



## 2 & 3-Flute High Performance Regular and Long Length Endmills, Square & Corner Radius, 45 Degree Helix, for Aluminum and Non-Ferrous Materials



- RedLine 2 & 3-Flute, 45 Degree Helix Endmills are designed for high speed machining in Aluminum, Brass and Bronze, and can be used for plunging, slotting and profiling in all non-ferrous materials.
- Aluminum, Brass, Bronze and other non-ferrous materials. These tools can be used for plunging, slotting and profiling.
- The ZrN coated tools allow for higher speeds, better tool life with a low affinity for Aluminum.
- These High Performance tools can be found on pages 14 & 17.

### ZrN Coated for Aluminum & Non-Ferrous Tools Speeds & Feeds

Material	Grades	SFM		Feed by Endmill Diameter (IPT)						
		Uncoated	ZrN Coated	1/8 (.1250)	1/4 (.2500)	3/8 (.3750)	1/2 (.5000)	5/8 (.6250)	3/4 (.7500)	1 (1.000)
<b>N - Non-Ferrous</b>										
Aluminum Alloys	2014, 2024, 6061, 7075	500+	650+	.0010-.0020	.0012-.0018	.0015-.0020	.0020-.0040	.0050-.0080	.009-.0110	.0110-.0150
Aluminm High Silicon	A380, A390	500+	600+	.0010-.0013	.0010-.0015	.0015-.0020	.0020-.0040	.0050-.0080	.0090-.0110	.0110-.0150
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	300-400	390-520	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0040	.0040-.0080	.0070-.0100
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	250-1000	325-1300	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100
Copper		400-500	520-650	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0040	.0040-.0080	.0070-.0100
Magnesium		500+	650+	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100
<b>S - High Temp Alloys</b>										
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	500+	650+	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040	.0040-.0050

- NOTES:**
- (1) Speeds and Feeds listed are estimated and will vary by application.
  - (2) Reduce Speeds by 20% when slotting.
  - (3) When exceeding 1/2 the end mill diameter while profiling, reduce feed rate by 25%.
  - (4) The use of Long and Extra Long Endmills require a reduction in feed by up to 50%.
  - (5) Optimum performance can be achieved when using coated & stub length tools.



## 2-Flute, Neck Relief Square & Standard Ball End, Extra High Performance Endmills, 45 Degree Helix for Aluminum and Non-Ferrous Materials.

- Redline 2 Flute, Extra High Performance Endills are designed for milling all Aluminum including die cast extrusions and other non ferrous alloys.
- These Extra High Performance tools can be found on pages 15 & 16.

### Aluminum & Non-Ferrous Speeds & Feeds

Material	Grades	Cut Type	Axial DOC	Radial DOC	# of Flutes	SFM	Feed by Endmill Diameter (IPT)						
							1/8 (.1250)	1/4 (.2500)	3/8 (.3750)	1/2 (.5000)	5/8 (.6250)	3/4 (.7500)	1 (1.000)
<b>N - Non-Ferrous</b>													
Aluminum Alloys	2024, 6061, 7075	Slotting	1 x D	1 x D	2	800	.0018	.0036	.0054	.0072	.0090	.0108	.0144
			.75 x D	1 x D	3	800	.0015	.0030	.0045	.0060	.0075	.0090	.0120
		Peripheral - Rough	1 x D	.75 x D	2	1000	.0025	.0050	.0075	.0100	.0125	.0150	.0200
			1 x D	.75 x D	3	1000	.0020	.0040	.0060	.0080	.0100	.0120	.0160
		Finish	1.5 x D	.01 x D	2	1200	.0030	.0060	.0090	.0120	.0150	.0210	.0240
			1.5 x D	.01 x D	3	1200	.0025	.0050	.0075	.0100	.0125	.0150	.0200
Aluminum High Silicon	A380, A390	Slotting	.75 x D	1 x D	2	500	.0013	.0026	.0039	.0052	.0065	.0078	.0104
			.5 x D	1 x D	3	500	.0011	.0022	.0033	.0044	.0055	.0066	.0088
		Peripheral - Rough	1 x D	.5 x D	2	700	.0016	.0033	.0049	.0065	.0081	.0098	.0130
			1 x D	.5 x D	3	700	.0014	.0028	.0041	.0055	.0069	.0083	.0110
		Finish	1.5 x D	.01 x D	2	900	.0020	.0041	.0061	.0082	.0102	.0122	.0163
			1.5 x D	.01 x D	3	900	.0017	.0035	.0052	.0069	.0086	.0104	.0138
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	Slotting	.75 x D	1 x D	2	500	.0011	.0022	.0033	.0044	.0055	.0066	.0088
			.75 x D	1 x D	3	500	.0009	.0018	.0027	.0036	.0045	.0054	.0072
		Peripheral - Rough	1 x D	.75 x D	2	575	.0011	.0022	.0033	.0044	.0055	.0066	.0088
			1 x D	.75 x D	3	575	.0013	.0026	.0039	.0052	.0065	.0078	.0104
		Finish	1.5 x D	.01 x D	2	650	.0018	.0036	.0054	.0072	.0090	.0108	.0144
			1.5 x D	.01 x D	3	650	.0015	.0030	.0045	.0060	.0075	.0090	.0120
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	Slotting	1 x D	1 x D	2	500	.0013	.0026	.0039	.0052	.0065	.0078	.0104
			1 x D	1 x D	3	500	.0011	.0022	.0033	.0044	.0055	.0066	.0088
		Peripheral - Rough	1 x D	.75 x D	2	700	.0016	.0033	.0049	.0065	.0081	.0098	.0130
			1 x D	.75 x D	3	700	.0014	.0028	.0041	.0055	.0069	.0083	.0110
		Finish	1.5 x D	.01 x D	2	900	.0020	.0041	.0061	.0082	.0102	.0122	.0163
			1.5 x D	.01 x D	3	900	.0017	.0035	.0052	.0069	.0086	.0104	.0138
Copper		Slotting	.75 x D	1 x D	2	500	.0011	.0022	.0033	.0044	.0055	.0066	.0088
			.75 x D	1 x D	3	500	.0009	.0018	.0027	.0036	.0045	.0054	.0072
		Peripheral - Rough	1 x D	.75 x D	2	575	.0011	.0022	.0033	.0044	.0055	.0066	.0088
			1 x D	.75 x D	3	575	.0013	.0026	.0039	.0052	.0065	.0078	.0104
		Finish	1.5 x D	.01 x D	2	650	.0018	.0036	.0054	.0072	.0090	.0108	.0144
			1.5 x D	.01 x D	3	650	.0015	.0030	.0045	.0060	.0075	.0090	.0120
Magnesium		Slotting	1 x D	1 x D	2	800	.0018	.0036	.0054	.0072	.0090	.0108	.0144
			.75 x D	1 x D	3	800	.0015	.0030	.0045	.0060	.0075	.0090	.0120
		Peripheral - Rough	1 x D	.75 x D	2	1000	.0025	.0050	.0075	.0100	.0125	.0150	.0200
			1 x D	.75 x D	3	1000	.0020	.0040	.0060	.0080	.0100	.0120	.0160
		Finish	1.5 x D	.01 x D	2	1200	.0030	.0060	.0090	.0120	.0150	.0210	.0240
			1.5 x D	.01 x D	3	1200	.0025	.0050	.0075	.0100	.0125	.0150	.0200

D = tool diameter. Reduce feed rates by 20% when using long length tools. Starting parameters shown.  
 NOTE: Speeds and Feeds listed are estimated and will vary by application.



## 3-Flute Standard, Neck Relief and Ball End, 37 Degree Helix, Extra High Performance Endmills for Milling Aluminum and Non-Ferrous Materials.

- RedLine 3 Flute, Standard and Neck Relief Extra High Performance End Mills are designed for Roughing, Finishing or Slotting in Aluminum and Non-Ferrous materials.
- The ZrN coated tools allow for higher speeds, better tool life with a low affinity for Aluminum.
- Use for straight line and helical ramping.
- These Extra High Performance tools can be found on pages 18-22, 24-25.

### Aluminum & Non-Ferrous Speeds & Feeds

Material	Grades	Cut Type	Axial DOC	Radial DOC	# of Flutes	SFM	Feed by Endmill Diameter (IPT)							
							1/8	1/4	5/16	3/8	1/2	5/8	3/4	1
							(.1250)	(.2500)	(.3125)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>N - Non-Ferrous</b>														
Aluminum Alloys	6061, 7075, 2024	Slotting	1 x D	1 x D	3	800	.0015	.0030	.0038	.0045	.0060	.0075	.0090	.0120
		Peripheral - Rough	<=2 x D	.5 x D	3	1000	.0020	.0040	.0050	.0060	.0080	.0100	.0120	.0160
			>2-3 x D	.5 x D	3	1000	.0019	.0038	.0047	.0056	.0075	.0094	.0113	.0150
			>3-4 x D	.45 x D	3	900	.0016	.0033	.0041	.0049	.0065	.0081	.0098	.0130
			>4-5 x D	.4 x D	3	800	.0015	.0029	.0036	.0044	.0058	.0073	.0087	.0116
		Finish	2.5 x D	.015 x D	3	1200	.0007	.0014	.0017	.0020	.0027	.0034	.0041	.0054
*Helical Ramp Angle 3.0 deg.					800	.0012	.0024	.0030	.0036	.0048	.0060	.0072	.0096	
Aluminum High Silicon	A380, A390	Slotting	.75 x D	1 x D	3	500	.0011	.0023	.0028	.0034	.0045	.0056	.0068	.0090
		Peripheral - Rough	<=2 x D	.4 x D	3	700	.0014	.0029	.0036	.0043	.0057	.0071	.0086	.0114
			>2-3 x D	.4 x D	3	700	.0014	.0028	.0034	.0041	.0055	.0069	.0083	.0110
			>3-4 x D	.375 x D	3	600	.0012	.0024	.0030	.0036	.0048	.0060	.0072	.0096
			>4-5 x D	.35 x D	3	500	.0010	.0020	.0025	.0030	.0040	.0050	.0060	.0080
		Finish	2.5 x D	.015 x D	3	900	.0006	.0013	.0016	.0019	.0025	.0031	.0038	.0050
*Helical Ramp Angle 2.5 deg.					500	.0009	.0018	.0023	.0027	.0036	.0045	.0054	.0072	
Magnesium Alloys		Slotting	1 x D	1 x D	3	800	.0015	.0030	.0038	.0045	.0060	.0075	.0090	.0120
		Peripheral - Rough	<=2 x D	.5 x D	3	1000	.0020	.0040	.0050	.0060	.0080	.0100	.0120	.0160
			>2-3 x D	.5 x D	3	1000	.0019	.0038	.0047	.0056	.0075	.0094	.0113	.0150
			>3-4 x D	.45 x D	3	900	.0016	.0033	.0041	.0049	.0065	.0081	.0098	.0130
			>4-5 x D	.4 x D	3	800	.0015	.0029	.0036	.0044	.0058	.0073	.0087	.0116
		Finish	2.5 x D	.015 x D	3	1200	.0007	.0014	.0017	.0020	.0027	.0034	.0041	.0054
*Helical Ramp Angle 3.0 deg.					800	.0012	.0024	.0030	.0036	.0048	.0060	.0072	.0096	
Copper Alloys, Brass		Slotting	.75 x D	1 x D	3	500	.0009	.0019	.0023	.0028	.0037	.0046	.0056	.0074
		Peripheral - Rough	<=2 x D	.4 x D	3	600	.0012	.0023	.0029	.0035	.0046	.0058	.0069	.0092
			>2-3 x D	.4 x D	3	600	.0011	.0023	.0028	.0034	.0045	.0056	.0068	.0090
			>3-4 x D	.375 x D	3	500	.0010	.0020	.0024	.0029	.0039	.0049	.0059	.0078
			>4-5 x D	.35 x D	3	450	.0008	.0017	.0021	.0025	.0033	.0041	.0050	.0066
		Finish	2.5 x D	.015 x D	3	650	.0005	.0011	.0013	.0016	.0021	.0026	.0032	.0042
*Helical Ramp Angle 2.5 deg.					500	.0007	.0015	.0019	.0022	.0030	.0037	.0044	.0059	
Bronze		Slotting	.75 x D	1 x D	3	500	.0009	.0018	.0022	.0026	.0035	.0044	.0053	.0070
		Peripheral - Rough	<=2 x D	.4 x D	3	600	.0011	.0022	.0028	.0033	.0044	.0055	.0066	.0088
			>2-3 x D	.4 x D	3	600	.0011	.0021	.0026	.0032	.0042	.0053	.0063	.0084
			>3-4 x D	.375 x D	3	500	.0009	.0018	.0022	.0026	.0035	.0044	.0053	.0070
			>4-5 x D	.35 x D	3	450	.0007	.0015	.0018	.0022	.0029	.0036	.0044	.0058
		Finish	2.5 x D	.015 x D	3	650	.0005	.0010	.0012	.0014	.0019	.0024	.0029	.0038
*Helical Ramp Angle 2.0 deg.					500	.0007	.0014	.0018	.0021	.0028	.0035	.0042	.0056	
Composites, Plastic, Fiberglass		Slotting	.75 x D	1 x D	3	500	.0011	.0023	.0028	.0034	.0045	.0056	.0068	.0090
		Peripheral - Rough	<=2 x D	.4 x D	3	700	.0014	.0029	.0036	.0043	.0057	.0071	.0086	.0114
			>2-3 x D	.4 x D	3	700	.0014	.0028	.0034	.0041	.0055	.0069	.0083	.0110
			>3-4 x D	.375 x D	3	600	.0012	.0024	.0030	.0036	.0048	.0060	.0072	.0096
			>4-5 x D	.35 x D	3	500	.0010	.0020	.0025	.0030	.0040	.0050	.0060	.0080
		Finish	2.5 x D	.015 x D	3	900	.0006	.0013	.0016	.0019	.0025	.0031	.0038	.0050
*Helical Ramp Angle 3.0 deg.					500	.0009	.0018	.0023	.0027	.0036	.0045	.0054	.0072	

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



## 3-Flute, Roughing, 37 Degree Helix, Extra High Performance Endmills for Aluminum and Non-Ferrous Materials.

- RedLine has a comprehensive offering of shank designs, corner radii, and tool lengths for milling all aluminums including die cast, extrusions and non-ferrous alloys.
- The ZrN coating allows for higher speeds, better tool life with a low affinity for Aluminum.
- Use for straight line and helical ramping.
- These Extra High Performance tools can be found on page 23.

### Aluminum & Non-Ferrous Speeds & Feeds

Material	Grades	Cut Type	Axial DOC	Radial DOC	# of Flutes	SFM	Feed by Endmill Diameter (IPT)								
							1/8 (.1250)	3/16 (.1875)	1/4 (.2500)	5/16 (.3125)	3/8 (.3750)	1/2 (.5000)	5/8 (.6250)	3/4 (.7500)	1 (1.000)
<b>N - Non-Ferrous</b>															
Aluminum Alloys	6061, 7075, 2024	Slotting	1 x D	1 x D	3	800	.0015	.0023	.0030	.0045	.0060	.0075	.0090	.0120	.0150
		Peripheral - Rough	<=2 x D	.5 x D	3	1000	.0020	.0030	.0040	.0060	.0080	.0100	.0120	.0160	.0200
			>2-3 x D	.5 x D	3	1000	.0019	.0028	.0038	.0056	.0075	.0094	.0113	.0150	.0188
			>3-4 x D	.45 x D	3	900	.0016	.0024	.0033	.0049	.0065	.0081	.0098	.0130	.0163
		*Helical Ramp Angle 3.0 deg.				800	.0012	.0018	.0024	.0036	.0048	.0060	.0072	.0096	.0120
Aluminum High Silicon	A380, A390	Slotting	.75 x D	1 x D	3	500	.0011	.0017	.0023	.0034	.0045	.0056	.0068	.0090	.0113
		Peripheral - Rough	<=2 x D	.4 x D	3	700	.0014	.0021	.0029	.0043	.0057	.0071	.0086	.0114	.0143
			>2-3 x D	.4 x D	3	700	.0014	.0021	.0028	.0041	.0055	.0069	.0083	.0110	.0138
			>3-4 x D	.375 x D	3	600	.0012	.0018	.0024	.0036	.0048	.0060	.0072	.0096	.0120
		*Helical Ramp Angle 2.5 deg.				500	.0009	.0014	.0018	.0027	.0036	.0045	.0054	.0072	.0090
Magnesium Alloys		Slotting	1 x D	1 x D	3	800	.0015	.0023	.0030	.0045	.0060	.0075	.0090	.0120	.0150
		Peripheral - Rough	<=2 x D	.5 x D	3	1000	.0020	.0030	.0040	.0060	.0080	.0100	.0120	.0160	.0200
			>2-3 x D	.5 x D	3	1000	.0019	.0028	.0038	.0056	.0075	.0094	.0113	.0150	.0188
			>3-4 x D	.45 x D	3	900	.0016	.0024	.0033	.0049	.0065	.0081	.0098	.0130	.0163
		*Helical Ramp Angle 3.0 deg.				800	.0012	.0018	.0024	.0036	.0048	.0060	.0072	.0096	.0120
Copper Alloys, Brass		Slotting	.75 x D	1 x D	3	500	.0009	.0014	.0019	.0028	.0037	.0046	.0056	.0074	.0093
		Peripheral - Rough	<=2 x D	.4 x D	3	600	.0012	.0017	.0023	.0035	.0046	.0058	.0069	.0092	.0115
			>2-3 x D	.4 x D	3	600	.0011	.0017	.0023	.0034	.0045	.0056	.0068	.0090	.0113
			>3-4 x D	.375 x D	3	500	.0010	.0015	.0020	.0029	.0039	.0049	.0059	.0078	.0098
		*Helical Ramp Angle 2.5 deg.				500	.0007	.0011	.0015	.0022	.0030	.0037	.0044	.0059	.0074
Bronze		Slotting	.75 x D	1 x D	3	500	.0009	.0013	.0018	.0026	.0035	.0044	.0053	.0070	.0088
		Peripheral - Rough	<=2 x D	.4 x D	3	600	.0011	.0017	.0022	.0033	.0044	.0055	.0066	.0088	.0110
			>2-3 x D	.4 x D	3	600	.0011	.0016	.0021	.0032	.0042	.0053	.0063	.0084	.0105
			>3-4 x D	.375 x D	3	500	.0009	.0013	.0018	.0026	.0035	.0044	.0053	.0070	.0088
		*Helical Ramp Angle 2.0 deg.				500	.0007	.0011	.0014	.0021	.0028	.0035	.0042	.0056	.0070
Composites, Plastic, Fiberglass		Slotting	.75 x D	1 x D	3	500	.0011	.0017	.0023	.0034	.0045	.0056	.0068	.0090	.0113
		Peripheral - Rough	<=2 x D	.4 x D	3	700	.0014	.0021	.0029	.0043	.0057	.0071	.0086	.0114	.0143
			>2-3 x D	.4 x D	3	700	.0014	.0021	.0028	.0041	.0055	.0069	.0083	.0110	.0138
			>3-4 x D	.375 x D	3	600	.0012	.0018	.0024	.0036	.0048	.0060	.0072	.0096	.0120
		*Helical Ramp Angle 3.0 deg.				500	.0009	.0014	.0018	.0027	.0036	.0045	.0054	.0072	.0090

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



## 5-Flute Square and Corner Radius, Standard and Neck Relief and Chip Control, 35 Degree Helix Extra High Performance Endmills for Aluminum.



- RedLine 5 Flute End Mills are (DLC) Diamond Like Carbon Coated to provide Extra High Performance when cutting Aluminum.
- With 5 Flutes you will get increased productivity with an excellent surface finish, and are designed to Rough, Slot, Finish and be used with High Efficiency Machining programs.
- 5-Flute Extra High Performance, Variable Helix End Mills
- These Extra High Performance tools can be found on page 26-32.

### Aluminum Speeds & Feeds

Material	Grades	Cut Type	Axial DOC	Radial DOC	# of Flutes	SFM	Feed by Endmill Diameter (IPT)					
							1/4	3/8	1/2	5/8	3/4	1
							(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>N - Non-Ferrous</b>												
Aluminum Alloys	6061, 7075, 2024	Slotting	1 x D	1 x D	5	600	.0015	.002250	.0030	.003750	.00450	.0060
		Peripheral - Rough	<=2 x D	.45 x D	5	1000	.0024	.003600	.0048	.006000	.00720	.0096
			>2-3 x D	.375 x D	5	900	.0023	.003450	.0046	.005750	.00690	.0092
			>3-4 x D	.35 x D	5	800	.00225	.003375	.0045	.005625	.00675	.0090
		Peripheral - HEM	<=2 x D	.25 x D	5	850	.00500	.007500	.0100	.012500	.01500	.0200
			>2-2.5 x D	.25 x D	5	800	.00500	.007500	.0100	.012500	.01500	.0200
			>2.5-3 x D	.25 x D	5	800	.00500	.007500	.0100	.012500	.01500	.0200
			>3-3.5 x D	.25 x D	5	800	.00475	.007125	.0095	.011875	.01425	.0190
		>3.5-4 x D	.20 x D	5	780	.00475	.007125	.0095	.011875	.01425	.0190	
		Finish	<= 4 x D	.01 x D	5	650	.00150	.002250	.0030	.003750	.00450	.0060

**NOTE: HEM (high efficiency machining) technical information can be found on page 208.**



### 3-Flute Extra High Performance, Variable Helix Endmills

- RedLine XHP Variable Helix 3-Flute tools are designed for fast metal removal. We control vibration and chatter through a unique dampening geometry and can handle faster speeds and feeds generated by the application of our AlCrN coating.
- Designed to run in a wide range of materials from cast irons and steels to titanium and high temperature alloys.
- These Extra High Performance tools can be found on pages 33-40.



XHP Variable Helix 3-Flute Tools Speeds & Feeds											
Material	Grades	Cut Type	Axial DOC	Radial DOC	SFM	Feed by Endmill Diameter (IPT)					
						AlCrN	1/32 (.0312)	1/16 (.0625)	3/32 (.0937)	1/8 (.1250)	3/16 (.1875)
<b>P - Steels</b>											
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	High Speed	1 x D	.1 x D	390	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	390	.0001	.0002	.0002	.0002	.0003	.0004
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	High Speed	1 x D	.1 x D	655	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	655	.0001	.0002	.0002	.0002	.0003	.0004
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	High Speed	1 x D	.1 x D	655	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	655	.0001	.0002	.0002	.0002	.0003	.0004
<b>M - Stainless Steels</b>											
Austenitic	301-304L, 310, 316L, 321, 347	High Speed	1 x D	.1 x D	325	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	325	.0001	.0002	.0002	.0002	.0003	.0004
Martensitic	403, 410, 416, 420, 430, 431, 440	High Speed	1 x D	.1 x D	325	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	325	.0001	.0002	.0002	.0002	.0003	.0004
Precipitation Hardening	12/8, 15/5, 17/4, AM-50/355/363, PH13-8MO, PH14-8/MO	High Speed	1 x D	.1 x D	325	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	325	.0001	.0002	.0002	.0002	.0003	.0004
<b>K - Cast Irons</b>											
Ductile	A536, J434, 60-40-18	High Speed	1 x D	.1 x D	655	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	655	.0001	.0002	.0002	.0002	.0003	.0004
Gray	A48, A436, A319, Class 20, G4000	High Speed	1 x D	.1 x D	655	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	655	.0001	.0002	.0002	.0002	.0003	.0004
Malleable	A220, A602, J158	High Speed	1 x D	.1 x D	655	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	655	.0001	.0002	.0002	.0002	.0003	.0004
<b>N - Non-Ferrous</b>											
Aluminum Alloys	2014, 2024, 6061, 7075	High Speed	1 x D	.1 x D	985	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	985	.0001	.0002	.0002	.0002	.0003	.0004
Aluminum High Silicon	A380, A390	High Speed	1 x D	.1 x D	985	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	985	.0001	.0002	.0002	.0002	.0003	.0004
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	High Speed	1 x D	.1 x D	400	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	400	.0001	.0002	.0002	.0002	.0003	.0004
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	High Speed	1 x D	.1 x D	390	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	390	.0001	.0002	.0002	.0002	.0003	.0004
Copper		High Speed	1 x D	.1 x D	400	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	400	.0001	.0002	.0002	.0002	.0003	.0004
Magnesium		High Speed	1 x D	.1 x D	800	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	800	.0001	.0002	.0002	.0002	.0003	.0004
<b>S - High Temp Alloys</b>											
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	High Speed	1 x D	.1 x D	260	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	260	.0001	.0002	.0002	.0002	.0003	.0004
Iron Base	Incoloy 800-802, Multimet N-155 Timkin 16-25-6, Carpenter 22-b3	High Speed	1 x D	.1 x D	260	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	260	.0001	.0002	.0002	.0002	.0003	.0004
Nickel Base	Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700	High Speed	1 x D	.1 x D	195	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	195	.0001	.0002	.0002	.0002	.0003	.0004
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	High Speed	1 x D	.1 x D	260	.0002	.0002	.0002	.0003	.0004	.0005
		Copy Milling	1 x D	.1 x D	260	.0001	.0002	.0002	.0002	.0003	.0004



## 3-Flute, High Performance Endmills, 60 Degree Helix

- RedLine 3-flute 60° endmills are perfect for slotting and profiling in all high temperature alloys like Hastalloy, Waspalloy, Inconel, and Titanium.
- If you are looking for additional speed you can achieve up to a 40% increase in surface footage over uncoated tools by purchasing tools with the AlTiN coating.
- These High Performance tools can be found on page 41.

### 3-Flute 60° Speeds & Feeds

Material	Grades	SFM	SFM	Feed by Endmill Diameter (IPT)								
				Uncoated	AlTiN	1/8	1/4	3/8	1/2	5/8	3/4	1
						(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>P - Steels</b>												
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	225-300	315-420	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
High Strength Tool Steel > 32 HRC		135-180	190-250	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	250-350	350-490	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040	.0040-.0050		
Low Carbon > 32 HRC	Reduce SFM by 40%	150-210	210-290	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	250-350	350-490	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040	.0040-.0050		
Medium Carbon > 32 HRC	Reduce SFM by 40%	150-210	210-290	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
<b>M - Stainless Steels</b>												
Austenitic	301-304L, 310, 316L, 321, 347	250-350	350-490	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Austenitic > 32 HRC		190-260	265-360	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Martensitic	403, 410, 416, 420, 430, 431, 440	200-350	280-490	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Martensitic > 32 HRC		150-260	210-360	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO	200-350	280-490	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Precipitation Hardening > 32 HRC		150-260	210-360	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
<b>K - Cast Irons</b>												
Ductile	A536, J434, 60-40-18	300-400	420-560	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
Gray	A48, A436, A319, Class 20, G4000	350-450	490-630	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
Malleable	A220, A602, J158	490-630	680-740	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
<b>N - Non-Ferrous</b>												
Aluminum Alloys	2014, 2024, 6061, 7075	> 500	>700	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0040	.0050-.0080	.0090-.0110	.0110-.0150		
Aluminum High Silicon	A380, A390	450	630	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0040	.0050-.0080	.0090-.0110	.0110-.0150		
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	300-400	420-560	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0040	.0040-.0080	.0070-.0100		
Composites		250-1000	350-1400	.0007-.0012	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
Copper		400-500	560-700	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0040	.0040-.0080	.0070-.0100		
Magnesium	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	> 500	>700	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
<b>S - High Temp W Alloys</b>												
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	200-275	280-385	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Cobalt Base > 32 HRC		130-180	180-250	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Iron Base	Incoloy 800-802, Multimet N-155 Timkin 16-25-6, Carpenter 22-b3	250-300	350-420	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Iron Base > 32 HRC		150-180	210-250	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Nickel Base	Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspalloy, Udimet 500 & 700	150-200	210-280	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Nickel Base >32 HRC		90-120	125-165	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	250-400	350-560	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040	.0040-.0050		

NOTE: Speeds and Feeds listed are estimated and will vary by application.



## 3-Flute, High Performance Endmills, 45 Degree Helix

- RedLine 3-flute 45° lead tools are recommended for slotting and profiling of stainless steel and other similar alloys. This tool is designed to run at higher speeds and feeds while producing excellent part finishes.
- These High Performance tools can be found on page 42.

### 3-Flute 45° Speeds & Feeds

Material	Grades	SFM	SFM	Feed by Endmill Diameter (IPT)								
				Uncoated	AlTiN	1/8	1/4	3/8	1/2	5/8	3/4	1
						(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>P - Steels</b>												
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	225-300	315-420	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
High Strength Tool Steel > 32 HRC		135-180	190-250	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	250-350	350-490	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040	.0040-.0050		
Low Carbon > 32 HRC	Reduce SFM by 40%	150-210	210-290	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	250-350	350-490	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040	.0040-.0050		
Medium Carbon > 32 HRC	Reduce SFM by 40%	150-210	210-290	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
<b>M - Stainless Steels</b>												
Austenitic	301-304L, 310, 316L, 321, 347	250-350	350-490	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Austenitic > 32 HRC		190-260	265-360	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Martensitic	403, 410, 416, 420, 430, 431, 440	200-350	280-490	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Martensitic > 32 HRC		150-260	210-360	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO	200-350	280-490	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Precipitation Hardening > 32 HRC		150-260	210-360	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
<b>K - Cast Irons</b>												
Ductile	A536, J434, 60-40-18	300-400	420-560	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
Gray	A48, A436, A319, Class 20, G4000	350-450	490-630	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
Malleable	A220, A602, J158	490-630	680-740	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
<b>N - Non-Ferrous</b>												
Aluminum Alloys	2014, 2024, 6061, 7075	> 500	>700	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0040	.0050-.0080	.0090-.0110	.0110-.0150		
Aluminum High Silicon	A380, A390	450	630	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0040	.0050-.0080	.0090-.0110	.0110-.0150		
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	300-400	420-560	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0040	.0040-.0080	.0070-.0100		
Composites		250-1000	350-1400	.0007-.0012	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
Copper		400-500	560-700	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0040	.0040-.0080	.0070-.0100		
Magnesium	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	> 500	>700	.0010-.0020	.0010-.0015	.0015-.0020	.0020-.0035	.0035-.0050	.0050-.0070	.0070-.0100		
<b>S - High Temp Alloys</b>												
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	200-275	280-385	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Cobalt Base > 32 HRC		130-180	180-250	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Iron Base	Incoloy 800-802, Multimet N-155 Timkin 16-25-6, Carpenter 22-b3	250-300	350-420	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Iron Base > 32 HRC		150-180	210-250	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Nickel Base	Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700	150-200	210-280	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040		
Nickel Base >32 HRC		90-120	125-165	.0003-.0005	.0004-.0005	.0005-.0008	.0010-.0015	.0012-.0015	.0015-.0020	.0020-.0030		
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	250-400	350-560	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0040	.0040-.0050		

NOTE: Speeds and Feeds listed are estimated and will vary by application.





## 4-Flute, High Performance, Variable Index Endmills, Square, Corner Radius & Ball End, 38 Degree Helix

- RedLine HP Variable 4-Flute tools are designed for fast metal removal. We control vibration and chatter through a unique dampening geometry and can handle faster speeds and feeds.
- Our HP Variable 4-flute tools can be ran wet or dry and can be used in a wide variety of applications, from roughing and finishing to slotting and pocketing.
- Designed to run in a wide range of materials from cast irons and steels to titanium and high temperature alloys.
- These High Performance tools can be found on pages 43-46, 56.

### HP Variable Index 4-Flute Tools Speeds & Feeds (Cont'd)

Material	Grades	Cut Type	Axial DOC	Radial DOC	Stub/Regular	Long/X-Long	Feed by Endmill Diameter (IPT)						
					SFM	SFM	1/8	1/4	3/8	1/2	5/8	3/4	1
					AlCrNX	AlCrNX	(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>P - Steels</b>													
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	Slotting	1 x D	1 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - Rough	1.25 x D	.3 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - HEM	2 x D	.15 x D	300-360	210-250	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
High Strength Tool Steel > 32 HRC	Reduce SFM by 40%	N/A	N/A	N/A	180-216	126-150	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	Slotting	1 x D	1 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - Rough	1.25 x D	.5 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - HEM	2 x D	.15 x D	560-660	400-550	.0008-.0016	.0036-.0040	.0060-.0064	.0070-.0074	.0078-.0082	.0082-.0086	.0108-.0112
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	Slotting	1 x D	1 x D	525-630	380-520	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - Rough	1.25 x D	.5 x D	525-630	380-520	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - HEM	2 x D	.15 x D	525-630	380-520	.0008-.0016	.0036-.0040	.0060-.0064	.0070-.0074	.0078-.0082	.0082-.0086	.0108-.0112
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>M - Stainless Steels</b>													
Austenitic	301-304L, 310, 316L, 321, 347	Slotting	1 x D	1 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - Rough	1.25 x D	.3 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - HEM	2 x D	.10 x D	300-360	210-250	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Austenitic > 32 HRC	Reduce SFM by 20%	N/A	N/A	N/A	240-288	168-200	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Martensitic	403, 410, 416, 420, 430, 431, 440	Slotting	1 x D	1 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - Rough	1.25 x D	.3 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - HEM	2 x D	.15 x D	300-360	210-250	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8M0, PH14-8/M0	Slotting	1 x D	1 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - Rough	1.25 x D	.3 x D	300-360	210-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - HEM	1.5 x D	.10 x D	300-360	210-250	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation Hardening > 32 HRC	Reduce SFM by 20%	N/A	N/A	N/A	240-288	168-200	N/A	N/A	N/A	N/A	N/A	N/A	N/A

D = tool diameter. Reduce feed rates by 20% when using long length tools. Starting parameters shown. Speeds and Feeds listed are estimated and will vary by application.

Endmills - Technical Info

**HP Variable Index 4-Flute Tools Speeds & Feeds**

Material	Grades	Cut Type	Axial DOC	Radial DOC	Stub/Regular	Long/X-Long	Feed by Endmill Diameter (IPT)						
					SFM	SFM	1/8	1/4	3/8	1/2	5/8	3/4	1
					AlCrNX	AlCrNX	(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>K - Cast Irons</b>													
Ductile	A536, J434 60-40-18	Slotting	1 x D	1 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - Rough	1.25 x D	.5 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - HEM	2 x D	.15 x D	560-660	400-550	.0008-.0016	.0036-.0040	.0060-.0064	.0070-.0074	.0078-.0082	.0082-.0086	.0108-.0112
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gray	A48, A436, A319 Class 20, G4000	Slotting	1 x D	1 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - Rough	1.25 x D	.5 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - HEM	2 x D	.15 x D	560-660	400-550	.0008-.0016	.0036-.0040	.0060-.0064	.0070-.0074	.0078-.0082	.0082-.0086	.0108-.0112
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Malleable	A220, A602, J158	Slotting	1 x D	1 x D	400-450	350-425	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - Rough	1.25 x D	.3 x D	400-450	350-425	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - HEM	2 x D	.15 x D	400-450	350-425	.0008-.0016	.0036-.0040	.0060-.0064	.0070-.0074	.0078-.0082	.0082-.0086	.0108-.0112
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>N - Non-Ferrous</b>													
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Composites	G-10, Fiber- glass, Graphite, Graphite Epoxy, Plastics	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper		Slotting	1 x D	1 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - Rough	1.25 x D	.3 x D	560-660	400-550	.0004-.0008	.0018-.0020	.0030-.0032	.0035-.0037	.0039-.0041	.0041-.0043	.0054-.0056
		Peripheral - HEM	2 x D	.15 x D	560-660	400-550	.0008-.0016	.0036-.0040	.0060-.0064	.0070-.0074	.0078-.0082	.0082-.0086	.0108-.0112
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Magnesium		Slotting	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>S - High Temp Alloys</b>													
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	Slotting	1 x D	1 x D	95-210	65-150	.0004-.0008	.0009-.0016	.0012-.0019	.0016-.0028	.0019-.0031	.0024-.0037	.0029-.0041
		Peripheral - Rough	1.25 x D	.25 x D	95-210	65-150	.0004-.0008	.0009-.0016	.0012-.0019	.0016-.0028	.0019-.0031	.0024-.0037	.0029-.0041
		Peripheral - HEM	1.5 x D	.10 x D	95-210	65-150	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cobalt Base > 32 HRC	Reduce SFM by 40%	N/A	N/A	N/A	95-210	39-90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron Base	Incoloy 800- 802, Multmet N-155, Timkin 16-25-6, Car- penter 22-b3	Slotting	1 x D	1 x D	95-210	65-150	.0004-.0008	.0009-.0016	.0012-.0019	.0016-.0028	.0019-.0031	.0024-.0037	.0029-.0041
		Peripheral - Rough	1.25 x D	.25 x D	95-210	65-150	.0004-.0008	.0009-.0016	.0012-.0019	.0016-.0028	.0019-.0031	.0024-.0037	.0029-.0041
		Peripheral - HEM	1.5 x D	.10 x D	95-210	65-150	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron Base > 32 HRC	Reduce SFM by 40%	N/A	N/A	N/A	95-210	39-90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel Base	Inconel 625/718, Inco 700, 713C, 718, Monel 400- 401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700	Slotting	1 x D	1 x D	95-210	65-150	.0004-.0008	.0009-.0016	.0012-.0019	.0016-.0028	.0019-.0031	.0024-.0037	.0029-.0041
		Peripheral - Rough	1.25 x D	.25 x D	95-210	65-150	.0004-.0008	.0009-.0016	.0012-.0019	.0016-.0028	.0019-.0031	.0024-.0037	.0029-.0041
		Peripheral - HEM	1.5 x D	.10 x D	95-210	65-150	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel Base > 32 HRC	Reduce SFM by 40%	N/A	N/A	N/A	95-210	39-90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Titanium	Commercially Pure, 6Al-4V ASTM 1/2/3, 6Al-25N- 4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	Slotting	1 x D	1 x D	240-375	150-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - Rough	1.25 x D	.3 x D	240-375	150-250	.0004-.0008	.0014-.0016	.0017-.0019	.0026-.0028	.0029-.0031	.0035-.0037	.0039-.0041
		Peripheral - HEM	1.5 x D	.10 x D	240-375	150-250	.0008-.0016	.0018-.0032	.0024-.0038	.0032-.0056	.0038-.0062	.0048-.0074	.0058-.0082
		Finish	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A



## 4-Flute, Extra High Performance Endmills, Variable Index, Square, Corner Radius & Ball End, 38 Degree Helix

- RedLine XHP Variable 4-Flute tools are designed for faster metal removal. We control vibration and chatter through a unique dampening geometry and can handle faster speeds and feeds generated by the application of our AlCrNX coating.
- Our XHP Variable 4-flute tools can be run wet or dry and can be used in a wide variety of applications, from roughing and finishing to slotting and pocketing.
- Designed to run in a wide range of materials from cast irons and steels to titanium and high temperature alloys.
- These tools are the ultimate for versatility, performance and lowest overall cost.
- These Extra High Performance tools can be found on pages 47-53, 57.

### XHP Variable Index 4-Flute Tools Speeds & Feeds (Cont'd)

Material	Grades	Cut Type	Axial DOC	Radial DOC	Stub/Reg	Long/X-Long	Feed by Endmill Diameter (IPT)							
							SFM	1/8	1/4	3/8	1/2	5/8	3/4	1
							AlCrNX	(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>P - Steels</b>														
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	Slotting	.75 x D	1 x D	300	240	.0004-.0006	.0010-.0012	.0014-.0018	.0020-.0024	.0024-.0030	.0029-.0036	.0038-.0048	
		Peripheral - Rough	1.25 x D	.3 x D	375	300	.0006-.0007	.0012-.0015	.0018-.0022	.0023-.0029	.0030-.0037	.0035-.0044	.0047-.0059	
		Peripheral - HEM	2 x D	.15 x D	475	380	.0010-.0012	.0019-.0024	.0028-.0035	.0038-.0047	.0047-.0059	.0057-.0071	.0076-.0095	
		Finish	1.5 x D	.015 x D	450	360	.0006-.0007	.0012-.0015	.0018-.0022	.0023-.0029	.0030-.0037	.0035-.0044	.0047-.0059	
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	Slotting	1 x D	1 x D	350	280	.0004-.0006	.0010-.0013	.0015-.0019	.0020-.0026	.0025-.0032	.0030-.0038	.0040-.0050	
		Peripheral - Rough	1.25 x D	.5 x D	425	340	.0006-.0008	.0013-.0016	.0020-.0024	.0026-.0032	.0032-.0040	.0038-.0048	.0050-.0064	
		Peripheral - HEM	2 x D	.15 x D	525	420	.0012-.0015	.0025-.0031	.0038-.0046	.0049-.0061	.0060-.0077	.0074-.0092	.0098-.0123	
		Finish	1.5 x D	.015 x D	500	400	.0007-.0009	.0014-.0018	.0022-.0027	.0029-.0036	.0035-.0044	.0042-.0053	.0057-.0071	
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	Slotting	1 x D	1 x D	300	240	.0004-.0006	.0010-.0012	.0014-.0018	.0020-.0024	.0024-.0030	.0029-.0036	.0038-.0048	
		Peripheral - Rough	1.25 x D	.5 x D	375	300	.0006-.0008	.0012-.0015	.0018-.0023	.0024-.0030	.0030-.0038	.0036-.0045	.0048-.0060	
		Peripheral - HEM	2 x D	.15 x D	475	380	.0011-.0014	.0022-.0028	.0034-.0042	.0045-.0056	.0056-.0070	.0067-.0084	.0090-.0110	
		Finish	1.5 x D	.015 x D	450	360	.0006-.0008	.0136-.0170	.0020-.0025	.0026-.0033	.0034-.0042	.0040-.0050	.0054-.0067	
<b>M - Stainless Steels</b>														
Austenitic	301-304L, 310, 316L, 321, 347	Slotting	.75 x D	1 x D	275	220	.0006-.0007	.0010-.0013	.0016-.0020	.0020-.0026	.0026-.0033	.0031-.0039	.0040-.0050	
		Peripheral - Rough	1.25 x D	.3 x D	325	260	.0006-.0008	.0013-.0016	.0020-.0025	.0026-.0033	.0033-.0041	.0039-.0049	.0050-.0065	
		Peripheral - HEM	2 x D	.10 x D	425	340	.0013-.0016	.0025-.0031	.0040-.0047	.0050-.0063	.0062-.0078	.0075-.0094	.0100-.0125	
		Finish	1.5 x D	.015 x D	400	320	.0006-.0008	.0014-.0017	.0020-.0025	.0026-.0033	.0034-.0042	.0040-.0050	.0054-.0067	
Martensitic	403, 410, 416, 420, 430, 431, 440	Slotting	.75 x D	1 x D	300	240	.0004-.0006	.0010-.0012	.0014-.0018	.0020-.0024	.0024-.0030	.0029-.0036	.0038-.0048	
		Peripheral - Rough	1.25 x D	.3 x D	375	300	.0006-.0007	.0012-.0015	.0018-.0022	.0023-.0029	.0030-.0037	.0035-.0044	.0047-.0059	
		Peripheral - HEM	2 x D	.15 x D	475	380	.0011-.0014	.0022-.0028	.0034-.0042	.0045-.0056	.0056-.0070	.0067-.0087	.0090-.0112	
		Finish	1.5 x D	.015 x D	450	360	.0006-.0007	.0012-.0015	.0018-.0022	.0023-.0029	.0030-.0037	.0035-.0044	.0047-.0059	
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363 PH13-8MO, PH14-8/MO	Slotting	.5 x D	1 x D	250	200	.0004-.0005	.0008-.0010	.0012-.0015	.0016-.0020	.0020-.0025	.0024-.0030	.0032-.0040	
		Peripheral - Rough	1.25 x D	.3 x D	300	240	.0005-.0006	.0010-.0013	.0015-.0019	.0020-.0025	.0025-.0031	.0030-.0038	.0040-.0050	
		Peripheral - HEM	1.5 x D	.10 x D	400	320	.0010-.0013	.0020-.0026	.0031-.0039	.0042-.0052	.0050-.0065	.0060-.0078	.0080-.0100	
		Finish	1.5 x D	.015 x D	375	300	.0005-.0006	.0010-.0013	.0015-.0019	.0020-.0026	.0026-.0032	.0030-.0038	.0040-.0050	
<b>K - Cast Irons</b>														
Ductile	A536, J434 60-40-18	Slotting	1 x D	1 x D	300	240	.0004-.0005	.0009-.0011	.0013-.0016	.0018-.0022	.0022-.0027	.0026-.0032	.0034-.0043	
		Peripheral - Rough	1.25 x D	.5 x D	375	300	.0056-.0007	.0011-.0014	.0016-.0020	.0022-.0027	.0027-.0034	.0033-.0041	.0043-.0054	
		Peripheral - HEM	2 x D	.15 x D	475	380	.0009-.0011	.0018-.0022	.0026-.0033	.0035-.0044	.0044-.0055	.0053-.0066	.0070-.0090	
		Finish	1.5 x D	.015 x D	450	360	.0056-.0007	.0012-.0015	.0018-.0022	.0024-.0030	.0030-.0037	.0036-.0045	.0048-.0060	

**XHP Variable Index 4-Flute Tools Speeds & Feeds**

Material	Grades	Cut Type	Axial DOC	Radial DOC	Stub/Reg		Feed by Endmill Diameter (IPT)						
					SFM	Long/X-Long SFM	1/8	1/4	3/8	1/2	5/8	3/4	1
					AlCrNX	AlCrNX	(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>K - Cast Irons</b>													
Gray	A48, A436, A319 Class 20, G4000	Slotting	1 x D	1 x D	325	260	.0004-.0006	.0010-.0012	.0014-.0018	.0020-.0024	.0024-.0030	.0029-.0036	.0038-.0048
		Peripheral - Rough	1.25 x D	.5 x D	400	320	.0006-.0008	.0012-.0015	.0018-.0023	.0024-.0030	.0030-.0038	.0036-.0045	.0048-.0060
		Peripheral - HEM	2 x D	.15 x D	500	400	.0010-.0013	.0020-.0028	.0031-.0039	.0040-.0053	.0050-.0066	.0060-.0079	.0084-.0105
		Finish	1.5 x D	.015 x D	475	380	.0006-.0008	.0014-.0017	.0020-.0025	.0026-.0033	.0034-.0042	.0040-.0050	.0054-.0067
Malleable	A220, A602, J158	Slotting	.75 x D	1 x D	250	200	.0004-.0005	.0009-.0011	.0013-.0016	.0018-.0022	.0022-.0027	.0026-.0032	.0034-.0043
		Peripheral - Rough	1.25 x D	.3 x D	325	260	.0006-.0007	.0011-.0014	.0016-.0020	.0022-.0027	.0027-.0034	.0033-.0041	.0043-.0054
		Peripheral - HEM	2 x D	.15 x D	425	340	.0009-.0011	.0018-.0022	.0026-.0033	.0035-.0044	.0044-.0055	.0053-.0066	.0070-.0090
		Finish	1.5 x D	.015 x D	400	320	.0005-.0007	.0012-.0015	.0018-.0022	.0024-.0030	.0030-.0037	.0036-.0045	.0048-.0060
<b>N - Non-Ferrous</b>													
Brass/Bronze	Aluminum Bronze Low Silicon Bronze	Slotting	.5 x D	1 x D	350	280	.0005-.0006	.0010-.0012	.0015-.0018	.0020-.0025	.0025-.0030	.0034-.0039	.0045-.0050
		Peripheral - Rough	1 x D	.5 x D	400	320	.0006-.0008	.0012-.0015	.0018-.0022	.0025-.0030	.0032-.0037	.0042-.0047	.0055-.0060
		Peripheral - HEM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Finish	1.5 x D	.01 x D	425	340	.0007-.0009	.0015-.0017	.0022-.0026	.0030-.0035	.0040-.0045	.0050-.0055	.0065-.0070
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	N/A	NA	NA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Copper		Slotting	.5 x D	1 x D	350	280	.0005-.0006	.0010-.0012	.0015-.0018	.0020-.0025	.0025-.0030	.0034-.0039	.0045-.0050
		Peripheral - Rough	1 x D	.5 x D	400	320	.0006-.0008	.0012-.0015	.0018-.0022	.0025-.0030	.0032-.0037	.0042-.0047	.0055-.0060
		Peripheral - HEM			N/A	N/A	—	—	—	—	—	—	—
		Finish	1.5 x D	.01 x D	425	340	.0007-.0009	.0015-.0017	.0022-.0026	.0030-.0035	.0040-.0045	.0050-.0055	.0065-.0070
Magnesium		N/A	NA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
<b>S - High Temp Alloys</b>													
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	Slotting	.25 x D	1 x D	60	48	.0004-.0005	.0009-.0011	.0013-.0016	.0017-.0021	.0022-.0027	.0026-.0032	.0034-.0042
		Peripheral - Rough	1.25 x D	.25 x D	90	72	.0006-.0007	.0010-.0013	.0016-.0020	.0022-.0027	.0026-.0033	.0032-.0040	.0040-.0053
		Peripheral - HEM	1.5 x D	.10 x D	225	180	.0007-.0009	.0014-.0018	.0022-.0027	.0029-.0036	.0035-.0044	.0042-.0053	.0057-.0071
		Finish	1.5 x D	.010 x D	125	100	.0006-.0008	.0013-.0016	.0018-.0023	.0025-.0031	.0031-.0039	.0038-.0047	.0050-.0060
Iron Base	Incoloy 800-802, Multimet N-155 Timkin 16-25-6, Carpenter 22-b3	Slotting	.25 x D	1 x D	60	48	.0004-.0005	.0009-.0011	.0013-.0016	.0017-.0021	.0022-.0027	.0026-.0032	.0034-.0042
		Peripheral - Rough	1.25 x D	.25 x D	90	72	.0006-.0007	.0010-.0013	.0016-.0020	.0022-.0027	.0026-.0033	.0032-.0040	.0040-.0053
		Peripheral - HEM	1.5 x D	.10 x D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Finish	1.5 x D	.010 x D	125	100	.0006-.0008	.0013-.0016	.0018-.0023	.0025-.0031	.0031-.0039	.0038-.0047	.0050-.0060
Nickel Base	Inconel 625/718, Inco 700, 713C, 718 Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly Udimet 500 & 700	Slotting	.25 x D	1 x D	60	48	.0004-.0005	.0009-.0011	.0013-.0016	.0017-.0021	.0022-.0027	.0026-.0032	.0034-.0042
		Peripheral - Rough	1.25 x D	.25 x D	90	72	.0006-.0007	.0010-.0013	.0016-.0020	.0022-.0027	.0026-.0033	.0032-.0040	.0040-.0053
		Peripheral - HEM	1.5 x D	.10 x D	225	180	.0007-.0009	.0014-.0018	.0022-.0027	.0029-.0036	.0035-.0044	.0042-.0053	.0057-.0071
		Finish	1.5 x D	.010 x D	125	100	.0006-.0008	.0013-.0016	.0018-.0023	.0025-.0031	.0031-.0039	.0038-.0047	.0050-.0060
Titanium	Commercially Pure, 6Al-4V ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si Ti-8Al-1Mo, Ti-8Al-4Mo	Slotting	.5 x D	1 x D	250	200	.0004-.0005	.0008-.0010	.0012-.0015	.0016-.0020	.0020-.0025	.0024-.0030	.0032-.0040
		Peripheral - Rough	1.25 x D	.3 x D	300	240	.0005-.0006	.0010-.0013	.0015-.0019	.0020-.0025	.0025-.0031	.0030-.0038	.0040-.0050
		Peripheral - HEM	1.5 x D	.10 x D	400	320	.0010-.0012	.0019-.0024	.0029-.0036	.0038-.0048	.0048-.0060	.0058-.0072	.0077-.0096
		Finish	1.5 x D	.015 x D	375	300	.0005-.0006	.0010-.0013	.0015-.0019	.0020-.0026	.0026-.0032	.0030-.0038	.0040-.0050

D = tool diameter. Reduce feed rates by 20% when using long length tools. Starting parameters shown.  
 NOTE: Speeds and Feeds listed are estimated and will vary by application.



## 4-Flute, High Performance Endmills, Square & Ball End, Roughers, Rougher/Finishers, 30 Degree Helix



- RedLine High Performance Roughers are designed to perform in hard to machine materials like stainless steel and titanium.
- Higher feed rates can be attained because of our radius chip breaker, without sacrificing finish.
- These High Performance tools can be found on pages 54-55 & 58.

### Solid Carbide Roughers Tools Speeds & Feeds

Material	Grades	Stub/Reg		Long		Feed by Endmill Diameter (IPT)					
		SFM	SFM	SFM	SFM	1/4	3/8	1/2	5/8	3/4	1
		Uncoated	AlTiN	Uncoated	AlTiN	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>S - Steels</b>											
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	200-230	250-320	140-160	180-210	.0003-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0035	.0035-.0040
High Strength Tool Steel >32 HRC		180-220	240-280	130-150	170-190	.0003-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0035	.0035-.0040
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	210-345	350-575	165-275	280-460	.0015-.0020	.0020-.0030	.0030-.0035	.0035-.0040	.0038-.0042	.0040-.0045
Low Carbon >32HRC		125-190	210-320	100-150	165-255	.0011-.0015	.0015-.0020	.0020-.0025	.0023-.0025	.0025-.0030	.0028-.0032
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	210-345	350-575	165-275	280-460	.0015-.0020	.0020-.0030	.0030-.0035	.0035-.0040	.0038-.0042	.0040-.0045
Medium Carbon >32 HRC		180-220	240-280	130-150	170-190	.0003-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0035	.0035-.0040
<b>M - Stainless Steels</b>											
Austenitic	301-304L, 310, 316L, 321, 347	150-300	250-500	120-240	200-400	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0035	.0035-.0040
Martensitic	403, 410, 416, 420, 430, 431, 440	135-255	225-430	110-200	180-340	.0015-.0020	.0020-.0030	.0030-.0035	.0035-.0040	.0038-.0042	.0040-.0045
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO	135-255	225-430	110-200	180-340	.0015-.0020	.0020-.0030	.0030-.0035	.0035-.0040	.0038-.0042	.0040-.0045
<b>K - Cast Irons</b>											
Ductile	A536, J434, 60-40-18	200-250	300-350	140-175	210-250	.0005-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0035	.0035-.0040
Gray	A48, A436, A319, Class 20, G4000	250-300	450-500	175-210	315-350	.0005-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0035	.0035-.0040
Malleable	A220, A602, J158	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>N - Non Ferrous</b>											
Aluminum Alloys		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aluminum High Silicon		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Magnesium		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>S - High Temp Alloys</b>											
Cobalt Base	Stellite, HS-21, Haynes 25/188	25-45	45-75	20-35	35-60	.0009-.0012	.0012-.0015	.0015-.0018	.0018-.0021	.0021-.0025	.0025-.0027
Cobalt Base >32HRC	X40, L605	25-45	45-75	20-35	35-60	.0009-.0012	.0012-.0015	.0015-.0018	.0018-.0021	.0021-.0025	.0025-.0027
Iron Base	Incoloy 800-802, Multmet N-155	25-45	45-75	20-35	35-60	.0009-.0012	.0012-.0015	.0015-.0018	.0018-.0021	.0021-.0025	.0025-.0027
Iron Base >32HRC	Timkin 16-25-6, Carpenter 22-b3	25-45	45-75	20-35	35-60	.0009-.0012	.0012-.0015	.0015-.0018	.0018-.0021	.0021-.0025	.0025-.0027
Nickel Base	Inconel 625/718, Inco 700, 713C, 718	40-85	65-145	30-65	50-115	.0009-.0012	.0012-.0015	.0015-.0018	.0018-.0021	.0021-.0025	.0025-.0027
Nickel Base >32HRC	Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700	30-65	55-110	25-50	45-90	.0009-.0012	.0012-.0015	.0015-.0018	.0018-.0021	.0021-.0025	.0025-.0027
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	75-130	125-215	60-100	100-170	.0009-.0012	.0012-.0015	.0015-.0018	.0018-.0021	.0021-.0025	.0025-.0027

NOTE: Speeds and Feeds listed are estimated and will vary by application.





## 5-Flute, Standard, Neck Relief, Ball End & Chip Control, 40 Degree Helix, Extra High Performance Endmills

- RedLine XHP Variable 5-Flute tools offer optimum metal removal rates. By controlling the vibration and chatter through a unique dampening geometry, and through the application of our advanced heat resistant coating over a fine micro-grain carbide substrate, our tools can handle faster speeds and feeds with excellent tool life in even the most difficult to machine materials like Stainless and Titanium.
- These tools can be optimized by using High Efficiency Machining technology.
- Used to Ramp, Plunge, Slot, Rough and Finish Profiles and can be found on pages 62-78.

### XHP Variable Index 5-Flute Tools Speeds & Feeds (Cont'd)

Material	Grades	Cut	Axial	Radial	Stub/Reg	Long/X-Long	Feed by Endmill Diameter (IPT)						
					SFM	SFM	1/8	1/4	3/8	1/2	5/8	3/4	1
					AICrNX	AICrNX	(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>P - Steels</b>													
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	Slotting	.5 x D	1 x D	275	220	.0004-.0005	.0009-.0011	.0013-.0016	.0018-.0022	.0022-.0027	.0026-.0032	.0034-.0043
		Peripheral - Rough	1.25 x D	.3 x D	350	280	.0006-.0007	.0012-.0015	.0018-.0022	.0023-.0029	.0030-.0037	.0035-.0044	.0048-.0059
		Peripheral - HEM	2 x D	.15 x D	475	380	.0010-.0012	.0020-.0024	.0028-.0035	.0038-.0047	.0047-.0059	.0060-.0071	.0076-.0095
		Finish	2 x D	.010 x D	350	280	.0011-.0014	.0022-.0027	.0033-.0041	.0043-.0054	.0054-.0068	.0065-.0081	.0087-.0110
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	Slotting	.5 x D	1 x D	325	260	.0006-.0007	.0011-.0014	.0017-.0021	.0022-.0028	.0030-.0035	.0034-.0042	.0045-.0056
		Peripheral - Rough	1.25 x D	.3 x D	400	320	.0008-.0010	.0015-.0019	.0023-.0029	.0030-.0038	.0038-.0048	.0046-.0057	.0060-.0076
		Peripheral - HEM	2 x D	.15 x D	525	420	.0012-.0015	.0025-.0031	.0037-.0046	.0049-.0061	.0060-.0077	.0070-.0092	.0100-.0123
		Finish	2 x D	.010 x D	400	320	.0014-.0018	.0030-.0035	.0040-.0053	.0056-.0070	.0070-.0088	.0080-.0106	.0110-.0141
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	Slotting	.5 x D	1 x D	300	240	.0005-.0006	.0010-.0013	.0015-.0019	.0020-.0026	.0026-.0032	.0030-.0038	.0040-.0050
		Peripheral - Rough	1.25 x D	.3 x D	375	300	.0007-.0009	.0014-.0017	.0020-.0026	.0028-.0035	.0035-.0044	.0040-.0052	.0056-.0070
		Peripheral - HEM	2 x D	.15 x D	500	400	.0010-.0014	.0020-.0028	.0034-.0042	.0045-.0056	.0056-.0070	.0070-.0084	.0090-.0110
		Finish	2 x D	.010 x D	375	300	.0013-.0016	.0026-.0032	.0038-.0048	.0050-.0064	.0064-.0080	.0077-.0096	.0100-.0129
<b>M - Stainless Steels</b>													
Austenitic	301-304L, 310, 316L, 321, 347	Slotting	.5 x D	1 x D	275	220	.0008-.0010	.0010-.0012	.0014-.0018	.0020-.0024	.0024-.0030	.0030-.0036	.0038-.0048
		Peripheral - Rough	1.25 x D	.3 x D	350	280	.0001-.0012	.0013-.0016	.0020-.0025	.0026-.0033	.0033-.0041	.0039-.0049	.0050-.0065
		Peripheral - HEM	2 x D	.10 x D	475	380	.0012-.0015	.0025-.0031	.0038-.0047	.0050-.0063	.0062-.0078	.0075-.0094	.0100-.0125
Martensitic	403, 410, 416, 420, 430, 431, 440	Finish	2 x D	.010 x D	350	280	.0016-.0020	.0024-.0030	.0036-.0045	.0048-.0060	.0060-.0075	.0070-.009	.0100-.0121
		Slotting	.5 x D	1 x D	300	240	.0048-.0006	.0010-.0013	.0015-.0019	.0020-.0026	.0026-.0032	.0030-.0038	.0040-.0050
		Peripheral - Rough	1.25 x D	.3 x D	375	300	.0007-.0009	.0014-.0017	.0020-.0026	.0028-.0035	.0035-.0044	.0040-.0052	.0056-.0070
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO	Peripheral - HEM	2 x D	.15 x D	500	400	.0011-.0014	.0022-.0028	.0034-.0042	.0045-.0056	.0060-.0070	.0067-.0084	.0090-.0112
		Finish	2 x D	.010 x D	375	300	.0013-.0016	.0026-.0032	.0038-.0048	.0050-.0064	.0064-.0080	.0077-.0096	.0100-.0129
		Slotting	.5 x D	1 x D	250	200	.0004-.0005	.0008-.0010	.0012-.0015	.0016-.0020	.0020-.0025	.0024-.0030	.0030-.0040
K - Cast Irons	A536, J434, 60-40-18	Peripheral - Rough	1.25 x D	.3 x D	375	300	.0006-.0008	.0013-.0016	.0020-.0025	.0026-.0033	.0033-.0041	.0040-.0049	.0050-.0065
		Peripheral - HEM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Finish	2 x D	.01 x D	375	300	.0012-.0015	.0024-.0030	.0036-.0045	.0048-.0060	.0060-.0075	.0072-.0090	.0100-.0121
Gray	A48, A436, A319, Class 20, G4000	Slotting	.5 x D	1 x D	300	240	.0005-.0006	.0010-.0012	.0014-.0018	.0019-.0024	.0024-.0030	.0029-.0036	.0038-.0048
		Peripheral - Rough	1.25 x D	.3 x D	375	300	.0006-.0008	.0013-.0016	.0020-.0025	.0026-.0033	.0033-.0041	.0040-.0049	.0050-.0065
		Peripheral - HEM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Malleable	A220, A602, J158	Finish	2 x D	.01 x D	375	300	.0012-.0015	.0024-.0030	.0036-.0045	.0048-.0060	.0060-.0075	.0072-.0090	.0100-.0121
		Slotting	.5 x D	1 x D	275	220	.0004-.0005	.0008-.0010	.0012-.0015	.0016-.0020	.0020-.0025	.0024-.0030	.0032-.0040
		Peripheral - Rough	1.25 x D	.3 x D	350	280	.0006-.0007	.0011-.0014	.0016-.0020	.0022-.0027	.0027-.0034	.0033-.0041	.0044-.0055
		Peripheral - HEM	2 x D	.15 x D	475	380	.0009-.0011	.0018-.0022	.0026-.0033	.0035-.0044	.0044-.0055	.0053-.0066	.0070-.0088
		Finish	2 x D	.01 x D	350	280	.0010-.0013	.0020-.0025	.0030-.0038	.0040-.0050	.0050-.0063	.0060-.0075	.0080-.0101

D = tool diameter. Reduce feed rates by 20% when using long length tools. Starting parameters shown.  
 NOTE: Speeds and Feeds listed are estimated and will vary by application.

**XHP Variable Index 5-Flute Tools Speeds & Feeds**

Material	Grades	Cut	Axial	Radial	Stub/Reg	Long/X-Long	Feed by Endmill Diameter (IPT)						
					SFM	SFM	1/8	1/4	3/8	1/2	5/8	3/4	1
					AlCrNX	AlCrNX	(.1250)	(.2500)	(.3750)	(.5000)	(.6250)	(.7500)	(1.000)
<b>N - Non-Ferrous</b>													
Brass/ Bronze	Aluminum Bronze, Low Silicon Bronze	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Composites	Fiberglass, Graphite, Graphite Epoxy	Slotting	.5 x D	1 x D	450	365	.0007	.0014	.0021	.0028	.0035	.0042	.0056
		Peripheral - Rough	1 x D	.5 x D	475	385	.0008	.0016	.0024	.0032	.0040	.0048	.0064
		Peripheral - HEM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Finish	1.5 x D	.01 x D	500	400	.0009	.0018	.0026	.0035	.0044	.0053	.0070
Copper		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Magnesium		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
<b>S - High Temp Alloys</b>													
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	Slotting	.25 x D	1 x D	70	56	.0001-.0002	.0004-.0005	.0006-.0007	.0008-.0010	.0010-.0012	.0012-.0015	.0016-.0020
		Peripheral - Rough	1.25 x D	.2 x D	80	64	.0003-.0004	.0006-.0008	.0010-.0012	.0013-.0016	.0016-.0020	.0020-.0024	.0026-.0032
		Peripheral - HEM	1.5 x D	.05 x D	90	72	.0015-.0020	.0035-.0040	.0055-.0060	.0075-.0080	.0095-.0100	.0110-.0120	.0150-.0160
		Finish	1.5 x D	.015 x D	100	80	.0002-.0003	.0006-.0007	.0009-.0011	.0012-.0015	.0017-.0021	.0022-.0028	.0022-.0028
Iron Base	Incoloy 800- 802, Multmet N-155, Timkin 16-25-6, Car- penter 22-b3	Slotting	.25 x D	1 x D	70	56	.0001-.0002	.0004-.0005	.0006-.0007	.0008-.0010	.0010-.0012	.0012-.0015	.0016-.0020
		Peripheral - Rough	1 x D	.2 x D	80	64	.0032-.0004	.0064-.0008	.0010-.0012	.0013-.0016	.0016-.0020	.0020-.0024	.0026-.0032
		Peripheral - HEM	1.5 x D	.05 x D	90	72	.0020	.0040	.0060	.0080	.0100	.0120	.0160
		Finish	1.5 x D	.015 x D	100	80	.0002-.0003	.0006-.0007	.0009-.0011	.0012-.0015	.0017-.0021	.0022-.0028	.0022-.0028
Nickel Base	Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Wa- spoloy, Udimet 500 & 700	Slotting	.25 x D	1 x D	70	56	.0001-.0002	.0004-.0005	.0006-.0007	.0008-.0010	.0010-.0012	.0012-.0015	.0016-.0020
		Peripheral - Rough	1 x D	.2 x D	80	64	.0003-.0004	.0006-.0008	.0010-.0012	.0013-.0016	.0016-.0020	.0020-.0024	.0026-.0032
		Peripheral - HEM	1.5 x D	.05 x D	90	72	.0015-.0020	.0035-.0040	.0055-.0066	.0075-.0080	.0095-.0100	.0111-.0012	.0150-.0160
		Finish	1.5 x D	.015 x D	100	80	.0002-.0003	.0006-.0007	.0009-.0011	.0012-.0015	.0017-.0021	.0022-.0028	.0022-.0028
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N- 4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	Slotting	.5 x D	1 x D	250	200	.0004-.0005	.0007-.0009	.0011-.0014	.0014-.0018	.0018-.0023	.0022-.0037	.0030-.0037
		Peripheral - Rough	1 x D	.3 x D	300	240	.0005-.0006	.0010-.0013	.0015-.0019	.0020-.0025	.0025-.0031	.0030-.0038	.0040-.0050
		Peripheral - HEM	1.5 x D	.10 x D	425	340	.0010-.0012	.0020-.0024	.0029-.0036	.0038-.0048	.0048-.0060	.0058-.0072	.0077-.0096
		Finish	1.5 x D	.010 x D	300	240	.0010-.0012	.0018-.0023	.0028-.0035	.0037-.0046	.0046-.0058	.0055-.0069	.0074-.0092

D = tool diameter. Reduce feed rates by 20% when using long length tools. Starting parameters shown.  
NOTE: Speeds and Feeds listed are estimated and will vary by application.





## XHP Tolerances Technical Information

<b>XHP Endmills Tolerances (Inch)</b>	
Size	Shank (H6)
<b>.0000-.1181</b>	+0/-.00024
<b>.1182-.2362</b>	+0/-.00031
<b>.2363-.3937</b>	+0/-.00035
<b>.3938-.7087</b>	+0/-.00043
<b>.7088-1.1810</b>	+0/-.00051
<b>1.182-1.9680</b>	+0/-.00063

<b>XHP Endmills Tolerances (mm)</b>	
Size	Shank (H6)
<b>0-3.00</b>	+0/-.006
<b>3.01-6.00</b>	+0/-.008
<b>6.01-10.00</b>	+0/-.009
<b>10.01-18.00</b>	+0/-.011
<b>18.01-30.00</b>	+0/-.013
<b>30.01-50.00</b>	+0/-.016





## 6-Flute, Extra High Performance, Finisher Endmills for Inconel, Corner Radius & Neck Relief, 45 Degree Helix



- RedLine 6-flute Finishers are your first choice for finishing inconel.
- These Extra High Performance tools can be found on pages 79-80.

**Note:** For added tool life apply tools with a corner radius.

Do not use tools with Weldon Flats in milling chucks or collet chucks for high speed applications.

### 6-Flute Finishers for Inconel Speeds & Feeds

Material	Grades	Diameter	Cut Type	Axial DOC	Radial DOC	SFM	RPM
						AICrNX	
<b>S - High Temp Alloys</b>							
Nickel Base	Inconel 625/718, Inco 700, 713C, 718	1/4	Rough	.300	.050	80	1222
			Slot	.165	.250	80	1222
		5/16	Rough	.390	.062	80	978
			Slot	.205	.313	80	978
		3/8	Rough	.470	.075	80	815
			Slot	.250	.375	80	815
		1/2	Rough	.625	.100	80	611
			Slot	.330	.500	80	611
		5/8	Rough	.780	.125	80	489
			Slot	.415	.625	80	489
		3/4	Rough	.935	.150	80	407
			Slot	.500	.750	80	407
		1	Rough	1.250	.200	80	306
			Slot	.665	1.000	80	306

**NOTE:** Speeds and Feeds listed are estimated and will vary by application.





## 7-Flute, Extra High Performance, Finisher Endmills, Square, Corner Radius & Chip Control, 40 Degree Helix

- More Flutes in the cut means greater production. For added tool life select tools with a Corner Radius
- Use with High Efficiency Machining Technology for best results. See pages 208-212.
- These Extra High Performance tools can be found on pages 86-90.

### 7-Flute Finishers Speeds & Feeds

Material	Grades	Cut Type	Axial DOC	Radial DOC	# of Flutes	SFM	Feed by Endmill Diameter (IPT)									
							3/16 (.1875)	1/4 (.2500)	3/8 (.3750)	1/2 (.5000)	5/8 (.6250)	3/4 (.7500)	1 (1.000)			
Low Carbon Steels <= 38 Rc	1018, 1020, 12L14, 5120, 8620	Peripheral - HEM	<=3 x D	.08 x D	7	485	.0028	.0038	.0056	.0075	.0094	.0113	.0150			
			>3xD-4xD	.08 x D	7	485	.0025	.0034	.0051	.0068	.0084	.0101	.0135			
			>4xD-5xD	.08 x D	7	465	.0023	.0030	.0045	.0060	.0075	.0090	.0120			
Medium Carbon Steels <= 48 HRC	1045, 4140, 4340, 5140	Peripheral - HEM	<=3 x D	.08 x D	7	450	.0027	.0036	.0053	.0071	.0089	.0107	.0142			
			>3xD-4xD	.08 x D	7	450	.0024	.0032	.0048	.0064	.0080	.0096	.0128			
			>4xD-5xD	.08 x D	7	425	.0021	.0028	.0043	.0057	.0071	.0085	.0114			
Tool and Die Steels <= 48 Rc	A2, D2, 01, S7, P20, H13	Peripheral - HEM	<=3 x D	.08 x D	7	420	.0024	.0032	.0048	.0064	.0080	.0096	.0128			
			>3xD-4xD	.08 x D	7	420	.0022	.0029	.0043	.0058	.0072	.0086	.0115			
			>4xD-5xD	.08 x D	7	395	.0019	.0026	.0038	.0051	.0064	.0077	.0102			
M - Stainless Steels		Peripheral - HEM	<=3 x D	.08 x D	7	450	.0024	.0032	.0048	.0064	.0080	.0096	.0128			
			>3xD-4xD	.08 x D	7	440	.0022	.0029	.0043	.0058	.0072	.0086	.0115			
			>4xD-5xD	.07 x D	7	425	.0019	.0026	.0038	.0051	.0064	.0077	.0102			
Austenitic Stainless Steels, FeNi Alloys	303, 304, 316, Invar, Kovar	Finish	3 x D	.015 x D	7	390	.0009	.0012	.0018	.0024	.0030	.0036	.0048			
			Martensitic & Ferritic Stainless Steels	410, 416, 440	Peripheral - HEM	<=3 x D	.08 x D	7	450	.0028	.0038	.0056	.0075	.0094	.0113	.0150
						>3xD-4xD	.08 x D	7	450	.0025	.0034	.0051	.0068	.0084	.0101	.0135
>4xD-5xD	.08 x D	7				425	.0023	.0030	.0045	.0060	.0075	.0090	.0120			
Precipitation Hardening	17-4, 15-5, 13-8	Peripheral - HEM	<=3 x D	.08 x D	7	440	.0023	.0031	.0047	.0062	.0078	.0093	.0124			
			>3xD-4xD	.08 x D	7	440	.0021	.0028	.0042	.0056	.0070	.0084	.0112			
			>4xD-5xD	.07 x D	7	415	.0019	.0025	.0037	.0050	.0062	.0074	.0099			
K - Cast Irons		Peripheral - HEM	<=3 x D	.1 x D	7	400	.0027	.0036	.0054	.0072	.0090	.0108	.0144			
			>3xD-4xD	.08 x D	7	400	.0024	.0032	.0049	.0065	.0081	.0097	.0130			
			>4xD-5xD	.08 x D	7	390	.0022	.0029	.0043	.0058	.0072	.0086	.0115			
Gray	ASTM-A48 Class 20, 25, 30, 35 & 40	Finish	3 x D	.015 x D	7	450	.0010	.0013	.0020	.0026	.0033	.0039	.0052			
			Cast Iron	Malleable	Peripheral - HEM	<=3 x D	.08 x D	7	390	.0022	.0029	.0044	.0058	.0073	.0087	.0116
						>3xD-4xD	.08 x D	7	390	.0020	.0026	.0039	.0052	.0065	.0078	.0104
>4xD-5xD	.08 x D	7				375	.0017	.0023	.0035	.0046	.0058	.0070	.0093			
S - High Temp Alloys		Peripheral - HEM	<=3 x D	.1 x D	7	405	.0015	.0021	.0031	.0041	.0051	.0062	.0082			
			>3xD-4xD	.08 x D	7	405	.0014	.0018	.0028	.0037	.0046	.0055	.0074			
			>4xD-5xD	.08 x D	7	390	.0012	.0016	.0025	.0033	.0041	.0049	.0066			
Titanium Alloys	6Al-4V, 6-2-4	Finish	3 x D	.015 x D	7	350	.0006	.0008	.0012	.0016	.0020	.0024	.0032			
			Difficult to Machine Titanium Alloys	10-2-3	Peripheral - HEM	<=2.5 x D	.08 x D	7	335	.0015	.0020	.0030	.0040	.0050	.0060	.0080
						>2.5xD-3.5xD	.07 x D	7	325	.0014	.0018	.0027	.0036	.0045	.0054	.0072
>3.5xD-4xD	.06 x D	7				305	.0012	.0016	.0024	.0032	.0040	.0048	.0064			
Hastalloy, Waspalloy		Peripheral - HEM	<=1.5 x D	.08 x D	7	100	.0035	.0047	.0071	.0094	.0118	.0141	.0188			
			>1.5xD-2.5xD	.08 x D	7	95	.0032	.0042	.0063	.0085	.0106	.0127	.0169			
			>2.5xD-3.5xD	.06 x D	7	85	.0028	.0038	.0056	.0075	.0094	.0113	.0150			
Inconel 718, Rene 88		Peripheral - HEM	<=1.5 x D	.07 x D	7	95	.0035	.0047	.0070	.0093	.0116	.0140	.0186			
			>1.5xD-2.5xD	.06 x D	7	90	.0031	.0042	.0063	.0084	.0105	.0126	.0167			
			>2.5xD-3xD	.06 x D	7	85	.0028	.0037	.0056	.0074	.0093	.0112	.0149			
		Finish	2 x D	.01 x D	7	85	.0018	.0024	.0036	.0048	.0060	.0072	.0096			

D = Tool Diameter  
HEM = High Efficiency Machining



## 9-Flute, Extra High Performance, Finisher Endmills, Corner Radius & Chip Control, 36 Degree Helix

- More Flutes in the cut means greater production. With an extra solid core get extra rigidity and extended tool life.
- Use with High Efficiency Machining Technology for best results. See pages 208-212.
- These Extra High Performance tools can be found on pages 91-93.



### 9-Flute Finishers Speeds & Feeds

Material	Grades	Cut Type	Axial DOC	Radial DOC	# of Flutes	SFM	Feed by Endmill Diameter (IPT)					
							1/4 (.2500)	3/8 (.3750)	1/2 (.5000)	5/8 (.6250)	3/4 (.7500)	1 (1.000)
Low Carbon Steels <= 38 Rc	1018, 1020, 12L14, 5120, 8620	Peripheral - HEM	<=3 x D	.08 x D	9	485	.0038	.0056	.0075	.0094	.0113	.0150
			>3xD-4xD	.08 x D	9	485	.0034	.0051	.0068	.0084	.0101	.0135
			>4xD-5xD	.08 x D	9	465	.0030	.0045	.0060	.0075	.0090	.0120
		Finish	3 x D	.015 x D	9	420	.0014	.0021	.0028	.0035	.0042	.0056
Medium Carbon Steels <= 48 HRC	1045, 4140, 4340, 5140	Peripheral - HEM	<=3 x D	.08 x D	9	450	.0036	.0053	.0071	.0089	.0107	.0142
			>3xD-4xD	.08 x D	9	450	.0032	.0048	.0064	.0080	.0096	.0128
			>4xD-5xD	.08 x D	9	425	.0028	.0043	.0057	.0071	.0085	.0114
		Finish	3 x D	.015 x D	9	390	.0013	.0019	.0025	.0031	.0038	.0050
Tool and Die Steels <= 48 Rc	A2, D2, O1, S7, P20, H13	Peripheral - HEM	<=3 x D	.08 x D	9	420	.0032	.0048	.0064	.0080	.0096	.0128
			>3xD-4xD	.08 x D	9	420	.0029	.0043	.0058	.0072	.0086	.0115
			>4xD-5xD	.08 x D	9	395	.0026	.0038	.0051	.0064	.0077	.0102
		Finish	3 x D	.015 x D	9	365	.0011	.0016	.0021	.0026	.0032	.0042
<b>M - Stainless Steels</b>												
Austenitic Stainless Steels, FeNi Alloys	303, 304, 316, Invar, Kovar	Peripheral - HEM	<=3 x D	.08 x D	9	450	.0032	.0048	.0064	.0080	.0096	.0128
			>3xD-4xD	.08 x D	9	440	.0029	.0043	.0058	.0072	.0086	.0115
			>4xD-5xD	.07 x D	9	425	.0026	.0038	.0051	.0064	.0077	.0102
		Finish	3 x D	.015 x D	9	390	.0012	.0018	.0024	.0030	.0036	.0048
Martensitic & Ferritic Stainless Steels	410, 416, 440	Peripheral - HEM	<=3 x D	.08 x D	9	450	.0038	.0056	.0075	.0094	.0113	.0150
			>3xD-4xD	.08 x D	9	450	.0034	.0051	.0068	.0084	.0101	.0135
			>4xD-5xD	.08 x D	9	425	.0030	.0045	.0060	.0075	.0090	.0120
		Finish	3 x D	.015 x D	9	390	.0013	.0019	.0025	.0031	.0038	.0050
Precipitation Hardening Stainless Steels	17-4, 15-5, 13-8	Peripheral - HEM	<=3 x D	.08 x D	9	440	.0031	.0047	.0062	.0078	.0093	.0124
			>3xD-4xD	.08 x D	9	440	.0028	.0042	.0056	.0070	.0084	.0112
			>4xD-5xD	.07 x D	9	415	.0025	.0037	.0050	.0062	.0074	.0099
		Finish	3 x D	.015 x D	9	380	.0010	.0015	.0020	.0025	.0030	.0040
<b>K - Cast Irons</b>												
Gray	ASTM-A48 Class 20, 25, 30, 35 & 40	Peripheral - HEM	<=3 x D	.1 x D	9	400	.0036	.0054	.0072	.0090	.0108	.0144
			>3xD-4xD	.08 x D	9	400	.0032	.0049	.0065	.0081	.0097	.0130
			>4xD-5xD	.08 x D	9	390	.0029	.0043	.0058	.0072	.0086	.0115
		Finish	3 x D	.015 x D	9	450	.0013	.0020	.0026	.0033	.0039	.0052
Cast Iron	Malleable	Peripheral - HEM	<=3 x D	.08 x D	9	390	.0029	.0044	.0058	.0073	.0087	.0116
			>3xD-4xD	.08 x D	9	390	.0026	.0039	.0052	.0065	.0078	.0104
			>4xD-5xD	.08 x D	9	375	.0023	.0035	.0046	.0058	.0070	.0093
		Finish	3 x D	.015 x D	9	350	.0011	.0016	.0021	.0026	.0032	.0042
<b>S - High Temp Alloys</b>												
Titanium Alloys	6Al-4V, 6-2-4	Peripheral - HEM	<=3 x D	.1 x D	9	405	.0021	.0031	.0041	.0051	.0062	.0082
			>3xD-4xD	.08 x D	9	405	.0018	.0028	.0037	.0046	.0055	.0074
			>4xD-5xD	.08 x D	9	390	.0016	.0025	.0033	.0041	.0049	.0066
		Finish	3 x D	.015 x D	9	350	.0008	.0012	.0016	.0020	.0024	.0032
Difficult to machine titanium alloys	10-2-3	Peripheral - HEM	<=2.5 x D	.08 x D	9	335	.0020	.0030	.0040	.0050	.0060	.0080
			>2.5xD-3.5xD	.07 x D	9	325	.0018	.0027	.0036	.0045	.0054	.0072
			>3.5xD-4xD	.06 x D	9	305	.0016	.0024	.0032	.0040	.0048	.0064
		Finish	3 x D	.01 x D	9	290	.0007	.0011	.0014	.0018	.0021	.0028
Hastalloy, Waspalloy		Peripheral - HEM	<=1.5 x D	.08 x D	9	100	.0045	.0068	.0090	.0113	.0135	.0180
			>1.5xD-2.5xD	.08 x D	9	95	.0041	.0061	.0081	.0101	.0122	.0162
			>2.5xD-3.5xD	.06 x D	9	85	.0036	.0054	.0072	.0090	.0108	.0144
		Finish	2 x D	.01 x D	9	90	.0024	.0036	.0048	.0060	.0072	.0096
Inconel 718, Rene 88		Peripheral - HEM	<=1.5 x D	.07 x D	9	95	.0046	.0068	.0091	.0114	.0137	.0182
			>1.5xD-2.5xD	.06 x D	9	90	.0041	.0061	.0082	.0102	.0123	.0164
			>2.5xD-3xD	.06 x D	9	85	.0036	.0055	.0073	.0091	.0109	.0146
		Finish	2 x D	.01 x D	9	85	.0023	.0035	.0046	.0058	.0069	.0092

D = Tool Diameter  
HEM = High Efficiency Machining





## 13-Flute, Extra High Performance, Finisher Endmills, Corner Radius & Chip Control, 30 Degree Helix

- More Flutes in the cut means greater production. With an extra solid core get extra rigidity and extended tool life.
- Use with High Efficiency Machining Technology for best results. See pages 208-212.
- These Extra High Performance tools can be found on pages 98-101.

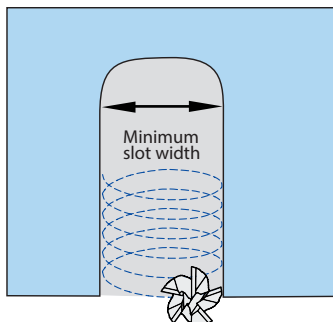


### 13-Flute Finishers Speeds & Feeds

Material	Grades	Cut	Axial	Radial	# of Flutes	SFM	Feed by Endmill Diameter (IPT)							
							1/2	5/8	3/4	1	1 1/4			
							(.5000)	(.6250)	(.7500)	(1.000)	(1.250)			
<b>P - Steels</b>														
Low Carbon Steels <= 38 Rc	1018, 1020, 12L14, 5120, 8620	Peripheral - HEM	<2 x D	.07 x D	13	450	.0044	.0055	.0066	.0088	.0066			
			2.5xD	.07 x D	13	430	.0039	.0049	.0059	.0078	.0059			
			3xD	.07 x D	13	420	.0036	.0045	.0054	.0072	.0054			
			3.5xD	.07 x D	13	410	.0034	.0043	.0051	.0068	.0051			
Medium Carbon Steels <= 48 HRC	1045, 4140, 4340, 5140	Peripheral - HEM	<2 x D	.06 x D	13	405	.0044	.0055	.0066	.0088	.0066			
			2.5xD	.06 x D	13	405	.0041	.0051	.0062	.0082	.0062			
			3xD	.05 x D	13	405	.0039	.0049	.0059	.0078	.0059			
			3.5xD	.05 x D	13	405	.0036	.0045	.0054	.0072	.0054			
Tool and Die Steels <= 48 Rc	A2, D2, 01, S7, P20, H13	Peripheral - HEM	<2 x D	.06 x D	13	420	.0045	.0056	.0068	.0090	.0068			
			2.5xD	.06 x D	13	420	.0040	.0050	.0060	.0080	.0060			
			3xD	.05 x D	13	415	.0037	.0046	.0056	.0074	.0056			
			3.5xD	.05 x D	13	415	.0035	.0044	.0053	.0070	.0053			
M - Stainless Steels		Finish	3 x D	.01 x D	13	385	.0015	.0019	.0023	.0030	.0023			
			<b>M - Stainless Steels</b>											
			Austenitic Stainless Steels, FeNi Alloys	303, 304, 316, Invar, Kovar	Peripheral - HEM	<2 x D	.06 x D	13	450	.0041	.0051	.0062	.0082	.0062
						2.5xD	.06 x D	13	450	.0040	.0050	.0060	.0080	.0060
3xD	.05 x D	13				450	.0037	.0046	.0056	.0074	.0056			
3.5xD	.05 x D	13				445	.0035	.0044	.0053	.0070	.0053			
Martensitic & Ferritic Stainless Steels	410, 416, 440	Peripheral - HEM	<2 x D	.06 x D	13	460	.0050	.0063	.0075	.0100	.0075			
			2.5xD	.06 x D	13	460	.0048	.0060	.0072	.0096	.0072			
			3xD	.06 x D	13	450	.0040	.0050	.0060	.0080	.0060			
			3.5xD	.06 x D	13	445	.0035	.0044	.0053	.0070	.0053			
Precipitation Hardening Stainless Steels	17-4, 15-5, 13-8	Peripheral - HEM	<2 x D	.06 x D	13	440	.0045	.0056	.0068	.0090	.0068			
			2.5xD	.06 x D	13	440	.0041	.0051	.0062	.0082	.0062			
			3xD	.05 x D	13	435	.0038	.0048	.0057	.0076	.0057			
			3.5xD	.05 x D	13	435	.0034	.0043	.0051	.0068	.0051			
K - Cast Irons		Finish	3 x D	.01 x D	13	400	.0017	.0021	.0026	.0034	.0026			
			<b>K - Cast Irons</b>											
			Gray	ASTM-A48 Class 20, 25, 30, 35 & 40	Peripheral - HEM	<2 x D	.07 x D	13	370	.0045	.0056	.0068	.0090	.0068
						2.5xD	.07 x D	13	370	.0040	.0050	.0060	.0080	.0060
3xD	.07 x D	13				360	.0034	.0043	.0051	.0068	.0051			
3.5xD	.06 x D	13				360	.0030	.0038	.0045	.0060	.0045			
Cast Iron	Malleable	Peripheral - HEM	<2 x D	.07 x D	13	380	.0048	.0060	.0072	.0096	.0072			
			2.5xD	.07 x D	13	380	.0042	.0053	.0063	.0084	.0063			
			3xD	.07 x D	13	365	.0039	.0049	.0059	.0078	.0059			
			3.5xD	.07 x D	13	365	.0036	.0045	.0054	.0072	.0054			
S - High Temp Alloys		Finish	3 x D	.01 x D	13	340	.0017	.0021	.0026	.0034	.0026			
			<b>S - High Temp Alloys</b>											
			Titanium Alloys	6Al-4V, 6-2-4	Peripheral - HEM	<2 x D	.08 x D	13	395	.0050	.0063	.0075	.0100	.0075
						2.5xD	.07 x D	13	390	.0045	.0056	.0068	.0090	.0068
3xD	.06 x D	13				380	.0041	.0051	.0062	.0082	.0062			
3.5xD	.06 x D	13				380	.0034	.0043	.0051	.0068	.0051			
Difficult to machine titanium alloys	10-2-3	Peripheral - HEM	<2 x D	0.06	13	350	.0050	.0063	.0075	.0100	.0075			
			2.5xD	0.06	13	330	.0036	.0045	.0054	.0072	.0054			
			3xD	0.055	13	315	.0035	.0044	.0053	.0070	.0053			
			3.5xD	0.05	13	310	.0032	.0040	.0048	.0064	.0048			
Hastalloy, Waspalloy		Peripheral - HEM	<2 x D	.07 X D	13	105	.0071	.0089	.0107	.0142	.0107			
			2.5xD	.065 x D	13	100	.0064	.0080	.0096	.0128	.0096			
			3xD	.055 x D	13	90	.0062	.0078	.0093	.0124	.0093			
			3.5xD	.05 x D	13	90	.0057	.0071	.0086	.0114	.0086			
Inconel 718, Rene 88		Peripheral - HEM	<2 x D	.06 x D	13	100	.0052	.0065	.0078	.0104	.0078			
			2.5xD	.05 x D	13	95	.0052	.0065	.0078	.0104	.0078			
			3xD	.05 x D	13	95	.0048	.0060	.0072	.0096	.0072			
			3.5xD	.04 x D	13	95	.0048	.0060	.0072	.0096	.0072			
		Finish	3 x D	.01 x D	13	90	.0023	.0029	.0035	.0046	.0035			

D = tool diameter.



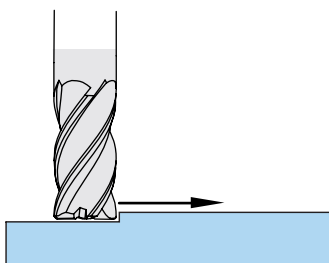


## HEM Slotting Guides

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

Tool Series	Min. Slot Width	Max Slot Depth
XHP 7 Flute Finishers - Pg 86-90	2 x end mill diameter	Full length of cut
XHP 9 Flute Finishers - Pg 91-93	2 x end mill diameter	Full length of cut
XHP 11 Flute Finishers - Pg 94-96	2.25 x end mill diameter	Full length of cut
XHP 13 Flute Finishers Pg 98-100	2.5 x end mill diameter	Full length of cut
XHP 5 Flute Aluminum & Non Ferrous DLC Pg 26-32	1.75 x end mill diameter	Full length of cut
XHP 5 Flute Variable Index - Pg 59-78	1.75 x end mill diameter	.8 x length of cut
HP 7 Flute Finishers - Pg 84-85	2 x end mill diameter	.8 x length of cut

Speed and feed parameters for HEM slotting can be found marked as "Peripheral-HEM" in the speed and feed charts for those series.

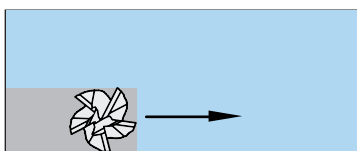


## Facing

When facing, an endmill with a corner radius is suggested for the best finish. Apply the adjustments below to the Peripheral Rough values from the application guide below by tool category.

### RDOC Formula

$$\text{Step-over} = (D - (2 \times \text{corner radius})) \times .75$$



### Tool Selection Guide:

- Category 1:** XHP 7, 9, 11 and 13 Flute Finishers
- Category 2:** XHP 5 Flute Aluminum & Non Ferrous DLC  
XHP 5 Flute Variable Index  
XHP 5 & 6 Flute Finishers

Projection Length	Category 1					
	Rough Facing			Finish Facing		
	SFM	IPT	ADOC	SFM	IPT	ADOC
0 to 3 x D	1.0 x chart value	.80 x chart value	.25 x D Max	1.0 x chart value	.70 x chart value	.07 x D Max
> 3 to 4 x D	1.0 x chart value	.80 x chart value	.25 x D Max	1.0 x chart value	.70 x chart value	.07 x D Max
> 4 to 5 x D	1.0 x chart value	.80 x chart value	.20 x D Max	1.0 x chart value	.70 x chart value	.05 x D Max
> 5 to 6 x D	1.0 x chart value	.80 x chart value	.20 x D Max	1.0 x chart value	.70 x chart value	.05 x D Max

Projection Length	Category 2					
	Rough Facing			Finish Facing		
	SFM	IPT	ADOC	SFM	IPT	ADOC
0 to 3 x D	1.2 x chart value	.85 x chart value	.25 x D Max	1.2 x chart value	.75 x chart value	.07 x D Max
> 3 to 4 x D	1.1 x chart value	.75 x chart value	.25 x D Max	1.1 x chart value	.65 x chart value	.07 x D Max
> 4 to 5 x D	1.0 x chart value	.65 x chart value	.25 x D Max	1.0 x chart value	.55 x chart value	.06 x D Max
> 5 to 6 x D	.9 x chart value	.55 x chart value	.25 x D Max	.9 x chart value	.45 x chart value	.05 x D Max

D = Tool Diameter

## 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 one-step or a two-step process depending on the number of flutes on the end mill. Tools with seven or fewer flutes only require one step; tools with more than seven flutes require two steps.

### Step 1: Create helical ramp entry hole

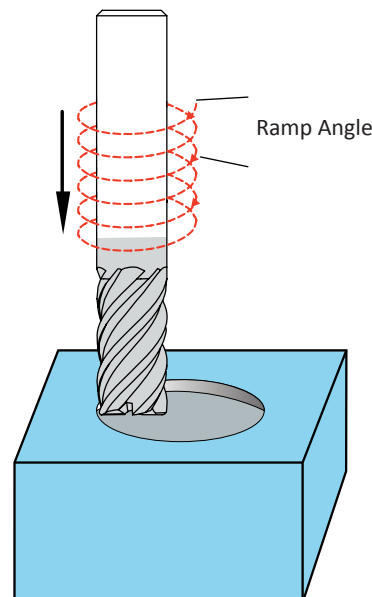
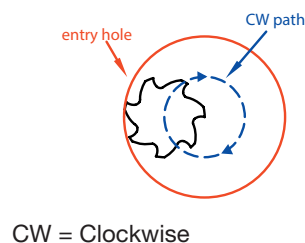
The diameter of the starting hole will be: (tool diameter x 2) - (corner radius x 2)

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 IPT reference the data that is shown in the speed and feed charts located in each tool series section.

Tool Series	Speed	Feed Adjustment – with high-pressure coolant	Feed Adjustment – with standard flood coolant	Ramp Angle
XHP 2 Flute Aluminum and Non-Ferrous	Tools on page 16, use Slotting Speeds & Feeds on page 185.			3° - 5°
XHP 3 Flute Alum & Non-Ferrous ZRN	Tools on pages 18-22 and 24-25, use Slotting Speeds & Feeds page 186.			3° - 5°
XHP 3 Flute Roughers Alum & Non-Ferrous ZRN	Tools on page 23, use Slotting Speeds and Feeds page 187.			3° - 5°
XHP 5 Flute Alum & Non-Ferrous DLC	Tools on pages 26-32	IPT x 1.6	IPT x 1.25	3°
XHP 4 Flute Variable Index	Tools on pages 43-53 and 57, use Slotting Speeds & Feeds pages 192-193.			1° - 2.5°
XHP 5 Flute Variable Index	Tools on pages 62-78, use Slotting Speeds & Feeds pages 198-199.			1° - 2.5°
XHP 5 & 6 Flute Finishers	Tools on pages 81-83, use Slotting Speeds & Feeds page 201.			1° - 2.5°
XHP 6 Flute Finisher for Inconel	Tools on pages 79-80, use Slotting Speeds & Feeds page 202.			1° - 2.5°
HP 7 Flute Finishers	Tools on pages 84-85, use Slotting Speeds & Feeds page 201.			1° - 2.5°
XHP 7 Flute Finishers	Tools on pages 86-90	IPT x 1.6	IPT x 1.25	0.5°
XHP 9 Flute Finishers	Tools on pages 91-93	IPT x 1.6	IPT x 1.25	0.5°
XHP 11 Flute Finishers	Tools on pages 94-96	IPT x 1.6	IPT x 1.25	0.5°
XHP 13 Flute Finishers	Tools on pages 98-100	IPT x 1.6	IPT x 1.25	0.5°

IPT = Inch per tooth from the speed and feed charts

Speed = Surface feet per minute (SFM)



## Step 2: There are two common methods to enlarge an existing hole.

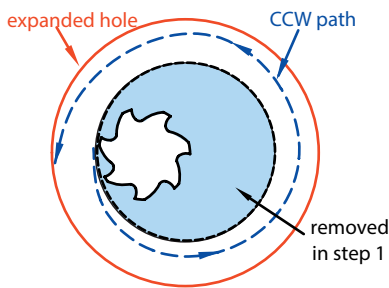
### Method #1 – Expand the entry hole from inside out.

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 diameter shown at right.

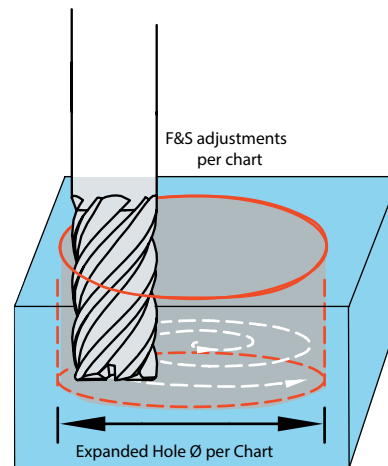
Once the expanded entry hole diameter is achieved, climb cut machining can begin at 100% of the Peripheral-HEM values in the feed and speed chart for the tool series you're using.

Tool Series	Expanded Hole $\phi$	Feed Rate Adjustment	Step-Over Adjustment
XHP 9 Flute Finishers	3 x D	IPT x .75	RDOC x .5
XHP 11 Flute Finishers	3.75 x D	IPT x .75	RDOC x .5
XHP 13 Flute Finishers	3.75 x D	IPT x .75	RDOC x .5

D = Tool Diameter



CCW = Counter-Clockwise



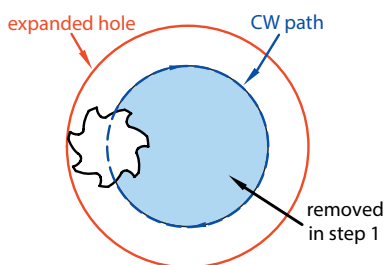
### Method #2 – Expand the entry hole with a second helical ramp move.

Method B will expand the entry hole by doing a second helical ramp entry hole of a larger diameter than in Step 1. After completing Step 1, retract the end from the hole, and machine the second helical ramp entry hole using the same speed, feed and location as the first hole.

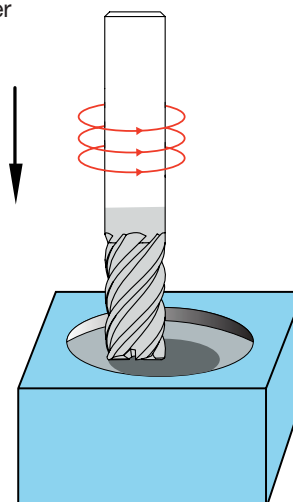
Once the expanded entry hole diameter is achieved, climb cut machining can begin at 100% of the Peripheral-HEM values in the feed and speed chart for the tool series you're using.

Tool Series	Expanded Hole $\phi$	Feed Rate Adjustment	Ramp Angle
XHP 9 Flute Finishers	3 x D	IPT x 1.6	0.5°
XHP 11 Flute Finishers	3.75 x D	IPT x 1.6	0.5°
XHP 13 Flute Finishers	3.75 x D	IPT x 1.6	0.5°

D = Tool Diameter



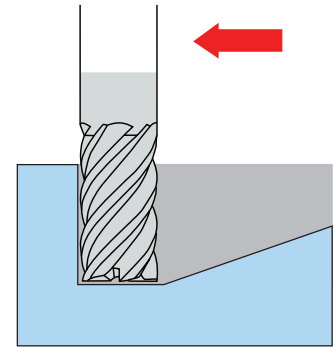
CW = Clockwise



## Adjustments for Straight-Line Ramps

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 extra-high performance RedLine endmills.

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,” and “Helical ramp” reference the data shown in the speed and feed charts located in each tool series section. Not all tools are designed to allow the chip clearance required for straight-line ramping, as indicated in the guide.



Tool Series	Max Ramp Angle	SFM	Feed	Max Ramp Depth	Max Ramp Length
XHP 7 Flute Finishers	Not recommended	-	-	-	-
XHP 9 Flute Finishers	Not recommended	-	-	-	-
XHP 11 Flute Finishers	Not recommended	-	-	-	-
XHP 13 Flute Finishers	Not recommended	-	-	-	-
XHP 5 Flute Aluminum & Non Ferrous DLC	10°	Slotting speed	Slotting IPT x .65	75% of D	(.75 x D) / drop per inch
XHP 5 Flute Variable Index	2.5°	Slotting speed	Slotting IPT x .75	50% of D	(.5 x D) / drop per inch
HP 7 Flute Finishers	2.5°	Slotting speed	Slotting IPT x .75	50% of D	(.5 x D) / drop per inch
XHP 5 & 6 Flute Finishers	Not recommended	-	-	-	-
XHP 6 Flute Finisher for Inconel	Not recommended	-	-	-	-
XHP 4 Flute Variable Index	2.5°	Slotting speed	Slotting IPT x .75	50% of D	(.5 x D) / drop per inch
XHP 3 Flute Aluminum & Non Ferrous ZRN	Helical ramp x 5	Same as chart	Same as chart	100% of D	(.75 x D) / drop per inch
XHP 3 Flute Roughers Aluminum & Non Ferrous ZRN	Helical ramp x 5	Same as chart	Same as chart	100% of D	(.75 x D) / drop per inch
XHP 2 Flute Aluminum and Non Ferrous	15°	Slotting speed	Slotting IPT x .70	50% of D	(.5 x D) / drop per inch

D = Tool Diameter

Use this guide to determine the maximum ramp length. ►

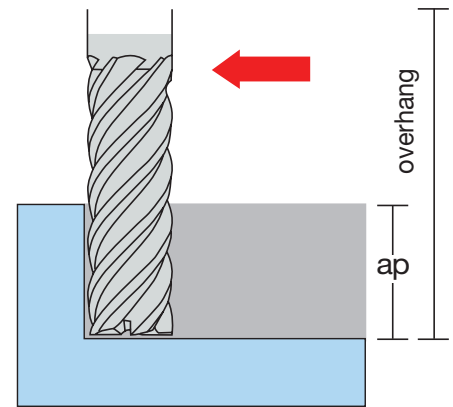
Ramp Angle	Drop (per inch)
0.5°	0.0088
1°	0.0175
2°	0.0375
2.5°	0.0438
3°	0.0525
5°	0.0875
10°	0.1750
15°	0.2625

## Long Reach Application Adjustments

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	SFM	Feed
> 1.25 to 3 x D	SFM x .95	IPT x .95
> 3 to 4 x D	SFM x .90	IPT x .90
> 4 to 5 x D	SFM x .80	IPT x .80
> 5 to 6 x D	SFM x .70	IPT x .70

D = Tool diameter  
 IPT = Inch per tooth  
 SFM = Surface feet per minute



## Tool Tip: Eliminate Wall Taper When Finishing

### STEP 1:

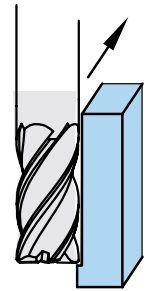
Run a climb cut finish pass using speed, feed and step-over values (RDOC) from the speed and feed charts. Adjust for tool projection if needed.

### 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.

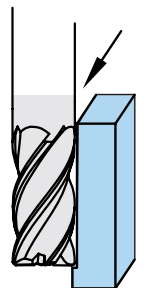
### Step 1:

Climb cut finish pass



### Step 2:

Conventional cut skim pass



## Ball Nose Endmill Adjustments

Tools found on pages 16, 24-25, 56-57, 76-78.

The speeds and feeds of ball nose end mills must be adjusted to ensure proper tool life. 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 below if the tool projection exceeds 2.5 x the tool diameter.

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

For easy reference, use the chart below.

Depth of Cut (ADOC)	1/8		1/4		3/8		1/2		3/4		1	
	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De
10% of tool diameter	.013	.075	.025	.150	.038	.225	.050	.300	.075	.450	.100	.600
20% of tool diameter	.025	.100	.050	.200	.075	.300	.100	.400	.150	.600	.200	.800
30% of tool diameter	.038	.115	.075	.229	.113	.344	.150	.458	.225	.687	.300	.917
40% of tool diameter	.050	.123	.100	.245	.150	.367	.200	.490	.300	.73	.400	.980
50% of tool diameter	.063	.125	.125	.250	.186	.375	.250	.500	.375	.7500	.500	1.000

#### STEP 3:

Calculate speed based on using the effective cutting diameter. Use the standard SFM to RPM conversion formula. Substitute the effective cutting diameter (De) for the actual tool diameter (D).

$$RPM = (SFM \times 3.82) / De$$

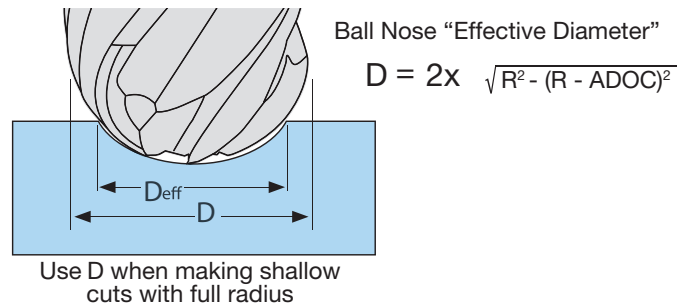
#### STEP 4:

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

$$IPT_{adj} = (D \times IPT) / De$$

#### 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.



STEP 5: The new feed rate is calculated:

$$IPM = RPM \times (Z \times IPT_{adj})$$

Z = # of flutes

D = Actual tool diameter

De = Effective cutting diameter

IPM = Inches per minute

RPM = Rotations per minute

SFM = Surface feet per minute

IPT = Feed rate from chart for slot milling

IPT adj = Adjusted chip load per tooth fractional

## If the axial depth of cut (ADOC) is $\geq 50\%$ of the tool diameter:

- Use the speed and feed values shown for the slotting operation in the speed and feed charts for the series of end 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.

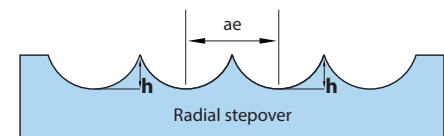
## Surface Finish

Radial depth of cut (RDOC), or step-over, is based on 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.

This chart calculates approximate scallop height using the following formula:

Tool Diameter	Step-over % of OD	Step-over Actual	Approx Scallop Height
1/8	10%	.013	.0003
	20%	.025	.0013
	30%	.038	.0028
1/4	10%	.025	.0006
	20%	.050	.0025
	30%	.075	.0056
3/8	10%	.038	.0009
	20%	.075	.0038
	30%	.113	.0084
1/2	10%	.050	.0013
	20%	.100	.0050
	30%	.150	.0113
3/4	10%	.075	.0019
	20%	.150	.0075
	30%	.225	.0169
1	10%	.100	.0025
	20%	.200	.0100
	30%	.300	.0225

$$h \sim (ae^2) / (8R)$$



**h** = Scallop height  
**ae** = Radial step-over  
**R** = Radius of end mill  
 (tool diameter x .5)

**General Purpose Micro Endmills Speeds & Feeds**

Material	Grades	SFM	SFM	Feed by Endmill Diameter (IPT)						
		Uncoated	AlTiN	(.0050)	(.0150)	(.0300)	(.0450)	(.0600)	(.0750)	(.1000)
<b>P - Steels</b>										
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	240	300	.00002	.00005	.00010	.00014	.00019	.00024	.00032
High Strength Tool Steel >32 HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	280	350	.00003	.00010	.00019	.00029	.00038	.00048	.00064
Low Carbon >32HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	200	250	.00002	.00005	.00010	.00014	.00019	.00024	.00032
Medium Carbon >32 HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>M - Stainless Steels</b>										
Austenitic	301-304L, 310, 316L, 321, 347	180-400	225-500	.00002	.00006	.00012	.00018	.00024	.00030	.00040
Austenitic >32 HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Martensitic	403, 410, 416, 420, 430, 431, 440	160	200	.00002	.00005	.00010	.00014	.00019	.00024	.00032
Martensitic >32 HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/ 363, PH13-8MO, PH14-8/MO	160	200	.00002	.00005	.00010	.00014	.00019	.00024	.00032
Precipitation Hardening >32 HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>K - Cast Irons</b>										
Ductile	A536, J434, 60-40-18	280	350	.00005	.00014	.00029	.00043	.00058	.00072	.00096
Gray	A48, A436, A319, Class 20, G4000	400	500	.00006	.00019	.00038	.00058	.00077	.00096	.00128
Malleable	A220, A602, J158	270	330	.00005	.00014	.00029	.00043	.00058	.00072	.00096
<b>N - Non-Ferrous</b>										
Aluminum Alloys		Max RPM	Max RPM	.00013	.00038	.00077	.00115	.00154	.00192	.00256
Aluminum High Silicon		Max RPM	Max RPM	.00006	.00019	.00038	.00058	.00077	.00096	.00128
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	600	750	.00006	.00019	.00038	.00058	.00077	.00096	.00128
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	800	1000	.00013	.00038	.00075	.00113	.00150	.00188	.00250
Copper		480	600	.00006	.00019	.00038	.00058	.00077	.00096	.00128
Magnesium		Max RPM	Max RPM	.00013	.00038	.00077	.00115	.00154	.00192	.00256
<b>S - High Temp Alloys</b>										
Cobalt Base	Stellite, HS-21, Haynes 25/188,	80	100	.00002	.00005	.00011	.00016	.00022	.00027	.00036
Cobalt Base >32HRC	X40, L605	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron Base	Incoloy 800-802, Multmet N-155	80	100	.00002	.00005	.00011	.00016	.00022	.00027	.00036
Iron Base >32HRC	Timkin 16-25-6, Carpenter 22-b3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel Base	Inconel 625/718, Inco 700, 713C, 718	80	100	.00002	.00005	.00011	.00016	.00022	.00027	.00036
Nickel Base >32HRC	Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspology, Udimet 500 & 700	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	200	250	.00002	.00007	.00014	.00022	.00029	.00036	.00048

**NOTE:** Speeds and Feeds listed are estimated and will vary by application.

These General Purpose tools can be found on pages 102-105, 110-113, 134-138, 160-164.



## General Purpose Carbide Endmills Speeds & Feeds

Material	Grades	SFM			Feed by Endmill Diameter (IPT)						
					1/8	1/4	3/8	1/2	5/8	3/4	1
		Uncoated	AlTiN	TiCN	(.1250)	(.2500)	(.3750)	(.5000)	(.625)	(.7500)	(1.000)
<b>P - Steels</b>											
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	150-225	210-315	185-310	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
High Strength Tool Steel		60-125	85-175	75-155	.0003-.0005	.0004-.0005	.0005-.0008	.0008-.0015	.0015-.0022	.0020-.0025	.0025-.0035
>32 HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	200-250	280-350	250-310	.0007-.0015	.0010-.0015	.0015-.002	.0020-.0025	.0025-.0030	.0030-.0035	.0040-.0050
Low Carbon >32HRC		125-175	175-245	155-215	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	200-250	280-350	250-310	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0030	.0030-.0035	.0040-.0050
Medium Carbon >32 HRC		125-175	175-245	155-215	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
<b>M - Stainless Steels</b>											
Austenitic	301-304L, 310, 316L, 321, 347	200-250	280-350	250-310	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
Austenitic >32 HRC		150-200	210-350	185-250	.0003-.0005	.0004-.0005	.0005-.0008	.008-.0015	.0015-.0022	.0020-.0025	.0025-.0035
Martensitic	403, 410, 416, 420, 430, 431, 440	150-250	210-350	185-310	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
Martensitic >32 HRC		125-175	175-245	155-215	.0003-.0005	.0004-.0005	.0005-.0008	.008-.0015	.0015-.0022	.0020-.0025	.0025-.0035
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355 /363, PH13-8MO, PH14-8/MO	150-250	210-350	185-310	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
Precipitation Hardening		125-175	175-245	155-215	.0003-.0005	.0004-.0005	.0005-.0008	.008-.0015	.0015-.0022	.0020-.0025	.0025-.0035
>32 HRC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>K - Cast Irons</b>											
Ductile	A536, J434, 60-40-18	300-400	420-560	375-500	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0040-.0060	.0080-.0120	.0100-.0120
Gray	A48, A436, A319, Class 20, G4000	250-350	350-490	310-435	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0040-.0060	.0060-.0080	.0080-.0100
Malleable	A220, A602, J158	275-375	375-515	340-465	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0040-.0060	.0060-.0080	.0080-.0100
<b>N - Non-Ferrous</b>											
Aluminum Alloys		>500	>500	>500	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0040-.0060	.0060-.0080	.0080-.0100
Aluminum High Silicon		450	450	560	.0010-.0015	.0015-.002	.0020-.0030	.0030-.0040	.0040-.0060	.0060-.0080	.0080-.0100
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	250-350	350-490	310-435	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0050	.0050-.0080	.0080-.0100
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	250-1000	350-1400	310-435	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0040-.0060	.0060-.0080	.0080-.0100
Copper		300-400	420-560	375-500	.0007-.0015	.0010-.0015	.0015-.0020	.0020-.0025	.0025-.0050	.0050-.0080	.0080-.0100
Magnesium		>500	>500	>500	.0010-.0015	.0015-.002	.0020-.0030	.0030-.0040	.0040-.0060	.0060-.0080	.0080-.0100
<b>S - High Temp Alloys</b>											
Cobalt Base	Stellite, HS-21, Haynes 25/188,	175-225	245-315	215-280	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
Cobalt Base >32HRC	X40, L605	125-175	175-245	155-215	.0003-.0005	.0004-.0005	.0005-.0008	.0080-.0015	.0015-.0022	.0020-.0025	.0025-.0035
Iron Base	Incoloy 800-802, Multmet N-155	175-225	245-315	215-280	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
Iron Base >32HRC	Timkin 16-25-6, Carpenter 22-b3	125-175	175-245	155-215	.0003-.0005	.0004-.0005	.0005-.0008	.0080-.0015	.0015-.0022	.0020-.0025	.0025-.0035
Nickel Base	Inconel 625/718, Inco 700, 713C, 718	125-175	175-245	155-215	.0005-.0010	.0008-.0010	.0010-.0015	.0015-.0020	.0020-.0030	.0030-.0040	.0035-.0045
Nickel Base >32HRC	Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700	70-115	100-160	85-140	.0003-.0005	.0004-.0005	.0005-.0008	.0080-.0015	.0015-.0022	.0020-.0025	.0025-.0035
Titanium	Commercially Pure, 6Al-4V ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si Ti-8Al-1Mo, Ti-8Al-4Mo	200-300	280-420	250-375	.0007-.0015	.0010-.0015	.0015-.002	.0020-.0025	.0025-.0030	.0030-.0035	.0040-.0050

- NOTES:**
- (1) Speeds and Feeds listed are estimated and will vary by application.
  - (2) Maximize rigidity to reduce chatter and increase tool life by applying the following tips.
    - Choose the largest diameter possible
    - Use the shortest LOC (Length of Cut) available
    - Use the toolholder which offers the shortest gage length
  - (3) To control chatter, increase feed or reduce speed.
  - (4) For extra long endmills, reduce SFM by 25%.
  - (5) Keep to a minimum at all times. As runout increases, the tools' performance decreases and tool life will be reduced.
  - (6) Use a coolant or air blast to evacuate chips to avoid premature damage to your carbide cutting tool, which may occur if chips are recut.

These General Purpose tools can be found on pages 106-109, 114-117, 150-159, 165-174, 180.

**General Purpose 3 & 4-Flute Long Reach Micro Endmills Speeds & Feeds**

Material	Grades	Cut Type	Axial DOC	Radial DOC	SFM		Feed by Endmill Diameter (IPT)						
					Uncoated	AlTiN	.0150	.0300	.0450	.0600	.0750	.0900	.1000
<b>P - Steels</b>													
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	Slotting	.2 x D	.2 x D	130	195	.00004	.00008	.00008	.00012	.00016	.00020	.00024
		Finish	.2 x D	.3 x D	130	195	.00003	.00006	.00006	.00009	.00012	.00015	.00018
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012	Slotting	.2 x D	.2 x D	195	400	.00020	.00020	.00030	.00030	.00040	.00050	.00060
		Finish	.2 x D	.3 x D	195	400	.00015	.00015	.00023	.00023	.00030	.00038	.00045
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	Slotting	.2 x D	.2 x D	195	260	.00030	.00030	.00040	.00050	.00060	.00070	.00080
		Finish	.2 x D	.3 x D	195	260	.00023	.00023	.00030	.00038	.00045	.00053	.00060
<b>M - Stainless Steels</b>													
Austenitic	301-304L, 310, 316L, 321, 347	Slotting	.2 x D	.2 x D	80	145	.00004	.00008	.00008	.00012	.00016	.00020	.00024
		Finish	.2 x D	.3 x D	80	145	.00004	.00008	.00008	.00012	.00016	.00020	.00024
Martensitic	403, 410, 416, 420, 430, 431, 440	Slotting	.2 x D	.2 x D	80	145	.00004	.00008	.00008	.00012	.00016	.00020	.00024
		Finish	.2 x D	.3 x D	80	145	.00004	.00008	.00008	.00012	.00016	.00020	.00024
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO	Slotting	.2 x D	.2 x D	80	145	.00004	.00008	.00008	.00012	.00016	.00020	.00024
		Finish	.2 x D	.3 x D	80	145	.00004	.00008	.00008	.00012	.00016	.00020	.00024
<b>K - Cast Irons</b>													
Ductile	A536, J434, 60-40-18	Slotting	.2 x D	.2 x D	195	260	.00040	.00080	.00100	.00120	.00160	.00200	.00230
		Finish	.2 x D	.3 x D	195	260	.00012	.00024	.00030	.00036	.00048	.00060	.00069
Gray	A48, A436, A319, Class 20, G4000	Slotting	.2 x D	.2 x D	195	260	.00040	.00080	.00100	.00120	.00160	.00200	.00230
		Finish	.2 x D	.3 x D	195	260	.00012	.00024	.00030	.00036	.00048	.00060	.00069
Malleable	A220, A602, J158	Slotting	.2 x D	.2 x D	195	260	.00040	.00080	.00100	.00120	.00160	.00200	.00230
		Finish	.2 x D	.3 x D	195	260	.00012	.00024	.00030	.00036	.00048	.00060	.00069
<b>N - Non-Ferrous</b>													
Aluminum Alloys	2014, 2024, 6061, 7075	Slotting	.2 x D	.2 x D	490	N/A	.00020	.00030	.00050	.00070	.00090	.00110	.00130
		Finish	.2 x D	.3 x D	490	N/A	.00003	.00005	.00009	.00012	.00015	.00019	.00022
Aluminum High Silicon	A380, A390	Slotting	.2 x D	.2 x D	490	N/A	.00020	.00030	.00050	.00070	.00090	.00110	.00130
		Finish	.2 x D	.3 x D	490	N/A	.00003	.00005	.00009	.00012	.00015	.00019	.00022
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	Slotting	.2 x D	.2 x D	365	400	.00020	.00030	.00040	.00050	.00060	.00070	.00080
		Finish	.2 x D	.3 x D	365	400	.00013	.00020	.00026	.00033	.00039	.00046	.00052
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	Slotting	.2 x D	.2 x D	260	N/A	.00010	.00020	.00030	.00040	.00040	.00050	.00050
		Finish	.2 x D	.3 x D	260	N/A	.00010	.00020	.00030	.00040	.00040	.00050	.00050
Copper		Slotting	.2 x D	.2 x D	400	500	.00020	.00030	.00040	.00050	.00060	.00070	.00080
		Finish	.2 x D	.3 x D	400	500	.00020	.00030	.00040	.00050	.00060	.00070	.00080
Magnesium		Slotting	.2 x D	.2 x D	800	800	.00020	.00030	.00040	.00050	.00060	.00070	.00080
		Finish	.2 x D	.3 x D	800	800	.00020	.00030	.00040	.00050	.00060	.00070	.00080
<b>S - High Temp Alloys</b>													
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	Slotting	.2 x D	.2 x D	N/A	80	.00006	.00008	.00008	.00012	.00012	.00015	.00024
		Finish	.2 x D	.3 x D	N/A	80	.00003	.00004	.00004	.00006	.00006	.00008	.00012
Iron Base	Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3	Slotting	.2 x D	.2 x D	N/A	300	.00010	.00020	.00030	.00040	.00050	.00060	.00070
		Finish	.2 x D	.3 x D	N/A	300	.00005	.00010	.00015	.00020	.00025	.00030	.00035
Nickel Base	Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700	Slotting	.2 x D	.2 x D	N/A	80	.00006	.00008	.00008	.00012	.00012	.00015	.00024
		Finish	.2 x D	.3 x D	N/A	80	.00003	.00004	.00004	.00006	.00006	.00008	.00012
Titanium	Commercially Pure, 6Al-4V ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	Slotting	.2 x D	.2 x D	N/A	80	.00004	.00008	.00008	.00012	.00016	.00020	.00024
		Finish	.2 x D	.3 x D	N/A	80	.00003	.00006	.00006	.00009	.00012	.00015	.00018

D = tool diameter. Reduce feed rates by 20% when using long length tools. Starting parameters shown. NOTE: Speeds and Feeds listed are estimated and will vary by application.

These General Purpose tools can be found on pages 118-133, 139-140 & 180.

## General Purpose Variable Index & Helix Endmills

Our General Purpose Variable index and Helix endmills are designed to offer a better performing tool at the same price as a general purpose tool. A special combination of an unequal index and variable helix angle helps you increase speeds and feeds, improve finish through reduced vibration while controlling harmonics. This Tool Is the Perfect Combination of Performance and Value!

### General Purpose Variable Index & Helix Endmills Speeds & Feeds

Material	Grades	Feed by Endmill Diameter (IPT)								
		SFM		1/8	1/4	3/8	1/2	5/8	3/4	1
		Uncoated	AITIN	(.1250)	(.2500)	(.3750)	(.5000)	(.625)	(.7500)	(1.000)
<b>P - Steels</b>										
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	225-250	250-350	.0009	.0010	.0013	.0017	.0023	.0028	.0040
High Strength Tool Steel >32 HRC		170-225	225-325	.0009	.0010	.0013	.0017	.0023	.0028	.0040
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	400-500	500-600	.0006	.0012	.0023	.0035	.0045	.0055	.0065
Low Carbon >32HRC		250-325	325-350	.0006	.0012	.0023	.0035	.0045	.0055	.0065
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	225-300	350-425	.0006	.0012	.0023	.0035	.0045	.0055	.0065
Medium Carbon >32 HRC		200-250	275-325	.0006	.0012	.0023	.0035	.0045	.0055	.0065
<b>M - Stainless Steels</b>										
Austenitic	301-304L, 310, 316L, 321, 347	250-300	300-335	.0005	.0006	.0009	.0010	.0023	.0035	.0055
Austenitic >32 HRC		170-200	200-250	.0005	.0006	.0009	.0010	.0023	.0035	.0055
Martensitic	403, 410, 416, 420, 430, 431, 440	375-425	425-450	.0010	.0012	.0017	.0020	.0035	.0045	.0065
Martensitic >32 HRC		335-375	375-400	.0010	.0012	.0017	.0020	.0035	.0045	.0065
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355 /363, PH13-8MO, PH14-8/MO	375-425	425-450	.0010	.0012	.0017	.0020	.0035	.0045	.0065
Precipitation Hardening >32 HRC		335-375	375-400	.0010	.0012	.0017	.0020	.0035	.0045	.0065
<b>K - Cast Irons</b>										
Ductile	A536, J434, 60-40-18	250-400	375-550	.0007	.0012	.0020	.0035	.0045	.0055	.0090
Gray	A48, A436, A319, Class 20, G4000	250-400	375-550	.0007	.0012	.0020	.0035	.0045	.0055	.0090
Malleable	A220, A602, J158	170-250	250-335	.0010	.0012	.0017	.0020	.0035	.0045	.0065
<b>N - Non -Ferrous</b>										
Aluminum Alloys		1200-1450	N/A	.0020	.0023	.0035	.0045	.0055	.0065	.0090
Aluminum High Silicon		900-1200	N/A	.0010	.0015	.0025	.0035	.0045	.0055	.0075
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze									
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper		450-800	750-1000	.0020	.0023	.0028	.0035	.0045	.0055	.0080
Magnesium		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>S - High Temp Alloys</b>										
Cobalt Base	Stellite, HS-21, Haynes 25/188,	300-350	325-375	.0007-.0009	.0008-.0010	.0013-.0017	.0018-.0023	.0023-.0028	.0030-.0034	.0040-.0045
Cobalt Base >32HRC	X40, L605	275-300	300-325	.0005-.0007	.0006-.0008	.0010-.0013	.0015-.0020	.0020-.0025	.0028-.0032	.0037-.0040
Iron Base	Incoloy 800-802, Multmet N-155	300-350	325-375	.0007-.0009	.0008-.0010	.0013-.0017	.0018-.0023	.0023-.0028	.0030-.0034	.0040-.0045
Iron Base >32HRC	Timkin 16-25-6, Carpenter 22-b3	275-300	300-325	.0005-.0007	.0006-.0008	.0010-.0013	.0015-.0020	.0020-.0025	.0028-.0032	.0037-.0040
Nickel Base	Inconel 625/718, Inco 700, 713C, 718	250-275	275-335	.0007-.0009	.0008-.0010	.0013-.0017	.0018-.0023	.0023-.0028	.0030-.0034	.0040-.0045
Nickel Base >32HRC	Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700	110-150	150-200	.0005-.0007	.0006-.0008	.0010-.0013	.0015-.0020	.0020-.0025	.0028-.0032	.0037-.0040
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	70-150	150-275	.0005-.0009	.0006-.0012	.0010-.0015	.0012-.0020	.0020-.0035	.0025-.0045	.0045-.0065

**NOTE: Speeds and Feeds listed are estimated and will vary by application.**

These General Purpose tools can be found on pages 141-149.

### Corner Rounding Endmills Speeds & Feeds

Material	Grades	SFM
<b>P - Steels</b>		
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, O1	80-90
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310	180
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	170
<b>M- Stainless Steels</b>		
Austenitic	301-304L, 310, 316L, 321, 347	100
Martensitic	403, 410, 416, 420, 430, 431, 440	110
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO	120
<b>K - Cast Irons</b>		
Ductile	A536, J434, 60-40-18	180
Gray	A48, A436, A319, Class 20, G4000	140
Malleable	A220, A602, J158	100
<b>N - Non-Ferrous</b>		
Aluminum Alloys	2014, 2024, 6061, 7075	300
Aluminum High Silicon	A380, A390	300
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	230-250
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	180-200
Copper		100-200
Magnesium		300
<b>S - High Temp Alloys</b>		
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	80
Iron Base	Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3	80
Nickel Base	Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700	80
Titanium	Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo	90

**NOTE: Speeds and Feeds listed are estimated and will vary by application.**  
 These General Purpose tools can be found on pages 175-179.

## High Speed Steel and Cobalt Endmills Speeds & Feeds

Material	Grades	SFM		Feed by Endmill Diameter (IPT)						
		SFM	SFM	1/8	1/4	3/8	1/2	5/8	3/4	1
		Uncoated	AITIN	(.1250)	(.2500)	(.3750)	(.5000)	(.0625)	(.7500)	(1.000)
<b>P - Steels</b>										
High Strength Tool Steel	A2, D2, P20, H11, H13, S2, 01	50-75	75-90	.0010	.0015	.0020	.0025	.0030	.0040	.0060
Low Carbon	A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012 5015, 9310	150-200	175-250	.0010	.0015	.0020	.0025	.0030	.0040	.0060
Medium Carbon	1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100	75-100	100-125	.0010	.0015	.0020	.0025	.0030	.0040	.0060
<b>M - Stainless Steels</b>										
Austenitic	301-304L, 310, 316L, 321, 347	115-150	120-170	.0010	.0015	.0020	.0025	.0030	.0035	.0040
Martensitic	403, 410, 416, 420, 430, 431, 440	20-50	30-60	.0010	.0015	.0020	.0025	.0030	.0035	.0040
Precipitation Hardening	12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO	90-110	100-120	.0010	.0015	.0020	.0025	.0030	.0035	.0040
<b>K - Cast Irons</b>										
Ductile	A536, J434, 60-40-18	75-100	90-120	.0010	.0020	.0030	.0035	.0040	.0045	.0050
Gray	A48, A436, A319, Class 20, G4000	90-130	100-150	.0010	.0020	.0030	.0040	.0050	.0060	.0080
Malleable	A220, A602, J158	100-150	115-170	.0010	.0020	.0030	.0040	.0050	.0060	.0080
<b>N - Non-Ferrous</b>										
Aluminum Alloys		600-800	800-1000	.0010	.0020	.0030	.0040	.0050	.0060	.0080
Aluminum High Silicon		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Brass/Bronze	Aluminum Bronze, Low Silicon Bronze	300-400	400-500	.0010	.0020	.0030	.0035	.0040	.0045	.0050
Composites	G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics	800-1000	950-1200	.0010	.0020	.0030	.0035	.0040	.0045	.0050
Copper		150-250	200-300	.0010	.0020	.0030	.0040	.0050	.0060	.0080
Magnesium		150-250	200-300	.0010	.0020	.0030	.0040	.0050	.0060	.0080
Titanium	Commercially Pure, 6Al-4V ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si Ti-8Al-1Mo, Ti-8Al-4Mo	70-100	80-120	.0010	.0015	.0020	.0025	.0030	.0040	.0060
<b>S - High Temp Alloys</b>										
Cobalt Base	Stellite, HS-21, Haynes 25/188, X40, L605	25-35	30-40	.0005	.0007	.0010	.0010	.0012	.0015	.0020
Iron Base	Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	30-40	35-45	.0005	.0007	.0010	.0010	.0012	.0015	.0020
Nickel Base	Inconel 625/718, Inco 700, 713C, 718 Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly Udimet 500 & 700	20-30	25-35	.0005	.0007	.0010	.0010	.0012	.0015	.0020

**NOTE: Speeds and Feeds listed are estimated and will vary by application.**  
 These General Purpose tools can be found on pages 181-183.

### Endmills Trouble Shooting Guide

Problem	Cause	Solution
<b>Breakage</b>	<ul style="list-style-type: none"> <li>• Feed rate too aggressive</li> <li>• D.O.C. too aggressive</li> <li>• Excessive tool overhang</li> <li>• Chip packing</li> <li>• Excessive wear</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce feed rate</li> <li>• Reduce axial and/or radial D.O.C.</li> <li>• Hold shank deeper, use shorter endmill</li> <li>• Adjust speed and/or feed, select endmill with fewer flutes, increase coolant pressure and/or air</li> <li>• Re-grind tool sooner</li> </ul>
<b>Burs</b>	<ul style="list-style-type: none"> <li>• Incorrect speed &amp; feed</li> <li>• Helix angle is incorrect for application</li> <li>• Primary cutting edge(s) are dull</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust speed &amp; feed</li> <li>• Change to correct helix angle, use climb milling</li> <li>• Re-grind tool sooner</li> </ul>
<b>Chattering</b>	<ul style="list-style-type: none"> <li>• Speed and/or feed too aggressive</li> <li>• Tool rigidity</li> <li>• Work-piece rigidity</li> <li>• Machine tool rigidity</li> <li>• D.O.C. too aggressive</li> <li>• Wrong tool geometry</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce speed and/or feed</li> <li>• Change tool holder, hold shank deeper and/or use shorter tool</li> <li>• Re-fixture work-piece and/or improve setup</li> <li>• Check spindle for run-out</li> <li>• Reduce axial and/or radial D.O.C.</li> </ul>
<b>Chip Packing</b>	<ul style="list-style-type: none"> <li>• Speed and/or feed too aggressive</li> <li>• Flute gullet too small for chips</li> <li>• Insufficient coolant volume and/or pressure</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce speed and/or feed</li> <li>• Use endmill with less flutes</li> <li>• Increase coolant and/or air pressure, reposition nozzle to point of cut</li> </ul>
<b>Edge Chipping</b>	<ul style="list-style-type: none"> <li>• Feed rate too aggressive</li> <li>• Feed rate too aggressive on initial cut</li> <li>• D.O.C. too aggressive</li> <li>• Tool rigidity</li> <li>• Work-piece rigidity</li> <li>• Machine tool rigidity</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce feed rate</li> <li>• Reduce feed rate on initial pass</li> <li>• Decrease axial and/or radial D.O.C.</li> <li>• Change tool holder, hold shank deeper and/or use shorter tool</li> <li>• Re-fixture work-piece and/or improve setup</li> <li>• Check spindle for run-out</li> </ul>
<b>Poor Dimensional Accuracy</b>	<ul style="list-style-type: none"> <li>• D.O.C. too aggressive</li> <li>• Tool Rigidity</li> <li>• Machine tool rigidity</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce axial and/or radial D.O.C.</li> <li>• Use tool with more flutes</li> <li>• Check, inspect &amp; repair machine tool, toolholder and fixtures</li> </ul>
<b>Poor Finish</b>	<ul style="list-style-type: none"> <li>• Feed rate too aggressive</li> <li>• Speed is too slow</li> <li>• D.O.C. too aggressive</li> <li>• Excessive wear</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce feed rate</li> <li>• Increase spindle speed (RPM)</li> <li>• Reduce axial and/or radial D.O.C.</li> <li>• Re-grind tool sooner</li> </ul>