

## 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.

### Metric

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 (mm)					
			• Preferred o Possible x Not Possible								8	10	12	16	20	25
						5%	10%	20%	30%	50%	ae > .3D use < 1D ap ae < .2D use < 2D ap					
			Max.	Air	MMS	vc - m/min 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 - mm/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	•	•	•	320	215	120	115	110	.0690	.0810	.1140	.1370	.1600	.2290
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	•	•	•	200	130	100	75	65	.0690	.0810	.1140	.1370	.1600	.2290
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	•	•	•	160	110	90	85	75	.0690	.0810	.1140	.1370	.1600	.2290
Hardened Steels	H	45-55 Rc	•	o	o	75	73	70	65	60	.0460	.0530	.0760	.0910	.1070	.1520
Hardened Steels		55-65 Rc	•	o	o	60	55	50	45	30	.0330	.0360	.0530	.0610	.0740	.1040
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	•	x	o	200	185	170	150	140	.0690	.0810	.1140	.1370	.1600	.2290
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	160	125	110	90	75	.0690	.0810	.1140	.1370	.1600	.2290
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	160	125	110	90	75	.0690	.0810	.1140	.1370	.1600	.2290

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.

### Metric Continued

For diameters 6mm and below, see Micro Charts starting on page 385.

Workpiece Material Group	ISO	Hardness	Coolant					Profile Milling (ae)					End Mill Diameter (mm)					
			• Preferred o Possible x Not Possible								8	10	12	16	20	25		
			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 - m/min Increase speeds by 30% for ALtima® coated tools					fz - mm/tooth										
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	•	x	x	30	25	25	20	20	.0200	.0230	.0300	.0380	.0480	.0640		
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	70	60	55	45	35	.0360	.0410	.0580	.0690	.0810	.1140		
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	130	125	115	110	90	.0690	.0810	.1140	.1370	.1600	.2290		
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	100	90	75	65	60	.0690	.0810	.1140	.1370	.1600	.2290		
Non-Ferrous, Plastic, Graphite	N		•			300	290	280	260	255	.0690	.0810	.1140	.1370	.1600	.2290		







## 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.

### Metric

For diameters 6 mm and below, see Micro Charts starting on page 385.

Workpiece Material Group	I S O	Hardness	Coolant			Slotting			End Mill Diameter (mm)					
			● Preferred ○ Possible x Not Possible						8	10	12	16	20	25
						25%	50%	100%	fz - mm/tooth					
			Max.	Air	MMS	vc - m/min 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	●	●	●	120	110	107	.0400	.0500	.0600	.0800	.1000	.1250
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	●	●	●	75	70	65	.0400	.0500	.0600	.0800	.1000	.1250
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	●	●	●	65	60	55	.0400	.0500	.0600	.0800	.1000	.1250
Hardened Steels	H	35-45 Rc	●	○	○	55	50	45	.0400	.0500	.0600	.0800	.1000	.1250
Hardened Steels		45-55 Rc	●	○	○	55	50	45	.0200	.0250	.0300	.0400	.0500	.0620
Hardened Steels		55-65 Rc	●	○	○	50	45	40	.0100	.0120	.0150	.0200	.0250	.0300
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	120	115	110	.0400	.0500	.0600	.0800	.1000	.1250
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	○	75	65	55	.0400	.0500	.0600	.0800	.1000	.1250
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	65	60	55	.0400	.0500	.0600	.0800	.1000	.1250

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.

### Metric Continued

For diameters 6 mm and below, see Micro Charts starting on page 385.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting			End Mill Diameter (mm)					
			• Preferred o Possible x Not Possible						8	10	12	16	20	25
						25%	50%	100%	fz - mm/tooth					
			Max.	Air	MMS	vc - m/min Increase speeds by 30% for ALtima® coated tools								
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	•	x	x	25	20	20	.0200	.0230	.0300	.0380	.0480	.0630
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	30	25	25	.0100	.0120	.0150	.0200	.0250	.0300
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	135	125	110	.0400	.0500	.0600	.0800	.1000	.1250
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	90	75	70	.0400	.0500	.0600	.0800	.1000	.1250
Non-Ferrous, Plastic, Graphite	N		•			230	180	140	.0400	.0500	.0600	.0800	.1000	.1250





## 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

### Metric - 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 > 6mm, see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Profile Milling 	End Mill Diameter (mm)								
			• Preferred	o Possible	x Not Possible		.4	.8	1.2	1.6	2.0	2.5	3.0	5.0	6.0
							13% Dia. ae				25% Dia. ae				
			Max.	Air	MMS		<2 Dia. ap				<2 Dia. ap				
vc - m/min Increase speed by 30% for ALtima® coated tools.						fz - mm/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	•	•	•	122	0.00170	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
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	•	•	•	92	0.00170	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
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	•	•	•	60	0.00170	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
Hardened Steels	H	45-55 Rc	•	o	o	30	0.00250	0.00760	0.01270	0.03500	0.04500	0.05300	0.07600	0.09100	0.10600
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	•	x	o	122	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
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	61	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
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	45	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
Cast Iron	K	160-200 HB	•	o	o	120	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
Malleable / Ductile Cast Iron	K	200-250 HB	•	o	o	76	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	•	x	x	22	0.00100	0.00200	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02000
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	45	0.00100	0.00200	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02000
Aluminum < 10 % Si	N		•			228	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540
Aluminum > 10 % Si	N		•				0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540

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


## Micro End Mill Recommended Cutting Data - Profile Milling

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

### Metric - 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 > 6mm, see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Profile Milling 	End Mill Diameter (mm)									
			● Preferred ○ Possible x Not Possible				vc - m/min Increase speed by 30% for ALtima® coated tools.	.4	.8	1.2	1.6	2.0	2.5	3.0	5.0	6.0
			Max.	Air	MMS			13% Dia. ae			25% Dia. ae					
								<1 Dia. ap			<1 Dia. ap					
						fz - mm/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	●	●	●	122	0.00170	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
Medium Carbon & High Carbon Steels, Alloy Steels & Easy to Ma- chine 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	●	●	●	92	0.00170	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
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	●	●	●	60	0.00170	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
Hardened Steels	H	45-55 Rc	●	○	○	30	0.00250	0.00760	0.01270	0.03500	0.04500	0.05300	0.07600	0.09100	0.10600	
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	122	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
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	○	61	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	45	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
Cast Iron	K	160-200 HB	●	○	○	120	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	76	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	x	x	22	0.00100	0.00200	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02000	
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	45	0.00100	0.00200	0.00380	0.00580	0.00680	0.00860	0.01010	0.01370	0.02000	
Aluminum < 10 % Si	N		●			228	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	
Aluminum > 10 % Si	N		●			228	0.00170	0.00360	0.00580	0.00680	0.00860	0.01010	0.01370	0.02050	0.02540	

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





## Micro End Mill Recommended Cutting Data - Slotting

Length	2 Flute Series		3 Flute Series
Standard	121	150	116

### Metric - 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 > 6mm, see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting	End Mill Diameter (mm)								
			● Preferred	○ Possible	x Not Possible		.4	.8	1.2	1.6	2.0	2.5	3.0	5.0	6.0
							14%-Dia. ap				35%-Dia. ap				
			Max.	Air	MMS	vc-m/min Increase speed by 30% for ALtima® coated tools.	fz - mm/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	●	●	●	122	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
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	●	●	●	100	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
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	●	●	●	60	.0013	.0028	.0043	.0048	.0061	.0074	.0098	.0147	.0198
Hardened Steels	H	35-45 Rc	●	○	○	30	.0008	.0015	.0023	.0028	.0033	.0041	.0056	.0081	.0109
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	122	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
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	○	60	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Cast Iron	K	160-200 HB	●	○	○	120	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	76	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	x	x	22	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
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	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Aluminum < 10 % Si	N		●			228	.0038	.0078	.0114	.0139	.0175	.0208	.0279	.0419	.0558
Aluminum > 10 % Si	N														

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





## Micro End Mill Recommended Cutting Data - Slotting

Length	2 Flute Series		3 Flute Series
Stub	164	166	169

### Metric - 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 > 6mm, see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting	End Mill Diameter (mm)								
			● Preferred	○ Possible	✗ Not Possible		.4	.8	1.2	1.6	2.0	2.5	3.0	5.0	6.0
							14%-Dia. ap			35%-Dia. ap					
			Max.	Air	MMS	vc - m/min Increase speed by 30% for ALtima® coated tools.	fz - mm/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	●	●	●	122	.0017	.0038	.0056	.0066	.0081	.0099	.0132	.0198	.0254
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	●	●	●	100	.0015	.0036	.0053	.0060	.0076	.0089	.0121	.0180	.0241
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	●	●	●	60	.0013	.0028	.0043	.0048	.0061	.0074	.0098	.0147	.0198
Hardened Steels	H	35-45 Rc	●	○	○	30	.0008	.0015	.0023	.0028	.0033	.0041	.0056	.0081	.0109
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	✗	○	122	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
Stainless Steel - Moderately Difficult 301, 302, 303 High Tensile, 304, 304L, 305, 420, 15-5PH, 17-4PH, 17-7PH	M	up to 28 Rc	●	✗	○	60	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	✗	○	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Cast Iron	K	160-200 HB	●	○	○	120	.0017	.0038	.0055	.0066	.0081	.0099	.0132	.0198	.0254
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	76	.0015	.0035	.0053	.0060	.0076	.0088	.0121	.0180	.0241
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	✗	✗	22	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Titanium Alloys 6Al-4V, 5Al-2.5 Sn, 6Al-2 Sn-4Zr-6Mo, 3 Al-8V-6Cr-4Mo-4Zr, 10V-2Fe-3Al, 13V-11Cr-3Al	S	up to 42 Rc	●	✗	✗	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Aluminum < 10 % Si	N		●			230	.0038	.0078	.0114	.0139	.0175	.0208	.0279	.0419	.0558
Aluminum > 10 % Si	N														

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







## Micro End Mill Recommended Cutting Data - Slotting

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

### Metric - 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 > 6mm, see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting	End Mill Diameter (mm)								
			● Preferred	○ Possible	x Not Possible		.4	.8	1.2	1.6	2.0	2.5	3.0	5.0	6.0
							14%-Dia. ap				35%-Dia. ap				
			Max.	Air	MMS	vc - m/min Increase speed by 30% for ALtima® coated tools.	fz - mm/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	●	●	●	122	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
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	●	●	●	100	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
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	●	●	●	60	.0013	.0028	.0043	.0048	.0061	.0074	.0098	.0147	.0198
Hardened Steels	H	35-45 Rc	●	○	○	30	.0008	.0015	.0023	.0028	.0033	.0041	.0056	.0081	.0109
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	●	x	○	122	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
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	○	60	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
Stainless Steel - Difficult to Machine 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M	over 28 Rc	●	x	○	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Cast Iron	K	160-200 HB	●	○	○	120	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
Malleable / Ductile Cast Iron	K	200-250 HB	●	○	○	76	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	●	x	x	22	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
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	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Aluminum < 10 % Si	N		●			228	.0038	.0078	.0114	.0139	.0175	.0208	.0279	.0419	.0558
Aluminum > 10 % Si	N														

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





## Micro End Mill Recommended Cutting Data - Slotting

Length	4 Flute Series	
Stub	163	165

### Metric - 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 > 6mm, see Charts Starting on page 376.

Workpiece Material Group	ISO	Hardness	Coolant			Slotting	End Mill Diameter (mm)								
			• Preferred	o Possible	x Not Possible		.4	.8	1.2	1.6	2.0	2.5	3.0	5.0	6.0
							14%-Dia. ap			35%-Dia. ap					
			Max.	Air	MMS	vc - m/min Increase speed by 30% for ALtima® coated tools.	fz - mm/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	•	•	•	122	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
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	•	•	•	100	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
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	•	•	•	60	.0013	.0028	.0043	.0048	.0061	.0074	.0098	.0147	.0198
Hardened Steels	H	35-45 Rc	•	o	o	30	.0008	.0015	.0023	.0028	.0033	.0041	.0056	.0081	.0109
Stainless Steel - Easy to Machine 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F	M	up to 28 Rc	•	x	o	122	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
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	60	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
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	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Cast Iron	K	160-200 HB	•	o	o	120	.0018	.0033	.0051	.0058	.0074	.0089	.0119	.0180	.0241
Malleable / Ductile Cast Iron	K	200-250 HB	•	o	o	76	.0015	.0030	.0048	.0053	.0069	.0081	.0109	.0165	.0218
High Temp Alloys Nimonic, Inconel, Monel, Hastelloy	S	up to 42 Rc	•	x	x	22	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
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	45	.0010	.0020	.0030	.0033	.0043	.0051	.0069	.0102	.0137
Aluminum < 10 % Si	N		•			228	.0038	.0078	.0114	.0139	.0175	.0208	.0279	.0419	.0558
Aluminum > 10 % Si	N		•												

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