IMCO

Power. Precision. Performance.

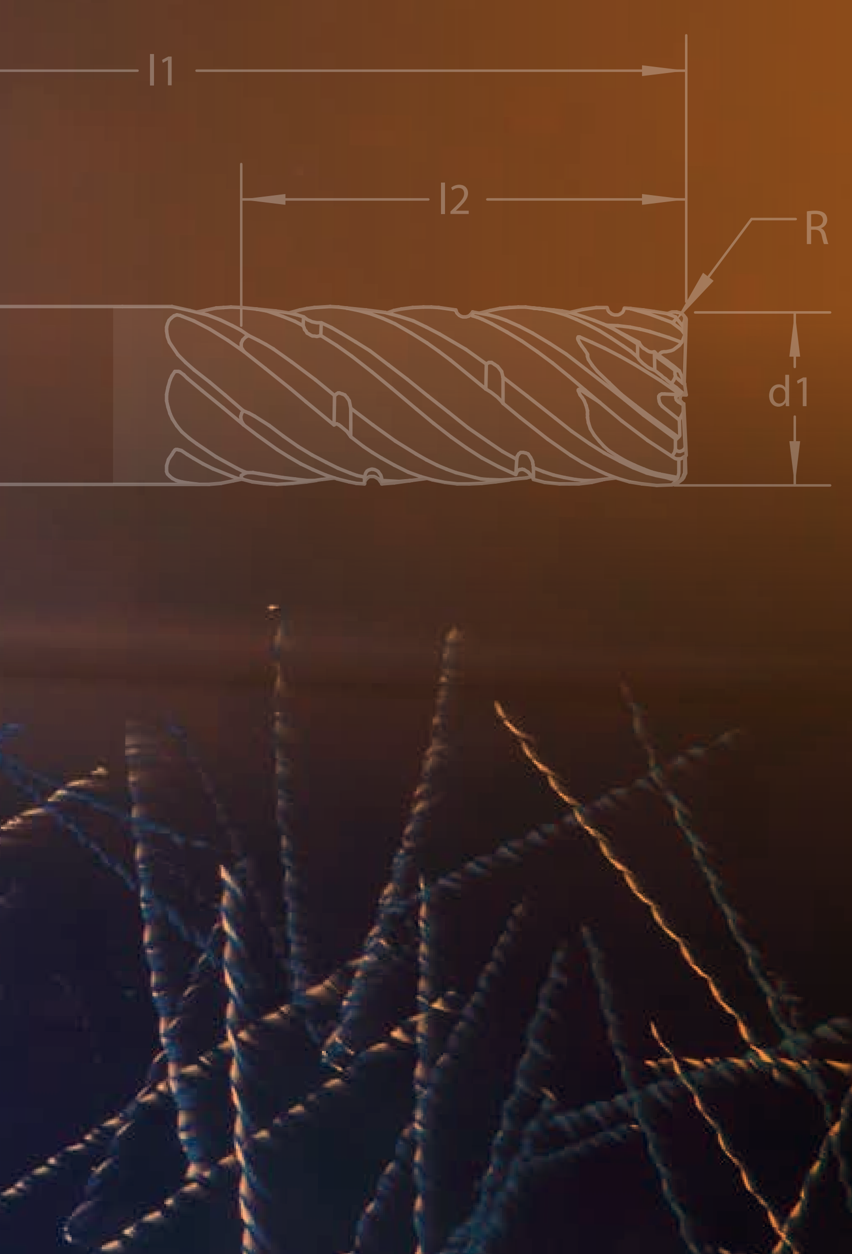
MACHINING REBOOTED.
PRODUCTIVITY RELOADED.

NEW POW•R•PATH
IP Series

THE PATH TO HIGHER PRODUCTIVITY


PLAIN
d2

Machining rebooted. Productivity reloaded.



First, materials evolved. Then, machining centers. Today, the machining process itself is transformed into a more efficient, more productive series of tool paths.

And now, new cutting tools made especially for this new way of machining are making it even more productive and more lucrative than ever.

The **NEW** POW•R•PATH IP Series. Only from IMCO.

Contents

How to spell higher productivity: H-E-M.

The nature of HEM tool paths creates opportunities for unique tools to get the full benefits of this way of machining. IMCO has developed a new class of tools specifically to get the most out of using HEM.

HIGH-EFFICIENCY MACHINING

Simply put, high-efficiency machining (HEM) is a strategy that uses advanced tool paths, unique cutting tools and high-quality tool holders to achieve the highest metal removal rate (MRR) possible to reduce machine time and the cost to produce a part.

HEM uses **advanced tool paths** that maintain a specified, consistent pressure on cutting tools and the machine spindle. Common characteristics of these tool paths are:

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

Light Radial Cuts

The amount of the radial stepover is determined by the type of material being machined, commonly 5%–10% of the diameter of the end mill.

HEM-specific design: IMCO designed the IP class of mills with 7 or 9 flutes to take full advantage of light radial cuts. Those extra flutes add to the stability and output of IP mills, compared to 4- or 5-flute mills. Just as important, the flute configuration, cutting edges and corner radii are all engineered specifically for the unique HEM cutting environment.

Deep Axial Cuts

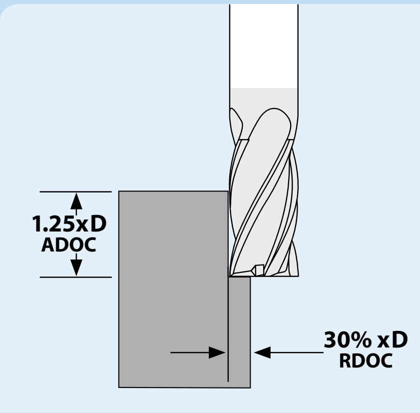
Depths of cut up to 4.5x the diameter of the mill can be achieved when combined with light radial stepovers. The true benefits of HEM can be measured beginning at depths equaling 2x the diameter.

Deep axial cuts can create stability issues when milling, resulting in chatter and slow speed and feed rates. IMCO IP mills are made with a very thick core, greatly increasing tool stability and reducing vibration and deflection. This thick core, combined with a substrate with high transverse rupture strength, results in long tool life for IP mills, even in deep cuts.

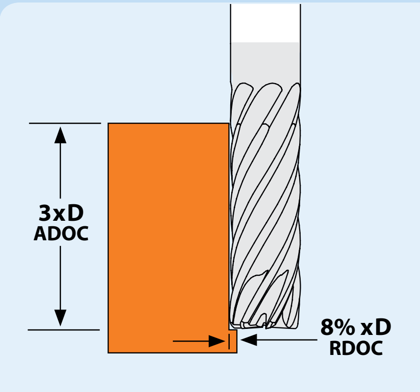
The benefits of combining light radial and deep axial cuts become evident when programming speeds and feeds. Light stepovers generate less heat in the cutting zone, allowing the use of much higher speeds and feeds. These higher speeds and feeds follow the well-accepted theory of chip-thinning adjustments and increase the metal removal rates well above those achieved with traditional machining methods. Light radial cuts also reduce cutting forces on the tool which, in turn, allow deeper axial cuts. **See example at right.**

Combining light radial and deep axial cuts may produce long, stringy chips in materials such as stainless steels and titanium. Applying IMCO's unique CMS (Chip Management System) to IP mills (IPC series) helps break those long chips into manageable lengths, so it's easier for air or coolant to take them out of the cutting zone. The IPC series is very effective in chip removal when machining deep pockets in a wide variety of materials.

Machining 316 stainless steel; must remove .150″ from a wall 1.5″ tall.

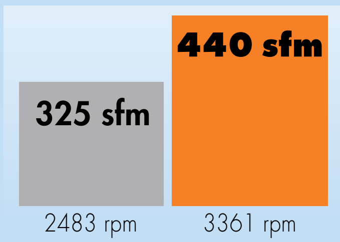


Traditional method using IMCO M924 Series ½″ OD 4-flute end mill, taking a radial DOC of 30% of the diameter and an axial DOC of 1.25xD (.625" in this example).

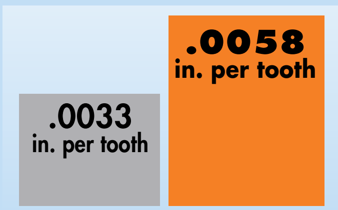


HEM method roughing out the same part using the IPT 7-flute mill, taking a radial DOC of 8% of the diameter and an axial DOC of 3xD (the full 1.5" of the wall in this example).

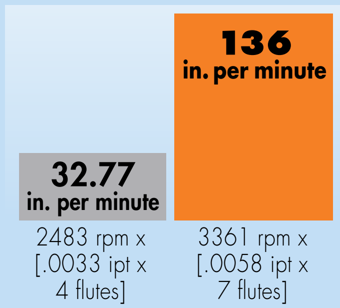
SPEED



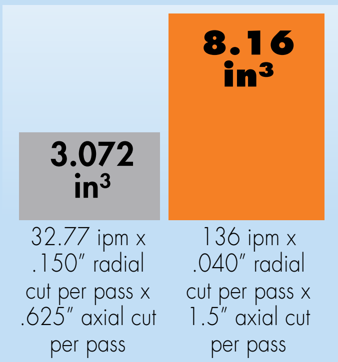
CHIP LOAD



FEED RATE



METAL REMOVAL RATE



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

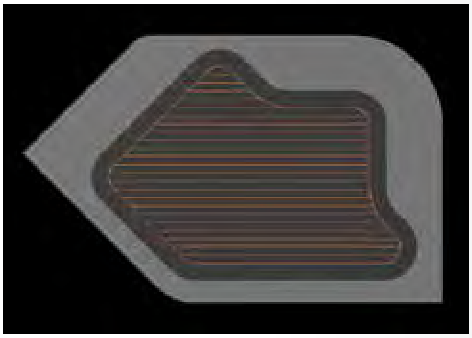
TECHNOLOGY SPOTLIGHT:

HEM vs. HSM

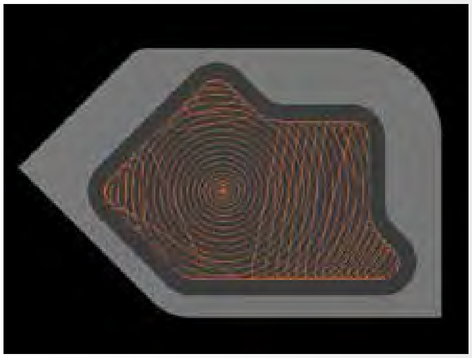
Elliptical tool paths make all the difference.

In simple, straight-line moves, HEM and HSM look very similar – they both use light radial cuts and deep axial cuts. But when machining slots, pockets and other shapes, the difference becomes obvious.

HEM software ensures the load, or pressure on the tool, is kept consistent from start to finish. Tool paths are created with this in mind. As a result, HEM tool paths maintain the feed rate – even in corners – without increasing cutting forces.



HSM/Traditional Toolpath



HEM Toolpath

This differs from simple HSM programming and traditional machining, which use zigzag tool paths that generate heavy tool engagement, intense pressure in 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 mill to survive the sharp turns.

IPT mills and the IPC series (with CMS) are specifically designed for HEM. The development process focused first on the tool paths and then the various materials. The result is a line of mills engineered from the ground up for high metal removal rates, long tool life and great time savings for shops using HEM software.

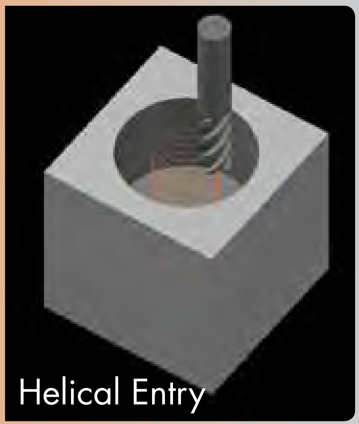
HEM and Slotting

Use light radial stepovers in elliptical tool paths to machine deep slots in only one or two axial depth settings. Called "trochoidal milling," this technique yields a large time savings when machining wide and/or deep slots and slots with dimensions that don't match common end mill diameters.

Tool Tip for Double Savings

Tool paths used in HEM will often allow you to use smaller-diameter tools to machine slots and pockets. For example, in traditional machining, a ½"-wide slot is machined with a ½"-diameter mill. Using HEM, a 3/8"-diameter mill can machine the same slot – *in less time*. Add the l ower cost of a smaller mill to higher MRR, and you have double savings.

HEM Tool Entry Moves



Helical ramp entry moves are common in HEM programming. Helical ramp entries can eliminate the need for drilling to start a pocket, saving set-up time for multiple tools and time for tool changes.

It is critical to have the proper coolant flow to evacuate the chips when utilizing a helical ramp entry.

See information on page 7.

The unique end geometry of IMCO IP mills saves time by rapidly creating the entry hole via helical interpolating to a desired depth. The ramp angle for IP mills should be kept at a light 0.5° angle. However, it should be programmed with the same spindle speed rate (rpm) used for side milling and a much greater feed rate – 1.6x the chip load for side milling. Please reference the speed and feed charts for specific information for the material being machined.

TOOL TIP

IP starter hole methods.

Proper chip evacuation is critical, especially when machining pockets. Using a helical ramp move as the entry method for the mill is a very efficient way to start machining a pocket. Caution must be used once the mill reaches its final depth in the Z axis. The end mill can potentially "outrun" the coolant and begin to re-cut chips. It is important to ensure that enough coolant is reaching the pocket floor to remove chips created during the ramping phase, before the mill starts running in the X and Y axes.

Use these guidelines when making a helical ramp move to start a pocket. Adjustments are listed by the type of coolant line positioning on the machine.

Speed and feed charts can be found on pages 18, 19, 22 and 23.

High-pressure through-spindle coolant with coolant ring

Helical hole size: Using the IP end mill, make the helical hole 2x the diameter of the mill.

Ramp angle: 0.5°

Ramping speed: Use the spindle speed shown in the speed and feed charts.

Ramping feed: Multiply the chip load value (see speed and feed charts) by 1.6.

First moves from starter hole in X and Y axes: No adjustments necessary. Simply run the speed, feed and tool engagement in the speed and feed charts for the material being machined.

Standard coolant hose positioned to allow for tool changes – OPTION 1

Helical hole size: Using the IP end mill, make the helical hole 2x the diameter of the mill.

Ramp angle: 0.5°

Ramping speed: Use the spindle speed shown in the speed and feed charts.

Ramping feed: Multiply the chip load value (see speed and feed charts) by 1.25.

First moves from starter hole in X and Y axes: To allow chips to be flushed from the hole, reduce the radial stepover to 50% of the value listed in the speed and feed charts for the material being machined, while maintaining the listed speed and feed rates. Once the hole is 3x the diameter of the mill when using the IPT7 and IPC7 (4x the diameter of the mill when using the IPC9), increase the stepover to the value shown in the charts.

Standard coolant hose positioned to allow for tool changes – OPTION 2

Helical hole size: Using the IMCO M525 end mill, make the helical hole 2x the diameter of the end mill.

Ramp angle: 2.5°

Ramping speed: Reduce the SFM shown in the IP application guide for the appropriate material by 25%.

Ramping feed: Reduce the chip load per tooth shown in the IP application guide for the appropriate material by 50%.

First moves from starter hole in X and Y axes: To allow chips to be flushed from the hole, reduce the IP charted radial step value by 50% and use the calculated spindle speed and feed rate used for helical entry to machine the starter hole to 3x the diameter of the end mill when using the IPT7 and IPC7 (4x the diameter of the end mill when using the IPC9).

Standard coolant hose positioned to allow for tool changes – OPTION 3

Hole size: Using an indexable drill, create a hole 3x the diameter of the IP mill.

First moves from drilled hole: No adjustments necessary. Simply run the speed, feed and tool engagement shown in the speed and feed charts for the material being machined.

TOOL TIP

Use IPT7 end mills to cut machining time.

No matter what your shop rate is per minute, using POW•R•PATH IP end mills can create huge time savings you can take to the bank.

In this comparison, machining in 316L (30 HRC) stainless steel, the IPT7 mill with HEM tool paths **cut machining time 66%** vs. a high-performance 4-flute end mill running traditional paths. **That's three parts with the IPT7 tool vs. just one with the 4-flute.**

	4-Flute Mill	IPT7 Mill
Roughing		
Tool dia.	½″	½″
Speed	2674 rpm (350 sfm)	**3438 rpm (450 sfm)**
Feed	32 ipm (.003 ipt)	**154 ipm (.0064 ipt)**
Axial DOC	.500″	**1.500″ (deeper cut)**
Radial DOC	.250″	**.040″ (light stepover)**
Cycle Time	**18½ min.**	**6½ min.**

These parameters were used to machine the part shown below.

TECHNOLOGY SPOTLIGHT:

HEM FAQ

Q: Is there only one company that specializes in HEM software?

A: No. Several very reputable companies have their own unique HEM software developed for your CAM system.

Q: Is it necessary to have a new, very advanced CNC machining center to take advantage of HEM?

A: Sort of. First, CNC is a must. Also, the machine needs to be well maintained and rigid. Finally, the algorithms for HEM tool paths can require a lot of programming code, so the machine's data processing rate will be important when trying to work at high table feed rates.

Q: If the tool needs to make more radial passes to complete the part, won't it wear out faster?

A: No. The light stepover generates less heat in the cutting area, reducing the damage to the mill's cutting edge. Light radial cuts also allow the use of multiple-fluted tools that put less wear on each cutting edge without sacrificing feed rates. The deep axial cut means more contact between the tool and the part, which can reduce both tool overhang and chatter.

Q: Do I need specific tool holders to machine with HEM tool paths?

A: No, but it is critical that you use a high-quality holder. There are two basic but important considerations. First, the runout of the end mill + tool holder + spindle interface must be kept to a minimum to ensure you get excellent tool life, wall straightness and surface finish. We strongly advise that you measure the TIR before using any new tool in an HEM tool path.

The second consideration is that the forces that pull the tool into the work piece increase with the axial engagement of the end mill. Since taking deep cuts is one of the advantages offered by HEM tool paths, choosing a holder that has a tight bond with the end mill is very important. As a result of these forces, the use of ER collets is not recommended. A wide range of other tool holding options is available for use in an HEM environment.

Q: Wet or dry? Should cuts using HEM tool paths be made with coolant or with an air blast?

A: It depends on the material and the tool selected.

The HEM advantage in all situations is that light radial cuts reduce heat in the cutting zone, which improves tool life in all materials.

Some materials can be machined effectively with only an air blast – materials in the categories of low- and medium-carbon steels and tool steels. Other materials, like stainless steels and titanium, require coolant in most situations. Finally, coolant should always be used when machining super alloys, such as Inconel and Hastalloy.

Tool choice is also very important. It is critical in every job, regardless of the tool path used, to get chips out of the cutting zone, and avoid re-cutting chips and damaging cutting edges. Coolant has traditionally been used to flush away chips.

But light radial cuts, combined with deep axial cuts used in HEM, tend to generate long, stringy chips.

The IMCO Chip Management System (CMS) is standard on all 9-fluted IPC tools and an option on 7-flute tools. The CMS breaks chips into smaller pieces that can easily be flushed away from the cutting zone to eliminate chip re-cutting. To machine dry, IMCO highly recommends using the tools with CMS.

Q: Is HEM just another machining fad?

A: No. HEM is a strategy with the sole purpose of improving productivity and efficiency. MRRs achievable with a high-quality end mill made for HEM tool paths and programs were inconceivable only five to 10 years ago. HEM techniques can be used to machine almost every material and increase profitability for shops using them.

Q: Is HEM the best method to run on every job?

A: No. The time savings achieved with HEM depends a lot on the part to be machined, especially its shape and size. HEM yields the biggest benefits when tools run at depths twice their diameter or greater.

Also, HEM tool paths should be classified as roughing tool paths. Finish passes with traditional speeds and feeds are often required to meet the desired part specifications.

IP mills are 7- or 9-flute mills that truly shine when used as roughing mills. Their unique design means that they can be used in a wide range of materials, from easy-to-machine low-carbon steels to super alloys like Inconel. HEM programming may not be practical for all jobs a shop may run, but when used, it makes a significant difference. The higher the MRR, the greater the profitability: *It's all about the cubes*.

POW•R•PATH
IP Series

The path to higher productivity.

Amplify the benefits of high-efficiency machining with POW•R•PATH IP Series cutting tools. Every aspect of POW•R•PATH mills is optimized specifically for HEM methods to make sure you get every advantage this modern machining system can provide. And there are plenty, starting with productivity increases that easily eclipse anything you've achieved until now.

POW•R•PATH IP Series Features

Corner radius helps protect cutting ends against chipping

Optimized rake and relief angles for superior sharpness, protection against premature wear

Seven or nine flutes allow higher cutting-edge engagement for high metal removal rates and amazing finish quality

Thick carbide core with high transverse rupture strength (TRS) for durability and longer tool life

IPT7 IPC9

High-strength flutes for higher cutting-edge engagement, more metal removal and longer tool life

Special flute design for reliable chip evacuation in any material, making it the ultimate cutting tool with universal application

Advanced AlCrNX coating keeps tool working cooler, longer in a variety of ferrous materials

Options

Corner radius
Helps prevent corner chipping.

Square end (7-flute only)
For routine machining, finishing.

Chip Management System (CMS)
Unique flute design controls chip size and maximizes tool life.

Choose the length for the job.

Use our "xD" column to pick the right length of cut for your mill. "xD" designates the axial depth of cut that the mill can make per pass – eliminating the need to choose a tool with extra flute length.

Excellent performance using high-efficiency machining in the following materials:

P — **Carbon and tool steels**
Low to medium carbon steels and tool steels

K — **Cast iron**
Malleable and gray cast irons

M — **Stainless steels**
Austenitic, martensitic, ferritic and precipitation-hardening stainless steels

S — **Heat-resistant super alloys**
Titanium and heat-resistant alloys

IPT7

Square End and Corner Radius

POW•R•PATH

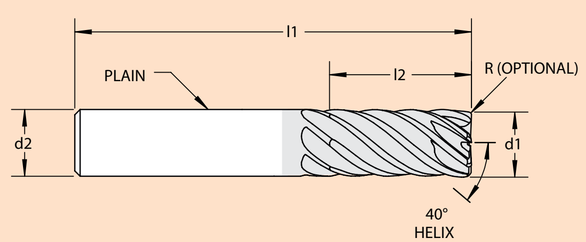
NEW TOOLS FOR THE NEW AGE OF MACHINING.

From the inside out and flute to radii, IPT7 mills are built to work harder, longer on continuous tool paths. IMCO's advanced coating deflects the blistering heat generated at aggressive speeds. And with proper coolant nozzle placement and volume (see TOOL TIP, page 14), you'll be generating a nonstop tsunami of chips – and finished parts – with a tool that just keeps going.

7-FLUTE

For high-efficiency machining (HEM) in materials ranging from low-carbon steels to high-temp alloys.

Get straighter walls in deep cuts, great metal removal rates and faster cycle times with IPT7's wide-core strength. IPT7's unique design keeps it stable even at high feed rates in cuts as deep as 4.5x the tool diameter. A corner radius is recommended in hard-to-machine metals or pieces likely to chip cutting edges.



in	d_1 +0.000 / -0.002	d_2 -0.0001 / -0.0004
mm	d_1 +0,000 / -0,050	d_2 -0,0025 / -0,0100

Model Code: IPT7
7-Flute w/Square End

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code	EZ-ID Number IPT7 - xxxx - xxxx - SQ (d1, l2)
3/16	3/16	2	3/8	2	63476	IPT7-0187-0375-SQ
		3	9/16	2	63479	IPT7-0187-0562-SQ
		4	3/4	2-1/2	63482	IPT7-0187-0750-SQ
1/4	1/4	2	1/2	2	63485	IPT7-0250-0500-SQ
		3	3/4	2-1/2	63489	IPT7-0250-0750-SQ
		4	1	3	63493	IPT7-0250-1000-SQ
3/8	3/8	2	3/4	2-1/2	63497	IPT7-0375-0750-SQ
		2.5	15/16	2-1/2	63502	IPT7-0375-0937-SQ
		3	1-1/8	3	63507	IPT7-0375-1125-SQ
		4	1-1/2	3-1/2	63512	IPT7-0375-1500-SQ
1/2	1/2	2	1	3	63516	IPT7-0500-1000-SQ
		2.5	1-1/4	3	63521	IPT7-0500-1250-SQ
		3	1-1/2	3-1/2	63526	IPT7-0500-1500-SQ
		3.5	1-3/4	3-1/2	63531	IPT7-0500-1750-SQ
		4	2	4	63536	IPT7-0500-2000-SQ
		4.5	2-1/4	4	63541	IPT7-0500-2250-SQ
5/8	5/8	2	1-1/4	3-1/2	63546	IPT7-0625-1250-SQ
		2.5	1-9/16	3-1/2	63552	IPT7-0625-1562-SQ
		3	1-7/8	4	63558	IPT7-0625-1875-SQ
		3.5	2-3/16	4	63564	IPT7-0625-2187-SQ
		4	2-1/2	5	63568	IPT7-0625-2500-SQ
3/4	3/4	2	1-1/2	4	63572	IPT7-0750-1500-SQ
		2.5	1-7/8	4	63578	IPT7-0750-1875-SQ
		3	2-1/4	5	63585	IPT7-0750-2125-SQ
		3.5	2-5/8	5	63592	IPT7-0750-1625-SQ
		4	3	6	63597	IPT7-0750-3000-SQ
1	1	2	2	4-1/2	63601	IPT7-1000-2000-SQ
		2.5	2-1/2	5	63608	IPT7-1000-2500-SQ
		3	3	6	63615	IPT7-1000-3000-SQ
		3.5	3-1/2	6	63619	IPT7-1000-3500-SQ
		4	4	7	63623	IPT7-1000-4000-SQ

Model Code: IPT7
7-Flute w/Square End

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code	EZ-ID Number IPT7 - xxxx - xxxx - SQ (d1, l2)
6	6	2	12	57	63670	IPT7-060-012-SQ
		3	18	63	63672	IPT7-060-018-SQ
		4	24	75	63674	IPT7-060-024-SQ
8	8	2	16	63	63676	IPT7-080-016-SQ
		3	24	63	63678	IPT7-080-024-SQ
		4	32	75	63680	IPT7-080-032-SQ
10	10	2	20	66	63682	IPT7-100-020-SQ
		2.5	25	72	63685	IPT7-100-025-SQ
		3	30	75	63688	IPT7-100-030-SQ
		4	40	88	63691	IPT7-100-040-SQ
12	12	2	24	73	63694	IPT7-120-024-SQ
		2.5	30	83	63699	IPT7-120-030-SQ
		3	36	83	63704	IPT7-120-036-SQ
		3.5	42	100	63709	IPT7-120-042-SQ
		4	48	100	63714	IPT7-120-048-SQ
16	16	2	32	82	63719	IPT7-160-032-SQ
		2.5	40	92	63724	IPT7-160-040-SQ
		3	48	100	63729	IPT7-160-048-SQ
		3.5	56	110	63734	IPT7-160-056-SQ
		4	64	125	63739	IPT7-160-064-SQ
20	20	2	40	104	63744	IPT7-200-040-SQ
		2.5	50	104	63749	IPT7-200-050-SQ
		3	60	125	63754	IPT7-200-060-SQ
		3.5	70	125	63759	IPT7-200-070-SQ
		4	80	150	63764	IPT7-200-080-SQ
25	25	2	50	120	63769	IPT7-250-050-SQ
		2.5	63	120	63774	IPT7-250-063-SQ
		3	75	150	63779	IPT7-250-075-SQ
		3.5	88	150	63784	IPT7-250-088-SQ

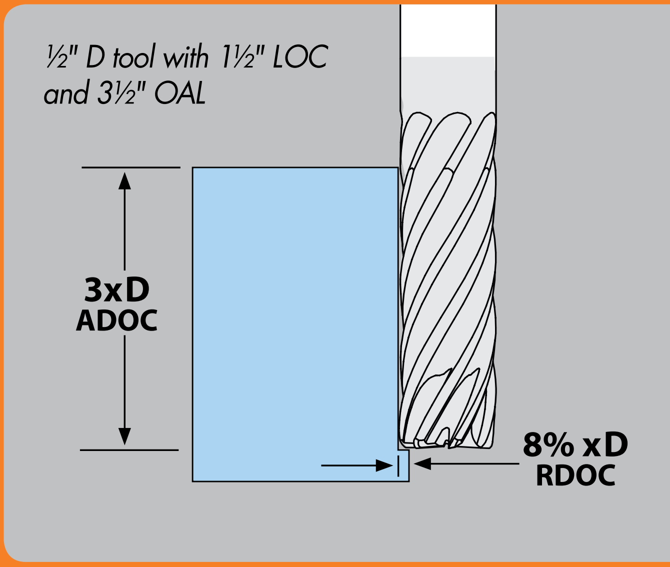
TOOL TIP

Deep Cuts = Big Savings

To get maximum benefit from HEM, you need to run at the maximum depth the end mill can handle. IMCO IP tools are specially designed to use the entire flute length.

We call it "Times D" machining. If your axial depth of cut is 1.5" with a ½" diameter IP tool, you are machining 3xD. Taking the maximum depth of cut increases your metal removal rate, which minimizes your machining time.

Determine your part's depth and the mill diameter, then select the correct IP tool for the job. The application guides starting on page 18 will direct you in the proper use of the tool.



Model Code: IPT7
7-Flute w/Corner Radius

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius (R) .015 CR	.030 CR	.060 CR	.090 CR	.125 CR	.187 CR	.250 CR	EZ-ID Number IPT7 - xxxx - xxxx - xxx (d1, l2, R)
3/16	3/16	2	3/8	2	63477	63478						IPT7-0187-0375-xxx
		3	9/16	2	63480	63481						IPT7-0187-0562-xxx
		4	3/4	2-1/2	63483	63484						IPT7-0187-0750-xxx
1/4	1/4	2	1/2	2	63486	63487	63488					IPT7-0250-0500-xxx
		3	3/4	2-1/2	63490	63491	63492					IPT7-0250-0750-xxx
		4	1	3	63494	63495	63496					IPT7-0250-1000-xxx
3/8	3/8	2	3/4	2-1/2	63498	63499	63500	63501				IPT7-0375-0750-xxx
		2.5	15/16	2-1/2	63503	63504	63505	63506				IPT7-0375-0937-xxx
		3	1-1/8	3	63508	63509	63510	63511				IPT7-0375-1125-xxx
		4	1-1/2	3-1/2	63513	63514	63515					IPT7-0375-1500-xxx
1/2	1/2	2	1	3		63517	63518	63519	63520			IPT7-0500-1000-xxx
		2.5	1-1/4	3		63522	63523	63524	63525			IPT7-0500-1250-xxx
		3	1-1/2	3-1/2		63527	63528	63529	63530			IPT7-0500-1500-xxx
		3.5	1-3/4	3-1/2		63532	63533	63534	63535			IPT7-0500-2000-xxx
		4	2	4		63537	63538	63539	63540			IPT7-0500-2000-xxx
		4.5	2-1/4	4		63542	63543	63544	63545			IPT7-0500-2250-xxx
5/8	5/8	2	1-1/4	3-1/2		63547	63548	63549	63550	63551		IPT7-0625-1250-xxx
		2.5	1-9/16	3-1/2		63553	63554	63555	63556	63557		IPT7-0625-1562-xxx
		3	1-7/8	4		63559	63560	63561	63562	63563		IPT7-0625-1875-xxx
		3.5	2-3/16	4		63565	63566		63567			IPT7-0625-2187-xxx
		4	2-1/2	5		63569	63570		63571			IPT7-0625-2500-xxx
3/4	3/4	2	1-1/2	4		63573	63574		63575	63576	63577	IPT7-0750-1500-xxx
		2.5	1-7/8	4		63579	63580	63581	63582	63583	63584	IPT7-0750-1875-xxx
		3	2-1/4	5		63586	63587	63588	63589	63590	63591	IPT7-0750-2250-xxx
		3.5	2-5/8	5		63593	63594	63595	63596			IPT7-0750-2625-xxx
		4	3	6		63598	63599		63600			IPT7-0750-3000-xxx
1	1	2	2	4-1/2		63602	63603	63604	63605	63606	63607	IPT7-1000-2000-xxx
		2.5	2-1/2	5		63609	63610	63611	63612	63613	63614	IPT7-1000-2500-xxx
		3	3	6		63616	63617		63618			IPT7-1000-3000-xxx
		3.5	3-1/2	6		63620	63621		63622			IPT7-1000-3500-xxx
		4	4	7		63624	63625		63626			IPT7-1000-4000-xxx

TOOL TIP

Aim for a chip-free cutting zone.

The proper location and volume of flood coolant are essential for a successful cut. Coolant plays a very important part in chip evacuation, especially when machining in a pocket or closed area. But simply blasting a large amount of coolant at the end mill isn't the most effective way to flush chips from the cutting zone. In fact, failure to direct the coolant properly increases the risk of re-cutting chips, causing tool damage and premature wear.

As this series of photos demonstrates, the most productive way to flush chips out of a pocket is to direct the coolant to the bottom of the cut. This allows the coolant to rebound off the tool and part floor, lifting the chips out and away from the tool's cutting edges

Coolant flow is perpendicular to the end mill, flowing past the end mill without hitting it directly. This will not evacuate the chips from the flutes sufficiently or provide proper cooling to the cutting edges.

Coolant flow is hitting the end mill nicely, but it is perpendicular to it. This will cool the end mill but will not lift and flush the chips out of the cutting zone.

Model Code: IPT7
7-Flute w/Corner Radius

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius (R) 0,5 CR	1,0 CR	1,5 CR	2,0 CR	3,0 CR	EZ-ID Number IPT7 - xxx - xxx - xxx (d1, l2, R)
6	6	2	12	57	63671					IPT7-060-012-050
		3	18	63	63673					IPT7-060-018-050
		4	24	75	63675					IPT7-060-024-050
8	8	2	16	63	63677					IPT7-080-016-050
		3	24	63	63679					IPT7-080-024-050
		4	32	75	63681					IPT7-080-032-050
10	10	2	20	66	63683	63684				IPT7-100-020-xxx
		2.5	25	72	63686	63687				IPT7-100-025-xxx
		3	30	75	63689	63690				IPT7-100-030-xxx
		4	40	88	63692	63693				IPT7-100-040-xxx
12	12	2	24	73		63695	63696	63697	63698	IPT7-120-024-xxx
		2.5	30	83		63700	63701	63702	63703	IPT7-120-030-xxx
		3	36	83		63705	63706	63707	63708	IPT7-120-036-xxx
		3.5	42	100		63710	63711	63712	63713	IPT7-120-042-xxx
		4	48	100		63715	63716	63717	63718	IPT7-120-048-xxx
16	16	2	32	82		63720	63721	63722	63723	IPT7-160-032-xxx
		2.5	40	92		63725	63726	63727	63728	IPT7-160-040-xxx
		3	48	100		63730	63731	63732	63733	IPT7-160-048-xxx
		3.5	56	110		63735	63736	63737	63738	IPT7-160-056-xxx
		4	64	125		63740	63741	63742	63743	IPT7-160-064-xxx
20	20	2	40	104		63745	63746	63747	63748	IPT7-200-040-xxx
		2.5	50	104		63750	63751	63752	63753	IPT7-200-050-xxx
		3	60	125		63755	63756	63757	63758	IPT7-200-060-xxx
		3.5	70	125		63760	63761	63762	63763	IPT7-200-070-xxx
		4	80	150		63765	63766	63767	63768	IPT7-200-080-xxx
25	25	2	50	120		63770	63771	63772	63773	IPT7-250-050-xxx
		2.5	63	120		63775	63776	63777	63778	IPT7-250-063-xxx
		3	75	150		63780	63781	63782	63783	IPT7-250-075-xxx
		3.5	88	150		63785	63786	63787	63788	IPT7-250-088-xxx

Coolant volume is weak and too high. The coolant is not aimed into the cutting zone, which limits its effectiveness in flushing the chips, lubricating and cooling at the point of cut.

This example of coolant placement shows plenty of flush at the end mill. The three spray nozzles are pointing down at the end mill, forcing the chips up and out of the cutting zone.

There is not enough coolant volume to adequately flush chips out of the cutting zone. This condition will result in re-cutting of chips and premature tool wear.

The best coolant flush for evacuating chips from a pocket uses a coolant flush-type collet and through-spindle coolant (if your machine is equipped with it). Coolant is forced all around the end mill – 360° – at high pressure. High-pressure coolant hits the bottom of the cut and lifts the chips out and away from the cutting zone quickly and efficiently.

IPC7

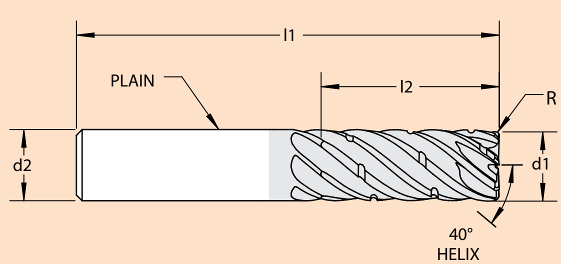
POW•R•PATH
HEM amped.

The POW•R•PATH IPC7 is specially designed to get the most out of every HEM job – literally. IMCO's unique Chip Management System (CMS) eliminates long, stringy chips when taking deep cuts in a variety of materials. The CMS breaks the chips into manageable lengths so the coolant or air blast can wash them clear of the cutting zone. The CMS also prevents end mill damage caused by re-cutting chips and "bird-nesting" – long chips that tangle and pile up in the cutting zone and the bottom of the machining center.

Corner Radius w/Chip Management System (CMS)

7-FLUTE

POW•R•PATH IPC7 cutting tools are designed to skate through all kinds of materials using light stepovers and continuous tool paths. The corner radius helps keep those cutting edges intact – and your productivity high – all through the extended tool life made possible with HEM. And with IMCO's Chip Management System, it's the ultimate universal cutting tool.



in d_1 +0.000 / -0.002 d_2 -0.0001 / -0.0004
mm d_1 +0,000 / -0,050 d_2 -0,0025 / -0,0100

Model Code: IPC7
7-Flute w/Corner Radius

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius (R) .030 CR	Order Code by Corner Radius (R) .060 CR	EZ-ID Number IPC7 - xxxx - xxxx - xxx (d1, l2, R)
3/8	3/8	3	1-1/8	3	63630		IPC7-0375-1125-030
		4	1-1/2	3-1/2	63631		IPC7-0375-1500-030
1/2	1/2	2.5	1-1/4	3	63632	63633	IPC7-0500-1250-xxx
		3	1-1/2	3-1/2	63634	63635	IPC7-0500-1500-xxx
		3.5	1-3/4	3-1/2	63636	63637	IPC7-0500-1750-xxx
		4	2	4	63638	63639	IPC7-0500-2000-xxx
5/8	5/8	2	1-1/4	3-1/2	63640	63641	IPC7-0625-1250-xxx
		2.5	1-9/16	3-1/2	63642	63643	IPC7-0625-1562-xxx
		3	1-7/8	4	63644	63645	IPC7-0625-1875-xxx
		3.5	2-3/16	4	63646	63647	IPC7-0625-2187-xxx
		4	2-1/2	5	63648	63649	IPC7-0625-2500-xxx
3/4	3/4	2	1-1/2	4	63650	63651	IPC7-0750-1500-xxx
		2.5	1-7/8	4	63652	63653	IPC7-0750-1875-xxx
		3	2-1/4	5	63654	63655	IPC7-0750-2250-xxx
		3.5	2-5/8	5	63656	63657	IPC7-0750-2625-xxx
		4	3	6	63658	63659	IPC7-0750-3000-xxx
1	1	2	2	4-1/2	63660	63661	IPC7-1000-2000-xxx
		2.5	2-1/2	5	63662	63663	IPC7-1000-2500-xxx
		3	3	6	63664	63665	IPC7-1000-3000-xxx
		3.5	3-1/2	6	63666	63667	IPC7-1000-3500-xxx
		4	4	7	63668	63669	IPC7-1000-4000-xxx

Model Code: IPC7
7-Flute w/Corner Radius

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius (R) 1,0 CR	EZ-ID Number IPC7 - xxx - xxx - xxx (d1, l2, R)
10	10	3	30	75	63790	IPC7-010-030-100
		4	40	88	63791	IPC7-010-040-100
12	12	2.5	30	83	63792	IPC7-012-030-100
		3	36	83	63793	IPC7-012-036-100
		3.5	42	100	63794	IPC7-012-042-100
		4	48	100	63795	IPC7-012-048-100
16	16	2	32	82	63796	IPC7-016-032-100
		2.5	40	92	63797	IPC7-016-040-100
		3	48	100	63798	IPC7-016-048-100
		3.5	56	110	63799	IPC7-016-056-100
		4	64	125	63800	IPC7-016-064-100
20	20	2	40	104	63801	IPC7-200-040-100
		2.5	50	104	63802	IPC7-200-050-100
		3	60	125	63803	IPC7-200-060-100
		3.5	70	125	63804	IPC7-200-070-100
		4	80	150	63805	IPC7-200-080-100
25	25	2	50	120	63806	IPC7-250-050-100
		2.5	63	120	63807	IPC7-250-063-100
		3	75	150	63808	IPC7-250-075-100
		3.5	88	150	63809	IPC7-250-088-100

IPT7 & IPC7 Series Application Guide – Speed & Feed (inch)

ISO Classification	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (SFM)	Feed (Inches per Tooth) 3/16	1/4	3/8	1/2	5/8	3/4	1
K	Cast Iron - Gray	Peripheral - HEM*	<=3 x D	.1 x D	7	400	0.0027	0.0036	0.0054	0.0072	0.0090	0.0108	0.0144
	ASTM-A48	Peripheral - HEM*	>3xD-4xD	.08 x D	7	400	0.0024	0.0032	0.0049	0.0065	0.0081	0.0097	0.0130
	Class 20, 25, 30, 35 & 40	Peripheral - HEM*	>4xD-5xD	.08 x D	7	390	0.0022	0.0029	0.0043	0.0058	0.0072	0.0086	0.0115
		Finish	3 x D	.015 x D	7	450	0.0010	0.0013	0.0020	0.0026	0.0033	0.0039	0.0052
	Cast Iron	Peripheral - HEM*	<=3 x D	.08 x D	7	390	0.0022	0.0029	0.0044	0.0058	0.0073	0.0087	0.0116
	Malleable	Peripheral - HEM*	>3xD-4xD	.08 x D	7	390	0.0020	0.0026	0.0039	0.0052	0.0065	0.0078	0.0104
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	375	0.0017	0.0023	0.0035	0.0046	0.0058	0.0070	0.0093
		Finish	3 x D	.015 x D	7	350	0.0008	0.0011	0.0016	0.0021	0.0026	0.0032	0.0042
P	Low Carbon Steel ≤ 38 Rc	Peripheral - HEM*	<=3 x D	.08 x D	7	485	0.0028	0.0038	0.0056	0.0075	0.0094	0.0113	0.0150
	1018, 1020, 12L14, 5120, 8620	Peripheral - HEM*	>3xD-4xD	.08 x D	7	485	0.0025	0.0034	0.0051	0.0068	0.0084	0.0101	0.0135
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	465	0.0023	0.0030	0.0045	0.0060	0.0075	0.0090	0.0120
		Finish	3 x D	.015 x D	7	420	0.0011	0.0014	0.0021	0.0028	0.0035	0.0042	0.0056
	Medium Carbon Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	7	450	0.0027	0.0036	0.0053	0.0071	0.0089	0.0107	0.0142
	1045, 4140, 4340, 5140	Peripheral - HEM*	>3xD-4xD	.08 x D	7	450	0.0024	0.0032	0.0048	0.0064	0.0080	0.0096	0.0128
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	425	0.0021	0.0028	0.0043	0.0057	0.0071	0.0085	0.0114
		Finish	3 x D	.015 x D	7	390	0.0009	0.0013	0.0019	0.0025	0.0031	0.0038	0.0050
	Tool & Die Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	7	420	0.0024	0.0032	0.0048	0.0064	0.0080	0.0096	0.0128
	A2, D2, O1, S7, P20, H13	Peripheral - HEM*	>3xD-4xD	.08 x D	7	420	0.0022	0.0029	0.0043	0.0058	0.0072	0.0086	0.0115
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	395	0.0019	0.0026	0.0038	0.0051	0.0064	0.0077	0.0102
		Finish	3 x D	.015 x D	7	365	0.0008	0.0011	0.0016	0.0021	0.0026	0.0032	0.0042
M	Austenitic Stainless Steels,	Peripheral - HEM*	<=3 x D	.08 x D	7	450	0.0024	0.0032	0.0048	0.0064	0.0080	0.0096	0.0128
	FeNi Alloys	Peripheral - HEM*	>3xD-4xD	.08 x D	7	440	0.0022	0.0029	0.0043	0.0058	0.0072	0.0086	0.0115
	303, 304, 316, Invar, Kovar	Peripheral - HEM*	>4xD-5xD	.07 x D	7	425	0.0019	0.0026	0.0038	0.0051	0.0064	0.0077	0.0102
		Finish	3 x D	.015 x D	7	390	0.0009	0.0012	0.0018	0.0024	0.0030	0.0036	0.0048
	Martensitic & Ferritic	Peripheral - HEM*	<=3 x D	.08 x D	7	450	0.0028	0.0038	0.0056	0.0075	0.0094	0.0113	0.0150
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	7	450	0.0025	0.0034	0.0051	0.0068	0.0084	0.0101	0.0135
	410, 416, 440	Peripheral - HEM*	>4xD-5xD	.08 x D	7	425	0.0023	0.0030	0.0045	0.0060	0.0075	0.0090	0.0120
		Finish	3 x D	.015 x D	7	390	0.0009	0.0013	0.0019	0.0025	0.0031	0.0038	0.0050
	Precipitation Hardening	Peripheral - HEM*	<=3 x D	.08 x D	7	440	0.0023	0.0031	0.0047	0.0062	0.0078	0.0093	0.0124
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	7	440	0.0021	0.0028	0.0042	0.0056	0.0070	0.0084	0.0112
	17-4, 15-5, 13-8	Peripheral - HEM*	>4xD-5xD	.07 x D	7	415	0.0019	0.0025	0.0037	0.0050	0.0062	0.0074	0.0099
		Finish	3 x D	.015 x D	7	380	0.0008	0.0010	0.0015	0.0020	0.0025	0.0030	0.0040
S	Titanium Alloys	Peripheral - HEM*	<=3 x D	.1 x D	7	405	0.0015	0.0021	0.0031	0.0041	0.0051	0.0062	0.0082
	6Al-4V, 6-2-4	Peripheral - HEM*	>3xD-4xD	.08 x D	7	405	0.0014	0.0018	0.0028	0.0037	0.0046	0.0055	0.0074
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	390	0.0012	0.0016	0.0025	0.0033	0.0041	0.0049	0.0066
		Finish	3 x D	.015 x D	7	350	0.0006	0.0008	0.0012	0.0016	0.0020	0.0024	0.0032
	Difficult to Machine	Peripheral - HEM*	<=2.5 x D	.08 x D	7	335	0.0015	0.0020	0.0030	0.0040	0.0050	0.0060	0.0080
	Titanium Alloys	Peripheral - HEM*	>2.5xD-3.5xD	.07 x D	7	325	0.0014	0.0018	0.0027	0.0036	0.0045	0.0054	0.0072
	10-2-3	Peripheral - HEM*	>3.5xD-4xD	.06 x D	7	305	0.0012	0.0016	0.0024	0.0032	0.0040	0.0048	0.0064
		Finish	3 x D	.01 x D	7	290	0.0005	0.0007	0.0011	0.0014	0.0018	0.0021	0.0028
	Hastalloy, Waspalloy	Peripheral - HEM*	<=1.5 x D	.08 x D	7	100	0.0035	0.0047	0.0071	0.0094	0.0118	0.0141	0.0188
		Peripheral - HEM*	>1.5xD-2.5xD	.08 x D	7	95	0.0032	0.0042	0.0063	0.0085	0.0106	0.0127	0.0169
		Peripheral - HEM*	>2.5xD-3.5xD	.06 x D	7	85	0.0028	0.0038	0.0056	0.0075	0.0094	0.0113	0.0150
		Finish	2 x D	.01 x D	7	90	0.0019	0.0025	0.0038	0.0050	0.0063	0.0075	0.0100
	Inconel 718, Rene 88	Peripheral - HEM*	<=1.5 x D	.07 x D	7	95	0.0035	0.0047	0.0070	0.0093	0.0116	0.0140	0.0186
		Peripheral - HEM*	>1.5xD-2.5xD	.06 x D	7	90	0.0031	0.0042	0.0063	0.0084	0.0105	0.0126	0.0167
		Peripheral - HEM*	>2.5xD-3xD	.06 x D	7	85	0.0028	0.0037	0.0056	0.0074	0.0093	0.0112	0.0149
		Finish	2 x D	.01 x D	7	85	0.0018	0.0024	0.0036	0.0048	0.0060	0.0072	0.0096

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

Common Machining Formulas:

$$RPM = \frac{SFM \times 3.82}{D}$$

$$SFM = RPM \times D \times .262$$

$$IPM = RPM \times IPT \times Z$$

$$MRR = RDOC \times ADOC \times IPM$$

D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SFM Surface Feet per Minute
IPM Inches per Minute
IPT Inch per Tooth
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

IPT7 & IPC7 Series Application Guide – Speed & Feed (metric)

ISO Classification	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	Cast Iron - Gray	Peripheral - HEM*	<=3 x D	.1 x D	7	122	0.0914	0.1518	0.1829	0.2432	0.3036	0.3658
	ASTM-A48	Peripheral - HEM*	>3xD-4xD	.08 x D	7	122	0.0823	0.1366	0.1646	0.2189	0.2732	0.3292
	Class 20, 25, 30, 35 & 40	Peripheral - HEM*	>4xD-5xD	.08 x D	7	119	0.0732	0.1214	0.1463	0.1946	0.2429	0.2926
		Finish	3 x D	.015 x D	7	137	0.0330	0.0548	0.0660	0.0878	0.1096	0.1321
	Cast Iron	Peripheral - HEM*	<=3 x D	.08 x D	7	119	0.0737	0.1223	0.1473	0.1959	0.2446	0.2946
	Malleable	Peripheral - HEM*	>3xD-4xD	.08 x D	7	119	0.0663	0.1100	0.1326	0.1763	0.2201	0.2652
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	114	0.0589	0.0978	0.1179	0.1567	0.1956	0.2357
		Finish	3 x D	.015 x D	7	107	0.0267	0.0443	0.0533	0.0709	0.0885	0.1067
P	Low Carbon Steel ≤ 38 Rc	Peripheral - HEM*	<=3 x D	.08 x D	7	148	0.0953	0.1581	0.1905	0.2534	0.3162	0.3810
	1018, 1020, 12L14, 5120, 8620	Peripheral - HEM*	>3xD-4xD	.08 x D	7	148	0.0857	0.1423	0.1715	0.2280	0.2846	0.3429
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	142	0.0762	0.1265	0.1524	0.2027	0.2530	0.3048
		Finish	3 x D	.015 x D	7	128	0.0356	0.0590	0.0711	0.0946	0.1181	0.1422
	Medium Carbon Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	7	137	0.0902	0.1497	0.1803	0.2399	0.2994	0.3607
	1045, 4140, 4340, 5140	Peripheral - HEM*	>3xD-4xD	.08 x D	7	137	0.0812	0.1347	0.1623	0.2159	0.2694	0.3246
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	130	0.0721	0.1197	0.1443	0.1919	0.2395	0.2885
		Finish	3 x D	.015 x D	7	119	0.0318	0.0527	0.0635	0.0845	0.1054	0.1270
	Tool & Die Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	7	128	0.0813	0.1349	0.1626	0.2162	0.2698	0.3251
	A2, D2, O1, S7, P20, H13	Peripheral - HEM*	>3xD-4xD	.08 x D	7	128	0.0732	0.1214	0.1463	0.1946	0.2429	0.2926
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	120	0.0650	0.1079	0.1300	0.1730	0.2159	0.2601
		Finish	3 x D	.015 x D	7	111	0.0267	0.0443	0.0533	0.0709	0.0885	0.1067
M	Austenitic Stainless Steels,	Peripheral - HEM*	<=3 x D	.08 x D	7	137	0.0813	0.1349	0.1626	0.2162	0.2698	0.3251
	FeNi Alloys	Peripheral - HEM*	>3xD-4xD	.08 x D	7	134	0.0732	0.1214	0.1463	0.1946	0.2429	0.2926
	303, 304, 316, Invar, Kovar	Peripheral - HEM*	>4xD-5xD	.07 x D	7	130	0.0650	0.1079	0.1300	0.1730	0.2159	0.2601
		Finish	3 x D	.015 x D	7	119	0.0305	0.0506	0.0610	0.0811	0.1012	0.1219
	Martensitic & Ferritic	Peripheral - HEM*	<=3 x D	.08 x D	7	137	0.0953	0.1581	0.1905	0.2534	0.3162	0.3810
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	7	137	0.0857	0.1423	0.1715	0.2280	0.2846	0.3429
	410, 416, 440	Peripheral - HEM*	>4xD-5xD	.08 x D	7	130	0.0762	0.1265	0.1524	0.2027	0.2530	0.3048
		Finish	3 x D	.015 x D	7	119	0.0318	0.0527	0.0635	0.0845	0.1054	0.1270
	Precipitation Hardening	Peripheral - HEM*	<=3 x D	.08 x D	7	134	0.0787	0.1307	0.1575	0.2094	0.2614	0.3150
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	7	134	0.0709	0.1176	0.1417	0.1885	0.2353	0.2835
	17-4, 15-5, 13-8	Peripheral - HEM*	>4xD-5xD	.07 x D	7	126	0.0630	0.1046	0.1260	0.1676	0.2091	0.2520
		Finish	3 x D	.015 x D	7	116	0.0254	0.0422	0.0508	0.0676	0.0843	0.1016
S	Titanium Alloys	Peripheral - HEM*	<=3 x D	.1 x D	7	123	0.0521	0.0864	0.1041	0.1385	0.1729	0.2083
	6Al-4V, 6-2-4	Peripheral - HEM*	>3xD-4xD	.08 x D	7	123	0.0469	0.0778	0.0937	0.1247	0.1556	0.1875
		Peripheral - HEM*	>4xD-5xD	.08 x D	7	119	0.0417	0.0691	0.0833	0.1108	0.1383	0.1666
		Finish	3 x D	.015 x D	7	107	0.0203	0.0337	0.0406	0.0541	0.0675	0.0813
	Difficult to Machine	Peripheral - HEM*	<=2.5 x D	.08 x D	7	102	0.0508	0.0843	0.1016	0.1351	0.1687	0.2032
	Titanium Alloys	Peripheral - HEM*	>2.5xD-3.5xD	.07 x D	7	99	0.0457	0.0759	0.0914	0.1216	0.1518	0.1829
	10-2-3	Peripheral - HEM*	>3.5xD-4xD	.06 x D	7	93	0.0406	0.0675	0.0813	0.1081	0.1349	0.1626
		Finish	3 x D	.01 x D	7	88	0.0178	0.0295	0.0356	0.0473	0.0590	0.0711
	Hastalloy, Waspalloy	Peripheral - HEM*	<=1.5 x D	.08 x D	7	30	0.1194	0.1982	0.2388	0.3176	0.3963	0.4775
		Peripheral - HEM*	>1.5xD-2.5xD	.08 x D	7	29	0.1074	0.1784	0.2149	0.2858	0.3567	0.4298
		Peripheral - HEM*	>2.5xD-3.5xD	.06 x D	7	26	0.0955	0.1585	0.1910	0.2540	0.3171	0.3820
		Finish	2 x D	.01 x D	7	27	0.0635	0.1054	0.1270	0.1689	0.2108	0.2540
	Inconel 718, Rene 88	Peripheral - HEM*	<=1.5 x D	.07 x D	7	29	0.1181	0.1961	0.2362	0.3142	0.3921	0.4724
		Peripheral - HEM*	>1.5xD-2.5xD	.06 x D	7	27	0.1063	0.1765	0.2126	0.2828	0.3529	0.4252
		Peripheral - HEM*	>2.5xD-3xD	.06 x D	7	26	0.0945	0.1569	0.1890	0.2513	0.3137	0.3780
		Finish	2 x D	.01 x D	7	26	0.0610	0.1012	0.1219	0.1622	0.2024	0.2438

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

NEW TOOL

IPC9

POW•R•PATH

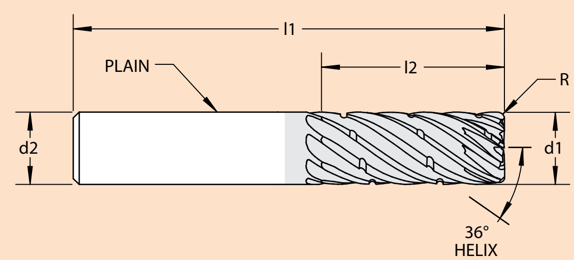
THE ULTIMATE METAL-REMOVING MACHINE.

The POW•R•PATH IPC9 is the total package. Its wide-diameter core makes deflection a non-issue. And with HEM's light radial cuts, you can engage more flute length, giving you straighter walls even in deep pockets. Add high-strength cutting edges and IMCO's Chip Management System and you have one metal-removing machine.

Corner Radius w/Chip Management System

9-FLUTE

This POW•R•PATH end mill with 9 cutting edges *plus* IMCO's Chip Management System (CMS) is a highly productive combination able to achieve very high metal removal rates. Its special design allows roughing with 9 flutes in HEM tool paths, and the CMS helps the coolant or air blast clear the chips from the cutting zone. The CMS also prevents end mill damage caused by re-cutting chips and "bird-nesting" – long chips that tangle and pile up in the cutting zone and the bottom of the machining center.



in d_1 +0.000 / -0.002 d_2 -0.0001 / -0.0004

mm d_1 +0,000 / -0,050 d_2 -0,0025 / -0,0100

Model Code: IPC9
9-Flute w/Corner Radius

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius (R) .015 CR	.030 CR	.060 CR	.125 CR	EZ-ID Number IPC9 - xxxx - xxxx - xxx (d1, l2, R)
1/4	1/4	2	1/2	2	63815	63816			IPC9-0250-0500-xxx
		2.5	5/8	2-1/2	63817	63818			IPC9-0250-0625-xxx
		3	3/4	2-1/2	63819	63820			IPC9-0250-0750-xxx
		3.5	7/8	3	63821	63822			IPC9-0250-0875-xxx
3/8	3/8	2	3/4	2-1/2	63823		63824		IPC9-0375-0750-xxx
		2.5	15/16	2-1/2	63825		63826		IPC9-0375-0937-xxx
		3	1-1/8	3	63827		63828		IPC9-0375-1125-xxx
		3.5	1-5/16	3-1/2	63829		63830		IPC9-0375-1312-xxx
1/2	1/2	2	1	3		63831		63832	IPC9-0500-1000-xxx
		2.5	1-1/4	3		63833		63834	IPC9-0500-1250-xxx
		3	1-1/2	3-1/2		63835		63836	IPC9-0500-1500-xxx
		3.5	1-3/4	3-1/2		63837		63838	IPC9-0500-1750-xxx
5/8	5/8	2	1-1/4	3-1/2		63839		63840	IPC9-0625-1250-xxx
		2.5	1-9/16	3-1/2		63841		63842	IPC9-0625-1562-xxx
		3	1-7/8	4		63843		63844	IPC9-0625-1875-xxx
		3.5	2-3/16	4		63845		63846	IPC9-0625-2187-xxx
3/4	3/4	2	1-1/2	4		63847		63848	IPC9-0750-1500-xxx
		2.5	1-7/8	4		63849		63850	IPC9-0750-1875-xxx
		3	2-1/4	5		63851		63852	IPC9-0750-2125-xxx
		3.5	2-5/8	5		63853		63854	IPC9-0750-2625-xxx
1	1	2	2	4-1/2		63855		63856	IPC9-1000-2000-xxx
		2.5	2-1/2	5		63857		63858	IPC9-1000-2500-xxx
		3	3	6		63859		63860	IPC9-1000-3000-xxx
		3.5	3-1/2	6		63861		63862	IPC9-1000-3500-xxx

Model Code: IPC9
9-Flute w/Corner Radius

Cutter Dia d1	Shank Dia d2	Max Axial Depth xD	Length of Cut l2	Overall Length l1	Order Code by Corner Radius (R) 0,5 CR	1,0 CR	1,5 CR	3,0 CR	EZ-ID Number IPC9 - xxx - xxx - xxx (d1, l2, R)
6	6	2	12	57	63865	63866			IPC9-060-012-xxx
		2.5	15	57	63867	63868			IPC9-060-015-xxx
		3	18	63	63869	63870			IPC9-060-018-xxx
		3.5	21	75	63871	63872			IPC9-060-021-xxx
8	8	2.5	20	63	63873	63874			IPC9-080-020-xxx
		3	24	63	63875	63876			IPC9-080-024-xxx
		3.5	28	75	63877	63878			IPC9-080-028-xxx
10	10	2	20	66	63879		63880		IPC9-100-020-xxx
		2.5	25	72	63881		63882		IPC9-100-025-xxx
		3	30	75	63883		63884		IPC9-100-030-xxx
		3.5	35	88	63885		63886		IPC9-100-035-xxx
12	12	2	24	73		63887		63888	IPC9-120-024-xxx
		2.5	30	83		63889		63890	IPC9-120-030-xxx
		3	36	83		63891		63892	IPC9-120-036-xxx
		3.5	42	100		63893		63894	IPC9-120-042-xxx
16	16	2	32	82		63895		63896	IPC9-160-032-xxx
		2.5	40	92		63897		63898	IPC9-160-040-xxx
		3	48	100		63899		63900	IPC9-160-048-xxx
		3.5	56	110		63901		63902	IPC9-160-056-xxx
20	20	2	40	104		63903		63904	IPC9-200-040-xxx
		2.5	50	104		63905		63906	IPC9-200-050-xxx
		3	60	125		63907		63908	IPC9-200-060-xxx
		3.5	70	125		63909		63910	IPC9-200-070-xxx
25	25	2	50	120		63911		63912	IPC9-250-050-xxx
		2.5	63	120		63913		63914	IPC9-250-063-xxx
		3	75	150		63915		63916	IPC9-250-075-xxx
		3.5	88	150		63917		63918	IPC9-250-088-xxx

IPC9 Series Application Guide – Speed & Feed (inch)

ISO Classification	Work Material	Type of Cut	Axial DOC	Radial DOC	Number of Flutes	Speed (SFM)	Feed (MM per Tooth)					
							1/4	3/8	1/2	5/8	3/4	1
K	Cast Iron - Gray	Peripheral - HEM*	<=3 x D	.1 x D	9	400	0.0036	0.0054	0.0072	0.0090	0.0108	0.0144
	ASTM-A48	Peripheral - HEM*	>3xD-4xD	.08 x D	9	400	0.0032	0.0049	0.0065	0.0081	0.0097	0.0130
	Class 20, 25, 30, 35 & 40	Peripheral - HEM*	>4xD-5xD	.08 x D	9	390	0.0029	0.0043	0.0058	0.0072	0.0086	0.0115
		Finish	3 x D	.015 x D	9	450	0.0013	0.0020	0.0026	0.0033	0.0039	0.0052
	Cast Iron	Peripheral - HEM*	<=3 x D	.08 x D	9	390	0.0029	0.0044	0.0058	0.0073	0.0087	0.0116
	Malleable	Peripheral - HEM*	>3xD-4xD	.08 x D	9	390	0.0026	0.0039	0.0052	0.0065	0.0078	0.0104
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	375	0.0023	0.0035	0.0046	0.0058	0.0070	0.0093
		Finish	3 x D	.015 x D	9	350	0.0011	0.0016	0.0021	0.0026	0.0032	0.0042
P	Low Carbon Steel ≤ 38 Rc	Peripheral - HEM*	<=3 x D	.08 x D	9	485	0.0038	0.0056	0.0075	0.0094	0.0113	0.0150
	1018, 1020, 12L14, 5120, 8620	Peripheral - HEM*	>3xD-4xD	.08 x D	9	485	0.0034	0.0051	0.0068	0.0084	0.0101	0.0135
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	465	0.0030	0.0045	0.0060	0.0075	0.0090	0.0120
		Finish	3 x D	.015 x D	9	420	0.0014	0.0021	0.0028	0.0035	0.0042	0.0056
	Medium Carbon Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	9	450	0.0036	0.0053	0.0071	0.0089	0.0107	0.0142
	1045, 4140, 4340, 5140	Peripheral - HEM*	>3xD-4xD	.08 x D	9	450	0.0032	0.0048	0.0064	0.0080	0.0096	0.0128
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	425	0.0028	0.0043	0.0057	0.0071	0.0085	0.0114
		Finish	3 x D	.015 x D	9	390	0.0013	0.0019	0.0025	0.0031	0.0038	0.0050
	Tool & Die Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	9	420	0.0032	0.0048	0.0064	0.0080	0.0096	0.0128
	A2, D2, O1, S7, P20, H13	Peripheral - HEM*	>3xD-4xD	.08 x D	9	420	0.0029	0.0043	0.0058	0.0072	0.0086	0.0115
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	395	0.0026	0.0038	0.0051	0.0064	0.0077	0.0102
		Finish	3 x D	.015 x D	9	365	0.0011	0.0016	0.0021	0.0026	0.0032	0.0042
M	Austenitic Stainless Steels,	Peripheral - HEM*	<=3 x D	.08 x D	9	450	0.0032	0.0048	0.0064	0.0080	0.0096	0.0128
	FeNi Alloys	Peripheral - HEM*	>3xD-4xD	.08 x D	9	440	0.0029	0.0043	0.0058	0.0072	0.0086	0.0115
	303, 304, 316, Invar, Kovar	Peripheral - HEM*	>4xD-5xD	.07 x D	9	425	0.0026	0.0038	0.0051	0.0064	0.0077	0.0102
		Finish	3 x D	.015 x D	9	390	0.0012	0.0018	0.0024	0.0030	0.0036	0.0048
	Martensitic & Ferritic	Peripheral - HEM*	<=3 x D	.08 x D	9	450	0.0038	0.0056	0.0075	0.0094	0.0113	0.0150
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	9	450	0.0034	0.0051	0.0068	0.0084	0.0101	0.0135
	410, 416, 440	Peripheral - HEM*	>4xD-5xD	.08 x D	9	425	0.0030	0.0045	0.0060	0.0075	0.0090	0.0120
		Finish	3 x D	.015 x D	9	390	0.0013	0.0019	0.0025	0.0031	0.0038	0.0050
	Precipitation Hardening	Peripheral - HEM*	<=3 x D	.08 x D	9	440	0.0031	0.0047	0.0062	0.0078	0.0093	0.0124
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	9	440	0.0028	0.0042	0.0056	0.0070	0.0084	0.0112
	17-4, 15-5, 13-8	Peripheral - HEM*	>4xD-5xD	.07 x D	9	415	0.0025	0.0037	0.0050	0.0062	0.0074	0.0099
		Finish	3 x D	.015 x D	9	380	0.0010	0.0015	0.0020	0.0025	0.0030	0.0040
S	Titanium Alloys	Peripheral - HEM*	<=3 x D	.1 x D	9	405	0.0021	0.0031	0.0041	0.0051	0.0062	0.0082
	6Al-4V, 6-2-4	Peripheral - HEM*	>3xD-4xD	.08 x D	9	405	0.0018	0.0028	0.0037	0.0046	0.0055	0.0074
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	390	0.0016	0.0025	0.0033	0.0041	0.0049	0.0066
		Finish	3 x D	.015 x D	9	350	0.0008	0.0012	0.0016	0.0020	0.0024	0.0032
	Difficult to Machine	Peripheral - HEM*	<=2.5 x D	.08 x D	9	335	0.0020	0.0030	0.0040	0.0050	0.0060	0.0080
	Titanium Alloys	Peripheral - HEM*	>2.5xD-3.5xD	.07 x D	9	325	0.0018	0.0027	0.0036	0.0045	0.0054	0.0072
	10-2-3	Peripheral - HEM*	>3.5xD-4xD	.06 x D	9	305	0.0016	0.0024	0.0032	0.0040	0.0048	0.0064
		Finish	3 x D	.01 x D	9	290	0.0007	0.0011	0.0014	0.0018	0.0021	0.0028
	Hastalloy, Waspalloy	Peripheral - HEM*	<=1.5 x D	.08 x D	9	100	0.0045	0.0068	0.0090	0.0113	0.0135	0.0180
		Peripheral - HEM*	>1.5xD-2.5xD	.08 x D	9	95	0.0041	0.0061	0.0081	0.0101	0.0122	0.0162
		Peripheral - HEM*	>2.5xD-3.5xD	.06 x D	9	85	0.0036	0.0054	0.0072	0.0090	0.0108	0.0144
		Finish	2 x D	.01 x D	9	90	0.0024	0.0036	0.0048	0.0060	0.0072	0.0096
	Inconel 718, Rene 88	Peripheral - HEM*	<=1.5 x D	.07 x D	9	95	0.0046	0.0068	0.0091	0.0114	0.0137	0.0182
		Peripheral - HEM*	>1.5xD-2.5xD	.06 x D	9	90	0.0041	0.0061	0.0082	0.0102	0.0123	0.0164
		Peripheral - HEM*	>2.5xD-3xD	.06 x D	9	85	0.0036	0.0055	0.0073	0.0091	0.0109	0.0146
		Finish	2 x D	.01 x D	9	85	0.0023	0.0035	0.0046	0.0058	0.0069	0.0092

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

Common Machining Formulas:

$$RPM = \frac{SFM \times 3.82}{D}$$

$$SFM = RPM \times D \times .262$$

$$IPM = RPM \times IPT \times Z$$

$$MRR = RDOC \times ADOC \times IPM$$

D Tool Cutting Diameter
Z Number of Flutes
RPM Revolutions per Minute
SFM Surface Feet per Minute
IPM Inches per Minute
IPT Inch per Tooth
MRR Metal Removal Rate
RDOC Radial Depth of Cut
ADOC Axial Depth of Cut

IPC9 Series Application Guide – Speed & Feed (metric)

ISO Classification	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	Cast Iron - Gray	Peripheral - HEM*	<=3 x D	.1 x D	9	122	0.0914	0.1518	0.1829	0.2432	0.3036	0.3658
	ASTM-A48	Peripheral - HEM*	>3xD-4xD	.08 x D	9	122	0.0823	0.1366	0.1646	0.2189	0.2732	0.3292
	Class 20, 25, 30, 35 & 40	Peripheral - HEM*	>4xD-5xD	.08 x D	9	119	0.0732	0.1214	0.1463	0.1946	0.2429	0.2926
		Finish	3 x D	.015 x D	9	137	0.0330	0.0548	0.0660	0.0878	0.1096	0.1321
	Cast Iron	Peripheral - HEM*	<=3 x D	.08 x D	9	119	0.0737	0.1223	0.1473	0.1959	0.2446	0.2946
	Malleable	Peripheral - HEM*	>3xD-4xD	.08 x D	9	119	0.0663	0.1100	0.1326	0.1763	0.2201	0.2652
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	114	0.0589	0.0978	0.1179	0.1567	0.1956	0.2357
		Finish	3 x D	.015 x D	9	107	0.0267	0.0443	0.0533	0.0709	0.0885	0.1067
P	Low Carbon Steel ≤ 38 Rc	Peripheral - HEM*	<=3 x D	.08 x D	9	148	0.0953	0.1581	0.1905	0.2534	0.3162	0.3810
	1018, 1020, 12L14, 5120, 8620	Peripheral - HEM*	>3xD-4xD	.08 x D	9	148	0.0857	0.1423	0.1715	0.2280	0.2846	0.3429
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	142	0.0762	0.1265	0.1524	0.2027	0.2530	0.3048
		Finish	3 x D	.015 x D	9	128	0.0356	0.0590	0.0711	0.0946	0.1181	0.1422
	Medium Carbon Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	9	137	0.0902	0.1497	0.1803	0.2399	0.2994	0.3607
	1045, 4140, 4340, 5140	Peripheral - HEM*	>3xD-4xD	.08 x D	9	137	0.0812	0.1347	0.1623	0.2159	0.2694	0.3246
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	130	0.0721	0.1197	0.1443	0.1919	0.2395	0.2885
		Finish	3 x D	.015 x D	9	119	0.0318	0.0527	0.0635	0.0845	0.1054	0.1270
	Tool & Die Steels ≤ 48 Rc	Peripheral - HEM*	<=3 x D	.08 x D	9	128	0.0813	0.1349	0.1626	0.2162	0.2698	0.3251
	A2, D2, O1, S7, P20, H13	Peripheral - HEM*	>3xD-4xD	.08 x D	9	128	0.0732	0.1214	0.1463	0.1946	0.2429	0.2926
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	120	0.0650	0.1079	0.1300	0.1730	0.2159	0.2601
		Finish	3 x D	.015 x D	9	111	0.0267	0.0443	0.0533	0.0709	0.0885	0.1067
M	Austenitic Stainless Steels,	Peripheral - HEM*	<=3 x D	.08 x D	9	137	0.0813	0.1349	0.1626	0.2162	0.2698	0.3251
	FeNi Alloys	Peripheral - HEM*	>3xD-4xD	.08 x D	9	134	0.0732	0.1214	0.1463	0.1946	0.2429	0.2926
	303, 304, 316, Invar, Kovar	Peripheral - HEM*	>4xD-5xD	.07 x D	9	130	0.0650	0.1079	0.1300	0.1730	0.2159	0.2601
		Finish	3 x D	.015 x D	9	119	0.0305	0.0506	0.0610	0.0811	0.1012	0.1219
	Martensitic & Ferritic	Peripheral - HEM*	<=3 x D	.08 x D	9	137	0.0953	0.1581	0.1905	0.2534	0.3162	0.3810
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	9	137	0.0857	0.1423	0.1715	0.2280	0.2846	0.3429
	410, 416, 440	Peripheral - HEM*	>4xD-5xD	.08 x D	9	130	0.0762	0.1265	0.1524	0.2027	0.2530	0.3048
		Finish	3 x D	.015 x D	9	119	0.0318	0.0527	0.0635	0.0845	0.1054	0.1270
	Precipitation Hardening	Peripheral - HEM*	<=3 x D	.08 x D	9	134	0.0787	0.1307	0.1575	0.2094	0.2614	0.3150
	Stainless Steels	Peripheral - HEM*	>3xD-4xD	.08 x D	9	134	0.0709	0.1176	0.1417	0.1885	0.2353	0.2835
	17-4, 15-5, 13-8	Peripheral - HEM*	>4xD-5xD	.07 x D	9	126	0.0630	0.1046	0.1260	0.1676	0.2091	0.2520
		Finish	3 x D	.015 x D	9	116	0.0254	0.0422	0.0508	0.0676	0.0843	0.1016
S	Titanium Alloys	Peripheral - HEM*	<=3 x D	.1 x D	9	123	0.0521	0.0864	0.1041	0.1385	0.1729	0.2083
	6Al-4V, 6-2-4	Peripheral - HEM*	>3xD-4xD	.08 x D	9	123	0.0469	0.0778	0.0937	0.1247	0.1556	0.1875
		Peripheral - HEM*	>4xD-5xD	.08 x D	9	119	0.0417	0.0691	0.0833	0.1108	0.1383	0.1666
		Finish	3 x D	.015 x D	9	107	0.0203	0.0337	0.0406	0.0541	0.0675	0.0813
	Difficult to Machine	Peripheral - HEM*	<=2.5 x D	.08 x D	9	102	0.0508	0.0843	0.1016	0.1351	0.1687	0.2032
	Titanium Alloys	Peripheral - HEM*	>2.5xD-3.5xD	.07 x D	9	99	0.0457	0.0759	0.0914	0.1216	0.1518	0.1829
	10-2-3	Peripheral - HEM*	>3.5xD-4xD	.06 x D	9	93	0.0406	0.0675	0.0813	0.1081	0.1349	0.1626
		Finish	3 x D	.01 x D	9	88	0.0178	0.0295	0.0356	0.0473	0.0590	0.0711
	Hastalloy, Waspalloy	Peripheral - HEM*	<=1.5 x D	.08 x D	9	30	0.1143	0.1897	0.2286	0.3040	0.3795	0.4572
		Peripheral - HEM*	>1.5xD-2.5xD	.08 x D	9	29	0.1029	0.1708	0.2057	0.2736	0.3415	0.4115
		Peripheral - HEM*	>2.5xD-3.5xD	.06 x D	9	26	0.0914	0.1518	0.1829	0.2432	0.3036	0.3658
		Finish	2 x D	.01 x D	9	27	0.0610	0.1012	0.1219	0.1622	0.2024	0.2438
	Inconel 718, Rene 88	Peripheral - HEM*	<=1.5 x D	.07 x D	9	29	0.1156	0.1918	0.2311	0.3074	0.3837	0.4623
		Peripheral - HEM*	>1.5xD-2.5xD	.06 x D	9	27	0.1040	0.1727	0.2080	0.2767	0.3453	0.4161
		Peripheral - HEM*	>2.5xD-3xD	.06 x D	9	26	0.0925	0.1535	0.1849	0.2459	0.3070	0.3698
		Finish	2 x D	.01 x D	9	26	0.0584	0.0970	0.1168	0.1554	0.1940	0.2337

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

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