

Series 146U, 136U Fractional				DC • in								
Hardness		Vc (sfm)		1/16	1/8	1/4	3/8	1/2	5/8	3/4	13/16	
P	CARBON STEELS 1018, 1040, 1080, 1090, 10L50, 1140, 1212, 12L15, 1525, 1536	≤ 175 Bhn or ≤ 7 HRc	285	RPM	17419	8710	4355	2903	2177	1742	1452	1340
			(228-342)	Fr	0.0016	0.0031	0.0062	0.0093	0.0124	0.0155	0.0186	0.0202
				Feed (ipm)	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
		≤ 275 Bhn or ≤ 28 HRc	255	RPM	15586	7793	3896	2598	1948	1559	1299	1199
			(204-306)	Fr	0.0013	0.0027	0.0054	0.0081	0.0108	0.0135	0.0162	0.0175
				Feed (ipm)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
		≤ 425 Bhn or ≤ 45 HRc	145	RPM	8862	4431	2216	1477	1108	886	739	682
			(116-174)	Fr	0.0011	0.0023	0.0045	0.0068	0.0090	0.0113	0.0135	0.0147
				Feed (ipm)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	ALLOY STEELS 4140, 4150, 4320, 5120, 5150, 8630, 86L20, 50100	≤ 275 Bhn or ≤ 28 HRc	220	RPM	13446	6723	3362	2241	1681	1345	1121	1034
			(176-264)	Fr	0.0015	0.0030	0.0059	0.0089	0.0119	0.0149	0.0178	0.0193
				Feed (ipm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
		≤ 375 Bhn or ≤ 40 HRc	135	RPM	8251	4126	2063	1375	1031	825	688	635
			(108-162)	Fr	0.0013	0.0027	0.0053	0.0080	0.0107	0.0133	0.0160	0.0173
				Feed (ipm)	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
	TOOL STEELS A2, D2, H13, L2, M2, P20, S7, T15, W2	≤ 200 Bhn or ≤ 13 HRc	125	RPM	7640	3820	1910	1273	955	764	637	588
			(100-150)	Fr	0.0012	0.0025	0.0050	0.0075	0.0099	0.0124	0.0149	0.0162
				Feed (ipm)	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
≤ 375 Bhn or ≤ 40 HRc		90	RPM	5501	2750	1375	917	688	550	458	423	
		(72-108)	Fr	0.0005	0.0011	0.0022	0.0033	0.0044	0.0055	0.0065	0.0071	
			Feed (ipm)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
M	STAINLESS STEELS (FREE MACHINING) 303, 416, 420F, 430F, 440F	≤ 185 Bhn or ≤ 9 HRc	265	RPM	16197	8098	4049	2699	2025	1620	1350	1246
			(212-318)	Fr	0.0008	0.0016	0.0032	0.0048	0.0064	0.0080	0.0096	0.0104
				Feed (ipm)	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
		≤ 275 Bhn or ≤ 28 HRc	170	RPM	10390	5195	2598	1732	1299	1039	866	799
			(136-204)	Fr	0.0006	0.0013	0.0025	0.0038	0.0050	0.0063	0.0075	0.0081
				Feed (ipm)	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	STAINLESS STEELS (DIFFICULT) 304, 316, 321, 13-8 PH, 15-5PH, 17-4 PH, Custom 450	≤ 275 Bhn or ≤ 28 HRc	130	RPM	7946	3973	1986	1324	993	795	662	611
			(104-156)	Fr	0.0006	0.0013	0.0025	0.0038	0.0050	0.0063	0.0076	0.0082
				Feed (ipm)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
		≤ 375 Bhn or ≤ 40 HRc	95	RPM	5806	2903	1452	968	726	581	484	447
			(76-114)	Fr	0.0006	0.0011	0.0023	0.0034	0.0045	0.0057	0.0068	0.0074
				Feed (ipm)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
K	GRAY CAST IRONS	≤ 220 Bhn or ≤ 19 HRc	250	RPM	15280	7640	3820	2547	1910	1528	1273	1175
			(200-300)	Fr	0.0016	0.0031	0.0063	0.0094	0.0126	0.0157	0.0188	0.0204
				Feed (ipm)	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
	DUCTILE CAST IRONS	≤ 260 Bhn or ≤ 26 HRc	220	RPM	13446	6723	3362	2241	1681	1345	1121	1034
			(176-264)	Fr	0.0015	0.0030	0.0059	0.0089	0.0119	0.0149	0.0178	0.0193
				Feed (ipm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

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Series 146U, 136U Fractional				DC • in								
		Hardness	Vc (sfm)	1/16	1/8	1/4	3/8	1/2	5/8	3/4	13/16	
N	ALUMINUM ALLOYS (WROUGHT) 2024, 6061, 7075	≤ 150 Bhn or ≤ 88 HRb	475	RPM	29032	14516	7258	4839	3629	2903	2419	2233
			Fr	0.0016	0.0031	0.0062	0.0093	0.0124	0.0155	0.0186	0.0202	
			Feed (ipm)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	
	ALUMINUM ALLOYS (CAST) A356, A380, 390	≤ 140 Bhn or ≤ 3 HRc	380	RPM	23226	11613	5806	3871	2903	2323	1935	1787
			Fr	0.0014	0.0028	0.0055	0.0083	0.0110	0.0138	0.0165	0.0179	
			Feed (ipm)	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	
S	TITANIUM ALLOYS Pure Titanium, Ti6Al4V, Ti6Al2Sn4Zr2Mo, Ti4Al4Mo2Sn0.5Si, Ti-6Al4V	≤ 275 Bhn or ≤ 28 HRc	175	RPM	10696	5348	2674	1783	1337	1070	891	823
			Fr	0.0007	0.0014	0.0028	0.0042	0.0055	0.0069	0.0083	0.0090	
			Feed (ipm)	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	
		≤ 350 Bhn or ≤ 38 HRc	130	RPM	7946	3973	1986	1324	993	795	662	611
			Fr	0.0006	0.0013	0.0025	0.0038	0.0050	0.0063	0.0076	0.0082	
			Feed (ipm)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
		≤ 440 Bhn or ≤ 47 HRc	70	RPM	4278	2139	1070	713	535	428	357	329
			Fr	0.0005	0.0009	0.0019	0.0028	0.0037	0.0047	0.0056	0.0061	
			Feed (ipm)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
H	ALLOY STEELS 4140, 4150, 4320, 5120, 5150, 8630, 86L20, 50100	≤ 450 Bhn or ≤ 48 HRc	95	RPM	5806	2903	1452	968	726	581	484	447
			Fr	0.0008	0.0016	0.0031	0.0047	0.0062	0.0078	0.0093	0.0101	
			Feed (ipm)	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
	TOOL STEELS A2, D2, H13, L2, M2, P20, S7, T15, W2	≤ 475 Bhn or ≤ 50 HRc	80	RPM	4890	2445	1222	815	611	489	407	376
			Fr	0.0007	0.0014	0.0029	0.0043	0.0057	0.0072	0.0086	0.0093	
			Feed (ipm)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	

reduce rates when material is harder than listed, when drilling conditions are not optimum, or coolant is not available
 rates shown are for drilling into a flat surface and should be lowered using the reduction multiplier when the workpiece is angled or curved
 reduce rates 10 to 20 percent when using drills without internal coolant
 always use the shortest overhang possible
 longer drills may require a spot drill operation to avoid walking on entry
 internal coolant required in ISO S and M material groups or when drilling depth exceeds 3xD
 Bhn (Brinell) HRc (Rockwell C) HRb (Rockwell B)
 $\text{rpm} = \text{Vc} \times 3.82 / \text{DC}$
 $\text{ipm} = \text{Fr} \times \text{rpm}$
 speed and feed for materials harder than listed
 refer to the SGS Tool Wizard® for complete technical information (www.kyocera-sgstool.com)

angle °	reduction multiplier	
	speed x	feed x
up to 30	1.0	0.6
over 30	0.7	0.4

Series 146U, 136U Metric		Hardness	Vc (m/mm)	DC • mm								
				1.5	3	6	8	10	12	16	20	
P	CARBON STEELS 1018, 1040, 1080, 1090, 10L50, 1140, 1212, 12L15, 1525, 1536	≤ 175 Bhn or ≤ 7 HRc	87	RPM	18419	9209	4605	3454	2763	2302	1727	1381
			(69-104)	Fr	0.037	0.074	0.149	0.199	0.248	0.298	0.397	0.496
				Feed (mm/min)	686	686	686	686	686	686	686	686
		≤ 275 Bhn or ≤ 28 HRc	78	RPM	16480	8240	4120	3090	2472	2060	1545	1236
			(62-93)	Fr	0.032	0.065	0.129	0.173	0.216	0.259	0.345	0.432
				Feed (mm/min)	533	533	533	533	533	533	533	533
		≤ 425 Bhn or ≤ 45 HRc	44	RPM	9371	4686	2343	1757	1406	1171	879	703
			(35-53)	Fr	0.027	0.054	0.108	0.145	0.181	0.217	0.289	0.361
				Feed (mm/min)	254	254	254	254	254	254	254	254
	ALLOY STEELS 4140, 4150, 4320, 5120, 5150, 8630, 86L20, 50100	≤ 275 Bhn or ≤ 28 HRc	67	RPM	14218	7109	3555	2666	2133	1777	1333	1066
			(54-80)	Fr	0.036	0.071	0.143	0.191	0.238	0.286	0.381	0.476
				Feed (mm/min)	508	508	508	508	508	508	508	508
		≤ 375 Bhn or ≤ 40 HRc	41	RPM	8725	4362	2181	1636	1309	1091	818	654
			(33-49)	Fr	0.032	0.064	0.128	0.171	0.213	0.256	0.342	0.427
				Feed (mm/min)	279	279	279	279	279	279	279	279
	TOOL STEELS A2, D2, H13, L2, M2, P20, S7, T15, W2	≤ 200 Bhn or ≤ 13 HRc	38	RPM	8078	4039	2020	1515	1212	1010	757	606
			(30-46)	Fr	0.030	0.060	0.119	0.159	0.199	0.239	0.319	0.398
				Feed (mm/min)	241	241	241	241	241	241	241	241
		≤ 375 Bhn or ≤ 40 HRc	27	RPM	5816	2908	1454	1091	872	727	545	436
			(22-33)	Fr	0.013	0.026	0.052	0.070	0.087	0.105	0.140	0.175
				Feed (mm/min)	76	76	76	76	76	76	76	76
M	STAINLESS STEELS (FREE MACHINING) 303, 416, 420F, 430F, 440F	≤ 185 Bhn or ≤ 9 HRc	81	RPM	17126	8563	4282	3211	2569	2141	1606	1284
			(65-97)	Fr	0.019	0.039	0.077	0.103	0.129	0.154	0.206	0.257
				Feed (mm/min)	330	330	330	330	330	330	330	330
		≤ 275 Bhn or ≤ 28 HRc	52	RPM	10987	5493	2747	2060	1648	1373	1030	824
			(41-62)	Fr	0.015	0.030	0.060	0.080	0.100	0.120	0.160	0.200
				Feed (mm/min)	165	165	165	165	165	165	165	165
	STAINLESS STEELS (DIFFICULT) 304, 316, 321, 13-8 PH, 15-5PH, 17-4 PH, Custom 450	≤ 275 Bhn or ≤ 28 HRc	40	RPM	8402	4201	2100	1575	1260	1050	788	630
			(32-48)	Fr	0.015	0.030	0.060	0.081	0.101	0.121	0.161	0.202
				Feed (mm/min)	127	127	127	127	127	127	127	127
		≤ 375 Bhn or ≤ 40 HRc	29	RPM	6140	3070	1535	1151	921	767	576	460
			(23-35)	Fr	0.014	0.027	0.055	0.073	0.091	0.109	0.146	0.182
				Feed (mm/min)	84	84	84	84	84	84	84	84
K	GRAY CAST IRONS	≤ 220 Bhn or ≤ 19 HRc	76	RPM	16157	8078	4039	3029	2424	2020	1515	1212
			(61-91)	Fr	0.038	0.075	0.151	0.201	0.252	0.302	0.402	0.503
				Feed (mm/min)	610	610	610	610	610	610	610	610
	DUCTILE CAST IRONS	≤ 260 Bhn or ≤ 26 HRc	67	RPM	14218	7109	3555	2666	2133	1777	1333	1066
			(54-80)	Fr	0.036	0.071	0.143	0.191	0.238	0.286	0.381	0.476
				Feed (mm/min)	508	508	508	508	508	508	508	508

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Series 146U, 136U Metric			Vc (m/mm)	DC • mm								
				1.5	3	6	8	10	12	16	20	
N	ALUMINUM ALLOYS (WROUGHT) 2024, 6061, 7075	≤ 150 Bhn or ≤ 88 HRb	145 (116-174)	RPM	30698	15349	7675	5756	4605	3837	2878	2302
			Fr	0.037	0.074	0.149	0.199	0.248	0.298	0.397	0.496	
			Feed (mm/min)	1143	1143	1143	1143	1143	1143	1143	1143	
	ALUMINUM ALLOYS (CAST) A356, A380, 390	≤ 140 Bhn or ≤ 3 HRc	116 (93-139)	RPM	24559	12279	6140	4605	3684	3070	2302	1842
			Fr	0.033	0.066	0.132	0.177	0.221	0.265	0.353	0.441	
			Feed (mm/min)	813	813	813	813	813	813	813	813	
S	TITANIUM ALLOYS Pure Titanium, Ti6Al4V, Ti6Al2Sn4Zr2Mo, Ti4Al4Mo2Sn0.5Si, Ti-6Al4V	≤ 275 Bhn or ≤ 28 HRc	53 (43-64)	RPM	11310	5655	2827	2121	1696	1414	1060	848
			Fr	0.017	0.033	0.066	0.089	0.111	0.133	0.177	0.222	
			Feed (mm/min)	188	188	188	188	188	188	188	188	
		≤ 350 Bhn or ≤ 38 HRc	40 (32-48)	RPM	8402	4201	2100	1575	1260	1050	788	630
			Fr	0.015	0.030	0.060	0.081	0.101	0.121	0.161	0.202	
			Feed (mm/min)	127	127	127	127	127	127	127	127	
		≤ 440 Bhn or ≤ 47 HRc	21 (17-26)	RPM	4524	2262	1131	848	679	565	424	339
			Fr	0.011	0.022	0.045	0.060	0.075	0.090	0.120	0.150	
			Feed (mm/min)	51	51	51	51	51	51	51	51	
H	ALLOY STEELS 4140, 4150, 4320, 5120, 5150, 8630, 86L20, 50100	≤ 450 Bhn or ≤ 48 HRc	29 (23-35)	RPM	6140	3070	1535	1151	921	767	576	460
			Fr	0.019	0.037	0.074	0.099	0.124	0.149	0.199	0.248	
			Feed (mm/min)	114	114	114	114	114	114	114	114	
	TOOL STEELS A2, D2, H13, L2, M2, P20, S7, T15, W2	≤ 475 Bhn or ≤ 50 HRc	24 (20-29)	RPM	5170	2585	1293	969	776	646	485	388
			Fr	0.017	0.034	0.069	0.092	0.115	0.138	0.183	0.229	
			Feed (mm/min)	89	89	89	89	89	89	89	89	

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 internal coolant required in ISO S and M material groups or when drilling depth exceeds 3xD
 Bhn (Brinell) HRc (Rockwell C) HRb (Rockwell B)
 $\text{rpm} = (\text{Vc} \times 1000) / (\text{DC} \times 3.14)$
 $\text{mm/min} = \text{Fr} \times \text{rpm}$
 speed and feed for materials harder than listed
 refer to the SGS Tool Wizard® for complete technical information (www.kyocera-sgstool.com)

angle °	reduction multiplier	
	speed x	feed x
up to 30	1.0	0.6
over 30	0.7	0.4