2, D2, O1, S7, P20, H13	Slotting	.5 x D	1 x D	5	84	.0259	.0346	.0430	.0518	.0689	.0860	.1037
		Peripheral - Rough	1.25 x D	.3 x D	5	107	.0353	.0471	.0587	.0707	.0940	.1174	.1414
		Peripheral - HEM*	3 x D	.05 x D	5	119	.1040	.1386	.1726	.2079	.2765	.3452	.4158
		Finish	2 x D	.015 x D	5	107	.0360	.0480	.0597	.0720	.0957	.1195	.1439
M	Martensitic & Ferritic Stainless Steels 410, 416, 440	Slotting	.5 x D	1 x D	5	91	.0307	.0410	.0510	.0614	.0817	.1020	.1229
		Peripheral - Rough	1.25 x D	.3 x D	5	114	.0419	.0559	.0695	.0838	.1114	.1391	.1676
		Peripheral - HEM*	3 x D	.05 x D	5	126	.1239	.1652	.2057	.2478	.3296	.4114	.4957
		Finish	2 x D	.015 x D	5	114	.0426	.0569	.0708	.0853	.1134	.1416	.1706
	Austenitic Stainless Steels, FeNi Alloys 303, 304, 316, Invar, Kovar	Slotting	.5 x D	1 x D	5	84	.0288	.0384	.0478	.0576	.0766	.0956	.1152
		Peripheral - Rough	1.25 x D	.3 x D	5	107	.0393	.0524	.0652	.0786	.1045	.1304	.1571
		Peripheral - HEM*	3 x D	.05 x D	5	119	.1185	.1580	.1967	.2370	.3152	.3934	.4740
		Finish	2 x D	.015 x D	5	107	.0400	.0533	.0664	.0800	.1063	.1327	.1599
	Precipitation Hardening Stainless Steels 17-4, 15-5	Slotting	.5 x D	1 x D	5	76	.0240	.0320	.0398	.0480	.0638	.0797	.0960
		Peripheral - Rough	1.25 x D	.3 x D	5	99	.0327	.0436	.0543	.0655	.0871	.1087	.1309
		Peripheral - HEM*	3 x D	.05 x D	5	110	.0950	.1267	.1577	.1900	.2527	.3154	.3800
		Finish	1.5 x D	.015 x D	5	99	.0333	.0444	.0553	.0666	.0886	.1106	.1333
S	Titanium Alloys 6Al-4V, 6-2-4	Slotting	.5 x D	1 x D	5	76	.0221	.0294	.0366	.0442	.0587	.0733	.0883
		Peripheral - Rough	1 x D	.3 x D	5	91	.0301	.0401	.0500	.0602	.0801	.1000	.1204
		Peripheral - HEM*	3 x D	.05 x D	5	101	.0875	.1167	.1452	.1750	.2327	.2905	.3500
		Finish	1.5 x D	.015 x D	5	91	.0307	.0409	.0509	.0613	.0815	.1018	.1226
	Difficult-to-Machine Titanium Alloys 10-2-3 Precipitation Hardening Stainless Steels M 13-8	Slotting	.25 x D	1 x D	5	61	.0163	.0218	.0271	.0326	.0434	.0542	.0653
		Peripheral - Rough	1 x D	.25 x D	5	76	.0236	.0314	.0391	.0471	.0627	.0782	.0942
		Peripheral - HEM*	3 x D	.05 x D	5	84	.0712	.0950	.1183	.1425	.1895	.2365	.2850
		Finish	1.5 x D	.01 x D	5	76	.0277	.0369	.0459	.0554	.0736	.0919	.1107

D = Tool Diameter *HEM= High-efficiency machining (chip thinning calculations have already been applied to HEM parameters shown)

≈ Approximately Equals < Less Than
≤ Less Than or Equal To > Greater Than
≥ Greater Than or Equal To = Equals
× Multiply

Common Machining Formulas

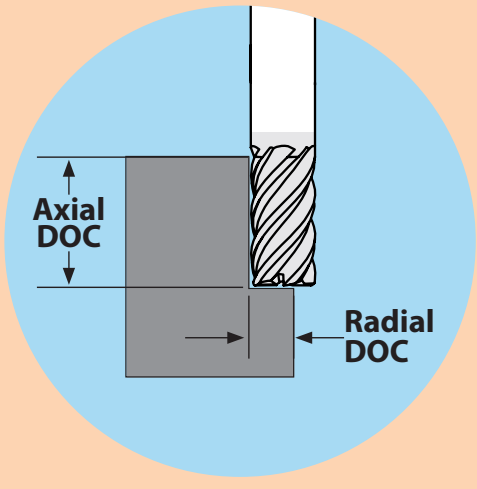
D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$



Technical Resources

Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

OMEGA-6

PERFORMANCE TO THE SIXTH POWER.

The Omega-6 end mill demonstrates remarkably longer tool life in hardened steels, even up to 58-62 HRC, running wet or dry. This tool excels in hardened materials, and it provides superior finishes in a wide range on non-hardened materials.

M7 Series Features

HARD CORE FOR HARD WORK.

The Omega-6 is a purpose-driven end mill for machining in hard metal applications. Available in both the second (M725/726) and first (M706) generations. Engineered with strong cutting edges and a thick core for long tool life when machining steels up to 62 HRC. Heat resistant coating yields great tool performance in both wet and dry machining conditions. An excellent tool for finishing applications in a wide range of materials.

		NUMBER OF FLUTES	END TYPES	HELIX ANGLE	COATING	SHANK TYPES	APPLICATION(S)
M725		Z5	SQ CR	50°	AlTiNX	PLAIN	ROUGH FINISH
M726		Z6	SQ CR	50°	AlTiNX	PLAIN	ROUGH FINISH
M726N		Z6	CR	50°	AlTiNX	PLAIN NECK	ROUGH FINISH

TOOL TIP

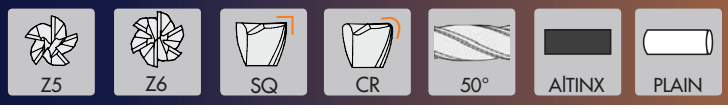
OMEGA-6:
MAX Heat. MAX Hardness. MAX Performance.

Some tools are just made for tough cutting conditions. The M7 series of end mills are that kind of tool. The Omega-6 is designed for hard milling in dry conditions — something that makes many tools have a meltdown.

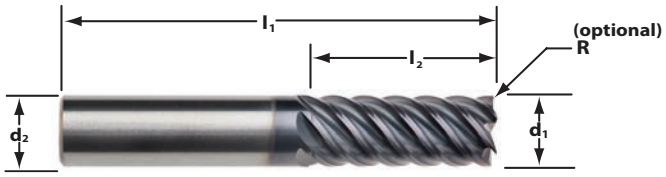
High-shear cutting action, reinforced cutting edges, and a heat-resistant coating combine to allow Omega-6 end mills to machine hardened tool steels with just an air blast – without sacrificing tool life – making it great for machining new molds or repairing used ones.

M7 tools are also versatile – they can run wet or dry – giving you the option of what best fits your shop. Omega-6 can also generate a great finish in a wide variety of materials.

M725/M726 OMEGA-6



For hardened steels and general finishing applications. The second generation of the Omega-6 end mill. The unique design of the M725/726 series uses a high strength core, reinforced cutting edges, and a heat resistant coating to yield long tool life in difficult machining conditions. Best when hard milling up to 62 HRC and when finishing in a wide range of materials.



mm: *d1: +0.000 / -0.050* *d2: -0.0025 / -0.0100*

K P M S

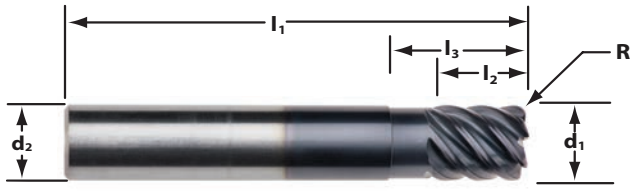
Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Number of Flutes	Order Code SQ	Order Code by Corner Radius 0.3 CR	0.5 CR	1.0 CR	1.5 CR
3	3	6	38	5	69138	69139	-	-	-
		8	38	5	69140	69141	-	-	-
4	4	7	50	5	69142	69143	-	-	-
		11	50	5	69144	69145	-	-	-
5	5	8	50	5	69146	69147	-	-	-
		13	50	5	69148	69149	-	-	-
6	6	13	57	6	69150	-	69151	-	-
		25	75	6	69152	-	69153	-	-
8	8	19	63	6	69154	-	69155	-	-
		32	75	6	69156	-	69157	-	-
10	10	22	72	6	69158	-	69159	69160	-
		40	88	6	69161	-	69162	69163	-
		46	100	6	69164	-	69165	69166	-
12	12	26	83	6	69167	-	69168	69169	69170
		50	100	6	69171	-	69172	69173	69174
		65	125	6	69175	-	69176	69177	69178
16	16	32	92	6	69179	-	-	69181	69182
		55	110	6	69183	-	-	69185	69186
		65	125	6	69187	-	-	69189	69190
20	20	38	104	6	69191	-	-	69193	69194
		65	125	6	69195	-	-	69197	69198
		85	150	6	69199	-	-	69201	69202

Inch sizes available upon request.

M726N OMEGA-6

Z6 | CR | 50° | NECK | AlTiNx | PLAIN

For hardened steels and general finishing applications. Adding a necked shank to the M726 design offers a high performance tool that permits clearance in deeper cavities and easier machining against tight walls. Neck relief and short to standard flute length combine to increase end mill stability in the cut for more precise tolerances. Great for work in pockets.



mm: *d1: +0.000 / -0.050* *d2: -0.0025 / -0.0100*

K P M S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Reach LBS l3	Overall Length l1	Number of Flutes	Order Code by Corner Radius 0.5 CR	1.0 CR
6	6	9	15	57	6	69421	-
		15	39	75	6	69557	-
		15	64	100	6	69559	-
8	8	11	17	63	6	69427	-
		19	39	75	6	69563	-
		19	64	100	6	69565	-
10	10	13	32	72	6	69567	-
		23	48	88	6	69570	-
		23	60	100	6	69573	-
12	12	15	38	83	6	-	69577
		27	55	100	6	-	69581
		27	80	125	6	-	69585
16	16	20	44	92	6	-	69589
		35	62	110	6	-	69593
		35	77	125	6	-	69597
20	20	24	54	104	6	-	69601
		43	75	125	6	-	69605
		43	100	150	6	-	69609

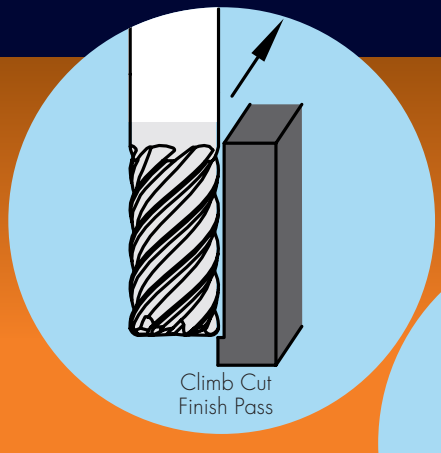
Inch sizes available upon request.

TOOL TIP

Eliminate wall taper when finishing

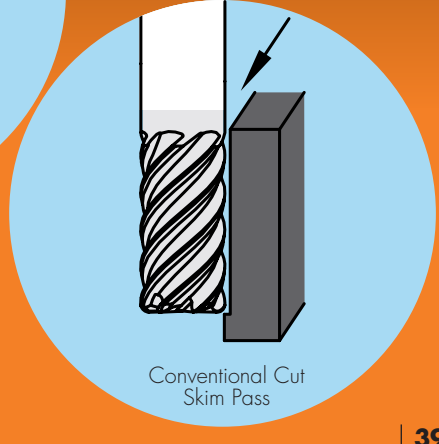
Step 1

Run finish pass using speed, feed, step-over (RDOC) and depth of cut (ADOC) values shown in the speed and feed charts.



Step 2

Re-run the finish pass using the same speeds and feeds but in the CONVENTIONAL direction. Simply retrace the prior finish pass – do not program to remove more stock. This skim pass will help eliminate taper caused by tool deflection during the first finish pass.



M725/M726 Series Application Guide - Speed & Feed

ISO Code	Number of Flutes	Type of Cut	Tool Dia.	Axial Max	Radial Max	Speed (M/Min)	RPM	MMPT	MM/Min
H 51 HRC–63 HRC	5	Roughing	3.0	3.0	.18	106	11,318	.0089	5039
		Roughing < 10,000		3.0	.18	94	9,973	.0089	443
		Finishing		6.0	.025	91	9,701	.0075	363
	5	Roughing	4.0	4.0	.275	64	5,093	.0180	458
		Finishing		8.0	.032	91	7,241	.0097	351
	6	Roughing	5.0	5.0	.345	80	5,093	.0200	509
		Finishing		10.0	.050	91	5,793	.0107	309
	6	Roughing	6.0	6.0	.380	122	6,472	.0254	986
		Finishing		12.0	.050	91	4,828	.0127	367
	6	Roughing	8.0	8.0	.558	121	4,814	.0330	953
		Finishing		16.0	.050	91	3,621	.0152	330
	6	Roughing	10.0	10.0	.800	121	3,851	.0400	924
		Finishing		20.0	.076	91	2,897	.0200	347
	6	Roughing	12.0	12.0	.960	121	3,210	.0480	924
		Finishing		24.0	.076	91	2,414	.0240	347
	6	Roughing	16.0	16.0	1.270	121	2,407	.0635	917
		Finishing		32.0	.127	91	1,810	.0330	358
	6	Roughing	20.0	20.0	1.524	121	1,926	.0760	878
		Finishing		40.0	.127	91	1,448	.0380	330
K H 43 HRC–50 HRC	5	Roughing	3.0	3.0	.254	152	16,127	.0152	1225
		Roughing < 10,000		3.0	.254	94	9,973	.0152	758
		Finishing		6.0	.025	121	12,838	.0076	487
		Finishing < 10,000		6.0	.025	94	9,973	.0076	379
	5	Rough	4.0	4.0	.320	152	12,095	.0192	1161
		Rough < 10,000		4.0	.320	125	9,947	.0192	954
		Finish		8.0	.025	121	9,629	.0103	495
	6	Roughing	5.0	5.0	.400	152	9,676	.0239	1156
		Finishing		10.0	.040	121	7,703	.0132	508
	6	Roughing	6.0	6.0	.480	152	8,064	.0305	1475
		Finishing		12.0	.075	121	6,419	.0170	654
	6	Roughing	8.0	8.0	.640	152	6,048	.0355	1288
		Finishing		16.0	.080	121	4,814	.0175	505
	6	Roughing	10.0	10.0	.800	152	4,838	.0453	1315
		Finishing		20.0	.130	121	3,851	.0266	614
	6	Roughing	12.0	12.0	.970	152	4,032	.0552	1335
		Finishing		24.0	.180	121	3,210	.0336	647
	6	Roughing	16.0	16.0	1.280	152	3,024	.0736	1335
		Finishing		32.0	.200	121	2,407	.0455	657
	6	Roughing	20.0	20.0	1.600	152	2,419	.0863	1252
		Finishing		40.0	.230	121	1,926	.0508	587
P M 36 HRC–42 HRC	5	Roughing	3.0	3.0	.240	182	19,310	.0254	2452
		Roughing < 10,000		3.0	.240	94	9,973	.0254	1266
		Finishing		6.0	.038	137	14,536	.0127	923
		Finishing < 10,000		6.0	.038	94	9,973	.0127	633
	5	Roughing	4.0	4.0	.320	182	14,483	.0280	2027
		Roughing < 10,000		4.0	.320	125	9,947	.0280	1392
		Finishing		8.0	.043	125	9,947	.0170	845
	6	Roughing	5.0	5.0	.400	182	11,586	.0345	1998
		Roughing < 10,000		5.0	.400	157	9,995	.0345	1724
		Finishing		10.0	.053	137	8,721	.0212	924
	6	Roughing	6.0	6.0	.600	183	9,708	.0510	2970
		Finishing		12.0	.076	152	8,064	.0254	1228
	6	Roughing	8.0	8.0	.800	183	7,281	.0635	2774
		Finishing		16.0	.076	152	6,048	.0330	1197
	6	Roughing	10.0	10.0	1.000	183	5,825	.0800	2795
		Finishing		20.0	.076	152	4,838	.0400	1161
	6	Roughing	12.0	12.0	1.200	183	4,854	.0960	2795
		Finishing		24.0	120	152	4,032	.0480	1161
	6	Roughing	16.0	16.0	1.600	183	3,641	.1270	2774
		Finishing		32.0	.127	152	3,024	.0635	1152
	6	Roughing	20.0	20.0	2.000	183	2,912	.1524	2663
		Finishing		40.0	.127	152	2,419	.0762	1106

INCONEX

WORK EXTRA LONG IN EXTRA DIFFICULT METALS.

The INCONEX M8 end mills are designed specifically for higher productivity in all hi-temp alloys. Optimized geometries, advanced chip management and proven performance. INCONEX M8 end mills are the best choice for success in difficult-to-machine metals.

M8 Series Features

WORK EXTRA LONG IN EXTRA DIFFICULT MATERIALS.

Engineered to meet the challenge of machining hi-temp alloys, the M806 series includes features made specifically with tool life in mind. Great for roughing cuts when using traditional tool paths.

		NUMBER OF FLUTES	END TYPES	HELIX ANGLE	COATING	SHANK TYPES	APPLICATION(S)
M806	 S	Z6	CR	30°	AlCrNX	PLAIN WELDON	ROUGH
M806N	 S	Z6	CR	30°	AlCrNX	PLAIN NECK	ROUGH

TOOL TIP

INCONEX:
Going the Extra Mile in Hi-Temp Alloys.

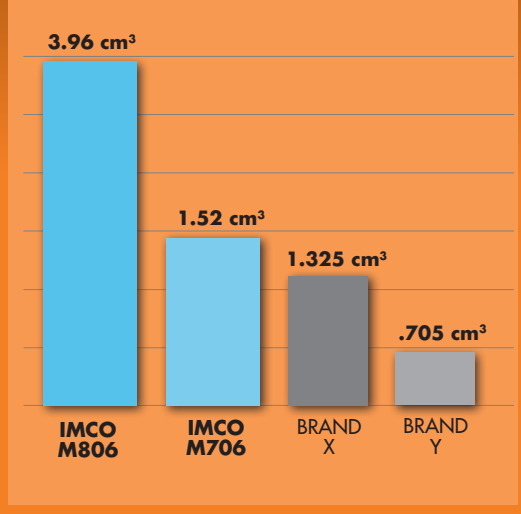
In tool development tests against our own tool (M706) and the leading competitors' products for hi-temp alloys, the INCONEX far outlasted all challengers in tool life.

Using our competitors' suggested speeds and feeds (80 SFM at 6 IPM) the INCONEX tools averaged over 2 x the tool life of the other brands – even surpassing our own Omega-6 M706.

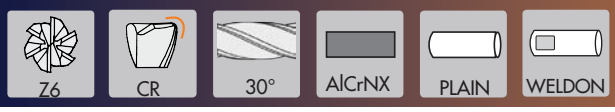
6.35 mm Tool in Inconel 718

MORE THAN 2x THE TOOL LIFE IN HI-TEMP ALLOYS

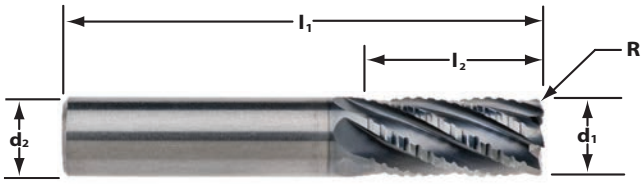
Total Metal Removed



M806 INCONEX



For high performance roughing in hi-temp alloys. The unique cutting edge design for chip control and the advanced coating reduces heat build-up in the cutting zone for optimized tool performance. The M806 is built for tool life when using traditional tool paths in very difficult to machine materials.



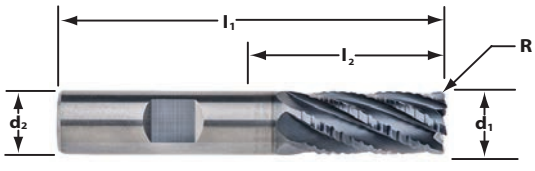
mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 0.5 CR	1.0 CR
6	6	13	57	68759	-
		19	63	68761	-
8	8	19	63	68763	-
		25	75	68765	-
10	10	22	72	-	68767
		32	80	-	68769
12	12	26	83	-	68771
		38	93	-	68773
16	16	34	92	-	68775
		50	108	-	68777
20	20	42	104	-	68779
		62	125	-	68781
25	25	52	120	-	68783

M806 w/WELDON

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 0.5 CR	1.0 CR
6	6	13	57	68760	-
		19	63	68762	-
8	8	19	63	68764	-
		25	75	68766	-
10	10	22	72	-	68768
		32	80	-	68770
12	12	26	83	-	68772
		38	93	-	68774
16	16	34	92	-	68776
		50	108	-	68778
20	20	42	104	-	68780
		62	125	-	68782
25	25	52	120	-	68784



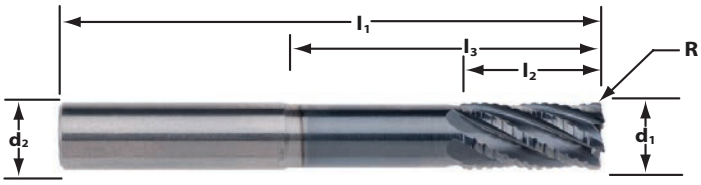
mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

Inch sizes available upon request.

M806N INCONEX

Z6 | CR | 30° | NECK | AlCrNX | PLAIN

For high performance roughing in hi-temp alloys. Adding a necked shank to the M806 design offers a high-performance tool that permits clearance in deeper cavities and easier machining against tight walls. Neck relief and short to standard flute length combine to increase end mill stability in the cut. Great for work in pockets.



mm: *d1: +0.000 / -0.050 d2: -0.0025 / -0.0100*

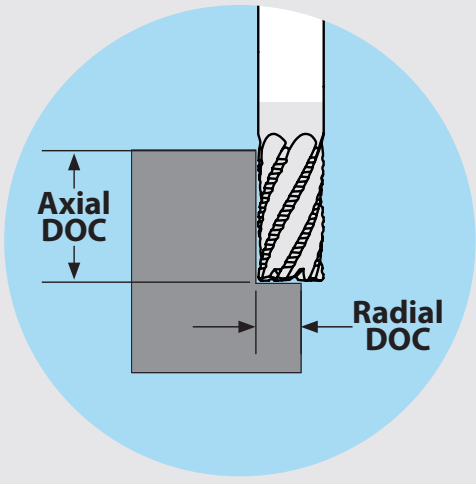
S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Reach LBS l3	Order Code by Corner Radius 0.5 CR	1.0 CR
6	6	12	75	39	68833	-
			100	64	68837	-
8	8	16	75	39	68841	-
10	10	20	88	48	-	68849
			100	60	-	68853
12	12	24	100	55	-	68857
			125	80	-	68861
16	16	32	110	62	-	68869
			150	102	-	68873
20	20	40	125	75	-	68877
			150	100	-	68881

Inch sizes available upon request.

M8 Series Application Guide - Speed & Feed

ISO Code	Type of Cut	Tool Dia.	Axial Depth	Radial Depth	Speed (M/Min)	RPM	MMPT	MM/min
S Inconel, Hastalloy, Waspalloy Not recommended for titanium	Roughing	6.0	1.25 x D	.2 x D	24.38	1239	.019	141.2
	Slotting		4.15	1 x D	24.38	1239	.0127	94.4
	Roughing	8.0	1.25 x D	.2 x D	24.38	970	.025	145.5
	Slotting		5.20	1 x D	24.38	970	.0160	93.1
	Roughing	10.0	1.25 x D	.2 x D	24.38	776	.031	144.3
	Slotting		6.35	1 x D	24.38	776	.0190	88.5
	Roughing	12.0	1.25 x D	.2 x D	24.38	647	.037	143.6
	Slotting		8.35	1 x D	24.38	647	.0254	98.5
	Roughing	16.0	1.25 x D	.2 x D	24.38	485	.050	145.5
	Slotting		10.50	1 x D	24.38	485	.0317	92.2
	Roughing	20.0	1.25 x D	.2 x D	24.38	388	.061	142.1
	Slotting		12.70	1 x D	24.38	388	.0380	88.4
	Roughing	25.0	1.25 x D	.2 x D	24.38	310	.080	148.8
	Slotting		16.90	1 x D	24.38	310	.0508	94.4



For using HEM techniques in hi-temp alloys, please reference the Pow•R•PATH line of end mills beginning on page 12.

Common Machining Formulas

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$

D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

Technical Resources

Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

POW•R•FEED

THE UNIVERSAL POWERHOUSE.

Get chatter-free machining, excellent surface finishes and incredible feed rates with POW•R•FEED M9 series end mills. These tools are beasts at virtually any machining task and material you throw at them.

M9 Series Features

REDEFINING HIGH PERFORMANCE AND VERSATILITY.

The M924, our second-generation POW•R•FEED end mill, is the merging of a 4-flute design with high-performance features and an advanced substrate creating a tool with the combination of flexibility and output. The reinforced cutting edges, corner radii, variable cutting edge indexing, and advanced coating increases metal removal creates and tool life across a wide range of materials.

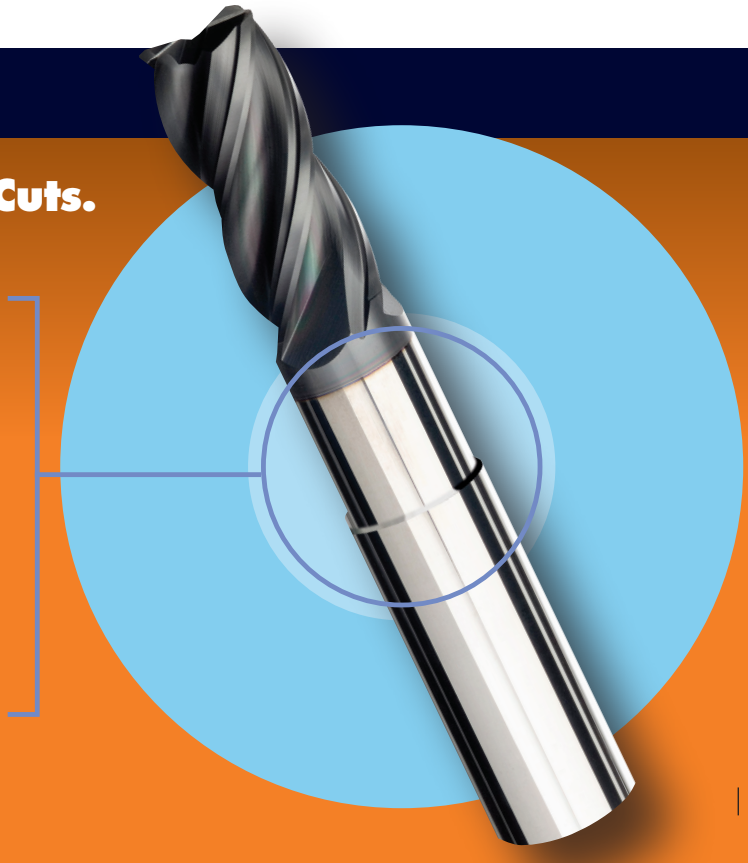
		NUMBER OF FLUTES	END TYPES	HELIX ANGLE	COATING	SHANK TYPES	APPLICATION(S)
M924	 K P M S	Z4	SQ CR BN	38°	AlCrNX	PLAIN WELDON	ROUGH FINISH
M924N	 K P M S	Z4	CR BN	38°	AlCrNX	PLAIN NECK	ROUGH FINISH

TOOL TIP

Increased Stability in Deep Cuts. Look For the Neck.

Reducing tool deflection is a key part of successfully milling deep pockets and slots. Using an end mill with a necked-down shank and a stub or standard flute length greatly improves tool stability in long-reach cuts. The necked shank retains much of the core strength of the carbide rod, increasing tool life and achieving more precise milled wall tolerances.

LBS, or Length Below Shank, designates the combined neck length plus the tool's flute length.

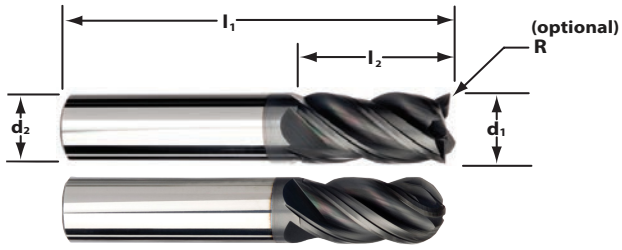


M924
POW•R•FEED

Z4 | SQ | CR | BN | 38° | AlCrNX | PLAIN

For high performance machining in materials ranging from low carbon steels to titanium. The second-generation POW•R•FEED, the M924 design yields enhanced tool life through strengthened cutting edges and corner radii. Very versatile tool - roughing, slotting, and finishing – in traditional tool paths in a variety of materials. Great tool in job shops and when used in production runs.

K P M S



mm: *d1: +0.000 / -0.050* *d2: -0.0025 / -0.0100*

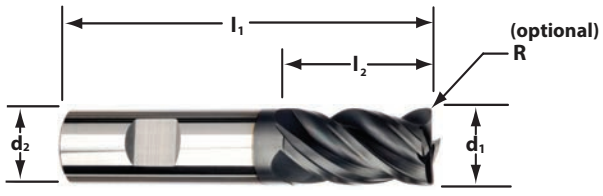
Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.3 CR	0.5 CR	0.75 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR	4.0 CR	Order Code BN
3	3	9	38	67900	-	-	-	-	-	-	-	-	-
		12	38	67902	67903	-	-	-	-	-	-	-	67736
	6	8	57	67908	67911	67737	-	-	-	-	-	-	68019
		12	57	67909	67910	-	-	-	-	-	-	-	-
3.5	6	10	57	67738	-	-	-	-	-	-	-	-	-
4	6	11	57	67914	67917	67739	-	-	-	-	-	-	68022
4.5	6	11	57	67938	-	-	-	-	-	-	-	-	-
5	6	13	57	67920	67923	67947	-	-	-	-	-	-	68096
6	6	10	54	-	-	67024	-	-	-	-	-	-	-
		13	57	67924	67925	67926	-	67025	67026	-	-	-	68013
		25	75	67932	67933	-	-	-	-	-	-	-	-
8	8	12	58	-	-	67027	-	-	-	-	-	-	-
		19	63	67939	-	67940	-	67028	67029	67973	-	-	68014
		32	75	67942	-	67943	-	-	-	-	-	-	-
10	10	14	66	-	-	67030	-	-	-	-	-	-	-
		22	72	67948	-	67949	-	67950	67031	67032	-	-	68015
		40	88	67953	-	67954	-	-	-	-	-	-	-
12	12	16	73	-	-	-	67033	-	-	-	-	-	-
		26	83	67959	-	67960	67034	67961	67035	67036	67038	-	68016
		50	100	67964	-	67965	-	-	-	-	-	-	-
		75	150	67967	-	67968	-	-	-	-	-	-	-
14	14	32	83	67970	-	-	-	67972	-	-	-	-	-
16	16	22	82	-	-	-	-	67039	-	-	-	-	-
		34	92	67975	-	67976	-	67977	67040	67041	67043	67974	68017
		55	110	67980	-	67981	-	-	-	-	-	-	-
		75	150	67983	-	67984	-	-	-	-	-	-	-
18	18	32	92	68064	-	-	-	68065	-	-	-	-	-
20	20	26	92	-	-	-	-	67044	-	-	-	-	-
		38	104	67986	-	-	-	67988	67045	67046	67048	68066	68018
		65	125	67996	-	-	-	68067	-	-	-	-	-
		85	150	67999	-	-	-	68068	-	-	-	-	-
25	25	38	104	68069	-	-	-	68099	-	-	-	-	-
		52	120	68002	-	-	-	68128	-	-	-	-	-
		85	150	68007	-	-	-	68130	-	-	-	-	-

Inch sizes available upon request.

M924 w/WELDON
POW•R•FEED

Z4 | CR | BN | 38° | AlCrNX | PLAIN | WELDON

For high performance machining in materials ranging from low carbon steels to titanium. The second-generation POW•R•FEED, the M924 design yields enhanced tool life through strengthened cutting edges and corner radii. Very versatile tool - roughing, slotting, and finishing – in traditional tool paths in a variety of materials. Great tool in job shops and when used in production runs.

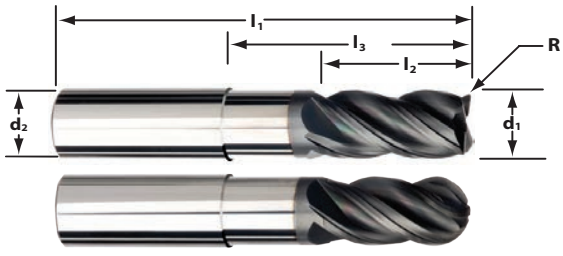


K P M S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR	4.0 CR
10	10	22	72	68977	68978	68979	68980	-	-
12	12	26	83	68981	68982	68983	68984	68985	-
16	16	34	92	68986	68987	68988	68989	68990	68991
20	20	38	104	-	68992	68993	68994	68995	68996

M924N

For high performance machining in materials ranging from low carbon steels to titanium. Adding a necked shank to the M924 design offers a high-performance tool that permits clearance in deeper cavities and easier machining against tight walls. Neck relief and short to standard flute length combine to increase end mill stability in the cut for more precise tolerances. Great for work in pockets.



mm: *d1: +0.000 / -0.050* *d2: -0.0025 / -0.0100*

K P M S

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Reach LBS l3	Overall Length l1	Order Code by Corner Radius 0.5 CR	1.0 CR	1.5 CR	Order Code BN
6	6	12	39	75	68020	-	-	68097
			64	100	68021	-	-	68098
8	8	16	39	75	68023	-	-	68100
			64	100	68024	-	-	68101
10	10	12	32	72	68025	68026	-	68102
			60	100	68027	68028	-	68103
			110	150	68029	68030	-	68104
12	12	15	38	83	68031	68032	68033	68105
			55	100	68034	68035	68036	68106
			80	125	68037	68038	68039	68107
			105	150	68040	68041	68042	68108
16	16	20	62	110	68043	68044	68045	68109
			102	150	68046	68047	68048	68110
20	20	25	50	100	68049	68050	68051	68111
			75	125	68052	68053	68054	68112
			100	150	68055	68056	68057	68113
25	25	32	64	120	68058	68059	68060	68114
			94	150	68061	68062	68063	68115

Inch sizes available upon request.

M924 Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 3.0	4.0	5.0	6.0	8.0	10.0	12.0	14.0	16.0	20.0	25.0
K	Cast Iron Gray	Slotting	1 x D	1 x D	4	99	.0144	.0192	.0240	.0288	.0384	.0478	.0576	.0672	.0766	.0956	.1198
		Peripheral - Rough	1.25 x D	.5 x D	4	122	.0180	.0240	.0300	.0360	.0480	.0598	.0720	.0840	.0958	.1195	.1497
		Finish	1.5 x D	.015 x D	4	145	.0198	.0264	.0330	.0396	.0528	.0657	.0792	.0924	.1053	.1315	.1647
	Cast Iron Ductile	Slotting	1 x D	1 x D	4	91	.0132	.0176	.0220	.0264	.0352	.0438	.0528	.0616	.0702	.0876	.1098
		Peripheral - Rough	1.25 x D	.5 x D	4	114	.0162	.0216	.0270	.0324	.0432	.0538	.0648	.0756	.0862	.1076	.1348
		Finish	1.5 x D	.015 x D	4	137	.0180	.0240	.0300	.0360	.0480	.0598	.0720	.0840	.0958	.1195	.1497
	Cast Iron Malleable	Slotting	.75 x D	1 x D	4	76	.0132	.0176	.0220	.0264	.0352	.0438	.0528	.0616	.0702	.0876	.1098
		Peripheral - Rough	1.25 x D	.5 x D	4	99	.0162	.0216	.0270	.0324	.0432	.0538	.0648	.0756	.0862	.1076	.1348
		Finish	1.5 x D	.015 x D	4	122	.0180	.0240	.0300	.0360	.0480	.0598	.0720	.0840	.0958	.1195	.1497
P	Low Carbon Steel 1018, 12L14, 8620	Slotting	1 x D	1 x D	4	107	.0156	.0208	.0260	.0312	.0416	.0518	.0624	.0728	.0830	.1036	.1298
		Peripheral - Rough	1.25 x D	.5 x D	4	130	.0192	.0256	.0320	.0384	.0512	.0637	.0768	.0896	.1021	.1275	.1597
		Finish	1.5 x D	.015 x D	4	152	.0216	.0288	.0360	.0432	.0576	.0717	.0864	.1008	.1149	.1434	.1797
	Medium Carbon Steel 4140, 4340	Slotting	1 x D	1 x D	4	91	.0144	.0192	.0240	.0288	.0384	.0478	.0576	.0672	.0766	.0956	.1198
		Peripheral - Rough	1.25 x D	.5 x D	4	114	.0180	.0240	.0300	.0360	.0480	.0598	.0720	.0840	.0958	.1195	.1497
		Finish	1.5 x D	.015 x D	4	137	.0198	.0264	.0330	.0396	.0528	.0657	.0792	.0924	.1053	.1315	.1647
	Tool & Die Steels <48 Rc A2, D2, H13, P20	Slotting	.75 x D	1 x D	4	91	.0144	.0192	.0240	.0288	.0384	.0478	.0576	.0672	.0766	.0956	.1198
		Peripheral -Rough	1.25 x D	.3 x D	4	114	.0174	.0232	.0290	.0348	.0464	.0578	.0696	.0812	.0926	.1155	.1448
		Finish	1.5 x D	.015 x D	4	137	.0180	.0240	.0300	.0360	.0480	.0598	.0720	.0840	.0958	.1195	.1497
M	Martensitic Stainless Steel 416, 410, 440C	Slotting	.75 x D	1 x D	4	91	.0144	.0192	.0240	.0288	.0384	.0478	.0576	.0672	.0766	.0956	.1198
		Peripheral - Rough	1.25 x D	.3 x D	4	114	.0174	.0232	.0290	.0348	.0464	.0578	.0696	.0812	.0926	.1155	.1448
		Finish	1.5 x D	.015 x D	4	137	.0180	.0240	.0300	.0360	.0480	.0598	.0720	.0840	.0958	.1195	.1497
	Austenitic Stainless Steel 303, 304, 316	Slotting	.75 x D	1 x D	4	84	.0156	.0208	.0260	.0312	.0416	.0518	.0624	.0728	.0830	.1036	.1298
		Peripheral - Rough	1.25 x D	.3 x D	4	99	.0192	.0256	.0320	.0384	.0512	.0637	.0768	.0896	.1021	.1275	.1597
		Finish	1.5 x D	.015 x D	4	122	.0198	.0264	.0330	.0396	.0528	.0657	.0792	.0924	.1053	.1315	.1647
	Precipitation Hardening Stainless Steel 17-4, 15-5, 13-8	Slotting	.5 x D	1 x D	4	76	.0120	.0160	.0200	.0240	.0320	.0398	.0480	.0560	.0638	.0797	.0998
		Peripheral - Rough	1.25 x D	.3 x D	4	91	.0150	.0200	.0250	.0300	.0400	.0498	.0600	.0700	.0798	.0996	.1248
		Finish	1.5 x D	.015 x D	4	114	.0156	.0208	.0260	.0312	.0416	.0518	.0624	.0728	.0830	.1036	.1298
S	Titanium Alloys 6AL-4V	Slotting	.5 x D	1 x D	4	76	.0120	.0160	.0200	.0240	.0320	.0398	.0480	.0560	.0638	.0797	.0998
		Peripheral - Rough	1.25 x D	.3 x D	4	91	.0150	.0200	.0250	.0300	.0400	.0498	.0600	.0700	.0798	.0996	.1248
		Finish	1.5 x D	.015 x D	4	114	.0156	.0208	.0260	.0312	.0416	.0518	.0624	.0728	.0830	.1036	.1298
	High Temperature Alloys Inconel, Haynes, Stellite, Hastalloy	Slotting	.25 x D	1 x D	4	18	.0126	.0168	.0210	.0252	.0336	.0418	.0504	.0588	.0670	.0837	.1048
		Peripheral - Rough	1.25 x D	.25 x D	4	27	.0162	.0216	.0270	.0324	.0432	.0538	.0648	.0756	.0862	.1076	.1348
		Finish	1.5 x D	.01 x D	4	38	.0186	.0248	.0310	.0372	.0496	.0617	.0744	.0868	.0989	.1235	.1547

D = Tool Diameter

≈ Approximately Equals
≤ Less Than or Equal To
≥ Greater Than or Equal To
× Multiply
< Less Than
> Greater Than
= Equals

Common Machining Formulas

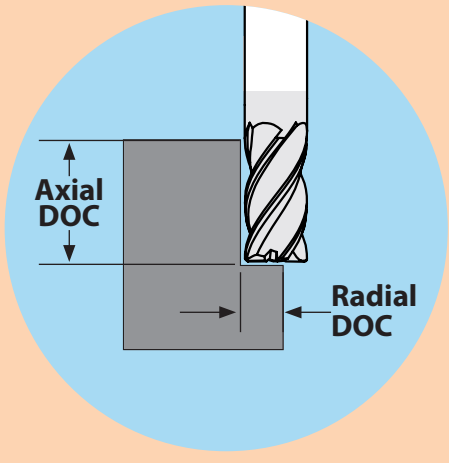
D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$



Technical Resources

Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

STREAKERS

SHEAR IT AND CLEAR IT.

IMCO's unique design makes STREAKERS end mills first-rate roughers and excellent finishers. Get high metal removal rates without maxing out horsepower.

M2 Series Features

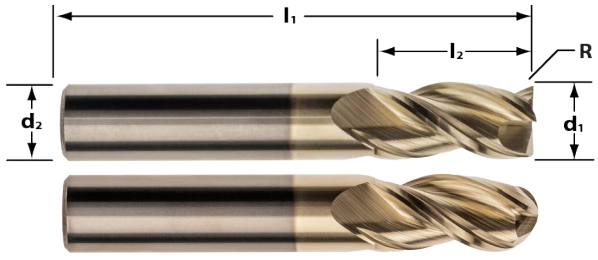
WON'T GUM UP THE WORKS.

Introducing the new members to the STREAKERS family – the M223 and M233 end mills. The M223 STREAKERS take the best features of our original tools and with new grinds for better part finishes and ZrN coating for extended tool life. The M233 is a true roughing end mill made to plow through gummy aluminium applications without packing up. The legacy members of the STREAKERS family retain their unique fluting and edge design to efficiently shear through aluminium alloys with great tool life.

		NUMBER OF FLUTES	END TYPES	HELIX ANGLE	COATING	SHANK TYPES	APPLICATION(S)
M223	 N	Z3	SQ CR BN	45°	ZRN	PLAIN	ROUGH FINISH
M223N	 N	Z3	SQ CR BN	45°	ZRN	PLAIN NECK	ROUGH FINISH
M233	 N	Z3	CR	37°	ZRN	PLAIN	ROUGH
M203	 N	Z3	SQ	45°	NONE	PLAIN	ROUGH FINISH
M202	 N	Z2	SQ BN	45°	NONE	PLAIN	ROUGH

M223 STREAKERS

For high-performance machining in aluminium alloys. Improved floor and wall finishes, better ramping ability, and longer tool life – all part of the new M223 STREAKERS design. The unique grinds curl and evacuate the gummy aluminium chip allowing for high feed rates without chip packing. Excellent for roughing and finishing.



mm: *d1: -0.025 / -0.0100* *d2: -0.0025 / -0.0100*

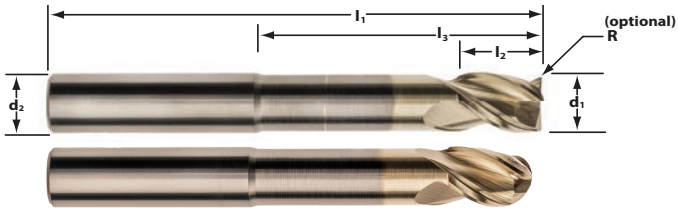
Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.3 CR	0.5 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR	Order Code BN
3	3	9	38	61220	61221	-	-	-	-	-	61222
4	4	12	50	61223	61224	-	-	-	-	-	61225
5	5	15	50	61226	61227	-	-	-	-	-	61228
6	6	13	57	61229	61230	61231	61232	-	-	-	61233
		18	63	61234	-	61235	61236	-	-	-	-
		24	75	61237	-	61238	61239	-	-	-	-
8	8	20	63	61240	-	61241	61242	-	-	-	61243
		32	75	61244	-	61245	61246	-	-	-	-
10	10	20	66	61247	61248	-	-	-	-	-	-
		22	72	61249	61250	-	-	-	-	-	-
		25	72	61251	61252	61253	61254	61255	-	-	61256
		30	75	61257	-	61258	61259	61260	-	-	-
		40	88	61261	-	61262	61263	61264	-	-	-
12	12	24	73	61265	61266	-	-	-	-	-	-
		26	83	61267	61268	61269	61270	61271	61272	61273	-
		30	83	61274	-	61275	61276	61277	61278	61279	61280
		36	88	61281	-	61282	61283	61284	-	61285	-
		48	100	61286	-	61287	61288	61289	61290	61291	-
16	16	32	92	61292	-	61293	61294	61295	61296	61297	61298
		48	110	61299	-	-	61300	61301	61302	61303	-
		64	125	61304	-	-	61305	61306	61307	61308	-
20	20	40	104	61309	-	-	61310	61311	61312	61313	61314
		60	125	61315	-	-	61316	61317	61318	61319	-
		80	150	61320	-	-	61321	61322	61323	61324	-
25	25	50	125	61325	-	-	-	-	-	-	-

Inch sizes available upon request.

M223N STREAKERS

Z3 | SQ | CR | BN | 45° | NECK | ZRN | PLAIN

For high-performance machining in aluminium alloys. Adding a necked shank to the M223 design offers a high-performance tool that can reach into deep cavities while minimizing tool deflection. Great for work in pockets.



mm: *d1: -0.025 / -0.0100 d2: -0.0025 / -0.0100*

N

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Reach LBS l3	Overall Length l1	Order Code SQ	Order Code by Corner Radius 0.3 CR	0.5 CR	1.0 CR	1.5 CR	2.0 CR	3.0 CR	Order Code BN
6	6	9	26	63	61342	61343	61344	61345	-	-	-	61346
			32	75	61347	61348	61349	61350	-	-	-	61351
8	8	12	34	75	61352	61353	61354	61355	-	-	-	61356
10	10	15	32	75	62010	62011	62014	62015	-	-	-	62023
			42	88	61357	61358	61359	61360	61361	-	-	61362
			52	100	61363	61364	61365	61366	61367	-	-	61368
12	12	18	38	88	61369	61370	61371	61372	61373	-	61374	61375
			50	100	61376	61377	61378	61379	61380	61381	61382	61383
			62	125	62027	62039	62045	62046	62047	62051	62052	62062
16	16	24	50	110	61384	-	61385	61386	61387	61388	61389	61390
			66	125	61391	-	61392	62099	61393	61394	61395	61396
			82	150	62100	-	62101	62102	62103	62123	62139	62143
20	20	30	62	125	61397	-	61398	62151	61399	62152	61400	61401
			82	135	62153	-	62154	62155	62156	62161	62164	62166
			102	150	61402	-	61403	62300	61404	61405	61406	61407

Inch sizes available upon request.

TOOL TIP

Coatings for Tools that Machine Aluminium.

IMCO offers two types of coating on end mills designed to machine aluminium and copper alloys:

taC (photo A)
The ultimate coating for high-output machining in non-ferrous materials. This thin film coating keeps the tool cutting edges sharp for a high-shear plane.Very hard with high thermal stability and excellent wear resistance.
Find the APT/C mills with taC coating on pages 24–26.

Zirconium Nitride (ZrN) (photo B)
Adds hardness and lubricity to the cutting edge. Reduces edge build-up common in machining gummy materials, enhancing tool life and surface finish.
All new M223 and M233 end mills are coated with ZrN.

M223 Series Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 3.0	4.0	5.0	6.0	7.0	8.0	10.0	12.0	16.0	20.0
N	Aluminium Alloys 6061, 7075, 2024	Slotting	1 x D	1 x D	3	244	.0360	.0479	.0600	.0720	.0840	.0960	.1195	.1440	.1915	.2390
		Peripheral - Rough	≤ 2 x D	.5 x D	3	305	.0480	.0639	.0800	.0960	.1120	.1280	.1593	.1920	.2553	.3187
		Peripheral - Rough	> 2 - 3 x D	.5 x D	3	305	.0450	.0599	.0750	.0900	.1050	.1200	.1494	.1800	.2394	.2988
		Peripheral - Rough	> 3 - 4 x D	.45 x D	3	274	.0390	.0519	.0650	.0780	.0910	.1040	.1295	.1560	.2075	.2589
		Peripheral - Rough	> 4 - 5 x D	.4 x D	3	244	.0348	.0463	.0580	.0696	.0812	.0928	.1155	.1392	.1851	.2311
		Finish	2.5 x D	.015 x D	3	366	.0162	.0216	.0270	.0324	.0378	.0432	.0538	.0648	.0862	.1076
		*Helical Ramp Angle	3.0 deg.	1 x D	3	244	.0288	.0384	.0480	.0576	.0672	.0768	.0956	.1152	.1532	.1912
	High Silicon Aluminium A380, A390	Slotting	.75 x D	1 x D	3	152	.0270	.0360	.0450	.0540	.0630	.0720	.0896	.1080	.1436	.1793
		Peripheral - Rough	≤ 2 x D	.4 x D	3	213	.0342	.0456	.0570	.0684	.0798	.0912	.1135	.1368	.1819	.2271
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	213	.0330	.0440	.0550	.0660	.0770	.0880	.1096	.1320	.1755	.2191
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	183	.0288	.0384	.0480	.0576	.0672	.0768	.0956	.1152	.1532	.1912
		Peripheral - Rough	> 4 - 5 x D	.35 x D	3	152	.0240	.0320	.0400	.0480	.0560	.0640	.0797	.0960	.1277	.1593
		Finish	2.5 x D	.015 x D	3	274	.0150	.0200	.0250	.0300	.0350	.0400	.0498	.0600	.0798	.0996
		*Helical Ramp Angle	2.5 deg.	1 x D	3	152	.0216	.0288	.0360	.0432	.0504	.0576	.0717	.0864	.1149	.1434
	Magnesium Alloys	Slotting	1 x D	1 x D	3	244	.0360	.0479	.0600	.0720	.0840	.0960	.1195	.1440	.1915	.2390
		Peripheral - Rough	≤ 2 x D	.5 x D	3	305	.0480	.0639	.0800	.0960	.1120	.1280	.1593	.1920	.2553	.3187
		Peripheral - Rough	> 2 - 3 x D	.5 x D	3	305	.0450	.0599	.0750	.0900	.1050	.1200	.1494	.1800	.2394	.2988
		Peripheral - Rough	> 3 - 4 x D	.45 x D	3	274	.0390	.0519	.0650	.0780	.0910	.1040	.1295	.1560	.2075	.2589
		Peripheral - Rough	> 4 - 5 x D	.4 x D	3	244	.0348	.0463	.0580	.0696	.0812	.0928	.1155	.1392	.1851	.2311
		Finish	2.5 x D	.015 x D	3	366	.0162	.0216	.0270	.0324	.0378	.0432	.0538	.0648	.0862	.1076
		*Helical Ramp Angle	3.0 deg.	1 x D	3	244	.0288	.0384	.0480	.0576	.0672	.0768	.0956	.1152	.1532	.1912
	Copper Alloys, Brass	Slotting	.75 x D	1 x D	3	152	.0222	.0296	.0370	.0444	.0518	.0592	.0737	.0888	.1181	.1474
		Peripheral - Rough	≤ 2 x D	.4 x D	3	183	.0276	.0368	.0460	.0552	.0644	.0736	.0916	.1104	.1468	.1832
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	183	.0270	.0360	.0450	.0540	.0630	.0720	.0896	.1080	.1436	.1793
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	152	.0234	.0312	.0390	.0468	.0546	.0624	.0777	.0936	.1245	.1554
		Peripheral - Rough	> 4 - 5 x D	.35 x D	3	137	.0198	.0264	.0330	.0396	.0462	.0528	.0657	.0792	.1053	.1315
		Finish	2.5 x D	.015 x D	3	198	.0126	.0168	.0210	.0252	.0294	.0336	.0418	.0504	.0670	.0837
		*Helical Ramp Angle	2.5 deg.	1 x D	3	152	.0178	.0237	.0296	.0355	.0414	.0474	.0590	.0710	.0945	.1179
	Bronze	Slotting	.75 x D	1 x D	3	152	.0210	.0280	.0350	.0420	.0490	.0560	.0697	.0840	.1117	.1394
		Peripheral - Rough	≤ 2 x D	.4 x D	3	183	.0264	.0352	.0440	.0528	.0616	.0704	.0876	.1056	.1404	.1753
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	183	.0252	.0336	.0420	.0504	.0588	.0672	.0837	.1008	.1341	.1673
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	152	.0210	.0280	.0350	.0420	.0490	.0560	.0697	.0840	.1117	.1394
		Peripheral - Rough	> 4 - 5 x D	.35 x D	3	137	.0174	.0232	.0290	.0348	.0406	.0464	.0578	.0696	.0926	.1155
		Finish	2.5 x D	.015 x D	3	198	.0114	.0152	.0190	.0228	.0266	.0304	.0378	.0456	.0606	.0757
		*Helical Ramp Angle	2.0 deg.	1 x D	3	152	.0168	.0224	.0280	.0336	.0392	.0448	.0558	.0672	.0894	.1115
	Composites, Plastic, Fiberglass	Slotting	.75 x D	1 x D	3	152	.0270	.0360	.0450	.0540	.0630	.0720	.0896	.1080	.1436	.1793
		Peripheral - Rough	≤ 2 x D	.4 x D	3	213	.0342	.0456	.0570	.0684	.0798	.0912	.1135	.1368	.1819	.2271
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	213	.0330	.0440	.0550	.0660	.0770	.0880	.1096	.1320	.1755	.2191
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	183	.0288	.0384	.0480	.0576	.0672	.0768	.0956	.1152	.1532	.1912
		Peripheral - Rough	> 4 - 5 x D	.35 x D	3	152	.0240	.0320	.0400	.0480	.0560	.0640	.0797	.0960	.1277	.1593
		Finish	2.5 x D	.015 x D	3	274	.0150	.0200	.0250	.0300	.0350	.0400	.0498	.0600	.0798	.0996
		*Helical Ramp Angle	3.0 deg.	1 x D	3	152	.0216	.0288	.0360	.0432	.0504	.0576	.0717	.0864	.1149	.1434

*Straight line Ramp Angle= Helical Ramp Angle x 5 for entry up to 1 x D.

≈ Approximately Equals
≤ Less Than or Equal To
≥ Greater Than or Equal To
× Multiply
< Less Than
> Greater Than
= Equals

Common Machining Formulas

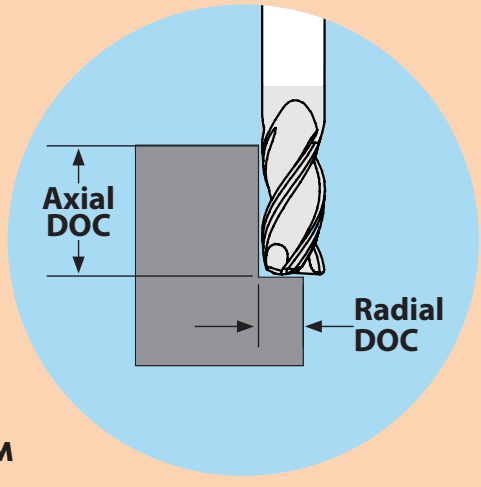
D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$



Technical Resources

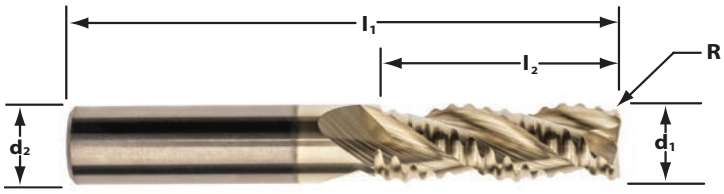
Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

M233 ROUGHER STREAKERS

For high performance machining in aluminium alloys. Special cutting edge serrations lowers the horsepower needed to plow through aluminium alloys at high metal removal rates. The ZrN coating helps reduce chip packing even in heavy tool engagement cuts.

Tool tip: M233 Rougher end mills show up to 20% power reduction from M223 in the same cut.



mm: *d1: +.000/-0.076* *d2: 0.0025/-0.0100*

N

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code by Corner Radius 0.5 CR	1.0 CR
6	6	13	57	61329	-
		18	63	61330	-
		24	75	61331	-
10	10	25	72	61332	-
		30	75	61333	-
		40	88	61334	-
12	12	30	83	-	61335
		36	88	-	61336
		48	100	-	61337
16	16	32	92	-	61338
		48	110	-	61339
20	20	40	104	-	61340
		60	125	-	61341

Inch sizes available upon request.

M233 Series Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/min)	Feed (MM per Tooth) 6.0	10.0	12.0	16.0	20.0
N	Aluminium Alloys 2024, 6061, 7075	Slotting	1 x D	1 x D	3	244	.0720	.1195	.1440	.1915	.2390
		Peripheral - Rough	≤ 2 x D	.5 x D	3	305	.0960	.1593	.1920	.2553	.3187
		Peripheral - Rough	> 2 - 3 x D	.5 x D	3	305	.0900	.1494	.1800	.2394	.2988
		Peripheral - Rough	> 3 - 4 x D	.45 x D	3	274	.0780	.1295	.1560	.2075	.2589
		*Helical Ramp Angle	3.0 deg.	1 x D	3	244	.0576	.0956	.1152	.1532	.1912
	High Silicon-Aluminium A380, A390	Slotting	.75 x D	1 x D	3	152	.0540	.0896	.1080	.1436	.1793
		Peripheral - Rough	≤ 2 x D	.4 x D	3	213	.0684	.1135	.1368	.1819	.2271
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	213	.0660	.1096	.1320	.1755	.2191
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	183	.0576	.0956	.1152	.1532	.1912
		*Helical Ramp Angle	2.5 deg.	1 x D	3	152	.0432	.0717	.0864	.1149	.1434
	Magnesium Alloys	Slotting	1 x D	1 x D	3	244	.0720	.1195	.1440	.1915	.2390
		Peripheral - Rough	≤ 2 x D	.5 x D	3	305	.0960	.1593	.1920	.2553	.3187
		Peripheral - Rough	> 2 - 3 x D	.5 x D	3	305	.0900	.1494	.1800	.2394	.2988
		Peripheral - Rough	> 3 - 4 x D	.45 x D	3	274	.0780	.1295	.1560	.2075	.2589
		*Helical Ramp Angle	3.0 deg.	1 x D	3	244	.0576	.0956	.1152	.1532	.1912
	Copper Alloys, Brass	Slotting	.75 x D	1 x D	3	152	.0444	.0737	.0888	.1181	.1474
		Peripheral - Rough	≤ 2 x D	.4 x D	3	183	.0552	.0916	.1104	.1468	.1832
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	183	.0540	.0896	.1080	.1436	.1793
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	152	.0468	.0777	.0936	.1245	.1554
		*Helical Ramp Angle	2.5 deg.	1 x D	3	152	.0355	.0590	.0710	.0945	.1179
	Bronze	Slotting	.75 x D	1 x D	3	152	.0420	.0697	.0840	.1117	.1394
		Peripheral - Rough	≤ 2 x D	.4 x D	3	183	.0528	.0876	.1056	.1404	.1753
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	183	.0504	.0837	.1008	.1341	.1673
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	152	.0420	.0697	.0840	.1117	.1394
		*Helical Ramp Angle	2.0 deg.	1 x D	3	152	.0336	.0558	.0672	.0894	.1115
	Composites, Plastics, Fiberglass	Slotting	.75 x D	1 x D	3	152	.0540	.0896	.1080	.1436	.1793
		Peripheral - Rough	≤ 2 x D	.4 x D	3	213	.0684	.1135	.1368	.1819	.2271
		Peripheral - Rough	> 2 - 3 x D	.4 x D	3	213	.0660	.1096	.1320	.1755	.2191
		Peripheral - Rough	> 3 - 4 x D	.375 x D	3	183	.0576	.0956	.1152	.1532	.1912
		*Helical Ramp Angle	3.0 deg.	1 x D	3	152	.0432	.0717	.0864	.1149	.1434

*Straight line Ramp Angle = Helical Ramp Angle x 5 for entry up to 1 x D.

Tool tip: M233 Rougher end mills show up to 20% power reduction from M223 in the same cut.

≈ Approximately Equals
≤ Less Than or Equal To
≥ Greater Than or Equal To
× Multiply
< Less Than
> Greater Than
= Equals

Common Machining Formulas

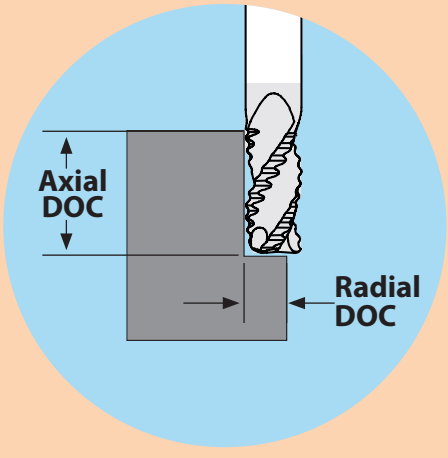
D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$



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Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

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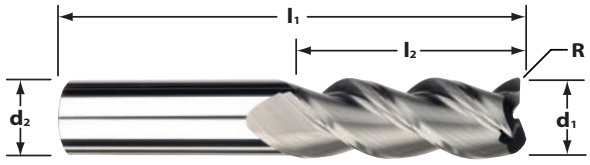
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

M203 STREAKERS

For high performance machining in aluminium alloys. Unique grinds curl and evacuate the gummy aluminium chip allowing for high feed rates without clogging. Excellent tool life. The three-flute design yields a superior finish.



mm: *d1: -0.0025 / -0.0100 d2: -0.0025 / -0.0100*

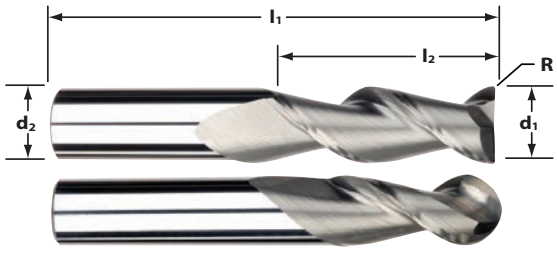
N

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code SQ
3	3	5	38	32522
4	4	11	50	33167
5	5	13	50	33169
6	6	16	57	33170
		29	75	34302
8	8	19	63	33172
		29	75	34303
10	10	22	72	33174
		40	88	34311
12	12	26	83	33175
		50	100	34305
16	16	32	92	33177
		57	125	34306
20	20	38	104	33179
		57	125	34307

Inch sizes available upon request.

M202

For high performance machining in aluminium alloys. Unique grinds curl and evacuate the gummy aluminium chip allowing for high feed rates without clogging. The two-flute design increases the chip evacuation area allowing for more tool engagement. Excellent tool life.



mm: *d1: -0.0025 / -0.0100 d2: -0.0025 / -0.0100*

N

Cutter Dia d1	Shank Dia d2	Length of Cut l2	Overall Length l1	Order Code SQ	Order Code BN
3	3	5	38	32971	-
		8	38	-	62400
4	4	11	50	36974	62401
5	5	13	50	36976	62411
6	6	16	57	62402	62412
8	8	19	63	62403	62413
10	10	22	72	62404	62414
12	12	26	83	62406	62416
16	16	32	92	62408	62418
20	20	38	104	62410	62420

Inch sizes available upon request.

M203/M202 Series Application Guide - Speed & Feed

ISO Code	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (M/Min)	Feed (MM per Tooth) 3.0	4.0	5.0	6.0	8.0	10.0	12.0	16.0	20.0
N	Aluminium Alloys 2024, 6061, 7075	Slotting	1 x D	1 x D	2	244	.0360	.0480	.0600	.0720	.0960	.1195	.1440	.1915	.2405
		Peripheral - Rough	1 x D	.75 x D	2	305	.0450	.0600	.0750	.0900	.1200	.1494	.1800	.2394	.3006
		Peripheral - Finish	1.5 x D	.01 x D	2	365	.0565	.0754	.0942	.1131	.1508	.1877	.2261	.3007	.3776
	High Silicon Aluminium A380, A390	Slotting	.75 x D	1 x D	2	153	.0312	.0416	.0520	.0624	.0832	.1036	.1248	.1660	.2084
		Peripheral - Rough	1 x D	.5 x D	2	213	.0390	.0520	.0650	.0780	.1040	.1295	.1560	.2075	.2605
		Peripheral - Finish	1.5 x D	.01 x D	2	274	.0490	.0653	.0817	.0980	.1307	.1627	.1960	.2606	.3273
	Magnesium Alloys	Slotting	1 x D	1 x D	2	244	.0360	.0480	.0600	.0720	.0960	.1195	.1440	.1915	.2405
		Peripheral - Rough	1 x D	.75 x D	2	305	.0450	.0600	.0750	.0900	.1200	.1494	.1800	.2394	.3006
		Peripheral - Finish	1.5 x D	.01 x D	2	365	.0565	.0754	.0942	.1131	.1508	.1877	.2261	.3007	.3776
	Copper Alloys Brass, Bronze	Slotting	.75 x D	1 x D	2	153	.0312	.0416	.0520	.0624	.0832	.1036	.1248	.1660	.2084
		Peripheral - Rough	1 x D	.75 x D	2	175	.0390	.0520	.0650	.0780	.1040	.1295	.1560	.2075	.2605
		Peripheral - Finish	1.5 x D	.01 x D	2	198	.0490	.0653	.0817	.0980	.1307	.1627	.1960	.2606	.3273
	Composites Plastics, Fiberglass	Slotting	1 x D	1 x D	2	153	.0312	.0416	.0520	.0624	.0832	.1036	.1248	.1660	.2084
		Peripheral - Rough	1 x D	.75 x D	2	213	.0390	.0520	.0650	.0780	.1040	.1295	.1560	.2075	.2605
		Peripheral - Finish	1.5 x D	.01 x D	2	274	.0490	.0653	.0817	.0980	.1307	.1627	.1960	.2606	.3273
	Aluminium Alloys 2024, 6061, 7075	Slotting	.75 x D	1 x D	3	244	.0312	.0416	.0520	.0624	.0832	.1036	.1248	.1660	.2084
		Peripheral - Rough	1 x D	.75 x D	3	305	.0390	.0520	.0650	.0780	.1040	.1295	.1560	.2075	.2605
		Peripheral - Finish	1.5 x D	.01 x D	3	365	.0490	.0653	.0817	.0980	.1307	.1627	.1960	.2606	.3273
	High Silicon Aluminium A380, A390	Slotting	.5 x D	1 x D	3	153	.0264	.0352	.0440	.0528	.0704	.0876	.1056	.1404	.1763
		Peripheral - Rough	1 x D	.5 x D	3	213	.0330	.0440	.0550	.0660	.0880	.1096	.1320	.1755	.2204
		Peripheral - Finish	1.5 x D	.01 x D	3	274	.0415	.0553	.0691	.0829	.1106	.1376	.1658	.2205	.2769
	Magnesium Alloys	Slotting	.75 x D	1 x D	3	244	.0312	.0416	.0520	.0624	.0832	.1036	.1248	.1660	.2084
		Peripheral - Rough	1 x D	.75 x D	3	305	.0390	.0520	.0650	.0780	.1040	.1295	.1560	.2075	.2605
		Peripheral - Finish	1.5 x D	.01 x D	3	365	.0490	.0653	.0817	.0980	.1307	.1627	.1960	.2606	.3273
	Copper Alloys Brass, Bronze	Slotting	.75 x D	1 x D	3	153	.0264	.0352	.0440	.0528	.0704	.0876	.1056	.1404	.1763
		Peripheral - Rough	1 x D	.75 x D	3	175	.0330	.0440	.0550	.0660	.0880	.1096	.1320	.1755	.2204
		Peripheral - Finish	1.5 x D	.01 x D	3	198	.0415	.0553	.0691	.0829	.1106	.1376	.1658	.2205	.2769
	Composites Plastics, Fiberglass	Slotting	1 x D	1 x D	3	153	.0264	.0352	.0440	.0528	.0704	.0876	.1056	.1404	.1763
		Peripheral - Rough	1 x D	.75 x D	3	213	.0330	.0440	.0550	.0660	.0880	.1096	.1320	.1755	.2204
		Peripheral - Finish	1.5 x D	.01 x D	3	274	.0415	.0553	.0691	.0829	.1106	.1376	.1658	.2205	.2769

D = Tool Diameter

≈ Approximately Equals
≤ Less Than or Equal To
≥ Greater Than or Equal To
× Multiply
< Less Than
> Greater Than
= Equals

Common Machining Formulas

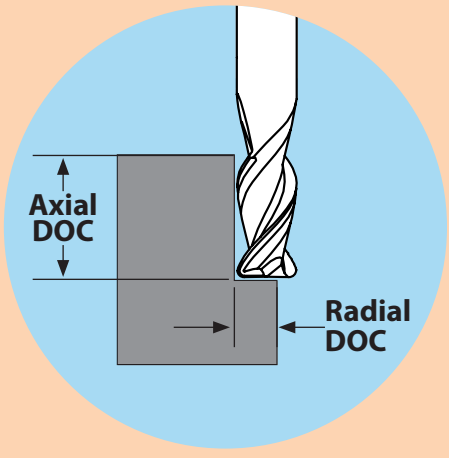
D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SMM Surface Meters per Minute
MMPM Millimeters per Minute
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

$$RPM = \frac{M/min \times 318.3}{D}$$

$$M/min = RPM \times D \times .00314$$

$$MMPM = RPM \times MMPT \times Z$$

$$MRR = RDOC \times ADOC \times MMPM$$



Technical Resources

Information on tips and adjustments for the following milling operations can be found in our Technical Resources section beginning on page 64.

- HEM slotting
- Face milling
- Helical entry ramping
- Straight line ramping
- Long tool projection adjustments
- Ball nose milling adjustments
- Other helpful tips and calculations

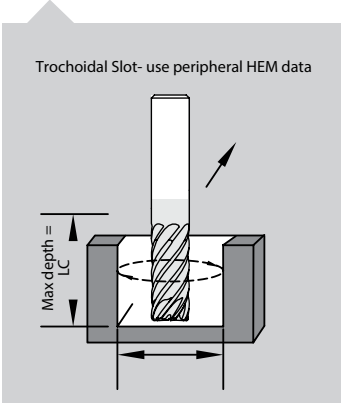
TECH SUPPORT

Use the guidelines in this section when machining a variety of tool paths. When necessary, adjustments refer back to the specific end mill speed and feed charts as listed throughout the catalogue and can be found on the following pages:

HEM SLOTTING GUIDES

The width of the desired slot will determine the number of flutes and end mill diameter that should be selected. The following guide shows the minimum slot width for each series of end mill.

Tool	Minimum Slot Width	Maximum Slot Depth
IPT/C 7	2 x end mill diameter	Full length of cut
IPT/C 9	2 x end mill diameter	Full length of cut
IPT/C 11	2.25 x end mill diameter	Full length of cut
IPT/C 13	2.5 x end mill diameter	Full length of cut
APT/C 5	1.75 x end mill diameter	Full length of cut
M525/C	1.75 x end mill diameter	.8 x length of cut
M527/C	2 x end mill diameter	.8 x length of cut



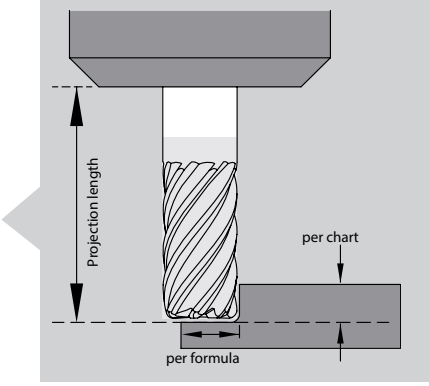
For operating parameters, use the data shown as "Peripheral HEM" in the speed and feed chart for each tool series.

FACING

When facing, the use of an end mill with a corner radius is suggested for the best finish. The adjustments below are to be applied to the Peripheral Rough values from the appropriate speed and feed chart for the end mill being used.

RDOC Formula

Stepover = (D - (2 x corner radius)) x .75



	Non - IP End Mills					
	Rough Facing			Finish Facing		
Projection Length	M/min	MMPT	ADOC	M/min	MMPT	ADOC
0 to 3 x D	1.2 x chart value	.85 x chart value	.25 x D Maximum	1.2 x chart value	.75 x chart value	.07 x D Maximum
> 3 to 4 x D	1.1 x chart value	.75 x chart value	.25 x D Maximum	1.1 x chart value	.65 x chart value	.07 x D Maximum
> 4 to 5 x D	1.0 x chart value	.65 x chart value	.25 x D Maximum	1.0 x chart value	.55 x chart value	.06 x D Maximum
> 5 to 6 x D	.9 x chart value	.55 x chart value	.25 x D Maximum	.9 x chart value	.45 x chart value	.05 x D Maximum

	IP End Mills					
	Rough Facing			Finish Facing		
Projection Length	M/min	MMPT	ADOC	M/min	MMPT	ADOC
0 to 3 x D	1.0 x chart value	.80 x chart value	.25 x D Maximum	1.0 x chart value	.70 x chart value	.07 x D Maximum
> 3 to 4 x D	1.0 x chart value	.80 x chart value	.25 x D Maximum	1.0 x chart value	.70 x chart value	.07 x D Maximum
> 4 to 5 x D	1.0 x chart value	.80 x chart value	.20 x D Maximum	1.0 x chart value	.70 x chart value	.05 x D Maximum
> 5 to 6 x D	1.0 x chart value	.80 x chart value	.20 x D Maximum	1.0 x chart value	.70 x chart value	.05 x D Maximum

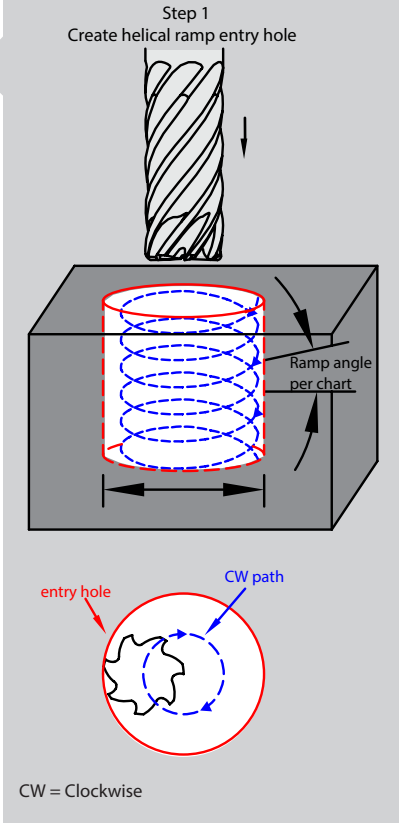
HELICAL RAMP TO CREATE AN ENTRY HOLE

Using a helical ramp move to generate an entry hole is a preferred method to enter the middle of a part. The creation of the entry hole can be either a 1 step or a 2 step process depending on the number of flutes on the end mill. Tools with 7 or fewer flutes only require 1 step, tools with more than 7 flutes require 2 steps.

Step 1: Create helical ramp entry hole

The diameter of the starting hole will be: *(tool diameter x 2) - (corner radius x 2)*

Use the following guide for speed, feed, and ramp angle parameters.
Note that the terms "Same as chart", "Slotting speed in chart", "Slotting feed in chart", and MMPT reference the data that is shown in the speed and feed charts located in each tool series section.



Tool	Speed	Feed Adjustment - with high pressure coolant	Feed Adjustment - with standard flood coolant	Ramp Angle
IPT/C 7	Same as chart	MMPT x 1.6	MMPT x 1.25	0.5°
IPT/C 9	Same as chart	MMPT x 1.6	MMPT x 1.25	0.5°
IPT/C 11	Same as chart	MMPT x 1.6	MMPT x 1.25	0.5°
IPT/C 13	Same as chart	MMPT x 1.6	MMPT x 1.25	0.5°
APT/C 5	Same as chart	MMPT x 1.6	MMPT x 1.25	3°
M525	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M527	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M503	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M726	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M706	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M806	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M924	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M904	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M905	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M223	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	3° - 5°
M233	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	3° - 5°
M203	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	3° - 5°
M202	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	3° - 5°
E14	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
E13	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
E12	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°
M104	Slotting speed in chart	Slotting feed in chart	Slotting feed in chart	1° - 2.5°

Step 2: There are two common methods to open up the starter hole.

Method A: Expand the entry hole from inside out

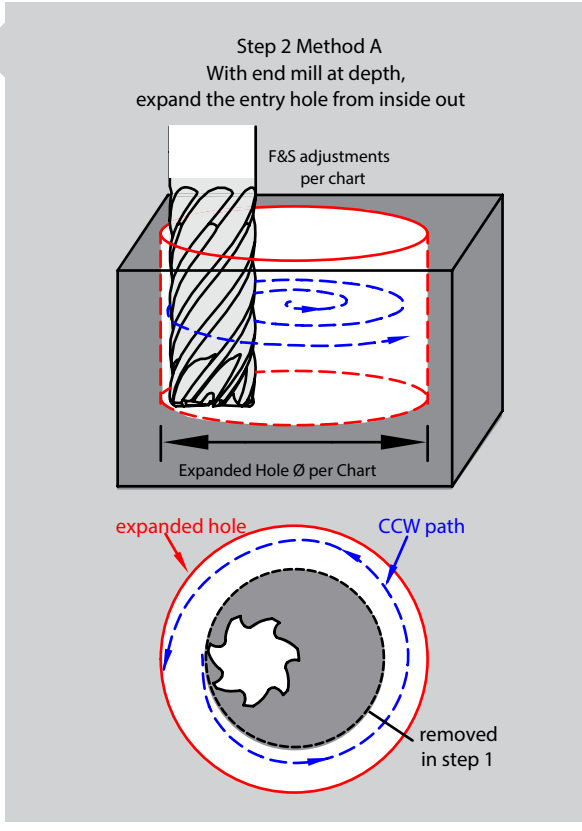
9, 11, and 13-flute tools

After reaching the desired entry hole depth in step 1, and with the end mill still at depth, expand the hole outwards using the feed rate adjustment found in the chart below. Continue until the entry hole is enlarged to the expanded hole diameter shown below.

Once expanded entry hole diameter is achieved, climb cut machining may now commence at 100% of the Peripheral–HEM values shown in the feed and speed application chart for each series of tool.

Tool	Expanded Hole Ø	Feed Rate Adjustment	Step-Over Adjustment
IPT/C 9	3 x D	MMPT x .75	RDOC x .5
IPT/C 11	3.75 x D	MMPT x .75	RDOC x .5
IPT/C 13	3.75 x D	MMPT x .75	RDOC x .5

D = Tool Diameter



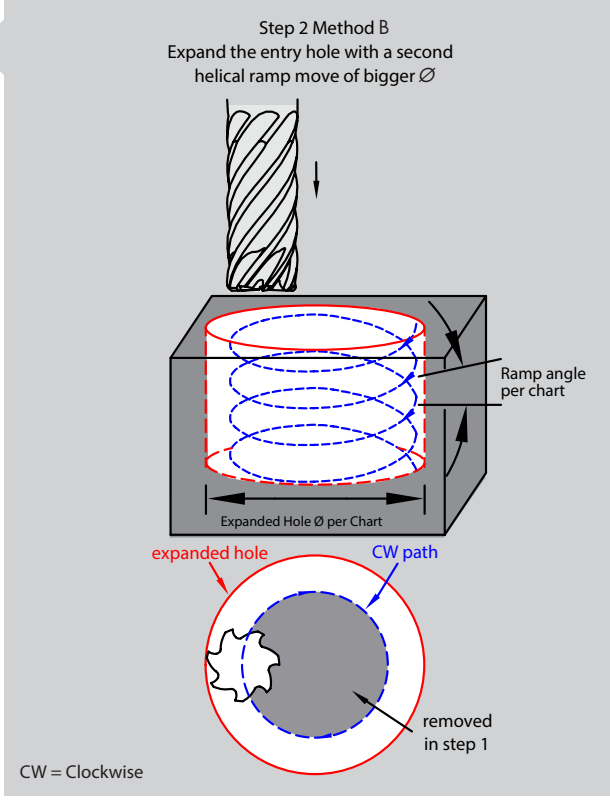
Method B: Expand the entry hole with a second helical ramp move

Method B will expand the entry hole by doing a second helical ramp entry hole of a larger diameter than in step 1. After completion of step 1, retract the end mill out of the hole and machine the second helical ramp entry hole using the same speed, feed, and location as used with the first hole.

Tool	Expanded Hole Ø	Feed Rate Adjustment	Ramp Angle
IPT/C 9	3 x D	MMPT x 1.6	0.5°
IPT/C 11	3.75 x D	MMPT x 1.6	0.5°
IPT/C 13	3.75 x D	MMPT x 1.6	0.5°

D = Tool Diameter

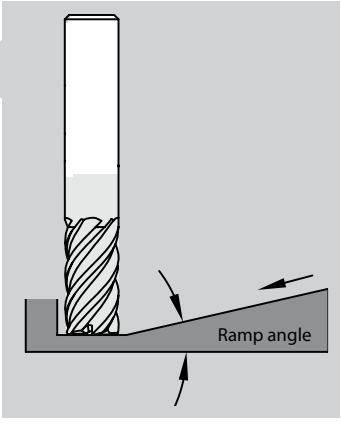
Once the expanded entry hole diameter is achieved, climb cut machining may now commence at 100% of the Peripheral–HEM values shown in the feed and speed application chart for each series of tool.



TECHNICAL RESOURCES

STRAIGHT LINE RAMP ADJUSTMENTS

Straight line ramp moves are an alternative method to enter the middle of a part. The following guide shows, speed, feed and ramp angle data for different IMCO end mills.

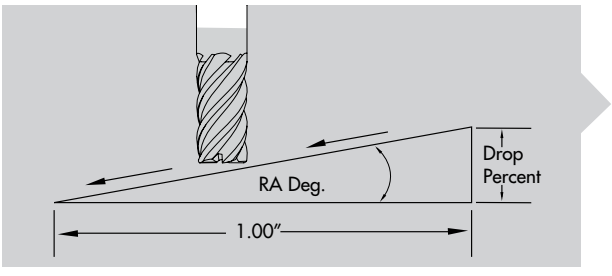


Use the following guide for speed, feed, and ramp angle parameters. Note that the terms "Same as chart", "Slotting speed in chart" and "Slotting IPT/MMPT," and "Helical ramp" (M223 and M233) reference the data that is shown in the speed and feed charts located in each tool series section. Not all tools are designed to allow for the required chip clearance required for straight line ramping, as indicated in the guide.

Tool	Max Ramp Angle	SFM / MMPM	Feed	Max Ramp Depth	Max Ramp Length
IPT/C 7	Not recommended	-	-	-	-
IPT/C 9	Not recommended	-	-	-	-
IPT/C 11	Not recommended	-	-	-	-
IPT/C 13	Not recommended	-	-	-	-
APT/C 5	10°	Slotting speed	Slotting MMPT x .65	75% of D	(.75 x D) / drop per mm
M525	2.5°	Slotting speed	Slotting MMPT x .75	50% of D	(.5 x D) / drop per mm
M527	2.5°	Slotting speed	Slotting MMPT x .75	50% of D	(.5 x D) / drop per mm
M726	Not recommended	-	-	-	-
M706	Not recommended	-	-	-	-
M806	Not recommended	-	-	-	-
M924	2.5°	Slotting speed	Slotting MMPT x .75	50% of D	(.5 x D) / drop per mm
M223	Helical ramp x 5	Same as chart	Same as chart	100% of D	(.75 x D) / drop per mm
M233	Helical ramp x 5	Same as chart	Same as chart	100% of D	(.75 x D) / drop per mm
M203	15°	Slotting speed	Slotting MMPT x .70	50% of D	(.5 x D) / drop per mm
M202	15°	Slotting speed	Slotting MMPT x .70	50% of D	(.5 x D) / drop per mm
E14	2.5°	Slotting speed	Slotting MMPT x .75	50% of D	(.5 x D) / drop per mm
E13	2.5°	Slotting speed	Slotting MMPTx .75	50% of D	(.5 x D) / drop per mm
E12	2.5°	Slotting speed	Slotting MMPT x .75	50% of D	(.5 x D) / drop per mm

D = Tool Diameter

Use the chart to the right for the drop per millimeter guide to determine the maximum ramp length.

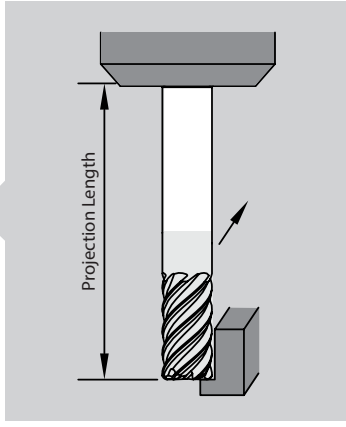


Ramp Angle	Drop Per MM
0.5°	0.224
1°	0.445
2°	0.953
2.5°	1.113
3°	1.334
5°	2.223
10°	4.445
15°	6.668

ADJUSTMENTS FOR LONG REACH APPLICATIONS

Using long length tools increases the amount of tool projection from the tool holder and the spindle. As the tool projection increases so does the amount of tool deflection. Tool deflection causes chatter, resulting in poor surface finish and reduced tool life. Tool options that help minimize tool deflection in long projection applications are:

- Use a larger diameter tool for the operation. Larger tools have larger cores, which reduces deflection.
- Use a tool with a necked shank, which shortens the flute length and increases the core strength of the end mill.



Speed and feed adjustments for long tool projections:

Adjustments must be made to reduce chatter and maximize tool life when using long length tools. The adjustments below are based on the total amount of tool projection and use the speed and feed data found in the application charts for each tool series.

Projection	M/min	Feed
> 1.25 to 3 x D	M/min x .95	MMPT x .95
> 3 to 4 x D	M/min x .90	MMPT x .90
> 4 to 5 x D	M/min x .80	MMPT x .80
> 5 to 6 x D	M/min x .70	MMPT x .70

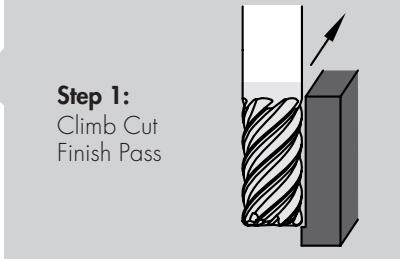
D = Tool Diameter
MMPT = Millimeter Per Tooth
MPM = Millimeters per minute

IMPORTANT NOTES: No adjustments are necessary when using the speed and feed data for HEM tool paths found in the charts for any of the POW•R•PATH and enDURO end mills. Use the data directly from the charts. This applies only when using HEM tool paths.

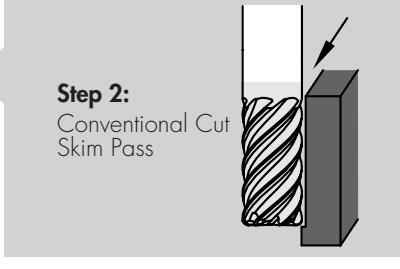
The M223 and M233 have the long projections adjustments already incorporated into the speed and feed charts for those series. Use the data directly from the charts with no adjustments for long projections.

TOOL TIP: ELIMINATE WALL TAPER WHEN FINISHING

Step 1: Run a climb cut finish pass using speed, feed and step-over values (RDOC) shown in the speed and feed charts. Adjust for tool projection if needed.



Step 2: Re-run the path using the same speeds and feeds but in a conventional cut direction. Simply retrace the prior finish pass - do not program to remove more stock. This skim pass, traveling in the opposite direction of the first pass, will help eliminate wall taper caused by tool deflection during the first pass.



ADJUSTMENTS FOR BALL NOSE END MILLS

The speeds and feeds of ball nose end mills must be adjusted to ensure proper tool life. The adjustments are based on the amount of tool engagement.

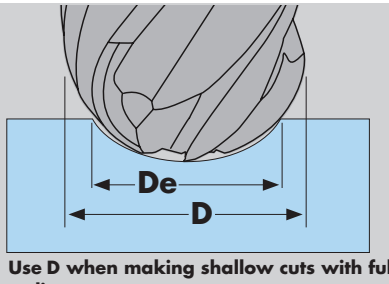
If the depth of cut (ADOC) is <50% of the tool diameter:

Adjustments must be made to determine the effective cutting diameter and to adjust for axial chip thinning. Follow these steps:

Step 1: Use speed and feed values for slot cuts from the speed and feed charts for the appropriate material and tool diameter. **Note:** Make an additional adjustment using the chart to the right if the tool projection exceeds 2.5 x the tool diameter.

Projection	Speed Adj	Feed Adj
> 2.5 to 3 x D	MMPM x .95	MMPT x .95
> 3 to 4 x D	MMPM x .90	MMPT x .90
> 4 to 5 x D	MMPM x .80	MMPT x .80
> 5 to 6 x D	MMPM x .70	MMPT x .70

Step 2: Determine the effective cutting diameter (De) of the end mill based on the axial depth of cut. The effective cutting diameter will be used to make both speed and feed adjustments.



Use D when making shallow cuts with full radius

Ball Nose "Effective Diameter"

$$D = 2x \sqrt{R^2 - (R - ADOC)^2}$$

For easy reference, you can use the chart below:

Depth of Cut (ADOC)	3.0		6.0		10.0		12.0		20.0		25.0	
	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De
10% of tool diameter	.300	1.800	.600	3.600	1.000	6.000	1.200	7.200	2.000	12.000	2.500	15.000
20% of tool diameter	.600	2.400	1.200	4.800	2.000	8.000	2.400	9.600	4.000	16.000	5.00	20.000
30% of tool diameter	.900	2.750	1.800	5.500	3.000	9.165	3.600	10.998	6.000	18.330	7.500	22.913
40% of tool diameter	1.200	2.940	2.400	5.880	4.000	9.800	4.800	11.760	8.000	19.600	10.000	24.500
50% of tool diameter	1.500	3.000	3.000	6.000	5.000	10.000	6.000	12.000	10.000	20.000	12.500	25.000

Step 3: Calculate speed based on using the effective cutting diameter. Use the standard M/min to RPM conversion formula but substitute the effective cutting diameter (De) for the actual tool diameter (D).

RPM = (SMM x 318.3) / De

D = actual tool diameter
De = effective cutting diameter
MMPT = feed rate from chart for slot milling

Step 4: Calculate the adjusted feed rate based on the effective cutting diameter and the axial chip thinning formula.

MMPTadj = (D x MMPT) / De

If the axial depth of cut (ADOC) is ≥50% of the tool diameter:

- Use the speed and feed values shown for the slotting operation in the application charts for the series of mill being used.
- If the tool projection exceeds 2.5 x the tool diameter, adjust the slotting speeds and feeds by the chart for long reach tool adjustments. This can be found on page 67.

The new feed rate is calculated:

MMPM = RPM x (Z x MMPTadj)

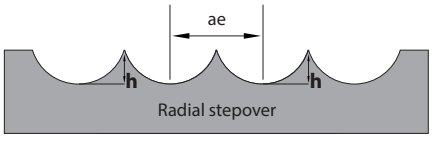
Z = # of flutes
IPT adj = adjusted chip load per tooth fractional
MMPTadj = adjusted chip load per tooth metric

SURFACE FINISH

Radial depth of cut (RDOC), or step-over, is based the desired finish. The lighter the step-over the lower the scallop height (material left uncut by the radius of the tool), and the better the finish. Below is a chart that calculates approximate scallop height using the following formula:

h ~ (ae²) / (8R)

h = scallop height
ae = radial step over
R = radius of the end mill
(tool diameter x .5)



Tool Diameter	Step-over % of OD	Step-over Actual	Approx Scallop Height
3.0 mm	10%	.300	.0075
	20%	.600	.0300
	30%	.900	.0675
6.0 mm	10%	.600	.0150
	20%	1.200	.0600
	30%	1.800	.1350
10.0 mm	10%	1.000	.0250
	20%	2.000	.1000
	30%	3.000	.2250
12.0 mm	10%	1.200	.0300
	20%	2.400	.1200
	30%	3.600	.2700
20.0 mm	10%	2.000	.0500
	20%	4.000	.2000
	30%	6.000	.4500
25.0 mm	10%	2.500	.0625
	20%	5.000	.2500
	30%	7.500	.5625

TECHNICAL RESOURCES

Tool Holder Recommendations When Using HEM

HEM tool paths reduce the amount of radial cutting forces exerted on the end mill, allowing more aggresive speeds and feeds and higher metal removal rates (MRR). Along with higher MRRs come higher axial cutting forces, which work to pull the end mill out of the holder and into the part. Using a holder with gripping power high enough to overcome these increased axial forces is critical for successful machining in HEM tool paths. For better tool life, it is also important to choose a holder that minimizes the run-out of the tool assembly.

Holder Type	Use in HEM Programming?
Press fit	Recommended
Shrink fit	Recommended
Mechanical chuck	Recommended
Hydraulic chuck	Only if ADOC < 3 x D
Advanced ER collet	Only if ADOC < 3 x D
Standard ER collet	Not recommended
Side lock holder	MUST keep run-out minimized

Determining Power Requirements

It can be helpful to understand the power requirements for an application. The following formulas calculate spindle and motor horsepower and spindle torque.

Step 1: Metal Removal Rate (MRR) = (Tool Feed Rate) x Radial DOC x Axial DOC

Step 2: Spindle HP = Metal Removal Rate x UHP

Step 3: Motor HP = Spindle HP / Efficiency

Step 4: Spindle Torque (ft. lbs.) = (Spindle HP x 63,030) / RPM

UHP Factors Ratings

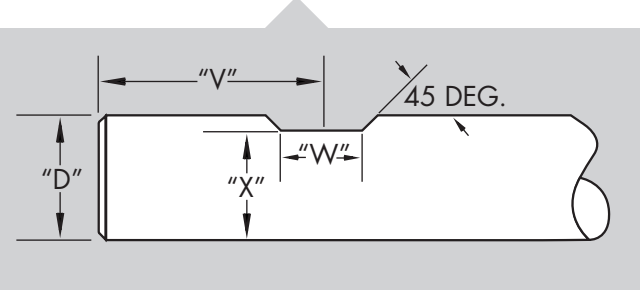
Material	Factor
Aluminum	0.3
Cast iron	0.8
Carbon steel	1
Alloy steel	1.1
Mold steel	1.2
Tool steel	1.2
Stainless steel	1.5
Titanium	1.8
Hi-temp alloys	2

Efficiency Ratings

Spindle Type	%
Direct drive	90%
Gear drive	85%
2 Belt	70%
1 Belt	50%
Average	80%

Weldon Flat Specifications

IMCO uses the location and dimensions specified in the ANSI B94.19-1985 standard when adding a Weldon flat to an end mill. All requests for locations and dimensions not matching the ANSI standard must be communicated in writing to IMCO.

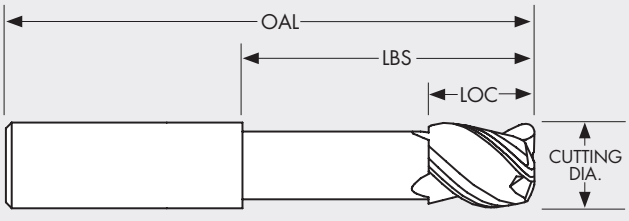


"D"	"W"	"X"	"V"
Shank Diameter	+.015 -0	'+0 -.010	+.015 -015
10 mm (.3937)	.276	.335	.787
12 mm (.4724)	.315	.409	.886
16 mm (.6299)	.394	.559	.945
20 mm (.7874)	.433	.716	.984
25 mm (.9843)	.472	.905	1.260
1.25	.516	1.156	1.140

EZ-QUOTE GUIDE

IMCO's smart coding system simplifies the way to communicate all of the features needed for a made-to-order tool. Just use the specifics of the tool you need quoted, "plug" them into the coding system, and you're there!

Each EZ-Quote part number actually describes the tool itself. It starts with general information (type of tool and tool family) and gets more specific as you go.



Building the EZ-Quote code, step by step.

Insert the numbers in the segments as indicated here. If a certain segment doesn't apply (neck dimension, taper or special shank), just skip it. Separate the segments with hyphens.

1 **Enter the model number.**

For example, the model number for a 5-Flute enDURO end mill would be M525.

2 Enter the **tool diameter** (always to three decimal places). Include the leading zero for diameters less than 10mm.

3 Enter the **length of cut (LOC).** Include the leading zero for an LOC less than 10mm.

4 Enter the **length below shank (LBS) or reach**. Include the leading zero for an LBS less than 100mm. Indicate that this is a neck dimension by placing an N before the number. (If the tool has no neck, you can skip this segment altogether.)

5 Enter the **end/corner** type or size. Include the leading zero for corner radii less than 1mm. For any other end/corner type, just indicate the type: SQ = square end, BN = ball nose, CC = corner chamfer.

6 If the **overall length** you need is not the standard length for the combination of tool diameter, LOC and LBS, then enter the overall length **(OAL)** here. Indicate that this is an overall length by placing an L before the number. If you do not specify an overall length, we will assume it is standard length.

7 Enter the code for the **type of shank** you need (W = Weldon flat, WN = whistle notch, P = plain). If you do not specify a shank style, we will assume it is a plain shank.

8 Enter the **coating** ONLY if it is different than the standard coating for that model.

1	2	3	4	5	6	7	8
MODEL	TOOL DIAMETER	LENGTH OF CUT (LOC)	LENGTH BELOW SHANK (LBS)	END	OVERALL LENGTH	SHANK	COATING
M525 –	060 –	008 –	N020 –	050 –	L075 –	P –	NONE

Segments highlighted in white may be omitted.

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