



VALUE AT THE SPINDLE

Series ZR
High Performance End Mills

Z-CARB X PR



Z-CARB X PR

GET AGGRESSIVE MAINTAIN PRECISION

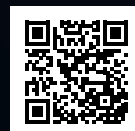
High Performance Milling with Extreme Plunging and Ramping Capabilities

The new plunging and ramping end mill is designed to excel in advanced axial workpiece entry techniques, including plunging, ramping, and helical interpolation, thanks to its unique end teeth design. This innovative feature, combined with completely variable geometry, allows for increased speeds and feeds while minimizing chatter and resonant vibrations, resulting in smoother and more efficient machining operations. The universal geometry of this end mill makes it suitable for use across a wide range of material groups, providing versatility in various applications and maintains excellent performance in slotting, advanced roughing, general roughing, semi-finishing, and finishing operations.

IDEAL FOR HIGH-EFFICIENCY ROUGHING AND FINISHING IN THE FOLLOWING **TARGET MATERIALS:**

P	STEEL
M	STAINLESS STEEL
K	CAST IRON

S	TITANIUM ALLOYS
S	HEAT-RESISTANT ALLOYS
H	HARDENED STEEL ($\leq 45\text{HRC}$)



View Online



Watch Video



FEATURES

OPEN END TOOTH DESIGN

Facilitates smooth and efficient chip evacuation when used in axial applications such as plunging, ramping, and helical interpolation

END TEETH WIPER FLAT

Increases corner strength and significantly improves workpiece floor surface finish

VARIABLE HELIX, RAKE, AND FLUTE INDEXING

Eliminates harmonics, suppresses chatter, produces ideal chip shape, and controls cutting zone temperature

SPECIALIZED FLUTE SHAPE

Provides excellent chip evacuation up to 2xD depth of cut

PROPRIETARY PVD COATING TECHNOLOGY

Provides exceptionally long tool life in a wide range of material applications

PREMIUM CARBIDE SUBSTRATE

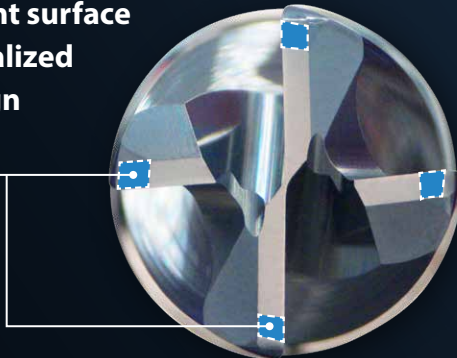
Balances toughness and hardness

COMPREHENSIVE OFFERING

- Available in metric and imperial sizes
- Square corner and popular corner radii
- Weldon flat in select configurations
- Available in **MEGACOAT NANO** or **Ti-NAMITE-X** coatings for a variety of applications

Achieves excellent surface finish with specialized wiper edge design

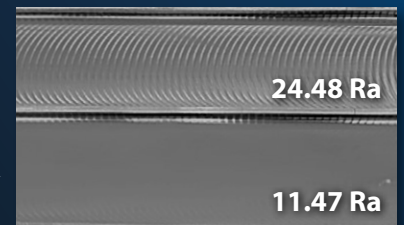
Wipers



Finish Comparison (Internal Evaluation)

Competitor A

Z-CARB X PR



17-4 Stainless Steel

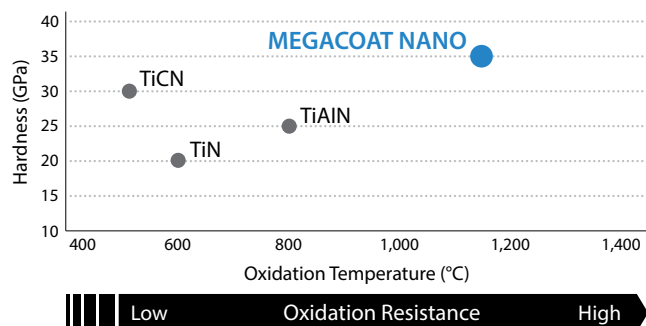
INNOVATIVE COATINGS DESIGNED FOR THE ULTIMATE PROTECTION AND ENDURANCE

MEGACOAT NANO NEW

The nano-layers of this coating provide high hardness for exceptional wear resistance and high oxidation resistance that allows for operation at high temperatures. The layered structure also gives the coating the toughness required to resist chipping. MEGACOAT NANO is particularly effective in high efficiency machining applications.

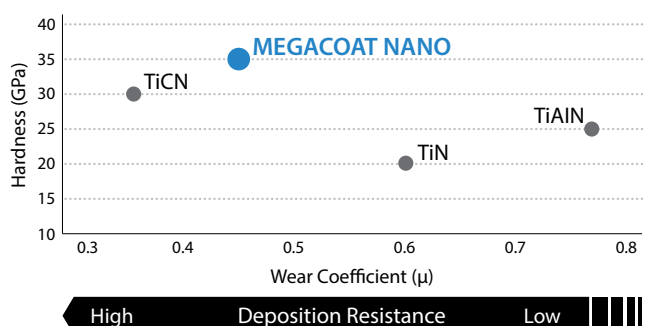


Coating Properties (Abrasion Resistance)



Achieves long tool life with special Nano coating layer

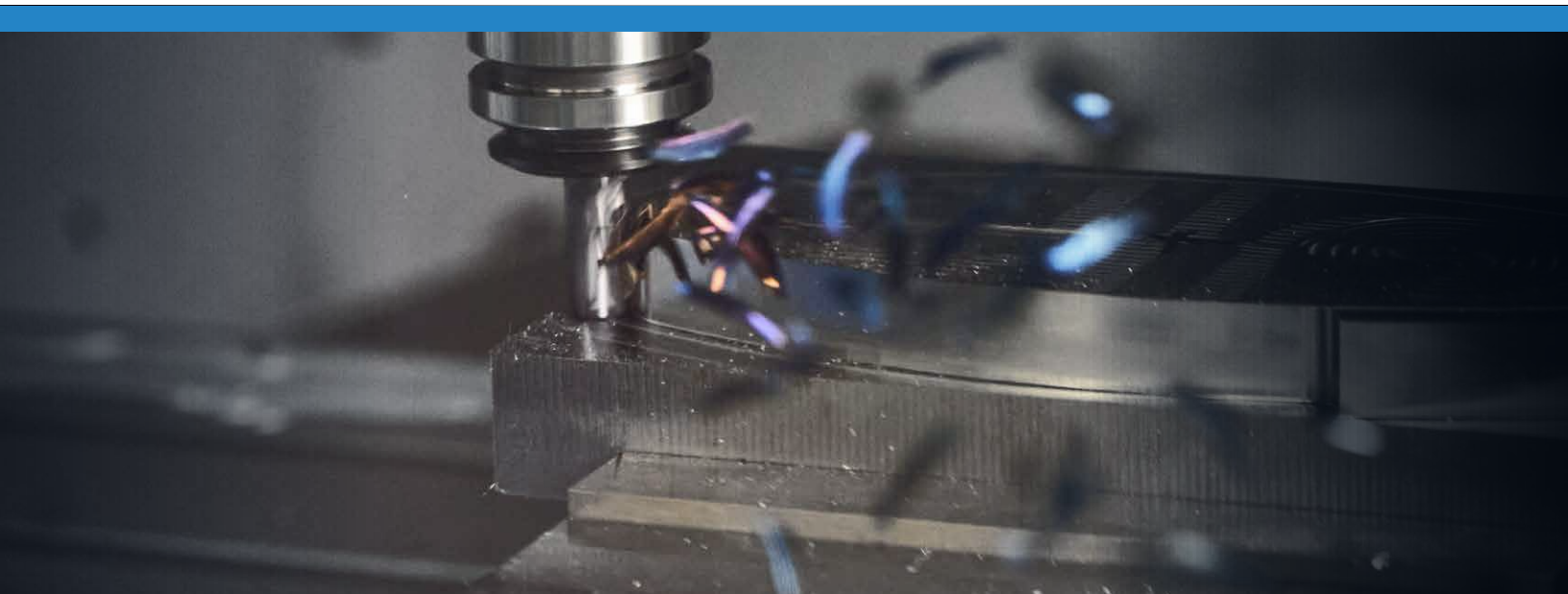
Coating Properties (Deposition Resistance)



Stable machining with excellent wear resistance

Ti-NAMITE-X

Meets a diverse range of applications from high- and low-alloy steels to hardened materials. Ti-NAMITE-X is suitable for operations which require high cutting speeds, high temperatures at the cutting edge, and high metal removal rates.



CUSTOMER SUCCESS

Total Cost Savings: **\$121,738**

INDUSTRY

Firearms

MATERIAL

4140 Steel (Forged)

PRODUCT

Z-Carb XPR 4-Flute Corner Radius

Ti-NAMITE-X (TX) Coated End Mill

APPLICATION

Milling

COMPETITOR TOOLS

0.500" 4-Flute Solid End Mill

COOLANT

Flood

SGS TOOL INFORMATION

0.500" Cutting Dia. (DC)

1.250" Length of Cut

3.250" Overall Length

EDP: 39871

GOALS

This firearm manufacturer needed to produce 200,000 total parts annually. With the annual job cost exceeding \$726,000, their goal was to reduce the overall cost by lowering cycle time and extending tool life. To achieve this goal, KYOCERA SGS application engineers looked for ways to increase tool life and decrease cost per part.

STRATEGY

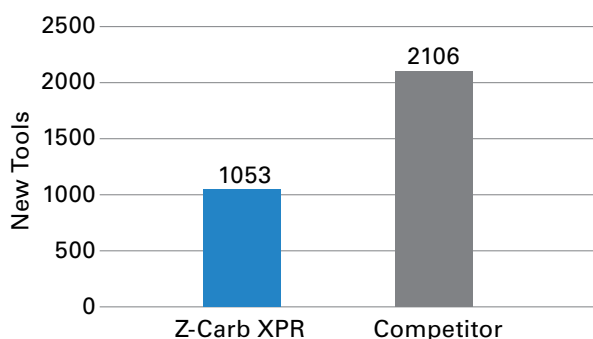
The existing application utilized a 1/2" 4-flute end mill to plunge and slot (blind) into the steel firearms component with a 2:57 (min/sec) cycle time per part and 95 cycles per tool. The new strategy increased feed rate with the Z-Carb XPR 4-flute end mill with aggressive plunging and ramping capabilities.

	Z-Carb XPR End Mill	Competitor End Mill
Cutting Diameter (DC)	0.500"	0.500"
RPM	3200	4500
SFM	419.20	589.50
Feed (IPM)	39.0	27.9
IPR	0.0122	0.0062
RADIAL DEPTH (AE)	0.500"	0.500"
AXIAL DEPTH (AP)	0.800"	0.800"

RESULTS

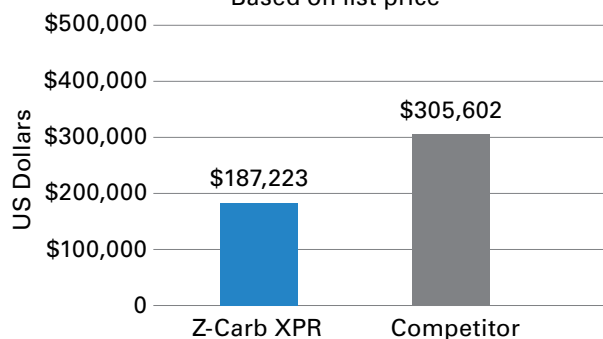
Using the SGS Z-Carb XPR 4-flute end mill with a Ti-NAMITE-X (TX) coating, the customer saw drastic tool life improvements and was able to double the amount of cycles per tool. While cycle time was only reduced by 1sec, the Z-Carb XPR's tool life lasted twice as long, showing only minimal wear compared to the competitor's end mill resulting in 50% annual savings in total new tool cost. These changes resulted in a 13% reduction in total costs and annual savings of over **\$121,000**.

Tools Required

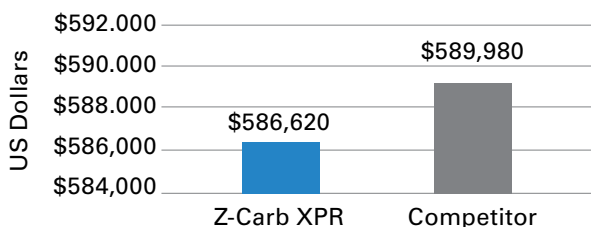


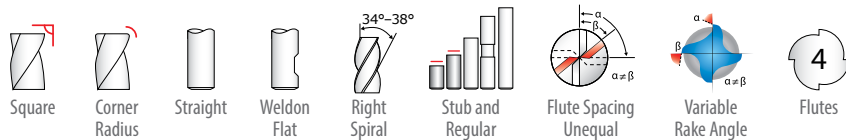
Total New Tool Cost

*Based on list price



Total Machining Cost



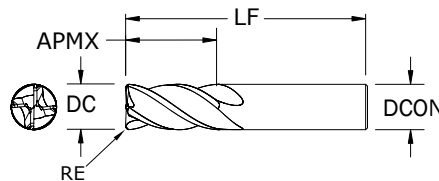


TOLERANCES (inch)

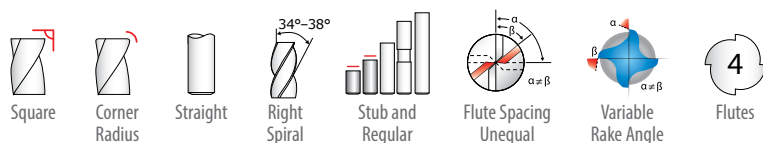
DIAMETER	DC	DCON
1/4	+0.0000 / -0.0012	h6
> 1/4 - 3/8	+0.0000 / -0.0016	h6
> 3/8 - 3/4	+0.0000 / -0.0020	h6

CORNER RADIUS TOLERANCES (inch)

RE = +0.0000 / -0.0020



Dimensions (in)					EDP Numbers by Coating and Type			
Cutting Diameter	Length of Cut	Overall Length	Shank Diameter	Corner Radius	Ti-NAMITE®-X (TX)		MEGACOAT NANO (MN)	
DC	APMX	LF	DCON	RE	Standard	Weldon Flat	Standard	Weldon Flat
1/4	1/2	2-1/2	1/4	—	39802	—	39800	—
1/4	1/2	2-1/2	1/4	0.010	39806	—	39804	—
1/4	1/2	2-1/2	1/4	0.015	39810	—	39808	—
1/4	1/2	2-1/2	1/4	0.020	39814	—	39812	—
1/4	1/2	2-1/2	1/4	0.030	39818	—	39816	—
1/4	3/4	2-1/2	1/4	—	39803	—	39801	—
1/4	3/4	2-1/2	1/4	0.010	39807	—	39805	—
1/4	3/4	2-1/2	1/4	0.015	39811	—	39809	—
1/4	3/4	2-1/2	1/4	0.020	39815	—	39813	—
1/4	3/4	2-1/2	1/4	0.030	39819	—	39817	—
5/16	13/16	2-1/2	5/16	—	39821	—	39820	—
5/16	13/16	2-1/2	5/16	0.015	39823	—	39822	—
5/16	13/16	2-1/2	5/16	0.020	39825	—	39824	—
5/16	13/16	2-1/2	5/16	0.030	39827	—	39826	—
3/8	5/8	2	3/8	0.020	39839	—	39836	—
3/8	7/8	2-1/2	3/8	—	39830	39831	39828	39829
3/8	7/8	2-1/2	3/8	0.010	39833	—	39832	—
3/8	7/8	2-1/2	3/8	0.015	39835	—	39834	—
3/8	7/8	2-1/2	3/8	0.020	39840	39841	39837	39838
3/8	7/8	2-1/2	3/8	0.030	39844	39845	39842	39843
3/8	7/8	2-1/2	3/8	0.060	39848	39849	39846	39847
7/16	1	2-3/4	7/16	—	39851	—	39850	—
7/16	1	2-3/4	7/16	0.020	39853	—	39852	—
1/2	5/8	2-1/2	1/2	0.030	39877	—	39872	—
1/2	1	3	1/2	—	39858	39859	39854	39855
1/2	1	3	1/2	0.010	39864	—	39862	—
1/2	1	3	1/2	0.015	39869	39870	39866	39867
1/2	1	3	1/2	0.030	39878	39879	39873	39874
1/2	1	3	1/2	0.060	39884	—	39882	—
1/2	1-1/4	3-1/4	1/2	—	39860	39861	39856	39857
1/2	1-1/4	3-1/4	1/2	0.010	39865	—	39863	—
1/2	1-1/4	3-1/4	1/2	0.015	39871	—	39868	—
1/2	1-1/4	3-1/4	1/2	0.030	39880	39881	39875	39876
1/2	1-1/4	3-1/4	1/2	0.060	39885	—	39883	—
9/16	1-1/8	3-1/2	9/16	—	39887	—	39886	—
9/16	1-1/8	3-1/2	9/16	0.030	39889	—	39888	—
5/8	1-1/4	3-1/2	5/8	—	39892	39893	39890	39891
5/8	1-1/4	3-1/2	5/8	0.030	39896	39897	39894	39895
5/8	1-1/4	3-1/2	5/8	0.040	39900	39901	39898	39899
5/8	1-1/4	3-1/2	5/8	0.060	39903	—	39902	—
3/4	1-1/2	4	3/4	—	39905	—	39904	—
3/4	1-1/2	4	3/4	0.030	39907	—	39906	—
3/4	1-1/2	4	3/4	0.040	39909	—	39908	—
3/4	1-1/2	4	3/4	0.060	39911	—	39910	—
3/4	1-1/2	4	3/4	0.125	39913	—	39912	—



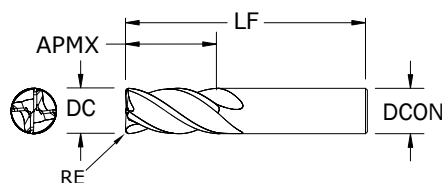
Z-CARB X PR

TOLERANCES (mm)

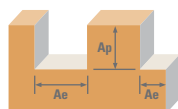
DIAMETER	DC	DCON
6	+0,000 / -0,030	h6
> 6 - 10	+0,000 / -0,040	h6
> 10 - 20	+0,000 / -0,050	h6

CORNER RADIUS TOLERANCES (mm)

RE = +0,000 / -0,050



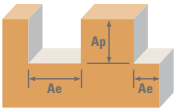
Dimensions (mm)					EDP Numbers by Coating and Type	
Cutting Diameter	Length of Cut	Overall Length	Shank Diameter	Corner Radius	TI-NAMITE®-X (TX)	MEGACOAT NANO (MN)
DC	APMX	LF	DCON	RE	Standard	Standard
6,0	13,0	57,0	6,0	–	47801	47800
6,0	13,0	57,0	6,0	0,50	47803	47802
6,0	13,0	57,0	6,0	1,00	47805	47804
8,0	19,0	63,0	8,0	–	47807	47806
8,0	19,0	63,0	8,0	0,50	47809	47808
8,0	19,0	63,0	8,0	1,00	47811	47810
8,0	19,0	63,0	8,0	2,00	47813	47812
10,0	22,0	72,0	10,0	–	47815	47814
10,0	22,0	72,0	10,0	0,50	47817	47816
10,0	22,0	72,0	10,0	1,00	47819	47818
10,0	22,0	72,0	10,0	2,00	47821	47820
12,0	26,0	83,0	12,0	–	47823	47822
12,0	26,0	83,0	12,0	0,50	47825	47824
12,0	26,0	83,0	12,0	0,75	47829	47828
12,0	26,0	83,0	12,0	1,00	47831	47830
14,0	26,0	83,0	14,0	–	47833	47832
14,0	26,0	83,0	14,0	1,00	47835	47834
16,0	32,0	92,0	16,0	–	47837	47836
16,0	32,0	92,0	16,0	1,00	47839	47838
16,0	32,0	92,0	16,0	2,00	47841	47840
16,0	32,0	92,0	16,0	3,00	47843	47842
20,0	38,0	104,0	20,0	–	47845	47844
20,0	38,0	104,0	20,0	1,00	47847	47846



Series ZR		Ae x DC		Vc (sfm)							
Fractional	Hardness					1/4	3/8	1/2	5/8	3/4	
P	CARBON STEELS 1018, 1040, 1080, 1090, 10L50, 1140, 1212, 12L15, 1525, 1536	 Profile	≤ 0.25	≤ APMX	675 (540-810)	RPM	10314	6876	5157	4126	3438
						Fz	0.0017	0.0029	0.0041	0.0045	0.0048
						Feed (ipm)	70	80	85	73	66
		 Slot	1	≤ 1	450 (360-540)	RPM	6876	4584	3438	2750	2292
						Fz	0.0014	0.0025	0.0035	0.0039	0.0042
						Feed (ipm)	39	45	48	42	39
		 Plunge	1	≤ 1	640 (512-768)	RPM	9779	6519	4890	3912	3260
						Fz	0.0013	0.0022	0.0032	0.0035	0.0038
						Feed (ipm)	49	58	62	54	49
	ALLOY STEELS 4140, 4150, 4320, 5120, 5150, 8630, 86L20, 50100	 Profile	≤ 0.25	≤ APMX	525 (420-630)	RPM	8022	5348	4011	3209	2674
						Fz	0.0011	0.0024	0.0036	0.0039	0.0042
						Feed (ipm)	35	50	58	50	45
		 Slot	1	≤ 1	350 (280-420)	RPM	5348	3565	2674	2139	1783
						Fz	0.0010	0.0021	0.0031	0.0034	0.0037
						Feed (ipm)	21	29	33	29	26
		 Plunge	1	≤ 1	500 (400-600)	RPM	7640	5093	3820	3056	2547
						Fz	0.0009	0.0019	0.0028	0.0031	0.0033
						Feed (ipm)	28	38	43	38	34
	TOOL STEELS A2, D2, H13, L2, M2, P20, S7, T15, W2	 Profile	≤ 0.25	≤ APMX	240 (192-288)	RPM	3667	2445	1834	1467	1222
						Fz	0.0009	0.0018	0.0026	0.0030	0.0033
						Feed (ipm)	13	17	19	17	16
		 Slot	1	≤ 0.5	160 (128-192)	RPM	2445	1630	1222	978	815
						Fz	0.0008	0.0016	0.0023	0.0026	0.0028
						Feed (ipm)	8	10	11	10	9
 Plunge		1	≤ 0.5	220 (176-264)	RPM	3362	2241	1681	1345	1121	
					Fz	0.0007	0.0014	0.0021	0.0023	0.0025	
					Feed (ipm)	10	13	14	12	11	
M	STAINLESS STEELS (FREE MACHINING) 303, 416, 420F, 430F, 440F	 Profile	≤ 0.25	≤ APMX	540 (432-648)	RPM	8251	5501	4126	3300	2750
						Fz	0.0011	0.0022	0.0032	0.0035	0.0038
						Feed (ipm)	36	47	53	46	42
		 Slot	1	≤ 1	360 (288-432)	RPM	5501	3667	2750	2200	1834
						Fz	0.0010	0.0019	0.0028	0.0031	0.0033
						Feed (ipm)	22	28	31	27	24
		 Plunge	1	≤ 1	510 (408-612)	RPM	7793	5195	3896	3117	2598
						Fz	0.0009	0.0017	0.0025	0.0028	0.0030
						Feed (ipm)	28	36	39	34	31
	STAINLESS STEELS (DIFFICULT) 304, 304L, 316, 316L	 Profile	≤ 0.25	≤ APMX	375 (300-450)	RPM	5730	3820	2865	2292	1910
						Fz	0.0009	0.0018	0.0026	0.0030	0.0034
						Feed (ipm)	21	27	30	28	26
		 Slot	1	≤ 0.5	250 (200-300)	RPM	3820	2547	1910	1528	1273
						Fz	0.0008	0.0016	0.0023	0.0026	0.0029
						Feed (ipm)	12	16	18	16	15
		 6° Ramp	1	≤ 0.5	350 (280-420)	RPM	5348	3565	2674	2139	1783
						Fz	0.0007	0.0014	0.0021	0.0023	0.0026
						Feed (ipm)	15	20	22	20	19
STAINLESS STEELS (PH) 13-8 PH, 15-5PH, 17-4 PH, CUSTOM 450	 Profile	≤ 0.25	≤ APMX	360 (288-432)	RPM	5501	3667	2750	2200	1834	
					Fz	0.0009	0.0018	0.0026	0.0030	0.0034	
					Feed (ipm)	20	26	29	26	25	
	 Slot	1	≤ 1	240 (192-288)	RPM	3667	2445	1834	1467	1222	
					Fz	0.0008	0.0016	0.0023	0.0026	0.0029	
					Feed (ipm)	12	15	17	15	14	
	 6° Ramp	1	≤ 1	340 (272-408)	RPM	5195	3463	2598	2078	1732	
					Fz	0.0007	0.0014	0.0021	0.0023	0.0026	
					Feed (ipm)	15	19	22	20	18	

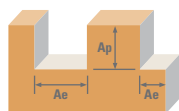
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Series ZR	Hardness		Ae x DC	Ap x DC	Vc (sfm)						
Fractional						1/4	3/8	1/2	5/8	3/4	
K	CAST IRONS (LOW & MEDIUM ALLOY) Gray, Malleable, Ductile	 Profile	≤ 0.25	≤ APMX	630 (504-756)	RPM	9626	6418	4813	3851	3209
						Fz	0.0013	0.0023	0.0033	0.0038	0.0042
						Feed (ipm)	50	59	64	58	54
		 Slot	1	≤ 1	420 (336-504)	RPM	6418	4278	3209	2567	2139
						Fz	0.0011	0.0020	0.0029	0.0033	0.0037
						Feed (ipm)	28	34	37	34	32
	CAST IRONS (HIGH ALLOY) Gray, Malleable, Ductile	 Plunge	1	≤ 1	600 (480-720)	RPM	9168	6112	4584	3667	3056
						Fz	0.0010	0.0018	0.0026	0.0030	0.0033
						Feed (ipm)	36	44	48	44	41
		 Profile	≤ 0.25	≤ APMX	375 (300-450)	RPM	5730	3820	2865	2292	1910
						Fz	0.0009	0.0018	0.0026	0.0030	0.0034
						Feed (ipm)	21	27	30	28	26
S	SUPER ALLOYS (NICKEL, COBALT, IRON BASE) Inconel 601, 617, 625, Incoloy, Monel 400	 Slot	1	≤ 0.375	70 (56-84)	RPM	3820	2547	1910	1528	1273
						Fz	0.0008	0.0016	0.0023	0.0026	0.0029
						Feed (ipm)	12	16	18	16	15
		 Plunge	1	≤ 1	350 (280-420)	RPM	5348	3565	2674	2139	1783
						Fz	0.0007	0.0014	0.0021	0.0023	0.0026
						Feed (ipm)	15	20	22	20	19
	SUPER ALLOYS (NICKEL, COBALT, IRON BASE) Inconel 718, X-750, Incoloy, Waspaloy, Hastelloy, Rene	 Profile	≤ 0.25	≤ APMX	105 (84-126)	RPM	1604	1070	802	642	535
						Fz	0.0006	0.0013	0.0019	0.0023	0.0026
						Feed (ipm)	4	5	6	6	6
		 Slot	1	≤ 0.375	70 (56-84)	RPM	1070	713	535	428	357
						Fz	0.0005	0.0011	0.0017	0.0020	0.0022
						Feed (ipm)	2	3	4	3	3
	TITANIUM ALLOYS Pure Titanium, Ti6Al4V, Ti6Al2Sn4Zr2Mo, Ti4Al4Mo2Sn0.5Si	 3° Ramp	1	≤ 0.5	100 (80-120)	RPM	1528	1019	764	611	509
						Fz	0.0005	0.0010	0.0015	0.0018	0.0020
						Feed (ipm)	3	4	5	4	4
		 Profile	≤ 0.25	≤ APMX	60 (48-72)	RPM	917	611	458	367	306
						Fz	0.0006	0.0011	0.0016	0.0020	0.0024
						Feed (ipm)	2	3	3	3	3
	TITANIUM ALLOYS (DIFFICULT) Ti10Al2Fe3Al, Ti5Al5V5Mo3Cr, Ti7Al4Mo, Ti3Al8V6Cr4Zr4Mo, Ti6Al6V6Sn, Ti15V3 Cr3Sn3Al	 Slot	1	≤ 0.375	40 (32-48)	RPM	611	407	306	244	204
						Fz	0.0005	0.0010	0.0014	0.0018	0.0021
						Feed (ipm)	1	2	2	2	2
		 3° Ramp	1	≤ 0.5	50 (40-60)	RPM	764	509	382	306	255
						Fz	0.0005	0.0009	0.0013	0.0016	0.0019
						Feed (ipm)	1	2	2	2	2
TITANIUM ALLOYS (DIFFICULT) Ti10Al2Fe3Al, Ti5Al5V5Mo3Cr, Ti7Al4Mo, Ti3Al8V6Cr4Zr4Mo, Ti6Al6V6Sn, Ti15V3 Cr3Sn3Al	 Profile	≤ 0.25	≤ APMX	270 (216-324)	RPM	4126	2750	2063	1650	1375	
					Fz	0.0010	0.0019	0.0027	0.0032	0.0036	
					Feed (ipm)	17	20	22	21	20	
	 Slot	1	≤ 0.5	180 (144-216)	RPM	2750	1834	1375	1100	917	
					Fz	0.0009	0.0017	0.0024	0.0028	0.0031	
					Feed (ipm)	10	12	13	12	11	
TITANIUM ALLOYS (DIFFICULT) Ti10Al2Fe3Al, Ti5Al5V5Mo3Cr, Ti7Al4Mo, Ti3Al8V6Cr4Zr4Mo, Ti6Al6V6Sn, Ti15V3 Cr3Sn3Al	 6° Ramp	1	≤ 0.5	250 (200-300)	RPM	3820	2547	1910	1528	1273	
					Fz	0.0008	0.0015	0.0022	0.0025	0.0028	
					Feed (ipm)	12	15	17	15	14	
	 Profile	≤ 0.25	≤ APMX	150 (120-180)	RPM	2292	1528	1146	917	764	
					Fz	0.0009	0.0017	0.0025	0.0030	0.0034	
					Feed (ipm)	8	10	11	11	10	
 Slot	1	≤ 0.375	100 (80-120)	RPM	1528	1019	764	611	509		
				Fz	0.0008	0.0015	0.0022	0.0026	0.0030		
				Feed (ipm)	5	6	7	6	6		
 6° Ramp	1	≤ 0.5	140 (112-168)	RPM	2139	1426	1070	856	713		
				Fz	0.0007	0.0014	0.0020	0.0023	0.0027		
				Feed (ipm)	6	8	9	8	8		

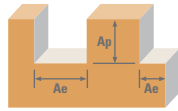
Note:

- Bhn (Brinell) HRc (Rockwell C)
- rpm = Vc x 3.82 / DC
- ipm = Fz x 4 x rpm
- Reduce speed and feed for materials harder than listed
- Reduce feed and Ae when finish milling (.02 x DC maximum)
- Refer to the KYOCERA SGS APEX® for complete technical information (www.kyocera-sgstool.com)



Series ZR Metric	Hardness		Ae x DC	Ap x DC	Vc (m/min)	DC • mm							
						6	8	10	12	16	20		
P	CARBON STEELS 1018, 1040, 1080, 1090, 10L50, 1140, 1212, 12L15, 1525, 1536	≤ 275 Bhn or ≤ 28 HRC	Profile			RPM	10920	8190	6552	5460	4095	3276	
				≤ 0.25	≤ APMX	206 (165-247)	Fz	0.0464	0.0668	0.0870	0.1071	0.1247	0.1376
						Feed (mm/min)	2025	2189	2280	2338	2043	1803	
			≤ 275 Bhn or ≤ 28 HRC	Slot			RPM	7280	5460	4368	3640	2730	2184
				1	≤ 1	137 (110-165)	Fz	0.0365	0.0526	0.0685	0.0843	0.0982	0.1083
						Feed (mm/min)	1063	1149	1197	1227	1072	946	
			≤ 275 Bhn or ≤ 28 HRC	Plunge			RPM	10354	7765	6212	5177	3883	3106
				1	≤ 1	195 (156-234)	Fz	0.0334	0.0482	0.0627	0.0772	0.0882	0.0992
						Feed (mm/min)	1384	1496	1558	1598	1369	1232	
	ALLOY STEELS 4140, 4150, 4320, 5120, 5150, 8630, 86L20, 50100	≤ 375 Bhn or ≤ 40 HRC	Profile			RPM	8493	6370	5096	4247	3185	2548	
				≤ 0.25	≤ APMX	160 (128-192)	Fz	0.0324	0.0518	0.0727	0.0932	0.1096	0.1207
						Feed (mm/min)	1100	1320	1481	1584	1396	1230	
			≤ 375 Bhn or ≤ 40 HRC	Slot			RPM	5662	4247	3397	2831	2123	1699
				1	≤ 1	107 (85-128)	Fz	0.0255	0.0408	0.0572	0.0734	0.0863	0.0950
						Feed (mm/min)	578	693	777	831	733	645	
			≤ 375 Bhn or ≤ 40 HRC	Plunge			RPM	8089	6067	4853	4044	3033	2427
				1	≤ 1	152 (122-183)	Fz	0.0233	0.0374	0.0524	0.0672	0.0771	0.0870
						Feed (mm/min)	755	906	1017	1087	935	844	
TOOL STEELS A2, D2, H13, L2, M2, P20, S7, T15, W2	≤ 375 Bhn or ≤ 40 HRC	Profile			RPM	3883	2912	2330	1941	1456	1165		
			≤ 0.25	≤ APMX	73 (59-88)	Fz	0.0259	0.0396	0.0541	0.0685	0.0826	0.0935	
					Feed (mm/min)	402	462	504	532	481	436		
		≤ 375 Bhn or ≤ 40 HRC	Slot			RPM	2588	1941	1553	1294	971	777	
			1	≤ 0.5	49 (39-59)	Fz	0.0204	0.0312	0.0426	0.0539	0.0650	0.0736	
					Feed (mm/min)	211	242	265	279	252	229		
		≤ 375 Bhn or ≤ 40 HRC	Plunge			RPM	3559	2669	2135	1780	1335	1068	
			1	≤ 0.5	67 (54-80)	Fz	0.0187	0.0286	0.0390	0.0493	0.0584	0.0674	
					Feed (mm/min)	266	305	333	351	312	288		
M	STAINLESS STEELS (FREE MACHINING) 303, 416, 420F, 430F, 440F	≤ 275 Bhn or ≤ 28 HRC	Profile			RPM	8736	6552	5242	4368	3276	2621	
				≤ 0.25	≤ APMX	165 (132-198)	Fz	0.0328	0.0488	0.0659	0.0829	0.0981	0.1090
						Feed (mm/min)	1145	1278	1382	1449	1285	1142	
			≤ 275 Bhn or ≤ 28 HRC	Slot			RPM	5824	4368	3494	2912	2184	1747
				1	≤ 1	110 (88-132)	Fz	0.0258	0.0384	0.0519	0.0653	0.0772	0.0858
						Feed (mm/min)	601	671	725	761	674	600	
			≤ 275 Bhn or ≤ 28 HRC	Plunge			RPM	8251	6188	4950	4125	3094	2475
				1	≤ 1	155 (124-187)	Fz	0.0236	0.0352	0.0475	0.0598	0.0692	0.0786
						Feed (mm/min)	780	870	941	987	856	778	
	STAINLESS STEELS (DIFFICULT) 304, 304L, 316, 316L	≤ 275 Bhn or ≤ 28 HRC	Profile			RPM	6067	4550	3640	3033	2275	1820	
				≤ 0.25	≤ APMX	114 (91-137)	Fz	0.0255	0.0390	0.0537	0.0683	0.0846	0.0979
						Feed (mm/min)	620	710	782	829	770	713	
			≤ 275 Bhn or ≤ 28 HRC	Slot			RPM	4044	3033	2427	2022	1517	1213
				1	≤ 0.5	76 (61-91)	Fz	0.0201	0.0307	0.0423	0.0538	0.0666	0.0771
						Feed (mm/min)	325	372	411	435	404	374	
			≤ 275 Bhn or ≤ 28 HRC	6° Ramp			RPM	5662	4247	3397	2831	2123	1699
				1	≤ 0.5	107 (85-128)	Fz	0.0184	0.0281	0.0387	0.0493	0.0599	0.0706
						Feed (mm/min)	417	477	526	558	509	480	
STAINLESS STEELS (PH) 13-8 PH, 15-5PH, 17-4 PH, CUSTOM 450	≤ 325 Bhn or ≤ 35 HRC	Profile			RPM	5824	4368	3494	2912	2184	1747		
			≤ 0.25	≤ APMX	110 (88-132)	Fz	0.0254	0.0390	0.0537	0.0683	0.0846	0.0979	
					Feed (mm/min)	592	681	751	796	739	684		
		≤ 325 Bhn or ≤ 35 HRC	Slot			RPM	3883	2912	2330	1941	1456	1165	
			1	≤ 1	73 (59-88)	Fz	0.0200	0.0307	0.0423	0.0538	0.0666	0.0771	
					Feed (mm/min)	311	358	394	418	388	359		
		≤ 325 Bhn or ≤ 35 HRC	6° Ramp			RPM	5500	4125	3300	2750	2063	1650	
			1	≤ 1	104 (83-124)	Fz	0.0183	0.0281	0.0387	0.0493	0.0599	0.0706	
					Feed (mm/min)	403	464	511	542	494	466		

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Series ZR Metric		Hardness			Vc (m/min)	DC • mm								
			Ae x DC	Ap x DC		6	8	10	12	16	20			
K	CAST IRONS (LOW & MEDIUM ALLOY) Gray, Malleable, Ductile	≤ 220 Bhn or ≤ 19 HRC	Profile 	≤ 0.25	≤ APMX	192 (154-230)	RPM	10192	7644	6115	5096	3822	3058	
							Fz	0.0363	0.0526	0.0699	0.0869	0.1059	0.1218	
							Feed (mm/min)	1481	1608	1709	1771	1619	1490	
			Slot 	1	≤ 1	128 (102-154)	RPM	6795	5096	4077	3397	2548	2038	
							Fz	0.0286	0.0414	0.0550	0.0684	0.0834	0.0959	
							Feed (mm/min)	777	844	897	929	850	782	
							RPM	9707	7280	5824	4853	3640	2912	
						Fz	0.0262	0.0379	0.0504	0.0626	0.0752	0.0878		
						Feed (mm/min)	1017	1104	1173	1216	1095	1023		
		CAST IRONS (HIGH ALLOY) Gray, Malleable, Ductile	≤ 260 Bhn or ≤ 26 HRC	Profile 	≤ 0.25	≤ APMX	114 (91-137)	RPM	6067	4550	3640	3033	2275	1820
								Fz	0.0255	0.0390	0.0537	0.0683	0.0846	0.0979
								Feed (mm/min)	620	710	782	829	770	713
	Slot 			1	≤ 1	76 (61-91)	RPM	4044	3033	2427	2022	1517	1213	
							Fz	0.0201	0.0307	0.0423	0.0538	0.0666	0.0771	
							Feed (mm/min)	325	372	411	435	404	374	
	S	SUPER ALLOYS (NICKEL, COBALT, IRON BASE) Inconel 601, 617, 625, Incoloy, Monel 400	≤ 300 Bhn or ≤ 32 HRC	Profile 	≤ 0.25	≤ APMX	32 (26-38)	RPM	1699	1274	1019	849	637	510
								Fz	0.0174	0.0287	0.0413	0.0536	0.0650	0.0735
								Feed (mm/min)	118	146	168	182	166	150
Slot 				1	≤ 0.375	21 (17-26)	RPM	1132	849	679	566	425	340	
							Fz	0.0137	0.0226	0.0325	0.0422	0.0512	0.0579	
							Feed (mm/min)	62	77	88	96	87	79	
							RPM	1618	1213	971	809	607	485	
						Fz	0.0125	0.0207	0.0298	0.0386	0.0458	0.0530		
						Feed (mm/min)	81	100	116	125	111	103		
SUPER ALLOYS (NICKEL, COBALT, IRON BASE) Inconel 718, X-750, Incoloy, Waspaloy, Hastelloy, Rene			≤ 400 Bhn or ≤ 43 HRC	Profile 	≤ 0.25	≤ APMX	18 (15-22)	RPM	971	728	582	485	364	291
								Fz	0.0166	0.0271	0.0386	0.0500	0.0611	0.0695
								Feed (mm/min)	65	79	90	97	89	81
	Slot 	1		≤ 0.375	12 (10-15)	RPM	647	485	388	324	243	194		
						Fz	0.0131	0.0213	0.0304	0.0394	0.0481	0.0547		
						Feed (mm/min)	34	41	47	51	47	42		
TITANIUM ALLOYS Pure Titanium, Ti6Al4V, Ti6Al2Sn4Zr2Mo, Ti4Al4Mo2Sn0.5Si	≤ 350 Bhn or ≤ 38 HRC	Profile 	≤ 0.25	≤ APMX	82 (66-99)	RPM	4368	3276	2621	2184	1638	1310		
						Fz	0.0286	0.0429	0.0577	0.0721	0.0894	0.1040		
						Feed (mm/min)	499	563	605	630	586	545		
		Slot 	1	≤ 0.5	55 (44-66)	RPM	2912	2184	1747	1456	1092	874		
						Fz	0.0225	0.0338	0.0454	0.0568	0.0704	0.0819		
						Feed (mm/min)	262	295	317	331	308	286		
						RPM	4044	3033	2427	2022	1517	1213		
					Fz	0.0206	0.0309	0.0416	0.0520	0.0635	0.0750			
					Feed (mm/min)	333	375	403	421	385	364			
	TITANIUM ALLOYS (DIFFICULT) Ti10Al2Fe3Al, Ti5Al5V5Mo3Cr, Ti7Al4Mo, Ti3Al8V6Cr4Zr4Mo, Ti6Al6V6Sn, Ti15V3 Cr3Sn3Al	≤ 440 Bhn or ≤ 47 HRC	Profile 	≤ 0.25	≤ APMX	46 (37-55)	RPM	2427	1820	1456	1213	910	728	
							Fz	0.0243	0.0375	0.0512	0.0648	0.0837	0.1007	
							Feed (mm/min)	235	273	298	314	305	293	
Slot 			1	≤ 0.375	30 (24-37)	RPM	1618	1213	971	809	607	485		
						Fz	0.0191	0.0295	0.0403	0.0510	0.0659	0.0793		
						Feed (mm/min)	124	143	156	165	160	154		
					RPM	2265	1699	1359	1132	849	679			
				Fz	0.0175	0.0270	0.0369	0.0467	0.0596	0.0726				
				Feed (mm/min)	158	184	201	212	203	197				

Note:

- Bhn (Brinell) HRc (Rockwell C)
- rpm = Vc x 3.82 / DC
- ipm = Fz x 4 x rpm
- Reduce speed and feed for materials harder than listed
- Reduce feed and Ae when finish milling (.02 x DC maximum)
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