



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

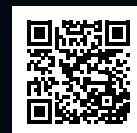
The new plunging and ramping end mill is designed to excel in advanced axial workpiece entry techniques, including plunging, ramping, and helical interpolation, thanks to its unique end teeth design. This innovative feature, combined with completely variable geometry, allows for increased speeds and 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

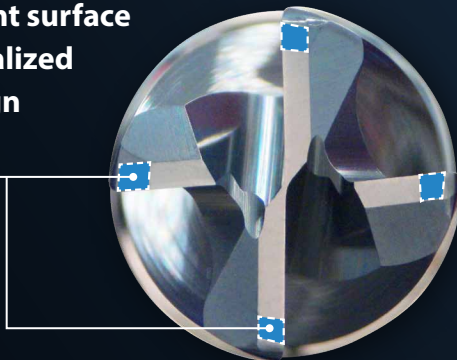
COMPREHENSIVE OFFERING

- 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)

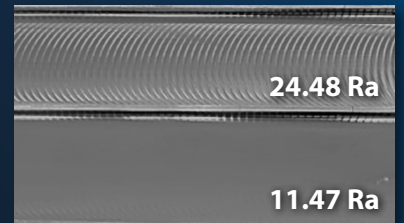
Competitor A

24.48 Ra

Z-CARB X PR

11.47 Ra

17-4 Stainless Steel



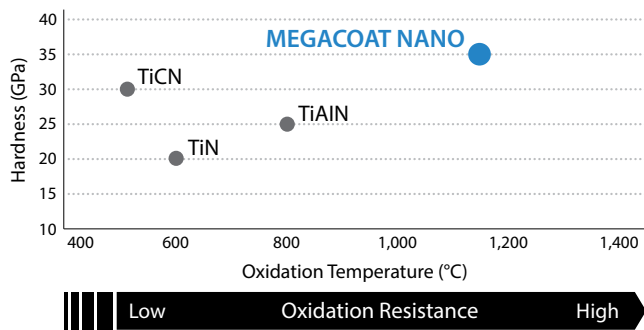
INNOVATIVE COATINGS DESIGNED FOR THE ULTIMATE PROTECTION AND ENDURANCE

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.

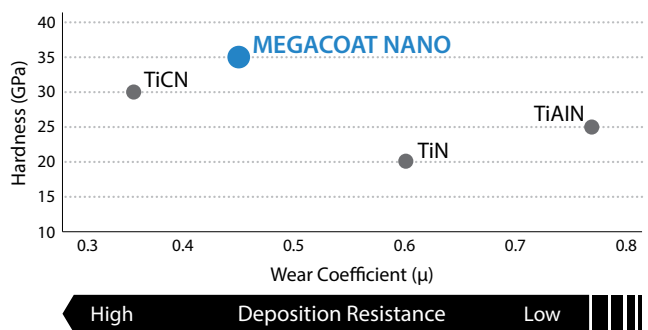


Coating Properties (Abrasion Resistance)



Achieves long tool life with special Nano coating layer

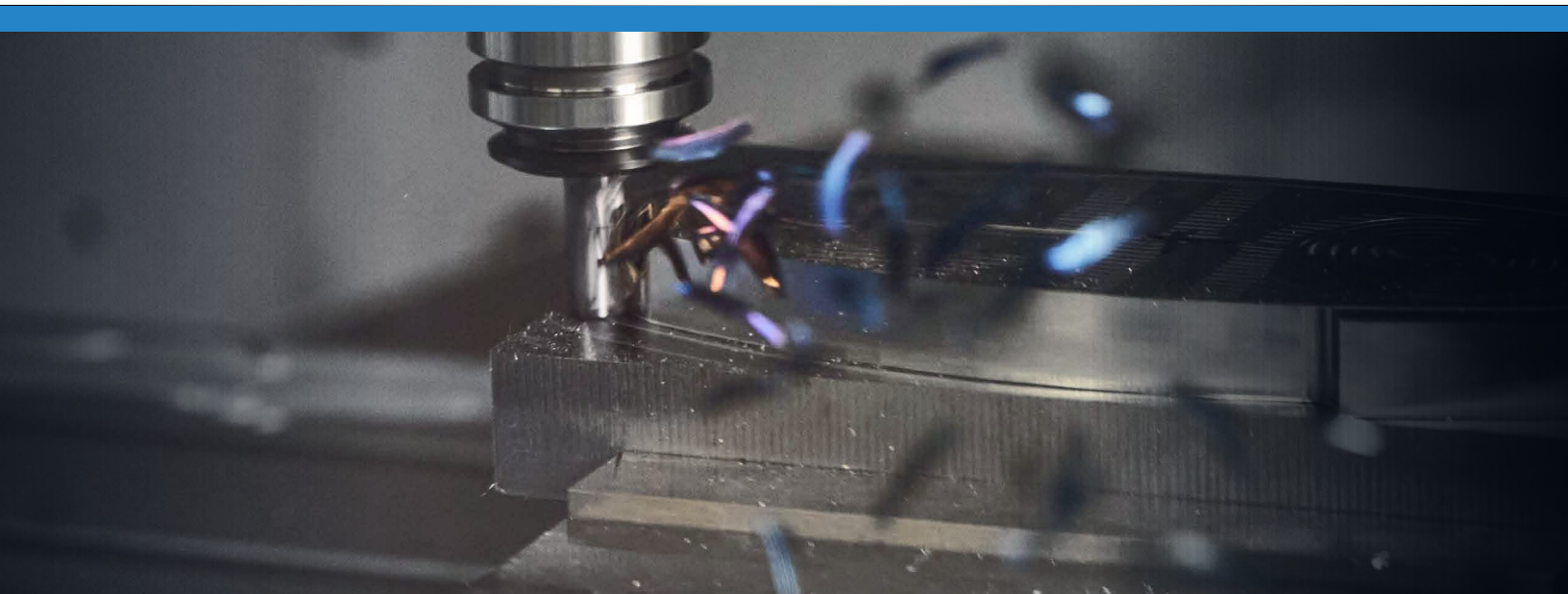
Coating Properties (Deposition Resistance)



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

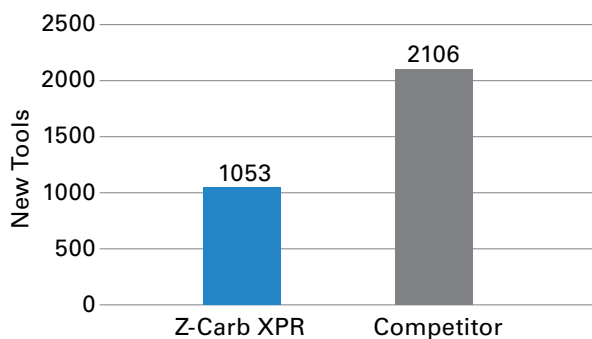
The existing application utilized a 1/2" 4-flute end mill to plunge and slot (blind) into the steel firearms component with a 2:57 (min/sec) cycle time per part and 95 cycles per tool. The new strategy increased feed rate with the Z-Carb XPR 4-flute end mill with aggressive plunging and ramping capabilities.

| | 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

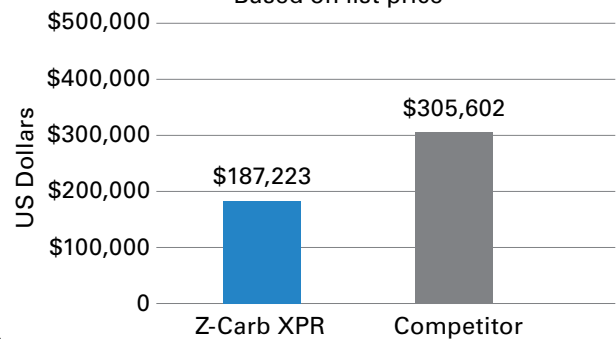
Using the SGS Z-Carb XPR 4-flute end mill with a Ti-NAMITE-X (TX) coating, the customer saw drastic tool life improvements and was able to double the amount of cycles per tool. While cycle time was only reduced by 1sec, the Z-Carb XPR's tool life lasted twice as long, showing only minimal wear compared 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

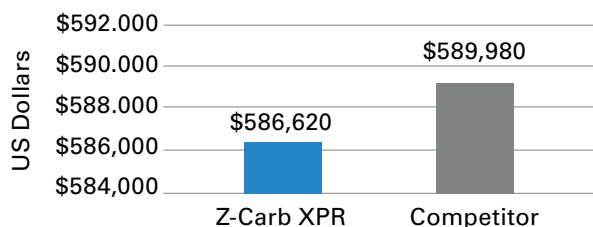


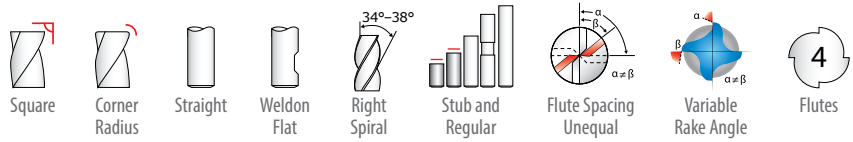
Total New Tool Cost

*Based on list price



Total Machining Cost



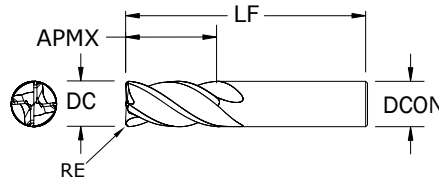


TOLERANCES (inch)

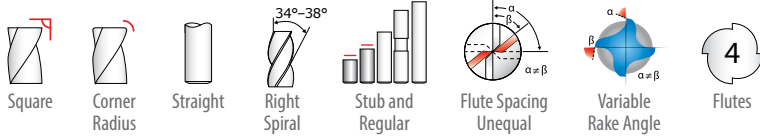
| DIAMETER | DC | DCON |
|-------------|-------------------|------|
| 1/4 | +0.0000 / -0.0012 | h6 |
| > 1/4 - 3/8 | +0.0000 / -0.0016 | h6 |
| > 3/8 - 3/4 | +0.0000 / -0.0020 | h6 |

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 | - |

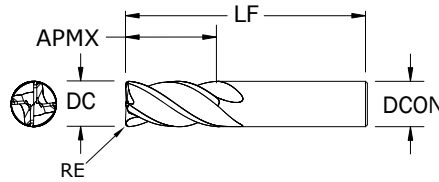


TOLERANCES (mm)

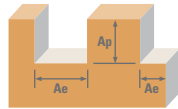
| DIAMETER | DC | DCON |
|-----------|-----------------|------|
| 6 | +0,000 / -0,030 | h6 |
| > 6 - 10 | +0,000 / -0,040 | h6 |
| > 10 - 20 | +0,000 / -0,050 | h6 |

CORNER RADIUS TOLERANCES (mm)

RE = +0,000 / -0,020

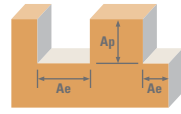


| Dimensions (mm) | | | | | EDP Numbers by Coating and Type | |
|------------------|---------------|----------------|----------------|---------------|---------------------------------|--------------------|
| Cutting Diameter | Length of Cut | Overall Length | Shank Diameter | Corner Radius | Ti-NAMITE®-X (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 |



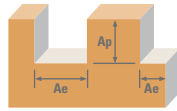
| Series ZR Fractional | Hardness | Profile | Ae x DC | Ap x DC | Vc (sfm) | | | | | | | |
|---|-----------------------------|---------|---------|---------|------------------|------------------|--------|--------|--------|--------|--------|------|
| | | | | | | 1/4 | 3/8 | 1/2 | 5/8 | 3/4 | | |
| CARBON STEELS 1018, 1040, 1080, 1090, 10L50, 1140, 1212, 12L15, 1525, 1536 | ≤ 275 Bhn or ≤ 28 HRc | 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 | ≤ 375 Bhn or ≤ 40 HRc | 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 | ≤ 375 Bhn or ≤ 40 HRc | 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 | |
| STAINLESS STEELS (FREE MACHINING) 303, 416, 420F, 430F, 440F | ≤ 275 Bhn or ≤ 28 HRc | 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 | ≤ 275 Bhn or ≤ 28 HRc | 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 | ≤ 325 Bhn or ≤ 35 HRc | 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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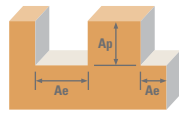
| Series ZR Fractional | Hardness | Profile Ae x DC | Ap x DC | Vc (sfm) | | | | | | | | |
|---|---|-----------------------------|--------------------|------------------|------------------|------------------|------------|--------|--------|--------|--------|--------|
| | | | | | 1/4 | 3/8 | 1/2 | 5/8 | 3/4 | | | |
| CAST IRONS (LOW & MEDIUM ALLOY) Gray, Malleable, Ductile | ≤ 220 Bhn or ≤ 19 HRc | Profile Ae x DC | ≤ 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 | |
| | 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 | | |
| | CAST IRONS (HIGH ALLOY) Gray, Malleable, Ductile | ≤ 260 Bhn or ≤ 26 HRc | Profile Ae x DC | ≤ 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 | ≤ 1 | 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 | |
| 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 601, 617, 625, Incoloy, Monel 400 | | ≤ 300 Bhn or ≤ 32 HRc | Profile Ae x DC | ≤ 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 | |
| | 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 | | |
| | SUPER ALLOYS (NICKEL, COBALT, IRON BASE) Inconel 718, X-750, Incoloy, Waspaloy, Hastelloy, Rene | ≤ 400 Bhn or ≤ 43 HRc | Profile Ae x DC | ≤ 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 |
| 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 Pure Titanium, Ti6Al4V, Ti6Al2Sn4Zr2Mo, Ti4Al4Mo2Sn0.5Si | | ≤ 350 Bhn or ≤ 38 HRc | Profile Ae x DC | ≤ 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 | |
| | 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 | | |
| | TITANIUM ALLOYS (DIFFICULT) Ti10Al2Fe3Al, Ti5Al5V5Mo3Cr, Ti7Al4Mo, Ti3Al8V6Cr4Zr4Mo, Ti6Al6V6Sn, Ti15V3 Cr3Sn3Al | ≤ 440 Bhn or ≤ 47 HRc | Profile Ae x DC | ≤ 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 | | |
| CARBON STEELS 1018, 1040, 1080, 1090, 10L50, 1140, 1212, 12L15, 1525, 1536 | ≤ 275 Bhn or ≤ 28 HRC | Profile | ≤ 0.25 | ≤ APMX | 206 (165-247) | RPM | 10920 | 8190 | 6552 | 5460 | 4095 | 3276 |
| | | | | | | Fz | 0.0464 | 0.0668 | 0.0870 | 0.1071 | 0.1247 | 0.1376 |
| | | | | | | Feed (mm/min) | 2025 | 2189 | 2280 | 2338 | 2043 | 1803 |
| | Slot | 1 | ≤ 1 | 137 (110-165) | RPM | 7280 | 5460 | 4368 | 3640 | 2730 | 2184 | |
| | | | | | Fz | 0.0365 | 0.0526 | 0.0685 | 0.0843 | 0.0982 | 0.1083 | |
| | | | | | Feed (mm/min) | 1063 | 1149 | 1197 | 1227 | 1072 | 946 | |
| | Plunge | 1 | ≤ 1 | 195 (156-234) | RPM | 10354 | 7765 | 6212 | 5177 | 3883 | 3106 | |
| | | | | | 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 | ≤ 0.25 | ≤ APMX | 160 (128-192) | RPM | 8493 | 6370 | 5096 | 4247 | 3185 | 2548 |
| | | | | | | Fz | 0.0324 | 0.0518 | 0.0727 | 0.0932 | 0.1096 | 0.1207 |
| | | | | | | Feed (mm/min) | 1100 | 1320 | 1481 | 1584 | 1396 | 1230 |
| | Slot | 1 | ≤ 1 | 107 (85-128) | RPM | 5662 | 4247 | 3397 | 2831 | 2123 | 1699 | |
| | | | | | Fz | 0.0255 | 0.0408 | 0.0572 | 0.0734 | 0.0863 | 0.0950 | |
| | | | | | Feed (mm/min) | 578 | 693 | 777 | 831 | 733 | 645 | |
| | Plunge | 1 | ≤ 1 | 152 (122-183) | RPM | 8089 | 6067 | 4853 | 4044 | 3033 | 2427 | |
| | | | | | 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 | ≤ 0.25 | ≤ APMX | 73 (59-88) | RPM | 3883 | 2912 | 2330 | 1941 | 1456 | 1165 |
| | | | | | | Fz | 0.0259 | 0.0396 | 0.0541 | 0.0685 | 0.0826 | 0.0935 |
| | | | | | | Feed (mm/min) | 402 | 462 | 504 | 532 | 481 | 436 |
| | Slot | 1 | ≤ 0.5 | 49 (39-59) | RPM | 2588 | 1941 | 1553 | 1294 | 971 | 777 | |
| | | | | | Fz | 0.0204 | 0.0312 | 0.0426 | 0.0539 | 0.0650 | 0.0736 | |
| | | | | | Feed (mm/min) | 211 | 242 | 265 | 279 | 252 | 229 | |
| | Plunge | 1 | ≤ 0.5 | 67 (54-80) | RPM | 3559 | 2669 | 2135 | 1780 | 1335 | 1068 | |
| | | | | | Fz | 0.0187 | 0.0286 | 0.0390 | 0.0493 | 0.0584 | 0.0674 | |
| | | | | | Feed (mm/min) | 266 | 305 | 333 | 351 | 312 | 288 | |
| STAINLESS STEELS (FREE MACHINING) 303, 416, 420F, 430F, 440F | ≤ 275 Bhn or ≤ 28 HRC | Profile | ≤ 0.25 | ≤ APMX | 165 (132-198) | RPM | 8736 | 6552 | 5242 | 4368 | 3276 | 2621 |
| | | | | | | Fz | 0.0328 | 0.0488 | 0.0659 | 0.0829 | 0.0981 | 0.1090 |
| | | | | | | Feed (mm/min) | 1145 | 1278 | 1382 | 1449 | 1285 | 1142 |
| | Slot | 1 | ≤ 1 | 110 (88-132) | RPM | 5824 | 4368 | 3494 | 2912 | 2184 | 1747 | |
| | | | | | Fz | 0.0258 | 0.0384 | 0.0519 | 0.0653 | 0.0772 | 0.0858 | |
| | | | | | Feed (mm/min) | 601 | 671 | 725 | 761 | 674 | 600 | |
| | Plunge | 1 | ≤ 1 | 155 (124-187) | RPM | 8251 | 6188 | 4950 | 4125 | 3094 | 2475 | |
| | | | | | 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 | ≤ 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 | ≤ 0.5 | 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 | |
| | 6° Ramp | 1 | ≤ 0.5 | 107 (85-128) | RPM | 5662 | 4247 | 3397 | 2831 | 2123 | 1699 | |
| | | | | | 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 | ≤ 0.25 | ≤ APMX | 110 (88-132) | RPM | 5824 | 4368 | 3494 | 2912 | 2184 | 1747 |
| | | | | | | Fz | 0.0254 | 0.0390 | 0.0537 | 0.0683 | 0.0846 | 0.0979 |
| | | | | | | Feed (mm/min) | 592 | 681 | 751 | 796 | 739 | 684 |
| | Slot | 1 | ≤ 1 | 73 (59-88) | RPM | 3883 | 2912 | 2330 | 1941 | 1456 | 1165 | |
| | | | | | Fz | 0.0200 | 0.0307 | 0.0423 | 0.0538 | 0.0666 | 0.0771 | |
| | | | | | Feed (mm/min) | 311 | 358 | 394 | 418 | 388 | 359 | |
| | 6° Ramp | 1 | ≤ 1 | 104 (83-124) | RPM | 5500 | 4125 | 3300 | 2750 | 2063 | 1650 | |
| | | | | | Fz | 0.0183 | 0.0281 | 0.0387 | 0.0493 | 0.0599 | 0.0706 | |
| | | | | | Feed (mm/min) | 403 | 464 | 511 | 542 | 494 | 466 | |

Continued on next page



| Series ZR Metric | Hardness | Ae x DC | Ap x DC | Vc (m/min) | DC • mm | | | | | | | | |
|---|---|-----------------------------|-------------|------------------|------------------|-----------------|---------------|--------|--------|--------|--------|--------|--------|
| | | | | | 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 | |
| | Plunge | 1 | ≤ 1 | 183 (146-219) | 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 | | |
| | S 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 | |
| Plunge | | 1 | ≤ 1 | 107 (85-128) | RPM | 5662 | 4247 | 3397 | 2831 | 2123 | 1699 | | |
| | | | | | Fz | 0.0184 | 0.0281 | 0.0387 | 0.0493 | 0.0599 | 0.0706 | | |
| | | | | | Feed (mm/min) | 417 | 477 | 526 | 558 | 509 | 480 | | |
| 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 | |
| | 3° Ramp | 1 | ≤ 0.5 | 30 (24-37) | 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 | | |
| | S 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 | |
| 3° Ramp | | 1 | ≤ 0.5 | 15 (12-18) | RPM | 809 | 607 | 485 | 404 | 303 | 243 | | |
| | | | | | Fz | 0.0120 | 0.0195 | 0.0278 | 0.0361 | 0.0431 | 0.0501 | | |
| | | | | | Feed (mm/min) | 39 | 47 | 54 | 58 | 52 | 49 | | |
| S 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 | |
| | 6° Ramp | 1 | ≤ 0.5 | 76 (61-91) | 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 | | |
| | S 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 | |
| 6° Ramp | | 1 | ≤ 0.5 | 43 (34-51) | 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)
 - Refer to the KYOCERA SGS APEX® for complete technical information (www.kyocera-sgstool.com)



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EDP 00067 09/2024
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