

MILLING RECOMMENDATIONS - GENERAL PURPOSE ENDMILLS



PROFILING

Workpiece Material Group	Hardness	Surface Feet Per Minute (SFM) Radial Depth of Cut (RDOC)					Inches Per Tooth (IPT)					
		SFM based on RDOC					IPT *(BASELINE)					
		Cutting Diameter Engaged					Cutting Diameter					
		5%	10%	20%	30%	50%	5/16	3/8	1/2	5/8	3/4	1
Steels Free Machining & Low Carbon: 10XX, 11XX, 12XX, 12LXX, ASTM A27, ASTM A36 Medium Carbon, High Carbon Steels, Alloy Steels & Easy to Machine Tool: 13XX, 41XX, 43XX, 51XX, 86XX, 93XX	P ≤ 28 Rc	1050	700	385	375	350						
	P 28-38 Rc	630	420	320	250	210	0.0027	0.0032	0.0045	0.0054	0.0063	0.0090
Tool & Die Steels A2, H13, L6, P20, S7	P 28-44 Rc	525	350	300	275	250	0.0027	0.0032	0.0045	0.0054	0.0063	0.0090
Stainless Steel Easy to Machine, 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F Moderately Difficult to Machine, Nitronic 50, Nitronic 60, 301, 303 304, 304L Incoloy 27-7MO, 316 316L, 321, 347 Difficult to Machine, 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M ≤ 28 Rc	650	600	550	500	450						
	M ≤ 28 Rc	525	400	350	300	250	0.0027	0.0032	0.0045	0.0054	0.0063	0.0090
	M > 28 Rc	525	400	350	300	250						
Super Alloys High Temp, Nimonic, Inconel, Monel, Hastelloy Titanium: Ti 3Al-2.5V, Ti 6Al-4V Ti 10V-2Fe-3Al	S ≤ 42 Rc	265	200	175	150	100	0.0014	0.0016	0.0023	0.0027	0.0032	0.0045
	S ≤ 42 Rc	230	200	175	150	125						
Hardened Materials	H 45-55 Rc	250	240	230	210	200	0.0018	0.0021	0.0030	0.0036	0.0042	0.0060
	H 55-65 Rc	200	180	160	150	100	0.0013	0.0014	0.0021	0.0024	0.0029	0.0041
Cast-Iron Gray: SAE J431, ASTM A48 Ductile & Malleable: ASTM A536, ASTM 897, ASTM A47, ASTM A220 ASTM A602	K ≤ 240 HB	425	400	375	350	300	0.0027	0.0032	0.0045	0.0054	0.0063	0.0090
	K > 240 HB	320	300	250	225	200						
Non-Ferrous Aluminum, Brass, Bronze, Copper, Plastics, Graphite	N	1000	960	920	880	840	0.0027	0.0032	0.0045	0.0054	0.0063	0.0090

*CHIP THINNING Adjustments	
RDOC	Increase IPT
50%	None
30%	1.1 x
25%	1.2 x
20%	1.3 x
15%	1.4 x
10%	1.8 x
7%	2.0 x
5%	2.3 x
3%	3.0 x
2%	3.5 x
1%	5.0 x



SLOTTING

Workpiece Material Group	Hardness	Surface Feet Per Minute (SFM) Radial Depth of Cut (RDOC)			Inches Per Tooth (IPT)					
		SFM			IPT *(BASELINE)					
		Cutting Diameter Engaged			Cutting Diameter					
		25%	50%	100%	5/16	3/8	1/2	5/8	3/4	1
Steels Free Machining & Low Carbon: 10XX, 11XX, 12XX, 12LXX, ASTM A27, ASTM A36 Medium Carbon, High Carbon Steels, Alloy Steels & Easy to Machine Tool: 13XX, 41XX, 43XX, 51XX, 86XX, 93XX	P ≤ 28 Rc	385	370	350						
	P 28-38 Rc	245	230	2210	0.0016	0.0019	0.0025	0.0031	0.0038	0.0050
Tool & Die Steels A2, H13, L6, P20, S7	P 28-44 Rc	210	195	175	0.0016	0.0019	0.0025	0.0031	0.0038	0.0050
Stainless Steel Easy to Machine, 430F, 301, 303, 410, 416 Annealed, 420F, 430, 430F Moderately Difficult to Machine, Nitronic 50, Nitronic 60, 301, 303 304, 304L Incoloy 27-7MO, 316 316L, 321, 347 Difficult to Machine, 302B, 304B, 309, 310, 316, 316B, 316L, 316Ti, 317, 317L, 321, PH13-8Mo, Nitronics	M ≤ 28 Rc	385	370	350						
	M ≤ 28 Rc	245	210	175	0.0016	0.0019	0.0025	0.0031	0.0038	0.0050
	M > 28 Rc	210	195	175						
Super Alloys High Temp, Nimonic, Inconel, Monel, Hastelloy Titanium: Ti 3Al-2.5V, Ti 6Al-4V Ti 10V-2Fe-3Al	S ≤ 42 Rc	125	105	90	0.0008	0.0010	0.0013	0.0016	0.0017	0.0026
	S ≤ 42 Rc	100	90	80						
Hardened Materials	H 34-45 Rc	245	230	210	0.0016	0.0019	0.0025	0.0031	0.0038	0.0050
	H 45-55 Rc	175	160	140	0.0008	0.0010	0.0013	0.0016	0.0020	0.0025
	H 55-65 Rc	150	125	100	0.0004	0.0005	0.0008	0.0008	0.0010	0.0012
Cast-Iron Gray: SAE J431, ASTM A48 Ductile & Malleable: ASTM A536, ASTM 897, ASTM A47, ASTM A220 ASTM A602	K ≤ 240 HB	450	400	350	0.0016	0.0019	0.0025	0.0031	0.0038	0.0050
	K > 240 HB	300	250	225						
Non-Ferrous Aluminum, Brass, Bronze, Copper, Plastics, Graphite	N	750	600	450	0.0016	0.0019	0.0025	0.0031	0.0038	0.0050

2 FLUTE - SINGLE END BALLNOSE



C2 Sub-Micron substrate for excellent wear resistance

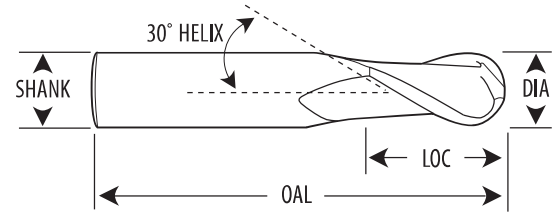
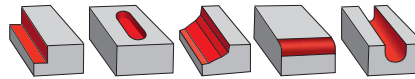
Universal 30° helix designed for proven success in various materials



Multiple coating options for specific machining needs

Ultimate chip clearance at high feed rates

Ball end minimizes tool deflection



DIAMETER TOLERANCE: +0.000 / -0.002" SHANK TOLERANCE: +0.0000 / -0.0005"

DIA	Dec In	LOC	Shank	OAL	Length	Bright	TiN	TiCN	AlTiN
1/64	0.0156	3/64	1/8	1-1/2	Regular	221-001000	221-000995	221-000996	221-000997
1/32	0.0313	1/16	1/8	1-1/2	Stub	219-001001	219-001002	219-001003	219-001004
		1/8	1/8	1-1/2	Regular	221-001005	221-001006	221-021005	221-001016
1.0mm	0.0394	4.0mm	3.0mm	39.0mm	Regular	221-001395	221-001400A	221-001400C	221-001400B
3/64	0.0469	3/32	1/8	1-1/2	Stub	219-001010	219-001011	219-001012	219-001013
		1/8	1/8	1-1/2	Regular	221-001007	221-001004	221-021007	221-001013
1.5mm	0.0591	5.0mm	3.0mm	39.0mm	Regular	221-001410	221-001410A	221-001410C	221-001410B
1/16	0.0625	1/8	1/8	1-1/2	Stub	219-001020	219-001021	219-001022	219-001023
		1/4	1/8	1-1/2	Regular	221-001008AA	221-001002	221-000999	221-001003
5/64	0.0781	5/32	1/8	1-1/2	Stub	219-001025	219-011025	219-021025	219-031025
		1/4	1/8	1-1/2	Regular	221-001009	221-001008	221-021009	221-001018
2.0mm	0.0787	8.0mm	3.0mm	39.0mm	Regular	221-001420	221-001420A	221-001420C	221-001420B
3/32	0.0938	3/16	1/8	1-1/2	Stub	219-001030	219-001031	219-001032	219-001033
		3/8	1/8	1-1/2	Regular	221-001010	221-001011	221-001012	221-001019
2.5mm	0.0984	9.5mm	3.0mm	39.0mm	Regular	221-001425	221-001425A	221-001425C	221-001425B
7/64	0.1094	7/32	1/8	1-1/2	Stub	219-001035	219-011035	219-021035	219-031035
		3/8	1/8	1-1/2	Regular	221-001014	221-001015	221-021014	221-001017
3.0mm	0.1181	12.0mm	3.0mm	39.0mm	Regular	221-001430	221-001430A	221-001430C	221-001430B
		1/4	1/8	1-1/2	Stub	219-001040	219-001041	219-001042	219-001043
		1/2	1/8	1-1/2	Regular	221-001020	221-001021	221-001026	221-001023
		3/4	1/8	2-1/4	Long	224-001001	224-001002	224-001003	224-001004
3.5mm	0.1378	1	1/8	3	X/Long	227-001001	227-001002	227-001003	227-001004
		12.0mm	4.0mm	51.0mm	Regular	221-001435	221-001435A	221-001435C	221-001435B
9/64	0.1406	9/32	3/16	2	Stub	219-001045	219-011045	219-021045	219-031045
		9/16	3/16	2	Regular	221-001024	221-001025	221-021024	221-001027
5/32	0.1563	5/16	3/16	2	Stub	219-001050	219-001051	219-001052	219-001053
		9/16	3/16	2	Regular	221-001030	221-001031	221-001032	221-001033
		3/4	3/16	2-1/2	Long	224-001005	224-001006	224-001007	224-001008
		1-1/8	3/16	3	X/Long	227-001005	227-001006	227-001007	227-001008
4.0mm	0.1575	14.0mm	4.0mm	51.0mm	Regular	221-001440	221-001440A	221-001440C	221-001440B

2 FLUTE - SINGLE END - BALLNOSE CONTINUED

DIA	Dec In	LOC	Shank	OAL	Length	Bright	TiN	TiCN	AlTiN
11/64	0.1719	5/16	3/16	2	Stub	219-001055	219-011055	219-021055	219-031055
		9/16	3/16	2	Regular	221-001034	221-001035	221-021034	221-001037
4.5mm	0.1772	16.0mm	5.0mm	51.0mm	Regular	221-001445	221-001445A	221-001445C	221-001445B
3/16	0.1875	3/8	3/16	2	Stub	219-001060	219-001061	219-001062	219-001063
		5/8	3/16	2	Regular	221-001040	221-001041	221-001042	221-001043
		3/4	3/16	2-1/2	Long	224-001012	224-001013	224-001014	224-001015
		1-1/8	3/16	3	X/Long	227-001010	227-001011	227-001012	227-001013
5.0mm	0.1969	16.0mm	5.0mm	51.0mm	Regular	221-001450	221-001450A	221-001450C	221-001450B
13/64	0.2031	3/8	1/4	2	Stub	219-001065	219-011065	219-021065	219-031065
		5/8	1/4	2-1/2	Regular	221-001044	221-001045	221-021044	221-001047
7/32	0.2188	7/16	1/4	2	Stub	219-001070	219-001071	219-001072	219-001073
		5/8	1/4	2-1/2	Regular	221-001050	221-001051	221-001052	221-001053
15/64	0.2344	7/16	1/4	2	Stub	219-001075	219-011075	219-021075	219-031075
		3/4	1/4	2-1/2	Regular	221-001054	221-001055	221-021054	221-001057
6.0mm	0.2362	19.0mm	6.0mm	63.0mm	Regular	221-001460	221-001460A	221-001460C	221-001460B
1/4	0.2500	1/2	1/4	2	Stub	219-001080	219-001081	219-001082	219-001083
		3/4	1/4	2-1/2	Regular	221-001060	221-001061	221-001059	221-001062
		1-1/8	1/4	3	Long	224-001020	224-001021	224-001022	224-001023
		1-1/2	1/4	4	X/Long	227-001020	227-001021	227-001022	227-001023
		1-1/2	1/4	6	Ext XX/Long	227-001025	227-001027	227-001028	227-001029
17/64	0.2656	3/4	5/16	2-1/2	Regular	221-001063	221-001064	221-001065	221-001066
7.0mm	0.2756	19.0mm	8.0mm	63.0mm	Regular	221-001470	221-001470A	221-001470C	221-001470B
9/32	0.2813	3/4	5/16	2-1/2	Regular	221-001070	221-001071	221-001072	221-001073
19/64	0.2969	13/16	5/16	2-1/2	Regular	221-001075	221-001076	221-001077	221-001078
		1/2	5/16	2	Stub	219-001090	219-001091	219-001092	219-001093
		13/16	5/16	2-1/2	Regular	221-001080	221-001081	221-001082	221-001079
		1-1/8	5/16	3	Long	224-001030	224-001031	224-001032	224-001033
		1-1/2	5/16	6	Ext XX/Long	227-001033A	227-001033C	227-001033D	227-001033B
		1-5/8	5/16	4	X/Long	227-001030	227-001031	227-001032	227-001033
8.0mm	0.3150	20.0mm	8.0mm	63.0mm	Regular	221-001480	221-001480A	221-001480C	221-001480B
21/64	0.3281	1	3/8	2-1/2	Regular	221-001083	221-001084	221-021083	221-031083
11/32	0.3438	1	3/8	2-1/2	Regular	221-001085	221-001086	221-001165	221-001087
9.0mm	0.3543	22.0mm	10.0mm	63.0mm	Regular	221-001490	221-001490A	221-001490C	221-001490B
23/64	0.3594	1	3/8	2-1/2	Regular	221-001088	221-001089	221-021088	221-031088
		5/8	3/8	2	Stub	219-001100	219-001101	219-001102	219-001103
		1	3/8	2-1/2	Regular	221-001090	221-001095	221-001167	221-001091
3/8	0.3750	1-1/8	3/8	3	Long	224-001040	224-001041	224-001042	224-001044
		1-1/2	3/8	6	Ext XX/Long	227-001035	227-001049	227-001037	227-001035A
		1-3/4	3/8	4	X/Long	227-001040	227-001041	227-001042	227-001043
		25/64	0.3906	1	7/16	2-3/4	Regular	221-001093	221-001094

2 FLUTE - SINGLE END - BALLNOSE CONTINUED

DIA	Dec In	LOC	Shank	OAL	Length	Bright	TiN	TiCN	AlTiN
10.0mm	0.3937	22.0mm	10.0mm	76.0mm	Regular	221-001500	221-001500A	221-001500C	221-001500B
13/32	0.4063	1	7/16	2-3/4	Regular	221-001096	221-001097	221-021096	221-001118
27/64	0.4219	1	7/16	2-3/4	Regular	221-001098	221-001099	221-021099	221-031099
11.0mm	0.4331	25.0mm	12.0mm	76.0mm	Regular	221-001510	—	221-001510C	221-001510B
7/16	0.4375	5/8	7/16	2-1/2	Stub	219-001110	219-001111	219-001112	219-001113
		1	7/16	2-3/4	Regular	221-001100	221-001101	221-001104	221-001119
		2	7/16	4	Long	224-001050	224-001051	224-001052	224-001053
		3	7/16	6	X/Long	227-001050	227-001051	227-001052	227-001053
29/64	0.4531	1	1/2	3	Regular	221-001102	221-001103	221-021102	221-031102
15/32	0.4688	1	1/2	3	Regular	221-001105	221-001106	221-021105	221-001123
12.0mm	0.4724	25.0mm	12.0mm	76.0mm	Regular	221-001520	221-001520A	221-001520C	221-001520B
31/64	0.4844	1	1/2	3	Regular	221-001108	221-001109	221-021108	221-031108
1/2	0.5000	5/8	1/2	2-1/2	Stub	219-001120	219-001121	219-001122	219-001123
		1	1/2	3	Regular	221-001110	221-001115	221-001116	221-001117
		1-1/2	1/2	4	Medium	224-001059	224-001059A	224-001059C	224-001059B
		1-1/2	1/2	6	Ext X/Long	227-001053A	227-001057	227-001058	227-001059
		2	1/2	4	Long	224-001060	224-001061	224-001062	224-001063
		3	1/2	6	X/Long	227-001054	227-001061	227-001062	227-001064
14.0mm	0.5512	32.0mm	14.0mm	90.0mm	Regular	221-001540	221-001540A	221-001540C	221-001540B
9/16	0.5625	1-1/4	9/16	3-1/2	Regular	221-001120	221-001121	221-001125	221-001124
5/8	0.6250	3/4	5/8	3	Stub	219-001130	219-001131	219-001132	219-001133
		1-1/4	5/8	3-1/2	Regular	221-001130	221-001131	221-001133	221-001134
		1-1/2	5/8	6	Ext X/Long	227-001073A	227-001073C	227-001073D	227-001073B
		2-1/4	5/8	5	Long	224-001070	224-001071	224-001072	224-001073
		3	5/8	6	X/Long	227-001070	227-001071	227-001072	227-001074
16.0mm	0.6299	32.0mm	16.0mm	102.0mm	Regular	221-001560	221-001560A	221-001560C	221-001560B
11/16	0.6875	1-1/2	3/4	4	Regular	221-001140	221-001141	221-021140	221-031140
18.0mm	0.7087	38.0mm	18.0mm	102.0mm	Regular	221-001580	221-001580A	221-001580C	221-001580B
3/4	0.7500	1	3/4	3	Stub	219-001140	219-001141	219-001142	219-001143
		1-1/2	3/4	4	Regular	221-001150	221-001151	221-001153	221-001154
		1-1/2	3/4	6	Ext X/Long	227-001085	227-001085A	227-001085B	227-001086
		2-1/4	3/4	5	Long	224-001080	224-001081	224-001082	224-001083
		3	3/4	6	X/Long	227-001080	227-001081	227-001082	227-001084
20.0mm	0.7874	38.0mm	20.0mm	102.0mm	Regular	221-001600	221-001600A	221-001600C	221-001600B
22.0mm	0.8661	38.0mm	22.0mm	102.0mm	Regular	221-001620	—	—	221-001620B
7/8	0.8750	1-1/2	7/8	4	Regular	221-001155	221-001156	221-021155	221-001158
25.0mm	0.9843	38.0mm	25.0mm	102.0mm	Regular	221-001650	—	—	221-001650B
1	1.0000	1-1/2	1	4	Regular	221-001160	221-001161	221-001163	221-001164
		1-1/2	1	6	Ext X/Long	227-001088	227-001088A	227-001088C	227-001089
		2-1/4	1	5	Long	224-001090	224-001091	224-001092	224-001093
		3	1	6	X/Long	227-001090	227-001091	227-001092	227-001094