

Cutting Speeds, Feeds & Insert Guide

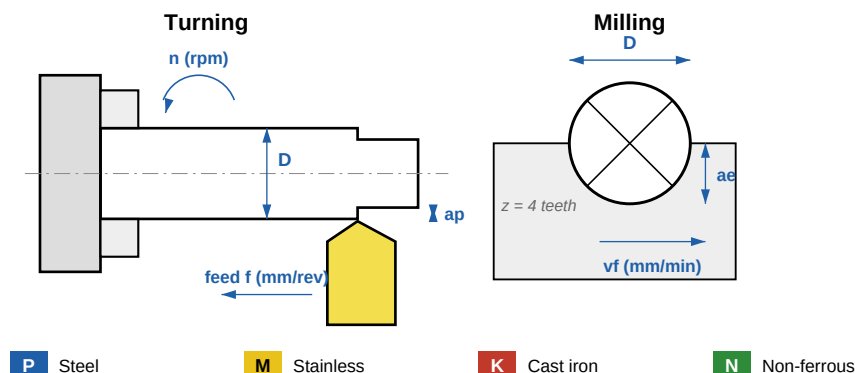
Mining and Industrial Suppliers (Pvt) Ltd

No 2 Hood Road, Southerton, Harare

Cutting speeds by material, the formulas, and a quick rpm table.

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$$n = Vc \times 1000 / (3.14 \times D) \quad \text{spindle speed, rpm}$$

$$Vc = 3.14 \times D \times n / 1000 \quad \text{cutting speed, m/min}$$

$$vf = f \times n \quad \text{feed rate - turning, drilling}$$

$$vf = fz \times z \times n \quad \text{feed rate - milling}$$

$$Q = ap \times ae \times vf / 1000 \quad \text{metal removal, cm}^3/\text{min}$$

Example: 10 mm HSS drill in mild steel, Vc 25 -> n = 25 x 1000 / 31.4 = 796 rpm; f 0.17 -> vf = 135 mm/min.
 Imperial: SFM x 0.3048 = m/min; IPR x 25.4 = mm/rev.

Cutting speed Vc (m/min) - uncoated HSS and coated carbide

Material	ISO	Hardness	HSS turn	Carbide turn	HSS drill	Carbide drill	HSS end mill	Carbide end mill
Free-cutting steel (EN1A, 1215)	P	under 180 HB	40 - 50	200 - 300	30 - 35	90 - 130	30 - 40	180 - 280
Mild steel (S275, EN3, 1020)	P	120 - 180 HB	30 - 40	180 - 280	25 - 30	80 - 120	25 - 35	150 - 250
Medium carbon steel (EN8, 1045)	P	180 - 250 HB	20 - 30	150 - 220	18 - 22	70 - 100	20 - 28	120 - 200
Alloy steel (EN19, 4140)	P	250 - 320 HB	15 - 20	120 - 180	12 - 16	60 - 90	15 - 20	100 - 160
Tool steel, annealed (O1, D2)	P	200 - 250 HB	10 - 15	80 - 140	8 - 12	40 - 70	10 - 15	70 - 120
Stainless 304 / 316	M	150 - 200 HB	12 - 18	120 - 180	8 - 12	40 - 70	10 - 15	80 - 140
Stainless free-machining (303)	M	160 - 220 HB	18 - 25	150 - 220	12 - 15	50 - 80	15 - 20	100 - 160
Grey cast iron	K	180 - 250 HB	20 - 30	120 - 200	20 - 25	70 - 110	18 - 25	100 - 180
Ductile (SG) cast iron	K	160 - 260 HB	15 - 25	100 - 180	15 - 20	60 - 90	15 - 20	90 - 150
Aluminium alloys	N	-	80 - 150	300 - 800	50 - 80	150 - 250	80 - 150	300 - 800
Brass and bronze	N	-	50 - 90	200 - 400	30 - 50	100 - 150	40 - 70	200 - 350
Copper	N	-	40 - 60	150 - 300	25 - 35	80 - 120	30 - 50	150 - 250
Plastics, acrylic, nylon	N	-	50 - 100	150 - 400	30 - 60	100 - 200	50 - 100	200 - 400
Titanium alloys	S	30 - 40 HRC	6 - 12	40 - 70	5 - 8	25 - 40	6 - 10	40 - 70
Nickel alloys (Inconel)	S	-	4 - 8	25 - 50	3 - 6	15 - 30	4 - 8	25 - 45
Hardened steel 45 - 55 HRC	H	45 - 55 HRC	-	40 - 80 (CBN 100 - 200)	-	20 - 40	-	40 - 80

Spindle speed (rpm) by diameter and cutting speed Vc (m/min)

Dia mm	10	15	20	25	30	40	60	80	100	150	200	300
1	3200	4750	6350	7950	9550	12500	19000	25500	32000	47500	63500	95500
2	1600	2400	3200	4000	4750	6350	9550	12500	16000	24000	32000	47500
3	1050	1600	2100	2650	3200	4250	6350	8500	10500	16000	21000	32000
4	795	1200	1600	2000	2400	3200	4750	6350	7950	12000	16000	24000
5	635	955	1250	1600	1900	2550	3800	5100	6350	9550	12500	19000
6	530	795	1050	1350	1600	2100	3200	4250	5300	7950	10500	16000
8	400	595	795	995	1200	1600	2400	3200	4000	5950	7950	12000
10	320	475	635	795	955	1250	1900	2550	3200	4750	6350	9550
12	265	400	530	665	795	1050	1600	2100	2650	4000	5300	7950
14	225	340	455	570	680	910	1350	1800	2250	3400	4550	6800
16	200	300	400	495	595	795	1200	1600	2000	3000	4000	5950
20	160	240	320	400	475	635	955	1250	1600	2400	3200	4750
25	125	190	255	320	380	510	765	1000	1250	1900	2550	3800
32	99	150	200	250	300	400	595	795	995	1500	2000	3000
40	80	120	160	200	240	320	475	635	795	1200	1600	2400
50	64	95	125	160	190	255	380	510	635	955	1250	1900
63	51	76	100	125	150	200	305	405	505	760	1000	1500
80	40	60	80	99	120	160	240	320	400	595	795	1200
100	32	48	64	80	95	125	190	255	320	475	635	955
125	25	38	51	64	76	100	155	205	255	380	510	765
160	20	30	40	50	60	80	120	160	200	300	400	595
200	16	24	32	40	48	64	95	125	160	240	320	475

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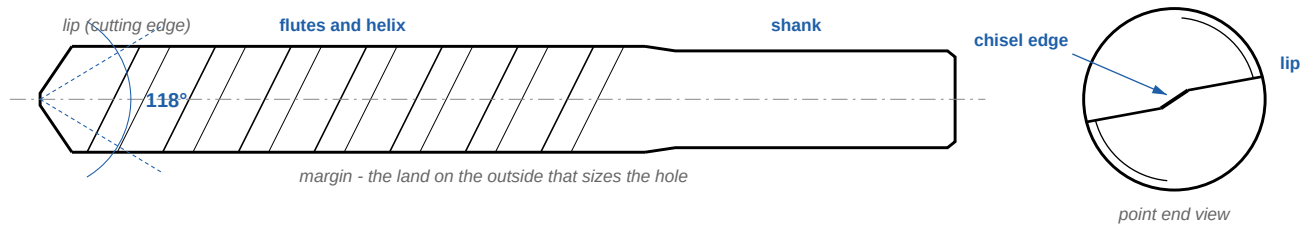
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Drilling - speeds, feeds, point angles and problems (HSS; solid carbide about 3 x the speed).

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Drill rpm and feed by diameter (HSS; Vc in m/min)

Drill mm	Mild steel (Vc 25)	Alloy steel (Vc 15)	Stainless (Vc 10)	Cast iron (Vc 22)	Aluminium (Vc 60)	Brass (Vc 40)	Feed mm/rev	mm/min mild steel
1	7950	4750	3200	7000	19000	12500	0.03	239
2	4000	2400	1600	3500	9550	6350	0.04	159
2.5	3200	1900	1250	2800	7650	5100	0.05	159
3	2650	1600	1050	2350	6350	4250	0.06	159
3.3	2400	1450	965	2100	5800	3850	0.06	145
4	2000	1200	795	1750	4750	3200	0.08	159
4.2	1900	1150	760	1650	4550	3050	0.08	152
5	1600	955	635	1400	3800	2550	0.09	143
6	1350	795	530	1150	3200	2100	0.11	146
6.8	1150	700	470	1050	2800	1850	0.12	140
8	995	595	400	875	2400	1600	0.14	139
8.5	935	560	375	825	2250	1500	0.15	140
10	795	475	320	700	1900	1250	0.17	135
10.2	780	470	310	685	1850	1250	0.17	133
12	665	400	265	585	1600	1050	0.2	133
14	570	340	225	500	1350	910	0.22	125
16	495	300	200	440	1200	795	0.24	119
18	440	265	175	390	1050	705	0.27	119
20	400	240	160	350	955	635	0.3	119
22	360	215	145	320	870	580	0.32	116
25	320	190	125	280	765	510	0.35	111
30	265	160	105	235	635	425	0.38	101

Feed per revolution (mm/rev, HSS) and point angles

Drill dia mm	Mild / medium steel	Alloy and tool steel	Stainless	Cast iron	Aluminium, brass
1 - 3	0.02 - 0.05	0.02 - 0.04	0.02 - 0.04	0.03 - 0.06	0.04 - 0.08
3 - 6	0.05 - 0.10	0.04 - 0.08	0.04 - 0.07	0.06 - 0.12	0.08 - 0.15
6 - 10	0.10 - 0.18	0.08 - 0.14	0.07 - 0.12	0.12 - 0.20	0.15 - 0.25
10 - 16	0.15 - 0.25	0.12 - 0.20	0.10 - 0.16	0.18 - 0.30	0.20 - 0.35
16 - 20	0.20 - 0.30	0.16 - 0.25	0.14 - 0.20	0.25 - 0.35	0.25 - 0.40
20 - 25	0.25 - 0.35	0.20 - 0.30	0.16 - 0.24	0.30 - 0.40	0.30 - 0.45
25 - 32	0.30 - 0.40	0.25 - 0.35	0.20 - 0.28	0.35 - 0.45	0.35 - 0.50

Point angle	Use it for
118°	General purpose HSS - mild steel, cast iron, brass
130 - 135° split point	Harder steel, stainless, sheet - self-centring, less walking
140°	Solid carbide drills, stainless
90° / 120°	Spot drills - match or exceed the drill point angle
60 - 90°	Plastics and acrylic (with zero rake)

Drilling problems

Problem	Likely cause	Fix
Drill wanders, hole oversize	No spot, point ground off-centre, lips unequal	Spot or centre drill first; split point; regrind lips equal
Chipped corners or lips	Speed too high, hard spots, no coolant	Slow down, flood coolant, check the material
Drill breaks	Chips packing in a deep hole; feeding hard at breakthrough	Peck every 1 - 2 x D beyond 3 x D deep; ease off as it breaks through
Squeals, rubs, no chips	Blunt, or too little lip clearance	Resharpener with 8 - 12° lip clearance; more feed in stainless
Blue chips, burnt drill (HSS)	Too fast for HSS	Drop the speed; coolant; carbide for production
Grabs in brass or thin sheet	Positive rake pulls the drill in	Dub the lips: stone a small flat on each cutting edge to zero rake; use a step drill for sheet
Rough or bell-mouthed hole	Feed too high, blunt, loose spindle	Less feed, sharpen; drill under-size and ream

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End mill feeds, and reading an ISO turning insert code (ISO 1832).

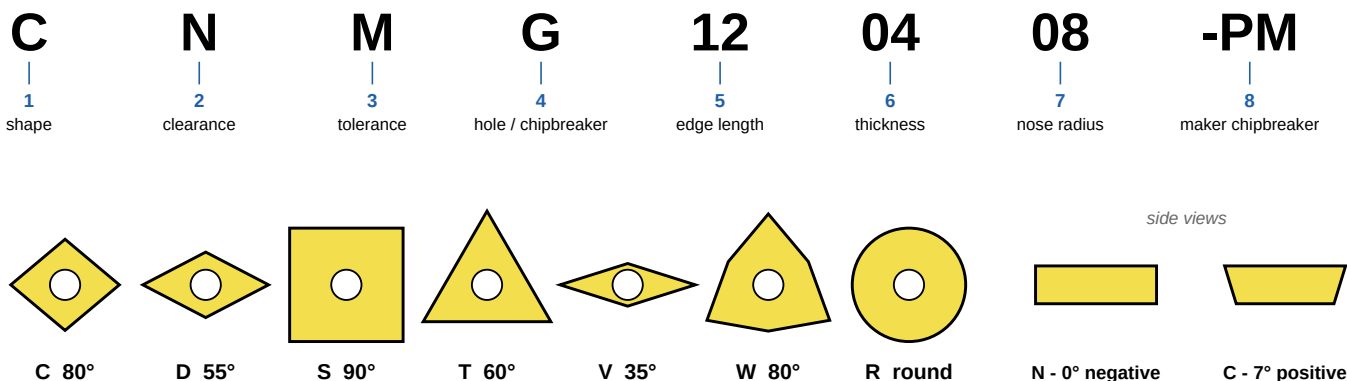
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End mill feed per tooth fz (mm) - full slot or 50% width

End mill dia mm	Steel HSS	Steel carbide	Stainless carbide	Cast iron carbide	Aluminium carbide
3	0.01	0.015	0.01	0.015	0.02
6	0.02	0.03	0.025	0.03	0.04
8	0.025	0.04	0.03	0.04	0.05
10	0.03	0.05	0.04	0.05	0.06
12	0.04	0.06	0.05	0.06	0.07
16	0.05	0.07	0.06	0.07	0.09
20	0.06	0.08	0.07	0.08	0.10
25	0.07	0.10	0.08	0.10	0.12

Width of cut ae	Multiply fz by
50% of D or more	1.0
30% of D	1.1
20% of D	1.25
10% of D	1.7
5% of D	2.3



1 Insert shape

Letter	Shape	Corner	Use it for
C	Rhombic	80°	General turning and facing - strong, the everyday insert
D	Rhombic	55°	Profiling and copying, reaching into shoulders
S	Square	90°	Roughing and chamfering - strongest corner, 8 edges (negative)
T	Triangle	60°	General turning and boring - economical
V	Rhombic	35°	Fine profiling and undercuts - weakest corner
W	Trigon	80°	Turning and facing - 6 edges on a negative insert
R	Round	-	Heavy roughing and profiling - strongest edge
K	Parallelogram	55°	Roughing and facing, special holders

2 Clearance 3 Tolerance 4 Hole and chipbreaker

Letter	Clearance	Notes
N	0°	Negative insert - double-sided, strongest, needs a rigid set-up
B	5°	Positive
C	7°	Positive - CCMT, DCMT: small parts, boring, low forces
P	11°	Positive - CCGT for aluminium and fine finishing
E	20°	Very positive

Letter	Tolerance	Notes
M	+/- 0.05 - 0.13 mm	Pressed - general turning
G	+/- 0.025 mm	Ground - finishing, precise positioning
E	+/- 0.025 mm	Ground
U	+/- 0.08 - 0.25 mm	Heavy roughing

Letter	Hole	Chipbreaker
N	None	None (clamped from the top)
R	None	One side
A	Plain	None
M	Plain	One side
G	Plain	Both sides (double-sided)
W	Countersunk	None (screw clamp)
T	Countersunk	One side (screw clamp)

5 Size (inscribed circle IC) 6 Thickness 7 Nose radius

IC mm	IC inch	C	D	S	T	V	W
6.35	1/4"	06	07	06	11	11	04
9.525	3/8"	09	11	09	16	16	06
12.7	1/2"	12	15	12	22	22	08
15.875	5/8"	16	-	15	27	-	10
19.05	3/4"	19	-	19	33	-	-

Code	Thickness mm
01	1.59
T1	1.98
02	2.38
03	3.18
T3	3.97
04	4.76
05	5.56
06	6.35
07	7.94

Code	Nose radius mm
00	sharp
02	0.2
04	0.4
08	0.8
12	1.2
16	1.6
24	2.4

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CNMG 12 04 08-PM P25 grade		
Vc	180 - 350 m/min	(250)
f	0.15 - 0.50 mm/rev	(0.25)
ap	0.5 - 5.5 mm	(2.5)
<div> <div>P</div> <div>●●</div> <div>M</div> <div>●○</div> <div>K</div> <div>●○</div> </div>		

- 1 The code: shape, clearance, tolerance, type, size, thickness, nose radius, chipbreaker (-PM = P steel, medium machining). The grade is the maker's own code - its ISO range (here P25) is printed on the box.
- 2 Vc, f and ap are the working ranges. Start at the figure in brackets - usually the middle.
- 3 Speed sets tool life: too fast wears the flank, too slow builds up an edge. Feed and depth must stay inside the chipbreaker range or the chips will not break.
- 4 The ISO squares show the materials the grade suits: two dots = main use, one dot = also suitable.
- 5 If the box gives only surface speed, work out the rpm from the diameter being cut (page 1). On a lathe, the rpm must rise as the diameter falls - use constant surface speed (G96) on CNC.

Chipbreakers and grades

Suffix (typical)	Application	Depth ap mm	Feed mm/rev
-F, -PF, -MF, -KF	Finishing	0.2 - 1.5	0.05 - 0.2
-M, -PM, -MM, -KM	Medium machining	1 - 5	0.15 - 0.45
-R, -PR, -MR, -KR	Roughing	3 - 8	0.3 - 0.8
-AL, polished, uncoated	Aluminium and non-ferrous	0.5 - 5	0.1 - 0.4
First letter P / M / K	Work material group the chipbreaker is made for		

Grade type	Use it for
P01 - P10 (low number)	Hard and wear-resistant - finishing at high speed, steady cuts
P20 - P30	General purpose - the starting point
P40 - P50 (high number)	Tough - roughing, interrupted cuts, low speed, poor set-ups
CVD coated (thick)	Steel and cast iron turning - heat and wear resistant
PVD coated (thin, sharp)	Stainless, small parts, milling, grooving
Uncoated / polished	Aluminium and non-ferrous - stops build-up
Cermet	Finishing steel - bright surface
CBN	Hardened steel over 45 HRC, chilled cast iron
PCD (diamond)	High-silicon aluminium, composites, non-ferrous - never steel

Nose radius and finish - maximum feed mm/rev for a target Ra ($Ra = f \times f \times 1000 / 32r$)

Target Ra um	r 0.4	r 0.8	r 1.2	r 1.6
0.4	0.07	0.10	0.12	0.14
0.8	0.10	0.14	0.18	0.20
1.6	0.14	0.20	0.25	0.29
3.2	0.20	0.29	0.35	0.40
6.3	0.28	0.40	0.49	0.57

Chips look like	Meaning	Change
Long, stringy, tangling	Too little feed or depth for the chipbreaker	More feed, or a finer chipbreaker (-F)
Short 6 and 9 shapes, C curls	Right	Keep it
Tight, blue, crushed	Too much feed for the chipbreaker	Less feed, or a roughing chipbreaker (-R)
Built-up edge, torn finish	Speed too low, or sticky material	More speed; sharp positive insert; coolant
Fast flank wear	Speed too high or grade too tough	Less speed, or a harder grade
Edge chipping	Grade too hard, vibration, interruptions	Tougher grade, stronger shape, check rigidity

Toolholder code (ISO 5608)

Position	Example PCLNR 2525 M 12	Common letters
1 Clamping	P - lever through the hole	C top clamp, M top clamp + pin, S screw, D rigid clamp
2 Insert shape	C - 80° rhombic	As insert shape
3 Holder style	L - 95° turn and face	J 93° profile, K 75°, S 45°, F 90° face, G 90°, R 75°
4 Insert clearance	N - 0° (negative)	C 7°, P 11°
5 Hand	R - right hand	L left, N neutral
6 - 7 Shank	25 x 25 mm	1616, 2020, 2525, 3232
8 Length	M - 150 mm	H 100, K 125, M 150, P 170, Q 180
9 Insert size	12 - 12.7 mm IC	As insert size code