

General Purpose End Mill Recommended Cutting Data - Profile Milling

Length	2 Flute Series		3 Flute Series	4 Flute Series			
Stub	164	166	169	163		165	
Standard	121	150	116	111	140	117	114
Long Length				122*			132*

*Chip thinning may not be possible with 122 and 132 series if radial width of cut exceeds 20%.

For ball nose end mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

Inch

For diameters 1/4" and below, see Micro Charts starting on page 385.

Workpiece Material Group	ISO	Hardness	Profile Milling (ae)					End Mill Diameters										
			Coolant ● Preferred ○ Possible x Not Possible										5/16	3/8	1/2	5/8	3/4	1
								5%	10%	20%	30%	50%	ae > .3D use < 1D ap ae < .2D use < 2D ap					
								2.3	1.8	1.2	1.1	1	← Multiply fz by this Factor based on ae. When finishing, use the standard fz per chart below. Only add chip thinning when roughing or semi-finishing.					
			Max.	Air	MMS	vc - SFM Increase speeds by 30% for ALtima® coated tools					fz - in/tooth							
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	●	●	●	1050	700	385	375	350	.0027	.0032	.0045	.0054	.0063	.0090		
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	●	●	●	630	420	320	250	210	.0027	.0032	.0045	.0054	.0063	.0090		
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	●	●	●	525	350	300	275	250	.0027	.0032	.0045	.0054	.0063	.0090		
Hardened Steels	H	45-55 Rc	●	○	○	250	240	230	210	200	.0018	.0021	.0030	.0036	.0042	.0060		
Hardened Steels		55-65 Rc	●	○	○	200	180	160	150	100	.0013	.0014	.0021	.0024	.0029	.0041		
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	650	600	550	500	450	.0027	.0032	.0045	.0054	.0063	.0090		
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	●	x	○	525	400	350	300	250	.0027	.0032	.0045	.0054	.0063	.0090		
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	525	400	350	300	250	.0027	.0032	.0045	.0054	.0063	.0090		

Technical data provided should be considered advisory only as variations may be necessary depending on the particular application.

General Purpose End Mill Recommended Cutting Data - Profile Milling

Length	2 Flute Series		3 Flute Series	4 Flute Series			
Stub	164	166	169	163		165	
Standard	121	150	116	111	140	117	114
Long Length				122*			132*

*Chip thinning may not be possible with 122 and 132 series if radial width of cut exceeds 20%.

For ball nose end mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

Inch Continued

For diameters 1/4" and below, see Micro Charts starting on page 385.

Workpiece Material Group	ISO	Hardness	Coolant			Profile Milling (ae)					End Mill Diameter					
			• Preferred ○ Possible x Not Possible								5/16	3/8	1/2	5/8	3/4	1
			Max.	Air	MMS	5%	10%	20%	30%	50%	ae > .3D use < 1D ap ae < .2D use < 2D ap					
						vc - SFM Increase speeds by 30% for ALtima® coated tools					← Multiply fz by this Factor based on ae. When finishing, use the standard fz per chart below. Only add chip thinning when roughing or semi-finishing.					
											fz - in/tooth					
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	•	x	x	100	90	80	70	60	.0008	.0009	.0012	.0015	.0019	.0025
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	•	x	x	230	200	175	150	125	.0014	.0016	.0023	.0027	.0032	.0045
Cast-Iron - Gray CG, ASTM A48, CLASS 20, 25, 30, 35, SAE J431C, GRADES G1800, G3000, G3500, GG 10, 15, 20, 25, 30, 35, 40	K	up to 240 HB	•	o	o	425	400	375	350	300	.0027	.0032	.0045	.0054	.0063	.0090
Cast Iron - Ductile & Malleable CGI 60-40-18, 65-45-12, D4018, D4512, D5506, 32510, 35108, M3210, M4504, M5503, 250, 300, 350, 400, 450	K	over 240 HB	•	o	o	320	300	250	225	200	.0027	.0032	.0045	.0054	.0063	.0090
Non-Ferrous, Plastics, Graphite	N		•			1000	960	920	880	840	.0027	.0032	.0045	.0054	.0063	.0090







General Purpose End Mill Recommended Cutting Data - Slotting

Length	2 Flute Series		3 Flute Series	4 Flute Series			
Stub	164	166	169	163	165		
Standard	121	150	116	111	140	117	114

For ball nose end mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

Inch

For diameters 1/4" and below, see Micro Charts starting on page 385.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting			End Mill Diameter					
			● Preferred ○ Possible x Not Possible						5/16	3/8	1/2	5/8	3/4	1
						25%	50%	100%	fz - in/tooth					
			Max.	Air	MMS	vc - SFM Increase speeds by 30% for ALtima® coated tools								
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	●	●	●	385	370	350	.0016	.0019	.0025	.0031	.0038	.0050
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	●	●	●	245	230	210	.0016	.0019	.0025	.0031	.0038	.0050
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	●	●	●	210	195	175	.0016	.0019	.0025	.0031	.0038	.0050
Hardened Steels	H	35-45 Rc	●	○	○	245	230	210	.0016	.0019	.0025	.0031	.0038	.0050
Hardened Steels		45-55 Rc	●	○	○	175	160	140	.0008	.0010	.0013	.0016	.0020	.0025
Hardened Steels		55-65 Rc	●	○	○	150	125	100	.0004	.0005	.0008	.0008	.0010	.0012
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	385	370	350	.0016	.0019	.0025	.0031	.0038	.0050
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	●	x	○	245	210	175	.0016	.0019	.0025	.0031	.0038	.0050
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	210	195	175	.0016	.0019	.0025	.0031	.0038	.0050

Technical data provided should be considered advisory only as variations may be necessary depending on the particular application.






General Purpose End Mill Recommended Cutting Data - Slotting

Length	2 Flute Series		3 Flute Series	4 Flute Series			
	Stub	164	166	169	163	165	
Standard	121	150	116	111	140	117	114

For ball nose end mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

Inch Continued

For diameters 1/4" and below, see Micro Charts starting on page 385.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting			End Mill Diameter					
			● Preferred ○ Possible x Not Possible						5/16	3/8	1/2	5/8	3/4	1
						25%	50%	100%	fz - in/tooth					
			Max.	Air	MMS	vc - SFM Increase speeds by 30% for ALtima® coated tools								
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	x	x	80	70	60	.0008	.0009	.0012	.0015	.0019	.0025
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	●	x	x	100	90	80	.0008	.0010	.0013	.0016	.0017	.0026
Cast-Iron - Gray CG, ASTM A48, CLASS 20, 25, 30, 35, SAE J431C, GRADES G1800, G3000, G3500, GG 10, 15, 20, 25, 30, 35, 40	K	up to 240 HB	●	○	○	450	400	350	.0016	.0019	.0025	.0031	.0038	.0050
Cast Iron - Ductile & Malleable CGI 60-40-18, 65-45-12, D4018, D4512, D5506, 32510, 35108, M3210, M4504, M5503, 250, 300, 350, 400, 450	K	over 240 HB	●	○	○	300	250	225	.0016	.0019	.0025	.0031	.0038	.0050
Non-Ferrous, Plastic, Graphite	N		●			750	600	450	.0016	.0019	.0025	.0031	.0038	.0050





Micro End Mill Recommended Cutting Data - Profile Milling

Length	2 Flute Series		3 Flute Series	4 Flute Series			
Standard	121	150	116	111	140	117	114
Long Length				122			132

Inch - Standard / Long Length

Ball Nose End Mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

For diameters > 1/4", see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Profile Milling 	End Mill Diameter (Inch)								
			• Preferred	o Possible	x Not Possible		.0150	.0310	.0470	.0620	.0780	.0930	.1250	.1870	.2500
							13% Dia. ae				25% Dia. ae				
			Max.	Air	MMS		<2 Dia. ap				<2 Dia. ap				
						vc - SFM Increase speed by 30% for ALtima® coated tools.									
						fz - in/tooth									
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	•	•	•	400	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	•	•	•	300	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	•	•	•	200	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Hardened Steels	H	45-55 Rc	•	o	o	100	0.00010	0.00030	0.00050	0.00140	0.00180	0.00210	0.00300	0.00360	0.00420
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	•	x	o	400	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	•	x	o	200	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	•	x	o	150	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Cast Iron	K	160-200 HB	•	o	o	400	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Malleable / Ductile Cast Iron	K	200-250 HB	•	o	o	250	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
High Temp Alloys Nimonics, Inconel, Monel, Hastelloy	S	up to 42 Rc	•	x	x	70	0.00004	0.00008	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00080
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	•	x	x	150	0.00004	0.00008	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00080
Aluminum < 10 % Si	N		•			750	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100
Aluminum > 10 % Si	N		•												

Technical data provided should be considered advisory only as variations may be necessary depending on the particular application.

For product information, call your local distributor.





Micro End Mill Recommended Cutting Data - Profile Milling

Length	2 Flute Series		3 Flute Series	4 Flute Series	
Stub	164	166	169	163	165

Inch - Stub Length

Ball Nose End Mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

For diameters > 1/4", see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Profile Milling 	End Mill Diameter (Inch)									
			● Preferred ○ Possible x Not Possible				vc - SFM Increase speed by 30% for ALtima® coated tools.	.0150	.0310	.0470	.0620	.0780	.0930	.1250	.1870	.2500
								13% Dia. ae			25% Dia. ae					
			Max.	Air	MMS			<1 Dia. ap			<1 Dia. ap					
fz - in/tooth																
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	●	●	●	400	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	●	●	●	300	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	●	●	●	200	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Hardened Steels	H	45-55 Rc	●	○	○	100	0.00010	0.00030	0.00050	0.00140	0.00180	0.00210	0.00300	0.00360	0.00420	
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	400	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	●	x	○	200	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	150	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Cast Iron	K	160-200 HB	●	○	○	400	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	250	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	x	x	70	0.00004	0.00008	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00080	
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	●	x	x	150	0.00004	0.00008	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00080	
Aluminum < 10 % Si	N		●			750	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	
Aluminum > 10 % Si	N		●			750	0.00007	0.00015	0.00023	0.00027	0.00034	0.00040	0.00054	0.00081	0.00100	

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
Micro End Mill Recommended Cutting Data - Slotting

Length	2 Flute Series		3 Flute Series
Standard	121	150	116

Inch - Standard 2-3 Flute

Ball Nose End Mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

For diameters > 1/4", see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting	End Mill Diameter (Inch)								
			● Preferred	○ Possible	x Not Possible		.0150	.0310	.0470	.0620	.0780	.0930	.1250	.1870	.2500
							14%-Dia. ap			35%-Dia. ap					
			Max.	Air	MMS	vc - SFM Increase speed by 30% for ALtima® coated tools.	fz - in/tooth								
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	●	●	●	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	●	●	●	300	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	●	●	●	200	.0001	.0001	.0002	.0002	.0002	.0003	.0004	.0006	.0008
Hardened Steels	H	35-45 Rc	●	○	○	100	.0001	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	●	x	○	200	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Cast Iron	K	160-200 HB	●	○	○	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	250	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	x	x	70	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	●	x	x	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Aluminum < 10 % Si	N		●			750	.0002	.0003	.0005	.0006	.0007	.0008	.0011	.0017	.0022
Aluminum > 10 % Si	N		●			750	.0002	.0003	.0005	.0006	.0007	.0008	.0011	.0017	.0022

Technical data provided should be considered advisory only as variations may be necessary depending on the particular application.

For product information, call your local distributor.





Micro End Mill Recommended Cutting Data - Slotting

Length	2 Flute Series		3 Flute Series
Stub	164	166	169

Inch - Stub Length 2-3 Flute

Ball Nose End Mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

For diameters > 1/4", see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting	End Mill Diameter (Inch)								
			● Preferred	○ Possible	✗ Not Possible		.0150	.0310	.0470	.0620	.0780	.0930	.1250	.1870	.2500
							14%-Dia. ap				35%-Dia. ap				
			Max.	Air	MMS		fz - in/tooth								
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	●	●	●	400	.0001	.0002	.0002	.0003	.0003	.0004	.0005	.0008	.0010
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	●	●	●	300	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	●	●	●	200	.0001	.0001	.0002	.0002	.0003	.0004	.0006	.0008	
Hardened Steels	H	35-45 Rc	●	○	○	100	.0001	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	✗	○	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	●	✗	○	200	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	✗	○	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Cast Iron	K	160-200 HB	●	○	○	400	.0001	.0002	.0002	.0003	.0003	.0004	.0005	.0008	.0010
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	250	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	✗	✗	70	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	●	✗	✗	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Aluminum < 10 % Si	N		●			750	.0002	.0003	.0005	.0006	.0007	.0008	.0011	.0017	.0022
Aluminum > 10 % Si	N														

Technical data provided should be considered advisory only as variations may be necessary depending on the particular application.

For product information, call your local distributor.





Micro End Mill Recommended Cutting Data - Slotting

Length	4 Flute Series			
Standard	111	140	117	114
Long Length	122			132

Inch - Standard / Long Length 4 Flute

Ball Nose End Mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

For diameters > 1/4", see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting 	End Mill Diameter (Inch)								
			● Preferred	○ Possible	✗ Not Possible		.0150	.0310	.0470	.0620	.0780	.0930	.1250	.1870	.2500
							14%-Dia. ap			35%-Dia. ap					
			Max.	Air	MMS		fz - in/tooth								
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	●	●	●	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	●	●	●	300	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	●	●	●	200	.0001	.0001	.0002	.0002	.0002	.0003	.0004	.0006	.0008
Hardened Steels	H	35-45 Rc	●	○	○	100	.0001	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	✗	○	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	●	✗	○	200	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	✗	○	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Cast Iron	K	160-200 HB	●	○	○	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	250	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	✗	✗	70	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	●	✗	✗	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Aluminum < 10 % Si	N		●			750	.0002	.0003	.0005	.0006	.0007	.0008	.0011	.0017	.0022
Aluminum > 10 % Si	N		●												

Technical data provided should be considered advisory only as variations may be necessary depending on the particular application.

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


Micro End Mill Recommended Cutting Data - Slotting

Length	4 Flute Series	
Stub	163	165

Inch - Stub Length 4 Flute

Ball Nose End Mills - If axial depth (ap) is less than the ball diameter, the speed is figured using the effective cutting diameter.

For diameters > 1/4", see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting	End Mill Diameter (Inch)								
			• Preferred o Possible x Not Possible					.0150	.0310	.0470	.0620	.0780	.0930	.1250	.1870
						vc - SFM Increase speed by 30% for ALtima® coated tools.		14%-Dia. ap			35%-Dia. ap				
			Max.	Air	MMS		fz - in/tooth								
Free Machining & Low Carbon Steels 1006, 1008, 1015, 1018, 1020, 1022, 1025, 1117, 1140, 1141, 11L08, 11L14, 1213, 12L13, 12L14, 1215, 1330	P	up to 28 Rc	•	•	•	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Machine Tool Steels 1030, 1035, 1040, 1045, 1050, 1052, 1055, 1060, 1085, 1095, 1541, 1551, 9255, 2515, 3135, 3415, 4130, 4137, 4140, 4150, 4320, 4340, 4520, 5015, 5115, 5120, 5132, 5140, 5155, 6150, 8620, 9262, 9840, 52100, O1, O2, O6, S2, W1 to W310	P	28 to 38 Rc	•	•	•	300	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
Tool Steels & Die Steels O7, M1, M2, M3, M4, M7, T1, T2, T4, T5, T8, T15, A2, A3, A6, A7, H10, H11, H12, H13, H19, H21, L3, L6, L7, P2, P20, S1, S5, S7, 52100, A 128, D2, D3, D4, D5, D7	P	28 to 44 Rc	•	•	•	200	.0001	.0001	.0002	.0002	.0002	.0003	.0004	.0006	.0008
Hardened Steels	H	35-45 Rc	•	o	o	100	.0001	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	•	x	o	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	•	x	o	200	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	•	x	o	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Cast Iron	K	160-200 HB	•	o	o	400	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0007	.0010
Malleable / Ductile Cast Iron	K	200-250 HB	•	o	o	250	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0007	.0009
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	•	x	x	70	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3Al-8V-6Cr-4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	•	x	x	150	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005
Aluminum < 10 % Si	N		•			750	.0002	.0003	.0005	.0006	.0007	.0008	.0011	.0017	.0022
Aluminum > 10 % Si	N		•												

Technical data provided should be considered advisory only as variations may be necessary depending on the particular application.

For product information, call your local distributor.