TECHNICAL INFORMATION

• Engineering Black Book • Material Grades • Cutting Data • Troubleshooting

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General

Drills

Taps

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Literature

Reamers

Enquiry forms for special tools

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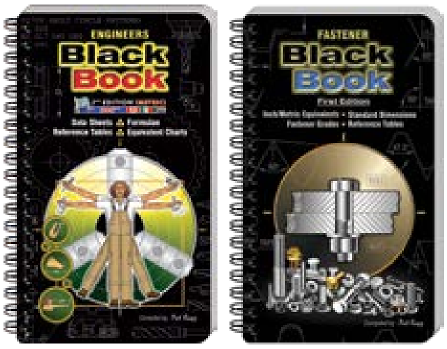
The ultimate reference book
- Matt laminated grease proof pages
- Wire bound to stay flat on workbench when reading
- Ideal for engineers, trades people, apprentices, machine shops, tool rooms, technical colleges

Engineers Black Book
- Tables • Standards • Illustrations • Grinding wheels • Conversion factors • Tapers
- Lubricants-coolants • Spur gear calculations • Hardening & tempering • G Codes
- Geometrical construction • Formulae • Engineering drawing standards • Plastics • Tolerances
- Bolts & nuts • Tungsten carbide • Keys & keyways • Weights of metal • Tapping drill sizes
- Speeds & feeds • Equivalent charts • Sharpening information

Fastener Black Book
- Screw thread fundamentals • Standards • Thread classes • Thread terminology • Grades
- Heat treatment • Materials & coatings • Failures & corrosion • Fastener strengths & markings
- Tolerances • Material selection • Hydrogen embrittlement • Screw thread profiles
- Torque control • Galling • Dimensional Specifications DIN / ISO / ANSI • Platings
- Elevated temperature effects



						Catalogue Code	L100	L200
						Discount Group	Z0502	Z0502
Size Ref.	**Description**	**Edition**	**Pages**	**Language**		**Merchandiser**	**Item #**	**Item #**
V2EN	Engineers Black Book	#3	164	English	🇬🇧	499999803	L100 V3EN	
V2NL	Engineers Black Book	#2	164	Dutch	🇳🇱	499999798	L100 V2NL	
V2FR	Engineers Black Book	#2	164	French	🇫🇷	499999797	L100 V2FR	
V2DE	Engineers Black Book	#2	164	German	🇩🇪	499999797	L100 V2DE	
V1EN	Fastener Black Book	#1	248	English	🇬🇧	499999803		L200 V1EN

BONUS:
Bookmarking tabs

BONUS:
Thread pitch identification gauge

sutton VENOM

ENDURANCE+ CUTTING FLUID

Venom Endurance+ Cutting Fluid
Venom Endurance+ Cutting Fluid is a highly efficient cutting and lubricating fluid. Formulated to increase tool life and enhance cutting performance in a broad range of metals including carbon steel, aluminium alloys, copper, brass, bronze and stainless steel.
Mild clinging action helps fluid adhere to the tool and part when vertical work is required.

Features
- Reduces torque and friction
- Extends tool life
- Improves surface finish
- Accurate thread quality
- Environmentally friendly mineral oil base with 10% organic coconut oil. Free from Trichloroethane – low odour

Fluide de coupe Venom Endurance +
Le fluide de coupe Venom Endurance + est un lubrification de coupe très efficaces Fluide. Formulé pour augmenter la durée de vie des outils et améliorer les performances de coupe dans un large panel de métaux, les aciers carbone, alliages d'aluminium, cuivres, laitons, bronzes et aciers inoxydable. Une légère action d'accrochage aide le fluide à adhérer à l'outil et à la pièce lors d'un travail vertical.

Fonctionnalités
- Réduit le couple et la friction
- Prolonge la durée de vie de l'outil
- Améliore la finition de l'état de surface
- Huile minérale écologique avec 10% d'huile de coco biologique. Sans trichloroéthane - une faible odeur

Venom Fluido da Taglio
Venom Endurance + Cutting Fluid è un fluido lubrificante da taglio altamente efficiente. Formulato per aumentare la durata dell'utensile e migliorare le prestazioni di taglio in a un'ampia gamma di metalli, compreso acciaio al carbonio, leghe di alluminio, rame, ottone, bronzo e acciaio inossidabile. Una leggera azione aderente aiuta il fluido ad aderire sul tagliente e sul materiale da tagliare, quando si lavora in verticale è obbligatorio.

Caratteristiche
- Riduce la coppia e l'attrito
- Allunga la vita dell'utensile
- Migliora la finitura superficiale
- Accurata qualità del filetto
- Olio minerale ecologico base con il 10% di olio di cocco biologico Senza tricloroetano - odore debole

Fluido De Corte
Venom Endurance + Cutting es un fluido líquido de corte y lubricación de alta eficiencia. Adecuado para aumentar la vida útil de la herramienta y mejorar el rendimiento de corte en una amplia gama de metales, incluido el carbono acero, aleaciones de aluminio, cobre, latón, bronce y acero inoxidable. La acción de adherencia suave ayuda a que el líquido se adhiera a la herramienta y a la pieza cuando se trabaja en vertical es necesario.

Características
- Reduce el par y la fricción
- Alarga la vida de la herramienta
- Mejora el acabado superficial
- Calidad de hilo mas precisa
- Aceite mineral ecológico base con un 10% de aceite de coco orgánico. Libre de tricloroetano - poco olor

EXTREME POWER CUTTING PASTE

Venom Extreme Power Cutting Paste
Formulated for superior tool life and cutting performance in carbon steel, aluminium alloys, copper, bronze, stainless steel, nickels, titaniums and other super alloys. Venom Extreme Power Cutting Paste is a high performance low melting point lubricant specifically designed to adhere to the cutting edges, even when using additional coolants.

Features
- Low melting point – adheres to cutting edge for greater tool protection
- Not affected by coolant
- Lowest torque required for higher performance
- Reduced friction for extremely high quality surface finish

Venom, pate de taraudage
Formulé pour une meilleure durée de vie et performance dans les aciers carbone, alliages aluminium, cuivres, bronzes, inox, titanes, inconels et les super alloys. Pâte de coupe. Le lubrifiant Venom Extreme Power a un point de fusion bas, il est conçu pour adhérer sur l'arêtes de coupe, même lors de l'utilisation liquides de refroidissement supplémentaires.

Fonctionnalités
- Bas point de fusion - adhère sur l'arete de coupe pour une meilleur protection d'outil
- Non affecté par le liquide de refroidissement
- Efforts de coupe réduit
- Couple et friction réduits, meilleur état de surface

Venom Pasta da Taglio
Formulato per una superiore durata utensile e prestazione di taglio su acciai al carbonio,leghe di Alluminio,rame, bronzo,acciaio inossidabile, leghe a base nickel, titanio e tutte le super leghe. La Pasta da taglio Venom Extreme Power Cutting è un lubrificante studiato appositamente per aderire ai bordi del tagliente utensile consentendo di mantenere basso il punto di fusione durante alte prestazioni,anche quando si utilizzano refrigeranti aggiuntivi.

Caratteristiche
- Basso punto di fusione - aderisce al tagliente per una maggiore protezione dell'utensile
- Compatibile con l'utilizzo di altri refrigeranti
- Riduce gli sforzi per prestazioni più elevate e durature
- Attrito ridotto estremamente garantendo finitura superficiale di alta qualità

Pasta De Corte
Formula para una vida útil y rendimiento de corte superior en acero al carbono, aleaciones de aluminio, cobre, bronce, acero inoxidable, níquel, titanio y otras superaleaciones. La pasta de corte Venom Extreme Power tiene un punto de fusión bajo de alto rendimiento lubricante diseñado específicamente para adherirse a los filos de corte, incluso cuando se utiliza refrigerantes adicionales.

Caratteristiche
- Punto de fusión bajo: se adhiere al filo para mayor proteccion de la herramienta
- No se ve afectado por el refrigerante
- El par más bajo requerido para mayor rendimiento
- Fricción reducida para un acabado superficial de alta calidad

ENDURANCE+ CUTTING FLUID | **EXTREME POWER CUTTING PASTE**

Suitable Applications
Cutting, drilling, tapping, milling, broaching, reaming, threading, sawing, boring, turning and holesaw cutting.

Applications appropriées
Perçage, taraudage, fraisage, brochage, alésage, filetage, sciage, alésage et découpage à la scie cloche.

Adatto ad Applicazioni di
Taglio, foratura, maschiatura, fresatura, brocciatura, alesatura, filettatura, sbavature, tornitura, sega e sega a tazza taglio

Aplicaciones adecuadas
Taladrar, roscar, fresar, brochado, escariado, roscado, serrado, torneado y corte con sierra de corona

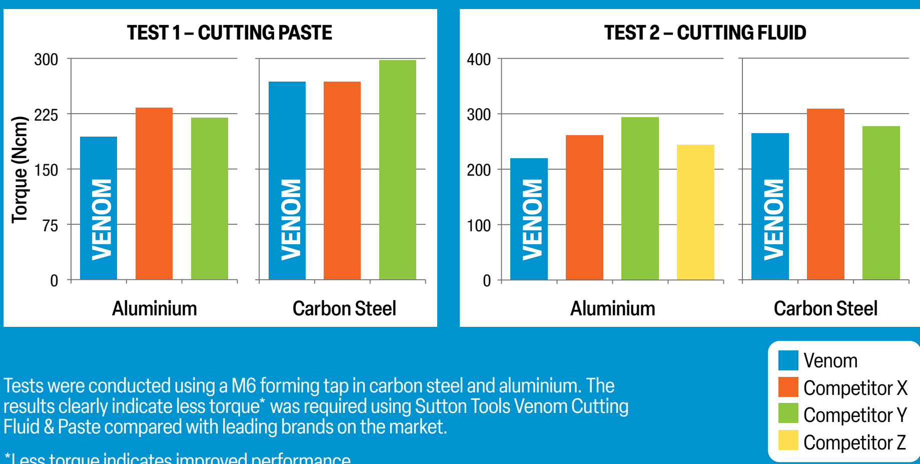
M800 0250

M800 0400

Catalogue Code	M800
Discount Group	Z1006

Size Ref.	Description		Item #
0250	Venom Cutting Fluid	250ml	M800 0250
0400	Venom Cutting Paste	400g	M800 0400

Tests indicate Sutton Tools Venom requires less torque – it performed up to 30% better than its competitors



Tests were conducted using a M6 forming tap in carbon steel and aluminium. The results clearly indicate less torque* was required using Sutton Tools Venom Cutting Fluid & Paste compared with leading brands on the market.

*Less torque indicates improved performance.

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Material Group		WKR	DIN	BS	EN	AFNOR	UNI	UNE	SS	JIS	AISI / SAE / UNS
ISO	VDI 3323	Germany	Germany	U.K.	U.K.	France	Italy	Spain	Sweden	Japan	USA
P	1	1.0402	C 22	050 A 20	2C	CC20	C 20 , C 21	F.112	1450		1020, G 10200
	1	1.0715	9 SMn 28	230 M 07		S250	CF 9 SMn 28	11SMn28	1912	SUM 22	1213, G 12130
	1	1.0722	10 SPb 20			10PbF2	CF 10 SPb 20	10SPb20			11 L 08
	1	1.0736	9 SMn 36	240 M 07	1B	S300	CF 9 SMn 36	12SMN35			1215, G 12150
	1	1.0737	9 SMnPb 36			S300Pb	CF 9 SMnPb 36	12SMnP35	1926		12 L 14, G 12144
	1	1.0401	C 15	080 M 15	CS	CC12	C16	F.111	1350	S 15 CK	1015, G 10170
	1	1.0718	9 SMnPb 28			S250Pb	CF 9 SMnPb 28	11SMnPb28	1914	SUM 22 L	12 L 13, G 12134
	1	1.1141	Ck 15	080 M 15	32C	XC12 , XC15 , XC18	C15		1370	S15C	1015, G 10170
	2	1.1170	28 Mn 6	150 M 28	14A	20M5	C 28 Mn			SCMn 1	1330
	2 / 3	1.0501	C 35	060 A 35		CC35	C 35	F.113	1550	S 35 C	1035, G 10350
	2 / 3	1.0503	C 45	080 M 46		CC45	C 45	F.114	1650	S45C	1045, G 10430
	2 / 3	1.1191	Ck 45	080 M 46			C 45	F.1140	1672	S48C	1045, G 10420
	2 / 3	1.0726	35 S 20	212 M 36	8M	35 MF 4		F.210.G	1957		1140, G 11400
	2 / 3	1.1157	40 Mn 4	150 M 36	15	35 M 5					1039, G10390
	2 / 3	1.1167	36 Mn 5	150 M 36		40 M 5		F.411	2120	SMn438(H)	1335, G 13350
	4 / 5	1.0535	C 55	070 M 55			C 55	F.1150	1655	S 55 C	1055
	4 / 5	1.0601	C 60	080 A 62	43D	CC 55	C 60			S 58 C	1060, G 10600
	4 / 5	1.1203	Ck 55	070 M 55		XC 55	C 50		1655	S 55 C	1055
	4 / 5	1.1221	Ck 60	080 A 62	43D	XC 60	C 60	F.1150	1665; 1678	S 58 C	1060, G 10640
	4 / 5	1.1545	C 105 W1	BW 1A			C 100 KU	F.5118	1880	SK 3	W 110, T 72301
	4 / 5	1.1274	Ck 101	060 A 96				F.5117	1870	SUP 4	1095, G 10950
	5 / 9	1.5120	38 MnSi 4								
	6 / 7	1.6657	10 NiCrMo 13-4	832 M 13	36C		15 NiCrMo 13	14NiCrMo131			
	6 / 7	1.5423	16 Mo 5	1503-245-420			16 Mo 5	16Mo5		SB 450 M	4520, G 45200
	6 / 7	1.7131	16 MnCr 5	527 M 17		16 MC 5	16 MnCr 5	F.1516	2511	SCR 415	5115, G 51170
	6 / 7	1.5622	14 Ni 6			16 N 6	14 Ni 6	15Ni6			A350LF5
	6 / 7	1.5415	15 Mo 3	1501-240		15 D 3	16 Mo 3	16Mo3	2912		A204GrA
	6 / 7	1.5752	14 NiCr 14	655 M 13	36A	12 NC 15				SNC 815 (H)	3310, 3415, 9314, G 33106
	6 / 7	1.6587	17 CrNiMo 6	820 A 16		18 NCD 6	18 NiCrMo 7				
	6 / 7	1.7262	15 CrMo 5			12 CD 4	12 CrMo 4	12CrMo4	2216		
	6 / 7	1.7335	13 CrMo 4-4	1501-620 Gr. 27		15 CD 3.5	14 CrMo 4 5	14CrMo45	2216		A 182-F11, F12
	6 / 7	1.7380	10 CrMo 9-10	1501-622 Gr. 31, 45		10 CD 9.10	12 CrMo 9 10	F.155	2218		A 182-F22, J 21890
	6 / 7	1.7715	14 MoV 6-3	1503-660-440							
	6 / 7	1.7015	10 Cr 3	523 M 15		12 C 3				SCr 415 (H)	5015, G 50150
	6 / 8	1.7033	34 Cr 4	530 A 32	18B	32 C 4	34 Cr 4 (KB)			SCr 430 (H)	5132, G 51320
	6 / 8	1.7218	25 CrMo 4	1717 CDS 110		25 CD 4 S	25 CrMo 4 (KB)	F.1251	2225	SCM 420, SCM 430	4130, G 41300
	6 / 8	1.6523	21 NiCrMo 2	805 M 20	362	20 NCD 2	20 NiCrMo 2	F.1522	2506	SNCM 220 (H)	8620, G 86170
	6 / 9	1.7220	34 CrMo 4	708 A 37		35 CD 4	35 CrMo 4		2234	SCM 432, SCCrM 3	4135, 4137, G 41350
	6 / 9	1.7225	42 CrMo 4	708 M 40		42 CD 4	42 CrMo 4		2244	SCM 440 (H)	4140, 4142, G 41400
	6 / 9	1.8509	41 CrAlMo 7	905 M 39	41B	40 CAD 6.12	41 CrAlMo 7			SACM 645	A355GrA, K 24065
	6 / 9	1.0961	60 SiCr 7			60 SC 7	60 SiCr 8				9262
	6 / 9	1.2067	100 Cr 6	BL 3							L 3, T 61203
	6 / 9	1.2419	105 WCr 6			105 WC 13	107 WCr 5 KU		2140	SKS 31	
	6 / 9	1.2542	45 WCrV 7	BS 1			45 WCrV 8 KU		2710		S 1, T 41901
	6 / 9	1.2713	55 NiCrMoV 6			55 NCDV 7		F.520.S		SKT 4	L 6, T 61206
	6 / 9	1.7035	41 Cr 4	530 M 40	18	42 C 4	41 Cr 4			SCr 440 (H)	5140, G 51400
	6 / 9	1.7176	55 Cr 3	527 A 60	48	55 C 3	55 Cr 3		2253	SUP 9 (A)	5155, G 51550
	6 / 9	1.6546	40 NiCrMo 2-2	311-Type 7		40 NCD 2	40 NiCrMo 2 (KB)			SNCM 240	8740, G 87400
	6 / 9	1.6511	36 CrNiMo 4	816 M 40	110	40 NCD 3	38 NiCrMo 4 (KB)				9840, G 98400
	6 / 9	1.6582	34 CrNiMo 6	817 M 40	24	35 NCD 6	35 NiCrMo 6 (KW)		2541	SNCM 447	4340
	6 / 9	1.7361	32 CrMo 12	722 M 24	40B	30 CD 12	32 CrMo 12		2240		
	6 / 9	1.8159	50 CrV 4	735 A 50	47	50 CV 4	51 CrV 4	51CrV4	2230	SUP 10	6145, 6150
	6 / 9	1.8523	39 CrMoV 13-9	897 M 39	40C		36 CrMoV 13 9				
	6 / 9	1.8161	58 CrV 4								
	10 / 11	1.5680	12 Ni 19			Z 18 N 5					2515
	10 / 11	1.2363	X100 CrMoV 5-1	BA 2		Z 100 CDV 5	X 100 CrMoV 5 1 KU	F.5227	2260	SKD 12	A 2, T 30102
	10 / 11	1.2436	X210 CrW 12				X 215 CrW 12 1 KU	F.5213	2312	SKD 2	D 4
	10 / 11	1.2601	X165 CrMoV 12				X 165 CrMoW 12 KU		2310		
	10 / 11	1.3343	S 6-5-2	BM 2		Z 85 WDCV 06.05.04.02	HS 6-5-2		2722	SKH 51	M 2, T 11302
	10 / 11	1.2344	X40 CrMoV 5-1	BH 13		Z 40 CDV 5	X 40 CrMo 5 1 1 KU	F.5318	2242	SKD 61	H 13, T 20813

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Material Group		WKR	DIN	BS	EN	AFNOR	UNI	UNE	SS	JIS	AISI / SAE / UNS
ISO	VDI 3323	Germany	Germany	U.K.	U.K.	France	Italy	Spain	Sweden	Japan	USA
P	10 / 11	1.2581	X30 WCrV 9-3	BH 21		Z 30 WCV 9	X 30 WCrV 9 3 KU			SKD 5	H 21, T 20821
	10 / 11	1.2080	X210 Cr 12	BD 3		Z 200 C 12	X 210 Cr 13 KU			SKD 1	D 3, T 30403
	10 / 11	1.3243	S 6-5-2-5	BM 35		Z 85 WDKCV 06.05.05.04.02	HS 6-5-2-5	HS 6-5-2-5	2723	SKH 55	M35
	10 / 11	1.3348	S 2-9-2			Z 100 DCWV 09.04.02.02	HS 2-9-2	HS 2-9-2	2782		M 7, T 11307
	10 / 11	1.3255	S 18-1-2-5	BT 4		Z 80 WKCV 18.05.04.0	HS 18-1-1-5	HS 18-1-1-5		SKH 3	T 4, T 12004
	10 / 11	1.3355	S 18-0-1	BT 1		Z 80 WCV 18.04.01	HS 18-0-1	HS 18-0-1		SKH 2	T 1, T 12001
	10 / 11	1.4718	X45 CrSi 9-3	401 S 45	52	Z 45 CS 9	X 45 CrSi 8			SUH 1	HNV 3, S 65007
	12 / 13	1.4104	X12 CrMoS 17	420 S 37		Z 10 CF 17	X 10 CrS 17	F.3117	2383	SUS 430 F	430 F, S 43020
	12 / 13	1.4000	X6 Cr 13	403 S 17		Z 6 C 13	X 6 Cr 13	F.3110	2301	SUS 403	403, S 40300
	12 / 13	1.4016	X6 Cr 17	430 S 15	60	Z 8 C 17	X 8 Cr 17	F.3113	2320	SUS 430	430, S 43000
	12 / 13	1.4113	X6 CrMo 17	434 S 17		Z 8 CD 17.01	X 8 CrMo 17			SUS 434	434, S 43400
	12 / 13	1.4006	X12 Cr 13	410 S 21	56A	Z10 C 13	X 12 Cr 13	F.3401	2302	SUS 410	410 S, S 41000
	12 / 13	1.4001	X7 Cr 14					F.8401		SUS 429	429
	12 / 13	1.4871	X53 CrMnNiN 21-9	349 S 52		Z 52 CMN 21.09	X 53 CrMnNiN 21 9			SUH 35	EV 8, S 63008
	12 / 13	1.4034	X46 Cr 13	420 S 45	56D	Z 40 C 14	X 40 Cr 14	F.3405	2304	SUS 420J2	
	12 / 13	1.4057	X19 CrNi 17-2	431 S 29	57	Z 15 CN 16.02	X 16 CrNi 16	F.3427	2321	SUS 431	431, S 43100
	12 / 13	1.4313	X3 CrNi 13-4	425 C 11		Z 5 CN 13.4	X 6 CrNi 13 04		2385	SCS 5	CA 6-NM, J 91540
	12 / 13	1.4027	G-X20Cr14	420 C 24	56B	Z 20 C 13 M				SCS 2	
M	14.1	1.4436	X3 CrNiMo 17-13-3	316 S 33		Z 6 CND 18.12.03	X 5 CrNiMo 17 13 2		2343	SUS 316	316, S 31600
	14.1	1.4310	X10 CrNi 18-8	301 S 21		Z 12 CN 17.07	X2CrNi18 07	F.3517	2331	SUS 301	301, S 30100
	14.1	1.4401	X5 CrNiMo 17-12-2	316 S 31	58J	Z 6 CND 17.11	X 5 CrNiMo 17 12	F.3543	2347	SUS 316	316, S 31600
	14.1	1.4429	X2CrNiMoN 17-13-3	316 S 62		Z 2 CND 17.13 Az	X 2 CrNiMoN 17 13 3		2375	SUS 316 LN	316 LN, S 31653
	14.1	1.4583	X6 CrNiMoNb 18-12				X 6 CrNiMoNb 17 13				318
	14.1	1.4305	X10 CrNiS 18-10	303 S 21	58M	Z 10 CNF 18.09	X 10 CrNi 18 09	F.3508	2346	SUS 303	303, S 30300
	14.1	1.4301	X5 CrNi 18-10	304 S 15	58E	Z 6 CN 18.09	X 5 CrNi 18 11	F.3504	2332 , 2333	SUS 304	304 , 304 H, S 30400
	14.1	1.4571	X6 CrNiMoTi17-12-2	320 S 31	58J	Z 6 CNT 17.12	X 6 CrNiMoTi 17 12	F.3535	2350	SUS 316 Ti	316 Ti, S 31635
	14.1	1.4311	X2 CrNiN 18 10	304 S 62		Z 2 CN 18 .10	X2CrNiN18 10	F.3541	2371	SUS 304 LN	304 LN, S 30453
	14.1	1.4308	G-X6CrNi 18-9	304 C 15	58E	Z 6 CN 18.10 M			2333	SCS 13	CF-8, J 92590
	14.1	1.4408	G-X6CrNiMo 18-10	316 C 16					2343	SCS 14	CF-8M, J 92900
	14.1	1.4581	G-X5CrNiMoNb 18	318 C 17		Z 4 CNDNb 18.12	GX5CrNiMoNb19 11 2			SCS 22	
	14.2	1.4845	X12 CrNi 25-21	310 S 24		Z 12 CN 25.20	X 6 CrNi 25 20	F.331	2361	SUH 310; SUS 310 S	310 S
	14.2	1.4462	X2CrNiMoN 22.5.3			Z3 CrNi 22.05 AZ					S31803 / S32205 (SAF2205)
	14.2	1.4541	X14 CrNiTi 18-10	321 S 12		Z 6 CNT 18.10	X 6 CrNiTi 18 11	F.3523	2337	SUS 321	321 H, S 32100
	14.2	1.4550	X6 CrNiNb 18-10	347 S 17	58F	Z 6 CNNb 18.10	X 6 CrNiNb 18 11	F.3524	2338	SUS 347	347, S 34700
	14.3	1.4545	X5CrNiCuNb15-5-4			EZ5CNU15-05					S15500, 15-5 PH
	14.3	1.4542	X5CrNiCuNb16-4			Z6CNU17-04					S17400, 17-4 PH; 630
K	15 / 16	0.6020	GG 20	180, 200/220, 220, Grade180, Grade260		FGL200, Ft20D	G 20	FG20	120	FC200	200/225, 25B, 30, 30B
	15	0.6010	GG-10		100	FT 10 D	G10		0110-00	FC100	
	15	0.6015	GG 15	Grade 150		FT 15 D	G 15	FG 15	0115-00	FC150	NO 25 B
	15	0.6660	GGL-NiCr202	L-NiCuCr202		L-NC 202			0523-00		A436 Type 2
	15	0.7040	GGG 40	SNG 420/12		FCS 400-12	GS400-12	FGE 38-17	0717-02	FCD400	60-40-18
	16	0.6030	GG30	Grade 300		Ft 30 D	G30	FG30	01 30-00	FC300	300/325, 40B, 45/50, 45B
	16	0.6035	GG-35	GRADE 350		Ft35D	G 35	FG 35	135	FC350	A48-50
	16	0.6040	GG40	GRADE400		Ft 40 D			140		A48-60 B
	16	0.7070	GGG-70	SNG700/2	EN-JS1070	FGS 700-2	GGG 70	GGG 70	07 37-01	FCD700, FCD700-2	100-70-03
	17	0.7033	GGG35.3						07 17-15		Ni-ResistD-5B, S-NiCr35-3
	17	0.7043	GGG-40.3	370/7	EN-JS1025	FGS 370/17			0717-15	FCD400-18L	60/40/18
	17	0.7050	GGG50	SNG500/7	EN-JS1050	FGS 500/7	GGG 50	FGE50-7	0727-02	FCD500, FCD500-7	65-45-12, 70-50-05, 80-55-06
	17	0.7652	GGG-NiMn 13 7	S-NiMn 137		S-Mn 137					
	17	0.7660	GGG-NiCr 20 2	Grade S6		S-NC 202			0772-00		A43D2, Ni-ResistD-2, S-NiCr20-2
	18	0.6025	GG25	Grade260		Ft 25 D	G25	FG25	0717-12		250/275, 35, 35B, 40
	18	0.7060	GGG60	SNG600/3	EN-JS1060	FGS600-3	G 25	FG 25	07 32-03	FC250	100-70-03, 80-55-06, 80-60-03
	18								0727-03	FCD600	A48 40 B
	19	0.8055	GTW55								
	19	0.8135	GTS-35-10	B 340/2		Mn 35-10		GTS 35	810		
	19	0.8145	GTS-45-06	P 440/7		Mn 450-6			0815-00		A220-40010
	19		GTS-35	B 340/12			0852-00	GMN 45			
	19			8 290/6		MN 32-8					
	19		GTS-35	B340/12		MN 35-10			0810-00		32510

Application Guide Material Workpiece

sutton

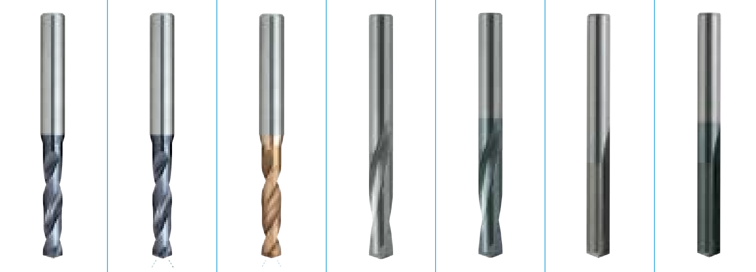
Material Group		WKR	DIN	BS	EN	AFNOR	UNI	UNE	SS	JIS	AISI / SAE / UNS
ISO	VDI 3323	Germany	Germany	U.K.	U.K.	France	Italy	Spain	Sweden	Japan	USA
K	20	0.8035	GTM-35	W340/3		MB35-7			814	AC4A	
	20	0.8040	GTW-40	W410/4		MB40-10			08 15	FCMW330	
	20	0.8045						GTM 35	852		
	20	0.8065	GTMW-65				GMB40	GTM 40			
	20	0.8155	GTS-55-04	P 510/4		Mn 550-4	GMB45	GTM 45			A220-50005
	20	0.8165	GTS-65-02	P 570/3		Mn 650-3			0854-00		70003
	20	0.8170	GTS-70-02	P 690/2		Mn 700-2	GMN 55, 65		0854-00	FCMP490	90001
	20		GTS-45	P440/7			20 Mn 7	F.1515-20 Mn 6		SMnC 420	400 10
	20		GTS-65	P 570/3		MP 60-3	C 36; C 38		1572	S 35 C	70003
N	21	3.0205							08 52		Al99
	21	3.0255	Al99.5	L31/34/36		A59050C	P-Al99.5		Al99.5	FCMP540	1000
	21	3.3315	AlMg1								
	21	3.0505	AlMn0.5Mg0.5								
	21	3.0275	Al99.7	4508, 9001-3, P-Al99.7		1070A	Al99.7			1070, A1070	1070A
	21	3.0285	Al99.8	1080A		1080A	4590, 9001-4, P-Al99.8			1080A, 1080A	1080A, 1080A
	22	3.1325	AlCuMg 1			2017A	P-AlCu4MgMnSi			2017	A92017
	22	3.1655	AlCuSiPb								
	22	3.2315	AlMgSi1								
	22	3.4345	AlZnMgCuO,5	L 86		AZ 4 GU/9051					7050
	22	3.1305	AlCuMg0.5	L86		A-U2G2117	P-AlCu2.5MgSi			2117	2117
	22	3.0517	AlMnCu								
	23	3.2381	G-AlSi 10 Mg	G-AlSi9Mg		A-S10G			AlSi10Mg	AC4A, ADC3	A03590
	23	3.2382	GD-AlSi10Mg						811-04	ADC3	
	23	3.2581	G-AlSi12	LM20		A-S12U	G-AlSi13CuMn		AlSi12Cu	AC3A	A04130
	23	3.3561	G-AlMg 5							AC7A, ADC5, Al-Mg6	
	23	3.5101	G-MgZn4sE1Zr1	MAG 5							ZE 41
	23	3.5103	MgSE3Zn27r1	MAG 6		G-TR3Z2					EZ 33
	23	3.5812	G-MgAl8Zn1	NMAG 1							AZ 81
	23	3.5912	G-MgAl9Zn1	MAG 7							AZ 91
	23	3.3549	AlMg5Mn								
	23	3.3555	AlMg5								
	23	3.3547	AlMg4.5, AlMg4.5Mn	5083		5183	P-AlMg4.4		AlMg4.5Mn	5082	A95083
	23-24	3.2383	G-AlSi0Mg(Cu)	LM9					4253		A360.2
	23-24			2789;1973		NF A32-201					A356-72
	23-24			LM25					4244	A5052	356.1
	23-24		G-AlSi12	LM 6					4261		A413.2
	23-24		G-AlSi 12 (Cu)	LM 20					4260	ADC12	A413.1
	23-24		GD-AlSi12						4247	A6061	A413.0
	23-24		GD-AlSi8Cu3	LM24					4250	A7075	A380.1
	24	2.1871	G-AlCu 4 TiMg								
	24	3.1754	G-AlCu5Ni1,5								
	24	3.2163	G-AlSi9Cu3							ADC10	
	24	3.2371	G-AlSi 7 Mg							AC4CH	4218 B
	24	3.2373	G-AlSI9MGWA			A-S7G			4251	C4BS	SC64D
	24	3.5106	G-MgAg3SE2Zr1	mag 12							QE 22
	24		G-ALMG5	LM5		A-SU12			4252		GD-AlSi12
	26	2.1090	G-CuSn 7 5 pb			U-E 7 Z 5 pb 4					C93200
	26	2.1096	G-CuSn5ZnPb	LG 2							c 83600
	26	2.1098	G-CuSn 2 Znpb								C 83600
	26	2.1182	G-CuPb15Sn	LB1		U-pb 15 E 8					C23000
	27	2.0240	CuZn 15								
	27	2.0321	CuZn 37	cz 108		CuZn 36, CuZn 37	C 2700				C27200
	27	2.0590	G-CuZn40Fe								
	27	2.0592	G-CuZn 35 Al 1	U-Z 36 N 3		HTB 1					C 86500
	27	2.1293	CuCrZr	CC 102		U-Cr 0.8 Zr					C 18200
	28	2.0060	E-Cu57								
	28	2.0375	CuZn36Pb3								
	28	2.0966	CuAl 10 Ni 5 Fe 4	Ca 104		U-A 10 N					C 63000
	28	2.0975	G-CuAl 10 Ni								B-148-52
	28	2.1050	G-CuSn 10	CT1							c 90700
	28	2.1052	G-CuSn 12	pb 2		UE 12 P					C 90800
	28	2.1292	G-CuCrF 35	CC1-FF							C 81500
	28	2.4764	CoCr20W15Ni								

Material Group		WKR	DIN	BS	EN	AFNOR	UNI	UNE	SS	JIS	AISI / SAE / UNS
ISO	VDI 3323	Germany	Germany	U.K.	U.K.	France	Italy	Spain	Sweden	Japan	USA
	31	1.4558	X 2 NiCrAlTi 32 20	NA 15							N 08800
	31	1.4562	X 1 NiCrMoCu 32 28 7								N 08031
	31	1.4563	X 1 NiCrMoCuN 31 27 4						2584		N 08028
	31	1.4864	X 12 NiCrSi 36 16	NA 17		Z 12 NCS 35.16				SUH 330	INCOLOY DS,, N08330
	31	1.4865	G-X40NiCrSi38 18	330 C 40			XG50NiCr39 19			SCH15	N 08004
	31	1.4958	X 5 NiCrAlTi 31 20								
	31	2.4668	NiCr19NbMo			NC20K14					AMS 5544
	32	1.4977	X 40 CoCrNi 20 20			Z 42 CNKDWNb					
	33	2.4360	NiCu30Fe	NA 13		NU 30					Monel 400
	33	2.4603				NC22FeD					5390A
	33	2.4610	NiMo16cR16Ti								Hastelloy C-4
	33	2.4630	NiCr20Ti	HR 5,203-4		NC 20 T					Nimonic 75
	33	2.4642	NiC29Fe			Nnc 30 Fe					Inconel 690
	33	2.4856	NiCr22Mo9Nb	NA 21		NC 22 FeDNb					INCONEL 625, N 26625
	33	2.4858	NiCr21Mo	NA 16		NC 21 Fe DU					Incoloy 825
	34	2.4375	NiCu30 Al	NA 18		NU 30 AT					Monel k-500
	34	2.4631	NiCr20TiAl	Hr40;601, NA 20		NC20TA					N 07080
	34	2.4668	NiCr19FeNbMo			NC 19 Fe Nb					Inconel 718
	34	2.4694	NiCr16fE7TiAl								Inconel
	34	2.4955	NiFe25Cr20NbTi								
	34	2.4668	NiCr19Fe19NbMo	HR8		NC19eNB					5383
S	34	2 4670	S-NiCr13A16MoNb	3146-3		NC12AD					5391
	34	2.4662	NiFe35Cr14MoTi			ZSNCDT42					5660
	34	2.4964	CoCr20W15Ni			KC20WN					5537C
	34		C0Cr22W14Ni			KC22WN					AMS 5772
	34										N07725, Inconel 725
	35	2.4669	NiCr15Fe7TiAl			NC 15 TNb A					Inconel X-750
	35	2.4685	G-NiMo28								Hastelloy B
	35	2.4810	G-NiMo30								Hastelloy C
	35	2.4973	NiCr19Co11MoTi			NC19KDT					AMS 5399
	35	3.7115	TiAl5Sn2								
	36	3.7025	Ti 1	2 TA 1							R 50250
	36	3.7225	Ti 1 pd	TP 1							R 52250
	36	2 4674	NiCo15Cr10MoAlTi								AMS 5397
	37	3.7124	TiCu2	2 TA 21-24							
	37	3.7145	TiAl6Sn2Zr4Mo2Si								R 54620
	37	3.7165	TiAl6V4	TA 10-13;TA 28		T-A 6 V					
	37	3.7185	TiAl4Mo4Sn2	TA 45-51; TA 57							
	37	3.7195	TiAl 3 V 2.5								
	37		TiAl4Mo4Sn4Si0.5								
	37		TiAl5Sn2.5	TA14/17		T-A5E					AMS R54520
	37		TiAl6V4	TA10-13/TA28		T-A6V					AMS R56400
	37		TiAl6V4ELI	TA11							AMS R56401
	38	1.1545	C 105 W1	BW 1A		Y1 105	C 100 KU	F-5118	1880	SK 3	W 1
	38	1.2762	75 CrMoNiW 6 7								
	38	1.4125	X105 CrMo 17			Z 100 CD 17					440C
	38	1.6746	32 nlcRmO 14 5	832 M 31		35 NCD 14					
	40	0.9620	G-X 260 NiCr 4 2	Grade 2 A			0512-00				Ni- Hard 2
	40	0.9625	G-X 330 Ni Cr 4 2	Grade 2 B							Ni- Hard 1
	40	0.9630	G-X 300 CrNiSi 9 5 2				0513-00				Ni-Hard 4
H	40	0.9640	G-X 300 CrMoNi 15 2 1								
	40	0.9650	G-X 260 Cr 27	Grade 3 D							A 532 III A 25% Cr
	40	0.9655	G-X 300 CrNMo 27 1	Grade 3 E							A 532 III A 25% Cr
	40	1.2419	105 WCr 6	105WC 13			0466-00				
	40	1.4841	X15 CrNiSi 25 20	314 S31		Z 15 CNS 25-20					310
	41	0.9635	G-X 300 CrMo 15 3								
	41	0.9645	G-X 260 CrMoNi 20 2 1					107 WCr 5 KU			

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

3 × D

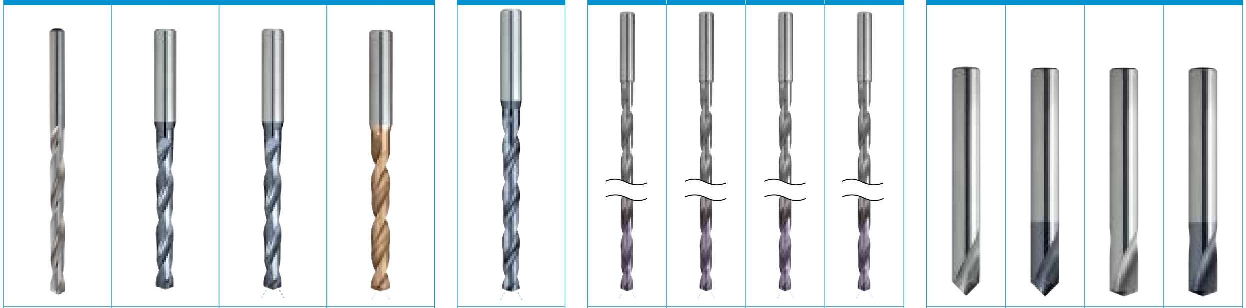


ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #
		Catalogue Code					D323		D329		D356		D304		D310		D300		D306	
		Material					VHM				VHM		VHM				VHM			
		Surface Finish					AlCrN				HELICA		Brt		TiCN		Brt		TiCN	
		Sutton Designation					N				VA		NH				GG/H			
		Geometry					R30		R30 - IK		R30 - IK		R15				Straight Flute			
		Drilling Depth					≤ 3xØ				≤ 3xØ		≤ 3xØ				≤ 3xØ			
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	90	8	130	8	130-180	7	-	-	-	-	-	-	-	-
	2		- 0.45 %C	A	190	640	90	8	130	8	110-160	7	-	-	-	-	-	-	-	-
	3			QT	250	840	85	8	110	8	110-160	7	80	4	100	4	-	-	-	-
	4		- 0.75 %C	A	270	910	85	8	110	8	110-160	7	80	4	100	4	-	-	-	-
	5			QT	300	1010	50	6	70	6	70-100	7	55	3	70	3	-	-	-	-
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	85	8	110	8	110-160	7	-	-	-	-	-	-	-	-
	7			QT	275	930	65	7	80	7	110-160	7	70	3	85	3	-	-	-	-
	8			QT	300	1010	50	6	70	6	70-100	7	55	3	70	3	-	-	-	-
	9			QT	350	1180	30	5	35	5	-	-	40	3	60	3	40	2	60	2
	10	Steel - High alloy, cast & tool		A	200	680	50	6	70	6	90-120	7	55	3	70	3	-	-	-	-
	11			HT	325	1100	30	5	35	5	-	-	40	3	60	3	40	2	60	2
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	-	-	30	4	40-50	5	40	3	60	3	-	-	-	-
	13		Martensitic	QT	240	810	30	5	35	5	40-50	5	40	3	60	3	40	2	60	2
M	14.1	Stainless Steel	Austenitic	AH	180	610	-	-	50	5	50-70	5	-	-	-	-	-	-	-	-
	14.2		Duplex		230	780	-	-	40	4	40-60	5	25	3	30	3	-	-	-	-
	14.3		Precipitation Hardening		300	780	20	4	30	4	40-50	5	25	3	30	3	-	-	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	75	6	150	9	-	-	90	3	100	3	90	3	100	3
	16		Pearlitic		260	880	65	6	120	8	-	-	80	3	85	3	80	3	85	3
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	65	5	100	8	-	-	80	3	85	3	80	3	85	3
	18		Pearlitic		250	840	65	5	100	8	-	-	80	3	85	3	80	3	85	3
	19	Cast Iron - Malleable	Ferritic		130	460	65	5	100	8	-	-	80	3	85	3	80	3	85	3
	20		Pearlitic		230	780	65	5	100	8	-	-	80	3	85	3	80	3	85	3
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	-	-	-	-	300-400	8	100-160	4	140-200	4	-	-	-	-
	22		Heat Treatable	AH	100	360	-	-	-	-	300-400	8	100-160	4	140-200	4	-	-	-	-
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	-	-	-	-	220-320	8	100-160	4	140-200	4	80	5	100	6
	24		Heat Treatable	AH	90	320	-	-	-	-	220-320	8	100-160	4	140-200	4	80	5	100	6
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	-	-	200	7	200-280	7	100-160	4	140-200	4	80	5	100	6
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	-	-	200	7	-	-	100-160	4	140-200	4	80	5	100	6
	27		Brass (CuZn, CuSnZn)		90	320	-	-	200	7	-	-	100-160	4	140-200	4	80	4	100	5
	28		Bronze (CuSn)		100	360	-	-	200	7	-	-	100-160	4	140-200	4	-	-	-	-
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	50-280	6	50-280	6	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	35	4	30-40	4	-	-	-	-	-	-	-	-
	32			AH	280	950	-	-	30	4	30-40	4	-	-	-	-	-	-	-	-
	33		Ni / Co based	A	250	840	-	-	35	4	30-40	4	-	-	-	-	-	-	-	-
	34			AH	350	1180	-	-	30	4	25	3	-	-	-	-	-	-	-	-
	35			C	320	1080	-	-	30	4	30-40	4	-	-	-	-	-	-	-	-
	36	Titanium & Ti alloys	CP Titanium		400 MPa		40	4	45	5	50-70	4	-	-	-	-	-	-	-	-
	37.1		Alpha alloys		860 MPa		35	3	40	4	40-60	4	-	-	-	-	-	-	-	-
	37.2		Alpha / Beta alloys	A	960 MPa		35	3	40	4	40-60	4	-	-	-	-	-	-	-	-
	37.3			AH	1170 MPa		-	-	35	4	30-50	4	-	-	-	-	-	-	-	-
	37.4		Beta alloys	A	830 MPa		35	3	40	4	40-60	4	-	-	-	-	-	-	-	-
	37.5			AH	1400 MPa		-	-	35	4	30-50	4	-	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		20	4	25	4	-	-	40	2	60	2	40	2	60	2
	38.2			HT	55 HRC		-	-	-	-	-	-	30	2	40	2	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	65	6	120	8	-	-	80	3	85	3	80	3	85	3
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-

Condition: A (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)
Bold = Optimal | Regular = Effective

Notes on Drilling

1. Step feeding or pecking is required for drilling greater than 3 x Ø.
2. When drilling cast surface & black (ie: not machined surface), reduce drilling speed by 20%.
3. For optimal positional accuracy and hole size, the use of spot drills is recommended prior to drilling desired hole, refer to our standard range (D175).
4. For hole depths greater than 7 x Ø, pre-drill initially to pilot start for more accurate hole position and eliminate drill wandering. The pilot can be drilled with short rigid drill, approx. 3 x Ø in depth and reduced feed to ensure accurate pilot hole.



5×D								8×D		12×D		15×D		20×D		30×D		NC SPOTTING									
D368		D326		D332		D358		D335		D371		D372		D373		D375		D355		D364		D365		D366			
VHM		VHM				VHM		VHM		VHM								VHM				VHM					
Brt		AlCrN				HELICA		AlCrN		Perturua Tip								Brt		AlCrN		Brt		AlCrN			
N		N				VA		N		N								NC				NC					
R30		R30		R30 - IK		R30 - IK		R30 - IK		R30 - IK								90°				142°					
≤5xØ		≤5xØ				≤5xØ		≤8xØ		≤12xØ		≤15xØ		≤20xØ		≤30xØ		-				-					
Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	VDI 3323	ISO
55	6	90	8	130	8	130-180	7	100	8	80	8	80	8	80	8	80	8	-	-	96	6	-	-	96	6	1	
55	6	90	8	130	8	110-160	7	100	8	80	8	80	8	80	8	80	8	-	-	96	6	-	-	96	6	2	
50	6	85	8	110	8	110-160	7	80	7	70	7	70	7	70	7	70	7	65	5	78	6	65	5	78	6	3	
50	6	85	8	110	8	110-160	7	80	7	70	7	70	7	70	7	70	7	65	5	78	6	65	5	78	6	4	
40	6	50	6	70	6	70-100	7	60	6	60	6	60	6	60	6	60	6	50	4	60	5	50	4	60	5	5	
55	6	85	8	110	8	110-160	7	80	7	80	6	80	6	80	6	80	6	-	-	78	6	-	-	78	6	6	
50	6	65	7	80	7	110-160	7	80	7	60	5	60	5	60	5	60	5	60	5	72	6	60	5	72	6	7	P
40	6	50	6	70	6	110-160	7	60	6	60	5	60	5	60	5	60	5	50	4	60	5	50	4	60	5	8	
-	-	30	5	35	5	-	-	30	5	40	5	40	5	40	5	40	5	-	-	60	5	-	-	60	5	9	
-	-	50	6	70	6	90-120	7	60	6	50	6	50	6	50	6	50	6	50	4	60	5	50	4	60	5	10	
-	-	30	5	35	5	-	-	30	5	40	5	40	5	40	5	40	5	-	-	60	5	-	-	60	5	11	
-	-	-	-	25	4	30-50	5	-	-	40	5	40	5	40	5	40	5	-	-	35	3	-	-	35	3	12	
-	-	30	5	35	5	40-50	5	30	5	30	4	30	4	30	4	30	4	-	-	60	5	-	-	60	5	13	
-	-	-	-	40	5	50-70	5	45	5	40	5	40	5	40	5	40	5	40	3	50	4	40	3	50	4	14.1	
-	-	-	-	35	4	40-60	5	-	-	30	4	30	4	30	4	30	4	35	3	40	3	35	3	40	3	14.2	M
-	-	20	4	25	4	30-50	5	-	-	40	5	40	5	40	5	40	5	30	3	35	3	30	3	35	3	14.3	
85	3	75	6	150	9	-	-	90	8	80	8	80	8	80	8	80	8	70	5	84	6	70	5	84	6	15	
55	3	65	6	120	8	-	-	80	8	70	8	70	8	70	8	70	8	70	4	84	5	70	4	84	5	16	
85	3	65	5	100	8	-	-	70	7	60	7	60	7	60	7	60	7	70	4	84	5	70	4	84	5	17	K
55	3	65	5	100	8	-	-	70	7	60	7	60	7	60	7	60	7	70	4	84	5	70	4	84	5	18	
-	-	65	5	100	8	-	-	70	7	60	7	60	7	60	7	60	7	70	4	84	5	70	4	84	5	19	
-	-	65	5	100	8	-	-	70	7	60	7	60	7	60	7	60	7	70	4	84	5	70	4	84	5	20	
100	4	-	-	-	-	300-400	8	-	-	100	5	100	5	100	5	100	5	200	5	-	-	200	5	-	-	21	
100	4	-	-	-	-	300-400	8	-	-	100	5	100	5	100	5	100	5	200	5	-	-	200	5	-	-	22	
100	4	-	-	-	-	220-320	8	-	-	100	5	100	5	100	5	100	5	180	4	-	-	180	4	-	-	23	
80	4	-	-	-	-	220-320	8	-	-	80	5	80	5	80	5	80	5	180	4	-	-	180	4	-	-	24	
80	4	-	-	250	7	200-280	7	-	-	80	5	80	5	80	5	80	5	180	4	-	-	180	4	-	-	25	N
-	-	-	-	250	7	-	-	-	-	-	-	-	-	-	-	-	-	130	4	-	-	130	4	-	-	26	
-	-	-	-	250	7	-	-	-	-	-	-	-	-	-	-	-	-	150	4	-	-	150	4	-	-	27	
-	-	-	-	250	7	-	-	-	-	-	-	-	-	-	-	-	-	200	4	-	-	200	4	-	-	28	
120	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	
-	-	-	-	35	4	30-40	4	-	-	-	-	-	-	-	-	-	-	-	-	40	5	-	-	40	3	31	
-	-	-	-	30	4	30-40	4	-	-	-	-	-	-	-	-	-	-	-	-	35	5	-	-	35	3	32	
-	-	-	-	35	4	30-40	4	-	-	-	-	-	-	-	-	-	-	-	-	40	5	-	-	40	3	33	
-	-	-	-	30	4	25-35	3	-	-	-	-	-	-	-	-	-	-	-	-	30	4	-	-	30	3	34	
-	-	-	-	30	4	30-40	4	-	-	-	-	-	-	-	-	-	-	-	-	35	5	-	-	35	3	35	
-	-	40	4	45	5	50-70	4	-	-	-	-	-	-	-	-	-	-	-	-	50	3	-	-	50	3	36	S
-	-	35	3	40	4	40-60	4	-	-	-	-	-	-	-	-	-	-	40	3	50	3	40	3	50	3	37.1	
-	-	35	3	40	4	40-60	4	-	-	-	-	-	-	-	-	-	-	40	3	50	3	40	3	50	3	37.2	
-	-	-	-	35	4	30-50	4	-	-	-	-	-	-	-	-	-	-	35	3	45	3	35	3	45	3	37.3	
-	-	35	3	40	4	40-60	4	-	-	-	-	-	-	-	-	-	-	40	3	50	3	40	3	50	3	37.4	
-	-	-	-	35	4	30-50	4	-	-	-	-	-	-	-	-	-	-	35	3	45	3	35	3	45	3	37.5	
-	-	20	4	25	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48	3	-	-	48	3	38.1	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	3	36	3	30	3	36	3	38.2	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	3	36	3	30	3	36	3	39.1	H
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	3	36	3	30	3	36	3	39.2	
-	-	65	6	120	8	-	-	-	-	-	-	-	-	-	-	-	-	70	3	84	3	70	3	84	3	40	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	3	36	3	30	3	36	3	41	

Feed Table (f) (mm/rev)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10
2.0	0.020	0.025	0.030	0.040	0.050	0.060	0.075	0.095	0.120	0.15
3.0	0.030	0.035	0.045	0.055	0.070	0.090	0.110	0.135	0.17	0.21
4.0	0.040	0.045	0.060	0.075	0.090	0.115	0.140	0.18	0.22	0.27
5.0	0.045	0.055	0.070	0.090	0.110	0.135	0.17	0.21	0.26	0.32
6.0	0.055	0.065	0.080	0.100	0.125	0.16	0.19	0.24	0.30	0.37
8.0	0.070	0.085	0.105	0.130	0.16	0.20	0.25	0.31	0.38	0.47
10.0	0.085	0.105	0.125	0.16	0.19	0.24	0.30	0.37	0.46	0.56
12.0	0.095	0.120	0.15	0.18	0.23	0.28	0.34	0.42	0.52	0.64
16.0	0.125	0.15	0.19	0.23	0.29	0.36	0.44	0.54	0.66	0.82
20.0	0.15	0.18	0.23	0.28	0.34	0.42	0.52	0.64	0.80	0.98
25.0	0.18	0.22	0.27	0.33	0.41	0.50	0.60	0.74	0.90	1.10

METRIC DRILLS (mm size)

- **Ø** = nominal tap size (mm)
- **n** = spindle speed (RPM)
- **V_c** = cutting speed (m/min)
- **f** = feed (mm/rev)
- **V_f** = feed rate (mm/min)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$V_f = f \times n$$

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

							D151		D177		D155		D153		D179		D180		D109	
		Catalogue Code					D151		D177		D155		D153		D179		D180		D109	
		Material					HSS Co		HSS Co		SPM		HSS Co		HSS		HSS		HSS Co	
		Surface Finish					TiAlN		TiAlN		TiAlN		TiAlN		TiAlN Tip		TiAlN Tip		Colour Temp	
		Sutton Designation					NH		WN		UNI		VA		N		VA		Hard Materials	
		Geometry					R40		R35		R40		R40		R30		R40		R25	
		Drilling Depth					≤ 3xØ		≤ 3xØ		≤ 3xØ		≤ 3xØ		≤ 5xØ		≤ 3xØ		-	
ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #
P	1	Steel - Non-alloy, cast & free cutting	~ 0.15 %C	A	125	440	**40**	**6**	**35**	**4**	**65**	**6**	**64**	**6**	**24**	**5**	**20**	**4**	-	-
	2		~ 0.45 %C	A	190	640	**30**	**6**	**30**	**4**	**55**	**6**	64	6	**20**	**5**	**16**	**4**	-	-
	3			QT	250	840	**30**	**6**	**30**	**4**	**50**	**6**	62	5	**18**	**5**	12	4	**15**	**5**
	4		~ 0.75 %C	A	270	910	**30**	**6**	**30**	**4**	**50**	**6**	62	5	**18**	**5**	12	4	15	5
	5			QT	300	1010	**15**	**4**	12	4	**25**	**6**	-	-	12	4	-	-	**12**	**4**
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**30**	**6**	**30**	**4**	**50**	**6**	62	5	**18**	**5**	**12**	**4**	-	-
	7			QT	275	930	**20**	**5**	20	4	**35**	**6**	30	4	**18**	**4**	12	4	**15**	**4**
	8			QT	300	1010	**15**	**4**	12	4	**25**	**6**	-	-	12	4	-	-	**12**	**4**
	9			QT	350	1180	12	4	-	-	15	5	-	-	10	3	-	-	10	4
	10	Steel - High alloy, cast & tool		A	200	680	**15**	**4**	12	4	**25**	**6**	-	-	**12**	**4**	-	-	12	4
	11			HT	325	1100	12	4	-	-	15	5	-	-	10	3	-	-	10	4
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	20	4	-	-	**14**	**4**	**12**	**4**	10	3	7	4	-	-
	13		Martensitic	QT	240	810	12	4	-	-	15	5	12	5	10	3	7	4	-	-
M	14.1	Stainless Steel	Austenitic	AH	180	610	20	5	15	3	16	5	**30**	**5**	10	4	**12**	**4**	10	4
	14.2		Duplex		230	780	15	5	10	4	12	5	**20**	**5**	8	4	**10**	**4**	8	4
	14.3		Precipitation Hardening		300	780	**20**	**4**	15	4	**14**	**4**	**12**	**4**	10	3	7	3	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	**30**	**6**	-	-	**44**	**6**	-	-	**25**	**6**	-	-	25	6
	16		Pearlitic		260	880	**25**	**6**	-	-	**39**	**6**	-	-	20	5	-	-	20	5
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	**25**	**6**	-	-	**44**	**5**	-	-	**18**	**6**	-	-	20	6
	18		Pearlitic		250	840	**25**	**6**	-	-	**44**	**5**	-	-	18	6	-	-	20	6
	19	Cast Iron - Malleable	Ferritic		130	460	**25**	**6**	-	-	**44**	**5**	-	-	**18**	**6**	-	-	20	6
	20		Pearlitic		230	780	**25**	**6**	-	-	**44**	**5**	-	-	18	6	-	-	20	6
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	-	-	**60**	**6**	88	5	**112**	**6**	-	-	**50**	**6**	-	-
	22		Heat Treatable	AH	100	360	-	-	**60**	**6**	88	5	**112**	**6**	-	-	**50**	**6**	-	-
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	**40**	**5**	**40**	**5**	**53**	**5**	**70**	**7**	30	4	**40**	**5**	-	-
	24		Heat Treatable	AH	90	320	**40**	**5**	**40**	**5**	**53**	**5**	**70**	**7**	30	4	**40**	**5**	-	-
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	**30**	**7**	30	8	-	-	-	-	20	6	-	-	-	-
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	60	5	**50**	**5**	39	4	**50**	**5**	30	4	50	5	-	-
	27		Brass (CuZn, CuSnZn)		90	320	40	5	35	5	**44**	**5**	-	-	25	4	-	-	**25**	**6**
	28		Bronze (CuSn)		100	360	30	5	**45**	**5**	33	4	**80**	**3**	25	4	30	5	-	-
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					50	4	70	5	70	5	50	4	35	4	50	4	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	32			AH	280	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	33		Ni / Co based	A	250	840	-	-	-	-	8	4	-	-	-	-	-	-	-	-
	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	35			C	320	1080	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	37.1		Alpha alloys		860 MPa		-	-	-	-	9	4	10	3	-	-	-	-	-	-
	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	-	-	8	3	-	-	-	-	-	-
	37.3			AH	1170 MPa		-	-	-	-	-	-	-	-			-	-	-	-
	37.4		Beta alloys	A	830 MPa		-	-	-	-	-	-	8	3	-	-	-	-	-	-
	37.5			AH	1400 MPa		-	-	-	-	-	-	-	-			-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	10	4	-	-	-	-	-	-	10	4
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	**25**	**6**	-	-	**39**	**6**	-	-	20	5	-	-	20	5
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Notes on Drilling

1. Step feeding or pecking is required for drilling greater than 3 x Ø.
2. When drilling cast surface & black (ie: not machined surface), reduce drilling speed by 20%.
3. For optimal positional accuracy and hole size, the use of spot drills is recommended prior to drilling desired hole, refer to our standard range (D175).
4. For hole depths greater than 7 x Ø, pre-drill initially to pilot start for more accurate hole position and eliminate drill wandering. The pilot can be drilled with short rigid drill, approx. 3 x Ø in depth and reduced feed to ensure accurate pilot hole.

												EXTRA LENGTH						NC SPOTTING				C BORE			
D163		D182		D165		D168		D169		D171		D194		D195		D196		D175		D176		C100			
HSS Co		HSS Co		HSS Co		SPM		HSS Co		HSS Co		HSS Co		HSS Co		HSS Co		HSS Co				HSS Co			
TiAlN		TiAlN		TiAlN		TiAlN		TiAlN		TiAlN		TiAlN		TiAlN		TiAlN		TiN				Brt			
NH		NH		WN		UNI		VA		NH		NH		NH		NH		N				N			
R40		R40 - IK		R35		R40		R40		R40		R40		R40		R40		90°		120°		-			
≤ 5xØ		≤ 5xØ		≤ 5xØ		≤ 5xØ		≤ 5xØ				≤ 10xØ		≤ 12xØ		≤ 14xØ		-				-			
Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	VDI 3323	ISO
24	5	65	7	29	4	60	7	58	6	30	5	25	5	20	5	20	5	35	4	35	4	30	3	1	P
20	5	55	7	25	4	45	7	58	6	16	5	13	5	10	5	10	5	25	4	25	4	30	3	2	
20	5	50	7	25	4	45	7	58	5	16	5	13	5	10	5	10	5	20	4	20	4	30	3	3	
20	5	50	7	25	4	45	7	58	5	16	5	13	5	10	5	10	5	20	4	20	4	30	3	4	
12	4	25	5	10	4	20	6	-	-	10	4	10	4	10	4	10	4	15	3	15	3	12	1	5	
20	5	50	7	25	4	45	7	58	5	16	5	13	5	10	5	10	5	20	4	20	4	30	3	6	
20	4	40	7	20	4	30	7	25	5	16	4	13	4	10	4	10	4	15	4	15	4	15	2	7	
12	4	25	5	10	4	20	6	-	-	10	4	10	4	10	4	10	4	15	3	15	3	12	1	8	
10	4	15	5	-	-	12	6	-	-	8	4	8	4	10	4	10	4	-	-	-	-	10	1	9	
12	4	25	5	10	4	20	6	-	-	10	4	10	4	10	4	10	4	15	3	15	3	12	1	10	
10	4	15	5	-	-	12	6	-	-	8	4	8	4	10	4	10	4	-	-	-	-	10	1	11	
12	4	14	3	-	-	10	3	12	5	10	4	10	4	10	4	10	4	10	2	10	2	14	1	12	
10	4	15	5	-	-	12	6	12	5	8	4	8	4	10	4	10	4	12	3	12	3	10	1	13	
12	4	16	4	12	3	10	4	25	5	10	4	10	4	10	4	10	4	10	3	10	3	16	2	14.1	M
-	-	12	4	10	4	8	4	14	5	-	-	-	-	-	-	-	-	15	2	15	2	12	1	14.2	
12	4	14	3	-	-	10	3	12	4	10	4	10	4	10	4	10	4	10	2	10	2	14	1	14.3	
24	6	40	6	-	-	40	6	-	-	19	6	15	6	12	6	12	6	30	5	30	5	25	2	15	K
20	5	35	6	-	-	35	6	-	-	16	5	13	5	10	5	10	5	20	4	20	4	16	2	16	
20	6	40	5	-	-	40	5	-	-	16	6	13	6	10	6	10	6	20	4	20	4	20	2	17	
20	6	40	5	-	-	40	5	-	-	16	6	13	6	10	6	10	6	20	4	20	4	20	2	18	
20	6	40	5	-	-	40	5	-	-	16	6	13	6	10	6	10	6	20	4	20	4	20	2	19	
20	6	40	5	-	-	40	5	-	-	16	6	13	6	10	6	10	6	20	4	20	4	20	2	20	
-	-	60	6	48	6	80	5	112	8	-	-	-	-	-	-	-	-	50	5	50	5	80	4	21	N
-	-	60	6	48	6	80	5	112	8	-	-	-	-	-	-	-	-	50	5	50	5	80	4	22	
32	5	40	5	32	5	48	5	70	6	26	5	20	5	16	5	16	5	35	4	35	4	60	3	23	
32	5	40	5	32	5	48	5	70	6	26	5	20	5	16	5	16	5	35	4	35	4	60	3	24	
25	6	40	5	25	7	30	6	-	-	18	5	18	5	16	5	16	5	30	4	30	4	-	-	25	
48	5	50	5	48	5	35	4	40	5	38	5	31	5	25	5	25	5	40	4	40	4	80	2	26	
32	5	36	5	32	5	40	5	-	-	26	5	20	5	16	5	16	5	30	4	30	4	-	-	27	
-	-	45	5	40	5	30	5	70	3	-	-	-	-	-	-	-	-	50	4	50	4	80	2	28	
50	4	70	5	60	5	60	4	-	-	40	4	40	4	40	4	40	4	30	4	30	4	-	-	29	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	
-	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	2	9	2	-	-	31	S
-	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	2	8	2	-	-	32	
-	-	8	3	-	-	8	4	-	-	-	-	-	-	-	-	-	-	9	2	9	2	-	-	33	
-	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	2	8	2	-	-	34	
-	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	
-	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36	
-	-	8	3	-	-	9	4	10	3	-	-	-	-	-	-	-	-	8	2	8	2	-	-	37.1	
-	-	8	3	-	-	-	-	8	3	-	-	-	-	-	-	-	-	8	2	8	2	-	-	37.2	
-	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37.3	
-	-	8	3	-	-	-	-	8	3	-	-	-	-	-	-	-	-	8	2	8	2	-	-	37.4	
-	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37.5	
-	-	10	4	-	-	8	4	-	-	-	-	-	-	-	-	-	-	10	3	10	3	-	-	38.1	H
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.2	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39.1	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39.2	
20	5	35	6	-	-	35	6	-	-	16	5	13	5	10	5	10	5	20	4	20	4	16	2	40	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41	

Feed Table (f) (mm/rev)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10
2.0	0.020	0.025	0.030	0.040	0.050	0.060	0.075	0.095	0.120	0.15
3.0	0.030	0.035	0.045	0.055	0.070	0.090	0.110	0.135	0.17	0.21
4.0	0.040	0.045	0.060	0.075	0.090	0.115	0.140	0.18	0.22	0.27
5.0	0.045	0.055	0.070	0.090	0.110	0.135	0.17	0.21	0.26	0.32
6.0	0.055	0.065	0.080	0.100	0.125	0.16	0.19	0.24	0.30	0.37
8.0	0.070	0.085	0.105	0.130	0.16	0.20	0.25	0.31	0.38	0.47
10.0	0.085	0.105	0.125	0.16	0.19	0.24	0.30	0.37	0.46	0.56
12.0	0.095	0.120	0.15	0.18	0.23	0.28	0.34	0.42	0.52	0.64
16.0	0.125	0.15	0.19	0.23	0.29	0.36	0.44	0.54	0.66	0.82
20.0	0.15	0.18	0.23	0.28	0.34	0.42	0.52	0.64	0.80	0.98
25.0	0.18	0.22	0.27	0.33	0.41	0.50	0.60	0.74	0.90	1.10
32.0	0.23	0.27	0.33	0.41	0.50	0.60	0.74	0.88	1.10	1.30
38.0	0.26	0.32	0.38	0.46	0.56	0.68	0.82	1.00	1.20	1.45
45.0	0.30	0.36	0.43	0.52	0.64	0.76	0.92	1.10	1.35	1.60
52.0	0.33	0.40	0.48	0.58	0.70	0.84	1.00	1.20	1.45	1.75
63.0	0.39	0.47	0.56	0.67	0.80	0.96	1.14	1.35	1.65	1.95

METRIC DRILLS (mm size)

Ø = nominal tap size (mm)
n = spindle speed (RPM)
V_c = cutting speed (m/min)
f = feed (mm/rev)
V_f = feed rate (mm/min)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

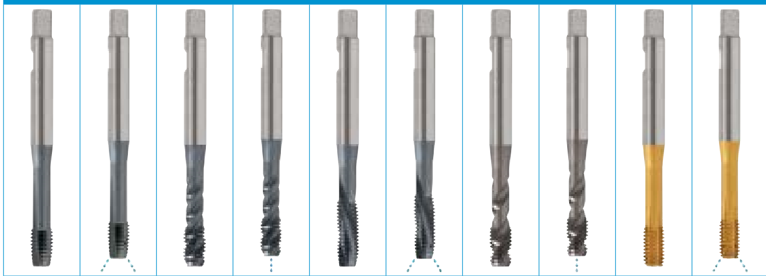
$$V_f = f \times n$$

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

SYNCHRO TAPPING



Catalogue Code M	T377	T379	T373	T375	T365	T367	T369	T371	T381	T383
MF	T766	T768	T762	T764	T754	T756	T758	T760	T770	T772
UNC										
UNF										
G (BSPF)										
Material	PM-HSSE V3		PM-HSSE V3		PM-HSSE V3		PM-HSSE V3		PM-HSSE V3	
Surface Finish	TiCN		TiCN		TiCN		CrN		TiN	
Sutton Designation	High Speed Cutting		High Speed Cutting		High Speed Cutting		High Speed Cutting		High Speed Cutting	
Geometry		IK	R50	R50 IK	L20	L20 IK	R45	R45 IK		IK
Thread Depth	≤ 2xØ		≤ 2xØ		≤ 2xØ		≤ 2xØ		≤ 2xØ	

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc (m/min)									
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	**39**	**47**	**31**	**31**	**31**	**37**	-	-	**25**	**30**
	2		- 0.45 %C	A	190	640	**39**	**47**	**31**	**31**	**31**	**37**	-	-	**25**	**30**
	3			QT	250	840	**32**	**39**	**26**	**26**	**26**	**31**	-	-	21	25
	4		- 0.75 %C	A	270	910	**36**	**43**	**29**	**29**	**29**	**34**	-	-	**23**	**27**
	5			QT	300	1010	29	35	23	23	23	28	-	-	-	-
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**39**	**47**	**31**	**31**	**31**	**37**	-	-	25	30
	7			QT	275	930	**26**	**31**	**21**	**21**	**21**	**25**	-	-	17	20
	8			QT	300	1010	19	23	16	16	16	19	-	-	-	-
	9			QT	350	1180	-	-	-	-	-	-	-	-	-	-
	10	Steel - High alloy, cast & tool		A	200	680	**26**	**31**	**21**	**21**	**21**	**25**	-	-	17	20
	11			HT	325	1100	-	-	-	-	-	-	-	-	-	-
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	**16**	**19**	**13**	**13**	**13**	**16**	-	-	-	-
	13		Martensitic	QT	240	810	10	12	8	8	8	9	-	-	-	-
M	14.1	Stainless Steel	Austenitic	AH	180	610	**19**	**23**	**16**	**16**	**16**	**19**	-	-	**12**	**15**
	14.2		Duplex		230	780	**13**	**16**	**10**	**10**	**10**	**12**	-	-	8	10
	14.3		Precipitation Hardening		300	780	10	12	8	8	8	9	-	-	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	**39**	**47**	**31**	**31**	**31**	**37**	-	-	-	-
	16		Pearlitic		260	880	32	39	26	26	26	31	-	-	-	-
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	**39**	**47**	**31**	**31**	**31**	**37**	-	-	-	-
	18		Pearlitic		250	840	32	39	26	26	26	31	-	-	-	-
	19	Cast Iron - Malleable	Ferritic		130	460	**49**	**58**	**39**	**39**	**39**	**47**	-	-	-	-
	20		Pearlitic		230	780	39	47	31	31	31	37	-	-	-	-
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	**39**	**47**	**31**	**31**	**31**	**37**	**31**	**31**	**25**	**30**
	22		Heat Treatable	AH	100	360	**49**	**58**	**39**	**39**	**39**	**47**	**39**	**39**	**31**	**37**
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	**49**	**58**	39	39	**39**	**47**	**39**	**39**	**31**	**37**
	24		Heat Treatable	AH	90	320	**49**	**58**	39	39	**39**	**47**	**39**	**39**	31	37
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	32	39	**26**	**26**	26	31	-	-	-	-
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	**26**	**31**	21	21	**21**	**25**	**21**	**21**	-	-
	27		Brass (CuZn, CuSnZn)		90	320	58	70	47	47	47	56	**47**	**47**	-	-
	28		Bronze (CuSn)		100	360	**45**	**54**	36	36	**36**	**44**	**36**	**36**	**29**	**35**
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	**10**	**12**	**8**	**8**	-	-	-	-	-	-
	32			AH	280	950	-	-	-	-	-	-	-	-	-	-
	33		Ni / Co based	A	250	840	**8**	**10**	**6**	**6**	-	-	-	-	-	-
	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-
	35			C	320	1080	-	-	-	-	-	-	-	-	-	-
	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	-	-	-	-
	37.1		Alpha alloys		860 MPa		-	-	-	-	**13**	**16**	-	-	-	-
	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	**13**	**16**	-	-	-	-
	37.3			AH	1170 MPa		-	-	-	-	-	-	-	-	-	-
	37.4		Beta alloys	A	830 MPa		-	-	-	-	**8**	**9**	-	-	-	-
	37.5			AH	1400 MPa		-	-	-	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	-	-	-	-
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	-	-	-	-	-
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered) **Bold =** Optimal | Regular = Effective

Notes on Tapping

1. The speeds listed above are a recommendation only, and are based on depth of thread listed, speeds can be adjusted on application.
As a general rule;
-If hole depth required is less than above mentioned = increase speed
-If hole depth required is more than above mentioned = reduce speed
2. Taps must be driven by the square to eliminate slippage, eg, ER-GB collets (square drive).
3. When using spiral flute taps with length compensation tapping attachment, it is recommended to short pitch the feed 95%, to eliminate tap cutting oversize, eg. M6x1 @ 1000RPM, Feed rate= 950mm/min.
4. Forming taps are suitable for materials with >10% elongation

BLIND / THROUGH HOLES

VDI 3323												
	T286	T288	T290	T292	T670	T741	T335	T357	T294	T296		
	T298	T299	T300	T301	T743	T744	T668	T669	T343	T345		
			T302	T303								
	T304	T305	T306	T307							T308	T808
	HSSE		HSSE		VHM		HSSE		SPM	VHM	HSSE	
	Brt	*TiN*	*Blu*	*TiCN*	*TiCN*		*TiCN*		*TiCN*		*Brt*	*TiCN*
	N		GG		GG		DC		XH	VH	UNI	
			Low Relief		Low Relief	IK		IK	Special Relief			
	≤ 1.5xØ		≤ 3xØ		≤ 3xØ		≤ 3xØ		≤ 1.5xØ		-	
	Vc (m/min)											
1	7	11	-	-	-	-	-	-	-	-	7	7
2	7	11	-	-	-	-	-	-	-	-	7	7
3	6	9	-	-	-	-	-	-	-	-	6	6
4	7	10	-	-	-	-	-	-	-	-	7	7
5	5	8	-	-	-	-	-	-	11	-	5	5
6	7	11	-	-	-	-	-	-	-	-	7	7
7	5	7	-	-	-	-	-	-	-	-	5	5
8	4	5	-	-	-	-	-	-	7	-	4	4
9	-	-	-	-	-	-	-	-	4	5	-	-
10	5	7	-	-	-	-	-	-	-	-	5	5
11	-	-	-	-	-	-	-	-	7	11	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	4	5	-	-
14.1	-	-	-	-	-	-	-	-	-	-	-	-
14.2	-	-	-	-	-	-	-	-	-	-	-	-
14.3	-	-	-	-	-	-	-	-	-	-	-	-
15	7	11	8	11	22	26	11	13	-	-	7	7
16	6	9	7	9	18	22	9	11	12	-	6	6
17	7	11	8	11	22	26	11	13	-	-	7	7
18	6	9	7	9	18	22	9	11	12	-	6	6
19	9	14	10	14	27	32	14	16	-	-	9	9
20	7	11	8	11	22	26	11	13	-	-	7	7
21	7	11	-	-	-	-	-	-	-	-	7	7
22	9	14	-	-	-	-	-	-	-	-	9	9
23	9	14	-	-	-	-	14	16	-	-	9	9
24	9	14	-	-	-	-	14	16	-	-	9	9
25	-	-	-	9	18	22	9	11	-	-	-	-
26	5	7	-	-	-	-	-	-	-	-	5	5
27	11	16	-	-	32	39	16	19	21	32	11	11
28	8	13	-	-	-	-	-	-	-	-	8	8
29	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-	-	-	-	-
34	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	-	-	-	-	-	-	-	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-
37.1	-	-	-	-	-	-	-	-	-	-	-	-
37.2	-	-	-	-	-	-	-	-	-	-	-	-
37.3	-	-	-	-	-	-	-	-	-	-	-	-
37.4	-	-	-	-	-	-	-	-	-	-	-	-
37.5	-	-	-	-	-	-	-	-	-	-	-	-
38.1	-	-	-	-	-	-	-	-	4	5	-	-
38.2	-	-	-	-	-	-	-	-	-	4	-	-
39.1	-	-	-	-	-	-	-	-	-	4	-	-
39.2	-	-	-	-	-	-	-	-	-	4	-	-
40	-	-	-	-	14	17	7	9	9	14	-	-
41	-	-	-	-	-	-	-	-	-	4	-	-

THROUGH HOLES

									VDI 3323	ISO
T100	T102	T104	T836	T687	T122	T126	T128	T130		
T154	T156	T157		T689						
T164	T166	T167		T693						
T173	T702	T175		T694						
T178	T179	T180		T700						
HSSE			PM-HSSE Co	PM-HSSE V3	HSSE	HSSE	HSSE			
Brt	*Blu*	*TiN*	*TiN*	*Hardlube*	*Ni*	*CrN*	*Brt*	*TiN*		
N			N+	UNI	W	Cu	W			
							Interrupted Threads			
≤ 3xØ				≤ 3xØ	≤ 3xØ	≤ 3xØ	≤ 3xØ			
Vc (m/min)									VDI 3323	ISO
12	13	18	14	22	18	-	12	18	1	P
12	13	18	14	22	18	-	12	18	2	P
10	11	15	12	18	15	-	10	15	3	P
11	12	17	13	20	17	-	11	17	4	P
-	-	14	11	-	-	-	-	-	5	P
12	13	18	14	22	18	-	12	18	6	P
8	9	12	10	14	12	-	8	12	7	P
-	-	9	7	-	-	-	-	-	8	P
-	-	-	-	-	-	-	-	-	9	P
8	9	12	10	14	-	-	-	12	10	P
-	-	-	-	-	-	-	-	-	11	P
-	6	8	6	9	-	-	5	8	12	P
-	-	-	-	5	-	-	-	-	13	P
-	7	9	7	11	-	-	6	9	14.1	M
-	4	6	5	7	-	-	4	6	14.2	M
-	3	5	4	-	-	-	-	-	14.3	M
12	13	18	14	22	-	-	-	-	15	K
-	-	15	12	18	-	-	-	-	16	K
12	13	18	14	22	-	-	-	-	17	K
-	-	15	12	18	-	-	-	-	18	K
15	17	23	18	27	-	-	-	-	19	K
12	13	18	14	22	-	-	-	-	20	K
12	-	18	14	22	18	18	12	18	21	N
15	-	23	18	27	23	23	15	23	22	N
15	-	23	18	27	23	23	-	-	23	N
15	-	23	18	27	23	23	-	-	24	N
-	-	-	-	18	-	15	-	-	25	N
8	-	12	10	14	12	12	8	12	26	N
18	-	27	22	32	27	27	18	27	27	N
-	-	-	-	-	21	21	14	21	28	N
-	-	-	-	-	-	-	-	-	29	N
-	-	-	-	-	-	-	-	-	30	N
-	-	-	-	-	-	-	-	-	31	S
-	-	-	-	-	-	-	-	-	32	S
-	-	-	-	-	-	-	-	-	33	S
-	-	-	-	-	-	-	-	-	34	S
-	-	-	-	-	-	-	-	-	35	S
-	-	-	-	-	-	-	-	-	36	S
-	-	-	-	-	-	-	-	-	37.1	S
-	-	-	-	-	-	-	-	-	37.2	S
-	-	-	-	-	-	-	-	-	37.3	S
-	-	-	-	-	-	-	-	-	37.4	S
-	-	-	-	-	-	-	-	-	37.5	S
-	-	-	-	-	-	-	-	-	38.1	H
-	-	-	-	-	-	-	-	-	38.2	H
-	-	-	-	-	-	-	-	-	39.1	H
-	-	-	-	-	-	-	-	-	39.2	H
-	-	-	-	-	-	-	-	-	40	H
-	-	-	-	-	-	-	-	-	41	H

METRIC TAPS (mm size)

- **Ø** = nominal tap size (mm)
- **P** = thread pitch (mm)
- **n** = spindle speed (RPM)
- **V_c** = cutting speed (m/min)
- **V_f** = feed rate (mm/min)
- **V_r** = feed rate per rev (mm/rev)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

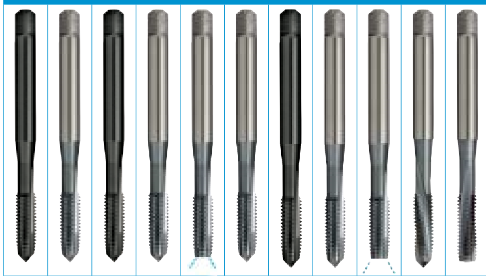
$$V_f = n \times P$$

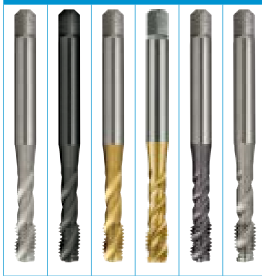
Application Guide Speeds & Feeds - DIN Taps

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.





	THROUGH HOLES											BLIND HOLES					
Catalogue Code M	T110	T112	T114	T116	T118	T840	T144	T146	T148	T152	T217	T187	T189	T241	T837	T684	T233
MF	T158	T161		T160		T844				T784	T792	T245	T247	T248		T686	T703
UNC	T170	T171		T697		T846		T666		T786	T794	T258	T260	T273		T691	
UNF	T176	T177		T698						T787	T795	T275	T701			T692	
G (BSPF)	T181	T182		T350								T281	T282	T283		T699	
Material	HSSE		PM-HSSE V3			PM-HSS Co						HSSE			HSSE	PM-HSSE V3	HSSE
Surface Finish	Blu	TiCN	Blu	TiCN		TiCN	Blu	TiCN		TiCN		Brt	Blu	TiN	TiN	Hardlube	CrN
Sutton Designation	VA		VA PM			NH+	H			Ti	Ni	N			N+	UNI	Al
Geometry					IK				IK	L12	R10	R40			R45	R50	R45
Thread Depth	≤ 3xØ		≤ 3xØ			≤ 3xØ	≤ 3xØ			≤ 3xØ		≤ 3xØ			≤2.5xØ	≤ 3xØ	≤ 3xØ

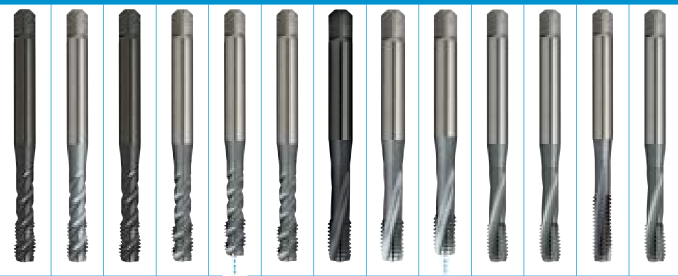
ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc (m/min) T110	T112	T114	T116	T118	T840	T144	T146	T148	T152	T217	Vc (m/min) T187	T189	T241	T837	T684	T233
P	1	Steel - Non-alloy, cast & free cutting	~ 0.15 %C	A	125	440	**13**	**18**	**16**	**22**	**26**	-	-	-	-	-	-	**10**	**11**	**14**	**14**	**17**	-
	2		~ 0.45 %C	A	190	640	**13**	**18**	**16**	**22**	**26**	-	-	-	-	-	-	**10**	**11**	**14**	**14**	**17**	-
	3			QT	250	840	11	15	13	18	22	**18**	-	-	-	-	-	8	**9**	**12**	**12**	**14**	-
	4		~ 0.75 %C	A	270	910	12	17	15	20	24	**20**	-	-	-	-	-	9	**10**	**13**	**13**	16	-
	5			QT	300	1010	-	-	-	-	-	**16**	**12**	**16**	**19**	-	-	-	-	11	11	-	-
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**13**	**18**	**16**	**22**	**26**	-	-	-	-	-	-	**10**	**11**	**14**	**14**	**17**	-
	7			QT	275	930	9	12	11	14	17	**14**	-	-	-	-	-	6	**7**	**10**	**10**	12	-
	8			QT	300	1010	-	-	-	-	-	**11**	**8**	**11**	**13**	-	-	-	-	7	7	-	-
	9			QT	350	1180	-	-	-	-	-	5	**4**	**5**	**6**	-	-	-	-	-	-	-	-
	10	Steel - High alloy, cast & tool		A	200	680	-	12	11	14	17	**14**	-	-	-	-	-	6	**7**	**10**	**10**	**12**	-
	11			HT	325	1100	-	-	-	-	-	11	**8**	**11**	**13**	-	-	-	-	-	-	-	-
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	6	**8**	7	**9**	**11**	9	7	9	11	-	-	-	4	6	6	**7**	-
	13		Martensitic	QT	240	810	-	5	-	5	6	5	**4**	**5**	**6**	5	-	-	-	-	-	4	-
M	14.1	Stainless Steel	Austenitic	AH	180	610	**7**	**9**	**8**	**11**	**13**	11	-	-	-	-	-	-	5	7	7	**9**	-
	14.2		Duplex		230	780	**4**	**6**	**5**	**7**	**9**	7	-	-	-	-	-	-	4	5	5	**6**	-
	14.3		Precipitation Hardening		300	780	3	**5**	4	**5**	**6**	**5**	4	5	6	4	-	-	3	4	4	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	-	-	-	-	-	22	16	**22**	**26**	-	-	10	11	14	14	17	-
	16		Pearlitic		260	880	-	-	-	-	-	18	13	**18**	**22**	-	-	-	-	12	12	14	-
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	-	-	-	-	-	22	16	**22**	**26**	-	-	10	11	14	14	17	-
	18		Pearlitic		250	840	-	-	-	-	-	18	13	**18**	**22**	-	-	-	-	12	12	14	-
	19	Cast Iron - Malleable	Ferritic		130	460	-	-	-	-	-	**27**	20	**27**	**32**	-	-	12	13	18	18	22	-
	20		Pearlitic		230	780	-	-	-	-	-	22	16	**22**	**26**	-	-	10	11	14	14	17	-
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	-	18	-	22	26	-	-	-	-	-	-	**10**	-	**14**	**14**	**17**	**14**
	22		Heat Treatable	AH	100	360	-	23	-	27	32	-	-	-	-	-	-	**12**	-	**18**	**18**	**22**	**18**
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	-	23	-	27	32	27	-	-	-	-	-	12	-	18	18	**22**	**18**
	24		Heat Treatable	AH	90	320	-	23	-	27	32	27	-	-	-	-	-	12	-	18	18	22	**18**
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	-	15	-	18	22	18	-	18	22	-	-	-	-	-	-	14	-
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	-	12	-	14	17	**14**	-	-	-	-	-	6	-	**10**	**10**	12	**10**
	27		Brass (CuZn, CuSnZn)		90	320	-	-	-	-	-	32	24	**32**	**39**	-	-	14	-	22	22	26	-
	28		Bronze (CuSn)		100	360	-	21	-	25	30	25	-	-	-	-	-	-	-	-	-	-	**17**
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	**5**	-	**5**	**6**	-	-	-	-	-	**4**	-	-	-	-	-	-
	32			AH	280	950	-	4	-	**5**	**5**	-	-	-	-	-	**4**	-	-	-	-	-	-
	33		Ni / Co based	A	250	840	-	4	-	**5**	**5**	-	-	-	-	-	**3**	-	-	-	-	-	-
	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-	**3**	-	-	-	-	-	-
	35			C	320	1080	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	10	14	16	-	-	-	-	-	-	-	-
	37.1		Alpha alloys		860 MPa		-	-	-	-	-	-	7	**9**	**11**	**9**	-	-	-	-	-	-	-
	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	-	-	7	**9**	**11**	**9**	-	-	-	-	-	-	-
	37.3			AH	1170 MPa		-	-	-	-	-	-	7	**9**	**11**	9	-	-	-	-	-	-	-
	37.4		Beta alloys	A	830 MPa		-	-	-	-	-	-	4	**5**	**6**	**5**	-	-	-	-	-	-	-
	37.5			AH	1400 MPa		-	-	-	-	-	-	3	**4**	**4**	4	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	5	4	**5**	**6**	-	-	-	-	-	-	-	-
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	14	11	**14**	**17**	-	-	-	-	-	-	-	-
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Condition: A (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)
Bold = Optimal | Regular = Effective

Notes on Tapping

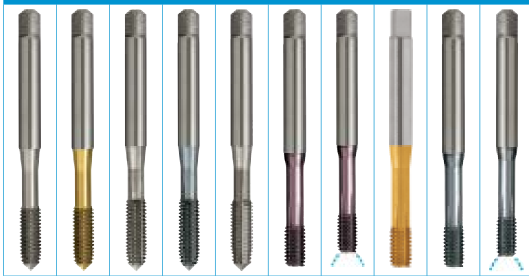
1. The speeds listed above are a recommendation only, and are based on depth of thread listed, speeds can be adjusted on application. As a general rule;
-If hole depth required is less than above mentioned = increase speed
-If hole depth required is more than above mentioned = reduce speed
2. Taps must be driven by the square to eliminate slippage, eg, ER-GB collets (square drive).
3. When using spiral flute taps with length compensation tapping attachment, it is recommended to short pitch the feed 95%, to eliminate tap cutting oversize, eg. M6x1 @ 1000RPM, Feed rate= 950mm/min.
4. Forming taps are suitable for materials with >10% elongation

BLIND HOLES



VDI 3323	T197	T201	T198	T205	T207	T842	T209	T211	T213	T215	T152	T217	T849	ISO
	T249	T251		T252		T845		T707		T788	T784	T792		
	T261	T262		T695		T847	T265	T667		T790	T846	T794	T854	
	T276	T277		T696						T791	T847	T795	T857	
	T284	T285		T352										
	HSSE		HSSE	PM-HSSE V3		PM-HSS Co								
	Blu	TiCN	Blu	TiCN		TiCN	Blu	TiCN						
	VA DH		VA DH	VA PM		NH+	H			Ti	Ti	Ni	EG	
	R45		R45		IK	R45	R15		IK	R15	L12	R10	R45	
	≤ 3xØ		≤ 3xØ	≤ 3xØ		≤ 2.5xØ	≤ 1.5xØ						≤ 3xØ	
	Vc (m/min)													
1	11	14	11	17	21		-	-	-	-	-	-	17	P
2	11	14	11	17	21		-	-	-	-	-	-	17	P
3	9	12	9	14	17		-	-	-	-	-	-	14	P
4	-	13	-	16	19		-	-	-	-	-	-	16	P
5	-	-	-	-	-		10	13	13	-	-	-	-	P
6	11	14	11	17	21		-	-	-	-	-	-	17	P
7	7	10	7	12	14		-	-	-	-	-	-	12	P
8	-	7	-	9	10		6	9	9	-	-	-	-	P
9	-	-	-	-	-		3	4	4	-	-	-	-	P
10	-	10	-	12	14		-	-	-	-	-	-	12	P
11	-	-	-	-	-		6	9	9	-	-	-	-	P
12	4	6	4	7	9		5	7	7	-	-	-	7	P
13	-	-	-	-	-		-	4	4	4	5	-	4	P
14.1	5	7	5	9	10		-	-	-	-	-	-	9	M
14.2	4	5	4	6	7		-	-	-	-	-	-	6	M
14.3	3	4	3	4	5		3	4	4	4	4	-	-	M
15	-	-	-	-	-		13	17	17	-	-	-	17	K
16	-	-	-	-	-		11	14	14	-	-	-	14	K
17	-	-	-	-	-		13	17	17	-	-	-	17	K
18	-	-	-	-	-		11	14	14	-	-	-	14	K
19	-	-	-	-	-		16	22	22	-	-	-	22	K
20	-	-	-	-	-		13	17	17	-	-	-	17	K
21	-	14	-	17	21		-	-	-	-	-	-	17	N
22	-	18	-	22	26		-	-	-	-	-	-	22	N
23	-	18	-	22	26		-	-	-	-	-	-	22	N
24	-	18	-	22	26		-	-	-	-	-	-	22	N
25	-	-	-	14	17		-	14	14	-	-	-	14	N
26	-	10	-	12	14		-	-	-	-	-	-	12	N
27	-	-	-	-	-		19	26	26	-	-	-	26	N
28	-	17	-	20	24		-	-	-	-	-	-	-	N
29	-	-	-	-	-		-	-	-	-	-	-	-	N
30	-	-	-	-	-		-	-	-	-	-	-	-	N
31	-	4	-	4	5		-	-	-	-	-	4	-	S
32	-	-	-	-	-		-	-	-	-	-	4	-	S
33	-	3	-	4	4		-	-	-	-	-	3	-	S
34	-	-	-	-	-		-	-	-	-	-	3	-	S
35	-	-	-	-	-		-	-	-	-	-	3	-	S
36	-	-	-	-	-		8	11	11	-	-	-	-	S
37.1	-	-	-	-	-		5	7	7	6	9	-	-	S
37.2	-	-	-	-	-		5	7	7	6	9	-	-	S
37.3	-	-	-	-	-		5	7	7	6	9	-	-	S
37.4	-	-	-	-	-		3	4	4	4	5	-	-	S
37.5	-	-	-	-	-		2	3	3	2	4	-	-	S
38.1	-	-	-	-	-		-	-	-	-	-	-	-	H
38.2	-	-	-	-	-		-	-	-	-	-	-	-	H
39.1	-	-	-	-	-		-	-	-	-	-	-	-	H
39.2	-	-	-	-	-		-	-	-	-	-	-	-	H
40	-	-	-	-	-		8	12	12	-	-	-	-	H
41	-	-	-	-	-		-	-	-	-	-	-	-	H

THREAD FORMING



VDI 3323	T309	T313		T319	T329	T325	T327	T331	T682	T747	ISO
				T773				T834			
			T361	T363							
	HSSE		HSSE		HSSE	SPM		PM-HSS Co	VHM		
	Brt	TiN	Brt	TiCN	CrN	TiAlN		TiN	TiCN		
	N		N		Cu	UNI		NH	N		
	No Groove		Multi-Coolant Groove		Multi-Cool-Groove	Multi-Cool-Groove	IK	Multi-Coolant Groove			
	≤ 3xØ		≤ 3xØ		≤ 3xØ	≤ 3xØ		≤ 3xØ	≤ 2xØ	≤ 2xØ	
	Vc (m/min)										
1	12	18	12	18	-	23	28	25	36	40	P
2	12	18	12	18	-	23	28	23	36	40	P
3	-	15	10	15	-	20	23	20	30	34	P
4	-	17	11	17	-	21	26	21	33	37	P
5	-	-	-	-	-	-	-	18	27	30	P
6	-	18	12	18	-	23	28	23	36	40	P
7	-	-	-	-	-	16	19	16	24	27	P
8	-	-	-	-	-	-	-	12	18	20	P
9	-	-	-	-	-	-	-	-	-	-	P
10	-	-	-	-	-	16	19	16	24	27	P
11	-	-	-	-	-	-	-	-	-	-	P
12	-	-	-	-	-	-	-	-	-	-	P
13	-	-	-	-	-	-	-	-	-	-	P
14.1	-	9	-	9	-	12	14	12	18	24	M
14.2	-	6	-	6	-	8	9	8	12	16	M
14.3	-	-	-	-	-	-	-	-	-	-	M
15	-	-	-	-	-	-	-	-	-	-	K
16	-	-	-	-	-	-	-	-	-	-	K
17	-	-	-	-	-	-	-	-	-	-	K
18	-	-	-	-	-	-	-	-	-	-	K
19	-	-	-	-	-	-	-	-	-	-	K
20	-	-	-	-	-	-	-	-	-	-	K
21	12	18	12	18	18	23	28	-	36	40	N
22	15	23	15	23	23	29	35	-	45	49	N
23	15	23	15	23	23	29	35	-	45	49	N
24	15	23	15	23	23	29	35	-	45	49	N
25	-	-	-	-	-	-	-	-	-	-	N
26	8	12	8	12	12	16	19	-	-	-	N
27	-	-	-	-	-	-	-	-	-	-	N
28	14	21	14	21	21	27	33	27	42	46	N
29	-	-	-	-	-	-	-	-	-	-	N
30	-	-	-	-	-	-	-	-	-	-	N
31	-	-	-	-	-	-	-	-	-	-	S
32	-	-	-	-	-	-	-	-	-	-	S
33	-	-	-	-	-	-	-	-	-	-	S
34	-	-	-	-	-	-	-	-	-	-	S
35	-	-	-	-	-	-	-	-	-	-	S
36	-	-	-	-	-	-	-	-	-	-	S
37.1	-	-	-	-	-	-	-	-	-	-	S
37.2	-	-	-	-	-	-	-	-	-	-	S
37.3	-	-	-	-	-	-	-	-	-	-	S
37.4	-	-	-	-	-	-	-	-	-	-	S
37.5	-	-	-	-	-	-	-	-	-	-	S
38.1	-	-	-	-	-	-	-	-	-	-	H
38.2	-	-	-	-	-	-	-	-	-	-	H
39.1	-	-	-	-	-	-	-	-	-	-	H
39.2	-	-	-	-	-	-	-	-	-	-	H
40	-	-	-	-	-	-	-	-	-	-	H
41	-	-	-	-	-	-	-	-	-	-	H

METRIC TAPS (mm size)

- **Ø** = nominal tap size (mm)
- **P** = thread pitch (mm)
- **n** = spindle speed (RPM)
- **V_c** = cutting speed (m/min)
- **V_f** = feed rate (mm/min)
- **V_r** = feed rate per rev (mm/rev)

$$n = \frac{V_c \times 1000}{\varnothing \times \pi} \simeq \frac{V_c}{\varnothing} \times 318$$

$$V_c = \frac{n \times \varnothing \times \pi}{1000} \simeq \frac{n \times \varnothing}{318}$$

$$V_f = n \times P$$

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	UNI
K	F	Cast Iron	GG	UNI
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	UNI
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

HARMONY UNI


	E482									E535		
Catalogue Code	E482									E535		
Material	VHM-ULTRA									VHM-ULTRA		
Surface Finish	AlCrN									AlCrN		
Sutton Designation	UNI									UNI		
Type of Cut: *Slotting*		●										
Finishing						●					●	
Universal				●								●
Trochoidal/Dynamic						●					●	
Roughing												
Ramping									●			
Profiling												
ap × Ø		1.0		1.0		2.0	Refer Ramp Angle				2.0	1.5
ae × Ø		1.0		0.3		0.1			1.0		0.1	0.4

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc	Feed #	Vc	Feed #	Vc	Feed #	Angle	Vc	Feed #	Vc	Feed #	
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	**130-150**	**11**	**150-180**	**11**	**160-200**	**16**	**45°**	**100-120**	**5**	**210**	**11**	**8**
	2		- 0.45 %C	A	190	640	**130-150**	**11**	**150-180**	**11**	**160-200**	**16**	**45°**	**100-120**	**5**	**210**	**11**	**8**
	3			QT	250	840	**90-110**	**8**	**120-150**	**9**	**110-130**	**14**	**15°**	**55-75**	**3**	**175**	**11**	**8**
	4		- 0.75 %C	A	270	910	**90-110**	**8**	**120-150**	**9**	**110-130**	**14**	**15°**	**55-75**	**3**	**175**	**11**	**8**
	5			QT	300	1010	**90-110**	**8**	**120-150**	**9**	**110-130**	**14**	**15°**	**55-75**	**3**	**175**	**11**	**8**
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**130-150**	**11**	**150-180**	**11**	**160-200**	**16**	**45°**	**100-120**	**5**	**210**	**11**	**8**
	7			QT	275	930	**90-110**	**8**	**120-150**	**9**	**110-130**	**14**	**15°**	**55-75**	**3**	**175**	**11**	**8**
	8			QT	300	1010	**90-110**	**8**	**120-150**	**9**	**110-130**	**14**	**15°**	**55-75**	**3**	**175**	**11**	**8**
	9			QT	350	1180	**50-70**	**8**	**60-80**	**7**	**80-100**	**12**				120	11	8
	10	Steel - High alloy, cast & tool		A	200	680	**130-150**	**11**	**150-180**	**11**	**160-200**	**16**	**15°**	**55-75**	**3**	**175**	**11**	**8**
	11			HT	325	1100	**50-70**	**8**	**60-80**	**7**	**80-100**	**12**				**120**	11	8
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	**130-150**	**11**	**150-180**	**11**	**160-200**	**16**	**15°**	**55-75**	**3**	90	11	8
	13		Martensitic	QT	240	810	**90-110**	**8**	**120-150**	**9**	**110-130**	**12**	**15°**	**55-75**	**3**	80	11	8
M	14.1	Stainless Steel	Austenitic	AH	180	610	**70-90**	**8**	**90-110**	**7**	**110-130**	**14**	**10°**	**60-80**	**4**	-	11	8
	14.2		Duplex		230	780	50-70	5	60-80	6	80-100	12	10°	60-80	4	-	11	8
	14.3		Precipitation Hardening		300	780	50-70	5	60-80	6	80-100	12	5°	45-65	3	-	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	**90-130**	**8**	**120-150**	**7**	**150**	**14**	**15°**	**60-80**	**4**	**150**	**11**	**8**
	16		Pearlitic		260	880	**90-130**	**8**	**120-150**	**7**	**150**	**14**	**15°**	**60-80**	**4**	150	11	8
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	**90-110**	**8**	**120-150**	**7**	**150**	**14**	**15°**	**60-80**	**4**	**150**	**11**	**8**
	18		Pearlitic		250	840	**90-110**	**8**	**120-150**	**7**	**150**	**14**	**15°**	**60-80**	**4**	150	11	8
	19	Cast Iron - Malleable	Ferritic		130	460	70-90	8	90-110	7	110	14	10°	45-65	3	**110**	**11**	**8**
	20		Pearlitic		230	780	70-90	8	90-110	7	110	14	10°	45-65	3	**110**	**11**	**8**
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	-	-	-	-	-	-	-	-	-	200	11	8
	22		Heat Treatable	AH	100	360	-	-	-	-	-	-	-	-	-	200	11	8
	23	Aluminum & Magnesium - cast alloy <12% Si	Non Heat Treatable		75	270	-	-	-	-	-	-	-	-	-	200	11	8
	24		Heat Treatable	AH	90	320	-	-	-	-	-	-	-	-	-	200	11	8
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	-	-	-	-	-	-	-	-	-	200	11	8
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	-	-	-	-	-	-	-	-	-	-	-	-
	27		Brass (CuZn, CuSnZn)		90	320	-	-	-	-	-	-	-	-	-	200	11	8
	28		Bronze (CuSn)		100	360	-	-	-	-	-	-	-	-	-	-	-	-
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	-	-	-	-	-	-	50	11	8
	32			AH	280	950	-	-	-	-	-	-	-	-	-	50	11	8
	33		Ni / Co based	A	250	840	-	-	-	-	-	-	-	-	-	50	11	8
	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-	-	-
	35			C	320	1080	-	-	-	-	-	-	-	-	-	50	11	8
	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	-	-	-	**70**	**11**	**8**
	37.1		Alpha alloys		860 MPa		-	-	-	-	-	-	-	-	-	**70**	**11**	**8**
	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	-	-	-	-	-	**70**	**11**	**8**
	37.3			AH	1170 MPa		-	-	-	-	-	-	-	-	-	**70**	**11**	**8**
	37.4		Beta alloys	A	830 MPa		-	-	-	-	-	-	-	-	-	**70**	**11**	**8**
	37.5			AH	1400 MPa		-	-	-	-	-	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	-	-	-	**120**	**11**	**8**
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	-	-	-	-	**120**	**11**	**8**
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	**100**	**11**	**8**

Condition: A (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Feed Table (f$_z$) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

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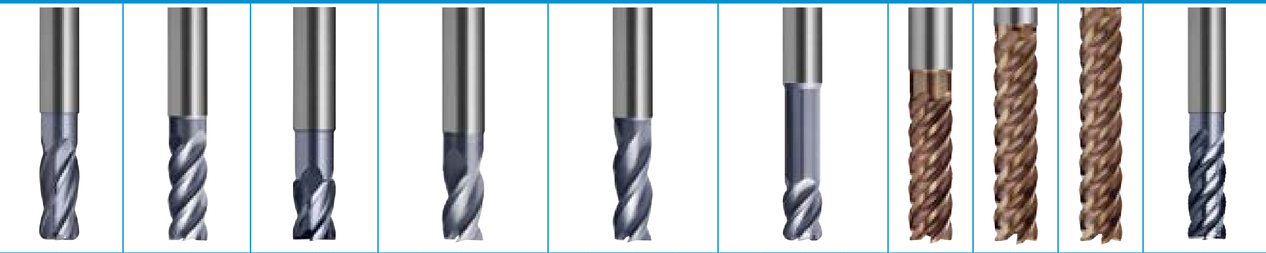

E559		E560	E426		E427	E533		E534	E422		E423		E424		E425		E430		E431		E483		E484		E485		E549		E550		
VHM-ULTRA			VHM-ULTRA			VHM-ULTRA			VHM-ULTRA				VHM-ULTRA				VHM-ULTRA				VHM						VHM-ULTRA				
AlCrN			AlCrN			AlCrN			AlCrN				AlCrN				AlCrN				TiAlN						AlCrN				
UNI			UNI			UNI			UNI				UNI				UNI				N						UNI				
										●				●																Slotting	
	●			●			●				●				●			●												Finishing	
		●			●			●				●				●			●									●		Universal	
	●			●			●													●		●		●		●				Tro/Dyn	
																													●	Roughing	
																														Ramping	
																														Profiling	
	1.5	1.5		1.0	1.0		0.25	1.0		0.25	1.0	1.0		0.25	1.0	1.0		0.25	1.0	1.0		3.0		4.0		5.0		1.5	1.5	↑↓ ap	
	0.1	0.4		0.2	0.4		1.0	0.25		1.0	0.25	0.4		1.0	0.1	0.4		1.0	0.2	0.3		0.05		0.05		0.05		0.4	0.4	←→ ae	
Vc	Feed #		Vc	Feed #		Vc	Feed #		Vc	Feed #			Vc	Feed #			Vc	Feed #			Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #		VDIA 3323	ISO
210	11	8	210	16	11	210	11	8	210	9	16	11	210	9	16	11	210	7	15	11	240-400	13-21	180-300	15-22	180-300	15-22	180	5	13	1	
210	11	8	210	16	11	210	11	8	210	9	16	11	210	9	16	11	210	7	15	11	240-400	13-21	180-300	15-22	180-300	15-22	180	5	13	2	
175	11	8	175	16	11	175	11	8	175	9	16	11	175	9	16	11	175	7	15	11	210-350	13-18	150-250	13-20	150-250	13-20	100	5	13	3	
175	11	8	175	16	11	175	11	8	175	9	16	11	175	9	16	11	175	7	15	11	210-350	13-18	150-250	13-20	150-250	13-20	100	5	13	4	
175	11	8	175	16	11	175	11	8	175	9	16	11	175	9	16	11	175	7	15	11	210-350	13-18	150-250	13-20	150-250	13-20	100	5	13	5	
210	11	8	210	16	11	210	11	8	210	9	16	11	210	9	16	11	210	7	15	11	240-400	13-21	180-300	15-22	180-300	15-22	180	5	13	6	
175	11	8	175	16	11	175	11	8	175	9	16	11	175	9	16	11	175	7	15	11	210-350	13-18	150-250	13-20	150-250	13-20	100	5	13	7	P
175	11	8	175	16	11	175	11	8	175	9	16	11	175	9	16	11	175	7	15	11	210-350	13-18	150-250	13-20	150-250	13-20	100	5	13	8	
120	11	8	120	16	11	120	11	8	120	9	16	11	120	9	16	11	120	7	15	11	210-350	11-18	150-250	13-20	150-250	13-20	80	5	13	9	
175	11	8	175	16	11	175	11	8	175	9	16	11	175	9	16	11	175	7	15	11	240-400	13-21	180-300	15-22	180-300	15-22	100	5	13	10	
120	11	8	120	16	11	120	11	8	120	9	16	11	120	9	16	11	120	7	15	11	210-350	11-18	150-250	13-20	150-250	13-20	80	5	13	11	
90	11	8	-	-	-	90	11	8	-	-	-	-	-	-	-	-	-	-	-	-	240-400	13-21	180-300	15-22	180-300	15-22	90	5	13	12	
80	11	8	-	-	-	80	11	8	-	-	-	-	-	-	-	-	-	-	-	-	210-350	13-18	150-250	13-20	150-250	13-20	80	5	13	13	
-	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	160-270	13-18	100-220	13-20	100-220	13-20	90	5	13	14.1	
-	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120-200	13-18	90-180	13-20	90-180	13-20	90	5	13	14.2	M
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150	11	8	150	16	11	150	11	8	150	9	16	11	150	9	16	11	150	7	15	11	210-350	13-18	150-300	13-18	150-300	13-18	140	5	13	15	
150	11	8	150	16	11	150	11	8	150	9	16	11	150	9	16	11	150	7	15	11	210-350	13-18	150-300	13-18	150-300	13-18	140	5	13	16	
150	11	8	150	16	11	150	11	8	150	9	16	11	150	9	16	11	150	7	15	11	210-350	13-18	150-300	13-18	150-300	13-18	140	5	13	17	K
150	11	8	150	16	11	150	11	8	150	9	16	11	150	9	16	11	150	7	15	11	210-350	13-18	150-300	13-18	150-300	13-18	140	5	13	18	
110	11	8	110	16	11	110	11	8	110	9	16	11	110	9	16	11	110	7	15	11	210-350	13-18	150-300	13-18	150-300	13-18	100	5	13	19	
110	11	8	110	16	11	110	11	8	110	9	16	11	110	9	16	11	110	7	15	11	210-350	13-18	150-300	13-18	150-300	13-18	100	5	13	20	
200	11	8	-	-	-	200	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	
200	11	8	-	-	-	200	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	
200	11	8	-	-	-	200	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	
200	11	8	-	-	-	200	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	
200	11	8	-	-	-	200	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	N
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200	11	8	-	-	-	200	11	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	
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50	11	8	50	16	11	50	11	8	50	9	16	11	50	9	16	11	50	7	15	11	-	-	-	-	-	-	50	5	13	31	
50	11	8	50	16	11	50	11	8	50	9	16	11	50	9	16	11	50	7	15	11	-	-	-	-	-	-	50	5	13	32	
50	11	8	50	16	11	50	11	8	50	9	16	11	50	9	16	11	50	7	15	11	-	-	-	-	-	-	50	5	13	33	
-	-	-	50	16	11	-	-	-	50	9	16	11	50	9	16	11	50	7	15	11	-	-	-	-	-	-	-	-	-	34	
50	11	8	50	16	11	50	11	8	50	9	16	11	50	9	16	11	50	7	15	11	-	-	-	-	-	-	50	5	13	35	
70	11	8	70	16	11	70	11	8	70	9	16	11	70	9	16	11	70	7	15	11	-	-	-	-	-	-	70	5	13	36	S
70	11	8	70	16	11	70	11	8	70	9	16	11	70	9	16	11	70	7	15	11	-	-	-	-	-	-	70	5	13	37.1	
70	11	8	70	16	11	70	11	8	70	9	16	11	70	9	16	11	70	7	15	11	-	-	-	-	-	-	70	5	13	37.2	
70	11	8	70	16	11	70	11	8	70	9	16	11	70	9	16	11	70	7	15	11	-	-	-	-	-	-	70	5	13	37.3	
70	11	8	70	16	11	70	11	8	70	9	16	11	70	9	16	11	70	7	15	11	-	-	-	-	-	-	70	5	13	37.4	
-	-	-	70	16	11	-	-	-	70	9	16	11	70	9	16	11	70	7	15	11	-	-	-	-	-	-	-	-	-	37.5	
120	11	8	120	16	11	120	11	8	120	9	16	11	120	9	16	11	120	7	15	11	-	-	-	-	-	-	-	-	-	38.1	
-	-	-	120	16	11	-	-	-	120	9	16	11	120	9	16	11	120	7	15	11	-	-	-	-	-	-	-	-	-	38.2	
-	-	-	100	16	11	-	-	-	100	9	16	11	100	9	16	11	100	7	15	11	-	-	-	-	-	-	-	-	-	39.1	H
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39.2	
120	11	8	120	16	11	120	11	8	120	9	16	11	120	9	16	11	120	7	15	11	-	-	-	-	-	-	-	-	-	40	
100	11	8	100	16	11	100	11	8	100	9	16	11	100	9	16	11	100	7	15	11	-	-	-	-	-	-	-	-	-	41	

METRIC ENDMILLS (mm size)

- **Ø** = nominal tool diameter (mm)
- **n** = Spindel speed (RPM)
- $\mathbf{v_c}$ = Cutting speed (m/min)
- $\mathbf{f_z}$ = Feed rate per tooth (mm/tooth)
- $\mathbf{v_f}$ = Feed rate (mm/min)
- **z** = No. cutting edges
- **Q** = Metal removal rate (cm³/min)
- $\mathbf{a_p}$ = Cutting depth (mm)
- $\mathbf{a_e}$ = Cutting width (mm)

$$n = \frac{v_c \times 1000}{Ø \times \pi} \simeq \frac{v_c}{Ø} \times 318$$

$$v_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

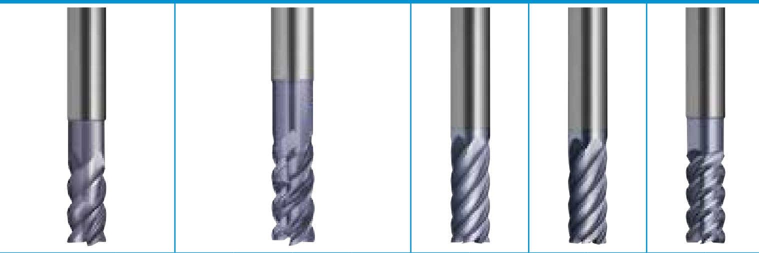
$$f_z = \frac{v_f}{z \times n} \qquad v_f = f_z \times z \times n$$

$$Q = \frac{a_p \times a_e \times v_f}{1000}$$

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al	W
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

HARMONY NH



Catalogue Code							E562	E564		E599				E432	E434	E436		E543	
Material							VHM-ULTRA			VHM-ULTRA				VHM-ULTRA				VHM-ULTRA	
Surface Finish							AlCrN			AlCrN				AlCrN				AlCrN	
Sutton Designation							NH			NH				NH				NH	
Type of Cut: Slotting								●			●								
Finishing															●		●		●
Universal									●				●						
Trochoidal/Dynamic															●		●		●
Roughing																			
Ramping																			
Profiling																			
↑↓ ap × Ø								0.5	1.0						2.0		2.0		1.75
←→ ae × Ø								1.0	0.4						0.05		0.06		0.05
ISO	**VDI^ 3323**	**Material**		**Condition**	**HB**	**N/mm²**	**Vc**	**Feed #**		**Vc**	**Feed #**	**Vc**	**Feed #**	**Vc**	**Feed #**	**Vc**	**Feed #**	**Vc**	**Feed #**
P	1	Steel - Non-alloy, cast & free cutting	~0.15 %C	A	125	440	-	-	-	180	10	180	11	210	11	210	11	-	-
P	2		~0.45 %C	A	190	640	-	-	-	180	10	180	11	210	11	210	11	-	-
P	3			QT	250	840	-	-	-	180	10	180	11	**175**	**11**	**175**	**11**	-	-
P	4		~0.75 %C	A	270	910	-	-	-	180	10	180	11	**175**	**11**	**175**	**11**	-	-
P	5			QT	300	1010	**175**	**9**	**10**	**150**	**9**	**150**	**10**	**175**	**11**	**175**	**11**	**100**	**11**
P	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	-	-	-	180	10	180	11	210	11	210	11	-	-
P	7			QT	275	930	-	-	-	180	10	180	11	**175**	**11**	**175**	**11**	**100**	**11**
P	8			QT	300	1010	**175**	**9**	**10**	**150**	**9**	**150**	**10**	**175**	**11**	**175**	**11**	**100**	**11**
P	9			QT	350	1180	**120**	**9**	**10**	90	9	90	10	**120**	**11**	**120**	**11**	**80**	**11**
P	10	Steel - High alloy, cast & tool		A	200	680	-	-	-	180	10	180	11	**175**	**11**	**175**	**11**	**100**	**11**
P	11			HT	325	1100	**120**	**9**	**10**	**90**	**9**	**90**	**10**	**120**	**11**	**120**	**11**	**80**	**11**
P	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	-	-	-	180	10	180	11	120	11	120	11	90	11
P	13		Martensitic	QT	240	810	**100**	**9**	**10**	**80**	**9**	**80**	**10**	**100**	**11**	**100**	**11**	**80**	**11**
M	14.1	Stainless Steel	Austenitic	AH	180	610	-	-	-	90	10	90	11	-	-	-	-	90	11
M	14.2		Duplex		230	780	**120**	**9**	**10**	**120**	**9**	**120**	**10**	-	-	-	-	**90**	**11**
M	14.3		Precipitation Hardening		300	780	**100**	**9**	**10**	**100**	**9**	**100**	**10**	-	-	-	-	**80**	**11**
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	-	-	-	120	9	120	10	**150**	**11**	**150**	**11**	**140**	**11**
K	16		Pearlitic		260	880	150	9	10	**100**	**9**	**100**	**10**	**150**	**11**	**150**	**11**	**140**	**11**
K	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	-	-	-	120	9	120	10	**150**	**11**	**150**	**11**	**140**	**11**
K	18		Pearlitic		250	840	**150**	**9**	**10**	**100**	**9**	**100**	**10**	**150**	**11**	**150**	**11**	**140**	**11**
K	19	Cast Iron - Malleable	Ferritic		130	460	-	-	-	120	9	120	10	**110**	**11**	**110**	**11**	**100**	**11**
K	20		Pearlitic		230	780	-	-	-	120	9	120	10	**110**	**11**	**110**	**11**	**100**	**11**
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	-	-	-					-	-	-	-	-	-
N	22		Heat Treatable	AH	100	360	-	-	-					-	-	-	-	-	-
N	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	-	-	-					-	-	-	-	-	-
N	24		Heat Treatable	AH	90	320	-	-	-					-	-	-	-	-	-
N	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	-	-	-					-	-	-	-	-	-
N	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	-	-	-					-	-	-	-	-	-
N	27		Brass (CuZn, CuSnZn)		90	320	-	-	-					-	-	-	-	-	-
N	28		Bronze (CuSn)		100	360	-	-	-					-	-	-	-	-	-
N	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-					-	-	-	-	-	-
N	30	Non-metallic - Hard rubber, wood etc.					-	-	-					-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	50	9	50	10	-	-	-	-	**50**	**11**
S	32			AH	280	950	**50**	**9**	**10**	**40**	**9**	**40**	**10**	50	11	50	11	**50**	**11**
S	33		Ni / Co based	A	250	840	-	-	-	50	9	50	10	-	-	-	-	**50**	**11**
S	34			AH	350	1180	**50**	**9**	**10**	**40**	**9**	**40**	**10**	**50**	**11**	**50**	**11**	**50**	**11**
S	35			C	320	1080	**50**	**9**	**10**	**40**	**9**	**40**	**10**	50	11	50	11	50	-
S	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	50	9	50	10	-	-	-	-	-	-
S	37.1		Alpha alloys		860 MPa		-	**9**	**10**	50	9	50	10	-	-	-	-	**70**	**11**
S	37.2		Alpha / Beta alloys	A	960 MPa		**70**	**9**	**10**	**60**	**9**	**60**	**10**	70	11	70	11	**70**	**11**
S	37.3			AH	1170 MPa		-	-	-	50	9	50	10	**70**	**11**	**70**	**11**	**70**	**11**
S	37.4		Beta alloys	A	830 MPa		**70**	**9**	**10**	**60**	**9**	**60**	**10**	70	11	70	11	**70**	**11**
S	37.5			AH	1400 MPa		-	-	-	50	9	50	10	**70**	**11**	**70**	**11**	-	-
H	38.1	Hardened steel		HT	45 HRC		120	9	10	100	9	100	10	**120**	**11**	**120**	**11**	80	11
H	38.2			HT	55 HRC		-	-	-					**120**	**11**	**120**	**11**	-	-
H	39.1			HT	58 HRC		-	-	-					100	11	100	11	-	-
H	39.2			HT	62 HRC		-	-	-					-	-	-	-	-	-
H	40	Cast Iron	Chilled	C	400	1350	**120**	**9**	**10**					**120**	**11**	**120**	**11**	**80**	**11**
H	41			HT	55 HRC		-	-	-					100	11	100	11	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

Feed Table (f_z) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

HARMONY VA														HARMONY Ti/Ni/VA			
E459		E460	E462		E463	E410		E411		E488				E481			
VHM-ULTRA			VHM-ULTRA			VHM-ULTRA				VHM-ULTRA				VHM-ULTRA			
HELICA			***HELICA***			***HELICA***				***AlCrN***				***Xceed***			
VA			VA			VA				VA-R				UNI			
	●			●			●				●					***Slotting***	
		●			●			●								***Finishing***	
		●			●				●							***Universal***	
		●			●											***Tro/Dyn***	
													●			***Roughing***	
																Ramping	
															●	***Profiling***	
	1.0	1.0		1.0	1.0		0.25	2.3	2.3						0.1	↑↓ ap	
	1.0	0.3		1.0	0.3		1.0	0.2	0.4						0.05	←→ ae	
Vc	Feed #		Vc	Feed #		Vc	Feed #			Vc	Feed #	Vc	Feed #	Vc	Feed #	VDI 3323	ISO
-	-	-	-	-	-	-	-	-	-	**100**	**7**	**150**	**8**	-	-	1	
-	-	-	-	-	-	-	-	-	-	**100**	**7**	**150**	**8**	-	-	2	
-	-	-	-	-	-	-	-	-	-	**100**	**7**	**150**	**8**	-	-	3	
-	-	-	-	-	-	-	-	-	-	**100**	**7**	**150**	**8**	-	-	4	
-	-	-	-	-	-	-	-	-	-	**100**	**7**	**150**	**8**	-	-	5	
210	12	9	210	12	9	-	-	-	-	**100**	**7**	**150**	**8**	-	-	6	
175	12	9	175	12	9	-	-	-	-	60	7	90	8	175	18	7	P
175	12	9	175	12	9	-	-	-	-	60	7	90	8	**175**	**18**	8	
120	12	9	120	12	9	-	-	-	-	60	7	90	8	**120**	**18**	9	
175	12	9	175	12	9	-	-	-	-	**100**	**6**	**150**	**7**	175	18	10	
120	12	9	120	12	9	-	-	-	-	60	6	90	7	**120**	**18**	11	
120	12	9	120	12	9	120	11	18	16	**100**	**6**	**150**	**7**	-	-	12	
100	12	9	100	12	9	100	11	18	16	**100**	**6**	**150**	**7**	-	-	13	
120	**12**	**9**	**120**	**12**	**9**	**120**	**11**	**18**	**16**	100	6	150	7	**90**	**18**	14.1	
120	**12**	**9**	**120**	**12**	**9**	**120**	**11**	**18**	**16**	**65**	**6**	**100**	**7**	90	18	14.2	M
100	**12**	**9**	**100**	**12**	**9**	**100**	**11**	**18**	**16**	**65**	**5**	**100**	**6**	80	18	14.3	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	K
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	21	
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	22	
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	23	
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	24	
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	25	N
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	26	
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	27	
200	11	8	200	11	8	-	-	-	-	-	-	-	-	-	-	28	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	
70	11	8	70	11	8	70	10	18	14	-	-	-	-	50	18	31	
70	11	8	**70**	11	8	**70**	**10**	**18**	**14**	-	-	-	-	**50**	**18**	32	
70	11	8	70	11	8	70	10	18	14	-	-	-	-	50	18	33	
70	11	8	**70**	11	8	**70**	**10**	**18**	**14**	-	-	-	-	**50**	**18**	34	
70	11	8	**70**	11	8	**70**	**10**	**18**	**14**	-	-	-	-	**50**	**18**	35	
90	11	8	90	11	8	90	10	18	14	-	-	-	-	70	18	36	S
90	11	8	**90**	11	8	**90**	**10**	**18**	**14**	**55**	**5**	**80**	**6**	70	18	37.1	
90	11	8	**90**	11	8	**90**	**10**	**18**	**14**	**55**	**5**	**80**	**6**	70	18	37.2	
-	-	-	-	-	-	-	-	-	-	40	5	60	6	**70**	**18**	37.3	
90	11	8	**90**	11	8	**90**	**10**	**18**	**14**	**55**	**5**	**80**	**6**	70	18	37.4	
90	11	8	90	11	8	90	10	18	14	40	5	60	6	**70**	**18**	37.5	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.1	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.2	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39.1	H
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39.2	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41	

METRIC ENDMILLS (mm size)

Ø = nominal tool diameter (mm)
n = Spindel speed (RPM)
v_c = Cutting speed (m/min)
f_z = Feed rate per tooth (mm/tooth)
v_f = Feed rate (mm/min)
z = No. cutting edges
Q = Metal removal rate (cm³/min)
a_p = Cutting depth (mm)
a_e = Cutting width (mm)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad V_f = f_z \times z \times n$$

$$Q = \frac{a_p \times a_e \times V_f}{1000}$$

Application Guide Speeds & Feeds - Carbide Endmills

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (> 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

HARMONY Ti




Catalogue Code		E464	E466		E468	E470		E476		E491		E477		E492
Material	VHM-ULTRA			VHM-ULTRA			VHM-ULTRA				VHM-ULTRA			
Surface Finish	*AlNova*			*AlNova*			*AlNova*				*AlNova*			
Sutton Designation	Ti			Ti			Ti-3XL				Ti-4XL			
Type of Cut: *Slotting*														
Finishing		●			●			●				●		
Universal			●			●				●				●
Trochoidal/Dynamic			●		●			●				●		
Roughing														
Ramping														
Profiling														
ap × Ø			1.5		1.5	1.0		3.0		3.0		4.0		4.0
ae × Ø			0.05		0.05	0.2		0.05		0.2		0.05		0.2

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc	Feed #	Feed #	Vc	Feed #	Feed #	Vc	F#	Vc	F#	Vc	F#	Vc	F#
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	2		- 0.45 %C	A	190	640	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	3			QT	250	840	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	4		- 0.75 %C	A	270	910	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	5			QT	300	1010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	7			QT	275	930	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	8			QT	300	1010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	9			QT	350	1180	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	10	Steel - High alloy, cast & tool		A	200	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	11			HT	325	1100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	13		Martensitic	QT	240	810	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	14.1	Stainless Steel	Austenitic	AH	180	610	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	14.2		Duplex		230	780	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	14.3		Precipitation Hardening		300	780	-	-	-	-	-	-	**80**	**11**	**60**	**13**	-	-	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	16		Pearlitic		260	880	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	18		Pearlitic		250	840	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	19	Cast Iron - Malleable	Ferritic		130	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	20		Pearlitic		230	780	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	22		Heat Treatable	AH	100	360	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	23	Aluminum & Magnesium - cast alloy <12% Si	Non Heat Treatable		75	270	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	24		Heat Treatable	AH	90	320	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	27		Brass (CuZn, CuSnZn)		90	320	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	28		Bronze (CuSn)		100	360	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	32			AH	280	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	33		Ni / Co based	A	250	840	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	35			C	320	1080	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	**70**	**10**	**70**	**7**	**65**	**10**	**65**	**7**
S	37.1		Alpha alloys		860 MPa		**80**	**17**	**14**	**80**	**17**	**14**	**65**	**10**	**55**	**7**	**60**	**10**	**50**	**7**
S	37.2		Alpha / Beta alloys	A	960 MPa		**80**	**17**	**14**	**80**	**17**	**14**	**65**	**10**	**50**	**7**	**60**	**10**	**45**	**7**
S	37.3			AH	1170 MPa		**80**	**17**	**14**	**80**	**17**	**14**	**50**	**10**	**40**	**7**	**45**	**10**	**35**	**7**
S	37.4		Beta alloys	A	830 MPa		**80**	**17**	**14**	**80**	**17**	**14**	**65**	**10**	**55**	**7**	**60**	**10**	**50**	**7**
S	37.5			AH	1400 MPa		**80**	**17**	**14**	**80**	**17**	**14**	**50**	**10**	**40**	**7**	**45**	**10**	**35**	**7**
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
H	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
H	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
H	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-
H	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Feed Table (f_z) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

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HARMONY Ti								HARMONY VH												HARMONY			
																							
E721								E495				E496		E497		E498		E499		E566	E568		
VHM-ULTRA								VHM-ULTRA												ULTRA			
Xceed								*Durana*												*Aldura*			
Ti-IK								NH												VH			
												●		●			●		●			*Slotting*	
	●								●													*Finishing*	
			●								●		●		●						●	*Universal*	
	●				●																	*Tro/Dyn*	
							●															*Roughing*	
																						Ramping	
																						Profiling	
	1.5		1.0		2.0		1.0														1.0	↑↓ ap	
	0.05		0.4		0.1		0.6														0.05	←→ ae	
Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	Feed #	VDI 3323	ISO
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	P
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	
120	16	90	10	120	16	70	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.1	M
120	12	90	11	110	12	70	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.2	
120	16	90	10	120	16	70	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.3	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	K
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	
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70	11	50	6	60	10	40	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31	S
70	11	50	6	60	10	40	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	
70	11	45	6	60	10	40	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	
60	11	40	6	55	10	30	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34	
60	11	40	6	55	10	30	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	
110	**15**	**80**	**11**	**110**	**14**	**60**	**10**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36	
110	**15**	**80**	**11**	**110**	**14**	**60**	**10**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37.1	
90	**14**	**70**	**10**	**90**	**13**	**50**	**9**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37.2	
90	**13**	**70**	**10**	**90**	**12**	**50**	**9**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37.3	
80	**13**	**60**	**8**	**80**	**12**	**45**	**7**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37.4	
80	**12**	**60**	**7**	**80**	**11**	**45**	**6**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37.5	
-	-	-	-	-	-	-	-	**40**	**5**	**50**	**8**	**40**	**4**	**40**	**5**	**100**	**9**	**100**	**9**	-	-	38.1	H
-	-	-	-	-	-	-	-	**20**	**4**	**30**	**7**	**20**	**3**	**30**	**4**	**80**	**9**	**80**	**9**	**60**	**12**	38.2	
-	-	-	-	-	-	-	-	15	3	20	6	15	2	20	3	60	7	60	7	**50**	**12**	39.1	
-	-	-	-	-	-	-	-	15	3	20	6	15	2	20	3	60	7	60	7	**30**	**12**	39.2	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**140**	**12**	41	

METRIC ENDMILLS (mm size)

Ø	= nominal tool diameter (mm)
n	= Spindel speed (RPM)
$\mathbf{v_c}$	= Cutting speed (m/min)
$\mathbf{f_z}$	= Feed rate per tooth (mm/tooth)
$\mathbf{v_f}$	= Feed rate (mm/min)
z	= No. cutting edges
Q	= Metal removal rate (cm³/min)
$\mathbf{a_p}$	= Cutting depth (mm)
$\mathbf{a_e}$	= Cutting width (mm)

$$n = \frac{v_c \times 1000}{\varnothing \times \pi} \simeq \frac{v_c}{\varnothing} \times 318$$

$$v_c = \frac{n \times \varnothing \times \pi}{1000} \simeq \frac{n \times \varnothing}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad v_f = f_z \times z \times n$$

$$Q = \frac{a_p \times a_e \times v_f}{1000}$$

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ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	UNI
K	F	Cast Iron	GG	UNI
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al W	UNI
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.



	E444			E310			E660		
Catalogue Code	E444			E310			E660		
Material	VHM			VHM			VHM-ULTRA		
Surface Finish	*Brt*			*Brt*			*Brt*		
Sutton Designation	Al			Al			Al		
Type of Cut: *Slotting*	●			●			●		
Finishing									
Universal		●			●			●	
Trochoidal/Dynamic									
Roughing			●			●			●
Ramping									
Profiling									
ap × Ø	1.0	1.5	1.5	1.0	1.5	1.5	1.0	1.5	1.5
ae × Ø	1.0	0.2	0.2	1.0	0.2	0.2	1.0	0.25	0.4

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc	Feed #			Vc	Feed #			Vc	Feed #		
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	-	-	-	-	-	-	-	-	-	-	-	-
P	2		- 0.45 %C	A	190	640	-	-	-	-	-	-	-	-	-	-	-	-
P	3			QT	250	840	-	-	-	-	-	-	-	-	-	-	-	-
P	4		- 0.75 %C	A	270	910	-	-	-	-	-	-	-	-	-	-	-	-
P	5			QT	300	1010	-	-	-	-	-	-	-	-	-	-	-	-
P	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	-	-	-	-	-	-	-	-	-	-	-	-
P	7			QT	275	930	-	-	-	-	-	-	-	-	-	-	-	-
P	8			QT	300	1010	-	-	-	-	-	-	-	-	-	-	-	-
P	9			QT	350	1180	-	-	-	-	-	-	-	-	-	-	-	-
P	10	Steel - High alloy, cast & tool		A	200	680	-	-	-	-	-	-	-	-	-	-	-	-
P	11			HT	325	1100	-	-	-	-	-	-	-	-	-	-	-	-
P	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	-	-	-	-	-	-	-	-	-	-	-	-
P	13		Martensitic	QT	240	810	-	-	-	-	-	-	-	-	-	-	-	-
M	14.1	Stainless Steel	Austenitic	AH	180	610	-	-	-	-	-	-	-	-	-	-	-	-
M	14.2		Duplex		230	780	-	-	-	-	-	-	-	-	-	-	-	-
M	14.3		Precipitation Hardening		300	780	-	-	-	-	-	-	-	-	-	-	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	-	-	-	-	-	-	-	-	-	-	-	-
K	16		Pearlitic		260	880	-	-	-	-	-	-	-	-	-	-	-	-
K	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	-	-	-	-	-	-	-	-	-	-	-	-
K	18		Pearlitic		250	840	-	-	-	-	-	-	-	-	-	-	-	-
K	19	Cast Iron - Malleable	Ferritic		130	460	-	-	-	-	-	-	-	-	-	-	-	-
K	20		Pearlitic		230	780	-	-	-	-	-	-	-	-	-	-	-	-
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	**220**	**3**	**11**	**16**	**220**	**8**	**14**	**18**	**400-500**	**16**	**18**	**17**
N	22		Heat Treatable	AH	100	360	**220**	**3**	**11**	**16**	**220**	**8**	**14**	**18**	**400-530**	**16**	**18**	**17**
N	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	**220**	**3**	**11**	**16**	**220**	**8**	**14**	**18**	**230-360**	**15**	**17**	**16**
N	24		Heat Treatable	AH	90	320	**220**	**3**	**11**	**16**	**220**	**8**	**14**	**18**	**230-360**	**15**	**17**	**16**
N	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	220	3	11	16	**220**	**8**	**14**	**18**	**230-360**	**15**	**17**	**16**
N	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	160	3	11	16	**160**	**8**	**14**	**18**	**100-210**	**14**	**16**	**15**
N	27		Brass (CuZn, CuSnZn)		90	320	160	3	11	16	**160**	**8**	**14**	**18**	**100-210**	**14**	**16**	**15**
N	28		Bronze (CuSn)		100	360	160	3	11	16	**160**	**8**	**14**	**18**	**100-210**	**14**	**16**	**15**
N	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	**490-600**	**18**	**20**	**19**
N	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	-	-	-	-	-	-	-	-	-
S	32			AH	280	950	-	-	-	-	-	-	-	-	-	-	-	-
S	33		Ni / Co based	A	250	840	-	-	-	-	-	-	-	-	-	-	-	-
S	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-	-	-
S	35			C	320	1080	-	-	-	-	-	-	-	-	-	-	-	-
S	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	-	-	-	-	-	-
S	37.1		Alpha alloys		860 MPa		-	-	-	-	-	-	-	-	-	-	-	-
S	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	-	-	-	-	-	-	-	-
S	37.3			AH	1170 MPa		-	-	-	-	-	-	-	-	-	-	-	-
S	37.4		Beta alloys	A	830 MPa		-	-	-	-	-	-	-	-	-	-	-	-
S	37.5			AH	1400 MPa		-	-	-	-	-	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	-	-	-	-	-	-
H	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-
H	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-
H	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-
H	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	-	-	-	-	-	-	-
H	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

Feed Table (f_z) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

								HARMONY																	
E670	E671	E672	E673	E661				E480				E478				E400				E402					
VHM-ULTRA				VHM-ULTRA				VHM-ULTRA				VHM-ULTRA				VHM-ULTRA				VHM-ULTRA					
ASX				Brt				Brt				Brt				CrN				CrN					
Al				Al				Al				Al				Al				Al					
	●				●				●				●				●				●			Slotting	
										●				●				●				●		Finishing	
		●				●				●				●				●				●		Universal	
										●				●				●				●		Tro/Dyn	
			●				●				●				●				●				●	Roughing	
																								Ramping	
																								Profiling	
	1.0	1.0	1.0		0.5	1.0	0.1		1.5	2.0	2.0		1.5	2.0	2.0		1.5	2.0	2.0		1.5	2.0	2.0	↑↓ ap	
	1.0	0.25	0.4		1.0	0.25	0.5		1.0	0.4	0.6		1.0	0.4	0.6		1.0	0.4	0.6		1.0	0.4	0.6	←→ ae	
Vc	Feed #			Vc	Feed #			Vc	Feed #			Vc	Feed #			Vc	Feed #			Vc	Feed #			VDIA 3323	ISO
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
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400-500	16	18	17	400-500	16	18	17	200	9	18	13	200	9	18	13	200	8	17	13	200	9	18	13	21	
400-530	16	18	17	400-530	16	18	17	200	9	18	13	200	9	18	13	200	8	17	13	200	9	18	13	22	
230-360	15	17	16	230-360	15	17	16	200	9	18	13	200	9	18	13	200	8	17	13	200	9	18	13	23	
230-360	15	17	16	230-360	15	17	16	200	9	18	13	200	9	18	13	200	8	17	13	200	9	18	13	24	
230-360	15	17	16	230-360	15	17	16	200	9	18	13	200	9	18	13	200	8	17	13	200	9	18	13	25	N
100-210	14	16	15	100-210	14	16	15	350	9	18	13	350	9	18	13	500	8	17	13	500	9	18	13	26	
100-210	14	16	15	100-210	14	16	15	350	9	18	13	350	9	18	13	500	8	17	13	500	9	18	13	27	
100-210	14	16	15	100-210	14	16	15	350	9	18	13	350	9	18	13	500	8	17	13	500	9	18	13	28	
490-600	18	20	19	490-600	18	20	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	
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METRIC ENDMILLS (mm size)

- **Ø** = nominal tool diameter (mm)
- **n** = Spindle speed (RPM)
- V_c = Cutting speed (m/min)
- f_z = Feed rate per tooth (mm/tooth)
- V_f = Feed rate (mm/min)
- **z** = No. cutting edges
- **Q** = Metal removal rate (cm³/min)
- a_p = Cutting depth (mm)
- a_e = Cutting width (mm)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad V_f = f_z \times z \times n$$

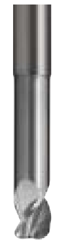
$$Q = \frac{a_p \times a_e \times V_f}{1000}$$

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

HARMONY

										
Catalogue Code	E668				E669				E408	
Material	VHM-ULTRA				VHM-ULTRA				VHM-ULTRA	
Surface Finish	*HCR*				*ASX*				*CrN*	
Sutton Designation	Al				Al				Al	
Type of Cut: *Slotting*		●				●					
Finishing											
Universal			●				●				
Trochoidal/Dynamic			●				●				
Roughing				●				●			
Ramping											
Profiling										●	●
ap × Ø		1.0	1.5	1.5		1.0	1.0	1.0		0.1	0.1
ae × Ø		1.0	0.25	0.4		1.0	0.25	0.4		0.1	0.05

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc	Feed #			Vc	Feed #			Vc	Feed #	
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	-	-	-	-	-	-	-	-	-	-	-
	2		- 0.45 %C	A	190	640	-	-	-	-	-	-	-	-	-	-	-
	3			QT	250	840	-	-	-	-	-	-	-	-	-	-	-
	4		- 0.75 %C	A	270	910	-	-	-	-	-	-	-	-	-	-	-
	5			QT	300	1010	-	-	-	-	-	-	-	-	-	-	-
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	-	-	-	-	-	-	-	-	-	-	-
	7			QT	275	930	-	-	-	-	-	-	-	-	-	-	-
	8			QT	300	1010	-	-	-	-	-	-	-	-	-	-	-
	9			QT	350	1180	-	-	-	-	-	-	-	-	-	-	-
	10	Steel - High alloy, cast & tool		A	200	680	-	-	-	-	-	-	-	-	-	-	-
	11			HT	325	1100	-	-	-	-	-	-	-	-	-	-	-
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	-	-	-	-	-	-	-	-	-	-	-
	13		Martensitic	QT	240	810	-	-	-	-	-	-	-	-	-	-	-
M	14.1	Stainless Steel	Austenitic	AH	180	610	-	-	-	-	-	-	-	-	-	-	-
	14.2		Duplex		230	780	-	-	-	-	-	-	-	-	-	-	-
	14.3		Precipitation Hardening		300	780	-	-	-	-	-	-	-	-	-	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	-	-	-	-	-	-	-	-	-	-	-
	16		Pearlitic		260	880	-	-	-	-	-	-	-	-	-	-	-
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	-	-	-	-	-	-	-	-	-	-	-
	18		Pearlitic		250	840	-	-	-	-	-	-	-	-	-	-	-
	19	Cast Iron - Malleable	Ferritic		130	460	-	-	-	-	-	-	-	-	-	-	-
	20		Pearlitic		230	780	-	-	-	-	-	-	-	-	-	-	-
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	400-500	**16**	**18**	**17**	400-500	**16**	**18**	**17**	**200**	**15**	**18**
	22		Heat Treatable	AH	100	360	400-530	**16**	**18**	**17**	400-530	**16**	**18**	**17**	**200**	**15**	**18**
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	**200**	**15**	**18**
	24		Heat Treatable	AH	90	320	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	**200**	**15**	**18**
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	**200**	**15**	**18**
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	**500**	**15**	**18**
	27		Brass (CuZn, CuSnZn)		90	320	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	**500**	**15**	**18**
	28		Bronze (CuSn)		100	360	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	**500**	**15**	**18**
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					490-600	**18**	**20**	**19**	490-600	**18**	**20**	**19**	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	-	-	-	-	-	-	-	-
	32			AH	280	950	-	-	-	-	-	-	-	-	-	-	-
	33		Ni / Co based	A	250	840	-	-	-	-	-	-	-	-	-	-	-
	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-	-
	35			C	320	1080	-	-	-	-	-	-	-	-	-	-	-
	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	-	-	-	-	-
	37.1		Alpha alloys		860 MPa		-	-	-	-	-	-	-	-	-	-	-
	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	-	-	-	-	-	-	-
	37.3			AH	1170 MPa		-	-	-	-	-	-	-	-	-	-	-
	37.4		Beta alloys	A	830 MPa		-	-	-	-	-	-	-	-	-	-	-
	37.5			AH	1400 MPa		-	-	-	-	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	-	-	-	-	-
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	-	-	-	-	-	-
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

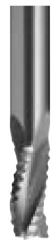
Bold = Optimal | Regular = Effective

Feed Table (f_z) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

												HARMONY 																				
E674						E675						E446				E662			E663				E665				E667					
VHM-ULTRA						VHM-ULTRA						VHM				VHM-ULTRA			VHM-ULTRA				VHM-ULTRA				VHM-ULTRA					
HCR						*HCR*						*Brt*				*CrN*			*HRC*				*HRC*				*HRC*					
Al						Al						Al				Al - IK			Al				Al				Al					
	●						●						●							●				●				●			*Slotting*	
																					●				●				●		*Finishing*	
					●						●			●																	*Universal*	
																					●				●				●		*Tro/Dyn*	
			●						●						●							●				●				●	*Roughing*	
																															Ramping	
																	●	●													*Profiling*	
	1.0		1.0		1.0		1.0		1.0		1.0		1.25	2.0	2.0		1.0	1.5		0.5	4.0	2.0		0.5	4.0	2.0		0.5	4.0	2.0	↑↓ ap	
	1.0		0.6		0.3		1.0		0.6		0.3		1.0	0.4	0.4		1.0	1.0		1.0	0.25	0.4		1.0	0.25	0.4		1.0	0.25	0.4	←→ ae	
Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	F#	Vc	Feed#			Vc	Feed#		Vc	Feed#			Vc	Feed#			Vc	Feed#			VDI 3323	ISO
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500	**11**	**500**	**18**	**500**	**20**	**350**	**11**	**350**	**18**	**350**	**20**	**220**	**14**	**17**	**19**		**15**	**16**	400-530	**16**	**18**	**17**	400-530	**16**	**18**	**17**	400-530	**16**	**18**	**17**	22	
500	**11**	**500**	**18**	**500**	**20**	**350**	**11**	**350**	**18**	**350**	**20**	**220**	**14**	**17**	**19**		**14**	**15**	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	23	
500	**11**	**500**	**18**	**500**	**20**	**350**	**11**	**350**	**18**	**350**	**20**	**220**	**14**	**17**	**19**		**14**	**15**	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	24	
500	**11**	**500**	**18**	**500**	**20**	**350**	**11**	**350**	**18**	**350**	**20**	220	14	17	19		**14**	**15**	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	230-360	**15**	**17**	**16**	25	
500	**11**	**500**	**18**	**500**	**20**	**350**	**11**	**350**	**18**	**350**	**20**	160	14	17	19		**14**	**15**	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	26	
500	**11**	**500**	**18**	**500**	**20**	**350**	**11**	**350**	**18**	**350**	**20**	-	-	-	-		**14**	**15**	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	27	
500	**11**	**500**	**18**	**500**	**20**	**350**	**11**	**350**	**18**	**350**	**20**	160	14	17	19		**14**	**15**	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	100-210	**14**	**16**	**15**	28	
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METRIC ENDMILLS (mm size)

Ø = nominal tool diameter (mm)
n = Spindle speed (RPM)
V_c = Cutting speed (m/min)
f_z = Feed rate per tooth (mm/tooth)
V_f = Feed rate (mm/min)
z = No. cutting edges
Q = Metal removal rate (cm^3/min)
a_p = Cutting depth (mm)
a_e = Cutting width (mm)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad V_f = f_z \times z \times n$$

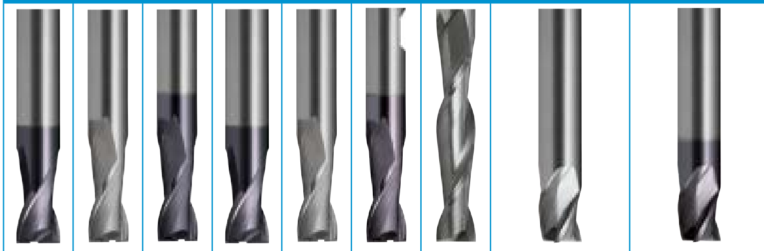
$$Q = \frac{a_p \times a_e \times V_f}{1000}$$

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

TECLINE



	E502	E600	E603	E304	E307	E507	E309 / E608	E509	E511
Catalogue Code	E502	E600	E603	E304	E307	E507	E309 E608	E509	E511
Material	VHM	VHM	VHM	VHM	VHM	VHM	VHM	VHM	VHM
Surface Finish	TiAlN	Brt	TiAlN	TiAlN	Brt	TiAlN	Brt	Brt	TiAlN
Sutton Designation	N	N	N	N	N	N	N	N	N
Type of Cut: *Slotting*	●	●	●	●	●	●	●	● (0.5 / 1.0)	● (0.5 / 1.0)
Finishing								● (1.5 / 0.2)	● (1.5 / 0.2)
Universal								● (1.5 / 0.2)	● (1.5 / 0.2)
Trochoidal/Dynamic									
Roughing									
Ramping									
Profiling									
ap × Ø	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.5 / 1.5 / 1.5	0.5 / 1.5 / 1.5
ae × Ø	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0 / 0.2 / 0.2	1.0 / 0.2 / 0.2

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	E502 Vc	E502 F#	E600 Vc	E600 F#	E603 Vc	E603 F#	E304 Vc	E304 F#	E307 Vc	E307 F#	E507 Vc	E507 F#	E309/E608 Vc	E309/E608 F#	E509 Vc	E509 Feed#			E511 Vc	E511 Feed#		
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	**125**	**7**	**100**	**7**	**144**	**8**	**125**	**7**	**100**	**7**	**125**	**7**	**70**	**4**	**90**	**7**	**7**	**13**	**125**	**7**	**7**	**13**
	2		- 0.45 %C	A	190	640	**125**	**7**	**100**	**7**	**144**	**8**	**125**	**7**	**100**	**7**	**125**	**7**	**70**	**4**	**90**	**7**	**7**	**13**	**125**	**7**	**7**	**13**
	3			QT	250	840	**70**	**7**	**56**	**7**	**80**	**8**	**70**	**7**	**56**	**7**	**70**	**7**	**45**	**4**	**50**	**7**	**7**	**13**	**70**	**7**	**7**	**13**
	4		- 0.75 %C	A	270	910	**70**	**7**	**56**	**7**	**80**	**8**	**70**	**7**	**56**	**7**	**70**	**7**	**45**	**4**	**50**	**7**	**7**	**13**	**70**	**7**	**7**	**13**
	5			QT	300	1010	70	7	-	-	80	8	70	7	-	-	70	7	-	-	50	7	7	13	70	7	7	13
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**125**	**7**	100	7	**144**	**8**	**125**	**7**	100	7	**125**	**7**	70	4	**90**	**7**	**7**	**13**	**125**	**7**	**7**	**13**
	7			QT	275	930	**70**	**7**	56	7	**80**	**8**	**70**	**7**	56	7	**70**	**7**	45	4	**50**	**7**	**7**	**13**	**70**	**7**	**7**	**13**
	8			QT	300	1010	70	7	-	-	80	8	70	7	-	-	70	7	-	-	50	7	7	13	70	7	7	13
	9			QT	350	1180	-	-	-	-	64	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	Steel - High alloy, cast & tool		A	200	680	70	7	56	7	**80**	**8**	70	7	56	7	70	7	45	4	50	7	7	13	70	7	7	13
	11			HT	325	1100	-	-	-	-	64	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45	7	7	13	65	7	7	13
	13		Martensitic	QT	240	810	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	7	7	13	55	7	7	13
M	14.1	Stainless Steel	Austenitic	AH	180	610	65	7	52	7	72	8	65	7	52	7	65	7	-	-	45	7	7	13	65	7	7	13
	14.2		Duplex		230	780	65	7	52	7	-	-	65	7	52	7	65	7	-	-	45	7	7	13	65	7	7	13
	14.3		Precipitation Hardening		300	780	55	7	-	-	-	-	55	7	-	-	55	7	-	-	45	7	7	13	55	7	7	13
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	**100**	**7**	80	7	112	8	**100**	**7**	80	7	**100**	**7**	55	4	**70**	**7**	**7**	**13**	**100**	**7**	**7**	**13**
	16		Pearlitic		260	880	100	7	80	7	112	8	100	7	80	7	100	7	55	4	70	7	7	13	100	7	7	13
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	**100**	**7**	80	7	112	8	**100**	**7**	80	7	**100**	**7**	55	4	**70**	**7**	**7**	**13**	**100**	**7**	**7**	**13**
	18		Pearlitic		250	840	100	7	80	7	112	8	100	7	80	7	100	7	55	4	70	7	7	13	100	7	7	13
	19	Cast Iron - Malleable	Ferritic		130	460	70	7	56	7	80	8	70	7	56	7	70	7	45	4	50	7	7	13	70	7	7	13
	20		Pearlitic		230	780	70	7	56	7	80	8	70	7	56	7	70	7	45	4	50	7	7	13	70	7	7	13
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	-	-	-	-	-	-	-	-	-	-	-	-	120	5	-	-	-	-	-	-	-	-
	22		Heat Treatable	AH	100	360	-	-	-	-	-	-	-	-	-	-	-	-	120	5	-	-	-	-	-	-	-	-
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	-	-	-	-	-	-	-	-	-	-	-	-	120	5	-	-	-	-	-	-	-	-
	24		Heat Treatable	AH	90	320	-	-	-	-	-	-	-	-	-	-	-	-	120	5	-	-	-	-	-	-	-	-
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	-	-	-	-	-	-	-	-	-	-	-	-	120	5	-	-	-	-	-	-	-	-
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	-	-	-	-	-	-	-	-	-	-	-	-	100	5	-	-	-	-	-	-	-	-
	27		Brass (CuZn, CuSnZn)		90	320	-	-	-	-	-	-	-	-	-	-	-	-	100	5	-	-	-	-	-	-	-	-
	28		Bronze (CuSn)		100	360	-	-	-	-	-	-	-	-	-	-	-	-	100	5	-	-	-	-	-	-	-	-
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	35	7	-	-	-	-	35	7	-	-	35	7	-	-	25	7	7	13	35	7	7	13
	32			AH	280	950	35	7	-	-	-	-	35	7	-	-	35	7	-	-	25	7	7	13	35	7	7	13
	33		Ni / Co based	A	250	840	35	7	-	-	-	-	35	7	-	-	35	7	-	-	25	7	7	13	35	7	7	13
	34			AH	350	1180	35	7	-	-	-	-	35	7	-	-	35	7	-	-	25	7	7	13	35	7	7	13
	35			C	320	1080	35	7	-	-	-	-	35	7	-	-	35	7	-	-	25	7	7	13	35	7	7	13
	36	Titanium & Ti alloys	CP Titanium		400 MPa		50	7	-	-	-	-	50	7	-	-	50	7	-	-	35	7	7	13	50	7	7	13
	37.1		Alpha alloys		860 MPa		50	7	-	-	-	-	50	7	-	-	50	7	-	-	35	7	7	13	50	7	7	13
	37.2		Alpha / Beta alloys	A	960 MPa		50	7	-	-	-	-	50	7	-	-	50	7	-	-	35	7	7	13	50	7	7	13
	37.3			AH	1170 MPa		50	7	-	-	-	-	50	7	-	-	50	7	-	-	35	7	7	13	50	7	7	13
	37.4		Beta alloys	A	830 MPa		50	7	-	-	-	-	50	7	-	-	50	7	-	-	35	7	7	13	50	7	7	13
	37.5			AH	1400 MPa		50	7	-	-	-	-	50	7	-	-	50	7	-	-	-	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Feed Table (f_z) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

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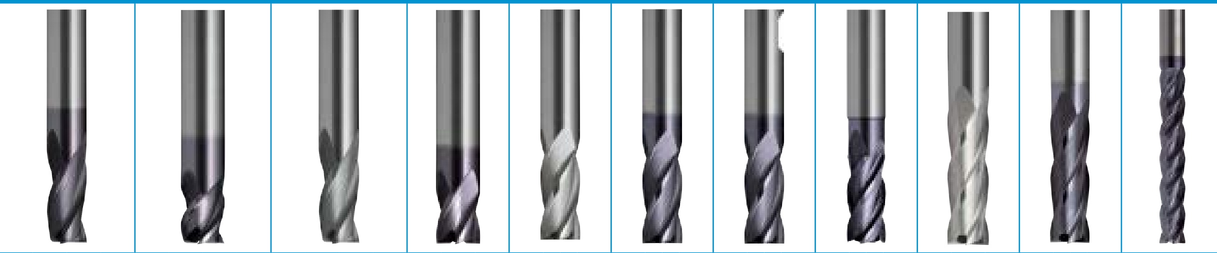

E515 E611				E519				E610				E527			E333 E601			E604 E336			E531 E532			E635 E636			E337			E340 E344			E637 E638				
VHM				VHM				VHM				VHM			VHM						VHM			VHM-ULTRA			VHM			VHM-ULTRA			VHM-ULTRA				
TiAlN				TiAlN				Brt				TiAlN			Brt			TiAlN			TiAlN			TiAlN			Brt			TiAlN			TiAlN				
N				W				N				N			N						N			N			N			N			N				
	●				●				●																											Slotting	
		●				●				●			●			●			●			●			●			●			●			●		Finishing	
			●				●				●			●			●			●			●			●			●			●			●	Universal	
																									●						●			●		Tro/Dyn	
																																				Roughing	
																																				Ramping	
																																				Profiling	
	0.5	1.5	1.5		0.25	1.0	1.0		0.5	1.5	1.5		1.0	1.0		1.5	1.5		1.5	1.5		1.5	1.5		1.5	1.5		2.5	2.5		3.0	3.0		4.0	4.0	↑↓ ap	
	1.0	0.1	0.2		1.0	0.1	0.2		1.0	0.1	0.2		0.1	0.5		0.1	0.5		0.1	0.2		0.1	0.5		0.1	0.2		0.05	0.1		0.05	0.1		0.05	0.1	←→ ae	
Vc	Feed#			Vc	Feed#			Vc	Feed#			Vc	Feed#		Vc	Feed#		Vc	Feed#		Vc	Feed#		Vc	Feed#		Vc	Feed#		Vc	Feed#		Vc	Feed#		VDI 3323	ISO
180	8	14	8	200	11	20	16	100	8	14	8	100	10	7	100	7	10	144	11	8	180	11	8	210	11	8	100	7	6	100	7	6	100	7	6	1	
180	8	14	8	200	11	20	16	100	8	14	8	100	10	7	100	7	10	144	11	8	180	11	8	210	11	8	100	7	6	100	7	6	100	7	6	2	
100	8	14	8	120	11	20	16	60	8	14	8	56	10	7	56	7	10	80	11	8	100	11	8	175	11	8	90	7	6	90	7	6	90	7	6	3	
100	8	14	8	120	11	20	16	60	8	14	8	56	10	7	56	7	10	80	11	8	100	11	8	175	11	8	90	7	6	90	7	6	90	7	6	4	
100	8	14	8	120	11	20	16	60	8	14	8	-	-	-	-	-	-	80	11	8	100	11	8	175	11	8	90	7	6	90	7	6	90	7	6	5	
180	8	14	8	200	11	20	16	80	8	14	8	100	10	7	100	7	10	144	11	8	180	11	8	210	11	8	100	7	6	100	7	6	100	7	6	6	
100	8	14	8	120	11	20	16	100	8	14	8	56	10	7	56	7	10	80	11	8	100	11	8	175	11	8	90	7	6	90	7	6	90	7	6	7	P
100	8	14	8	120	11	20	16	100	8	14	8	-	-	-	-	-	-	80	11	8	100	11	8	175	11	8	90	7	6	90	7	6	90	7	6	8	
80	8	14	8	-	-	-	-	60	8	14	8	-	-	-	-	-	-	64	11	8	80	11	8	120	11	8	60	7	6	60	7	6	60	7	6	9	
100	8	14	8	-	-	-	-	60	8	14	8	56	10	7	56	7	10	80	11	8	100	11	8	175	11	8	90	6	5	90	6	5	90	6	5	10	
80	8	14	8	-	-	-	-	60	8	14	8	-	-	-	-	-	-	64	11	8	80	11	8	120	11	8	60	6	5	60	6	5	60	6	5	11	
90	8	14	8	-	-	-	-	70	8	14	8	-	-	-	-	-	-	-	-	-	90	11	8	90	11	8	70	6	5	70	6	5	70	6	5	12	
80	8	14	8	-	-	-	-	60	8	14	8	-	-	-	-	-	-	-	-	-	80	11	8	80	11	8	60	6	5	60	6	5	60	6	5	13	
90	8	14	8	-	-	-	-	50	8	14	8	52	10	7	52	7	10	72	11	8	90	11	8	-	11	8	50	7	6	50	7	6	50	7	6	14.1	
90	8	14	8	-	-	-	-	50	8	14	8	52	10	7	52	7	10	72	11	8	90	11	8	-	11	8	50	7	6	50	7	6	50	7	6	14.2	M
80	8	14	8	-	-	-	-	60	8	14	8	-	-	-	-	-	-	-	-	-	80	11	8	-	-	-	40	7	6	40	7	6	40	7	6	14.3	
140	8	14	8	-	-	-	-	50	8	14	8	80	10	7	80	7	10	112	11	8	140	11	8	150	11	8	90	7	6	90	7	6	90	7	6	15	
140	8	14	8	-	-	-	-	50	8	14	8	80	10	7	80	7	10	112	11	8	140	11	8	150	11	8	90	7	6	90	7	6	90	7	6	16	
140	8	14	8	-	-	-	-	50	8	14	8	80	10	7	80	7	10	112	11	8	140	11	8	150	11	8	90	7	6	90	7	6	90	7	6	17	K
140	8	14	8	-	-	-	-	50	8	14	8	80	10	7	80	7	10	112	11	8	140	11	8	150	11	8	90	7	6	90	7	6	90	7	6	18	
100	8	14	8	-	-	-	-	40	8	14	8	56	10	7	56	7	10	80	11	8	100	11	8	110	11	8	90	7	6	90	7	6	90	7	6	19	
100	8	14	8	-	-	-	-	40	8	14	8	56	10	7	56	7	10	80	11	8	100	11	8	110	11	8	90	7	6	90	7	6	90	7	6	20	
-	-	-	-	260	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	11	8	150	7	6	150	7	6	150	7	6	21	
-	-	-	-	260	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	11	8	150	7	6	150	7	6	150	7	6	22	
-	-	-	-	260	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	11	8	150	7	6	150	7	6	150	7	6	23	
-	-	-	-	260	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	11	8	150	7	6	150	7	6	150	7	6	24	
-	-	-	-	260	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	11	8	150	7	6	150	7	6	150	7	6	25	N
-	-	-	-	190	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120	7	6	120	7	6	120	7	6	26	
-	-	-	-	190	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	11	8	120	7	6	120	7	6	120	7	6	27	
-	-	-	-	190	8	18	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120	7	6	120	7	6	120	7	6	28	
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.2	
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METRIC ENDMILLS (mm size)

- **Ø** = nominal tool diameter (mm)
- **n** = Spindel speed (RPM)
- **V_c** = Cutting speed (m/min)
- **f_z** = Feed rate per tooth (mm/tooth)
- **V_f** = Feed rate (mm/min)
- **z** = No. cutting edges
- **Q** = Metal removal rate (cm^3/min)
- **a_p** = Cutting depth (mm)
- **a_e** = Cutting width (mm)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad V_f = f_z \times z \times n$$

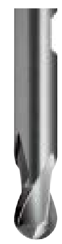
$$Q = \frac{a_p \times a_e \times V_f}{1000}$$

Application Guide Speeds & Feeds - Carbide Endmills

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

							TECLINE												
																			
						Catalogue Code	E609			E547		E450				E453		E454	
						Material	VHM			VHM		VHM				VHM		VHM	
						Surface Finish	*Brt*			*TiAlN*		*TiAlN*				*Brt*		*TiAlN*	
						Sutton Designation	N			N		WN				N		N	
						Type of Cut: *Slotting*							●						
						Finishing		●											
						Universal			●					●					
						Trochoidal/Dynamic													
						Roughing					●				●				
						Ramping													
						Profiling											●		●
						↑↓ ap × Ø		5.0	5.0		1.5		0.75	1.0	1.0		0.025		0.025
						←→ ae × Ø		0.05	0.1		0.5		1.0	0.4	0.4		0.05		0.05
ISO	**VDI^ 3323**	**Material**		**Condition**	**HB**	**N/mm²**	**Vc**	**Feed #**		**Vc**	**Feed #**	**Vc**	**Feed #**			**Vc**	**Feed #**	**Vc**	**Feed #**
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	**70**	**6**	**5**	**180**	**12**	**180**	**3**	**5**	**9**	**80-140**	**19**	**110-200**	**20**
	2		- 0.45 %C	A	190	640	**70**	**6**	**5**	**180**	**12**	**180**	**3**	**5**	**9**	**80-140**	**19**	**110-200**	**20**
	3			QT	250	840	60	6	5	100	12	**100**	**3**	**5**	**9**	**45-100**	**19**	**60-145**	**20**
	4		- 0.75 %C	A	270	910	60	6	5	100	12	**100**	**3**	**5**	**9**	**45-100**	**19**	**60-145**	**20**
	5			QT	300	1010	60	6	5	100	10	100	3	5	9	-	-	60-145	20
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**70**	**6**	**5**	180	12	**180**	**3**	**5**	**9**	**80-140**	**19**	**110-200**	**20**
	7			QT	275	930	60	6	5	100	12	**100**	**3**	**5**	**9**	45-100	19	**60-145**	**20**
	8			QT	300	1010	60	6	5	100	10	100	3	5	9	-	-	60-145	20
	9			QT	350	1180	40	6	5	-	-	-	-	-	-	-	-	45-95	20
	10	Steel - High alloy, cast & tool		A	200	680	60	6	5	100	10	100	3	5	9	45-100	19	**60-145**	**20**
	11			HT	325	1100	40	6	5	-	-	-	-	-	-	-	-	45-95	20
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	45	6	5	-	-	-	-	-	-	-	-	-	-
	13		Martensitic	QT	240	810	40	6	5	-	-	-	-	-	-	-	-	-	-
M	14.1	Stainless Steel	Austenitic	AH	180	610	-	-	-	-	-	-	-	-	-	40-60	19	55-90	20
	14.2		Duplex		230	780	-	-	-	-	-	-	-	-	-	40-60	19	55-90	20
	14.3		Precipitation Hardening		300	780	-	-	-	-	-	-	-	-	-	-	-	-	-
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	60	6	5	140	10	**140**	**3**	**5**	**9**	70-100	19	95-145	20
	16		Pearlitic		260	880	60	6	5	140	10	**140**	**3**	**5**	**9**	70-100	19	95-145	20
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	60	6	5	140	10	**140**	**3**	**5**	**9**	70-100	19	95-145	20
	18		Pearlitic		250	840	60	6	5	140	10	**140**	**3**	**5**	**9**	70-100	19	95-145	20
	19	Cast Iron - Malleable	Ferritic		130	460	40	6	5	100	10	**100**	**3**	**5**	**9**	55-80	19	80-110	20
	20		Pearlitic		230	780	40	6	5	100	10	**100**	**3**	**5**	**9**	55-80	19	80-110	20
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	100	6	5	**300**	**16**	-	-	-	-	-	-	-	-
	22		Heat Treatable	AH	100	360	100	6	5	**300**	**16**	-	-	-	-	-	-	-	-
	23	Aluminum & Magnesium - cast alloy <12% Si	Non Heat Treatable		75	270	100	6	5	**300**	16	-	-	-	-	-	-	-	-
	24		Heat Treatable	AH	90	320	100	6	5	**300**	16	-	-	-	-	-	-	-	-
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	100	6	5	**300**	16	-	-	-	-	-	-	-	-
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	80	6	5	-	-	-	-	-	-	-	-	-	-
	27		Brass (CuZn, CuSnZn)		90	320	80	6	5	-	-	-	-	-	-	-	-	-	-
	28		Bronze (CuSn)		100	360	80	6	5	-	-	-	-	-	-	-	-	-	-
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	-	-	**50**	**3**	**5**	**9**	-	-	-	-
	32			AH	280	950	-	-	-	-	-	**50**	**3**	**5**	**9**	-	-	-	-
	33		Ni / Co based	A	250	840	-	-	-	-	-	**50**	**3**	**5**	**9**	-	-	-	-
	34			AH	350	1180	-	-	-	-	-	**50**	**3**	**5**	**9**	-	-	-	-
	35			C	320	1080	-	-	-	-	-	**50**	**3**	**5**	**9**	-	-	-	-
	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	**70**	**3**	**5**	**9**	-	-	-	-
	37.1		Alpha alloys		860 MPa		-	-	-	-	-	**70**	**3**	**5**	**9**	-	-	-	-
	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	-	**70**	**3**	**5**	**9**	-	-	-	-
	37.3			AH	1170 MPa		-	-	-	-	-	**70**	**3**	**5**	**9**	-	-	-	-
	37.4		Beta alloys	A	830 MPa		-	-	-	-	-	**70**	**3**	**5**	**9**	-	-	-	-
	37.5			AH	1400 MPa		-	-	-	-	-	**70**	**3**	**5**	**9**	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		25	6	5	-	-	-	-	-	-	-	-	-	-
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	-	-	-	-	-	**100**	**3**	**5**	**9**	-	-	-	-
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Feed Table (f_z) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

TECLINE																									
E602		E605		E551		E553		E555		E315		E606		E607		E557		E320		E440		E442			
VHM		VHM		VHM				VHM-ULTRA		VHM		VHM		VHM		VHM-ULTRA		VHM		VHM-ULTRA					
Brt		*TiAIN*		*Brt*		*TiAIN*		*AlCrN*		*Brt*		*Brt*		*TiAIN*		*AlCrN*		*Brt*		*AlCrN*					
N		N		N				N		N		N		N		N		N							
																								Slotting	
																								Finishing	
																								Universal	
																								Tro/Dyn	
																								Roughing	
																								Ramping	
	●		●		●		●		●		●		●		●		●		●		●		●	*Profiling*	
	0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025	↑↓ ap	
	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05	←→ ae	
Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	Vc	Feed#	VDI 3323	ISO
80-140	**19**	**110-200**	**20**	**100-175**	**19**	**140-250**	**20**	**140-250**	**20**	**100-175**	**19**	**100-175**	**19**	**140-250**	**16**	**140-250**	**16**	**100-175**	**19**	-	-	-	-	1	
80-140	**19**	**110-200**	**20**	**100-175**	**19**	**140-250**	**20**	**140-250**	**20**	**100-175**	**19**	**100-175**	**19**	**140-250**	**16**	**140-250**	**16**	**100-175**	**19**	-	-	-	-	2	
45-100	**19**	**60-145**	**20**	**55-125**	**19**	**75-180**	**20**	**75-180**	**20**	**55-125**	**19**	**55-125**	**19**	**75-180**	**16**	**75-180**	**16**	**55-125**	**19**	175	18	175	18	3	
45-100	**19**	**60-145**	**20**	**55-125**	**19**	**75-180**	**20**	**75-180**	**20**	**55-125**	**19**	**55-125**	**19**	**75-180**	**16**	**75-180**	**16**	**55-125**	**19**	175	18	175	18	4	
-	-	60-145	20	55-125	19	**75-180**	**20**	**75-180**	**20**	55-125	19	55-125	19	75-180	16	**75-180**	**16**	55-125	19	**175**	**18**	**175**	**18**	5	
80-140	**19**	**110-200**	**20**	**100-175**	**19**	**140-250**	**20**	**140-250**	**20**	**100-175**	**19**	**100-175**	**19**	**140-250**	**16**	**140-250**	**16**	**100-175**	**19**	-	-	-	-	6	
45-100	19	**60-145**	**20**	55-125	19	**75-180**	**20**	**75-180**	**20**	55-125	19	55-125	19	**75-180**	**16**	**75-180**	**16**	55-125	19	175	18	175	18	7	**P**
-	-	60-145	20	55-125	19	**75-180**	**20**	**75-180**	**20**	55-125	19	55-125	19	75-180	16	**75-180**	**16**	55-125	19	**175**	**18**	**175**	**18**	8	
-	-	45-95	20	40-85	19	60-120	20	60-120	20	40-85	19	40-85	19	60-120	16	60-120	16	40-85	19	**120**	**18**	**120**	**18**	9	
45-100	19	**60-145**	**20**	55-125	19	**75-180**	**20**	**75-180**	**20**	55-125	19	55-125	19	**75-180**	**16**	**75-180**	**16**	55-125	19	175	18	175	18	10	
-	-	45-95	20	40-85	19	60-120	20	60-120	20	40-85	19	40-85	19	60-120	16	60-120	16	40-85	19	**120**	**18**	**120**	**18**	11	
-	-	-	-	50-75	19	70-110	20	70-110	20	50-75	19	-	-	-	-	70-110	16	-	-	-	-	-	-	12	
-	-	-	-	40-70	19	60-100	20	60-100	20	40-70	19	-	-	-	-	60-100	16	-	-	-	-	-	-	13	
40-60	19	55-90	20	**50-75**	**19**	**70-110**	**20**	**70-110**	**20**	**50-75**	**19**	**50-75**	**19**	**70-110**	**16**	**70-110**	**16**	**50-75**	**19**	-	-	-	-	14.1	
40-60	19	55-90	20	50-75	19	**70-110**	**20**	70-110	20	50-75	19	50-75	19	70-110	16	70-110	16	50-75	19	-	-	-	-	14.2	**M**
-	-	-	-	40-70	19	60-100	20	60-100	20	40-70	19	-	-	-	-	60-100	16	-	-	-	-	-	-	14.3	
70-100	19	95-145	20	85-125	19	**120-180**	**20**	**120-180**	**20**	85-125	19	85-125	19	120-180	16	**120-180**	**16**	85-125	19	**150**	**18**	**150**	**18**	15	
70-100	19	95-145	20	85-125	19	**120-180**	**20**	**120-180**	**20**	85-125	19	85-125	19	120-180	16	**120-180**	**16**	85-125	19	**150**	**18**	**150**	**18**	16	
70-100	19	95-145	20	85-125	19	**120-180**	**20**	**120-180**	**20**	85-125	19	85-125	19	120-180	16	**120-180**	**16**	85-125	19	**150**	**18**	**150**	**18**	17	**K**
70-100	19	95-145	20	85-125	19	**120-180**	**20**	**120-180**	**20**	85-125	19	85-125	19	120-180	16	**120-180**	**16**	85-125	19	**150**	**18**	**150**	**18**	18	
55-80	19	80-110	20	70-100	19	**100-140**	**20**	**100-140**	**20**	70-100	19	70-100	19	100-140	16	**100-140**	**16**	70-100	19	**110**	**18**	**110**	**18**	19	
55-80	19	80-110	20	70-100	19	**100-140**	**20**	**100-140**	**20**	70-100	19	70-100	19	100-140	16	**100-140**	**16**	70-100	19	**110**	**18**	**110**	**18**	20	
-	-	-	-	-	-	**150-450**	**20**	150-450	20	-	-	-	-	150-450	16	150-450	16	-	-	-	-	-	-	21	
-	-	-	-	-	-	**150-450**	**20**	150-450	20	-	-	-	-	150-450	16	150-450	16	-	-	-	-	-	-	22	
-	-	-	-	-	-	**150-450**	**20**	150-450	20	-	-	-	-	150-450	16	150-450	16	-	-	-	-	-	-	23	
-	-	-	-	-	-	**150-450**	**20**	150-450	20	-	-	-	-	150-450	16	150-450	16	-	-	-	-	-	-	24	
-	-	-	-	-	-	150-450	20	150-450	20	-	-	-	-	150-450	16	150-450	16	-	-	-	-	-	-	25	**N**
-	-	-	-	-	-	**120-350**	**20**	120-350	20	-	-	-	-	120-350	16	120-350	16	-	-	-	-	-	-	26	
-	-	-	-	-	-	**120-350**	**20**	120-350	20	-	-	-	-	120-350	16	120-350	16	-	-	-	-	-	-	27	
-	-	-	-	-	-	**120-350**	**20**	120-350	20	-	-	-	-	120-350	16	120-350	16	-	-	-	-	-	-	28	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	
-	-	-	-	-	-	-	-	40-90	20	-	-	-	-	-	-	40-90	16	-	-	50	18	50	18	31	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**50**	**18**	**50**	**18**	32	
-	-	-	-	-	-	-	-	40-90	20	-	-	-	-	-	-	40-90	16	-	-	50	18	50	18	33	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**50**	**18**	**50**	**18**	34	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**50**	**18**	**50**	**18**	35	
-	-	-	-	-	-	-	-	60-200	20	-	-	-	-	-	-	60-200	16	-	-	70	18	70	18	36	**S**
-	-	-	-	-	-	-	-	60-200	20	-	-	-	-	-	-	60-200	16	-	-	70	18	70	18	37.1	
-	-	-	-	-	-	-	-	60-200	20	-	-	-	-	-	-	60-200	16	-	-	70	18	70	18	37.2	
-	-	-	-	-	-	-	-	60-200	20	-	-	-	-	-	-	60-200	16	-	-	**70**	**18**	**70**	**18**	37.3	
-	-	-	-	-	-	-	-	60-200	20	-	-	-	-	-	-	60-200	16	-	-	70	18	70	18	37.4	
-	-	-	-	-	-	-	-	60-200	20	-	-	-	-	-	-	60-200	16	-	-	**70**	**18**	**70**	**18**	37.5	
-	-	-	-	-	-	**80-120**	**20**	-	-	-	-	-	-	-	-	-	-	-	-	**120**	**18**	**120**	**18**	38.1	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**120**	**18**	**120**	**18**	38.2	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**100**	**18**	**100**	**18**	39.1	**H**
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39.2	
-	-	-	-	-	-	**70-100**	**20**	**70-100**	**20**	-	-	-	-	-	-	**70-100**	**16**	-	-	-	-	-	-	40	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**100**	**18**	**100**	**18**	41	

METRIC ENDMILLS (mm size)

- **Ø** = nominal tool diameter (mm)
- **n** = Spindle speed (RPM)
- **V_c** = Cutting speed (m/min)
- **f_z** = Feed rate per tooth (mm/tooth)
- **V_f** = Feed rate (mm/min)
- **z** = No. cutting edges
- **Q** = Metal removal rate (cm^3/min)
- **a_p** = Cutting depth (mm)
- **a_e** = Cutting width (mm)

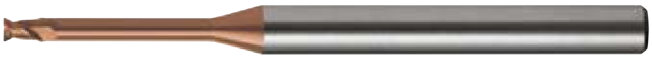
$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

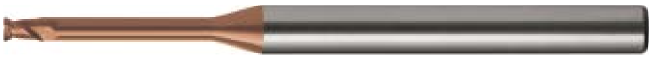
$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad V_f = f_z \times z \times n$$

$$Q = \frac{a_p \times a_e \times V_f}{1000}$$

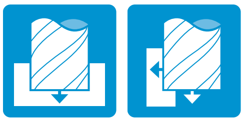
sutton

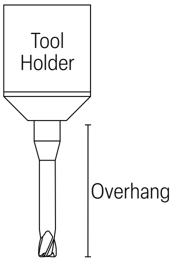




E580 Carbide, Micro, 2 Flute, Long Reach, **Sq End**

E581 Carbide, Micro, 2 Flute, **Corner Rad**





Application Notes:

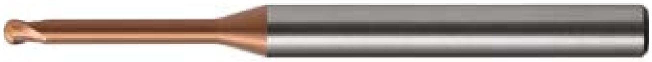
- Above conditions based on 5xØ overhang
- For 6xØ overhang, reduce ap by 10%
- For 8xØ overhang, reduce ap by 25%
- For 10xØ overhang, reduce ap by 50%
- For plunge in Z-Axis direction or ramping at 1° incline, reduce feed rate between 60% to 70%

LEGEND

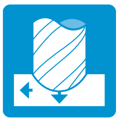
- **Ø** = nominal tool diameter (mm)
- **n** = Spindle speed (RPM^{-1})
- $\mathbf{v_c}$ = Cutting speed (m/min)
- $\mathbf{F_z}$ = Feed rate per tooth (mm/tooth)
- $\mathbf{v_f}$ = Feed rate (mm/min)
- $\mathbf{a_p}$ = Cutting depth (mm)
- $\mathbf{a_e}$ = Cutting width (mm)

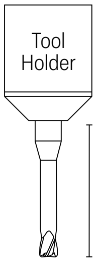
		ISO	P					M					S					H				
		VDI	5, 8, 9, 10, 11					14.2, 14.3					34, 35, 37.3, 37.5					38.1				
		Material	Steel - Low alloy & cast Steel - High alloy, cast & tool					Stainless Steel					High temp. alloys Titanium & Ti alloys					Hardened Steel				
Ø	l_3	ae x Ø	ap	Vc	Fz	n	Vf	ap	Vc	Fz	n	Vf	ap	Vc	Fz	n	Vf	ap	Vc	Fz	n	Vf
0.2	0.5	1.0	0.028	25	0.003	40000	240	0.028	25	0.003	40000	240	0.028	25	0.003	40000	240	0.040	25	0.003	40000	240
0.2	1	1.0	0.011	23	0.003	37400	210	0.011	23	0.003	37400	210	0.011	23	0.003	37400	210	0.016	23	0.003	37400	210
0.2	1.5	1.0	0.008	22	0.003	34800	182	0.008	22	0.003	34800	182	0.008	22	0.003	34800	182	0.011	22	0.003	34800	182
0.4	2	1.0	0.022	47	0.004	37400	280	0.022	47	0.004	37400	280	0.022	47	0.004	37400	280	0.032	47	0.004	37400	280
0.4	4	1.0	0.011	37	0.003	29600	175	0.011	37	0.003	29600	175	0.011	37	0.003	29600	175	0.016	37	0.003	29600	175
0.5	2	1.0	0.035	62	0.007	39099	513	0.035	62	0.007	39099	513	0.035	62	0.007	39099	513	0.050	63	0.004	40000	320
0.5	4	1.0	0.018	50	0.005	31474	332	0.018	50	0.005	31474	332	0.018	50	0.005	31474	332	0.025	51	0.003	32200	207
0.5	6	1.0	0.012	42	0.004	26391	234	0.012	42	0.004	26391	234	0.012	42	0.004	26391	234	0.017	43	0.003	27000	146
0.6	4	1.0	0.028	59	0.007	31246	423	0.028	59	0.007	31246	423	0.028	59	0.007	31246	423	0.040	63	0.007	33554	443
0.6	6	1.0	0.017	50	0.006	26577	306	0.017	50	0.006	26577	306	0.017	50	0.006	26577	306	0.024	54	0.006	28540	321
0.8	4	1.0	0.045	65	0.007	26042	410	0.045	65	0.007	26042	410	0.045	65	0.007	26042	410	0.064	75	0.007	29762	466
0.8	6	1.0	0.032	61	0.007	24231	355	0.032	61	0.007	24231	355	0.032	61	0.007	24231	355	0.046	70	0.007	27693	404
0.8	8	1.0	0.022	52	0.006	20610	257	0.022	52	0.006	20610	257	0.022	52	0.006	20610	257	0.032	59	0.006	23555	292
1.0	6	1.0	0.047	61	0.008	19385	337	0.047	61	0.008	19385	337	0.047	61	0.008	19385	337	0.067	70	0.008	22155	383
1.0	8	1.0	0.035	56	0.008	17937	289	0.035	56	0.008	17937	289	0.035	56	0.008	17937	289	0.050	64	0.008	20499	328
1.0	10	1.0	0.028	52	0.007	16489	244	0.028	52	0.007	16489	244	0.028	52	0.007	16489	244	0.040	59	0.007	18844	277
1.0	12	1.0	0.023	47	0.006	15040	203	0.023	47	0.006	15040	203	0.023	47	0.006	15040	203	0.033	54	0.006	17189	231
1.0	16	1.0	0.018	38	0.005	12144	132	0.018	38	0.005	12144	132	0.018	38	0.005	12144	132	0.025	44	0.005	13878	150
1.2	6	1.0	0.067	65	0.010	17361	357	0.067	65	0.010	17361	357	0.067	65	0.010	17361	357	0.096	75	0.010	19841	406
1.2	10	1.0	0.042	56	0.008	14947	265	0.042	56	0.008	14947	265	0.042	56	0.008	14947	265	0.060	64	0.008	17083	301
1.2	12	1.0	0.034	52	0.008	13740	224	0.034	52	0.008	13740	224	0.034	52	0.008	13740	224	0.048	59	0.008	15703	254
1.5	6	1.0	0.105	70	0.013	14855	391	0.105	70	0.013	14855	391	0.105	70	0.013	14855	391	0.150	80	0.013	16977	444
1.5	8	1.0	0.084	65	0.012	13889	341	0.084	65	0.012	13889	341	0.084	65	0.012	13889	341	0.120	75	0.012	15873	388
1.5	12	1.0	0.053	56	0.010	11958	253	0.053	56	0.010	11958	253	0.053	56	0.010	11958	253	0.075	64	0.010	13666	287
1.5	16	1.0	0.042	52	0.009	10992	214	0.042	52	0.009	10992	214	0.042	52	0.009	10992	214	0.060	59	0.009	12563	243
1.5	20	1.0	0.032	47	0.008	10027	178	0.032	47	0.008	10027	178	0.032	47	0.008	10027	178	0.046	54	0.008	11459	202
2.0	6	1.0	0.187	70	0.015	11141	350	0.187	70	0.015	11141	350	0.187	70	0.015	11141	350	0.267	80	0.015	12733	398
2.0	8	1.0	0.140	70	0.015	11141	350	0.140	70	0.015	11141	350	0.140	70	0.015	11141	350	0.200	80	0.015	12733	398
2.0	10	1.0	0.112	65	0.014	10416	306	0.112	65	0.014	10416	306	0.112	65	0.014	10416	306	0.160	75	0.014	11905	348
2.0	12	1.0	0.093	61	0.013	9692	265	0.093	61	0.013	9692	265	0.093	61	0.013	9692	265	0.133	70	0.013	11077	301
2.0	16	1.0	0.070	56	0.012	8968	227	0.070	56	0.012	8968	227	0.070	56	0.012	8968	227	0.100	64	0.012	10250	258
2.0	20	1.0	0.056	52	0.011	8244	192	0.056	52	0.011	8244	192	0.056	52	0.011	8244	192	0.080	59	0.011	9422	218
2.0	25	1.0	0.047	47	0.010	7520	159	0.047	47	0.010	7520	159	0.047	47	0.010	7520	159	0.067	54	0.010	8594	181
2.5	8	1.0	0.233	70	0.018	8913	336	0.233	70	0.018	8913	336	0.233	70	0.018	8913	336	0.333	80	0.018	10186	382
2.5	12	1.0	0.175	70	0.018	8913	336	0.175	70	0.018	8913	336	0.175	70	0.018	8913	336	0.250	80	0.018	10186	382
3.0	16	1.0	0.168	65	0.020	6944	285	0.168	65	0.020	6944	285	0.168	65	0.020	6944	285	0.240	75	0.020	7936	325
3.0	20	1.0	0.140	61	0.018	6461	247	0.140	61	0.018	6461	247	0.140	61	0.018	6461	247	0.200	70	0.018	7385	281
3.0	25	1.0	0.105	56	0.017	5979	212	0.105	56	0.017	5979	212	0.105	56	0.017	5979	212	0.150	64	0.017	6833	241

sutton



E582 Carbide, Micro, 2 Flute, Long Reach, **Ballnose**





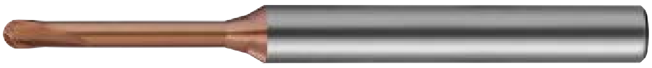
Application Notes:

- Above conditions based on 5xØ overhang
- For 6xØ overhang, reduce ap by 10%
- For 8xØ overhang, reduce ap by 25%
- For 10xØ overhang, reduce ap by 50%
- For plunge in Z-Axis direction or ramping at 1° incline, reduce feed rate between 60% to 70%

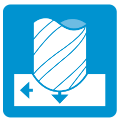
LEGEND

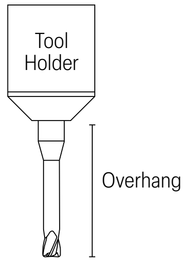
- **Ø** = nominal tool diameter (mm)
- **n** = Spindle speed (RPM⁻¹)
- v_c = Cutting speed (m/min)
- F_z = Feed rate per tooth (mm/tooth)
- v_f = Feed rate (mm/min)
- a_p = Cutting depth (mm)
- a_e = Cutting width (mm)

			ISO	P				M				S				H			
			VDI	5, 8, 9, 10, 11				14.2, 14.3				34, 35, 37.3, 37.5				38.1			
			Material	Steel - Low alloy & cast Steel - High alloy, cast & tool				Stainless Steel				High temp. alloys Titanium & Ti alloys				Hardened Steel			
Ø	l_3	ae x Ø	ap x Ø	Vc	Fz	n	Vf	Vc	Fz	n	Vf	Vc	Fz	n	Vf	Vc	Fz	n	Vf
0.2	0.5	0.05	0.20	25	0.003	40000	240	25	0.003	40000	240	25	0.003	40000	240	25	0.003	40000	240
0.2	1	0.05	0.20	25	0.003	40000	240	25	0.003	40000	240	25	0.003	40000	240	25	0.003	40000	240
0.2	1.5	0.05	0.15	21	0.002	34000	144	21	0.002	34000	144	21	0.002	34000	144	21	0.002	34000	144
0.4	2	0.05	0.20	50	0.004	40000	320	50	0.004	40000	320	50	0.004	40000	320	50	0.004	40000	320
0.4	4	0.02	0.10	35	0.003	28000	160	35	0.003	28000	160	35	0.003	28000	160	35	0.003	28000	160
0.5	2	0.05	0.20	62	0.006	39099	433	62	0.006	39099	433	62	0.006	39099	433	63	0.004	40000	320
0.5	6	0.02	0.10	43	0.004	27369	217	43	0.004	27369	217	43	0.004	27369	217	44	0.003	28000	160
0.6	2	0.05	0.20	68	0.006	35916	448	68	0.006	35916	448	68	0.006	35916	448	73	0.006	38568	469
0.6	4	0.05	0.15	57	0.004	30528	269	57	0.004	30528	269	57	0.004	30528	269	62	0.004	32783	281
0.6	6	0.02	0.10	47	0.004	25141	224	47	0.004	25141	224	47	0.004	25141	224	51	0.004	26998	234
0.6	8	0.02	0.10	47	0.004	25141	224	47	0.004	25141	224	47	0.004	25141	224	51	0.004	26998	234
0.8	4	0.05	0.20	70	0.007	27852	406	70	0.007	27852	406	70	0.007	27852	406	80	0.007	31831	462
0.8	6	0.05	0.15	60	0.005	23674	244	60	0.005	23674	244	60	0.005	23674	244	68	0.005	27056	277
0.8	8	0.02	0.10	49	0.005	19496	203	49	0.005	19496	203	49	0.005	19496	203	56	0.005	22282	231
1.0	4	0.05	0.20	70	0.009	22282	395	70	0.009	22282	395	70	0.009	22282	395	80	0.009	25465	449
1.0	6	0.05	0.15	60	0.006	18940	237	60	0.006	18940	237	60	0.006	18940	237	68	0.006	21645	269
1.0	8	0.05	0.15	60	0.006	18940	237	60	0.006	18940	237	60	0.006	18940	237	68	0.006	21645	269
1.0	10	0.02	0.10	49	0.006	15597	197	49	0.006	15597	197	49	0.006	15597	197	56	0.006	17826	224
1.0	12	0.02	0.10	49	0.006	15597	197	49	0.006	15597	197	49	0.006	15597	197	56	0.006	17826	224
1.0	14	0.02	0.10	49	0.006	15597	197	49	0.006	15597	197	49	0.006	15597	197	56	0.006	17826	224
1.0	20	0.02	0.10	42	0.006	13369	158	42	0.006	13369	158	42	0.006	13369	158	48	0.006	15279	179
1.2	8	0.05	0.15	60	0.006	15783	210	60	0.006	15783	210	60	0.006	15783	210	68	0.006	18037	239
1.2	10	0.05	0.15	60	0.006	15783	210	60	0.006	15783	210	60	0.006	15783	210	68	0.006	18037	239
1.2	12	0.02	0.10	49	0.006	12998	175	49	0.006	12998	175	49	0.006	12998	175	56	0.006	14854	199
2.0	6	0.05	0.20	70	0.014	11141	315	70	0.014	11141	315	70	0.014	11141	315	80	0.014	12733	359
2.0	8	0.05	0.20	70	0.014	11141	315	70	0.014	11141	315	70	0.014	11141	315	80	0.014	12733	359
2.0	12	0.05	0.15	60	0.010	9469	189	60	0.010	9469	189	60	0.010	9469	189	68	0.010	10823	215
2.0	16	0.05	0.15	60	0.010	9469	189	60	0.010	9469	189	60	0.010	9469	189	68	0.010	10823	215
2.0	20	0.02	0.10	49	0.010	7798	158	49	0.010	7798	158	49	0.010	7798	158	56	0.010	8913	179
2.0	30	0.02	0.10	49	0.010	7798	158	49	0.010	7798	158	49	0.010	7798	158	56	0.010	8913	179
3.0	10	0.05	0.20	70	0.019	7427	289	70	0.019	7427	289	70	0.019	7427	289	80	0.019	8488	328
3.0	16	0.05	0.20	70	0.019	7427	289	70	0.019	7427	289	70	0.019	7427	289	80	0.019	8488	328
3.0	25	0.05	0.15	60	0.013	6313	173	60	0.013	6313	173	60	0.013	6313	173	68	0.013	7215	197
3.0	30	0.02	0.10	49	0.013	5199	144	49	0.013	5199	144	49	0.013	5199	144	56	0.013	5942	164



E489 Carbide, Micro, 2 Flute, Long Reach, **Ballnose**





Application Notes:

- Above conditions based on 5xØ overhang
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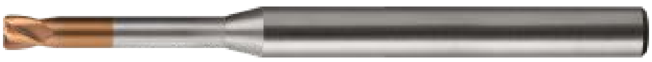
- For 8xØ overhang, reduce ap by 25%
- For 10xØ overhang, reduce ap by 50%
- For plunge in Z-Axis direction or ramping at 1° incline, reduce feed rate between 60% to 70%

LEGEND

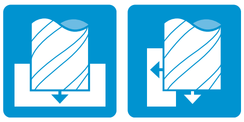
- **Ø** = nominal tool diameter (mm)
- **n** = Spindle speed (RPM⁻¹)
- v_c = Cutting speed (m/min)
- F_z = Feed rate per tooth (mm/tooth)
- v_f = Feed rate (mm/min)
- a_p = Cutting depth (mm)
- a_e = Cutting width (mm)

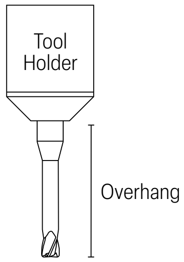
		ISO	H		H	
		VDI	45-55 HRC		55-62HRC	
		Material	Hardened Steel		Hardened Steel	
Ø	l_3	ap x Ø	n	Vf	n	Vf
1.0	2	0.04	40000	4000	40000	4000
1.0	3	0.04	40000	4000	40000	4000
1.0	4	0.02	40000	4000	40000	4000
1.0	6	0.02	35000	2000	35000	2000
1.0	8	0.01	30000	1600	30000	1600
1.0	10	0.01	20000	1000	20000	1000
1.0	14	0.008	18000	600	18000	480
1.0	18	0.004	13000	300	13000	240
1.0	20	0.004	13000	250	13000	200
1.0	25	0.004	13000	200	13000	160
1.2	4	0.05	40000	4000	35000	3500
1.2	6	0.05	40000	4000	35000	3500
1.2	8	0.05	40000	3000	27000	2000
1.2	10	0.03	27000	1900	24000	1700
1.2	12	0.02	16000	1100	16000	1000
1.2	16	0.01	16000	500	14000	400
1.2	20	0.005	12000	350	10000	300
1.2	24	0.004	12000	300	10000	250
1.4	6	0.06	40000	4500	28000	3200
1.4	8	0.06	40000	4500	28000	3200
1.4	12	0.03	32000	3000	19000	1800
1.4	16	0.02	15000	1000	14000	800
1.5	3	0.07	40000	5000	32000	4000
1.5	4	0.07	40000	5000	32000	4000
1.5	6	0.06	40000	5000	32000	4000
1.5	8	0.06	40000	5000	28000	3500
1.5	10	0.04	40000	4500	21000	2400
1.5	12	0.04	32000	3400	19000	2000
1.5	16	0.02	13000	1200	13000	1200
1.5	20	0.02	12000	900	9000	700
1.5	25	0.01	10000	750	8000	600
1.5	30	0.01	8000	500	7000	400
1.6	6	0.07	40000	5000	26000	3200
1.6	8	0.07	40000	5000	26000	3200
1.6	12	0.04	35000	3800	20000	2100
1.6	16	0.03	13000	1200	12000	1100
1.6	20	0.015	10000	750	8000	600
1.8	6	0.08	40000	5000	25000	3100
1.8	8	0.08	40000	5000	25000	3100
1.8	12	0.04	36000	3800	18000	1900
1.8	16	0.025	25000	2500	14000	1300
1.8	20	0.02	10000	1000	8000	800
2.0	4	0.1	40000	6000	24000	3400
2.0	6	0.1	40000	6000	24000	3400
2.0	8	0.1	40000	5000	24000	3000

		ISO	H		H	
		VDI	45-55 HRC		55-62HRC	
		Material	Hardened Steel		Hardened Steel	
Ø	l_3	ap x Ø	n	Vf	n	Vf
2.0	10	0.07	40000	5000	24000	3000
2.0	12	0.05	40000	5000	24000	2600
2.0	16	0.03	32000	3500	16000	1700
2.0	20	0.03	10000	1000	10000	1000
2.0	25	0.02	10000	1000	8000	800
2.0	30	0.015	10000	800	8000	800
2.0	40	0.01	10000	500	8000	400
2.5	8	0.11	36000	5000	20000	2600
2.5	10	0.11	36000	5000	20000	2600
2.5	12	0.075	36000	5000	20000	2600
2.5	16	0.075	36000	4600	18000	2000
2.5	20	0.05	26000	3000	13000	1400
2.5	25	0.04	10000	1100	8000	800
2.5	30	0.03	8000	800	7000	700
2.5	35	0.03	8000	500	5000	400
3.0	6	0.15	32000	6400	16000	3000
3.0	10	0.13	32000	5100	16000	2200
3.0	16	0.13	32000	4500	16000	1800
3.0	20	0.13	27000	3800	14000	1600
3.0	30	0.09	9000	1000	7000	700
3.0	35	0.08	6000	700	6000	600
3.0	40	0.07	6000	600	5000	400
3.0	45	0.06	5000	500	4000	350
3.0	50	0.05	4000	400	3000	300
3.0	60	0.04	4000	350	3000	250
4.0	10	0.2	24000	4800	12000	2200
4.0	16	0.15	24000	3800	12000	1500
4.0	20	0.15	24000	3800	12000	1500
4.0	30	0.08	20000	3000	10000	1100
4.0	35	0.08	12000	1700	8000	900
4.0	40	0.06	11000	1500	5000	500
4.0	45	0.05	10000	1300	5000	500
4.0	50	0.04	8000	1000	4000	400
4.0	55	0.03	7000	800	3000	300
4.0	60	0.03	6000	700	3000	250
5.0	15	0.2	19000	3400	10000	1400
5.0	20	0.2	19000	3400	10000	1400
5.0	25	0.2	19000	3400	10000	1400
5.0	30	0.15	19000	3200	8000	1000
5.0	40	0.13	16000	2700	8000	1000
5.0	45	0.1	14000	2000	8000	900
5.0	50	0.1	12000	1500	7000	800
5.0	60	0.08	10000	1200	6000	700
6.0	15	0.2	16000	3500	8000	1000
6.0	30	0.15	16000	3000	8000	800



E598 Carbide, Micro, 4 Flute, Long Reach, **Corner Rad**





Application Notes:

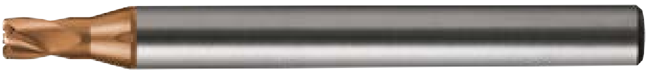
- Above conditions based on 5xØ overhang
- For 6xØ overhang, reduce ap by 10%
- For 8xØ overhang, reduce ap by 25%
- For 10xØ overhang, reduce ap by 50%
- For plunge in Z-Axis direction or ramping at 1° incline, reduce feed rate between 60% to 70%

LEGEND

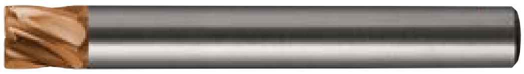
- **Ø** = nominal tool diameter (mm)
- **n** = Spindle speed (RPM⁻¹)
- v_c = Cutting speed (m/min)
- F_z = Feed rate per tooth (mm/tooth)
- v_f = Feed rate (mm/min)
- a_p = Cutting depth (mm)
- a_e = Cutting width (mm)

ISO	P					H					H				
VDI	35 ≤ HRC ≤ 45					45 ≤ HRC ≤ 52					≥ 52 - 68 HRC				
Material	Pre-hardened Steel					Hardened Steel					Hardened Steel				
Ø	ap	Vc	Fz	n	Vf	ap	Vc	Fz	n	Vf	ap	Vc	Fz	n	Vf
1	0.030	96	0.020	30600	2480	0.025	85	0.018	27000	1940	0.023	79	0.016	25200	1590
1	0.019	78	0.020	24800	2000	0.016	69	0.018	21900	1570	0.014	64	0.016	20400	1280
1	0.019	69	0.020	22000	1780	0.016	61	0.018	19400	1400	0.014	57	0.016	18100	1140
1	0.012	61	0.020	19300	1560	0.010	53	0.018	17000	1220	0.009	50	0.016	15900	1000
1	0.012	54	0.016	17100	1080	0.010	47	0.016	15100	950	0.009	44	0.013	14100	760
1	0.010	54	0.015	17100	1040	0.008	47	0.015	15100	880	0.007	44	0.012	14100	700
1	0.007	54	0.015	17100	1000	0.006	47	0.013	15100	810	0.005	44	0.011	14100	630
1	0.005	41	0.015	12900	750	0.004	36	0.013	11300	610	0.004	33	0.011	10600	480
1.5	0.052	106	0.022	22500	2000	0.042	94	0.019	20000	1550	0.039	87	0.017	18500	1270
1.5	0.048	101	0.022	21400	1900	0.039	89	0.019	18900	1470	0.036	83	0.017	17600	1210
1.5	0.048	81	0.022	17100	1520	0.039	71	0.019	15100	1170	0.036	66	0.017	14100	970
1.5	0.036	72	0.020	15200	1220	0.029	63	0.018	13400	990	0.027	59	0.016	12500	810
1.5	0.024	63	0.017	13300	920	0.020	56	0.017	11800	810	0.018	52	0.015	11000	640
2	0.064	123	0.042	19600	3310	0.052	109	0.034	17300	2340	0.048	102	0.029	16200	1910
2	0.056	112	0.042	17900	3010	0.046	99	0.034	15800	2120	0.042	92	0.029	14700	1730
2	0.044	102	0.040	16200	2600	0.036	90	0.034	14300	1920	0.033	84	0.03	13300	1570
2	0.032	91	0.038	14500	2190	0.026	80	0.034	12800	1720	0.024	75	0.029	11900	1400
2	0.032	86	0.038	13700	2070	0.026	75	0.034	12000	1620	0.024	70	0.03	11200	1330
2	0.032	81	0.038	12900	1950	0.026	71	0.034	11300	1530	0.024	67	0.029	10600	1250
2	0.030	75	0.038	12000	1830	0.025	67	0.032	10600	1370	0.023	62	0.028	9900	1110
2	0.028	70	0.038	11200	1710	0.023	62	0.030	9900	1200	0.021	58	0.026	9300	980
2	0.020	70	0.038	11200	1710	0.016	62	0.030	9900	1200	0.015	58	0.026	9300	980
2	0.014	67	0.038	10700	1620	0.011	59	0.030	9400	1140	0.010	55	0.026	8800	930
2.5	0.077	119	0.038	15100	2290	0.062	104	0.034	13300	1820	0.058	97	0.03	12400	1490
2.5	0.072	114	0.038	14500	2190	0.059	101	0.034	12800	1720	0.054	93	0.029	11900	1400
2.5	0.067	108	0.038	13800	2100	0.055	96	0.033	12200	1620	0.050	90	0.029	11400	1320
2.5	0.062	104	0.038	13200	2000	0.051	91	0.033	11600	1510	0.047	85	0.028	10800	1230
2.5	0.058	98	0.038	12500	1900	0.047	87	0.032	11100	1410	0.043	81	0.028	10300	1150
2.5	0.053	93	0.038	11900	1800	0.043	82	0.031	10500	1310	0.040	77	0.027	9800	1070
2.5	0.048	88	0.038	11200	1710	0.039	78	0.030	9900	1200	0.036	73	0.026	9300	980
2.5	0.036	86	0.038	11000	1660	0.029	76	0.030	9700	1170	0.027	71	0.027	9000	960
2.5	0.024	84	0.038	10700	1620	0.020	74	0.030	9400	1140	0.018	69	0.026	8800	930
3	0.072	128	0.053	13600	2860	0.059	113	0.042	12000	2020	0.054	106	0.037	11200	1650
3	0.064	128	0.053	13600	2860	0.052	113	0.042	12000	2020	0.048	106	0.037	11200	1650
3	0.056	128	0.053	13600	2860	0.046	113	0.042	12000	2020	0.042	106	0.037	11200	1650
3	0.048	128	0.053	13600	2860	0.039	113	0.042	12000	2020	0.036	106	0.037	11200	1650
3	0.040	128	0.053	13600	2860	0.033	113	0.042	12000	2020	0.030	106	0.037	11200	1650
3	0.040	115	0.053	12200	2570	0.033	100	0.042	10600	1790	0.030	95	0.037	10100	1490
3	0.040	104	0.053	11000	2320	0.033	91	0.042	9700	1640	0.030	86	0.037	9100	1340
3	0.036	92	0.050	9800	1970	0.029	81	0.041	8600	1400	0.027	76	0.035	8100	1140
3	0.032	81	0.047	8600	1620	0.026	72	0.038	7600	1160	0.024	67	0.033	7100	930
4	0.184	147	0.065	11700	3060	0.150	131	0.052	10400	2160	0.138	122	0.045	9700	1760
4	0.164	134	0.065	10700	2780	0.133	117	0.052	9300	1940	0.123	109	0.046	8700	1590
4	0.144	121	0.065	9600	2510	0.117	103	0.052	8200	1720	0.108	98	0.046	7800	1420
4	0.136	109	0.062	8700	2170	0.111	96	0.049	7600	1500	0.102	89	0.044	7100	1240
4	0.120	99	0.058	7900	1830	0.098	87	0.046	6900	1280	0.090	80	0.041	6400	1050
4	0.104	88	0.054	7000	1500	0.085	78	0.043	6200	1060	0.078	73	0.037	5800	860

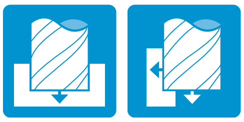
sutton

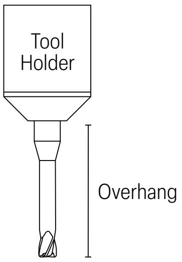


E650 Carbide, 4 Flute, up to 6mm



E650 Carbide, 6 Flute, over 6mm





Application Notes:

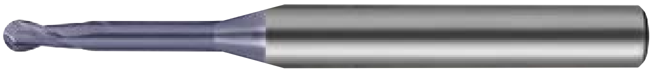
- Above conditions based on 5xØ overhang
- For 6xØ overhang, reduce ap by 10%
- For 8xØ overhang, reduce ap by 25%
- For 10xØ overhang, reduce ap by 50%
- For plunge in Z-Axis direction or ramping at 1° incline, reduce feed rate between 60% to 70%

LEGEND

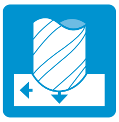
Ø = nominal tool diameter (mm)
n = Spindle speed (RPM^{-1})
v_c = Cutting speed (m/min)
F_z = Feed rate per tooth (mm/tooth)
v_f = Feed rate (mm/min)
a_p = Cutting depth (mm)
a_e = Cutting width (mm)

		ISO	P			H			H		
		VDI	35 ≤ HRC ≤ 45			45 ≤ HRC ≤ 52			≥ 52 - 68 HRC		
		Material	Pre-hardened Steel			Hardened Steel			Hardened Steel		
Ø	ae x Ø	ap x Ø	Vc	n	Vf	Vc	n	Vf	Vc	n	Vf
2	0.31	0.05	90	14300	2150	80	12700	1910	70	11100	1670
3	0.31	0.05	90	9500	2280	80	8500	2040	70	7400	1780
4	0.31	0.05	90	7200	2880	80	6400	2560	70	5600	2240
6	0.31	0.05	90	4800	2220	80	4200	1940	70	3700	1710
8	0.31	0.05	90	3600	4050	80	3200	3600	70	2800	3150
10	0.31	0.05	90	2900	3520	80	2500	3040	70	2200	2670
12	0.31	0.05	90	2400	3130	80	2100	2740	70	1900	2480

sutton



E490 Carbide, Micro, 2 Flute, Long Reach, Ballnose

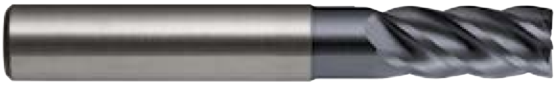


LEGEND

- **Ø** = nominal tool diameter (mm)
- **n** = Spindle speed (RPM⁻¹)
- **v_c** = Cutting speed (m/min)
- **F_z** = Feed rate per tooth (mm/tooth)
- **v_f** = Feed rate (mm/min)
- **a_p** = Cutting depth (mm)
- **a_e** = Cutting width (mm)

			ISO	P				M				S				H			
			VDI	5, 8, 9, 10, 11				14.2, 14.3				34, 35, 37.3, 37.5				38.1			
			Material	Steel - Low alloy & cast Steel - High alloy, cast & tool				Stainless Steel				High temp. alloys Titanium & Ti alloys				Hardened Steel			
Ø	l_3	ae x Ø	ap x Ø	Vc	Fz	n	Vf	Vc	Fz	n	Vf	Vc	Fz	n	Vf	Vc	Fz	n	Vf
0.8	6	0.05D	0.15D	68	0.005	27056	277	60	0.005	23674	244	60	0.005	23674	244	51	0.003	20292	153
0.8	8	0.02D	0.10D	56	0.005	22282	231	49	0.005	19496	203	49	0.005	19496	203	42	0.003	16711	127
1.0	6	0.05D	0.15D	68	0.006	21645	269	60	0.005	18940	237	60	0.006	18940	237	51	0.004	16234	136
1.0	8	0.05D	0.15D	68	0.006	21645	269	60	0.005	18940	237	60	0.006	18940	237	51	0.004	16234	136
1.0	12	0.02D	0.10D	56	0.006	17826	224	49	0.005	15597	197	49	0.006	15597	197	42	0.004	13369	113
1.2	8	0.05D	0.15D	68	0.006	18037	239	60	0.006	15783	210	60	0.006	15783	210	51	0.004	13528	121
1.2	12	0.02D	0.10D	56	0.006	14854	199	49	0.006	12998	175	49	0.006	12998	175	42	0.004	11141	101
1.4	12	0.05D	0.15D	68	0.007	15461	239	60	0.007	13528	210	60	0.007	13528	210	51	0.005	11595	113
1.5	8	0.05D	0.20D	80	0.011	16977	372	70	0.011	14855	327	70	0.011	14855	327	60	0.007	12732	191
1.5	12	0.05D	0.15D	68	0.007	14430	223	60	0.007	12626	196	60	0.007	12626	196	51	0.005	10822	115
1.5	16	0.02D	0.10D	56	0.008	11884	186	49	0.008	10398	163	49	0.008	10398	163	42	0.005	8912	96
1.6	16	0.02D	0.10D	56	0.008	11141	183	49	0.008	9748	161	49	0.008	9748	161	42	0.005	8356	95
1.8	16	0.05D	0.15D	68	0.008	12025	212	60	0.008	10522	187	60	0.008	10522	187	51	0.006	9019	108
2.0	8	0.05D	0.20D	80	0.014	12733	359	70	0.014	11141	315	70	0.014	11141	315	60	0.009	9550	181
2.0	10	0.05D	0.15D	68	0.010	10823	215	60	0.010	9469	189	60	0.010	9469	189	51	0.006	8117	109
2.0	16	0.05D	0.15D	68	0.010	10823	215	60	0.010	9469	189	60	0.010	9469	189	51	0.006	8117	109
2.0	20	0.02D	0.10D	56	0.010	8913	179	49	0.010	7798	158	49	0.010	7798	158	42	0.006	6685	91
3.0	16	0.05D	0.20D	80	0.019	8488	328	70	0.019	7427	289	70	0.019	7427	289	60	0.013	6366	169
3.0	25	0.05D	0.15D	68	0.013	7215	197	60	0.013	6313	173	60	0.013	6313	173	51	0.009	5411	101
4.0	16	0.05D	0.20D	80	0.024	6366	313	70	0.024	5571	275	70	0.024	5571	275	60	0.016	4775	161
4.0	20	0.05D	0.20D	80	0.024	6366	313	70	0.024	5571	275	70	0.024	5571	275	60	0.016	4775	161

sutton



HARMONY Ni

E472-E475 Carbide, 5 Flute, R40/42**,** DIN6527L, Harmony Ni

ROUGHING

ISO	VDI 3323	Material		Condition	HB	N/mm²	Common Grades	Vc (m/min)	Tool Engagement Angle	Recommended ae	Max ap	6mm	8mm	10mm	12mm	16mm	20mm
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	1020, S1214L	270	53°	0.2x d1	l_2	0.044	0.070	0.088	0.106	0.140	0.176
	2		- 0.45 %C	A	190	640	1045	270				0.044	0.070	0.088	0.106	0.140	0.176
	3			QT	250	840		270				0.044	0.070	0.088	0.106	0.140	0.176
	4		- 0.75 %C	A	270	910	1055, 1060	270				0.044	0.070	0.088	0.106	0.140	0.176
	5			QT	300	1010		210				0.042	0.063	0.081	0.096	0.129	0.159
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	4140, 4340	270				0.044	0.070	0.088	0.106	0.140	0.176
	7			QT	275	930		270				0.044	0.070	0.088	0.106	0.140	0.176
	8			QT	300	1010		210				0.042	0.063	0.081	0.096	0.129	0.159
	9			QT	350	1180		210				0.042	0.063	0.081	0.096	0.129	0.159
	10	Steel - High alloy, cast & tool		A	200	680	A2, H13 (SKD61), D2	270				0.044	0.070	0.088	0.106	0.140	0.176
	11			HT	325	1100		210				0.042	0.063	0.081	0.096	0.129	0.159
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	SS430, 431, 440C	210				0.042	0.063	0.081	0.096	0.129	0.159
	13		Martensitic	QT	240	810		210				0.042	0.063	0.081	0.096	0.129	0.159
M	14.1	Stainless Steel	Austenitic	AH	180	610	303, 304, 316	150	46°	0.15 x d1	l_2	0.039	0.054	0.066	0.081	0.105	0.132
	14.2		Duplex		230	780	321, 341	100	37°	0.1 x d1		0.048	0.063	0.081	0.096	0.129	0.162
	14.3		Precipitation Hardening		300	780	15-5Ph, 17-4Ph	100				0.048	0.063	0.081	0.096	0.129	0.162
S	31	High temp. alloys	Fe based	A	200	680		60	31°	0.08 x d1	l_2	0.045	0.060	0.075	0.090	0.120	0.150
	32			AH	280	950		50				0.045	0.060	0.075	0.090	0.120	0.150
	33		Ni / Co based	A	250	840	Inconel 625	50				0.045	0.060	0.075	0.090	0.120	0.150
	34			AH	350	1180	Inconel 718	40				0.045	0.060	0.075	0.090	0.120	0.150
	35			C	320	1080	Inconel 718	30				0.045	0.060	0.075	0.090	0.120	0.150

UNIVERSAL

ISO	VDI 3323	Material		Condition	HB	N/mm²	Common Grades	Vc (m/min)	Tool Engagement Angle	Recommended ae	Max ap	6mm	8mm	10mm	12mm	16mm	20mm
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	1020, S1214L	290	46°	0.15x d1	I2	0.051	0.084	0.105	0.126	0.168	0.210
	2		- 0.45 %C	A	190	640	1045	290				0.051	0.084	0.105	0.126	0.168	0.210
	3			QT	250	840		290				0.051	0.084	0.105	0.126	0.168	0.210
	4		- 0.75 %C	A	270	910	1055, 1060	290				0.051	0.084	0.105	0.126	0.168	0.210
	5			QT	300	1010		230				0.051	0.075	0.096	0.114	0.153	0.189
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	4140, 4340	290				0.051	0.084	0.105	0.126	0.168	0.210
	7			QT	275	930		290				0.051	0.084	0.105	0.126	0.168	0.210
	8			QT	300	1010		230				0.051	0.075	0.096	0.114	0.153	0.189
	9			QT	350	1180		230				0.051	0.075	0.096	0.114	0.153	0.189
	10	Steel - High alloy, cast & tool		A	200	680	A2, H13 (SKD61), D2	290				0.051	0.084	0.105	0.126	0.168	0.210
	11			HT	325	1100		230				0.051	0.075	0.096	0.114	0.153	0.189
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	SS430, 431, 440C	230				0.051	0.075	0.096	0.114	0.153	0.189
	13		Martensitic	QT	240	810		230				0.051	0.075	0.096	0.114	0.153	0.189
M	14.1	Stainless Steel	Austenitic	AH	180	610	303, 304, 316	170	37°	0.10 x d1	I2	0.048	0.063	0.081	0.096	0.129	0.162
	14.2		Duplex		230	780	321, 341	110	31°	0.08 x d1		0.054	0.069	0.087	0.105	0.141	0.174
	14.3		Precipitation Hardening		300	780	15-5Ph, 17-4Ph	110				0.054	0.069	0.087	0.105	0.141	0.174
S	31	High temp. alloys	Fe based	A	200	680		60	26°	0.05 x d1	I2	0.045	0.060	0.075	0.090	0.120	0.150
	32			AH	280	950		50				0.045	0.060	0.075	0.090	0.120	0.150
	33		Ni / Co based	A	250	840	Inconel 625	50				0.045	0.060	0.075	0.090	0.120	0.150
	34			AH	350	1180	Inconel 718	40				0.045	0.060	0.075	0.090	0.120	0.150
	35			C	320	1080	Inconel 718	30				0.045	0.060	0.075	0.090	0.120	0.150

FINISHING

ISO	VDI 3323	Material		Condition	HB	N/mm²	Common Grades	Vc (m/min)	Tool Engagement Angle	Recommended ae	Max ap	6mm	8mm	10mm	12mm	16mm	20mm
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	1020, S1214L	300	18°	0.02x d1	l_2	0.039	0.063	0.078	0.093	0.123	0.153
	2		- 0.45 %C	A	190	640	1045	300				0.039	0.063	0.078	0.093	0.123	0.153
	3			QT	250	840		300				0.039	0.063	0.078	0.093	0.123	0.153
	4		- 0.75 %C	A	270	910	1055, 1060	300				0.039	0.063	0.078	0.093	0.123	0.153
	5			QT	300	1010		250				0.039	0.057	0.069	0.084	0.111	0.141
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	4140, 4340	300				0.039	0.063	0.078	0.093	0.123	0.153
	7			QT	275	930		300				0.039	0.063	0.078	0.093	0.123	0.153
	8			QT	300	1010		250				0.039	0.057	0.069	0.084	0.111	0.141
	9			QT	350	1180		250				0.039	0.057	0.069	0.084	0.111	0.141
	10	Steel - High alloy, cast & tool		A	200	680	A2, H13 (SKD61), D2	300				0.039	0.063	0.078	0.093	0.123	0.153
	11			HT	325	1100		250				0.039	0.057	0.069	0.084	0.111	0.141
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	SS430, 431, 440C	250				0.039	0.057	0.069	0.084	0.111	0.141
	13		Martensitic	QT	240	810		250				0.039	0.057	0.069	0.084	0.111	0.141
M	14.1	Stainless Steel	Austenitic	AH	180	610	303, 304, 316	170	18°	0.02 x d1	l_2	0.030	0.039	0.048	0.060	0.078	0.099
	14.2		Duplex		230	780	321, 341	120	11°	0.01 x d1		0.039	0.051	0.063	0.075	0.102	0.126
	14.3		Precipitation Hardening		300	780	15-5Ph, 17-4Ph	120				0.039	0.051	0.063	0.075	0.102	0.126
S	31	High temp. alloys	Fe based	A	200	680		70	11°	0.01 x d1	l_2	0.033	0.042	0.054	0.066	0.087	0.108
	32			AH	280	950		60				0.033	0.042	0.054	0.066	0.087	0.108
	33		Ni / Co based	A	250	840	Inconel 625	60				0.033	0.042	0.054	0.066	0.087	0.108
	34			AH	350	1180	Inconel 718	50				0.033	0.042	0.054	0.066	0.087	0.108
	35			C	320	1080	Inconel 718	40				0.033	0.042	0.054	0.066	0.087	0.108

Guide to the cutting conditions

CAM programming software is required to control the cycle/toolpaths, with different information needed to suit the various conditions, such as material type.

These cutting conditions are a guide for Dynamic & Trochoidal applications & will vary subject to the users own machine conditions & set-up variables.

Careful consideration has been given to chip loads based on the step over (ae) size of cut to ensure chip thinning is eliminated, with deflection kept to a minimum.

Workpiece Material

- LOW MACHINABILITY / HARDER TO MACHINE = increase in process reliability
- HIGH MACHINABILITY / EASY TO MACHINE = increase in productivity

Machine Size

- Larger Machines = high spindle torque, stable feed, ideal for medium & larger tools
- Smaller Machines = higher spindle speed, shorter acceleration & deceleration, ideal for small to medium tools

Workpiece Clamping

E486/E493 & E487/E494 Carbide, 7 & 9 Flute, R40/42 Ni, Extra Long

ROUGHING

ISO	VDI 3323	Material		Condition	HB	N/mm²	Common Grades	Vc (m/min)	Tool Engagement Angle	Recommended ae	Max ap	6mm	8mm	10mm	12mm	16mm	20mm
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	1020, S1214L	270	53°	0.2x d1	l_2	0.044	0.070	0.088	0.106	0.140	0.176
	2		- 0.45 %C	A	190	640	1045	270				0.044	0.070	0.088	0.106	0.140	0.176
	3			QT	250	840		270				0.044	0.070	0.088	0.106	0.140	0.176
	4		- 0.75 %C	A	270	910	1055, 1060	270				0.044	0.070	0.088	0.106	0.140	0.176
	5			QT	300	1010		210				0.042	0.063	0.081	0.096	0.129	0.159
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	4140, 4340	270				0.044	0.070	0.088	0.106	0.140	0.176
	7			QT	275	930		270				0.044	0.070	0.088	0.106	0.140	0.176
	8			QT	300	1010		210				0.042	0.063	0.081	0.096	0.129	0.159
	9			QT	350	1180		210				0.042	0.063	0.081	0.096	0.129	0.159
	10	Steel - High alloy, cast & tool		A	200	680	A2, H13 (SKD61), D2	270				0.044	0.070	0.088	0.106	0.140	0.176
	11			HT	325	1100		210				0.042	0.063	0.081	0.096	0.129	0.159
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	SS430, 431, 440C	210				0.042	0.063	0.081	0.096	0.129	0.159
	13		Martensitic	QT	240	810		210				0.042	0.063	0.081	0.096	0.129	0.159
M	14.1	Stainless Steel	Austenitic	AH	180	610	303, 304, 316	150	46°	0.15 x d1	l_2	0.039	0.054	0.066	0.081	0.105	0.132
	14.2		Duplex		230	780	321, 341	100	37°	0.1 x d1		0.048	0.063	0.081	0.096	0.129	0.162
	14.3		Precipitation Hardening		300	780	15-5Ph, 17-4Ph	100				0.048	0.063	0.081	0.096	0.129	0.162
S	31	High temp. alloys	Fe based	A	200	680		60	31°	0.08 x d1	l_2	0.045	0.060	0.075	0.090	0.120	0.150
	32			AH	280	950		50				0.045	0.060	0.075	0.090	0.120	0.150
	33		Ni / Co based	A	250	840	Inconel 625	50				0.045	0.060	0.075	0.090	0.120	0.150
	34			AH	350	1180	Inconel 718	40				0.045	0.060	0.075	0.090	0.120	0.150
	35			C	320	1080	Inconel 718	30				0.045	0.060	0.075	0.090	0.120	0.150

UNIVERSAL

ISO	VDI 3323	Material		Condition	HB	N/mm²	Common Grades	Vc (m/min)	Tool Engagement Angle	Recommended ae	Max ap	6mm	8mm	10mm	12mm	16mm	20mm
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	1020, S1214L	300	46°	0.15x d1	l_2	0.051	0.084	0.105	0.126	0.168	0.210
	2		- 0.45 %C	A	190	640	1045	300				0.051	0.084	0.105	0.126	0.168	0.210
	3			QT	250	840		300				0.051	0.084	0.105	0.126	0.168	0.210
	4		- 0.75 %C	A	270	910	1055, 1060	300				0.051	0.084	0.105	0.126	0.168	0.210
	5			QT	300	1010		250				0.051	0.075	0.096	0.114	0.153	0.189
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	4140, 4340	300				0.051	0.084	0.105	0.126	0.168	0.210
	7			QT	275	930		300				0.051	0.084	0.105	0.126	0.168	0.210
	8			QT	300	1010		250				0.051	0.075	0.096	0.114	0.153	0.189
	9			QT	350	1180		250				0.051	0.075	0.096	0.114	0.153	0.189
	10	Steel - High alloy, cast & tool		A	200	680	A2, H13 (SKD61), D2	300				0.051	0.084	0.105	0.126	0.168	0.210
	11			HT	325	1100		250				0.051	0.075	0.096	0.114	0.153	0.189
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	SS430, 431, 440C	250				0.051	0.075	0.096	0.114	0.153	0.189
	13		Martensitic	QT	240	810		250				0.051	0.075	0.096	0.114	0.153	0.189
M	14.1	Stainless Steel	Austenitic	AH	180	610	303, 304, 316	170	37°	0.10 x d1	l_2	0.048	0.063	0.081	0.096	0.129	0.162
	14.2		Duplex		230	780	321, 341	120	31°	0.08 x d1		0.054	0.069	0.087	0.105	0.141	0.174
	14.3		Precipitation Hardening		300	780	15-5Ph, 17-4Ph	120				0.054	0.069	0.087	0.105	0.141	0.174
S	31	High temp. alloys	Fe based	A	200	680		70	26°	0.05 x d1	l_2	0.045	0.060	0.075	0.090	0.120	0.150
	32			AH	280	950		60				0.045	0.060	0.075	0.090	0.120	0.150
	33		Ni / Co based	A	250	840	Inconel 625	60				0.045	0.060	0.075	0.090	0.120	0.150
	34			AH	350	1180	Inconel 718	50				0.045	0.060	0.075	0.090	0.120	0.150
	35			C	320	1080	Inconel 718	40				0.045	0.060	0.075	0.090	0.120	0.150

FINISHING

ISO	VDI 3323	Material		Condition	HB	N/mm²	Common Grades	Vc (m/min)	Tool Engagement Angle	Recommended ae	Max ap	6mm	8mm	10mm	12mm	16mm	20mm
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	1020, S1214L	300	18°	0.02x d1	l_2	0.039	0.063	0.078	0.093	0.123	0.153
	2		- 0.45 %C	A	190	640	1045	300				0.039	0.063	0.078	0.093	0.123	0.153
	3			QT	250	840		300				0.039	0.063	0.078	0.093	0.123	0.153
	4		- 0.75 %C	A	270	910	1055, 1060	300				0.039	0.063	0.078	0.093	0.123	0.153
	5			QT	300	1010		250				0.039	0.057	0.069	0.084	0.111	0.141
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	4140, 4340	300				0.039	0.063	0.078	0.093	0.123	0.153
	7			QT	275	930		300				0.039	0.063	0.078	0.093	0.123	0.153
	8			QT	300	1010		250				0.039	0.057	0.069	0.084	0.111	0.141
	9			QT	350	1180		250				0.039	0.057	0.069	0.084	0.111	0.141
	10	Steel - High alloy, cast & tool		A	200	680	A2, H13 (SKD61), D2	300				0.039	0.063	0.078	0.093	0.123	0.153
	11			HT	325	1100		250				0.039	0.057	0.069	0.084	0.111	0.141
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	SS430, 431, 440C	250				0.039	0.057	0.069	0.084	0.111	0.141
	13		Martensitic	QT	240	810		250				0.039	0.057	0.069	0.084	0.111	0.141
M	14.1	Stainless Steel	Austenitic	AH	180	610	303, 304, 316	170	18°	0.02 x d1	l_2	0.030	0.039	0.048	0.060	0.078	0.099
	14.2		Duplex		230	780	321, 341	120	11°	0.01 x d1		0.039	0.051	0.063	0.075	0.102	0.126
	14.3		Precipitation Hardening		300	780	15-5Ph, 17-4Ph	120				0.039	0.051	0.063	0.075	0.102	0.126
S	31	High temp. alloys	Fe based	A	200	680		70	11°	0.01 x d1	l_2	0.033	0.042	0.054	0.066	0.087	0.108
	32			AH	280	950		60				0.033	0.042	0.054	0.066	0.087	0.108
	33		Ni / Co based	A	250	840	Inconel 625	60				0.033	0.042	0.054	0.066	0.087	0.108
	34			AH	350	1180	Inconel 718	50				0.033	0.042	0.054	0.066	0.087	0.108
	35			C	320	1080	Inconel 718	40				0.033	0.042	0.054	0.066	0.087	0.108

- Stable = optimised metal removal rate can be achieved
- Unstable = reduce feed for increased process reliability

Tool Clamping

- HA shank style = higher concentricity aids in longer tool life, but with increased pull out in extremely tough materials when heavy cuts are taken.
- HB shank style = lower concentricity but eliminates pull out, ideal for larger machines & tool diameters.

Tool engagement angle

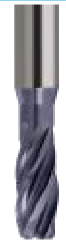
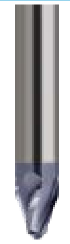
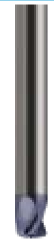
- For Concave milling paths, engagement angle increases, therefore tool stress increases - ae & fz must be reduced by 20%
- 90° Corner radius milling paths = tool radius, conditions affected dramatically – vc & fz must be reduced by 70%.
- 90° Corner radius milling paths < tool radius, condition is stable - ae & fz must be reduced by 30%
- For Convex milling paths, engagement angle decreases, therefore tool stress decreases - ae & fz can be increased.

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

HARMONY 5 AXIS

				
Catalogue Code	E700	E701	E702 E703	E704
Material	VHM-ULTRA	VHM-ULTRA	VHM-ULTRA	VHM-ULTRA
Surface Finish	AlCrN	AlCrN	AlCrN	AlCrN
Sutton Designation	UNI	UNI	UNI	UNI
Type	Oval	Barrel	Taper	R30
Type of Cut: *Slotting*				
Finishing	●	●	●	●
Universal				
Roughing				
Profiling	●	●	●	●
Stock Allowance:	0.05-0.3mm	0.05-0.2mm	0.05-0.2mm	0.05-0.2mm

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	E700 Vc	E700 Feed #	E701 Vc	E701 Feed #	E702/E703 Vc	E702/E703 Feed #	E704 Vc	E704 Feed #
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	**200**	**0.008**	**200**	**0.008**	**200**	**0.007**	**280**	**0.008**
P	2		- 0.45 %C	A	190	640	**190**	**0.007**	**190**	**0.007**	**190**	**0.007**	**250**	**0.007**
P	3			QT	250	840	**180**	**0.007**	**180**	**0.007**	**180**	**0.006**	**240**	**0.007**
P	4		- 0.75 %C	A	270	910	**160**	**0.006**	**160**	**0.006**	**160**	**0.005**	**210**	**0.006**
P	5			QT	300	1010	**150**	**0.006**	**150**	**0.006**	**150**	**0.005**	**200**	**0.006**
P	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**180**	**0.007**	**180**	**0.007**	**180**	**0.006**	**240**	**0.007**
P	7			QT	275	930	**180**	**0.007**	**180**	**0.007**	**180**	**0.006**	**240**	**0.007**
P	8			QT	300	1010	**150**	**0.006**	**150**	**0.006**	**150**	**0.005**	**200**	**0.006**
P	9			QT	350	1180	**150**	**0.006**	**150**	**0.006**	**150**	**0.005**	**200**	**0.006**
P	10	Steel - High alloy, cast & tool		A	200	680	180	0.007	180	0.007	180	0.006	240	0.007
P	11			HT	325	1100	150	0.006	150	0.006	150	0.005	200	0.006
P	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	140	0.005	140	0.005	140	0.004	160	0.005
P	13		Martensitic	QT	240	810	130	0.005	130	0.005	130	0.004	150	0.005
M	14.1	Stainless Steel	Austenitic	AH	180	610	**80**	**0.005**	**80**	**0.005**	**80**	**0.004**	**120**	**0.005**
M	14.2		Duplex		230	780	**80**	**0.005**	**80**	**0.005**	**80**	**0.004**	**120**	**0.005**
M	14.3		Precipitation Hardening		300	780	**40**	**0.004**	**40**	**0.004**	**40**	**0.003**	**60**	**0.004**
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	200	0.008	200	0.008	200	0.007	300	0.007
K	16		Pearlitic		260	880	200	0.008	200	0.008	200	0.007	300	0.007
K	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	180	0.007	180	0.007	180	0.006	270	0.006
K	18		Pearlitic		250	840	180	0.007	180	0.007	180	0.006	270	0.006
K	19	Cast Iron - Malleable	Ferritic		130	460								
K	20		Pearlitic		230	780								
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210								
N	22		Heat Treatable	AH	100	360								
N	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270								
N	24		Heat Treatable	AH	90	320								
N	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460								
N	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390								
N	27		Brass (CuZn, CuSnZn)		90	320								
N	28		Bronze (CuSn)		100	360								
N	29	Non-metallic - Thermosetting & fiber-reinforced plastics												
N	30	Non-metallic - Hard rubber, wood etc.												
S	31	High temp. alloys	Fe based	A	200	680	30	0.004	30	0.004	30	0.003		
S	32			AH	280	950	30	0.004	30	0.004	30	0.003		
S	33		Ni / Co based	A	250	840	30	0.004	30	0.004	30	0.003		
S	34			AH	350	1180	30	0.004	30	0.004	30	0.003		
S	35			C	320	1080	30	0.004	30	0.004	30	0.003		
S	36	Titanium & Ti alloys	CP Titanium		400 MPa		100	0.006	100	0.006	100	0.005	150	0.006
S	37.1		Alpha alloys		860 MPa		80	0.005	80	0.005	80	0.004	120	0.005
S	37.2		Alpha / Beta alloys	A	960 MPa		80	0.005	80	0.005	80	0.004	120	0.005
S	37.3			AH	1170 MPa		80	0.005	80	0.005	80	0.004	120	0.005
S	37.4		Beta alloys	A	830 MPa		80	0.005	80	0.005	80	0.004	120	0.005
S	37.5			AH	1400 MPa		60	0.005	60	0.005	60	0.004	90	0.005
H	38.1	Hardened steel		HT	45 HRC									
H	38.2			HT	55 HRC									
H	39.1			HT	58 HRC									
H	39.2			HT	62 HRC									
H	40	Cast Iron	Chilled	C	400	1350								
H	41			HT	55 HRC									

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Feed Table (f_z) (mm/tooth)

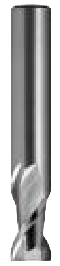
Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

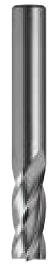
Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	DIN
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.






Catalogue Code	E179 | E183	E180 | E184	E191		E192	
Material	HSS Co.8	HSS Co.8	HSS Co.8		HSS Co.8	
Surface Finish	*Brt*	*TiAlN*	*Brt*		*TiAlN*	
Sutton Designation	N	N	N		N	
Geometry	R30	R30	R30		R30	
Type of Cut: *Slotting*	●	●				
Finishing			●		●	
Universal				●		●
Roughing						
Profiling						
↑↓ ap × Ø	0.5	0.5	1.5	1.5	1.5	1.5
←→ ae × Ø	1.0	1.0	0.1	0.1	0.1	0.25

ISO	VDI^ 3323	Material		Condition	HB	N/mm²	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #	Vc	Feed #
P	1	Steel - Non-alloy, cast & free cutting	~ 0.15 %C	A	125	440	**30**	**6**	**36**	**6**	**40**	**4**	**40**	**5**	**50**	**4**	**40**	**5**
	2		~ 0.45 %C	A	190	640	**30**	**6**	**36**	**6**	**40**	**4**	**40**	**5**	**50**	**4**	**40**	**5**
	3			QT	250	840	30	6	**36**	**6**	40	4	40	5	50	4	40	5
	4		~ 0.75 %C	A	270	910	30	6	**36**	**6**	40	4	40	5	50	4	40	5
	5			QT	300	1010	20	5	25	5	25	3	25	4	30	3	25	4
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**30**	**6**	**36**	**6**	**40**	**4**	**40**	**5**	**50**	**4**	**40**	**5**
	7			QT	275	930	25	5	30	5	30	3	30	4	40	4	35	5
	8			QT	300	1010	20	5	25	5	25	3	25	4	30	3	25	4
	9			QT	350	1180	-	-	18	4	-	-	-	-	25	3	20	4
	10	Steel - High alloy, cast & tool		A	200	680	20	5	**25**	**5**	25	3	25	4	**30**	**3**	**25**	**4**
	11			HT	325	1100	-	-	18	4	-	-	-	-	25	3	20	4
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	-	-	-	-	10	2	10	3	12	2	10	3
	13		Martensitic	QT	240	810	15	4	18	4	22	3	22	4	25	3	20	4
M	14.1	Stainless Steel	Austenitic	AH	180	610	-	-	18	5	-	-	-	-	20	3	16	4
	14.2		Duplex		230	780	-	-	15	3	-	-	-	-	15	1	12	3
	14.3		Precipitation Hardening		300	780	-	-	-	-	-	-	-	-	12	2	10	3
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	30	5	**35**	**5**	35	3	35	4	**40**	**3**	**32**	**4**
	16		Pearlitic		260	880	25	4	30	4	25	2	25	3	30	2	24	3
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	20	3	25	3	22	2	22	3	-	-	-	-
	18		Pearlitic		250	840	20	3	25	3	22	2	22	3	-	-	-	-
	19	Cast Iron - Malleable	Ferritic		130	460	20	3	25	3	22	2	22	3	-	-	-	-
	20		Pearlitic		230	780	20	3	25	3	22	2	22	3	-	-	-	-
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	**70**	**6**	85	6	**70**	**5**	**70**	**6**	75	5	60	6
	22		Heat Treatable	AH	100	360	**70**	**6**	85	6	**70**	**5**	**70**	**6**	75	5	60	6
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	50	5	55	5	55	4	55	5	60	4	45	5
	24		Heat Treatable	AH	90	320	50	5	55	5	55	4	55	5	60	4	45	5
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	30	6	35	6	-	-	-	-	50	4	35	5
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	25	5	30	5	40	4	40	5	40	4	32	5
	27		Brass (CuZn, CuSnZn)		90	320	-	-	-	-	-	-	-	-	-	-	-	-
	28		Bronze (CuSn)		100	360	50	6	55	6	70	5	70	6	75	5	60	6
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	-	-	-	-	-	-	-	-	-	-	-	-
	32			AH	280	950	-	-	-	-	-	-	-	-	-	-	-	-
	33		Ni / Co based	A	250	840	-	-	-	-	-	-	-	-	-	-	-	-
	34			AH	350	1180	-	-	-	-	-	-	-	-	-	-	-	-
	35			C	320	1080	-	-	-	-	-	-	-	-	-	-	-	-
	36	Titanium & Ti alloys	CP Titanium		400 MPa		-	-	-	-	-	-	-	-	-	-	-	-
	37.1		Alpha alloys		860 MPa		-	-	-	-	-	-	-	-	-	-	-	-
	37.2		Alpha / Beta alloys	A	960 MPa		-	-	-	-	-	-	-	-	-	-	-	-
	37.3			AH	1170 MPa		-	-	-	-	-	-	-	-	-	-	-	-
	37.4		Beta alloys	A	830 MPa		-	-	-	-	-	-	-	-	-	-	-	-
	37.5			AH	1400 MPa		-	-	-	-	-	-	-	-	-	-	-	-
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	-	-	-	-	-	-
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	-	-	**30**	**4**	25	-	25	3	**-**	**3**	**24**	**3**
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-	-	-

METRIC ENDMILLS (mm size)

Ø = nominal tool diameter (mm)
n = Spindle speed (RPM)
V_c = Cutting speed (m/min)
f_z = Feed rate per tooth (mm/tooth)
V_f = Feed rate (mm/min)
z = No. cutting edges
Q = Metal removal rate (cm³/min)
a_p = Cutting depth (mm)
a_e = Cutting width (mm)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad v_f = f_z \times z \times n$$

$$Q = \frac{a_p \times a_e \times v_f}{1000}$$

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	UNI
K	F	Cast Iron	GG	UNI
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al | W	UNI
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.





Catalogue Code	E202	E206	E151	E251 E255	E252
Material	HSS Co.8	HSS Co.8	SPM	SPM	SPM
Surface Finish	TiAlN	TiAlN	TiAlN	AlCrN	AlCrN
Sutton Designation	N	N	UNI	VA	VA
Geometry	R30 NF	R30 NF (Long)	R45 HRS	R30 VA-R	R30 VA-R (Long)
Type of Cut: *Slotting*					
Finishing					
Universal					
Roughing	●	●	●	●	●
Profiling					
↑↓ ap × Ø	1.5	1.5	1.0	1.0	1.0
←→ ae × Ø	0.25	0.25	0.5	0.5	0.5

ISO	VDI 3323	Material		Condition	HB	N/mm²	E202 Vc	E202 Feed #	E206 Vc	E206 Feed #	E151 Vc	E151 Feed #	E251/E255 Vc	E251/E255 Feed #	E252 Vc	E252 Feed #
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440	**50**	**9**	**50**	**9**	70	6	40	4	40	4
	2		- 0.45 %C	A	190	640	**50**	**9**	**50**	**9**	70	6	40	4	40	4
	3			QT	250	840	**50**	**9**	**50**	**9**	60	6	40	4	40	4
	4		- 0.75 %C	A	270	910	**50**	**9**	**50**	**9**	60	6	40	4	40	4
	5			QT	300	1010	**40**	**7**	**40**	**7**	**40**	**4**	**40**	**4**	**40**	**4**
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610	**50**	**9**	**50**	**9**	60	6	40	4	40	4
	7			QT	275	930	**50**	**9**	**50**	**9**	40	5	**40**	**4**	**40**	**4**
	8			QT	300	1010	**40**	**7**	**40**	**7**	**40**	**4**	**40**	**4**	**40**	**4**
	9			QT	350	1180	25	6	25	6	**30**	**4**	-	-	-	-
	10	Steel - High alloy, cast & tool		A	200	680	**40**	**7**	**40**	**7**	40	4	**40**	**4**	**40**	**4**
	11			HT	325	1100	25	6	25	6	**30**	**4**	-	-	-	-
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680	15	4	15	4	15	3	25	6	25	6
	13		Martensitic	QT	240	810	25	6	25	6	**30**	**4**	**30**	**4**	**30**	**4**
M	14.1	Stainless Steel	Austenitic	AH	180	610	**25**	**5**	**25**	**5**	25	4	**40**	**10**	**40**	**10**
	14.2		Duplex		230	780	**20**	**5**	**20**	**5**	15	2	**40**	**10**	**40**	**10**
	14.3		Precipitation Hardening		300	780	15	4	15	4	15	3	25	6	25	6
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610	**30**	**9**	**30**	**9**	**60**	**8**	-	-	-	-
	16		Pearlitic		260	880	30	9	30	9	40	8	-	-	-	-
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570	**30**	**9**	**30**	**9**	**25**	**8**	-	-	-	-
	18		Pearlitic		250	840	30	9	30	9	25	8	-	-	-	-
	19	Cast Iron - Malleable	Ferritic		130	460	30	9	30	9	**25**	**8**	-	-	-	-
	20		Pearlitic		230	780	30	9	30	9	25	8	-	-	-	-
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210	90	15	90	15	-	-	-	-	-	-
	22		Heat Treatable	AH	100	360	90	15	90	15	-	-	-	-	-	-
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270	60	15	60	15	80	8	-	-	-	-
	24		Heat Treatable	AH	90	320	60	15	60	15	80	8	-	-	-	-
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460	-	-	-	-	-	-	-	-	-	-
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390	**60**	**14**	**60**	**14**	-	-	-	-	-	-
	27		Brass (CuZn, CuSnZn)		90	320	80	10	80	10	-	-	-	-	-	-
	28		Bronze (CuSn)		100	360	**70**	**14**	**70**	**14**	-	-	-	-	-	-
	29	Non-metallic - Thermosetting & fiber-reinforced plastics					-	-	-	-	-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.					-	-	-	-	-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680	20	5	20	5	-	-	25	4	25	4
	32			AH	280	950	10	5	10	5	-	-	15	4	15	4
	33		Ni / Co based	A	250	840	20	5	20	5	-	-	25	4	25	4
	34			AH	350	1180	8	5	8	5	-	-	10	4	10	4
	35			C	320	1080	10	5	10	5	-	-	15	4	15	4
	36	Titanium & Ti alloys	CP Titanium		400 MPa		22	8	22	8	-	-	30	5	30	5
	37.1		Alpha alloys		860 MPa		18	8	18	8	-	-	15	4	15	4
	37.2		Alpha / Beta alloys	A	960 MPa		18	8	18	8	-	-	15	4	15	4
	37.3			AH	1170 MPa		12	8	12	8	-	-	12	4	12	4
	37.4		Beta alloys	A	830 MPa		18	8	18	8	-	-	15	4	15	4
	37.5			AH	1400 MPa		12	8	12	8	-	-	12	4	12	4
H	38.1	Hardened steel		HT	45 HRC		-	-	-	-	-	-	20	3	20	3
	38.2			HT	55 HRC		-	-	-	-	-	-	-	-	-	-
	39.1			HT	58 HRC		-	-	-	-	-	-	-	-	-	-
	39.2			HT	62 HRC		-	-	-	-	-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350	30	9	30	9	40	8	-	-	-	-
	41			HT	55 HRC		-	-	-	-	-	-	-	-	-	-

Condition: **A** (Annealed), **AH** (Age Hardened), **C** (Cast), **HT** (Hardened & Tempered), **QT** (Quenched & Tempered)

Bold = Optimal | Regular = Effective

Feed Table (f_z) (mm/tooth)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013	0.014	0.016	0.018	0.020	0.022	0.024	0.026	0.030
3	0.002	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.016	0.018	0.020	0.023	0.025	0.028	0.032	0.034	0.038	0.042
4	0.004	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.016	0.018	0.021	0.023	0.026	0.030	0.032	0.036	0.040	0.044	0.045	0.050
5	0.005	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.020	0.023	0.025	0.030	0.032	0.036	0.040	0.044	0.050	0.055	0.060	0.065
6	0.006	0.008	0.009	0.011	0.013	0.016	0.018	0.021	0.024	0.028	0.030	0.034	0.038	0.042	0.045	0.050	0.055	0.060	0.070	0.075
8	0.010	0.012	0.014	0.017	0.019	0.022	0.025	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.065	0.075	0.080	0.085	0.095
10	0.013	0.015	0.018	0.021	0.024	0.028	0.032	0.036	0.040	0.045	0.050	0.055	0.060	0.070	0.075	0.085	0.090	0.100	0.11	0.12
12	0.016	0.019	0.022	0.026	0.030	0.034	0.038	0.044	0.050	0.055	0.060	0.065	0.075	0.080	0.090	0.100	0.11	0.12	0.13	0.14
16	0.020	0.024	0.028	0.034	0.038	0.044	0.050	0.055	0.060	0.070	0.080	0.085	0.095	0.11	0.12	0.13	0.14	0.16	0.17	0.18
20	0.022	0.028	0.032	0.038	0.044	0.050	0.060	0.065	0.075	0.085	0.095	0.11	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.23
25	0.025	0.032	0.038	0.045	0.055	0.060	0.070	0.080	0.090	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.29

Notes on Milling

1. Above values are guidelines for the size and type of cut nominated.
2. For long series tools, reduce speed by 40% and feed by 20%.

sutton

ISO	VDI	Material Group	Sutton	
P	A	Steel	N	UNI
M	R	Stainless Steel	VA	
K	F	Cast Iron	GG	
N	N	Non-Ferrous Metals, Aluminiums & Coppers	Al W	
S	S	Titaniums & Super Alloys	Ti	Ni
H	H	Hard Materials (≥ 45 HRC)	H	

^ VDI 3323 material groups can also be determined by referring to the workpiece material cross reference listing. Refer to main index of this section.

							Catalogue Code	E456		E457		E458	
							Material	VHM					
							Surface Finish	TiAlN					
							Sutton Designation	N					
							Type of Cut:	Finishing					
ISO	VDI^ 3323	Material		Condition	HB	N/mm²		Vc	Feed #	Vc	Feed #	Vc	Feed #
P	1	Steel - Non-alloy, cast & free cutting	- 0.15 %C	A	125	440		180	16	180	15	180	16
	2		- 0.45 %C	A	190	640		180	16	180	15	180	16
	3			QT	250	840		100	16	100	15	100	16
	4		- 0.75 %C	A	270	910		100	16	100	15	100	16
	5			QT	300	1010		100	16	100	15	100	16
	6	Steel - Low alloy & cast < 5% of alloying elements		A	180	610		180	16	180	15	180	16
	7			QT	275	930		100	16	100	15	100	16
	8			QT	300	1010		100	16	100	15	100	16
	9			QT	350	1180		80	16	80	15	80	16
	10	Steel - High alloy, cast & tool		A	200	680		100	16	100	15	100	16
	11			HT	325	1100		80	16	80	15	80	16
	12	Steel - Corrosion resistant & cast	Ferritic / Martensitic	A	200	680		90	16	90	15	90	16
	13		Martensitic	QT	240	810		80	16	80	15	80	16
M	14.1	Stainless Steel	Austenitic	AH	180	610		90	16	90	15	90	16
	14.2		Duplex		230	780		90	16	90	15	90	16
	14.3		Precipitation Hardening		300	780		80	16	80	15	80	16
K	15	Cast Iron - Grey (GG)	Ferritic / Pearlitic		180	610		140	16	140	15	140	16
	16		Pearlitic		260	880		140	16	140	15	140	16
	17	Cast Iron - Nodular (GGG)	Ferritic		160	570		140	16	140	15	140	16
	18		Pearlitic		250	840		140	16	140	15	140	16
	19	Cast Iron - Malleable	Ferritic		130	460		100	16	100	15	100	16
	20		Pearlitic		230	780		100	16	100	15	100	16
N	21	Aluminum & Magnesium - wrought alloy	Non Heat Treatable		60	210		-	-	-	-	-	-
	22		Heat Treatable	AH	100	360		-	-	-	-	-	-
	23	Aluminum & Magnesium - cast alloy ≤12% Si	Non Heat Treatable		75	270		-	-	-	-	-	-
	24		Heat Treatable	AH	90	320		-	-	-	-	-	-
	25	Al & Mg - cast alloy >12% Si	Non Heat Treatable		130	460		-	-	-	-	-	-
	26	Copper & Cu alloys (Brass/Bronze)	Free cutting, Pb > 1%		110	390		-	-	-	-	-	-
	27		Brass (CuZn, CuSnZn)		90	320		-	-	-	-	-	-
	28		Bronze (CuSn)		100	360		-	-	-	-	-	-
	29	Non-metallic - Thermosetting & fiber-reinforced plastics						-	-	-	-	-	-
	30	Non-metallic - Hard rubber, wood etc.						-	-	-	-	-	-
S	31	High temp. alloys	Fe based	A	200	680		50	16	50	15	50	16
	32			AH	280	950		50	16	50	15	50	16
	33		Ni / Co based	A	250	840		50	16	50	15	50	16
	34			AH	350	1180		50	16	50	15	50	16
	35			C	320	1080		50	16	50	15	50	16
	36	Titanium & Ti alloys	CP Titanium		400 MPa			70	16	70	15	70	16
	37.1		Alpha alloys		860 MPa			70	16	70	15	70	16
	37.2		Alpha / Beta alloys	A	960 MPa			70	16	70	15	70	16
	37.3			AH	1170 MPa			70	16	70	15	70	16
	37.4		Beta alloys	A	830 MPa			70	16	70	15	70	16
	37.5			AH	1400 MPa			70	16	70	15	70	16
H	38.1	Hardened steel		HT	45 HRC			80	16	80	15	80	16
	38.2			HT	55 HRC			60	16	60	15	60	16
	39.1			HT	58 HRC			-	-	-	-	-	-
	39.2			HT	62 HRC			-	-	-	-	-	-
	40	Cast Iron	Chilled	C	400	1350		60	16	60	15	60	16
	41			HT	55 HRC			-	-	-	-	-	-

	Cat Code	C107		C108		C110	
	Material	HSS Co		HSS Co		HSS Co	
	Surf Fin	Brt		TiAlN		TiAlN	
	Sutton Des	N		UNI		UNI	
	Standard	90°					
ISO	VDI^ 3323	Vc	Feed #	Vc	Feed #	Vc	Feed #
P	1	36	3	44	3	20	3
	2	30	3	36	3	20	3
	3	30	2	36	2	20	3
	4	30	2	36	2	20	3
	5	14	1	16	1	20	3
	6	30	2	36	2	20	3
	7	18	2	22	2	20	3
	8	14	1	16	1	20	3
	9	-	-	10	1	20	3
	10	14	1	16	1	20	3
	11	-	-	10	1	20	3
	12	10	1	12	1	20	3
	13	-	-	10	1	20	3
M	14.1	12	2	14	2	20	3
	14.2	10	1	12	1	20	3
	14.3	10	1	12	1	20	3
K	15	24	2	28	2	15	4
	16	24	2	28	2	15	4
	17	20	2	25	2	15	4
	18	20	2	25	2	15	4
	19	20	2	25	2	15	4
	20	-	-	25	2	15	4
N	21	48	4	58	4	50	5
	22	48	4	58	4	50	5
	23	36	4	44	4	50	5
	24	36	4	44	4	50	5
	25	30	4	44	4	50	5
	26	78	2	94	2	50	5
	27	48	2	58	2	50	5
	28	60	2	72	2	50	5
	29	30	4	44	4	50	5
	30	-	-	-	-	50	5
S	31	5	2	8	2	15	3
	32	4	2	5	2	15	3
	33	5	2	8	2	15	3
	34	-	-	5	2	15	3
	35	-	-	5	2	15	3
	36	8	3	10	3	15	3
	37.1	7	3	9	3	15	3
	37.2	7	3	9	3	15	3
	37.3	-	-	8	2	15	3
	37.4	7	3	9	3	15	3
	37.5	-	-	8	2	15	3
H	38.1	-	-	-	-	10	2
	38.2	-	-	-	-	10	2
	39.1	-	-	-	-	-	2
	39.2	-	-	-	-	-	2
	40	24	2	28	2	10	-
	41	-	-	-	-	10	-

METRIC ENDMILLS (mm size)

- **Ø** = nominal tool diameter (mm)
- **n** = Spindel speed (RPM)
- $\mathbf{V_c}$ = Cutting speed (m/min)
- $\mathbf{f_z}$ = Feed rate per tooth (mm/tooth)
- $\mathbf{V_f}$ = Feed rate (mm/min)
- **z** = No. cutting edges
- **Q** = Metal removal rate (cm³/min)
- $\mathbf{a_p}$ = Cutting depth (mm)
- $\mathbf{a_e}$ = Cutting width (mm)

$$n = \frac{V_c \times 1000}{Ø \times \pi} \simeq \frac{V_c}{Ø} \times 318$$

$$V_c = \frac{n \times Ø \times \pi}{1000} \simeq \frac{n \times Ø}{318}$$

$$f_z = \frac{V_f}{z \times n} \qquad V_f = f_z \times z \times n$$

$$Q = \frac{a_p \times a_e \times V_f}{1000}$$

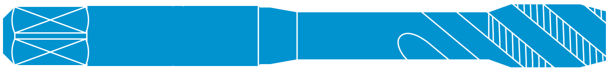
Feed Table (f) (mm/rev)

Ø	Feed # 1	2	3	4	5	6	7	8	9	10
2.0	0.020	0.025	0.030	0.040	0.050	0.060	0.075	0.095	0.120	0.15
3.0	0.030	0.035	0.045	0.055	0.070	0.090	0.110	0.135	0.17	0.21
4.0	0.040	0.045	0.060	0.075	0.090	0.115	0.140	0.18	0.22	0.27
5.0	0.045	0.055	0.070	0.090	0.110	0.135	0.17	0.21	0.26	0.32
6.0	0.055	0.065	0.080	0.100	0.125	0.16	0.19	0.24	0.30	0.37
8.0	0.070	0.085	0.105	0.130	0.16	0.20	0.25	0.31	0.38	0.47
10.0	0.085	0.105	0.125	0.16	0.19	0.24	0.30	0.37	0.46	0.56
12.0	0.095	0.120	0.15	0.18	0.23	0.28	0.34	0.42	0.52	0.64
16.0	0.125	0.15	0.19	0.23	0.29	0.36	0.44	0.54	0.66	0.82
20.0	0.15	0.18	0.23	0.28	0.34	0.42	0.52	0.64	0.80	0.98
25.0	0.18	0.22	0.27	0.33	0.41	0.50	0.60	0.74	0.90	1.10

sutton

Code	Problem
1	Breaking of drill
2	Outer corner breaks down
3	Cutting edges chip
4	Drill splits up centre
5	Drill will not enter work
6	Hole rough
7	Hole oversize
8	Tang breaks

1	2	3	4	5	6	7	8	Possible Reason	Solution
•				•	•			Dull point	Sharpen
•								Drill has front taper due to wearing	Sharpen
•			•	•				Insufficient lip clearance on point	Grind correctly
•		•						Lip clearance too great	Regrind to correct clearance angle
•								Drill in incorrectly point ground	Regrind correctly
•	•							Flutes clogged with chips	Remove drill from hole and to clear flutes
•								Spring or backlash in drill press, fixture or work	Check each item for rigidity and alignment
•		•	•		•			Feed too heavy	Reduce Feed
	•							Cutting speed too high	Reduce speed
	•				•			Dry cutting, no lubricant at cutting edges	Apply cutting fluid
				•				Drill web (core) diameter too big	Thin web to original size
					•			Fixture/Clamping not rigid	Secure job firmly
						•		Unequal angle or uneven length of cutting edges	Regrind to same lip lengths and angles
						•		Spindle run-out/Loose spindle	Check machine
							•	Bad fit between shank taper & socket. The drive & alignment is controlled by the taper fit	Remove dirt, nicks or burrs, or replace worn socket

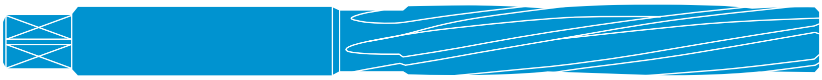


Code	Problem
1	Thread is oversize
2	Axial miscutting of thread
3	Thread is undersize
4	Thread has bellmouthed entry
5	Thread surface is rough and unclean
6	Low tool life
7	Partial or complete tap breakage on FORWARD or BACKWARD movement

1	2	3	4	5	6	7	Possible reason	Solution
●		●	●	●	●	●	Wrong tap, cutting geometry of the tap is not suitable for this operation	Use correct tap for the material group (see Expert Tool System, at www.suttontools.com)
●				●	●		Tap hole diameter is undersize	Tap hole diameter should be in accordance to DIN336 or respective standard. For cold forming taps, a special hole diameter is needed.
●			●			●	Misalignment - tap hole position, or angle is not correct	a) check workpiece clamping b) check machine settings
●							The axial machine spindle movement is not free and easy	a) use mechanical feed b) use tap holder with length compensation
●							Cold welding on the thread flanks of the tap	a) use a new tap b) improve and check lubrication c) remove cold welding area from tap d) use tap with surface treatment or coatings
●							Poor guidance of the tap because of little thread depth	a) use mechanical feed b) use tap that has better guiding characteristics
●				●	●		Speed is too high	a) improve lubrication b) lower speed
●				●	●		Chip clogging	a) use tap with different flute form b) use coated taps c) use tap set
●				●	●		The lubrication wrong, additives or the coolant supply is not sufficient	Make sure that the coolant is correct and that the supply is sufficient
	●						Spiral fluted taps are over pressured in the initial cutting phase (retracting pulling force)	Spiral fluted taps should only be lightly pushed into the tap hole until it begins to cut. The tap holder should immediately begin to apply tension to the tap.
	●						Spiral pointed taps (gun taps) are not receiving enough pressure in the initial cutting phase	Spiral pointed taps and even left hand spiral flute taps must have a stronger pressure until they begin to cut. The tap holder should immediately begin to apply pressure to the tap (pushing force)
●		●					Tolerance on the tap is not identical to the tolerance on the drawing or on the gauge	Use a tap which has a correct tolerance
			●				Wrong initial cutting pressure has been used or the machine spindle is not moving along its axis free and easy	a) use mechanical feed b) use tap holder with length compensation
				●	●		Tap is over loaded, either from coarse pitch and/or tough material	Use set of taps
					●		Cold welding, material build-up (pick-up)	a) improve coolant supply, use taps with surface treatments or coatings b) check if surface treatment is correct for this application
					●	●	Hardened walls in drilled hole	a) use drill best suited to material being drilled b) use new drill or boring tool c) resharpen drilling or boring tools d) if possible, heat treatment and coatings should only be made after threading
						●	Over loading of teeth in the chamfer area	a) use a longer chamfer (check if the tap hole is blind hole or through) b) use increased number of teeth in the chamfer area by selecting tap with increased number of flutes
						●	Tap hole chamfer is missing or wrong	Countersink tap hole chamfer with correct angle
						●	Tap crashed against the bottom of tap hole	Use tap holder with length compensation and over load clutch

Code	Problem	Possible Reason
1	Poor workpiece finish	Cutting edge wear, cutter radial run-out
2	Splintering of workpiece edge	Unsuitable cutting conditions, unsuitable shape of cutting edge
3	Non-parallel or uneven surface	Low stiffness of the cutter or of the workpiece (loose)
4	Extreme flank wear	
5	Extreme crater wear	
6	Breaks and shelling due to thermal shock	Unsuitable cutting conditions, unsuitable shape of cutting edge
7	Formation of built-up edges	
8	Poor chip clearance, chip blockage	
9	Lack of Rigidity	Difficult cutting conditions, clamping of the workpiece
10	End mill cutter breaks	Unsuitable cutting conditions, flute length of the cutter

1	2	3	4	5	6	7	8	9	10	Solution
●						●	●			increase cutting speed
			●	●				●		reduce cutting speed
						●	●			increase feed rate
●	●	●		●	●		●	●	●	reduce feed rate
●	●	●		●	●			●	●	reduce cutting depth
							●	●	●	change cutter diameter and cut width
●			●	●		●	●			check use of cooling lubricant, flush swarf away
	●	●	●	●	●	●	●	●		increase clearance angle (Radial relief)
	●			●	●					increase wedge angle (Rake angle)
	●									increase number of teeth
		●					●	●	●	reduce number of teeth
							●			select larger chip space (Cutter)
●	●	●	●		●					change shape of minor cutting edge
		●			●					cutter - change radial run-out
	●	●			●			●	●	change cutter stiffness, flue length (l/D ratio)
	●	●			●			●		select machine with higher power and stiffness



Code	Problem
1	Breakage
2	Excessive wear
3	Chattering
4	Poor surface finish

1	2	3	4	Possible reason	Solution
●		●		Dirt or burrs in spindle or socket in which reamer is held	clean spindle
●	●			Misalignment of two or more parts of the set-up. This condition can cause a bell-mouthed hole	align holes or use bridge style reamer
●	●	●	●	Too fast or too slow speeds	adjust
●	●	●	●	Too much or too little feed	adjust
	●			Wrong type of coolant	refer to lubricant supplier's literature
●				No lubricant between guide bushing and reamer	apply
	●		●	Lack of lubricant	increase
●				Bottoming in blind holes	reduce depth travel of reamer
		●		Lack of sufficient stock to ream	drill smaller hole
●	●		●	Too much stock to ream	drill larger hole
●		●		Entering work too fast	slow down the approach feed, until all cutting edges are located in the hole
●	●	●	●	Badly drilled holes – too rough, tapered or bell-mouthed. Bell-mouthed holes may cause the reamer to wedge rather than cut	replace drill
●		●		Oversize or undersize bushings	use suitable bush
●		●		Lack of rigidity in machine or work holder	improve rigidity
●	●		●	Improperly designed reamer for the job	use a different reamer

Trade Name	Coating	Coating Structure	Micro-hardness	Coeff. of Friction vs Steel	Thermal Stability	Colour	Application and Benefits
Brt	-	-	-	0.8 – 1.0	-	-	• For general purpose applications
Blu	Steam Oxide	-	-	0.8 – 1.0	-	Blue - Black	• For ferrous metals • Prevents chip build-up on the cutting edges, especially in low carbon steels • Oxide layer protects surface • Good carrier of lubricants
ASX	TiB2-based	Mono Layer	>4000 HV	<0.1	up to 900°C	Silver	• For high-performance machining of aluminum and aluminum alloys • ASX prevents the formation of built-up edges to a particularly large extent • Reduces friction on the face and makes machining easier • High degree of hardness also guarantees excellent wear protection
CrN	Chromium Nitride	Gradient Coating	1750 HV	0.5	up to 1292°F	Silver - Grey	• Cutting and forming of copper, nickel, and monel metal • Enhanced thermal stability and oxidation resistance • Excellent corrosion resistance • Low internal stress of coating results in excellent adhesion under high loads
TiN	Titanium Nitride	Mono Layer	2300 HV	0.4	up to 1112°F	Gold - Yellow	• General purpose use • Wide range of materials • 3 to 8 times longer tool life than uncoated tools • Higher tool speeds and feeds than uncoated tools
TiCN	Titanium Carbonitride	Gradient Coating	3000 HV	0.4	up to 752°F	Blue - Grey	• High performance applications • Difficult to machine materials • Abrasive materials - cast iron and aluminium alloys • Adhesive materials - copper and copper based alloys
Futura Nano (TiAlN)	Titanium Aluminium Nitride	Nano Layer	3300 HV	0.3 – 0.35	up to 1652°F	Violet - Grey	• Abrasive materials – cast iron and heat treated steel • Difficult to machine materials, such as stainless steel • Higher speeds and feeds • Reduces or eliminates use of coolants
Latuma	AlTiN based	Arc	>3500 HV	-	upto 1000°C	Grey	• For challenging conditions • Highly resistant to crater wear and oxidation • Ideal for wet and dry machining
Pertura	Highly resis-tant to crater wear and oxidation	Nano Layer	3300 HV	0.3	1000 deg C	Aubergine - Grey	• Versatile application in high end drilling • High tool lifetimes • Trouble-free chip transport • Reduction of cutting forces • Extremely high service life, even with deep-hole and dry drilling
Xceed	Ideal for wet and dry machining"	Nano Layer	3300 HV	0.4	up to 900°C	Blue - Grey	• Hard materials • Difficult to machine materials, eg. Ti alloys, Inconel • High speeds and feeds • Dry or MQL machiningw • Machining of hardened steels (>52HRC)
Alcrona (AlCrN)	Aluminium Chromium Nitride	Mono Layer	3200 HV	0.35	up to 2012°F	Blue - Grey	• Low alloy steels and high tensile steels • Hardened steels up to 54 HRC • Ideal for carbide tools
Durana	AlTiN/ TiSiXN	Mono Layer	>3800 HV	<0.4	up to 1000°C	Bronze	• AlTiN-based and TiSiXN layers gives Durana a high degree of ductility and superior abrasive wear resistance • Hugely improved performance during demanding machining operations.
Helica	Alcrona based	Multi Layer	3000 HV	0.25	up to 1100°C	Copper	• Longer tool life • Higher cutting speeds and feeds • Superb chip evacuation • Greater number of regrinds • Improved drill hole quality • Excellent performance in abrasive material
TiSiN	TiSi based	Multi Layer	3600 HV	0.3	<1200°C	Copper	• Suitable for high speed (wet / dry) and hard machining for difficult materials above 52 HRC. • Suitable for high speed machining with hardened steels above 60 HRC to maximum of 63 HRC • Vc and Vf = +50%
TiSiNos	AlTiSiN based	Mono Layer	>3800 HV	<0.4	up to 1000°C	Bronze	• Latest generation PVD coating for long tool life in difficult to machine materials, such as Super Alloys & Stainless Steels
Aldura	TiAlN + AlCrN	Multi Layer	3300 HV	<0.4	>1100°C	Blue - Grey	• High speed machining • Suitable for minimum quantity lubrication (MQL) and dry machining • Machining of hardened steels (>60HRC) • Ideal for carbide tools
AlNova	Alcrona based	Multi Layer	3200 HV	0.35	>1100°C	Light Grey	• Even high thermal stresses hardly effect the superior hardness of the coating • Its high hot hardness results in excellent abrasion resistance even at high cutting speeds
Hardlube	TiAlN + WC/C	Nano Layer	3000 HV	0.15 – 0.20	up to 1472°F	Dark Grey	• Excellent friction and lubricating properties of the coating provide optimal chip flow • Tapping and drilling of hard to machine materials • Suitable for minimum quantity lubrication (MQL) and dry machining
HCR	ta-C-based	Advanced Arc	>5000 HV	<0.1	up to 500°C	Rainbow-dark grey-black	• For machining non-ferrous metals as well as composite and plastic materials. • sp3 content of 60 – 70% • Hard coating maintains cutting edge sharpness in machining abrasive materials

Abbreviations	Type	Application	Description
HSS	Conventional high speed steel	Standard tool material for most common applications	Used for the manufacturing of cutting tools such as twist drills, endmills and taps.
HSS Co	5% cobalt grade of high speed steel	High-heat resistance, especially suited for roughing or when coolant insufficient	Cobalt alloyed, tungsten-molybdenum high speed steel possessing high hardness, excellent cutting properties, high-red hardness and good toughness.
HSSE Co 8%	8% cobalt grade of high speed steel	Increased heat resistance and hardness, suitable for difficult-to-machine materials	Available for applications that require a strong resistance to softening at elevated cutting temperatures. The ability of the steel to maintain its “red-hot hardness” is provided by the addition of cobalt. The high hot hardness is required for machining difficult materials such as nickel-base, titanium and highly alloyed steel.
HSSE	Premium grade of high speed steel	Wide range of machine taps	Vanadium grade gives high wear resistance and toughness for most tapping applications.
PM-HSSE V3	Powdered metallurgy - vanadium grade of high speed steel	Materials with hardness up to 40 HRC Difficult-to-machine materials eg. stainless steels	PM-HSS V3 for higher performance tools, incorporates very fine and uniform grain structure allowing a high hardness to be achieved, whilst maintaining good toughness.
PM-HSS Co	Powdered metallurgy - 8% Cobalt grade of high speed steel	Materials with hardness up to 45 HRC	The addition of cobalt provides this material with the ability to maintain its strength and hardness level when exposed to extremely high cutting temperatures. This makes PM-HSS Co suitable for heavy duty tapping, in materials such as high alloyed steels to non-ferrous metals like Ni-base alloys & Ti-alloys.
SPM	Powdered metallurgy - 11% Cobalt grade of high speed steel	Special applications, requiring very high edge hardness. Cutting tools with the appropriate geometry can be applied to workpiece materials with hardness up to 55 HRC	An excellent bridge material between high speed steel and carbide. SPM offers very high red hardness, wear resistance and the highest compressive strength of any high speed steel.
VHM	Sub-micron grade of solid Carbide (ISO K15-K30)	Tapping hardened steel	Ultra fine grain type (0.8µm) with maximum toughness & high hardness, therefore especially recommended for rotating tools to machine hardened parts.
VHM	Sub-micron grade of solid Carbide (ISO K40)	Sutton standard grade for endmills & drills	Ultra fine grain type (0.6µm) offers the ideal combination of hardness & toughness for high performance drilling & general milling applications
VHM-ULTRA	Sub-micron grade of solid Carbide (ISO K40-K50)	High performance grade for endmills	Ultra fine grain type (0.5µm) offers the best wear resistance for high performance milling applications.

Computer controlled vacuum heat treatment ensures consistent high quality

Metric	Imperial	Inch	Gauge
0.010		0.0004	
0.100		0.0039	
0.150		0.0059	97
0.160		0.0063	96
0.170		0.0067	95
0.180		0.0071	94
0.190		0.0075	93
0.200		0.0079	92
0.210		0.0083	91
0.220		0.0087	90
0.230		0.0091	89
0.240		0.0094	88
0.254		0.0100	87
0.270		0.0106	86
0.280		0.0110	85
0.290		0.0114	84
0.300		0.0118	
0.305		0.0120	83
0.317		0.0125	82
0.330		0.0130	81
0.343		0.0135	80
0.368		0.0145	79
0.397	1/64	0.0156	
0.400		0.0157	
0.406		0.0160	78
0.457		0.0180	77
0.500		0.0197	
0.508		0.0200	76
0.533		0.0210	75
0.572		0.0225	74
0.600		0.0236	
0.610		0.0240	73
0.635		0.0250	72
0.660		0.0260	71
0.700		0.0276	
0.711		0.0280	70
0.742		0.0292	69
0.787		0.0310	68
0.794	1/32	0.0313	
0.800		0.0315	
0.813		0.0320	67
0.838		0.0330	66
0.889		0.0350	65
0.900		0.0354	
0.914		0.0360	64
0.940		0.0370	63
0.965		0.0380	62
0.991		0.0390	61
1.000		0.0394	
1.016		0.0400	60
1.041		0.0410	59
1.067		0.0420	58

Metric	Imperial	Inch	Gauge
1.092		0.0430	57
1.181		0.0465	56
1.191	3/64	0.0469	
1.321		0.0520	55
1.397		0.0550	54
1.500		0.0591	
1.511		0.0595	53
1.588	1/16	0.0625	
1.613		0.0635	52
1.702		0.0670	51
1.778		0.0700	50
1.854		0.0730	49
1.900		0.0748	
1.930		0.0760	48
1.984	5/64	0.0781	
1.994		0.0785	47
2.000		0.0787	
2.057		0.0810	46
2.083		0.0820	45
2.184		0.0860	44
2.261		0.0890	43
2.375		0.0935	42
2.381	3/32	0.0938	
2.438		0.0960	41
2.489		0.0980	40
2.500		0.0984	
2.527		0.0995	39
2.578		0.1015	38
2.642		0.1040	37
2.705		0.1065	36
2.778	7/64	0.1094	
2.794		0.1100	35
2.819		0.1110	34
2.870		0.1130	33
2.946		0.1160	32
3.000		0.1181	
3.048		0.1200	31
3.100		0.1220	
3.175	1/8	0.1250	
3.200		0.1260	
3.264		0.1285	30
3.300		0.1299	
3.400		0.1339	
3.454		0.1360	29
3.500		0.1378	
3.569		0.1405	28
3.572	9/64	0.1406	
3.600		0.1417	
3.658		0.1440	27
3.700		0.1457	
3.734		0.1470	26
3.797		0.1495	25

Metric	Imperial	Inch	Gauge
3.800		0.1496	
3.861		0.1520	24
3.900		0.1535	
3.912		0.1540	23
3.969	5/32	0.1563	
3.988		0.1570	22
4.000		0.1575	
4.039		0.1590	21
4.089		0.1610	20
4.100		0.1614	
4.200		0.1654	
4.216		0.1660	19
4.300		0.1693	
4.305		0.1695	18
4.366	11/64	0.1719	
4.394		0.1730	17
4.400		0.1732	
4.496		0.1770	16
4.500		0.1772	
4.572		0.1800	15
4.600		0.1811	
4.623		0.1820	14
4.700		0.1850	13
4.762	3/16	0.1875	
4.800		0.1890	12
4.851		0.1910	11
4.900		0.1929	
4.915		0.1935	10
4.978		0.1960	9
5.000		0.1969	
5.055		0.1990	8
5.100		0.2008	
5.105		0.2010	7
5.159	13/64	0.2031	
5.182		0.2040	6
5.200		0.2047	
5.220		0.2055	5
5.300		0.2087	
5.309		0.2090	4
5.400		0.2126	
5.410		0.2130	3
5.500		0.2165	
5.556	7/32	0.2188	
5.600		0.2205	
5.613		0.2210	2
5.700		0.2244	
5.791		0.2280	1
5.800		0.2283	
5.900		0.2323	
5.944		0.2340	A
5.953	15/64	0.2344	
6.000		0.2362	

Metric	Imperial	Inch	Gauge
6.045		0.2380	**B**
6.100		0.2402	
6.147		0.2420	**C**
6.200		0.2441	
6.248		0.2460	**D**
6.300		0.2480	
6.350	**1/4**	0.2500	**E**
6.400		0.2520	
6.500		0.2559	
6.528		0.2570	**F**
6.600		0.2598	
6.629		0.2610	**G**
6.700		0.2638	
6.747	**17/64**	0.2656	
6.756		0.2660	**H**
6.800		0.2677	
6.900		0.2717	
6.909		0.2720	**I**
7.000		0.2756	
7.036		0.2770	**J**
7.100		0.2795	
7.137		0.2810	**K**
7.144	**9/32**	0.2813	
7.200		0.2835	
7.300		0.2874	
7.366		0.2900	**L**
7.400		0.2913	
7.493		0.2950	**M**
7.500		0.2953	
7.541	**19/64**	0.2969	
7.600		0.2992	
7.671		0.3020	**N**
7.700		0.3031	
7.800		0.3071	
7.900		0.3110	
7.938	**5/16**	0.3125	
8.000		0.3150	
8.026		0.3160	**O**
8.100		0.3189	
8.200		0.3228	
8.204		0.3230	**P**
8.300		0.3268	
8.334	**21/64**	0.3281	
8.400		0.3307	
8.433		0.3320	**Q**
8.500		0.3346	
8.600		0.3386	
8.611		0.3390	**R**
8.700		0.3425	
8.731	**11/32**	0.3438	
8.800		0.3465	
8.839		0.3480	**S**

Metric	Imperial	Inch	Gauge
8.900		0.3504	
9.000		0.3543	
9.093		0.3580	**T**
9.100		0.3583	
9.128	**23/64**	0.3594	
9.200		0.3622	
9.300		0.3661	
9.347		0.3680	**U**
9.400		0.3701	
9.500		0.3740	
9.525	**3/8**	0.3750	
9.576		0.3770	**V**
9.600		0.3780	
9.700		0.3819	
9.800		0.3858	
9.804		0.3860	**W**
9.900		0.3898	
9.922	**25/64**	0.3906	
10.000		0.3937	
10.084		0.3970	**X**
10.200		0.4016	
10.262		0.4040	**Y**
10.319	**13/32**	0.4063	
10.490		0.4130	**Z**
10.500		0.4134	
10.716	**27/64**	0.4219	
10.800		0.4252	
11.000		0.4331	
11.112	**7/16**	0.4375	
11.200		0.4409	
11.500		0.4528	
11.509	**29/64**	0.4531	
11.800		0.4646	
11.906	**15/32**	0.4688	
12.000		0.4724	
12.200		0.4803	
12.303	**31/64**	0.4844	
12.500		0.4921	
12.700	**1/2**	0.5000	
12.800		0.5039	
13.000		0.5118	
13.097	**33/64**	0.5156	
13.494	**17/32**	0.5313	
13.500		0.5315	
13.891	**35/64**	0.5469	
14.000		0.5512	
14.288	**9/16**	0.5625	
14.500		0.5709	
14.684	**37/64**	0.5781	
15.000		0.5906	
15.081	**19/32**	0.5938	
15.478	**39/64**	0.6094	

Metric	Imperial	Inch	Gauge
15.500		0.6102	
15.875	**5/8**	0.6250	
16.000		0.6299	
16.272	**41/64**	0.6406	
16.500		0.6496	
16.669	**21/32**	0.6563	
17.000		0.6693	
17.066	**43/64**	0.6719	
17.462	**11/16**	0.6875	
17.500		0.6890	
17.859	**45/64**	0.7031	
18.000		0.7087	
18.256	**23/32**	0.7188	
18.500		0.7283	
18.653	**47/64**	0.7344	
19.000		0.7480	
19.050	**3/4**	0.7500	
19.447	**49/64**	0.7656	
19.500		0.7677	
19.844	**25/32**	0.7813	
20.000		0.7874	
20.241	**51/64**	0.7969	
20.500		0.8071	
20.638	**13/16**	0.8125	
21.000		0.8268	
21.034	**53/64**	0.8281	
21.431	**27/32**	0.8438	
21.500		0.8465	
21.828	**55/64**	0.8594	
22.000		0.8661	
22.225	**7/8**	0.8750	
22.500		0.8858	
22.622	**57/64**	0.8906	
23.000		0.9055	
23.019	**29/32**	0.9063	
23.416	**59/64**	0.9219	
23.500		0.9252	
23.812	**15/16**	0.9375	
24.000		0.9449	
24.209	**61/64**	0.9531	
24.500		0.9646	
24.606	**31/32**	0.9688	
25.000		0.9843	
25.003	**63/64**	0.9844	
25.400	**1**	1.0000	

Tensile Strength vs Hardness (≈)

Tensile Strength			Hardness	
N/mm²	**Kg/mm²**	**Tons/Inch²**	**Brinell [HB]**	**Rockwell [HRC (HRB)]**
400	40.8	26.0	119	69 HRB
450	45.9	29.0	133	75 HRB
500	50.1	32.4	149	81 HRB
550	56.0	35.6	163	85.5 HRB
600	61.0	38.9	178	89 HRB
650	66.2	42.1	193	92 HRB
700	71.4	45.3	208	95 HRB
750	76.5	48.5	221	97 HRB
800	81.6	51.8	238	22 HRC
850	86.7	55.1	252	25 HRC
900	91.8	58.3	266	27 HRC
1000	102.0	64.7	296	31 HRC
1100	112.2	71.2	325	35 HRC
1200	122.4	77.7	354	38 HRC
1300	132.6	84.1	383	41 HRC
1400	142.8	90.5	408	44 HRC
1500	152.9	97.0	444	47 HRC
1600	163.1	103.5	461	49 HRC
1700	173.3	109.9	477	50 HRC
1800	183.5	116.4	514	52 HRC
1900	193.7	122.9	549	54 HRC
2000	203.9	129.3	584	56 HRC
2100	214.1	135.8	607	57 HRC
2200	224.3	142.2	622	58 HRC
2300	233.1	148.7	653	60 HRC

Conversion of values depends on the actual alloy content; this chart therefore indicates a general conversion only.

Manufacturing Tolerances

Nominal Diameter in mm above	up to and including	Tolerance Grade in Microns									1 Micron = 0.001mm			
		e8	h5	h6	h7	h8	h9	h10	js12	js14	k8	k9	k10	m7
0	3	-14	0	0	0	0	0	0	+50	+125	+14	+25	+40	+12
		-18	-4	-6	-10	-14	-25	-40	-50	-125	0	0	0	+2
3	6	-20	0	0	0	0	0	0	+60	+150	+18	+30	+48	+16
		-38	-5	-8	-12	-18	-30	-48	-60	-150	0	0	0	+4
6	10	-25	0	0	0	0	0	0	+75	+180	+22	+36	+58	+21
		-47	-6	-9	-15	-22	-36	-58	-75	-180	0	0	0	+6
10	18	-32	0	0	0	0	0	0	+90	+215	+27	+43	+70	+25
		-59	-8	-11	-18	-27	-43	-70	-90	-215	0	0	0	+7
18	30	-40	0	0	0	0	0	0	+105	+260	+33	+52	+84	+29
		-73	-9	-13	-21	-33	-52	-84	-105	-260	0	0	0	+8
30	50	-50	0	0	0	0	0	0	+125	+310	+39	+62	+100	+34
		-89	-11	-16	-25	-39	-62	-100	-125	-310	0	0	0	+9
50	80	-60	0	0	0	0	0	0	+150	+370	+46	+74	+120	+41
		-106	-13	-19	-30	-46	-74	-120	-150	-370	0	0	0	+11
80	120	-72	0	0	0	0	0	0	+175	+435	+54	+87	+140	+48
		-126	-15	-22	-35	-54	-87	-140	-175	-435	0	0	0	+13

Conversion: 1 micron equals .00004 inches

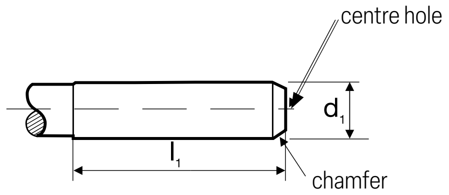
High Speed Steel Straight Shanks

DIN 1835

Form A (plain)

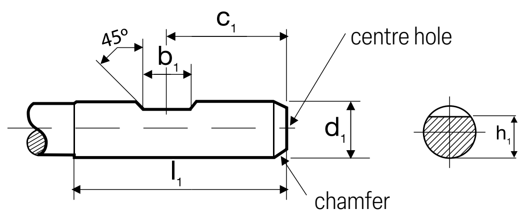
d_1 h6	l_1 +2 -0
3	28
4	28
5	28
6	36
8	36
10	40
12	45

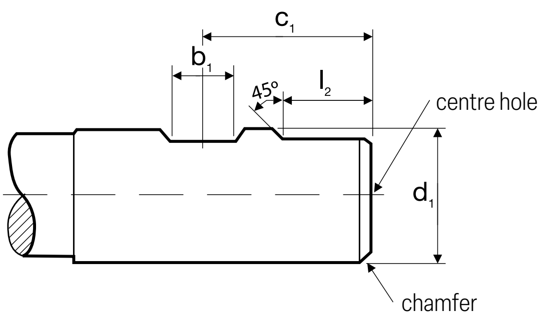
d_1 h6	l_1 +2 -0
16	48
20	50
25	56
32	60
40	70
50	80
63	90



Form B (with drive flat)

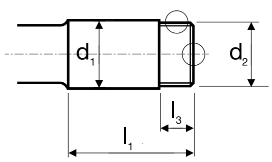
d_1 h6	b_1 +0.05 -0	c_1 0 -1	h_1 h13	l_1 +2 -0	l_2 +1 -0
6	4.2	18	4.8	36	-
8	5.5	18	6.6	36	-
10	7	20	8.4	40	-
12	8	22.5	10.4	45	-
16	10	24	14.2	48	-
20	11	25	18.2	50	-
25	12	32	23	56	17
32	14	36	30	60	19
40	14	40	38	70	19
50	18	45	47.8	80	23
63	18	50	60.8	90	23



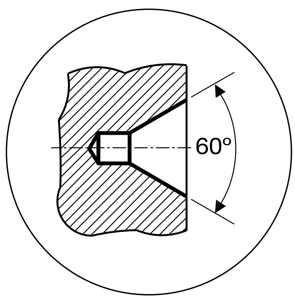


Form D (screwed shank)

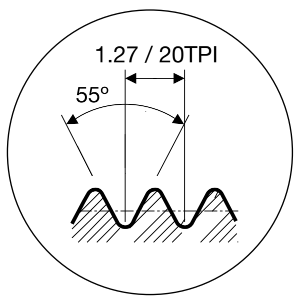
d_1	l_1 +2 -0	l_3 +1 -0	d_2
6	36	10	5.9
10	40	10	9.9
12	45	10	11.9
16	48	10	15.9
20	50	15	19.9
25	56	15	24.9
32	60	15	31.9



thread undercut or
thread runout released



centering hole



thread profile
DIN ISO 228
Whitworth Form

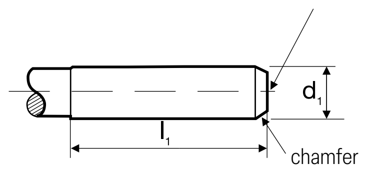
Carbide Straight Shanks

Form HA (plain)

d_1 h6	l_1 +2 -0
2	28
3	28
4	28
5	28
6	36
8	36
10	40

DIN6535

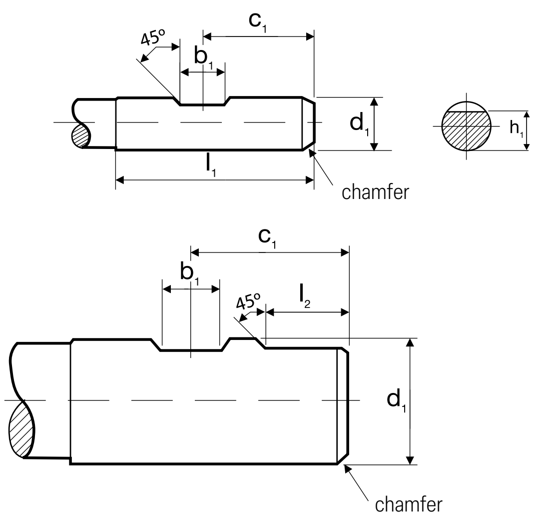
d_1 h6	l_1 +2 -0
12	45
14	45
16	48
18	48
20	50
25	56
32	60



Form HB (with drive flat)

d_1 h6	b_1 +0.05 -0	c_1 0 -1	h_1 h11	l_1 +2 -0	l_2 +1 -0
6	4.2	18	5.1	36	-
8	5.5	18	6.9	36	-
10	7	20	8.5	40	-
12	8	22.5	10.4	45	-
14	8	22.5	12.7	45	-
16	10	24	14.2	48	-
18	10	24	16.2	48	-
20	11	25	18.2	50	-
25	12	32	23	56	17
32	14	36	30	60	19

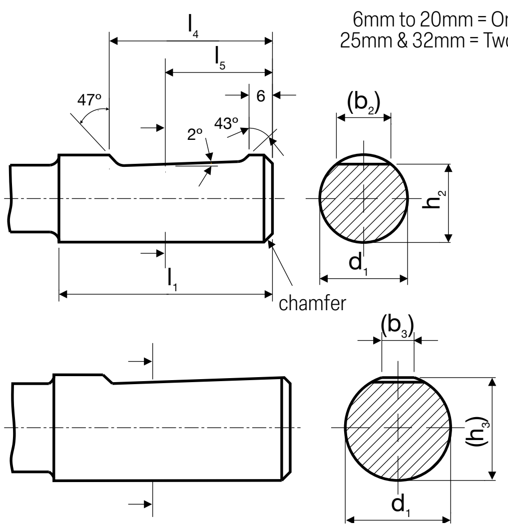
6mm to 20mm = One Drive Flat
25mm & 32mm = Two Drive Flats



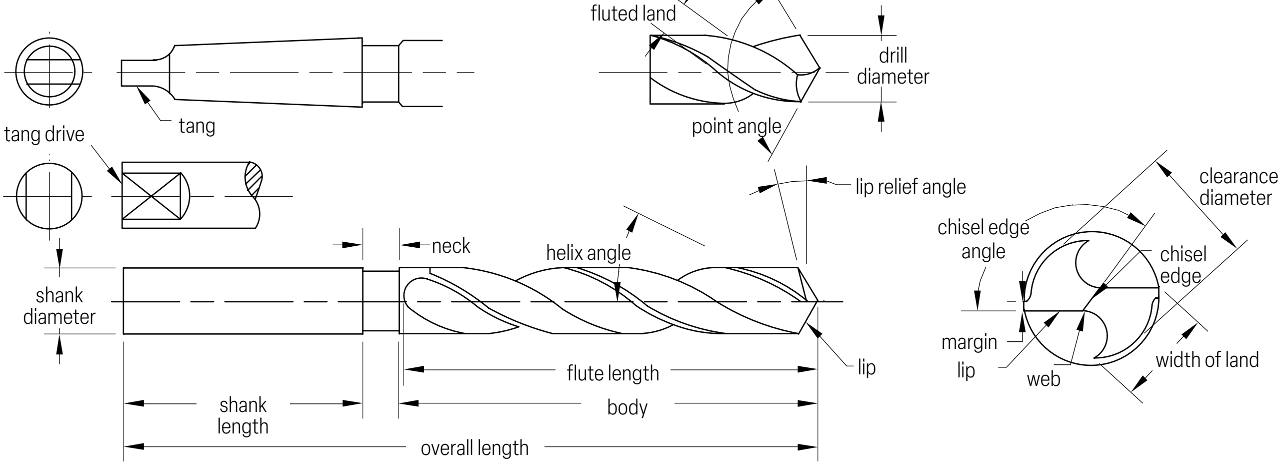
Form HE (with whistle notch flat)

d_1 h6	b_2	b_3	h_2 h11	h_3	l_1 +2 0	l_4 0 -1	l_5
6	4.3	-	5.1	-	36	25	18
8	5.5	-	6.9	-	36	25	18
10	7.1	-	8.5	-	40	28	20
12	8.2	-	10.4	-	45	33	22.5
14	8.1	-	12.7	-	45	33	22.5
16	10.1	-	14.2	-	48	36	24
18	10.8	-	16.2	-	48	36	24
20	11.4	-	18.2	-	50	38	25
25	13.6	9.3	23	24.1	56	44	32
32	15.5	9.3	30	31.2	60	48	35

6mm to 20mm = One Drive Flat
25mm & 32mm = Two Drive Flats



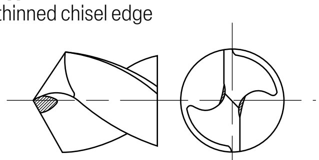
Drill Definitions



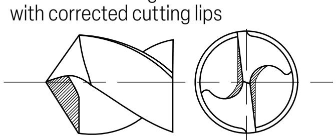
*Drills manufactured to ANSI B94-11. The overall length and flute length are measured to the corner of the outer lip.

Drill Point Types (DIN1412)

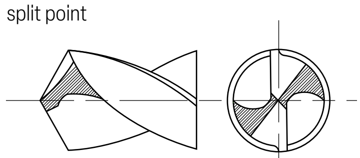
Type A
thinned chisel edge



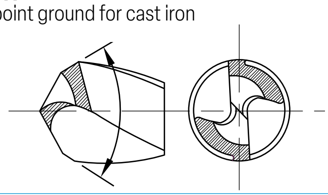
Type B
thinned chisel edge
with corrected cutting lips



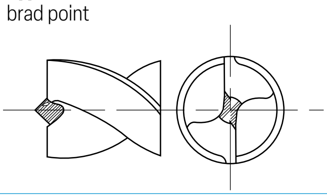
Type C
split point



Type D
point ground for cast iron



Type E
brad point



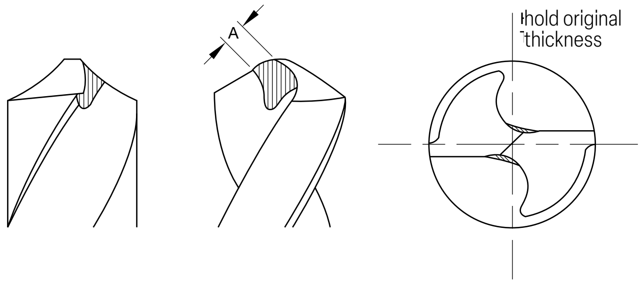
Drill Tolerances DIN / ISO 286, Part 2

Drill Diameter at Point (mm)		Diameter Tolerance h8 (mm)		Back Taper (mm)		
Over	Inclusive	Plus (+)	Minus (-)	(Tapering of Diameter)†		
0.20	3.00	0.000	0.014	0.000	to	0.008
3.00	6.00	0.000	0.018	0.002	to	0.008
6.00	10.00	0.000	0.022	0.002	to	0.009
10.00	18.00	0.000	0.027	0.003	to	0.011
18.00	30.00	0.000	0.033	0.004	to	0.015
30.00	50.00	0.000	0.039	0.004	to	0.015

† The Drill diameter usually reduces towards the shank end; tolerance per 10mm of flute length.

Web Thinning

On most drills the web increases in thickness towards the shank with the result that, as the drill is shortened by repeated sharpening, the chisel edge will become wider. As the chisel edge does not cut but forces the metal out of the way, too wide a chisel edge will result in more pressure required for penetration, leading to greater heat generation and a resultant loss of life.



Cutting Fluids

The use of cutting fluids is an advantage in most drilling operations and an essential in some. The two main functions of the cutting fluid are lubrication and cooling. The purpose of lubrication is to reduce friction by lubricating the surfaces tool and work, to facilitate easier sliding of the chips up the flute and to prevent the chips welding to the cutting edges. In production work, particularly when drilling deep holes, the cooling action of the fluid is often more important than the lubrication. Overheating will shorten the life of the drill. Intermittent feed on deep holes, where possible, not only clears the chips but permits more effective cooling.

Speeds

The speed of a drill is the rate at which the periphery of the drill moves in relation to the work being drilled. As a rule, with a drill working within its speed range for a specific material, more holes between sharpenings will be achieved if the speed is reduced and less holes if the speed is increased. Thus, for each production run, a speed must be established which will result in the highest rate of production without excessive breakdown time or drill usage. The factors governing speed are: component material, hardness of material, depth of hole, quality required, condition of drilling machine, efficiency of cutting fluid.

Feeds

The feed of the drill is governed by the drill size and the component material. As with speeds, an increase in feed will lessen the number of holes produced sharpening but it is essential that a constant feed be maintained. If a drill is allowed to dwell, breakdown of the cutting edges will result.

Small Drill Feeds and Speeds

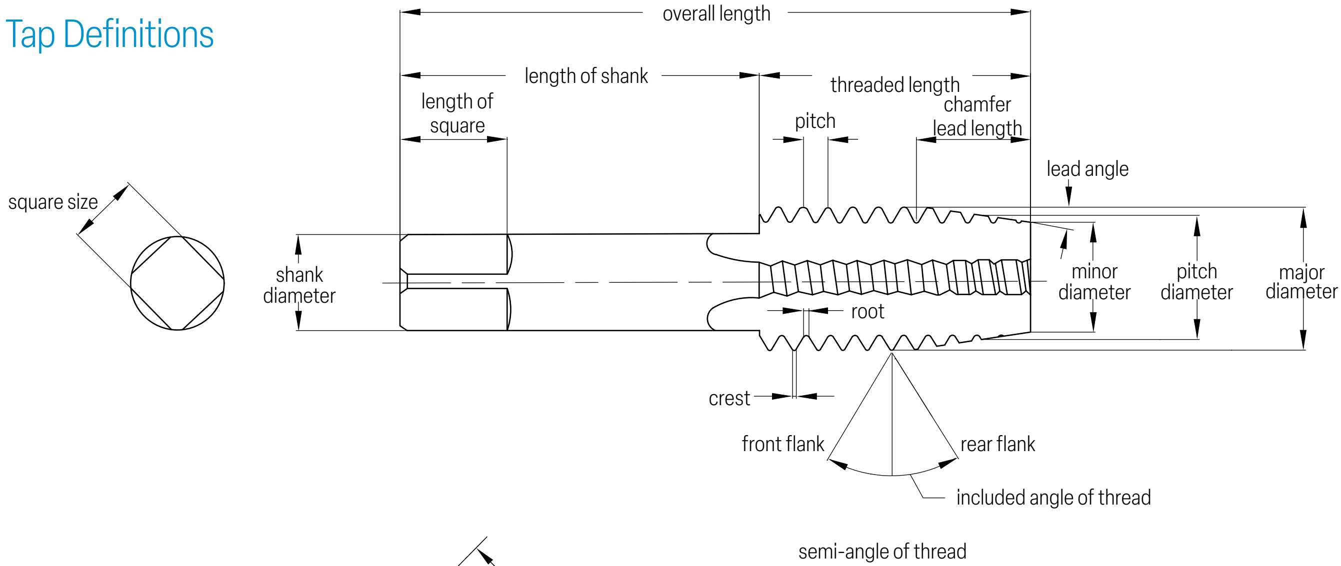
Breakdown of small drills can most often be attributed to two faults: speed too high and feed too low. A feed which will produce CHIPS not POWDER, coupled with a speed compatible with the strength of the drill is essential for small hole drilling. Feeds must be based on thickness of chip, not mm/min, and speeds adjusted accordingly. EXAMPLE: A 1mm drill is to operate at a feed of 0.013mm /rev, drilling steel. While the material may permit a speed of 30m/min or 9,500 RPM it is obvious that the drill could not withstand a load of 0.013mm feed at this speed; a penetration rate of 124mm/min. The correct procedure is to retain the feed but reduce the speed to obtain a penetration within the capacity of the strength of the drill.

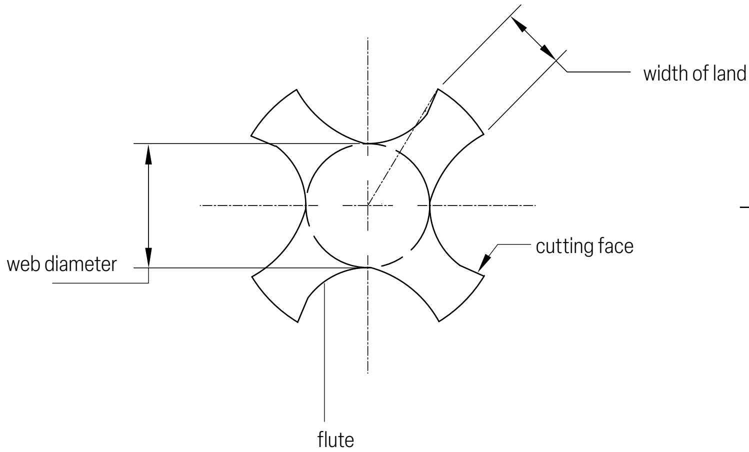
Deep Hole Drilling

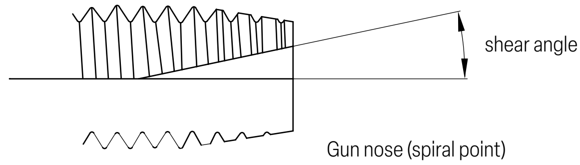
When drilling deep holes, speeds and feeds should be reduced as follows:

Depth of hole	Reduction percent %	
	Speed	**Feed**
3 times drill diameter	10	10
4 times drill diameter	30	10
5 times drill diameter	30	20
6 to 8 times drill diameter	35 to 40	20

Tap Definitions

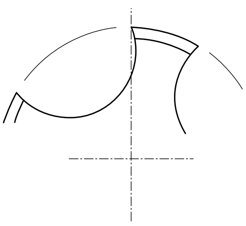




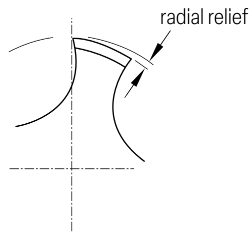


Gun nose (spiral point)

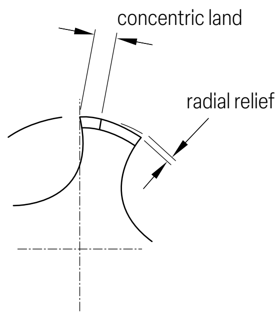
Thread Relief Types



Concentric threads
(no radial relief)

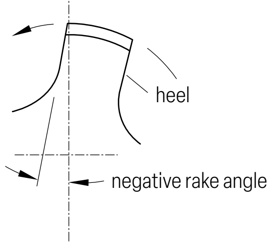


Eccentric threads
(relieved to cutting edge)

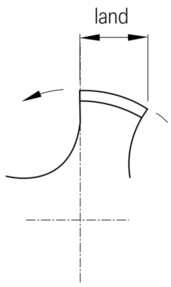


Con-eccentric threads
(relieved to a land)

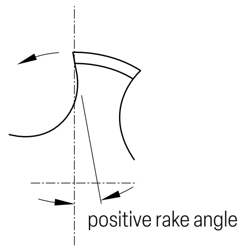
Cutting Faces



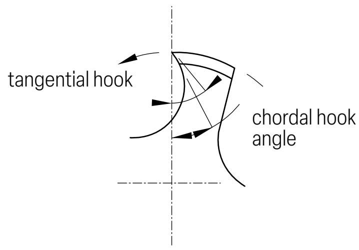
Negative rake



Radial rake



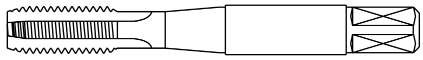
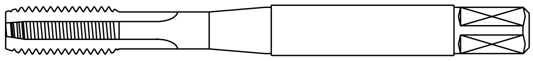
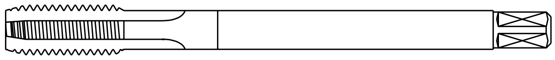
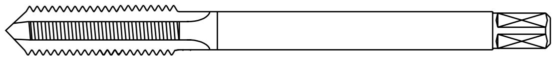
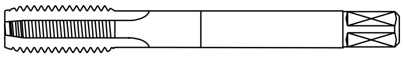
Positive rake



Hook

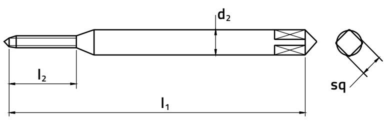
sutton

Construction dimensions / designs

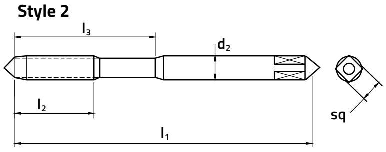
Short Machine & Hand Taps	ISO 529 JIS (J TYPE)	
Reinforced Shank Taps	DIN371	
Reduced Shank Taps	DIN374 / DIN376 / DIN5156	
Machine Nut Taps	ANSI B949 Standard	
Pipe Taps	Rc(BSPT), G (BSPF), Rp (BSPPL) - ISO2284 Standard NPT, NPTF, NPSF - ANSI B949 Standard	

Tap Styles

Style 1



Style 2



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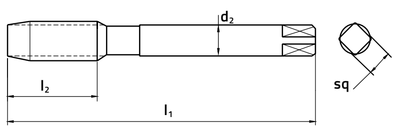
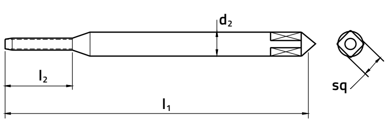
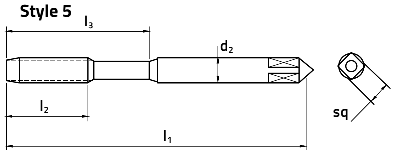


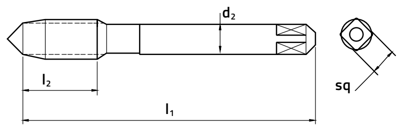
Style 4



Style 5

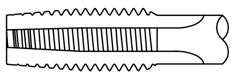
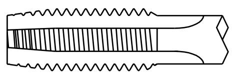
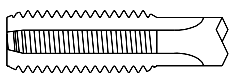
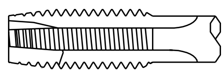
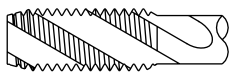


Style 6



Chamfer Type / Length

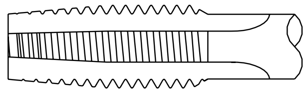
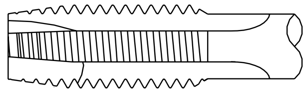
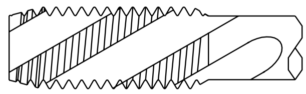
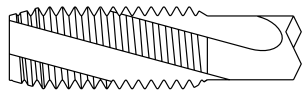
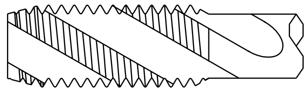
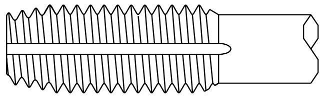
Table below is in accordance with ISO8830 / DIN2197

Terminology	Form	Number of threads on lead	Chamfer angle (≈)	Type of flute	Main area of application	Illustration
TAPER	**A**	6 to 8	5°	Hand or straight flutes	Short through holes	
INTERMEDIATE	**D**	3.5 to 5	8°	Hand or straight	Generally for through holes	
BOTTOMING	**E***	1.5 to 2	23°	Hand or straight flutes	Blind holes with very short thread runout	
INTERMEDIATE	**B**	3.5 to 5	10°	Straight, with spiral point	Through holes in medium & long chipping materials	
BOTTOMING	**C**	2 to 3	15°	Spiral fluted	Generally for blind holes	

* Use of this type is not recommended

Tap Types - Helix direction/ Helical pitch / Fluteless

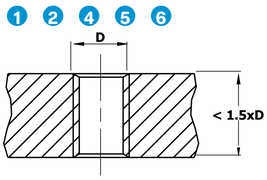
The helix angle depends primarily upon the hole form, eg. Through hole , blind hole, deep blind hole, etc., but the material, eg short chips, long chips, also has a strong influence on the direction of the helix. The following basic forms have derived during the development of taps:

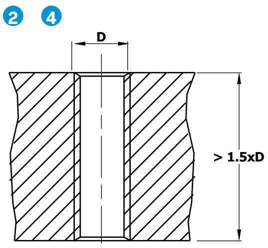
Description	Illustration
1 Straight Flutes (Hand) - Suitable for through or blind holes. The flutes only have room for a small amount of chips. The chips are not transported axially. Therefore, it is not advisable to cut deep through or blind holes (except in short chipping materials), with this type.	
2 Straight Flutes with (Gun) – Suitable for through holes, the gun point curls the chip forward ahead of the tap & out of the hole. Therefore, chip clogging is avoided and coolant can flow without problems.	
3 Spiral Flutes (LH Spiral, right hand cutting) – Suitable for interrupted through holes, where cross-holes exist. The direction of the flutes, curls & transports the chips forward of the tap, similar to Gun taps (also, opposite to RH spiral flutes). However, in applications where another hole intersects with the tapped hole, the helical flutes maintain the pitching of the thread.	
4 15° Spiral Flutes (RH Spiral) – Suitable for blind holes, best suited to tough short chipping materials, up to 1.5 x D in depth. This particular tap design has no advantages for soft, and long chipping materials, especially over 1.5 x d_1 in depth. Due to the slow helix angle not transporting the chips well, clogging is possible.	
5 40° to 50° Spiral Flutes (RH Spiral) – Suitable for blind holes, best suited to long chipping materials, the high helix angle & the direction of the flutes, curls & transports the chips back out of the hole. This particular tap style is required to cut on reversal; therefore flute rake is required on the both front & back flute faces.	
6 Thredflo/Roll taps (fluteless) - Suitable for blind & through holes. This type of tap internally rolls a thread, therefore displacing the metal rather than cutting, like the above mentioned styles. Due to torque generated when producing roll threads, much higher machine power is required. Roll threads also produce much stronger threads than cut threads, as the grain structure of the thread remains uniform through the thread form profile. Note! Tapping drill size is not the same as a cut thread tap.	

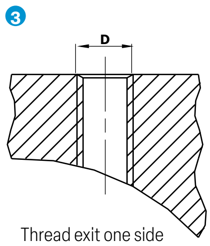
The above basic tool types are available in different variations, which have been designed & developed in respect to the specific materials and working conditions.

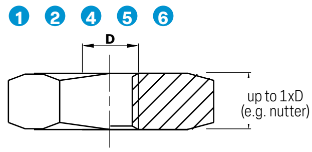
Tap Hole Types

Through Holes

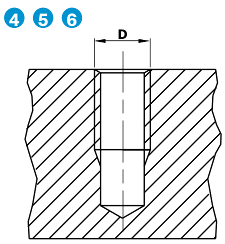


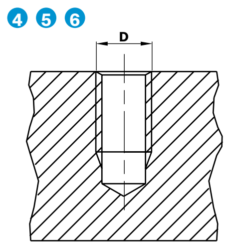


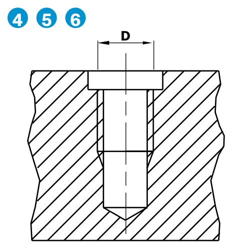


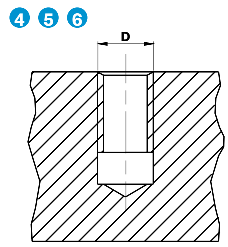


Blind Holes









For blind holes, there are generally two thread runout forms used at the bottom of the tap hole. One form has a recessed diameter at the bottom of the hole, and the other form has a standard runout. Other types of holes are respective to construction designs, eg.

a) The bore is smaller than the tap hole diameter (typical for pipes)
b) As step hole, where the following diameter (second step), is smaller than the tap hole diameter.

Geometry

Sutton Designation	Description	Tap geometry	Surface
GG	For cast iron – iron is a very abrasive material, therefore to increase tool life the taps are always surface treated or coated to resist the abrasion. The thread limit for this range is 6HX, which is high limit of the 6H tolerance allowing for longer wear life.	Straight flutes with low rake angle	TiCN Plasma Nitride Ni
N	For normal, general purpose type materials – suited to a wide range of materials, with normal rakes & relief's. This is existing geometry that Sutton Tools has historically manufactured.	Normal rake angle & normal thread relief	Bright Blu TiN
UNI	For normal, general purpose type materials – suited to a wide range of materials, with normal rakes & high relief's. However tap material is powder metal high speed steel (PMHSS), which due to its finer grain structure than that of conventional HSS, higher hardness can be achieved with excellent toughness, along with TiAlN surface coating allowing for better tool life than normal taps.	Normal rake angle & high thread relief	Bright TiAlN
VA	For stainless and tough steels – to avoid clogging in tough, long chipping materials such as stainless steel, it is essential that the chip flows continuously in an axial direction. Best suited to rigid tapping applications due to high thread relief. TiCN & TiN coating has proven to be best suited for these materials.	High rake angle & thread relief	TiCN Blu
VAPM	For stainless and tough steels – geometry similar to VA range, however tap material is powder metal high speed steel (PMHSS), which due to its finer grain structure than that of conventional HSS, higher hardness can be achieved with excellent toughness, allowing for better tool life than VA taps.	High rake angle & thread relief	TiCN
H	For hard materials forming short chips – the low rakes & relief's combined with a hard surface coating, allow excellent tool life.	Low rake angle & thread relief	TiCN
W	For soft materials – due to the very high rake angle with a low thread relief, allows for excellent chip flow & gauging in soft materials.	High rake angle & low thread relief	Bright CrN
AI	For malleable aluminium with long chips – to avoid clogging when threading in aluminium which forms long chips, it is essential that the chip flows continuously in an axial direction. Generally these taps have 1 less flute than normal taps & therefore have larger flute space, which more adequate for large volumes of chips to help avoid clogging.	High rake angle, high helix, 2 flutes, low thread relief	Bright Plasma Nitride

Lubricants

Use:
Use of a suitable lubricant or cutting compound is necessary on most tapping operations. The type of lubricant as well as the method of application is often of extreme importance and can be responsible for the success or failure of a tapping operation.

Recommendation:
Better results can sometimes be obtained by the use of one of the many modified or specialised lubricants recommended by cutting oil specialists.
The general principle is to have more EP (Extreme Pressure) additives added with the degree of difficulty, usually hardness increase. Oils stick, and improve frictional properties essential in tapping tough applications.

Application:
Proper application of the lubricant is just as important as the type used. To be effective, ample quantities of lubricant must reach the chamfer or cutting portion of the tap during the entire tapping operation. In many cases, the lubricant must also aid in controlling or disposing of the chips.

Flow:
The flow of lubricant should be directed into the hole rather than at the tap and should have sufficient pressure to wash the chips away from the hole as much as possible. Also, if the flow is not continuous, it should start before the tap enters the hole and continue until the tap is completely reversed out of the hole. In this way, ample oil is provided at the start of the cut and loose chips will be suspended in the oil so that they do not interfere with the tap backing out of the hole. On machines where the work revolves and the tap is stationary, it is desirable to use several streams of lubricant on opposite sides of the tap, especially on horizontal tapping.

Cleanliness:
Tapping lubricants must always be clean. If filter equipment is not used, the lubricant must be replaced periodically to eliminate fine chips, grit and foreign matter that accumulate in the tank. Also, it is very important that the piping and tank are thoroughly flushed and cleaned before filling with new lubricant. The dilution of lubricants often changes during use so that additions may be necessary to maintain the recommended proportion of active materials.

Tapping drill

The tapping drill hole diameter should be drilled as large as possible, within the respective fitting just under the upper permissible dimension of the tolerance.
If the tapping drill hole diameter is too small, then this will cause the thread root diameter (minor diameter) to cut the material. This should be avoided, because the small chips which derive from the root of thread, clog the normal chip flow and rip pieces of material out of the finished thread. Consequently, the tap is overloaded and often breaks because of the high torque.
Another problem which occurs in certain materials due to thread root diameter cutting, is when a chip-bulge has been formed around the root radius. The minor diameter of the tap is clogged with small chips, which leads to a clamping of the tool teeth are ripped out, which leads to tool breakage. It is therefore, necessary that the material which is to be tapped, be taken into account when determining the tap hole diameter. Typical materials which do not squeeze or clamp are iron, brass and bronze and materials which squeeze are steels, steel castings and malleable steels. The tap cuts more economically, when the tap drill hole diameter is within the upper range of the permissible tolerance.

Warning: When drilling holes in materials which tend to work harden, care is needed to ensure the drills are sharp otherwise tap life is decreased.

Tapping drill formula

The correct size of drill to give the desired percentage of thread can be calculated by using the following formula:

Thread Type	Formula	Example
Metric (ISO)	Drill Size = Nom, Tap Dia, in mm – Pitch	M6 × 1 = 5.00mm drill
Whitworth Form Threads (inch calculation)	Drill Size = Nom, Tap Dia, $-\frac{1.28}{TPI} \times$ % of thread depth	1/4 BSW 75% thread required: Drill Size = $0.250 - \frac{1.28}{20} \times \frac{75}{100} = 0.250 - 0.048$ Therefore Drill Size = 0.202 Nearest Standard Drill = 5.1mm = 0.2007 inch
Unified Form Threads (inch calculation)	Drill Size = Nom, Tap Dia, $-\frac{1.30}{TPI} \times$ % of thread depth	1/4 UNC 75% thread required: Drill Size = $0.250 - \frac{1.30}{20} \times \frac{75}{100} = 0.250 - 0.049$ Therefore Drill Size = 0.201 Nearest Standard Drill = 5.1mm = 0.2007 inch

All sizes are "suggested sizes" only and may be varied to suit individual requirements

M ISO Metric Coarse (60°)		
Tap Size	Pitch mm	Tapping Drill mm
M1.6	0.35	1.25
M2	0.4	1.6
M2.5	0.45	2.05
M3	0.5	2.5
M3.5	0.6	2.9
M4	0.7	3.3
M4.5	0.75	3.7
M5	0.8	4.2
M6	1.0	5.0
M8	1.25	6.8
M10	1.5	8.5
M12	1.75	10.2
M14	2.0	12.0
M16	2.0	14.0
M18	2.5	15.5
M20	2.5	17.5
M22	2.5	19.5
M24	3.0	21.0
M27	3.0	24.0
M30	3.5	26.5
M33	3.5	29.5
M36	4.0	32.0
M42	4.5	37.5
M45	4.5	40.5
M48	5.0	43.0
M52	5.0	47.0
M56	5.5	50.5

MF ISO Metric Fine (60°)		
Tap Size	Pitch mm	Tapping Drill mm
M4	0.5	3.5
M5	0.5	4.5
M6	0.75	5.3
M8	1.0	7.0
M10**	1.0	9.0
M10	1.25	8.8
M12**	1.25	10.8
M12	1.5	10.5
M14**	1.25	12.8
M14	1.5	12.5
M16*	1.5	14.5
M18**	1.5	16.5
M20*	1.5	18.5
M22	1.5	20.5
M24	2.0	22.0
M25*	1.5	23.5
M32*	1.5	30.5
M40*	1.5	38.5
M50*	1.5	48.5

*Metric Conduit **Spark Plug

8UN (8 TPI) Unified National Form (60°)		
Tap Size	T.P.I.	Tapping Drill mm
1-1/8	8	25.5
1-1/4	8	28.5
1-3/8	8	31.75
1-1/2	8	35.0
1-5/8	8	38.0
1-3/4	8	41.5
1-7/8	8	44.5
2	8	47.5

UNC Unified National Coarse (60°)		
Tap Size	T.P.I.	Tapping Drill mm
#2 (0.086)	56	1.85
#3 (0.099)	48	2.1
#4 (0.112)	40	2.3
#5 (0.125)	40	2.6
#6 (0.138)	32	2.8
#8 (0.164)	32	3.4
#10 (0.190)	24	3.8
#12 (0.216)	24	4.5
1/4	20	5.1
5/16	18	6.6
3/8	16	8.0
7/16	14	9.4
1/2	13	10.8
9/16	12	12.2
5/8	11	13.5
3/4	10	16.5
7/8	9	19.5
1	8	22.2
1-1/8	7	25.0
1-1/4	7	28.0
1-3/8	6	31.0
1-1/2	6	34.0
1-3/4	5	39.5
2	4.5	45.0

UNF Unified National Fine (60°)		
Tap Size	T.P.I.	Tapping Drill mm
#3 (0.099)	56	2.1
#4 (0.112)	48	2.35
#5 (0.125)	44	2.65
#6 (0.138)	40	2.9
#8 (0.164)	36	3.5
#10 (0.190)	32	4.1
#12 (0.216)	28	4.6
3/16*	32	4.0
1/4	28	5.5
5/16	24	6.9
3/8	24	8.5
7/16	20	9.8
1/2	20	11.5
9/16	18	12.8
5/8	18	14.5
3/4	16	17.5
7/8	14	20.5
1	12	23.5
1*	14	24.0
1-1/8	12	26.5
1-1/4	12	29.5
1-3/8	12	33.01
1-1/2	12	36.0

*UNS

UNEF Unified National Form (60°)		
Tap Size	T.P.I.	Tapping Drill mm
1/4	32	5.6
5/16	32	7.2
3/8	32	8.8
1/2	28	11.8
5/8	24	14.75
3/4	20	18
1	20	24.2

BSW British Standard Whitworth (55°)		
Tap Size	T.P.I.	Tapping Drill mm
1/16*	60	1.2
3/32*	48	1.85
1/8	40	2.55
5/32*	32	3.2
3/16	24	3.7
7/32*	24	4.5
1/4	20	5.1
5/16	18	6.5
3/8	16	7.9
7/16	14	9.3
1/2	12	10.5
9/16	12	12.1
5/8	11	13.5
3/4	10	16.25
7/8	9	19.25
1	8	22.0
1-1/8	7	24.75
1-1/4	7	28.0
1-1/2	6	33.5
1-3/4	5	39.0
2	4-1/2	44.5

*WHIT. Form

BSF British Standard Fine (55°)		
Tap Size	T.P.I.	Tapping Drill mm
3/16	32	4.0
7/32	28	4.6
1/4	26	5.3
5/16	22	6.8
3/8	20	8.3
7/16	18	9.8
1/2	16	11.0
9/16	16	12.7
5/8	14	14.0
11/16	14	15.5
3/4	12	16.75
7/8	11	19.75
1	10	22.75
1-1/8	9	25.5
1-1/4	9	28.5
1-1/2	8	34.5
1-3/4	7	41.0

BSB British Standard Brass (55°)		
Tap Size	T.P.I.	Tapping Drill mm
1/4	26	5.2
5/16	26	6.8
3/8	26	8.4
7/16	26	10.0
1/2	26	11.6
9/16	26	13.2
5/8	26	14.8
3/4	26	18.0
7/8	26	20.8
1	26	24.3

Rc (BSPT)*
ISO Rc Taper Series 1:16 (55°)

Tap Size	T.P.I.	Drill Only*	Drill & Reamer
Rc 1/16	28	6.4	6.2
Rc 1/8	28	8.4	8.4
Rc 1/4	19	11.2	10.8
Rc 3/8	19	14.75	14.5
Rc 1/2	14	18.25	18.0
Rc 3/4	14	23.75	23.0
Rc 1	11	30.0	29.0
Rc 1-1/4	11	38.5	38.0
Rc 1-1/2	11	44.5	44.0
Rc 2	11	56.0	55.0

G (BSPF)
ISO G Parallel Series (55°)

Tap Size	T.P.I.	Tapping Drill mm
G 1/16	28	6.8
G 1/8	28	8.8
G 1/4	19	11.8
G 3/8	19	15.3
G 1/2	14	19.0
G 5/8	14	21.0
G 3/4	14	24.5
G 7/8	14	28.5
G 1	11	31.0
G 1-1/4	11	39.5
G 1-1/2	11	45.5
G 1-3/4	11	51.5
G 2	11	57.5
G 2-1/2	11	72.5

Rp (BSPPL)
Sealing pipe thread parallel (55°)

Tap Size	T.P.I.	Tapping Drill mm
Rp 1/8	28	8.6
Rp 1/4	19	11.5
Rp 3/8	19	15.0
Rp 1/2	14	18.5
Rp 3/4	14	24.0
Rp 1	11	30.2
Rp 1-1/4	11	39.0
Rp 1-1/2	11	45.0
Rp 2	11	56.4

Pg
Steel conduit (80°)

Tap Size	T.P.I.	Tapping Drill mm
Pg7	20	11.3
Pg9	18	13.9
Pg11	18	17.3
Pg13.5	18	19.1
Pg16	18	21.2
Pg21	15	26.8

Thread forming
(Fluteless taps)

Tap Size	T.P.I.	Tapping Drill mm
Metric coarse		
M1	0.25	0.9
M1.1	0.25	1.0
M1.2	0.25	1.1
M1.4	0.3	1.28
M1.6	0.35	1.45
M1.7	0.35	1.55
M1.8	0.35	1.65
M2.0	0.40	1.8
M2.2	0.45	2.0
M2.3	0.4	2.1
M2.5	0.45	2.3
M2.6	0.45	2.4
M3	0.5	2.8
M3.5	0.6	3.2
M4	0.7	3.7
M5	0.8	4.6
M6	1.0	5.5
M8	1.25	7.4
M10	1.5	9.3
M12	1.75	11.2
BSW		
1/8	40	2.9
5/32	32	3.6
3/16	24	4.3
1/4	20	5.8
5/16	18	7.3
3/8	16	8.8

NPT-NPTF*
National Pipe Taper 1:16 (60°)

Tap Size	T.P.I.	Drill Only*	Drill & Reamer
1/16	27	6.3	6.0
1/8	27	8.5	8.2
1/4	18	11.0	10.8
3/8	18	14.5	14.0
1/2	14	18.0	17.5
3/4	14	23.0	23.0
1	11-1/2	29.0	28.5
1-1/4	11-1/2	37.5	37.0
1-1/2	11-1/2	44	43.5
2	11-1/2	55.5	55.0

NPSF
National Pipe Straight (60°)

Tap Size	T.P.I.	Tapping Drill mm
1/8	27	8.6
1/4	18	11.3
3/8	18	14.5
1/2	14	18.0

*Taper pipe threads of improved quality are obtained when taper is pre-formed using Sutton Tools Taper Pipe Reamers.

Thread forming
(Fluteless taps)

Tap Size	T.P.I.	Tapping Drill mm
UNC		
#1 (0.073)	64	1.7
#2 (0.086)	56	2.0
#3 (0.099)	48	2.3
#4 (0.112)	40	2.6
#5 (0.125)	40	2.9
#6 (0.138)	32	3.2
#8 (0.164)	32	3.8
#10 (0.190)	24	4.4
#12 (0.216)	24	5.0
1/4	20	5.8
5/16	18	7.3
3/8	16	8.8
7/16	14	10.2
1/2	13	11.7
UNF		
#1 (0.073)	72	1.7
#2 (0.086)	64	2.0
#3 (0.099)	56	2.3
#4 (0.112)	48	2.6
#5 (0.125)	44	2.9
#6 (0.138)	40	3.2
#8 (0.164)	36	3.9
#10 (0.190)	32	4.5
#12 (0.216)	28	5.1
1/4	28	6.0
5/16	24	7.5
3/8	24	9.0
7/16	20	10.6
1/2	20	12.1
G (BSPF)		
1/8	28	9.25
1/4	19	12.5
3/8	19	16.0
1/2	14	20.0
5/8	14	22.0
3/4	14	25.5
7/8	14	29.25
1	11	32.0

BA
(47.5°)

Tap Size	Pitch mm	Tapping Drill mm
0	1	5.1
1	0.9	4.5
2	0.81	4.0
3	0.73	3.4
4	0.66	3.0
5	0.59	2.65
6	0.53	2.3
7	0.48	2.05
8	0.43	1.8
9	0.39	1.55
10	0.35	1.4
11	0.31	1.2
12	0.28	1.05
13	0.25	0.98
14	0.23	0.8
15	0.21	0.7
16	0.19	0.6

Fluteless taps

Fluteless taps do not cut threads in the same manner as conventional taps – but actually FORM and FLOW the threads with an absence of chips. Used under suitable conditions, these taps produce threads with a high degree of finish not possible with ordinary taps. Ductile materials are most appropriate for forming of threads and must have a minimum 10% elongation.

Benefits of thread forming

- Higher speeds and tool life
- Reduced possibility of breakage due to no cutting edges and robust tool construction

Figure 1. No chips produced

Figure 2. Higher tensile strength threads produced due to grain structure following the thread form

Figure 3. For use in through and blind holes applications

What's New?

Figure 4. New polygon profile

Figure 5. New radiused blend on polygon profile

Figure 6. Thread profile with radius crest

Figure 7. Polished tool surface, surface finish

Figure 1.

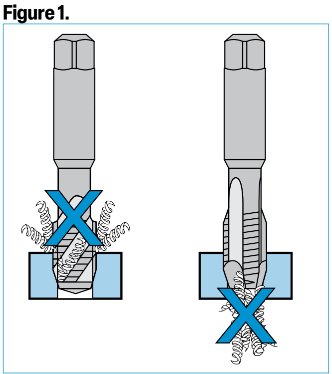


Figure 2.

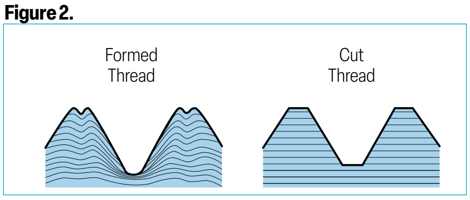


Figure 3.

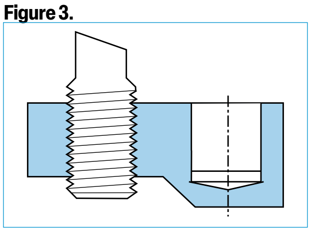


Figure 4.

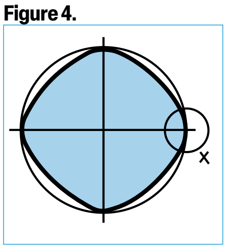


Figure 5.

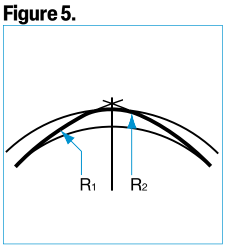


Figure 6.

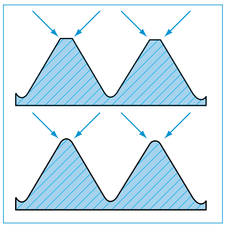
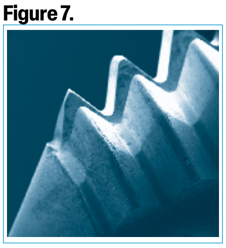


Figure 7.



Suitable for wide range materials

-Low carbon steels
-Leaded steels
-Austenitic stainless steels
-Alloy steels; typically up to 1200 N/mm², (36 Rc) with a minimum 10% elongation
-Aluminium die castings alloys (low silicon, 10% max;)
-Wrought aluminium alloys (Ductile)
-Zinc die casting alloys
-Copper and copper alloys

Percentage of thread required

Because the thread produced by a fluteless tap is substantially stronger than a conventional thread, greater tool life and efficiency may be obtained when forming up to 65% thread.
Threads may be formed up to 80% of depth, but tool life will be reduced and work clamping pressure necessarily increased. Greater tapping speeds allow the metal to flow far more readily, so 60 feet per minute minimum may be used as a guide, but this could increase with the type of material being tapped. A depth of 65% is recommended for the ductile materials mentioned, but this percentage will be reduced for less ductile materials to maintain all-round efficiency.

Tapping drill formula for fluteless taps

Refer Tapping Drill Size Chart for recommended sizes (Suitable for Unified, Whitworth and Metric sizes only).
The formula to calculate the theoretical hole size for a required percentage of thread is:

Formula	Example
Drill size = nominal thread dia. (in mm)– (0.007 x % of thread x pitch)	Drill size for 65% of thread in a M6 x 1.0 threaded hole would be: Drill size = 6 – (0.007 x 65 x 1.0 (pitch)) = 5.54mm (Use 5.50mm drill (Stockable drill) = 71%)

It is to be noted that the drill size for fluteless tapping is always larger than the P.D. of the thread. A drill size equal to the P.D. of the thread would produce 100% of thread, but this is NOT recommended.
As the additional driving torque is only up to 50% increase, any conventional driving equipment using the square as a drive is suitable for fluteless tapping.

Lubrication

In general it is best to use a good cutting oil or lubricant rather than a coolant for fluteless tapping. Sulphur base and mineral oils, along with most friction reducing lubricants recommended for use in cold extrusion or metal drawing, have proven best for this work. Make sure lubricant is clean, free from chips swarf and filings in suspension, which produce a poor finish and jamming, sometimes breakage – extra filtration may be required.

Countersinking

Because the fluteless tap displaces metal, some metal will be displaced above the mouth of the hole during tapping, countersink or chamfer the hole prior to tapping will reduce the extrusion within the countersink and not interfere with the mating part.

(Fluteless) Roll Taps:

Thread Size			ISO Coarse		UNC		BSW	
Metric	Fraction	M/C Screw Gauge	Pitch mm	Tapping Drill mm	T.P.I.	Tapping Drill mm	T.P.I.	Tapping Drill mm
M1.0			0.25	0.90				
M1.1			0.25	1.00				
M1.2			0.25	1.10				
M1.4			0.3	1.25				
M1.6			0.35	1.45				
M1.7			0.35	1.55				
M1.8			0.35	1.65				
M2.0			0.4	1.80				
M2.2			0.45	2.00				
M2.3			0.4	2.10				
M2.5			0.45	2.30				
M2.6			0.45	2.40				
M3.0			0.5	2.75				
	1/8						40	2.90
M3.5			0.6	3.20				
		#6			32	3.10		
	5/32						32	3.60
M4			0.7	3.70				
		#8			32	3.80		
	3/16						24	4.30
		#10			24	4.30		
M5			0.8	4.60				
M6			1.0	5.55				
	1/4				20	5.80	20	5.80
	5/16				18	7.30	18	7.30
M8			1.25	7.40				
	3/8				16	8.80	16	8.80
M10			1.50	9.30				

Thread Systems

The ISO standard is the international standard intended to be adopted throughout the world to unify and rationalise screw threads at an international level. The ISO standard recognises two groups of screw threads, (a) ISO metric, a complete thread system in metric units and (b) ISO inch Unified which is covered by British Standard BS 1580 and American Standard ANSI – B1-1 – Unified screw thread systems. The Whitworth and BA screw threads are obsolete but still widely used during the period of transition.
All measurements must have a controlling point or base from which to start. In the case of a screw thread, this control point is called BASIC or theoretically correct size, which is calculated on the basis of a full thread form. Thus, on a given screw thread, we have the Basic Major Diameter, the Basic Pitch Diameter, and the Basic Minor Diameter. The Basic Profile is the profile to which the deviations, which define the limits of the external and internal threads, are applied.
While it is impossible in practice to form screw threads to their precise theoretical or BASIC sizes, it is possible and practical to establish limits to which the deviation must not exceed. These are called the "Maximum" and "Minimum" Limits. If the product is no smaller than the "Minimum Limit" and no larger than the "Maximum Limit", then it is within the size limits required. This difference between the Maximum and Minimum Limits is the TOLERANCE.
In actual practice, the Basic size is not necessarily between Maximum and Minimum Limits. In most cases, the Basic Size is one of the Limits.
In general, tolerances for internal threads will be above Basic and for external threads, below Basic.

Basic Profile for ISO Inch (Unified) and ISO Metric

The basic form is derived from an equilateral triangle which is truncated 1/8 of the height at the major diameter and 1/4 of the height at the minor diameter.
The corresponding flats have a width of P/8 and P/4 respectively. **Figure 1**.
In practice major diameter clearance is provided by the tap beyond the P/8 flat on internal threads and beyond the P/4 flat on external threads.
These clearances are usually rounded.

ISO Metric Tolerance Positions

Three tolerance positions are standardised for bolts and two for nuts. These are designated e, g and h for bolts and G and H for nuts. As in the ISO System for limits and fits, small letters are used to designate tolerance positions for bolts and capital letters are used for nut tolerance positions. Also the letters h and H are used for tolerance positions having the maximum metal limit coincided with the basic size, i.e., with a fundamental deviation of zero. **Figure 2**.

ISO Metric Tolerance Grades

A series of tolerance grades designated 4, 5, 6, 7 and 8 for nut pitch diameters.
An extended series of tolerance grades, designated 3, 4, 5, 6, 7,8 and 9, for bolt pitch diameters.
An important factor here is that for the same tolerance grade the nut pitch diameter tolerance is 1.32 x the corresponding bolt pitch diameter tolerance.
Size and recommendations of fits can be obtained from the Australian Standards AS 1275 or AS 1721.

Figure 1

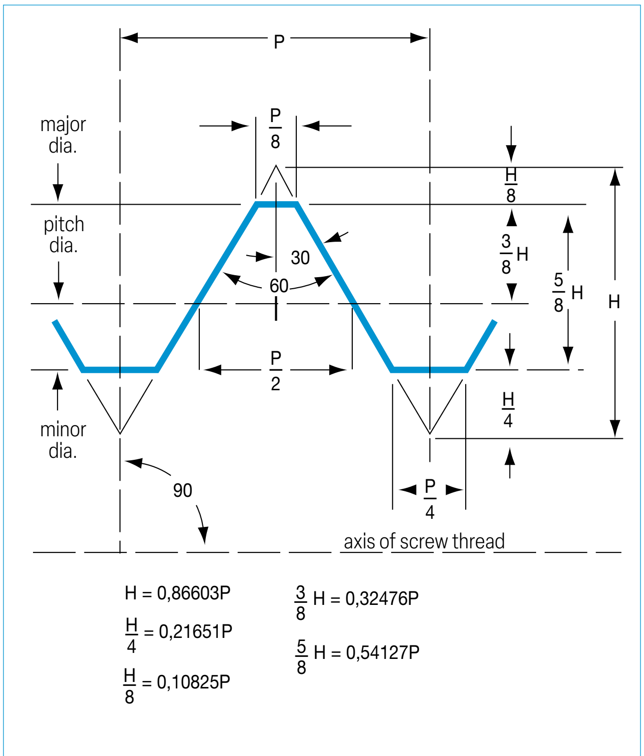
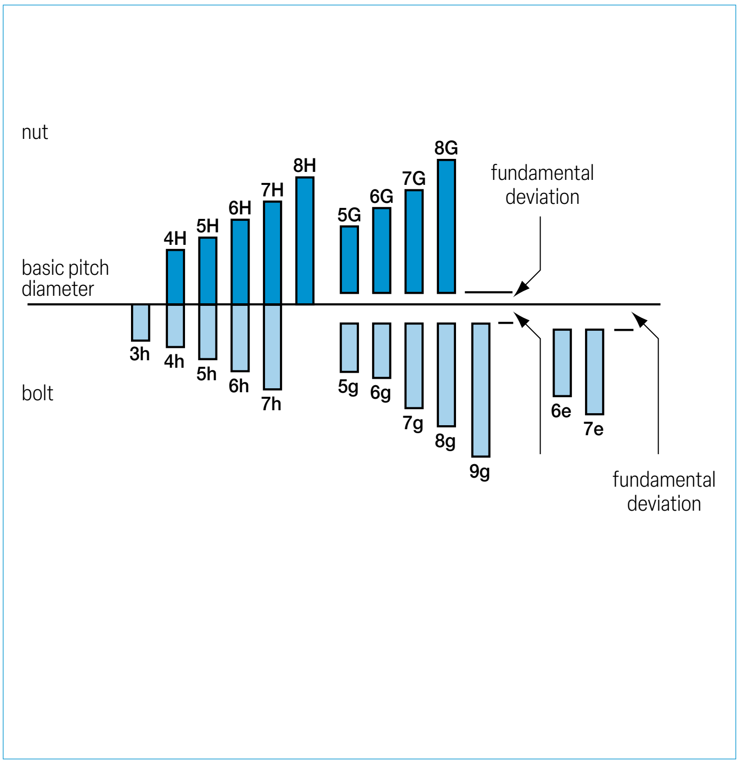


Figure 2



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Metric Taps; Comparison Tap Limits & Product Classes and Grades

Product Tolerance					Tap Limits					
Tap Size mm	Pitch	ISO Tolerance Class	6H Upper Deviation Tolerance µm	JIS 2 Old/JIS Product Tolerance µm	ISO Tap Grade	Tap Limits Microns µm	Recommended Limit P 1 µm	P 2 µm	P 3 µm	P 4 µm
M1.0	x 0.25	5H	56	60	ISO 1	+ 6 / 17	+ 10 / 25			
M1.1	x 0.25	5H	56	60	ISO 1	+ 6 / 17	+ 10 / 25			
M1.2	x 0.25	5H	56	60	ISO 1	+ 6 / 17	+ 10 / 25			
M1.4	x 0.3	5H	60	60	ISO 1	+ 6 / 18	+ 10 / 25			
M1.6	x 0.35	5H	67	85	ISO 1	+ 7 / 20	+ 10 / 25	+ 25 /40		
M1.7	x 0.35	6H	85	85	ISO 2	+ 20 / 34	+ 10 / 25	+ 25 /40		
M1.8	x 0.35	6H	85	85	ISO 2	+ 20 / 34	+ 10 / 25	+ 25 /40		
M2.0	x 0.4	6H	90	70	ISO 2	+ 21 / 36	+ 10 / 25	+ 25 /40		
M2.2	x 0.45	6H	95	95	ISO 2	+ 23 / 38	+ 10 / 25	+ 25 /40		
M2.3	x 0.4	6H	90	95	ISO 2	+ 21 / 36	+ 10 / 25	+ 25 /40		
M2.5	x 0.45	6H	95	95	ISO 2	+ 23 / 38	+ 10 / 25	+ 25 /40		
M2.6	x 0.45	6H	95	95	ISO 2	+ 23 / 38	+ 10 / 25	+ 25 /40		
M3.0	x 0.5	6H	100	100	ISO 2	+ 24 / 40	+ 10 / 25	+ 25 /40		
M3.5	x 0.6	6H	112	90	ISO 2	+ 27 / 45	+ 10 / 25	+ 25 /40		
M4.0	x 0.7	6H	118	118	ISO 2	+ 29 / 48		+ 20 /40		
M5	x 0.8	6H	125	125	ISO 2	+ 30 / 50		+ 20 /40		
M6	x 1.0	6H	150	120	ISO 2	+ 35 / 59		+ 20 /40		
M7	x 1.0	6H	150	120	ISO 2	+ 35 / 59		+ 20 /40		
M8	x 1.25	6H	160	130	ISO 2	+ 38 / 63		+ 20 /40	+ 40 / 60	
M10	x 1.5	6H	180	140	ISO 2	+ 42 / 70		+ 20 /40	+ 40 / 60	
M12	x 1.75	6H	200	160	ISO 2	+ 48 / 80			+ 40 / 60	+ 60 / 80
M14	x 2.0	6H	212	170	ISO 2	+ 51 / 85			+ 40 / 60	+ 60 / 80
M16	x 2.0	6H	212	170	ISO 2	+ 51/ 85			+ 40 / 60	+ 60 / 80
M18	x 2.5	6H	224	190	ISO 2	+ 54 / 90			+ 40 / 60	+ 60 / 80
M20	x 2.5	6H	224	190	ISO 2	+ 54 / 90			+ 40 / 60	+ 60 / 80
M22	x 2.5	6H	224	190	ISO 2	+ 54 / 90			+ 40 / 60	+ 60 / 80
M24	x 3.0	6H	265	200	ISO 2	+ 64 / 106			+ 40 / 60	+ 60 / 80

P limits; they stock the smaller P limit for SP Taps, and the larger P limit for PO taps.
Where there is only the one “P” limit; it is the same limit for both SP & PO Taps

The ISO metric system of tap tolerances comprises three classes of tap sizes which are calculated from the Grade 5 nut tolerance, irrespective of the nut grade to be cut as follows:

ISO, Class 1 – Class 2 – Class 3

The tolerances of these three classes are determined in terms of a tolerance unit t, the value of which is equal to the pitch tolerance value TD2 grade 5 of nut (extrapolated up to pitch 0.2mm):

t = TD_2 grade 5

The value of the tap pitch diameter tolerance is the same for all three classes 1, 2 and 3: it is equal to 20% of t.

The position of the tolerance of the tap with respect to the basic pitch diameter results from the lower deviation the values of which are (see **Figure 3**):

for tap class 1: + 0.1 t

for tap class 2: + 0.3 t

for tap class 3: + 0.5 t

Choice of tolerance class of the tap with respect to the class of thread to be produced.

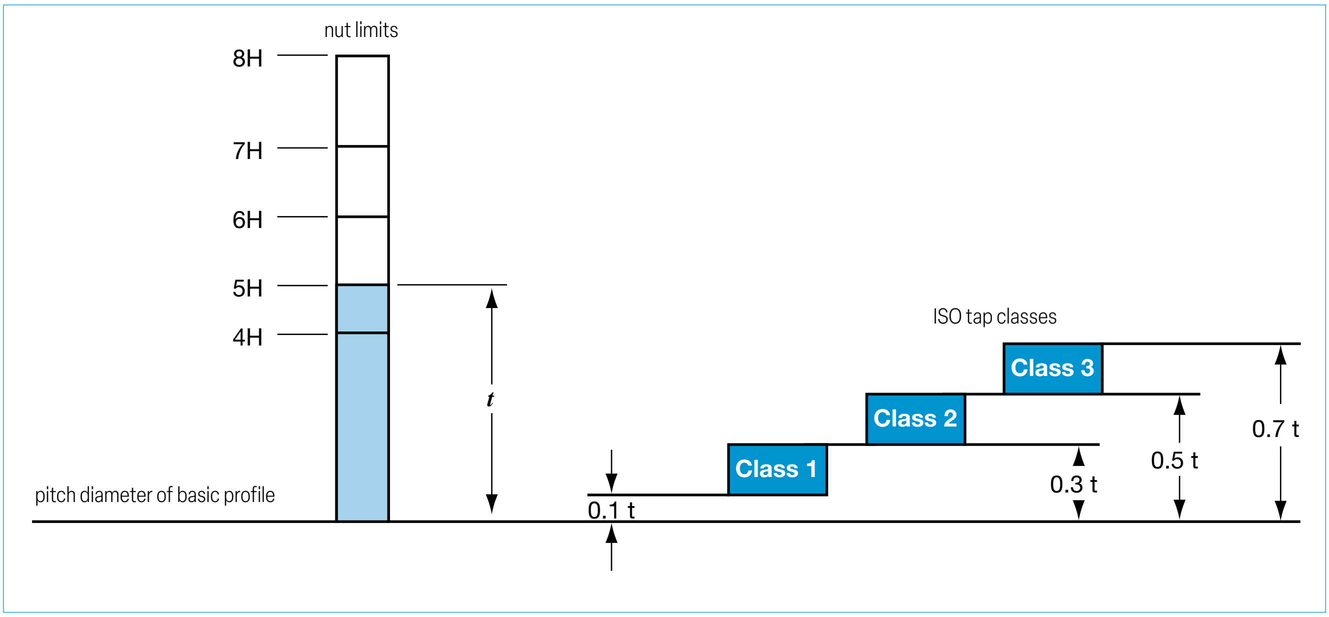
Unless otherwise specified, the taps of classes 1 to 3 will generally be used for the manufacture of nuts of the following classes:

ISO, Class 1: for nuts of limits 4H and 5H

ISO, Class 2: for nuts of limits 6H and 5G

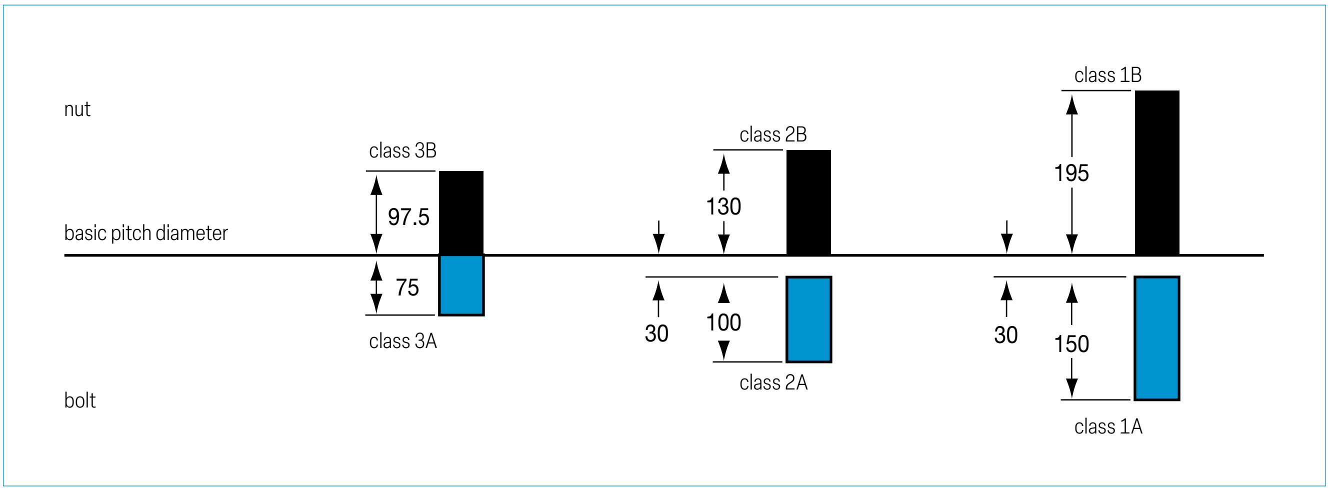
ISO, Class 3: for nuts of limits 7H – 8H and 6G.

Figure 3



This system is well known. It has now been accepted by ISO as the recommended tolerance for ISO inch threads down to 0.06 inch nominal diameter.
The arrangement of the allowance and the various classes of pitch diameter tolerance for a normal length of engagement of the mating threads is shown in this diagram. The pitch diameter tolerance for Class 2A bolts is shown as 100 units, and the fundamental deviation and other tolerances are shown as percentages of the Class 2A tolerance. **Figure 4**.

Figure 4

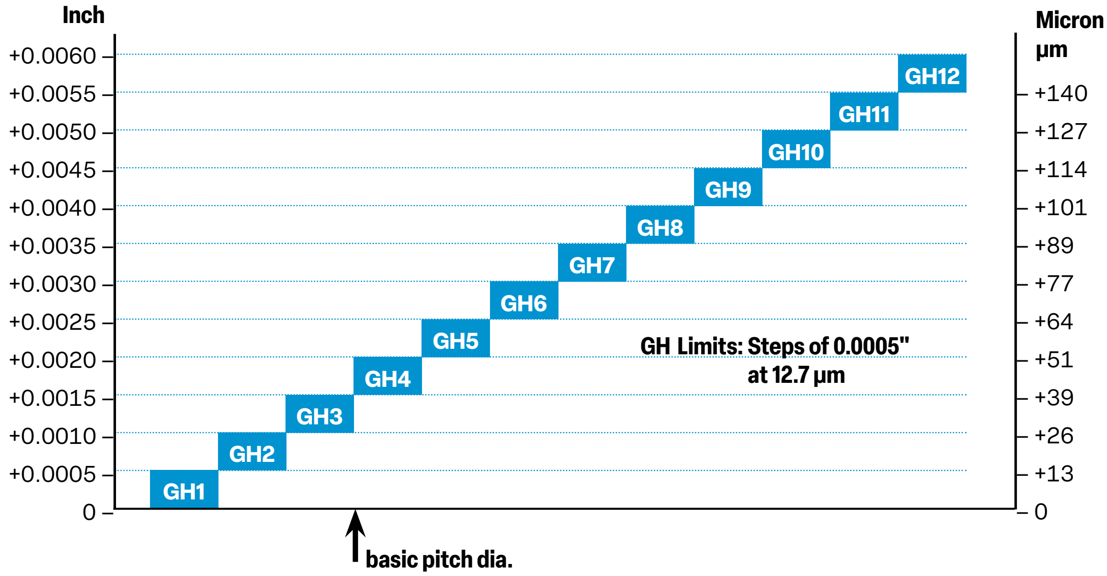


Unified Taps
The "GH" System

This system provides for a range of pitch diameters for each size of tap: the height limit of pitch diameters being the basic pitch diameter plus increments or units of .0005". It is designated by the letter "GH" followed by a numeral indicating the number or units applying to the particular "GH" size. The tap manufacturer's tolerance is applied as minus.
This is the limit which will normally be supplied. Alternative "GH" limits other than those shown in the price list can be made to special order.

GH Limits for JIS Roll Taps

GH Limits are applied to JIS Metric and Unified Thredflo Tap Threads due to market demands in the JIS standard.



For Sutton Tools Metric (mm) Roll / Fluteless Taps (Limit same as the "RH" & "G" Limits)
GH Limits: Steps of 0.0127 mm
N = GH number

GH LIMITS

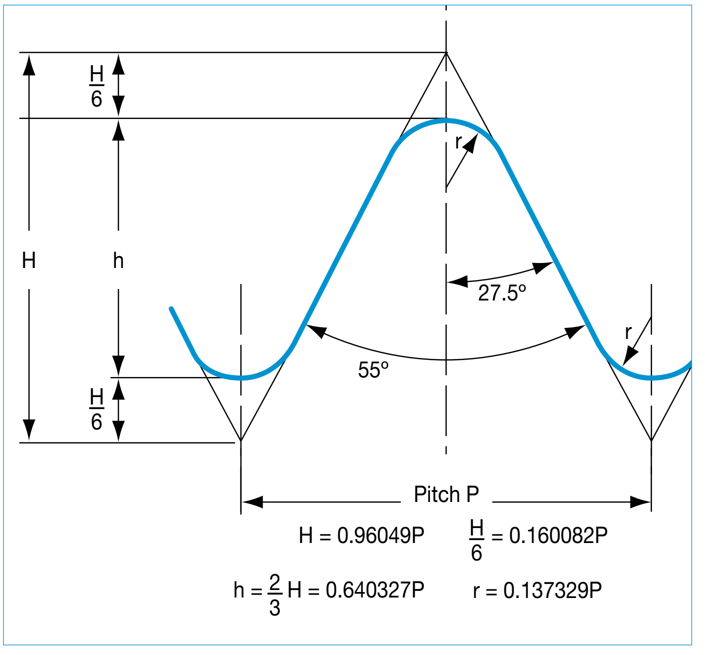
Upper limit: 0.0005" x N
Lower limit: (0.0005" x N) – 0.0005

Basic Profile for Whitworth (BSW, BSF and WHIT.) Thread forms

British Standard Whitworth Form

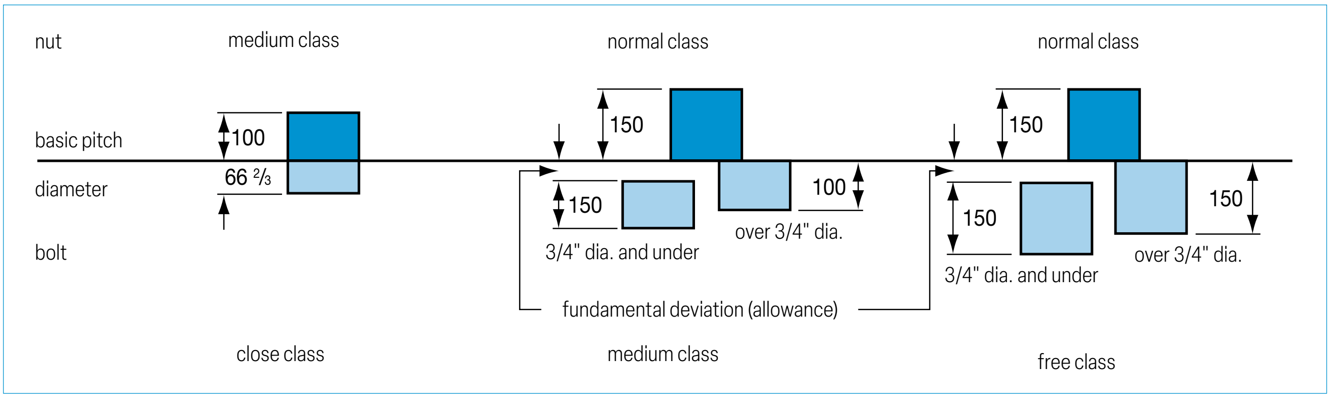
The sides of the thread form an angle of 55° with one another, and the top and bottom of the full triangle are truncated one-sixth of the height. The actual depth of the thread is equal to two-thirds of the height of the generating triangle and is equal to 0.6403 times the pitch. The crests and roots are rounded to a radius of 0.137329 times the pitch. **Figure 5**.

Figure 5



The Whitworth Screw Thread Tolerance System

Figure 6

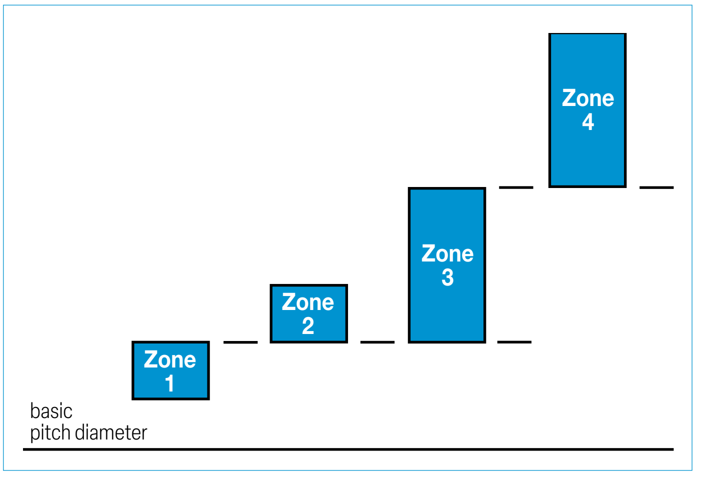


Pitch diameter tolerance zones of recommended combinations of classes of bolts and nuts having Whitworth screw threads. **Figure 6**.

British Tap Size Zone Limits

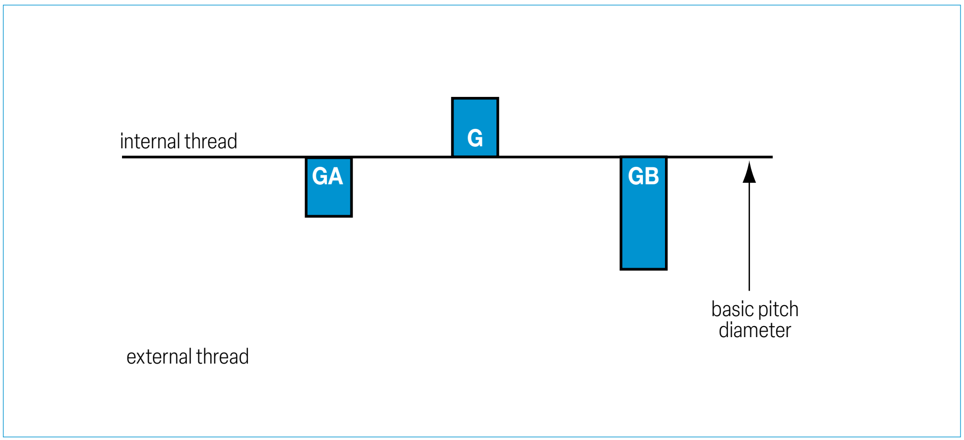
British Standard Zone 3 and Zone 4 limits are normally applied to Whitworth and BA taps.
The values for position and tolerances are formulated and must be obtained from the standard's tables.
The accompanying chart shows the zone limits relationship for ground threads. **Figure 7**.

Figure 7

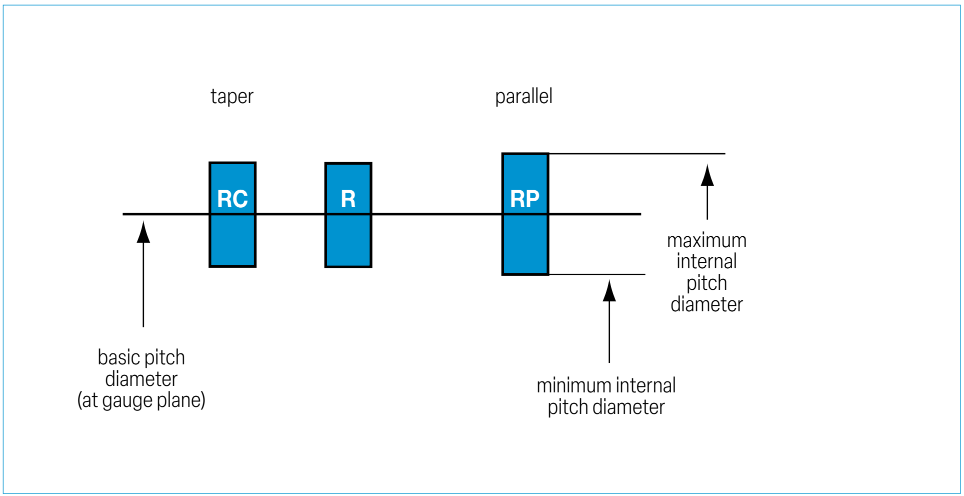


The International Standard Pipe Tap Thread System (ISO) has been derived from the original Whitworth gas and water pipe tap threads, formerly known as BSPF (Fastening) and BSPT (Taper), these systems have been so widely used throughout Europe and the United Kingdom that they have been metricated, whilst still retaining the Whitworth thread form. These popular thread systems are the basis for the ISO parallel "G" series and the taper "R" series, these systems are endorsed and in agreement with the current British and Australian standards. For comparison, the pitch diameter tolerance zones are given for both the parallel and taper systems.

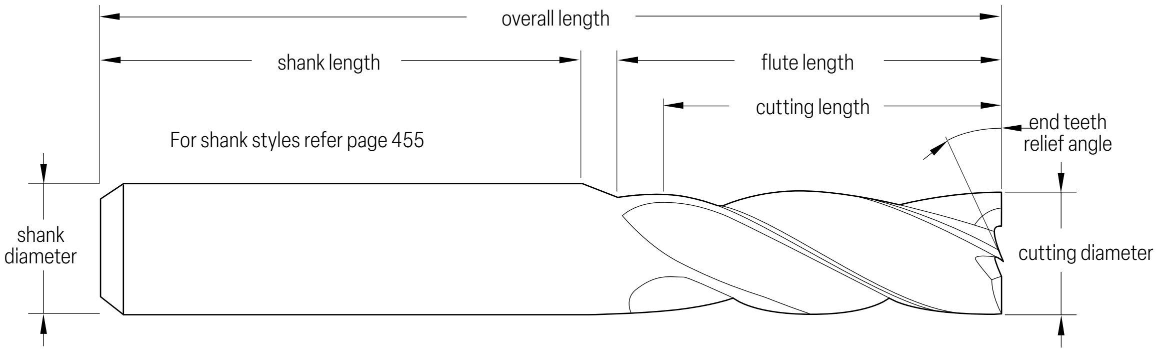
"G" Fastening Parallel Pipe Threads – ISO 228, AS1722 PT2 and BS2779.
This parallel thread system has only one positive internal thread tolerance and two classes of external tolerances. This series constitutes a fine series of fastening connecting pipe threads for general engineering purposes, the assembly tolerances on these threads are such as to make them unsuitable for pressure tight seal by the threads themselves. For the conveying of fluids, the seal may be produced by gaskets, flanges, or "O" rings etc.

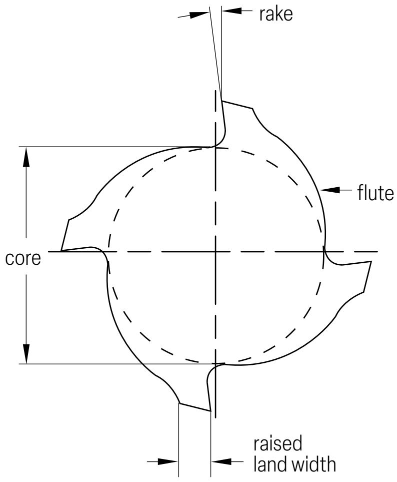


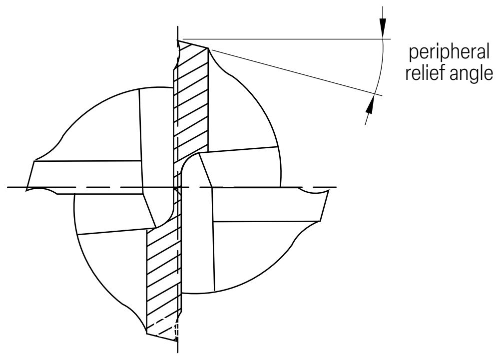
"R" Sealing Taper Pipe Threads – ISO 7, AS1722 PT1 and BS21. The taper rate is 1-16 on diameter.
This series is for tubes and fittings where pressure tight joints are made by threads, these threads therefore must have a full form profile (no truncations). The series include a taper external thread (R) for assembly with either taper internal (Rc) or parallel internal (Rp) threads. The Rp series has a unilateral tolerance (+/–) which normally requires a special below basic low limit tap, to allow for sizing deviations at the start of the internal thread, the size is gauged at this position, with an Rc taper gauge. The low limit Rp tap size, allows a minimum accommodation length to be machined, with an equivalent material saving possible.



Endmill Definitions





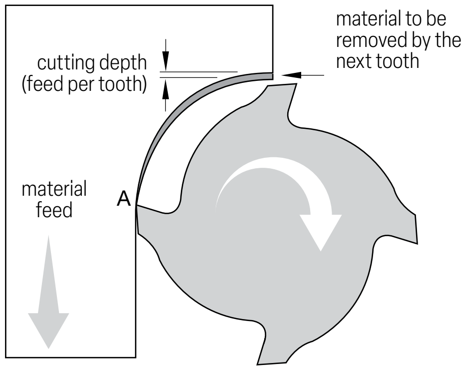


Conventional milling versus climb milling

A milling cutter can cut in two directions, sometimes known as climb or conventional.

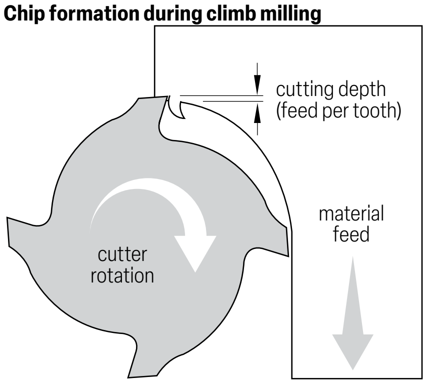
Conventional milling: The depth of the cut starts at zero thickness, and increases up to the maximum. The cut is so light at the beginning that the tool does not cut, but slides across the surface of the material, until sufficient pressure is built up and the tooth suddenly bites and begins to cut. This deforms the material (at point A on the diagram, left), work hardening it, and dulling the tool. The sliding and biting behaviour leaves a poor finish on the material.

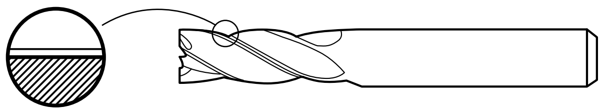
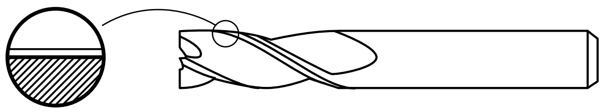
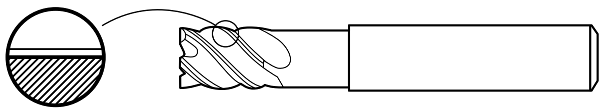
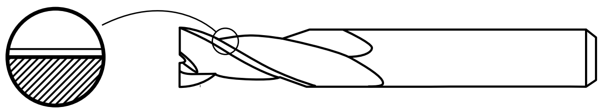
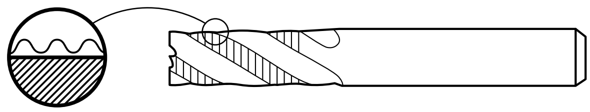
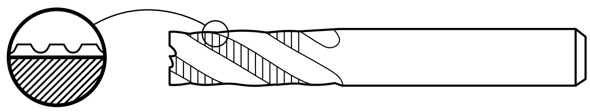
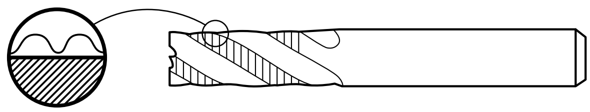
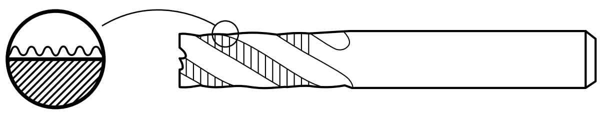
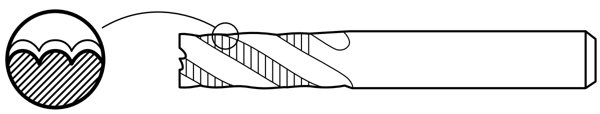
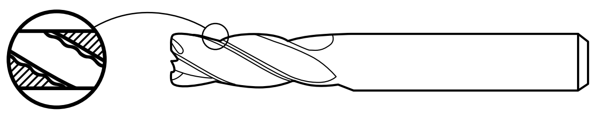
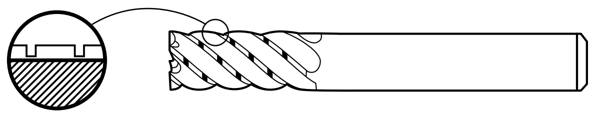
Conventional milling. Point A become work hardened

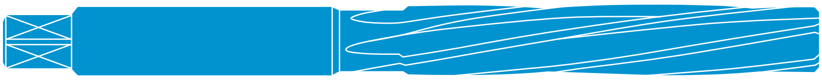


Climb milling: Each tooth engages the material at a definite point, and the width of the cut starts at the maximum and decreases to zero. The chips are disposed behind the cutter, leading to easier swarf removal. The tooth does not rub on the material, and so tool life may be longer. However, climb milling can apply larger loads to the machine, and so is not recommended for older milling machines, or machines which are not in good condition. This type of milling is used predominantly on mills with a backlash eliminator.

Chip formation during climb milling



Type	Description	Application	Illustration
N	Finishing Form		
W	Slotting & Finishing - Use in soft materials, quick spiral 45° up to 600 N/mm^2		
VA	Optimised geometry for Austenitic Stainless Steels & other long chipping materials up to 1000 N/mm^2		
Al & CU	For slotting wrought aluminium alloys with efficient chip evacuation, due to high relief angles and 40° spiral		
NR	Normal Roughing Form - general purpose		
NF	Semi Roughing Form - Ideally suited to soft, long chipping materials.		
WR	Coarse Form - ideally suited to soft, non-ferrous materials.		
HR	Fine Pitch Roughing Form - ideally suited to hard, short chipping materials		
HRS	Special Fine Pitch Roughing Form - Universal use		
Ti	Wave Form - ideally suited to titanium & nickel alloys		
STF	Special tooth form - Semi Roughing Form, ideally suited to materials up to 1400 N/mm^2		



Hints on use

Feeds

In reaming, feeds are usually much higher than those used for drilling. The amount per feed may vary with the material, but a good starting point would be between 0.038mm and 0.10mm per flute per revolution. Too low a feed may result in glazing, excessive wear, and occasionally chatter. Too high a feed tends to reduce the accuracy of the hole and may lower the quality of the finish. The basic idea is to use as high a feed as possible and still produce the required accuracy and finish.

Stock to be removed

For the same reason, insufficient stock for reaming may result in a burnishing rather than a cutting action. It is very difficult to generalise on this phase as it is closely tied with the type of material the finish required, depth of hole, and chip capacity of the reamer. For machine reaming 0.20mm for a 6mm hole, 0.30mm for a 12mm hole, and 0.50mm for a 50mm hole, would be a typical starting point guide.
For hand reaming, stock allowances are much smaller, partly because of the difficulty in hand forcing the reamer through greater stock.
A common allowance is 0.08mm to 0.13mm.

Speeds

The most efficient speed for machine reaming is closely tied in with the type of material being reamed, the rigidity of the set-up, and the tolerance or finish required. Quite often the best speed is found to lie around two-thirds the speed used for drilling the same material.

A lack of rigidity in the set-up may necessitate slower speeds, while occasionally a very compact, rigid operation may permit still higher speeds.

When close tolerances and fine finish are required it is usually found necessary to finish the reamer at considerably lower speeds.

In general, reamers do not work well when they chatter. Consequently, one primary consideration in selecting a speed is to stay low enough to eliminate chatter. Other ways of reducing chatter will be considered later, but this one rule holds: SPEEDS MUST NOT BE SO HIGH AS TO PERMIT CHATTER.

The following charts gives recommended surface meter per minute values which may be used as a basis from which to start.

Material	m/min
Aluminium and its alloys	20 – 35
Brass and Bronze, ordinary	20 – 35
Bronze, high tensile	18 – 22
Monel Metal	8 – 12
Cast Iron, soft	22 – 35
Cast iron, hard	18 – 22
Cast Iron, chilled	7 – 10
Malleable Iron	18 – 20
Steel, Annealed	13 – 18
Steel, Alloy	12 – 13
Steel, Alloy 300-400 Brinell	7 – 10
Stainless Steel	5 – 12

Chatter

The presence of chatter while reaming has a very bad effect on reamer life and on the finish of the hole. Chatter may be the result of several causes, some of which are listed:

1. Excessive speed.
2. Too much clearance on reamer.
3. Lack of rigidity in jig or machine.
4. Insecure holding of work.
5. Excessive overhang of reamer in spindle.
6. Excessive looseness in floating holder.
7. Too light a feed.

Correcting the cause can materially increase both reamer life and the quality of the reamed holes.

Coolants for Reaming

In reaming, the emphasis is usually on finish and a lubricant is normally chosen for this purpose rather than for cooling. Quite often this means a straight cutting oil.

Limit of tolerance on cutting diameter

The tolerance on the cutting diameter measured immediately behind the bevel or taper lead for parallel reamers listed is M6 as specified in BS122-PT2-1964. It is not practicable to standardise reamer limits to suit each grade of hole and the limits chosen are intended to produce H7 holes.

Nominal Diameter Range				Cutting Edge Diameter			
Inch		mm		Inch		mm	
Over	Up to and including	Over	Up to and including	High +	Low +	High +	Low +
0.0394	0.1181	1	3	0.0004	0.0001	0.009	0.002
0.1181	0.2362	3	6	0.0005	0.0002	0.012	0.004
0.2362	0.3937	6	10	0.0006	0.0002	0.015	0.006
0.3937	0.7087	10	18	0.0007	0.0003	0.018	0.007
0.7087	1.1181	18	30	0.0008	0.0003	0.021	0.008
1.1811	1.9085	30	50	0.0010	0.0004	0.025	0.009
1.9085	3.1496	50	80	0.0012	0.0004	0.030	0.011

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Company: ________ **Contact:** ________

Address: ________ **Phone:** ________

State / Province: ________ **Fax:** ________

Country: ________ **Email:** ________

Tap Details

Quantity:

Basic Geometry

☐ Thread Cutting
☐ Thread Forming

Size: ________________

Thread Limit: __________

NB: If special thread form, please supply details on separate drawing.

d_1 __________________
d_2 __________________
l_1 __________________
l_2 __________________
l_3 __________________
l_4 __________________
sq a/f ________________

Tool Material

☐ HSS
☐ HSSE
☐ PM-HSSE V3
☐ PM-HSS Co
☐ SPM
☐ VHM

Coating

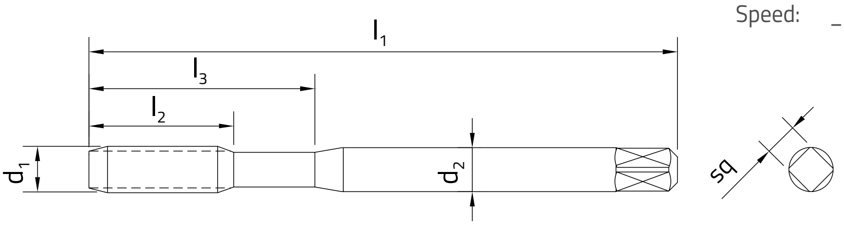
☐ Uncoated
☐ Steam Oxide
☐ TiN
☐ TiAlN
☐ TiCN
☐ other ______________

Existing Method

Manufacturer: ___________
____

Dimensions: ___________
Tolerance: ____________

Product No: ___________
Speed: ______________



Workpiece Details

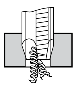
Component: ________________________________

Material Group: ________________________________

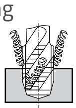
Material Grade: ________________________________

Characteristics of Material:
☐ Short Chipping ☐ Long Chipping

Hole Type:
☐ Through Hole



☐ Blind Hole



Tapping Hole Size: ___________ ☐ Drilled ☐ Cast ☐ Punched

Hole Depth: ________________________________

Machine Details

Machine Type:
☐ CNC
☐ Semi Auto
☐ Manual

Machine Direction:
☐ Vertical
☐ Horizontal
☐ Oblique

Work Piece Holder:
☐ Stationary
☐ Rotating

Coolant:
☐ Neat Oil
☐ Mist / Dry
☐ Emulsion >5%
☐ Emulsion >10%

Feed:
☐ CNC
☐ Mechanical
☐ Pneumatic
☐ Hydraulic
☐ Manual

Tapping Attachment:
☐ Tapping Chuck
☐ Tension
☐ Compression
☐ Tapping Attachment
☐ Tapping Chuck (rigid)
☐ Collet Chuck (length compensating)

Drawing / Notes

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Customer No.: New Customer ☐

Order No. | | | | | | | | | | | |

Company:

Contact:

Address:

Phone:

State / Province:

Fax:

Country:

Email:

Drill Details

Quantity:

Basic Geometry

Tool Type:
- ☐ Drill
- ☐ Step Drill
- ☐ Countersinks
- ☐ Subland Drills
- ☐ Core Drills
- ☐ Centre Drills

Total Length (mm): ______________________________

Number of Steps:
- ☐ Without
- ☐ With ____________________________________ steps

Step Diameter (mm):
- ☐ d_1 __________________ ☐ d_2 __________________
- ☐ d_3 __________________ ☐ d_4 __________________
- ☐ d_5 __________________ ☐ d_6 __________________

Tool Material:

- ☐ HSS
- ☐ HSSE
- ☐ PM-HSSE V3
- ☐ other ____

Plus Coating:

☐ Yes ☐ No

- ☐ TiN
- ☐ TiCN
- ☐ TiAlN
- ☐ Steam Oxide
- ☐ other ____

Plus Internal Cooling:

☐ Yes ☐ No

Point Design

Point Geometry:
- ☐ Relieved Cone
- ☐ For Grey Cast Iron
- ☐ Centre Point
- ☐ Facet Point Grind
- ☐ other ____

Special Point Grind, Form: ☐ A ☐ B ☐ C

Spiral: ☐ RH ☐ LH

Shank Design:

- ☐ Reinforced
- ☐ Without Flat
- ☐ With Flat
- ☐ Parallel Straight Shank
- ☐ Morse Taper
- ☐ other ____

Drawing / Notes

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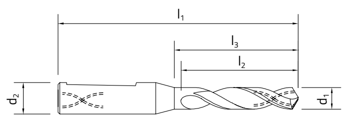
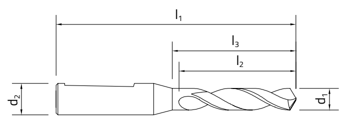
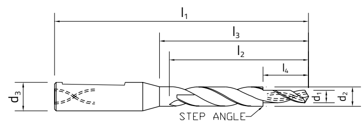
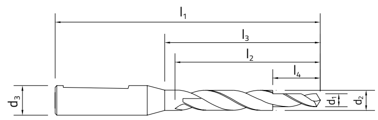
Company:	Contact:
Address:	Phone:
State / Province:	Fax:
Country:	Email:

SOLID CARBIDE DRILL WITHOUT STEP

	WITH Internal Cooling (Quantity:)	WITHOUT Internal Cooling (Quantity:)
		
Carbide grade	(specify if known)	(specify if known)
Norm-Ø d_1	(4 – 20mm)	(3 – 20mm)
Shank-Ø d_2	(DIN 6535)	(DIN 6535)
Shank length l_3	(DIN 6535)	(DIN 6535)
Shank form	☐ HA ☐ HE (DIN 6535)	☐ HA ☐ HE (DIN 6535)
Drilling depth l_3	(maximum 7 x D)	(maximum 7 x D)
Flute length l_2	(9.5 – 155mm)	(9.5 – 155mm)
Total length l_1	(60 – 205mm)	(60 – 205mm)
Point angle	☐ 120° ☐ 130° ☐ 140°	☐ 120° ☐ 130° ☐ 140°
Point geometry	(specify if known)	(specify if known)
Surface finish/coating	☐ Uncoated ☐ TiN ☐ TiCN ☐ TiAN ☐ AlCrN	☐ Uncoated ☐ TiN ☐ TiCN ☐ TiAN ☐ AlCrN
Cost per tool	$	$

SOLID CARBIDE STEP DRILL

	WITH Internal Cooling (Quantity:)	WITHOUT Internal Cooling (Quantity:)
		
Carbide grade	(specify if known)	(specify if known)
Step-Ø d_1	(4 – 20mm)	(3 – 20mm)
Body-Ø d_2	(4 – 20mm)	(3 – 20mm)
Shank-Ø d_3	(DIN 6535)	(DIN 6535)
Shank length l_3	(DIN 6535)	(DIN 6535)
Shank form	☐ HA ☐ HE (DIN 6535)	☐ HA ☐ HE (DIN 6535)
Step length l_4	(3 – 100mm)	(3 – 100mm)
Drilling depth l_3	(maximum 7 x D)	(maximum 7 x D)
Flute length l_2	(9.5 – 155mm)	(9.5 – 155mm)
Total length l_1	(60 – 205mm)	(60 – 205mm)
Point angle	☐ 120° ☐ 130° ☐ 140°	☐ 120° ☐ 130° ☐ 140°
Step angle	☐ 60° ☐ 90° ☐ 120°	☐ 60° ☐ 90° ☐ 120°
Point geometry	(specify if known)	(specify if known)
Surface finish/coating	☐ Uncoated ☐ TiN ☐ TiCN ☐ TiAN ☐ AlCrN	☐ Uncoated ☐ TiN ☐ TiCN ☐ TiAN ☐ AlCrN
Cost per tool	$	$

Please copy and fax to our Special Sales Dept. on (61 3) 9464 0015

Item # 499980185C

Special Sales
T: (61 3) 9280 0800 F: (61 3) 9464 0015 E: specsales@sutton.com.au

sutton®

APPLICATION MILLING - SPECIAL ENQUIRY

Customer No.: ____________ New Customer ☐

Order No. | | | | | | | | | | | | |

Company: ____________

Contact: ____________

Address: ____________

Phone: ____________

State / Province: ____________

Fax: ____________

Country: ____________

Email: ____________

Endmill Details

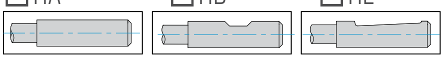
Quantity:

Basic Geometry

			Range
Norm-Ø d_2			(3 – 20mm)
Shank-Ø d_2 to DIN 6535			(4 – 20mm)
Shank length l_3 to DIN 6535			mm
Total length	l_1 Ø 3 – 10mm		(28 – 100mm)
	from Ø 10 – 20mm		(56 – 150mm)
Cutting length	l_2 Ø 3 – 10mm		(3 – 40mm)
	from Ø 10 – 20mm		(10 – 65mm)
Helix angle	w_2 Ø 3 – 6mm		(20° – 45°)
	from Ø 6 – 20mm		(20° – 55°)
No. of cutting edges	Ø 3 – 6mm		(2 – 4mm)
	from Ø 6 – 20mm		(2 – 6mm)
	from Ø 16 – 20mm		(2 – 8mm)

Shank Design

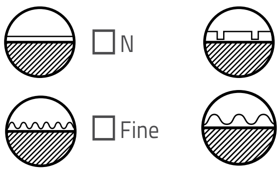
Straight Shank (DIN 6535) ☐ HA ☐ HB ☐ HE



Peripheral Geometry

Finishing endmills
(Ø 3 – 20mm) ☐ N ☐ with Chip Breaker

Roughing endmills
(Ø 6 – 20mm) ☐ Fine ☐ Coarse



Face Geometry

Point angle w_s ____________ (180° + 5°)

Cutting to Centre ☐ Yes ☐ No

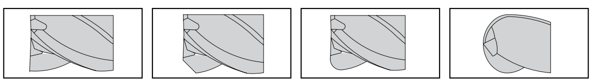
Corner Preparation

Sharp edge ☐ Yes ☐ No

Corner protection ____________ mm x 45° (Ø 0.03 – 1.5mm)

Corner radius ____________ mm x d_1 (Ø 0.3 – 2/3mm)

Ballnose ☐ Yes ☐ No



Plus Internal Cooling

☐ Yes ☐ No

(Ø 4 – 20mm)

Plus Coating

☐ Yes ☐ No

☐ TiN ☐ TiCN ☐ TiAN ☐ AlCrN (Ø 4 – 20mm)

Tool Material

Specify grade (if known)

☐ Carbide ____________

☐ PM-HSSE ____________

☐ HSS-Co ____________

☐ HSS ____________

Detail Regarding Application

Range of applications ____________

Material description ____________

Material hardness ____________ (N/mm² or HRC)

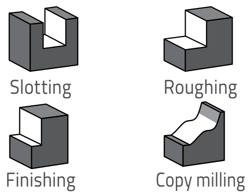
Application types

☐ Slotting

☐ Roughing

☐ Finishing

☐ Copy milling



Drawing / Notes

Item # 499980185D