



TiN
(Titanium Nitride)

General purpose coating - low heat resistance. Good lubricity.



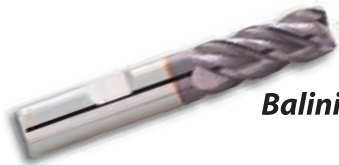
TiCN
(Titanium Carbonitride)

Good abrasion resistance. Recommended for aluminum, brass and bronze applications. Low heat resistance - good lubricity.



TiALN - Balinit® FUTURA
(Titanium Aluminum Nitride)

Multi-layer coating with good thermal stability for increased speeds and feeds. For semi-dry to dry cutting of most steels, high-nickel alloys, stainless steel and cast iron. Excellent heat resistance - good lubricity. For materials that are 40Rc and under.



Balinit® X.CEED

A single-layer coating whose hardness, oxidation resistance and thermal stability were optimized for material hardness above 52 HRC and high-speed machining of materials that are difficult to work (titanium alloys, Inconel). Competes with ALTiN.



Balinit® HARDLUBE

Multi-layer coating with thermal stability and lubricating properties needed for the drilling of steels, high-nickel alloys, stainless steel, cast iron, aluminum, brass, and bronze. Excellent heat resistance - great lubricity.



Balinit® HELICA

G6 Generation coating. Greater abrasion resistance, extra shear strength, lower adhesion tendency, maximum toughness and a very smooth surface achieve a quantum leap in drilling performance. This coating is particularly advantageous for carbide drills.



ALUMASTAR®
(Titanium Diboride - TiB₂)

A thin film coating with a low affinity for aluminum, ideal for machining aluminum alloys. The resistance to adhesion of aluminum allows higher speeds or feeds. Coating thickness is intentionally kept lower in order to maintain a sharp edge.



CRYSTALLINE DIAMOND

Improved productivity in composites and non-ferrous metals. Excellent choice for cutting graphite, fiberglass, and silicon-based aluminum. Can be added to a special for milling or drilling applications.

General Solid Carbide Milling Guide

Fractional

Type	Rc Hardness	MILLING SFM (Vc)					CHIPLOAD PER FLUTE (Fz)				
		2 f ute stub / std.	2 f ute extra length	3 & 4 f ute stub / std.	3 & 4 f ute extra length	Diamond Coated	1/32" - 1/8"	1/8" - 1/4"	1/4" - 1/2"	1/2" - 1"	1" - 1-1/4"
COBALT BASE ALLOYS											
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	-	-	175 - 225	150 - 200	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
	> 35	-	-	125 - 175	100 - 150	-	.0003" - .0005"	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	.0020" - .0040"
NICKEL BASE ALLOYS											
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	-	-	125 - 175	100 - 150	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
	> 35	-	-	70 - 115	70 - 100	-	.0003" - .0005"	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	.0020" - .0040"
IRON BASE ALLOYS											
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	-	-	175 - 225	150 - 200	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
	> 35	-	-	125 - 175	100 - 150	-	.0003" - .0005"	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	.0020" - .0040"
MONEL											
Monel - 65% Nickel		175 - 300	125 - 175	175 - 300	125 - 175	-	.0007" - .0015"	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"	.0040" - .0060"
TITANIUM ALLOYS											
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		200 - 300	125 - 250	200 - 300	125 - 250	-	.0007" - .0015"	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"	.0040" - .0060"
		-	-	175 - 225	150 - 200	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
STAINLESS STEELS											
13/8, 15/5, 17-4, pH Types	< 35	-	-	150 - 250	100 - 150	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
	> 35	-	-	125 - 175	80 - 150	-	.0003" - .0005"	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	.0020" - .0040"
Inox, 200 Series, 300 Series	< 35	-	-	200 - 250	125 - 175	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
	> 35	-	-	150 - 200	100 - 150	-	.0003" - .0005"	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	.0020" - .0040"
304L, 316L, Nitronic 50, Inox	< 35	-	-	90 - 125	80 - 120	-	.0005" - .0008"	.0008" - .0015"	.0010" - .0020"	.0020" - .0040"	.0030" - .0050"
	> 35	-	-	75 - 110	60 - 90	-	.0003" - .0005"	.0005" - .0010"	.0010" - .0015"	.0010" - .0030"	.0020" - .0040"
400 Series	< 35	-	-	150 - 250	100 - 150	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
	> 35	-	-	125 - 175	80 - 150	-	.0003" - .0005"	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	.0020" - .0040"
HIGH STRENGTH TOOL STEELS											
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 30	-	-	150 - 225	125 - 175	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
	30 - 38	-	-	90 - 125	80 - 120	-	.0003" - .0005"	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	.0020" - .0040"
	> 38	-	-	60 - 90	50 - 80	-	.0002" - .0004"	.0003" - .0007"	.0008" - .0015"	.0010" - .0025"	.0015" - .0035"
MEDIUM ALLOY TOOL STEELS											
200, 250, 300, 8620	< 35	-	-	175 - 250	150 - 200	-	.0007" - .0015"	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"	.0040" - .0060"
	> 35	-	-	100 - 175	100 - 150	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
CARBON STEELS											
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	-	-	175 - 250	150 - 200	-	.0007" - .0015"	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"	.0040" - .0060"
	> 35	-	-	100 - 175	100 - 150	-	.0005" - .0010"	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	.0030" - .0050"
CAST MATERIAL											
Steel		225 - 325	175 - 250	250 - 350	175 - 250	-	.0010" - .0020"	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	.0050" - .0100"
Ductile Iron		200 - 300	125 - 200	200 - 300	125 - 200	-	.0005" - .0015"	.0010" - .0030"	.0015" - .0040"	.0020" - .0060"	.0030" - .0080"
Gray Iron		225 - 325	175 - 250	250 - 350	175 - 250	-	.0010" - .0020"	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	.0050" - .0100"
Aluminum		250 - 350	250 - 350	250 - 350	250 - 350	-	.0010" - .0020"	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	.0050" - .0100"
ALUMINUM											
Aircraft Grade (6061, 7075)	Standard Speed	300 - 500	300 - 500	300 - 500	300 - 500	-	.0010" - .0020"	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	.0050" - .0150"
	High Speed	<i>(SEE HIGH SPEED ALUMINUM CHART - PAGE 196)</i>									
MAGNESIUM											
		300 - 500	300 - 500	300 - 500	300 - 500	-	.0010" - .0020"	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	.0050" - .0100"
COPPER											
Copper Alloys		300 - 400	250 - 350	300 - 450	250 - 350	-	.0007" - .0015"	.0010" - .0025"	.0015" - .0035"	.0020" - .0080"	.0040" - .0100"
BRASS, BRONZE											
Brass, Aluminum/Bronze, Low Silicon Bronze		300 - 400	200 - 300	275 - 375	200 - 300	-	.0007" - .0015"	.0010" - .0025"	.0015" - .0035"	.0020" - .0080"	.0040" - .0100"
COMPOSITE MATERIAL											
Glass Epoxy, Fiberglass, Plastics		200 - 400	200 - 400	200 - 400	200 - 400	200 - 500	.0010" - .0020"	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	.0050" - .0100"
Graphite, G10		<i>(SEE GRAPHITE CHART - PAGE 202)</i>				300 - 1000	.0010" - .0020"	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	.0050" - .0100"

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

High Performance Solid Carbide Milling Guide

Fractional

Type	Rc Hardness	MILLING SFM (Vc)				CHIPLOAD PER FLUTE (Fz)			
		Aluminum Series		All Other High Performance Series		1/8" - 1/4"	1/4" - 1/2"	1/2" - 1"	
		Uncoated	Coated	Uncoated	X.Ceed Coated				
COBALT BASE ALLOYS									
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	-	-	200 - 275	275 - 400	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
	> 35	-	-	125 - 175	175 - 250	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	
NICKEL BASE ALLOYS									
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	-	-	150 - 200	200 - 300	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
	> 35	-	-	90 - 125	125 - 200	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	
IRON BASE ALLOYS									
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	-	-	200 - 300	250 - 350	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
	> 35	-	-	150 - 200	200 - 250	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	
MONEL									
Monel - 65% Nickel		-	-	200 - 300	275 - 400	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"	
TITANIUM ALLOYS									
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si			200 - 400	400 - 600	250 - 350	300 - 500	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"
5553 / Beta Titanium		-	-	225 - 275	250 - 300	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
STAINLESS STEELS									
13/8, 15/5, 17-4, pH Types	< 35	-	-	200 - 350	250 - 300	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
	> 35	-	-	150 - 250	200 - 250	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	
Inox, 200 Series, 300 Series	< 35	-	-	250 - 350	300 - 400	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
	> 35	-	-	175 - 275	225 - 300	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	
304L, 316L, Nitronic 50, Inox	< 35	-	-	125 - 200	250 - 300	.0008" - .0015"	.0010" - .0020"	.0020" - .0040"	
	> 35	-	-	90 - 125	200 - 250	.0005" - .0010"	.0010" - .0015"	.0010" - .0030"	
400 Series	< 35	-	-	200 - 350	250 - 300	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
	> 35	-	-	150 - 250	200 - 250	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	
HIGH STRENGTH TOOL STEELS									
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 30	-	-	225 - 300	250 - 350	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
	30 - 38	-	-	125 - 200	150 - 250	.0005" - .0015"	.0010" - .0020"	.0010" - .0030"	
	> 38	(SEE HIGH ROCKWELL CHART - PAGE 198)							
MEDIUM ALLOY TOOL STEELS									
200, 250, 300, 8620	< 35	-	-	250 - 350	250 - 400	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"	
	> 35	-	-	150 - 200	150 - 300	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
CARBON STEELS									
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	-	-	250 - 350	300 - 500	.0010" - .0025"	.0015" - .0040"	.0030" - .0050"	
	> 35	-	-	150 - 200	250 - 400	.0008" - .0020"	.0010" - .0030"	.0020" - .0040"	
CAST MATERIAL									
Steel		-	-	175 - 250	250 - 400	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	
Ductile Iron		-	-	200 - 300	350 - 500	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	
Gray Iron		-	-	175 - 250	300 - 500	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	
Aluminum		300 - 400	350 - 500	300 - 400	-	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	
ALUMINUM									
Aircraft Grade (6061, 7075)	Standard Speed	300 - 500	400 - 700	300 - 500	400 - 600	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	
	High Speed	(SEE HIGH SPEED ALUMINUM CHART - PAGE 196)							
MAGNESIUM									
		300 - 400	300 - 600	300 - 400	350 - 600	.0015" - .0040"	.0020" - .0060"	.0030" - .0100"	
COPPER									
Copper Alloys		300 - 400	400 - 600	200 - 400	350 - 600	.0010" - .0025"	.0015" - .0035"	.0020" - .0080"	
BRASS, BRONZE									
Brass, Aluminum/Bronze, Low Silicon Bronze		300 - 400	400 - 600	200 - 400	300 - 500	.0010" - .0025"	.0015" - .0035"	.0020" - .0080"	

Beryllium added to any material adds hardness and some nickel content. If tool displays chatter, increase feed (IPM) up to 30% and reduce speed (RPM) by 10%. More detailed information is available on succeeding pages regarding the following materials: Aluminum, High Rockwell Steels, Graphite, and VRX end mills

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

General Solid Carbide Milling Guide

Metric

Type	Rc Hardness	MILLING M/Min. (Vc)					CHIPLOAD PER FLUTE (Fz)				
		2 f ute stub / std.	2 f ute extra length	3 & 4 f ute stub / std.	3 & 4 f ute extra length	DIAMOND COATED	1.0 - 3.0	3.0 - 6.0	6.0 - 12.0	12.0 - 25.0	25.0 - 32.0
COBALT BASE ALLOYS											
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	-	-	50 - 70	45 - 60	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
	> 35	-	-	35 - 50	30 - 45	-	.005 - .015	.010 - .035	.025 - .050	.025 - .075	.050 - .100
NICKEL BASE ALLOYS											
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	-	-	35 - 50	30 - 45	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
	> 35	-	-	20 - 35	15 - 25	-	.005 - .015	.010 - .035	.025 - .050	.025 - .075	.050 - .100
IRON BASE ALLOYS											
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	-	-	50 - 70	45 - 60	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
	> 35	-	-	35 - 50	30 - 45	-	.005 - .015	.010 - .035	.025 - .050	.025 - .075	.050 - .100
MONEL											
Monel - 65% Nickel		50 - 90	35 - 50	50 - 90	35 - 50	-	.015 - .035	.025 - .065	.035 - .100	.075 - .125	.100 - .150
TITANIUM ALLOYS											
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		60 - 90	35 - 75	60 - 90	35 - 75	-	.015 - .035	.025 - .065	.035 - .100	.075 - .125	.100 - .150
		-	-	50 - 65	45 - 60	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
STAINLESS STEELS											
13/8, 15/5, 17-4, pH Types	< 35	-	-	45 - 75	30 - 45	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
	> 35	-	-	35 - 50	25 - 45	-	.005 - .015	.010 - .035	.025 - .050	.025 - .075	.050 - .100
Inox, 200 Series, 300 Series	< 35	-	-	60 - 80	40 - 55	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
	> 35	-	-	45 - 60	30 - 45	-	.005 - .015	.010 - .035	.025 - .050	.025 - .075	.050 - .100
304L, 316L, Nitronic 50, Inox	< 35	-	-	25 - 40	25 - 35	-	.010 - .020	.020 - .035	.025 - .050	.035 - .075	.050 - .100
	> 35	-	-	20 - 35	15 - 25	-	.005 - .015	.010 - .025	.025 - .035	.025 - .050	.035 - .075
400 Series	< 35	-	-	45 - 75	30 - 45	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
	> 35	-	-	35 - 50	25 - 40	-	.005 - .015	.010 - .035	.025 - .050	.025 - .075	.050 - .100
HIGH STRENGTH TOOL STEELS											
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 30	-	-	45 - 60	35 - 50	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
	30 - 38	-	-	30 - 45	25 - 35	-	.005 - .015	.010 - .035	.025 - .050	.025 - .075	.050 - .100
	> 38	-	-	15 - 30	10 - 25	-	.003 - .008	.005 - .020	.015 - .040	.020 - .065	.035 - .090
MEDIUM ALLOY TOOL STEELS											
200, 250, 300, 8620	< 35	-	-	55 - 75	45 - 60	-	.015 - .035	.025 - .065	.035 - .100	.075 - .125	.100 - .150
	> 35	-	-	35 - 55	30 - 45	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
CARBON STEELS											
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	-	-	55 - 75	45 - 60	-	.015 - .035	.025 - .065	.035 - .100	.075 - .125	.100 - .150
	> 35	-	-	35 - 55	30 - 45	-	.010 - .025	.020 - .050	.025 - .075	.050 - .100	.075 - .125
CAST MATERIAL											
Steel		70 - 100	50 - 75	75 - 105	50 - 75	-	.025 - .050	.035 - .100	.050 - .150	.075 - .250	.125 - .250
Ductile Iron		60 - 90	35 - 60	60 - 90	35 - 60	-	.015 - .035	.025 - .075	.035 - .100	.050 - .150	.075 - .200
Gray Iron		70 - 100	50 - 75	75 - 105	50 - 75	-	.025 - .050	.035 - .100	.050 - .150	.075 - .250	.125 - .250
Aluminum		75 - 105	75 - 105	75 - 105	75 - 105	-	.025 - .050	.035 - .100	.050 - .150	.075 - .250	.125 - .250
ALUMINUM											
Aircraft Grade (6061, 7075)	Standard Speed	90 - 150	90 - 150	90 - 150	90 - 150	-	.025 - .050	.035 - .100	.050 - .150	.075 - .250	.125 - .300
	High Speed	(SEE HIGH SPEED ALUMINUM CHART - PAGE 196)									
MAGNESIUM											
		90 - 150	90 - 150	90 - 150	90 - 150	-	.025 - .050	.035 - .100	.050 - .150	.075 - .250	.125 - .250
COPPER											
Copper Alloys		120 - 150	75 - 105	90 - 135	75 - 105	-	.020 - .040	.025 - .065	.040 - .090	.050 - .200	.075 - .250
BRASS, BRONZE											
Brass, Aluminum/Bronze, Low Silicon Bronze		90 - 120	60 - 90	75 - 115	60 - 90	-	.020 - .040	.025 - .065	.040 - .090	.050 - .200	.075 - .250
COMPOSITE MATERIAL											
Glass Epoxy, Fiberglass, Plastics		60 - 120	60 - 120	60 - 120	60 - 120	60 - 150	.025 - .050	.035 - .100	.050 - .150	.075 - .250	.125 - .250
Graphite, G10		(SEE GRAPHITE CHART - PAGE 202)				90 - 300	.025 - .050	.035 - .100	.050 - .150	.075 - .250	.125 - .250

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

High Performance Solid Carbide Milling Guide

Metric

Type	Rc Hardness	MILLING M/Min. (Vc)				CHIPLOAD PER FLUTE (Fz)		
		Aluminum Series		All Other High Performance Series		3.0 - 6.0	6.0 - 12.0	12.0 - 25.0
		Uncoated	Coated	Uncoated	X.Ceed Coated			
COBALT BASE ALLOYS								
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-4, L-605	< 35	-	-	60 - 80	80 - 120	.020 - .050	.025 - .075	.050 - .100
	> 35	-	-	40 - 50	50 - 75	.010 - .035	.025 - .050	.025 - .075
NICKEL BASE ALLOYS								
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	-	-	45 - 60	60 - 90	.020 - .050	.025 - .075	.050 - .100
	> 35	-	-	25 - 40	40 - 60	.010 - .035	.025 - .050	.025 - .075
IRON BASE ALLOYS								
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	-	-	60 - 90	75 - 105	.020 - .050	.025 - .075	.050 - .100
	> 35	-	-	45 - 60	60 - 75	.010 - .035	.025 - .050	.025 - .075
MONEL								
Monel - 65% Nickel		-	-	60 - 90	80 - 120	.025 - .065	.035 - .100	.075 - .125
TITANIUM ALLOYS								
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		60 - 120	120 - 180	75 - 105	90 - 150	.025 - .065	.035 - .100	.075 - .125
5553 / Beta Titanium		-	-	65 - 80	75 - 90	.020 - .050	.025 - .075	.050 - .100
STAINLESS STEELS								
13/8, 15/5, 17-4, pH Types	< 35	-	-	60 - 105	75 - 90	.020 - .050	.025 - .075	.050 - .100
	> 35	-	-	45 - 75	60 - 75	.010 - .035	.025 - .050	.025 - .075
Inox, 200 Series, 300 Series	< 35	-	-	75 - 105	90 - 120	.020 - .050	.025 - .075	.050 - .100
	> 35	-	-	50 - 80	65 - 90	.010 - .035	.025 - .050	.025 - .075
304L, 316L, Nitronic 50, Inox	< 35	-	-	40 - 60	75 - 90	.020 - .035	.025 - .050	.035 - .075
	> 35	-	-	25 - 40	60 - 75	.010 - .025	.025 - .035	.025 - .050
400 Series	< 35	-	-	60 - 105	75 - 90	.020 - .050	.025 - .075	.050 - .100
	> 35	-	-	45 - 75	60 - 75	.010 - .035	.025 - .050	.025 - .075
HIGH STRENGTH TOOL STEELS								
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 30	-	-	65 - 90	75 - 105	.020 - .050	.025 - .075	.050 - .100
	30 - 38	-	-	40 - 60	45 - 75	.010 - .035	.025 - .050	.025 - .075
	> 38	(SEE HIGH ROCKWELL CHART - PAGE 199)						
MEDIUM ALLOY TOOL STEELS								
200, 250, 300, 8620	< 35	-	-	75 - 105	75 - 120	.025 - .065	.035 - .100	.075 - .125
	> 35	-	-	45 - 60	45 - 90	.020 - .050	.025 - .075	.050 - .100
CARBON STEELS								
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	-	-	75 - 105	90 - 150	.025 - .065	.035 - .100	.075 - .125
	> 35	-	-	45 - 60	75 - 120	.020 - .050	.025 - .075	.050 - .100
CAST MATERIAL								
Steel		-	-	50 - 75	75 - 120	.035 - .100	.050 - .150	.075 - .250
Ductile Iron		-	-	60 - 90	105 - 150	.035 - .100	.050 - .150	.075 - .250
Gray Iron		-	-	50 - 75	90 - 150	.035 - .100	.050 - .150	.075 - .250
Aluminum		90 - 120	90 - 150	90 - 120	-	.035 - .100	.050 - .150	.075 - .250
ALUMINUM								
Aircraft Grade (6061, 7075)	Standard Speed	90 - 150	120 - 210	90 - 150	120 - 180	.035 - .100	.050 - .150	.075 - .250
	High Speed	(SEE HIGH SPEED ALUMINUM CHART - PAGE 196)						
MAGNESIUM								
		90 - 120	90 - 180	90 - 120	105 - 180	.035 - .100	.050 - .150	.075 - .250
COPPER								
Copper Alloys		90 - 120	120 - 180	60 - 120	105 - 180	.025 - .065	.040 - .090	.050 - .200
BRASS, BRONZE								
Brass, Aluminum/Bronze, Low Silicon Bronze		90 - 120	120 - 180	60 - 120	90 - 150	.025 - .065	.040 - .090	.050 - .200

Beryllium added to any material adds hardness and some nickel content. If tool displays chatter, increase feed (M/Min.) up to 30% and reduce speed (RPM) by 10%. More detailed information is available on succeeding pages regarding the following materials: Aluminum, High Rockwell Steels, Graphite, and VRX end mills

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL End Mill Application Guide for Aircraft Grade Aluminum

Fractional

Diameter	SLOTTING		SIDE MILLING
	Axial = .5xD	Axial = 1xD	Axial ≤ 1xD Radial ≤ .5xD
	SFM = 1500 - 2000	SFM = 750 - 1500	SFM = 1500 - 2000
	CPT = 1.5% - 3% of diameter	CPT = 1% - 2% of diameter	CPT = 2% - 3% of diameter
3/16"	.0028" - .0056"	.0018" - .0037"	.0037" - .0056"
1/4"	.0037" - .0074"	.0025" - .0050"	.0050" - .0075"
5/16"	.0052" - .0104"	.0031" - .0062"	.0062" - .0094"
3/8"	.0055" - .0110"	.0037" - .0074"	.0075" - .0112"
1/2"	.0075" - .0150"	.0050" - .0100"	.0100" - .0150"
5/8"	.0093" - .0186"	.0062" - .0125"	.0125" - .0187"
3/4"	.0112" - .0224"	.0075" - .0150"	.0150" - .0225"
1"	.0150" - .0300"	.0100" - .0200"	.0200" - .0300"

Metric

Diameter	SLOTTING		SIDE MILLING
	Axial = .5xD	Axial = 1xD	Axial ≤ 1xD Radial ≤ 0.5xD
	M/Min. = 450 - 760	M/Min. = 225 - 450	M/Min. = 450 - 760
	CPT = 1.5% - 3% of diameter	CPT = 1% - 2% of diameter	CPT = 2% - 3% of diameter
4.0	.060 - .120	.040 - .080	.080 - .120
6.0	.090 - .180	.060 - .120	.120 - .180
8.0	.120 - .240	.080 - .160	.160 - .240
10.0	.150 - .300	.100 - .200	.200 - .300
12.0	.180 - .360	.120 - .240	.240 - .360
16.0	.240 - .480	.160 - .320	.320 - .480
20.0	.300 - .600	.200 - .400	.400 - .600
25.0	.375 - .750	.250 - .500	.500 - .750

CPT = Chipload per flute (Fz)

END MILL NOTES: Climb milling recommended for best finish
 Figures shown are based on 6061 / 7075
 CAT 50 Taper holders are recommended for 3/4" and 1" diameter end mills
 In controlled slotting tests, 4000 SFM, 1% diameter Chipload Per Flute, and 50% of Dia. axial depth were obtained
 In cases for tools with slower SFM (M/Min.), reference Series 242M/842M, page 62

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL VRX/VHM Series End Mills

Application Guide

Fractional

Material	Rc	SFM (Vc)	CHIPLOAD PER FLUTE Recommendations (Fz)									*Profiling	Slotting
			1/8"	3/16"	1/4"	5/16"	3/8"	1/2"	5/8"	3/4"	1"	Radial	Axial
Stainless Steel: 303		290-375	.0004"-.0008"	.0008"-.0010"	.0010"-.0015"	.0013"-.0020"	.0015"-.0020"	.0020"-.0030"	.0025"-.0035"	.0030"-.0040"	.0035"-.0045"	1 x D	1 x D
Stainless Steel: 304, 316, 400 Series, Kovar, Invar		250-300	.0003"-.0006"	.0006"-.0010"	.0008"-.0015"	.0010"-.0020"	.0012"-.0020"	.0015"-.0020"	.0020"-.0025"	.0025"-.0030"	.0025"-.0035"	1 x D	1 x D
Stainless Steel: 304L, 316L, 17/4, 15/5, 13/8, PH Materials	< 35	250-300	.0003"-.0006"	.0006"-.0008"	.0007"-.0010"	.0010"-.0015"	.0015"-.0020"	.0015"-.0025"	.0020"-.0030"	.0025"-.0035"	.0030"-.0040"	1 x D	1 x D
	> 35	200-250	.0003"-.0006"	.0006"-.0008"	.0007"-.0010"	.0008"-.0010"	.0010"-.0015"	.0010"-.0020"	.0015"-.0025"	.0020"-.0030"	.0020"-.0030"	0.5 x D	0.5 x D
High Temperature Alloys: Inconel 625/718, A286	< 35	125-175	.0004"-.0008"	.0008"-.0010"	.0010"-.0015"	.0012"-.0020"	.0020"-.0025"	.0025"-.0030"	.0030"-.0035"	.0030"-.0035"	.0030"-.0040"	0.5 x D	0.3 x D
	> 35	80-100	.0003"-.0006"	.0007"-.0010"	.0008"-.0010"	.0010"-.0015"	.0010"-.0015"	.0010"-.0015"	.0012"-.0020"	.0015"-.0025"	.0015"-.0025"	0.2 x D	0.2 x D
Titanium: 6AL4V, CP		150-200	.0004"-.0008"	.0008"-.0010"	.0010"-.0015"	.0010"-.0020"	.0015"-.0020"	.0020"-.0030"	.0025"-.0030"	.0030"-.0035"	.0030"-.0040"	1 x D	1 x D
Carbon Steels: 1000 Series	< 35	400-600	.0004"-.0008"	.0008"-.0010"	.0010"-.0015"	.0010"-.0020"	.0015"-.0020"	.0020"-.0030"	.0025"-.0035"	.0030"-.0040"	.0035"-.0045"	0.3 x D	0.5 x D
	> 35	275-425	.0003"-.0006"	.0006"-.0008"	.0008"-.0012"	.0010"-.0015"	.0010"-.0020"	.0015"-.0025"	.0020"-.0025"	.0020"-.0030"	.0025"-.0035"	0.3 x D	0.5 x D
High Strength Tool Steel: 4130, 4140, A2, D2, P20, H13	< 30	250-350	.0003"-.0006"	.0006"-.0010"	.0008"-.0015"	.0010"-.0020"	.0012"-.0020"	.0015"-.0022"	.0020"-.0025"	.0025"-.0030"	.0025"-.0035"	0.5 x D	1 x D
	30-38	150-200	.0003"-.0006"	.0006"-.0008"	.0007"-.0010"	.0008"-.0010"	.0010"-.0015"	.0010"-.0020"	.0015"-.0025"	.0020"-.0030"	.0020"-.0030"	0.3 x D	1 x D
	> 38	(SEE HIGH ROCKWELL CHART - PAGE 198)											
Gray Cast Iron		400-500	.0005"-.0010"	.0010"-.0020"	.0010"-.0020"	.0015"-.0020"	.0015"-.0025"	.0020"-.0035"	.0025"-.0035"	.0030"-.0040"	.0040"-.0050"	1 x D	1 x D

Metric

Material	Rc	M/Min. (Vc)	CHIPLOAD PER FLUTE - Metric Recommendations (Fz)									*Profiling	Slotting
			3.0	5.0	6.0	8.0	10.0	12.0	16.0	20.0	25.0	Radial	Axial
Stainless Steel: 303		90-115	.010-.020	.020-.025	.025-.038	.033-.050	.038-.050	.050-.076	.063-.089	.076-.102	.089-.114	1 x D	1 x D
Stainless Steel: 304, 316, 400 Series, Kovar, Invar		75-90	.008-.015	.015-.025	.020-.038	.025-.050	.030-.050	.038-.050	.050-.063	.063-.076	.063-.089	1 x D	1 x D
Stainless Steel: 304L, 316L, 17/4, 15/5, 13/8, PH Materials	< 35	75-85	.008-.015	.015-.020	.018-.025	.025-.038	.038-.050	.038-.063	.050-.076	.063-.089	.076-.102	1 x D	1 x D
	> 35	60-75	.008-.015	.015-.020	.018-.025	.020-.025	.025-.038	.025-.050	.038-.063	.050-.076	.050-.076	.5 x D	.5 x D
High Temperature Alloys: Inconel 625/718, A286	< 35	40-55	.010-.020	.020-.025	.025-.038	.030-.050	.050-.063	.063-.076	.076-.089	.076-.089	.076-.102	.5 x D	.3 x D
	> 35	25-30	.008-.015	.018-.025	.020-.025	.025-.038	.025-.038	.025-.038	.030-.050	.038-.063	.038-.063	.2 x D	.2 x D
Titanium: 6AL4V, CP		45-60	.010-.020	.020-.025	.025-.038	.025-.050	.038-.050	.050-.076	.063-.076	.076-.089	.076-.102	1 x D	1 x D
Carbon Steels: 1000 Series	< 35	125-185	.010-.020	.020-.025	.025-.038	.025-.050	.038-.050	.050-.076	.063-.089	.076-.102	.089-.114	.3 x D	.5 x D
	> 35	85-130	.008-.015	.015-.020	.020-.030	.025-.038	.025-.050	.038-.063	.050-.063	.050-.076	.063-.089	.3 x D	.5 x D
High Strength Tool Steel: 4130, 4140, A2, D2, P20, H13	< 30	75-110	.008-.015	.015-.025	.020-.038	.025-.050	.030-.050	.038-.056	.050-.063	.063-.076	.063-.089	.5 x D	1 x D
	30-38	45-60	.006-.015	.015-.020	.018-.025	.020-.025	.025-.038	.025-.050	.038-.063	.050-.076	.050-.076	.3 x D	1 x D
	> 38	(SEE HIGH ROCKWELL CHART - PAGE 199)											
Gray Cast Iron		125-150	.013-.025	.025-.050	.025-.050	.038-.050	.038-.063	.050-.089	.063-.089	.076-.102	.102-.127	1 x D	1 x D

* For profiling, axial = 1xD

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

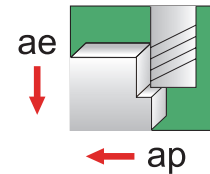
GARR TOOL Milling Guide for High Rc Finishers in Hardened Steel (*Fractional*)

(Reference series: 545MA, 545BA, 545RA, VRX)

DIAMETER	38 - 45 HRc		45 - 50 HRc		50 - 55 HRc		55 - 60 HRc		60 - 65 HRc		65 - 70 HRc	
	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)
1/8"	13750	.0009"	7650	.0008"	5350	.0006"	3820	.0005"	2300	.0004"	1850	.0003"
3/16"	9200	.0012"	5100	.0010"	3570	.0008"	2550	.0007"	1530	.0006"	1225	.0004"
1/4"	6900	.0015"	3850	.0012"	2675	.0010"	1910	.0008"	1150	.0007"	925	.0006"
3/8"	4600	.0018"	2550	.0015"	1800	.0012"	1275	.0010"	765	.0009"	615	.0008"
1/2"	3450	.0022"	1950	.0018"	1350	.0014"	955	.0012"	575	.0012"	460	.0010"
5/8"	2750	.0027"	1550	.0022"	1100	.0020"	765	.0018"	460	.0015"	370	.0013"
3/4"	2300	.0030"	1275	.0027"	900	.0025"	640	.0022"	390	.0017"	310	.0017"
1"	1720	.0033"	960	.0030"	675	.0027"	480	.0025"	290	.0023"	230	.0019"

Profiling / Side Cutting	
Axial (ae)	1xD
Radial (ap)	5% of Dia.

Slotting / Pocket Milling	
Axial (ae)	5% of Dia.
Radial (ap)	1xD



High Speed Machining

DIAMETER	38 - 45 HRc		45 - 50 HRc		50 - 55 HRc		55 - 60 HRc		60 - 65 HRc		65 - 70 HRc	
	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)
1/8"	36670	.0006"	30600	.0005"	24500	.0004"	18340	.0004"	13750	.0003"	11460	.0002"
3/16"	24450	.0009"	20400	.0008"	16300	.0006"	12230	.0005"	9200	.0004"	7650	.0003"
1/4"	18340	.0012"	15300	.0010"	12230	.0008"	9200	.0007"	6900	.0005"	5750	.0004"
3/8"	12225	.0015"	10200	.0012"	8150	.0010"	6100	.0008"	4600	.0007"	3850	.0006"
1/2"	9170	.0018"	7650	.0015"	6100	.0012"	4600	.0010"	3450	.0009"	2870	.0008"
5/8"	7335	.0022"	6100	.0018"	4900	.0014"	3700	.0012"	2750	.0011"	2300	.0010"
3/4"	6115	.0027"	5100	.0022"	4100	.0020"	3100	.0018"	2300	.0014"	1900	.0013"
1"	4585	.0030"	3820	.0027"	3100	.0025"	2300	.0022"	1720	.0019"	1450	.0017"

Profiling / Side Cutting	
Axial (ae)	1xD
Radial (ap)	2% of Dia.

Slotting / Pocket Milling	
Axial (ae)	2% of Dia.
Radial (ap)	1xD

D = Tool Diameter

Example: 2% of Dia., when D = 1/2" (.02 x .500") = .010" per pass

Preferable method is to run tools with air blast to keep chips away from the cutting edge.
If air is not available, either coolant spray or dry machining is acceptable.

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

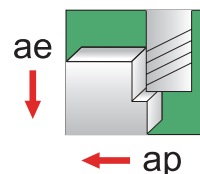
GARR TOOL Milling Guide for High Rc Finishers in Hardened Steel (Metric)

(Reference series: 545MA, 545BA, 545RA, VRX)

DIAMETER	38 - 45 HRC		45 - 50 HRC		50 - 55 HRC		55 - 60 HRC		60 - 65 HRC		65 - 70 HRC	
	M/Min. = 135	M/Min. = 75	M/Min. = 75	M/Min. = 50	M/Min. = 50	M/Min. = 40	M/Min. = 40	M/Min. = 25	M/Min. = 25	M/Min. = 20	M/Min. = 20	
	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)
3.0	14500	.025	8100	.020	5650	.015	4050	.010	2400	.008	1950	.007
4.0	10900	.030	6100	.025	4200	.020	3000	.015	1800	.010	1450	.008
6.0	7300	.035	4050	.030	2800	.025	2000	.020	1200	.015	970	.010
8.0	5450	.040	3000	.035	2100	.030	1500	.025	900	.020	725	.015
12.0	3650	.055	2000	.045	1400	.035	1000	.030	600	.025	480	.020
16.0	2700	.065	1500	.055	1050	.050	750	.045	450	.030	360	.025
18.0	2400	.075	1350	.065	950	.060	675	.055	400	.045	320	.030
20.0	2150	.078	1200	.070	850	.065	600	.058	360	.050	290	.040
25.0	1750	.080	1000	.075	700	.070	500	.060	300	.055	250	.045

Profiling / Side Cutting	
Axial (ae)	1xD
Radial (ap)	5% of Dia.

Slotting / Pocket Milling	
Axial (ae)	5% of Dia.
Radial (ap)	1xD



High Speed Machining

DIAMETER	38 - 45 HRC		45 - 50 HRC		50 - 55 HRC		55 - 60 HRC		60 - 65 HRC		65 - 70 HRC	
	M/Min. = 365	M/Min. = 305	M/Min. = 305	M/Min. = 240	M/Min. = 240	M/Min. = 180	M/Min. = 180	M/Min. = 135	M/Min. = 135	M/Min. = 115	M/Min. = 115	
	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)	RPM	CPT (Fz)
3.0	38800	.020	32300	.015	25800	.008	19400	.008	14500	.007	12100	.005
4.0	29100	.025	24200	.020	19400	.015	14500	.010	10900	.008	9100	.007
6.0	19400	.030	16100	.025	12900	.020	9700	.015	7300	.010	6050	.008
8.0	14500	.035	12100	.030	9700	.025	7250	.020	5450	.015	4500	.010
12.0	9700	.045	8075	.035	6450	.030	4850	.025	3650	.020	3000	.015
16.0	7250	.055	6050	.045	4850	.035	3600	.030	2700	.025	2300	.020
18.0	6450	.065	5400	.055	4300	.050	3200	.045	2400	.030	2000	.025
20.0	5800	.070	4850	.060	3850	.055	2900	.050	2150	.040	1800	.028
25.0	4650	.075	3870	.065	3100	.060	2300	.055	1750	.045	1450	.030

Profiling / Side Cutting	
Axial (ae)	1xD
Radial (ap)	2% of Dia.

Slotting / Pocket Milling	
Axial (ae)	2% of Dia.
Radial (ap)	1xD

D = Tool Diameter

Example: 2% of Dia., when D = 12mm (.02 x 12mm) = .24mm per pass

Preferable method is to run tools with air blast to keep chips away from the cutting edge.
If air is not available, either coolant spray or dry machining is acceptable.

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

Speed and Feed Recommendations for Cutting Die Molds (*Fractional*)

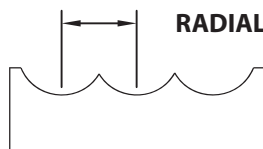
Roughing

(Reference series: VRX, 350MX)

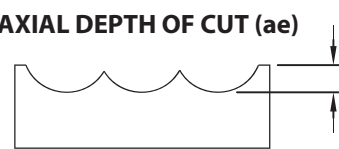
DIAMETER	RPM		CHIPLOAD PER FLUTE (Fz)	
	40 - 50 HRc	50 - 60 HRc	40 - 50 HRc	50 - 60 HRc
1/32"	20,000 - 40,000	20,000 - 40,000	.0005" - .0007"	.0004" - .0005"
1/16"	20,000 - 40,000	20,000 - 40,000	.0010" - .0015"	.0008" - .0010"
3/32"	20,000 - 32,000	20,000 - 30,000	.0015" - .0020"	.0010" - .0015"
1/8"	18,000 - 24,000	15,000 - 20,000	.0020" - .0025"	.0015" - .0020"
3/16"	12,000 - 16,000	10,000 - 14,000	.0030" - .0040"	.0020" - .0030"
1/4"	9,000 - 12,000	7,500 - 10,000	.0040" - .0050"	.0025" - .0040"
5/16"	7,000 - 10,000	6,000 - 8,500	.0050" - .0065"	.0035" - .0050"
3/8"	6,000 - 8,000	5,000 - 7,000	.0060" - .0075"	.0045" - .0060"
1/2"	4,500 - 6,000	4,000 - 5,500	.0080" - .0100"	.0055" - .0080"
5/8"	3,500 - 5,000	3,000 - 4,500	.0090" - .0110"	.0065" - .0090"
3/4"	3,000 - 4,000	2,500 - 3,500	.0100" - .0120"	.0075" - .0100"
1"	2,300 - 3,000	2,000 - 2,500	.0110" - .0130"	.0085" - .0110"

Semi-Finishing and Finishing

DIAMETER	RPM		CHIPLOAD PER FLUTE (Fz)	
	40 - 50 HRc	50 - 60 HRc	40 - 50 HRc	50 - 60 HRc
1/32"	20,000 - 40,000	20,000 - 40,000	.0004" - .0005"	.0003" - .0004"
1/16"	20,000 - 40,000	20,000 - 40,000	.0008" - .0010"	.0005" - .0008"
3/32"	20,000 - 40,000	20,000 - 40,000	.0010" - .0015"	.0008" - .0012"
1/8"	20,000 - 40,000	20,000 - 36,000	.0015" - .0020"	.0010" - .0015"
3/16"	20,000 - 32,000	20,000 - 25,000	.0020" - .0030"	.0015" - .0020"
1/4"	18,000 - 25,000	15,000 - 18,000	.0025" - .0040"	.0020" - .0030"
5/16"	14,000 - 19,000	12,000 - 14,000	.0035" - .0050"	.0025" - .0040"
3/8"	12,000 - 16,000	10,000 - 12,000	.0045" - .0060"	.0030" - .0045"
1/2"	9,000 - 12,000	7,500 - 9,000	.0055" - .0080"	.0040" - .0060"
5/8"	6,500 - 9,000	5,000 - 7,000	.0065" - .0090"	.0050" - .0070"
3/4"	5,500 - 7,500	4,000 - 6,000	.0075" - .0100"	.0060" - .0080"
1"	4,000 - 6,000	3,500 - 5,500	.0085" - .0110"	.0070" - .0090"



RADIAL STEP OVER (ap)



AXIAL DEPTH OF CUT (ae)

Roughing	
Axial (ae)	15% - 25% of Dia.
Radial (ap)	20% - 30% of Dia.

Semi-Finishing	
Axial (ae)	5% - 8% of Dia.
Radial (ap)	2% - 5% of Dia.

Finishing	
Axial (ae)	1% - 3% of Dia.
Radial (ap)	.5% - 1% of Dia.

High pressure air is recommended for clearing chips away from the cut.

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

Speed and Feed Recommendations for Cutting Die Molds (Metric)

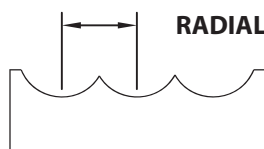
Roughing

(Reference series: VRX, 950MX)

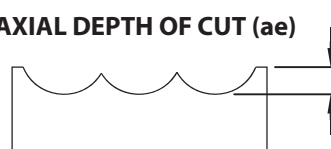
DIAMETER	RPM		CHIPLOAD PER FLUTE (Fz)	
	40 - 50 HRc	50 - 60 HRc	40 - 50 HRc	50 - 60 HRc
1.0	20,000 - 40,000	20,000 - 40,000	.013 - .018	.010 - .013
1.5	20,000 - 40,000	20,000 - 40,000	.025 - .038	.020 - .025
2.0	20,000 - 32,000	20,000 - 30,000	.038 - .050	.025 - .038
3.0	18,000 - 24,000	15,000 - 20,000	.050 - .065	.038 - .050
4.0	12,000 - 16,000	10,000 - 14,000	.075 - .100	.050 - .075
6.0	9,000 - 12,000	7,500 - 10,000	.100 - .125	.065 - .100
8.0	7,000 - 10,000	6,000 - 8,500	.125 - .165	.088 - .125
10.0	6,000 - 8,000	5,000 - 7,000	.150 - .190	.110 - .150
12.0	4,500 - 6,000	4,000 - 5,500	.200 - .250	.140 - .200
16.0	3,500 - 5,000	3,000 - 4,500	.225 - .275	.165 - .225
20.0	3,000 - 4,000	2,500 - 3,500	.250 - .300	.190 - .250
25.0	2,300 - 3,000	2,000 - 2,500	.275 - .325	.215 - .275

Semi-Finishing and Finishing

DIAMETER	RPM		CHIPLOAD PER FLUTE (Fz)	
	40 - 50 HRc	50 - 60 HRc	40 - 50 HRc	50 - 60 HRc
1.0	20,000 - 40,000	20,000 - 40,000	.010 - .013	.008 - .010
1.5	20,000 - 40,000	20,000 - 40,000	.020 - .025	.013 - .020
2.0	20,000 - 40,000	20,000 - 40,000	.025 - .038	.020 - .030
3.0	20,000 - 40,000	20,000 - 36,000	.038 - .050	.025 - .038
4.0	20,000 - 32,000	20,000 - 25,000	.050 - .075	.038 - .050
6.0	18,000 - 25,000	15,000 - 18,000	.065 - .100	.050 - .075
8.0	14,000 - 19,000	12,000 - 14,000	.088 - .125	.065 - .100
10.0	12,000 - 16,000	10,000 - 12,000	.110 - .150	.075 - .110
12.0	9,000 - 12,000	7,500 - 9,000	.140 - .200	.100 - .150
16.0	6,500 - 9,000	5,000 - 7,000	.165 - .225	.125 - .175
20.0	5,500 - 7,500	4,000 - 6,000	.190 - .250	.150 - .200
25.0	4,000 - 6,000	3,500 - 5,500	.215 - .275	.175 - .225



RADIAL STEP OVER (ap)



AXIAL DEPTH OF CUT (ae)

Roughing	
Axial (ae)	15% - 25% of Dia.
Radial (ap)	20% - 30% of Dia.

Semi-Finishing	
Axial (ae)	5% - 8% of Dia.
Radial (ap)	2% - 5% of Dia.

Finishing	
Axial (ae)	1% - 3% of Dia.
Radial (ap)	.5% - 1% of Dia.

High pressure air is recommended for clearing chips away from the cut.

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

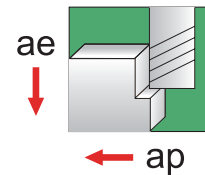
Speed and Feed Recommendations for Diamond Coated End Mills in Graphite

Fractional

DIAMETER	RPM	CHIPLOAD PER FLUTE (Fz)
1/32" - 1/16"	15,000 - 35,000	.0005" - .0010"
1/16" - 1/8"	8000 - 31,000	.0008" - .0015"
1/8" - 3/16"	8000 - 31,000	.0010" - .0020"
3/16" - 1/4"	8000 - 25,000	.0010" - .0020"
1/4" - 5/16"	6000 - 23,000	.0020" - .0040"
5/16" - 3/8"	6000 - 20,000	.0020" - .0040"
3/8" - 1/2"	6000 - 20,000	.0030" - .0050"
1/2" - 5/8"	4500 - 15,000	.0050" - .0060"
5/8" - 3/4"	4500 - 12,000	.0060" - .0070"
3/4" - 1"	4500 - 12,000	.0070" - .0080"

Generally, tools will run at maximum RPM in relation to the corresponding parameters below:

	SLOTING	PROFILING
Axial (ae)	5% of Dia.	1xD
Radial (ap)	1xD	10% of Dia.



Metric

DIAMETER	RPM	CHIPLOAD PER FLUTE (Fz)
1.0 - 3.0	15,000 - 35,000	.015 - .030
3.0 - 6.0	8000 - 31,000	.030 - .050
6.0 - 10.0	6000 - 31,000	.050 - .100
10.0 - 12.0	6000 - 25,000	.080 - .130
16.0 - 20.0	4500 - 15,000	.130 - .150
20.0 - 25.0	4500 - 12,000	.150 - .200

These recommendations are suggested for use primarily in graphite cutting applications. Rigid work holding, machine stability and part integrity are critical!

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

SFM (M/Min.) / RPM Conversion Charts

Fractional

SFM	DIAMETER														
	.0625"	.0938"	.1250"	.1562"	.1875"	.2188"	.2500"	.3125"	.3750"	.4375"	.5000"	.6250"	.7500"	.8750"	1.000"
	1/16"	3/32"	1/8"	5/32"	3/16"	7/32"	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	7/8"	1"
	RPM														
50	3050	2040	1530	1220	1020	875	765	610	510	440	380	310	250	220	190
75	4580	3060	2290	1830	1530	1310	1150	920	760	570	570	460	380	330	285
100	6100	4080	3050	2450	2040	1750	1530	1220	1020	760	760	610	510	440	385
125	7630	5100	3820	3050	2550	2180	1920	1530	1270	950	950	770	630	550	475
150	9150	6120	4570	3670	3060	2620	2290	1830	1530	1140	1140	920	760	660	575
175	10,680	7140	5350	4270	3570	3060	2680	2140	1780	1330	1330	1080	880	770	665
200	12,200	8150	6100	4900	4070	3500	3100	2450	2000	1500	1500	1200	1000	875	750
300	18,500	12,200	9200	7300	6100	5250	4600	3700	3100	2300	2300	1800	1500	1300	1100
400	24,500	16,300	12,200	9800	8150	7000	6100	4900	4100	3050	3050	2450	2050	1750	1525
500	30,500	20,400	15,300	12,200	10,200	8700	7600	6100	5100	3800	3800	3100	2500	2200	1900
750	45,800	36,700	22,900	18,300	15,300	13,100	11,500	9200	7600	5700	5700	4600	3800	3770	2850
1000	-	40,800	30,600	24,500	20,400	17,500	15,300	12,200	10,200	7650	7650	6100	5100	4400	3800
1500	-	-	40,800	36,700	30,600	26,200	22,900	18,300	15,300	11,300	11,300	9200	7600	6500	5700
2000	-	-	-	49,000	40,800	35,000	30,600	24,400	20,400	15,300	15,300	12,200	10,200	8700	7600
3000	-	-	-	-	-	52,500	45,900	36,600	30,600	22,900	22,900	18,300	15,300	13,100	11,400
4000	-	-	-	-	-	-	-	48,800	40,800	30,600	30,600	24,400	20,400	17,500	15,200
5000	-	-	-	-	-	-	-	-	51,000	38,200	38,200	30,600	25,500	21,800	19,000

Metric

M/Min.	DIAMETER														
	.0394"	.0787"	.1181"	.1575"	.1969"	.2362"	.3150"	.3937"	.4724"	.5512"	.6299"	.7087"	.7874"	.8661"	.9843"
	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	25.0
	RPM														
15	4800	2400	1600	1200	960	800	600	480	400	340	300	265	240	220	190
22	7000	3500	2300	1750	1400	1170	875	700	585	500	440	390	350	320	280
30	10,000	4800	3200	2400	1900	1590	1200	955	800	685	600	530	480	440	380
38	12,100	6000	4000	3025	2420	2020	1515	1210	1000	870	760	670	600	550	485
45	14,300	7200	4800	3600	2870	2390	1790	1430	1200	1020	900	800	710	650	575
53	16,880	8440	5630	4220	3375	2815	2110	1690	1400	1200	1055	940	845	770	675
60	19,110	9550	6370	4780	3825	3185	2390	1910	1590	1365	1200	1060	955	870	765
90	28,770	14,350	9550	7165	5735	4780	3585	2870	2390	2050	1790	1590	1430	1300	1150
120	38,220	19,100	12,750	9550	7645	6370	4780	3820	3185	2730	2490	2120	1910	1740	1530
150	47,770	23,885	15,925	11,950	9550	7965	5970	4780	3980	3410	2990	2650	2390	2170	1900
230	-	36,625	24,400	18,315	14,650	12,210	9150	7325	6100	5230	4580	4070	3660	3330	2930
300	-	47,770	31,850	23,885	19,110	15,925	11,950	9550	7960	6825	5970	5300	4780	4340	3820
450	-	-	47,770	35,830	28,660	23,885	17,915	14,330	11,950	10,240	8960	7960	7170	6510	5730
600	-	-	-	47,770	38,220	31,850	23,885	19,100	15,920	13,650	12,000	10,600	9550	8685	7600
900	-	-	-	-	-	47,770	35,830	28,660	23,885	20,475	17,900	15,900	14,330	13,030	11,500
1200	-	-	-	-	-	-	47,770	38,210	31,850	27,300	23,885	21,230	19,100	17,370	15,300
1500	-	-	-	-	-	-	-	47,770	39,810	34,210	29,860	26,540	23,885	21,710	19,100

GARR TOOL Drill Selector Guide

Fractional

Type	Rc Hardness	RECOMMENDED SFM BY SERIES						
		1100,1120	4000	1200,1205,1520,1600,1400	1500,1510,1300	1700	1700K	1800H
COBALT BASE ALLOYS								
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	80 - 120	80 - 120	100 - 150	100 - 150	-	-	-
	> 35	-	-	80 - 110	80 - 110	-	-	-
NICKEL BASE ALLOYS								
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	100 - 125	100 - 125	125 - 150	125 - 175	-	-	-
	> 35	-	-	100 - 125	100 - 125	-	-	-
IRON BASE ALLOYS								
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	150 - 175	150 - 175	150 - 200	175 - 200	-	-	-
	> 35	-	-	150 - 175	150 - 200	-	-	-
MONEL								
Monel - 65% Nickel		-	-	100 - 150	100 - 150	-	-	-
TITANIUM ALLOYS								
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		125 - 175	125 - 175	150 - 200	150 - 200	-	-	-
STAINLESS STEELS								
(Precipitation) 13/8, 15/5, 17-4, pH Types	< 35	-	125 - 150	125 - 175	150 - 200	-	-	-
	> 35	-	-	80 - 125	100 - 150	-	-	-
(Austenitic) Inox, 200 Series, 300 Series	< 35	-	125 - 150	100 - 175	150 - 200	-	-	-
	> 35	-	-	100 - 125	125 - 150	-	-	-
(Austenitic) 304L, 316L, Nitronic 50, Inox	< 35	-	100 - 125	80 - 100	90 - 125	-	-	-
	> 35	-	-	60 - 90	80 - 100	-	-	-
(Martensitic) 400 Series	< 35	-	125 - 150	100 - 150	125 - 175	-	-	-
	> 35	-	-	80 - 125	100 - 140	-	-	-
HIGH STRENGTH TOOL STEELS								
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 35	-	125 - 150	100 - 175	125 - 175	-	-	-
	> 35	-	-	80 - 130	80 - 130	-	-	-
MEDIUM ALLOY TOOL STEELS								
200, 250, 300, 8620	< 35	-	125 - 150	125 - 175	125 - 175	-	-	-
	> 35	-	-	100 - 150	100 - 150	-	-	-
CARBON STEELS								
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	-	125 - 150	125 - 175	150 - 200	-	-	-
	> 35	-	-	100 - 125	100 - 175	-	-	-
CAST MATERIAL								
Steel		150 - 200	150 - 200	125 - 175	-	150 - 250	175 - 300	-
Ductile Iron		200 - 400	200 - 400	125 - 200	150 - 250	175 - 300	200 - 400	-
Gray Iron		175 - 300	175 - 300	100 - 200	150 - 250	175 - 300	200 - 400	-
Aluminum		200 - 400	200 - 400	150 - 300	-	250 - 400	300 - 450	500 - 700
ALUMINUM								
Aircraft Grade (6061, 7075)		-	300	250 - 500	-	-	-	500 - 700
MAGNESIUM								
		-	300	200 - 500	-	-	-	200 - 400
COPPER								
Copper Alloys		-	300	150 - 300	-	-	-	-
BRASS, BRONZE								
Brass, Aluminum/Bronze, Low Silicon Bronze		-	-	150 - 300	-	-	-	200 - 400
		-	-	125 - 200	-	-	-	200 - 400
COMPOSITE MATERIAL								
Glass Epoxy, Fiberglass, Plastics, Graphite, G10		200	200	150 - 300	150 - 300	-	-	-

INCREASE SFM 20%-40% FOR HARDLUBE COATING

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL Drilling Guide

Fractional

Type	Rc Hardness	CHIPLOAD PER FLUTE (Fz)				
		1/16" - 1/8"	1/8" - 1/4"	1/4" - 3/8"	3/8" - 1/2"	1/2" - 5/8"
COBALT BASE ALLOYS						
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	.0004" - .0010"	.0008" - .0020"	.0015" - .0025"	.0020" - .0040"	.0025" - .0050"
	> 35	.0004" - .0010"	.0005" - .0010"	.0010" - .0015"	.0010" - .0020"	.0015" - .0030"
NICKEL BASE ALLOYS						
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, AZ86	< 35	.0005" - .0015"	.0010" - .0015"	.0015" - .0025"	.0020" - .0040"	.0025" - .0050"
	> 35	.0004" - .0010"	.0008" - .0015"	.0010" - .0015"	.0015" - .0030"	.0020" - .0040"
IRON BASE ALLOYS						
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	.0010" - .0015"	.0010" - .0020"	.0015" - .0035"	.0020" - .0050"	.0030" - .0060"
	> 35	.0008" - .0015"	.0010" - .0020"	.0015" - .0025"	.0020" - .0040"	.0025" - .0050"
MONEL						
Monel - 65% Nickel		.0004" - .0010"	.0008" - .0015"	.0010" - .0015"	.0015" - .0030"	.0020" - .0040"
TITANIUM ALLOYS						
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		.0008" - .0015"	.0010" - .0020"	.0015" - .0030"	.0020" - .0040"	.0025" - .0050"
STAINLESS STEELS						
(Precipitation) 13/8, 15/5, 17-4, pH Types	< 35	.0005" - .0015"	.0010" - .0020"	.0015" - .0035"	.0020" - .0040"	.0025" - .0050"
	> 35	.0004" - .0010"	.0008" - .0015"	.0010" - .0015"	.0015" - .0030"	.0020" - .0040"
(Austenitic) Inox, 200 Series, 300 Series	< 35	.0005" - .0015"	.0010" - .0020"	.0015" - .0035"	.0020" - .0040"	.0025" - .0050"
	> 35	.0004" - .0010"	.0008" - .0015"	.0010" - .0015"	.0015" - .0030"	.0020" - .0040"
(Austenitic) 304L, 316L, Nitronic 50, Inox	< 35	.0004" - .0010"	.0008" - .0015"	.0010" - .0015"	.0015" - .0030"	.0020" - .0040"
	> 35	.0003" - .0008"	.0005" - .0010"	.0010" - .0015"	.0010" - .0020"	.0015" - .0030"
(Martensitic) 400 Series	< 35	.0005" - .0015"	.0010" - .0020"	.0015" - .0035"	.0020" - .0040"	.0025" - .0050"
	> 35	.0004" - .0010"	.0008" - .0015"	.0010" - .0015"	.0015" - .0030"	.0020" - .0040"
HIGH STRENGTH TOOL STEELS						
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 35	.0005" - .0015"	.0010" - .0020"	.0015" - .0025"	.0015" - .0030"	.0020" - .0040"
	> 35	.0004" - .0010"	.0010" - .0020"	.0010" - .0020"	.0015" - .0030"	.0020" - .0040"
MEDIUM ALLOY TOOL STEELS						
200, 250, 300, 8620	< 35	.0010" - .0015"	.0015" - .0025"	.0020" - .0030"	.0020" - .0040"	.0025" - .0050"
	> 35	.0005" - .0010"	.0010" - .0015"	.0010" - .0025"	.0015" - .0030"	.0020" - .0040"
CARBON STEELS						
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	.0010" - .0015"	.0015" - .0025"	.0020" - .0030"	.0020" - .0040"	.0025" - .0050"
	> 35	.0005" - .0010"	.0010" - .0020"	.0010" - .0025"	.0015" - .0035"	.0020" - .0040"
CAST MATERIAL						
Steel		.0008" - .0015"	.0010" - .0020"	.0015" - .0030"	.0020" - .0040"	.0025" - .0050"
Ductile Iron		.0010" - .0020"	.0010" - .0030"	.0015" - .0035"	.0025" - .0040"	.0030" - .0050"
Gray Iron		.0010" - .0020"	.0010" - .0030"	.0015" - .0035"	.0025" - .0040"	.0030" - .0050"
Aluminum		.0010" - .0020"	.0015" - .0040"	.0020" - .0050"	.0030" - .0060"	.0035" - .0070"
ALUMINUM						
Aircraft Grade (6061, 7075)		.0010" - .0020"	.0015" - .0040"	.0020" - .0050"	.0030" - .0060"	.0035" - .0070"
MAGNESIUM						
		.0010" - .0020"	.0010" - .0030"	.0015" - .0035"	.0025" - .0040"	.0030" - .0050"
COPPER						
Copper Alloys		.0010" - .0020"	.0010" - .0030"	.0015" - .0035"	.0025" - .0040"	.0030" - .0050"
BRASS, BRONZE						
Brass, Aluminum/Bronze, Low Silicon Bronze		.0010" - .0020"	.0010" - .0030"	.0015" - .0035"	.0025" - .0040"	.0030" - .0050"
		.0008" - .0015"	.0010" - .0020"	.0015" - .0030"	.0020" - .0040"	.0025" - .0050"
COMPOSITE MATERIAL						
Glass Epoxy, Fiberglass, Plastics, Graphite, G10		.0010" - .0020"	.0010" - .0030"	.0015" - .0035"	.0025" - .0040"	.0030" - .0050"

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL Drill Selector Guide

Metric

Type	Rc Hardness	RECOMMENDED M/Min. BY SERIES						
		1100,1120	4000	1200,1205,1520,1600,1400	1500,1510,1300	1700	1700K	1800H
COBALT BASE ALLOYS								
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	25 - 40	25 - 40	30 - 45	30 - 45	-	-	-
	> 35	-	-	25 - 35	25 - 35	-	-	-
NICKEL BASE ALLOYS								
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	30 - 40	30 - 40	40 - 45	40 - 50	-	-	-
	> 35	-	-	30 - 40	30 - 40	-	-	-
IRON BASE ALLOYS								
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	45 - 55	45 - 55	45 - 60	50 - 60	-	-	-
	> 35	-	-	40 - 50	45 - 60	-	-	-
MONEL								
Monel - 65% Nickel		-	-	30 - 45	30 - 45	-	-	-
TITANIUM ALLOYS								
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		-	40 - 50	45 - 60	45 - 60	-	-	-
STAINLESS STEELS								
(Precipitation) 13/8, 15/5, 17-4, pH Types	< 35	-	40 - 45	40 - 50	45 - 60	-	-	-
	> 35	-	-	25 - 40	30 - 45	-	-	-
(Austenitic) Inox, 200 Series, 300 Series	< 35	-	40 - 45	30 - 50	45 - 60	-	-	-
	> 35	-	-	30 - 40	40 - 45	-	-	-
(Austenitic) 304L, 316L, Nitronic 50, Inox	< 35	-	30 - 40	25 - 30	30 - 40	-	-	-
	> 35	-	-	20 - 30	25 - 30	-	-	-
(Martensitic) 400 Series	< 35	-	40 - 45	30 - 45	40 - 55	-	-	-
	> 35	-	-	25 - 40	30 - 45	-	-	-
HIGH STRENGTH TOOL STEELS								
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 35	-	40 - 45	30 - 55	40 - 55	-	-	-
	> 35	-	-	25 - 40	25 - 40	-	-	-
MEDIUM ALLOY TOOL STEELS								
200, 250, 300, 8620	< 35	-	40 - 45	40 - 55	40 - 55	-	-	-
	> 35	-	-	30 - 45	30 - 45	-	-	-
CARBON STEELS								
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	-	40 - 45	40 - 55	45 - 60	-	-	-
	> 35	-	-	30 - 40	30 - 55	-	-	-
CAST MATERIAL								
Ductile Iron		60 - 120	60 - 120	40 - 60	45 - 75	50 - 90	60 - 120	-
Gray Iron		50 - 90	50 - 90	30 - 60	45 - 75	50 - 90	60 - 120	-
Aluminum		60 - 120	60 - 120	45 - 90	-	75 - 120	90 - 135	150 - 210
Steel		45 - 60	45 - 60	40 - 55	-	45 - 75	50 - 90	-
ALUMINUM								
Aircraft Grade (6061, 7075)		-	90	75 - 150	-	-	-	150 - 210
MAGNESIUM								
		-	90	60 - 150	-	-	-	60 - 120
COPPER								
Copper Alloys		-	90	45 - 90	-	-	-	-
BRASS, BRONZE								
Brass, Aluminum/Bronze, Low Silicon Bronze		-	-	45 - 90	-	-	-	60 - 120
		-	-	40 - 60	-	-	-	60 - 120
COMPOSITE MATERIAL								
Glass Epoxy, Fiberglass, Plastics, Graphite, G10		60	60	45 - 90	45 - 90	-	-	-

INCREASE M/Min. 20%-40% FOR HARDLUBE COATING

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL Drilling Guide

Metric

TECHNICAL

Type	Rc Hardness	CHIPLOAD PER FLUTE (Fz)				
		2.0 - 3.0	3.0 - 6.0	6.0 - 10.0	10.0 - 13.0	13.0 - 16.0
COBALT BASE ALLOYS						
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-4, L-605	< 35	.010 - .025	.020 - .050	.040 - .065	.050 - .100	.065 - .125
	> 35	.010 - .025	.013 - .025	.025 - .040	.025 - .050	.040 - .075
NICKEL BASE ALLOYS						
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	.013 - .040	.025 - .040	.040 - .065	.050 - .100	.065 - .125
	> 35	.010 - .025	.020 - .040	.025 - .040	.040 - .075	.050 - .100
IRON BASE ALLOYS						
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	.025 - .040	.025 - .050	.040 - .090	.050 - .100	.075 - .150
	> 35	.020 - .040	.025 - .050	.040 - .065	.040 - .075	.065 - .125
MONEL						
Monel - 65% Nickel		.010 - .025	.020 - .040	.025 - .040	.040 - .075	.050 - .100
TITANIUM ALLOYS						
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		.020 - .040	.025 - .050	.040 - .075	.050 - .100	.065 - .125
STAINLESS STEELS						
(Precipitation) 13/8, 15/5, 17-4, pH Types	< 35	.013 - .040	.025 - .050	.040 - .090	.050 - .100	.065 - .125
	> 35	.010 - .025	.020 - .040	.025 - .040	.040 - .075	.050 - .100
(Austenitic) Inox, 200 Series, 300 Series	< 35	.013 - .040	.025 - .050	.040 - .090	.050 - .100	.065 - .125
	> 35	.010 - .025	.020 - .040	.025 - .040	.040 - .075	.050 - .100
(Austenitic) 304L, 316L, Nitronic 50, Inox	< 35	.010 - .025	.020 - .040	.025 - .040	.040 - .075	.050 - .100
	> 35	.008 - .020	.013 - .025	.025 - .040	.025 - .050	.040 - .075
(Martensitic) 400 Series	< 35	.013 - .040	.025 - .050	.040 - .090	.050 - .100	.065 - .125
	> 35	.010 - .025	.020 - .040	.025 - .040	.040 - .075	.050 - .100
HIGH STRENGTH TOOL STEELS						
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 35	.013 - .040	.025 - .050	.040 - .065	.050 - .100	.075 - .125
	> 35	.010 - .025	.025 - .050	.025 - .050	.040 - .075	.050 - .100
MEDIUM ALLOY TOOL STEELS						
200, 250, 300, 8620	< 35	.025 - .040	.040 - .065	.050 - .075	.050 - .100	.065 - .125
	> 35	.013 - .040	.025 - .050	.025 - .065	.040 - .075	.050 - .100
CARBON STEELS						
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	.025 - .040	.040 - .065	.050 - .075	.050 - .100	.065 - .125
	> 35	.013 - .040	.025 - .050	.025 - .065	.040 - .090	.050 - .100
CAST MATERIAL						
Steel		.020 - .040	.025 - .050	.040 - .075	.050 - .100	.065 - .125
Ductile Iron		.025 - .050	.025 - .075	.040 - .090	.065 - .100	.075 - .125
Gray Iron		.025 - .050	.025 - .075	.040 - .090	.065 - .100	.075 - .125
Aluminum		.025 - .050	.025 - .100	.050 - .125	.075 - .150	.090 - .180
ALUMINUM						
Aircraft Grade (6061, 7075)		.025 - .050	.025 - .100	.050 - .125	.075 - .150	.090 - .180
MAGNESIUM						
		.025 - .050	.025 - .075	.040 - .090	.065 - .100	.075 - .125
COPPER						
Copper Alloys		.025 - .050	.025 - .075	.040 - .090	.065 - .100	.075 - .125
BRASS, BRONZE						
Brass, Aluminum/Bronze, Low Silicon Bronze		.025 - .050	.025 - .075	.040 - .090	.065 - .100	.075 - .125
		.020 - .040	.025 - .050	.040 - .075	.050 - .100	.065 - .125
COMPOSITE MATERIAL						
Glass Epoxy, Fiberglass, Plastics, Graphite, G10		.025 - .050	.025 - .075	.040 - .090	.065 - .100	.075 - .125

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL High Performance Drilling Guide

Fractional

TECHNICAL

Type	Rc Hardness	Recommended SFM		CHIPLOAD PER FLUTE (Fz)				
		NON-COOLANT	COOLANT FED	1/8" - 1/4"	1/4" - 3/8"	3/8" - 1/2"	1/2" - 5/8"	5/8" - 3/4"
		1580H 1280H 1580HD	1580KH 1280KH 1880KH 1580KD 1280KD					
COBALT BASE ALLOYS								
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	225	300	.0015" - .0025"	.0025" - .0035"	.0030" - .0040"	.0035" - .0045"	.0040" - .0060"
	> 35	180	240	.0010" - .0020"	.0020" - .0030"	.0025" - .0035"	.0030" - .0040"	.0035" - .0050"
NICKEL BASE ALLOYS								
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	225	300	.0015" - .0025"	.0025" - .0035"	.0030" - .0040"	.0035" - .0050"	.0040" - .0060"
	> 35	180	240	.0010" - .0020"	.0020" - .0030"	.0025" - .0035"	.0030" - .0040"	.0035" - .0050"
IRON BASE ALLOYS								
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	300	375	.0020" - .0030"	.0030" - .0035"	.0030" - .0040"	.0040" - .0050"	.0040" - .0060"
	> 35	240	300	.0010" - .0020"	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0035" - .0050"
MONEL								
Monel - 65% Nickel		225	300	.0015" - .0025"	.0020" - .0030"	.0025" - .0035"	.0030" - .0040"	.0040" - .0060"
TITANIUM ALLOYS								
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		350	425	.0015" - .0025"	.0025" - .0035"	.0030" - .0040"	.0035" - .0045"	.0040" - .0060"
STAINLESS STEELS								
(Precipitation) 13/8, 15/5, 17-4, pH Types	< 35	300	375	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"	.0045" - .0060"
	> 35	240	300	.0010" - .0020"	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"
(Austenitic) Inox, 200 Series, 300 Series	< 35	300	375	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"	.0045" - .0060"
	> 35	225	300	.0015" - .0020"	.0020" - .0025"	.0025" - .0030"	.0030" - .0040"	.0040" - .0050"
304L, 316L, Nitronic 50, Inox	< 35	175	225	.0015" - .0020"	.0020" - .0025"	.0025" - .0035"	.0035" - .0045"	.0035" - .0050"
	> 35	100	150	.0008" - .0015"	.0015" - .0020"	.0020" - .0030"	.0030" - .0040"	.0030" - .0050"
(Martensitic) 400 Series	< 35	300	375	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"	.0045" - .0060"
	> 35	240	300	.0010" - .0020"	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"
HIGH STRENGTH TOOL STEELS								
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 35	300	375	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"	.0050" - .0060"
	> 35	240	300	.0010" - .0020"	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"
MEDIUM ALLOY TOOL STEELS								
200, 250, 300, 8620	< 35	300	375	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"	.0050" - .0070"
	> 35	240	300	.0010" - .0020"	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"
CARBON STEELS								
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	300	375	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"	.0050" - .0070"
	> 35	240	300	.0010" - .0020"	.0020" - .0030"	.0030" - .0035"	.0035" - .0040"	.0040" - .0050"
CAST MATERIAL								
Steel		300	450	.0040" - .0050"	.0040" - .0050"	.0050" - .0060"	.0070" - .0080"	.0080" - .0120"
Ductile Iron		600	700	.0040" - .0050"	.0040" - .0050"	.0050" - .0060"	.0070" - .0080"	.0080" - .0120"
Gray Iron		625	750	.0040" - .0050"	.0040" - .0050"	.0050" - .0060"	.0070" - .0080"	.0080" - .0120"
ALUMINUM								
2014, 2024, 6061-(T1-T6), 7075		700	850	.0050" - .0060"	.0070" - .0080"	.0090" - .0100"	.0090" - .0100"	.0090" - .0120"
Die Cast, Extruded		500	650	.0040" - .0050"	.0060" - .0070"	.0080" - .0090"	.0080" - .0090"	.0080" - .0100"
MAGNESIUM								
		600	725	.0050" - .0060"	.0070" - .0080"	.0090" - .0100"	.0090" - .0100"	.0090" - .0120"
COPPER								
Copper Alloys		600	725	.0040" - .0050"	.0040" - .0050"	.0050" - .0060"	.0070" - .0080"	.0080" - .0100"
BRASS								
Short Chips		600	725	.0050" - .0060"	.0070" - .0080"	.0090" - .0100"	.0090" - .0100"	.0100" - .0120"
Long Chips		475	600	.0040" - .0050"	.0060" - .0070"	.0080" - .0090"	.0080" - .0090"	.0080" - .0100"
BRONZE								
Short Chips		400	525	.0040" - .0050"	.0040" - .0050"	.0060" - .0070"	.0080" - .0090"	.0080" - .0120"
Long Chips		275	325	.0030" - .0040"	.0030" - .0040"	.0050" - .0060"	.0070" - .0080"	.0080" - .0100"

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL High Performance Drilling Guide

Metric

Type	Rc Hardness	Recommended M/Min.		CHIPLOAD PER FLUTE (Fz)				
		NON-COOLANT	COOLANT FED	3.0 - 6.0	6.0 - 10.0	10.0 - 13.0	13.0 - 16.0	16.0 - 20.0
		1580H 1280H 1580HD	1580KH 1280KH 1880KH 1580KD 1280KD					
COBALT BASE ALLOYS								
Powdered Metal, Stellite, Hs-21, Haynes 25/188, X-40, L-605	< 35	70	90	.035 - .060	.060 - .085	.075 - .100	.085 - .110	.095 - .130
	> 35	55	70	.025 - .050	.050 - .075	.060 - .085	.075 - .100	.095 - .110
NICKEL BASE ALLOYS								
Invar, Kovar, Inconel-625/718, Waspalloy, Rene, Hastalloy, A286	< 35	70	90	.035 - .060	.060 - .085	.075 - .100	.085 - .125	.085 - .110
	> 35	55	70	.025 - .050	.050 - .075	.060 - .085	.075 - .100	.085 - .100
IRON BASE ALLOYS								
Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3	< 35	90	115	.050 - .075	.075 - .085	.085 - .100	.100 - .125	.110 - .140
	> 35	70	90	.025 - .050	.050 - .075	.075 - .085	.085 - .100	.095 - .110
MONEL								
Monel - 65% Nickel		70	90	.035 - .060	.050 - .075	.060 - .085	.075 - .100	.085 - .120
TITANIUM ALLOYS								
Commercially Pure, 6Al-4V, Astm 1/2/3, 6Al-25N-4Zr-2Mo-Si		105	130	.035 - .060	.060 - .085	.075 - .100	.085 - .110	.095 - .130
STAINLESS STEELS								
(Precipitation) 13/8, 15/5, 17-4, pH Types	< 35	90	115	.050 - .075	.075 - .085	.085 - .100	.100 - .125	.100 - .140
	> 35	70	90	.025 - .050	.050 - .075	.075 - .085	.085 - .100	.085 - .110
(Austenitic) Inox, 200 Series, 300 Series	< 35	90	115	.050 - .075	.075 - .085	.085 - .100	.100 - .125	.100 - .140
	> 35	70	90	.035 - .050	.050 - .060	.060 - .075	.075 - .100	.075 - .110
(Austenitic) 304L, 316L, Nitronic 50, Inox	< 35	55	70	.035 - .050	.050 - .060	.060 - .085	.085 - .110	.075 - .110
	> 35	30	45	.025 - .035	.035 - .050	.050 - .075	.075 - .100	.075 - .110
(Martensitic) 400 Series	< 35	90	115	.050 - .075	.075 - .085	.085 - .100	.100 - .125	.100 - .130
	> 35	70	90	.025 - .050	.050 - .075	.075 - .085	.085 - .100	.085 - .110
HIGH STRENGTH TOOL STEELS								
4140, 4340, 6150, 5210, A2, D2, P20, H11, H13, S2, O1	< 35	90	115	.050 - .075	.075 - .085	.085 - .100	.100 - .125	.100 - .130
	> 35	70	90	.025 - .050	.050 - .075	.075 - .085	.085 - .100	.085 - .100
MEDIUM ALLOY TOOL STEELS								
200, 250, 300, 8620	< 35	90	115	.050 - .075	.075 - .085	.085 - .100	.100 - .125	.100 - .140
	> 35	70	90	.025 - .050	.050 - .075	.075 - .085	.085 - .100	.085 - .110
CARBON STEELS								
Platinum, A36, 12L14, 1000's, 1100's, 1300's	< 35	90	115	.050 - .075	.075 - .085	.085 - .100	.100 - .125	.100 - .140
	> 35	70	90	.025 - .050	.050 - .075	.075 - .085	.085 - .100	.085 - .120
CAST MATERIAL								
Steel		90	135	.100 - .125	.100 - .125	.125 - .150	.175 - .200	.200 - .300
Ductile Iron		90	215	.100 - .125	.100 - .125	.125 - .150	.175 - .200	.200 - .300
Gray Iron		190	225	.100 - .125	.100 - .125	.125 - .150	.175 - .200	.200 - .300
ALUMINUM								
2014, 2024, 6061-(T1-T6), 7075		215	260	.125 - .150	.175 - .200	.225 - .250	.225 - .250	.230 - .280
Die Cast, Extruded		150	200	.100 - .120	.150 - .175	.200 - .225	.200 - .225	.200 - .250
MAGNESIUM								
		185	220	.125 - .150	.175 - .200	.225 - .250	.225 - .250	.230 - .280
COPPER								
Copper Alloys		185	220	.100 - .125	.100 - .125	.125 - .150	.175 - .200	.200 - .250
BRASS								
Short Chips		185	220	.125 - .150	.175 - .200	.225 - .250	.225 - .250	.250 - .280
Long Chips		145	180	.100 - .125	.150 - .175	.200 - .225	.200 - .225	.220 - .250
BRONZE								
Short Chips		120	160	.100 - .125	.100 - .125	.150 - .175	.200 - .225	.230 - .280
Long Chips		85	100	.060 - .085	.075 - .100	.125 - .150	.175 - .200	.200 - .220

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.

GARR TOOL Aluminum Series Drill Application Guide

Fractional

CHIPLOAD PER FLUTE (Fz)								
Material	Type	SFM	3/16"	1/4"	5/16"	3/8"	1/2"	5/8"
Aluminum Alloy	6061	600 - 800	.002" - .004"	.004" - .005"	.004" - .006"	.005" - .007"	.006" - .008"	.007" - .010"
Cast Aluminum	380	450 - 600	.002" - .004"	.004" - .005"	.004" - .006"	.005" - .007"	.006" - .008"	.007" - .010"
Magnesium		400 - 600	.002" - .004"	.004" - .005"	.004" - .006"	.005" - .007"	.006" - .008"	.007" - .010"
Copper & Brass		400 - 600	.001" - .002"	.002" - .003"	.002" - .003"	.002" - .004"	.003" - .005"	.003" - .006"
Titanium	6Al-4V	100 - 300	.001" - .002"	.002" - .003"	.002" - .003"	.002" - .004"	.003" - .005"	.003" - .006"

Metric

CHIPLOAD PER FLUTE (Fz)								
Material	Type	M/Min.	4.0	6.0	8.0	10.0	12.0	16.0
Aluminum Alloy	6061	180 - 240	.050 - .100	.100 - .125	.100 - .150	.125 - .175	.150 - .200	.175 - .250
Cast Aluminum	380	135 - 180	.050 - .100	.100 - .125	.100 - .150	.125 - .175	.150 - .200	.175 - .250
Magnesium		120 - 180	.050 - .100	.100 - .125	.100 - .150	.125 - .175	.150 - .200	.175 - .250
Copper & Brass		120 - 180	.025 - .050	.050 - .075	.050 - .075	.050 - .100	.075 - .125	.075 - .150
Titanium	6Al-4V	30 - 90	.025 - .050	.050 - .075	.050 - .075	.050 - .100	.075 - .125	.075 - .150

PHYSICAL PROPERTIES AND CHARACTERISTICS OF ALUMASTAR COATING	
Property/Characteristic	Description
Nomenclature	TiB ₂
Color	Silver
Hardness	4000 Hv
Coating Thickness	1-2 μm
Thermal Stability	850° C (1562° F)
Deposition Temperature	450° C (842° F)
Applications	Aluminum, AlSi Alloys (<12% Si), Magnesium, Copper, Titanium Alloys, Non-ferrous

NOTE - ABOVE ARE STARTING PARAMETERS ONLY. HIGHER RESULTS MAY BE ACHIEVED WITH OPTIMUM CONDITIONS.