

HSS, HSS-E Cobalt and HSS-E Vanadium (materials used to manufacture tools)

Material Type	EN10027-1 Steel Name	DIN	Carbon C.	Chromium Cr.	Molybdenum Mo.	Tungsten W.	Vanadium V.	Cobalt Co.	Material Applications
M2	HS 6-5-2	1.3343	0.90	4.10	5.00	6.40	1.90		Drills, taps & some milling cutters-normal HSS Steel.
M35	HS 6-5-2-5	1.3243	0.92	4.10	5.00	6.40	1.90	4.80	DIN taps reamers & milling cutters a tough Cobalt material
M42	HS 2-10-1-8	1.3247	1.08	4.10	9.50	1.50	1.20	8.00	Cobalt drills, DIN cutters & toolbits cobalt for a higher hot hardness.
WKE45	HS 9-4-3-10	(1.3208)	1.40	4.20	3.50	8.50	3.40	11.00	Toolbits only for extreme applications.
ASP23*	HS 6-5-3	1.3342	1.28	4.20	3.20	6.40	3.10		Drills & taps for added toughness chipping resistance and abrasive wear.
ASP30*	HS 6-5-3-8		1.28	4.20	5.00	6.40	3.10	8.50	Special drills taps & cutters, chip resisting & higher hot hardness.
ASP60*	HS 6-7-6-10	(1.3241)	2.30	4.20	7.00	6.50	6.50	10.50	Quality cutters. For extreme applications.
PM M4*	HS 6-5-4		1.40	4.00	5.00	5.50	4.00		ISO PMC taps & special taps high vanadium for wear resistance.
PM T15*	HS 12-0-5-5	1.3202	1.60	4.00		12.00	5.00	5.00	Special and cobalt taps for extreme applications.

* Powder metallurgy grades.

Self Tapping Screws

Drill sizes for use with hardened steel type self tapping screws for fastening sheet metal. All drill sizes are approximate.

Screw Size	Material Thickness			Drill Diameter
	Inch	MM.	SWG	
No2 (0.086") 2.2mm	0.018	0.45	26	1.60
	0.036	0.91	20	1.85
	0.064	1.62	16	1.95
No 4 (0.112") or 2.9mm	0.018	0.45	26	2.05
	0.036	0.91	20	2.30
	0.064	1.62	16	2.40
	0.080	2.03	14	2.60
No6 (0.138") or 3.5mm	0.018	0.45	26	2.35
	0.036	0.91	20	2.80
	0.064	1.62	16	2.95
	0.080	2.03	14	3.10
	0.104	2.64	12	3.20
No8 (0.164") or 4.2mm	0.028	0.71	22	2.90
	0.036	0.91	20	3.10
	0.064	1.22	18	3.20
	0.080	1.62	16	3.40
	0.104	2.64	12	3.70
	0.125	3.18	1/8"	3.80
No 10 (0.186") or 4.8mm	0.028	0.71	22	3.40
	0.048	1.22	18	3.60
	0.064	1.62	16	3.80
	0.104	2.64	12	4.10
	0.125	3.18	1/8"	4.30
	0.187	4.75	3/16"	4.50
No12 (0.212") or 5.5mm	0.028	0.71	22	4.10
	0.048	1.22	18	4.30
	0.064	1.62	16	4.50
	0.104	2.64	12	4.80
	0.125	3.18	1/8"	4.90
	0.187	4.75	3/16"	5.10
No14 (0.242")	0.048	1.22	18	4.80
	0.064	1.62	16	5.20
	0.125	3.18	1/8"	5.40
	0.187	4.75	3/16"	5.70
6.3mm	0.036	0.91	20	5.00
	0.048	1.22	18	5.20
	0.060	1.52		5.80
	0.075	1.90		5.90

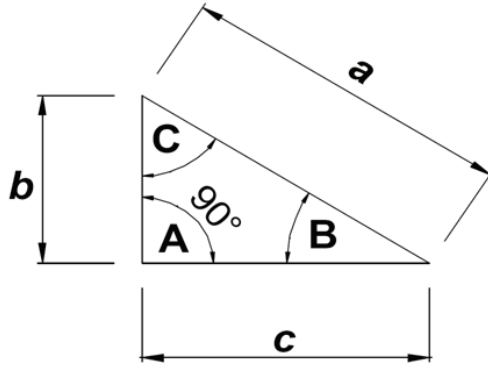
The drill diameter varies with the thickness of material being drilled.

For aluminium and similar soft materials decrease the drill diameter by 0.1mm or 5% of diameter on No10 and larger screws.

Using the larger drill size on thin materials will result in stripped threads. Using the smallest drill in thick materials will need very high torque values to drive the screw and can result in the head shearing off the screw.

Note that British Standard Wire Gauge as used to describe sheet metal thickness has no relation to the "ANSI" Number drills listed in the decimal equivalent chart.

No.14 and 6.3 metric screws are not interchangeable in the drill sizes, so we have not amalgamated the listings.

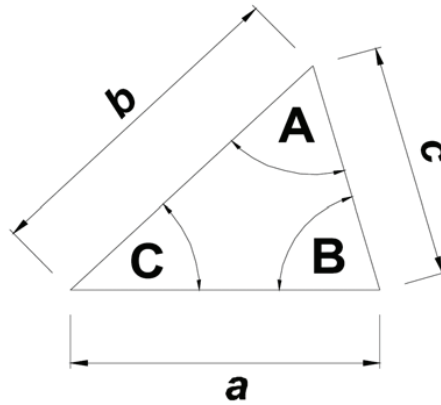


As shown in the sketch the sides of the right angled triangle are designated a, b, c.

Angle A opposite the hypotenuse is the right angle and is therefore always one of the known quantities.

Sides & Angles	Formulas For Sides & Angles To Be Found		
Sides a & b	$c = \sqrt{a^2 - b^2}$	$\sin B = \frac{b}{a}$	$C = 90^\circ - B$
Sides a & c	$b = \sqrt{a^2 - c^2}$	$\sin C = \frac{c}{a}$	$B = 90^\circ - C$
Sides b & c	$a = \sqrt{b^2 + c^2}$	$\tan B = \frac{b}{c}$	$C = 90^\circ - B$
Side a: Angle B	$b = a \times \sin B$	$c = a \times \cos B$	$C = 90^\circ - B$
Side a: Angle C	$b = a \times \cos C$	$c = a \times \sin B$	$B = 90^\circ - C$
Side b: Angle B	$a = \frac{b}{\sin B}$	$c = \frac{b}{\tan B}$	$C = 90^\circ - B$
Side b: Angle C	$a = \frac{b}{\cos C}$	$c = b \times \tan C$	$B = 90^\circ - C$
Side c: Angle B	$a = \frac{c}{\cos B}$	$b = c \times \tan B$	$C = 90^\circ - B$
Side c: Angle C	$a = \frac{c}{\sin C}$	$b = \frac{c}{\tan C}$	$B = 90^\circ - C$

Oblique Angles Triangles



One Side Known "a" and Two Angles Known "A" & "B"

$$C = 180^\circ - (A + B)$$

$$\text{side } b = \frac{a \times \sin B}{\sin A} \quad \text{side } c = \frac{a \times \sin C}{\sin A}$$

Two Sides Known "a" & "b" and Angle Known "C"

$$B = 180^\circ - (A + C) \quad \text{side } c = \sqrt{a^2 + b^2 - (2ab \times \cos C)}$$

$$\tan A = \frac{a \times \sin C}{b - (a \times \cos C)} \quad \text{side } c = \frac{a \times \sin C}{\sin A}$$

Two Sides Known "a" & "b" and Angle Known "A"

$$C = 180^\circ - (A + B)$$

$$\sin B = \frac{b \times \sin A}{a} \quad \text{side } c = \frac{a \times \sin C}{\sin A}$$

All Sides Known "a", "b" & "c"

$$C = 180^\circ - (A + B)$$

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc} \quad \sin B = \frac{b \times \sin A}{a}$$

$$\text{Area is } = \frac{a \times b \times c \times \sin C}{2}$$

Manufacturing Tolerances To BS EN 20286-2, ISO286-2 (Old BS Standard 4500)

Tolerances given are in Microns 1/1000 of a mm (0.001mm)

Diameter Ranges																		
	0 - 3mm	>3 to 10	>6 to 10	>10 to 18	>18 - 30	>30 to 50	>50 to 80	>80 -120	>120 -180									
Cutter Diameter Of Slot Drills And Tri-cutters, Cutter Width Of Woodruff Cutters																		
e8	-14	-28	-20	-38	-25	-47	-32	-59	-40	-73	-50	-89	-60	-106	-72	-126	-85	-148
Size Of Shank With Back Taper On Parallel Shank Drill																		
f11	-6	-66	-10	-85	-13	-103	-16	-126	-20	-150	-25	-185	-30	-220	-36	-255	-43	-290
Shank Tolerance Of DIN / ISO Cutters																		
h6	0	-6	0	-8	0	-9	0	-11	0	-13	0	-16	0	-19	0	-22	0	-22
Diameter On Drills & Shanks Of Screw Shank Cutters																		
h8	0	-14	0	-18	0	-22	0	-27	0	-33	0	-39	0	-46	0	-54	0	-63
Shank Tolerance On ISO Taps And DIN Reamers																		
h9	0	-25	0	-30	0	-36	0	-43	0	-52	0	-62	0	-74	0	-87	0	-100
Square Tolerance on ISO Taps, Outside Diameter Of Woodruff Cutters																		
h11	0	-60	0	-75	0	-90	0	-110	0	-130	0	-160	0	-190	0	-220	0	-250
Driving Squares On Hand Reamers																		
h12	0	-100	0	-120	0	-150	0	-180	0	-210	0	250	0	-300	0	-350	0	-400
Tolerance For Toolbits																		
h13	0	-140	0	-180	0	-220	0	270	0	-330	0	-390	0	-460	0	-540	0	-630

Low case "h8" means a shaft or external feature.

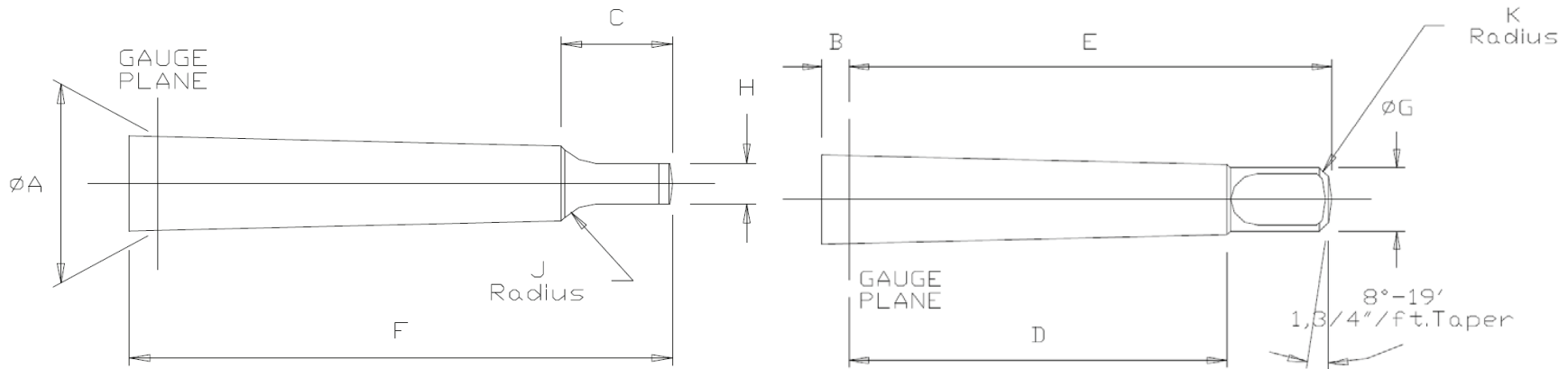
Manufacturing Tolerances To BS EN 20286-2, ISO286-2 (Old BS Standard 4500)

Tolerances given are in Microns 1/1000 of a mm (0.001mm)

Diameter Ranges In mm's																			
0 - 3mm		>3 to 10		>6 to 10		>10 to 18		>18 - 30		>30 to 50		>50 to 80		>80 -120		>120 -180			
Cutter Diameters On ISO End Mills																			
js12	+50	-50	+60	-60	+75	-75	+90	-90	+105	-105	+125	-125	+150	-105	+175	-175	+200	-200	
Cutting Diameter Of Ripping Cutters																			
js14	+125	-125	+150	-150	+180	-180	+215	-215	+260	-260	+310	-310	+370	-370	+435	-435	+500	-500	
British Standard Reamer										Tolerance only now used for extra length reamers, see reamers page 23.									
m6	+8	+2	+12	+4	+15	+6	+18	+7	+21	+8	+25	+9	+30	+11	+35	+13	+40	-15	
Hole Produced By DIN / ISO Standard Reamer																			
H7	+10	0	+12	0	+15	0	+18	0	+21	0	+25	0	+30	0	+35	0	+40	0	
Hole Produced By Old British Standard Reamer																			
H8	+14	0	+18	0	+22	0	+27	0	+33	0	+39	0	+46	0	+54	0	+60	0	
Improved Hole Size By Split Point Drills, TiN Coated Drills																			
H10	+40	0	+48	0	+58	0	+70	0	+84	0	+100	0	+120	0	+140	0	+160	0	
Hole Produced By Standard Twist Drill (Size For Fitted Bolt Hole)																			
H12	+100	0	+120	0	+150	0	+180	0	+210	0	+250	0	+300	0	+350	0	+400	0	
Width Of Slot Produced By Metric Slot Drill																			
P9	-6	-31	-12	-42	-15	-51	-18	-61	-22	-74	-26	-88	-32	-106	-37	-124	-43	-143	

An upper case letter "H8" means a hole or slot, an internal feature.

General Dimensions Of Morse Taper Shanks



		A	B	C	D	E	F	G	H	J	K
No. Of Morse Taper	Taper Per Foot On Dia.	Dia. At Gauge Plane	Overhang	Tang Length	Gauge Plane To Tang	Gauge Plane To End Of Shank mm	Overall Length	Dia.	Thickness	Radius	Corner Radius
No.1 Morse	0.59858	12.065	3.5	13.5	48.5	62.0	65.5	8.70	5.2	5.0	1.2
No.2 Morse	0.59941	17.780	5.0	16.0	49.0	75.0	80.0	13.50	6.3	6.0	1.6
No.3 Morse	0.60235	23.825	5.0	20.0	74.0	94.0	99.0	18.50	7.9	7.0	2.0
No.4 Morse	0.62326	31.267	6.5	24.0	93.5	117.5	124.0	26.50	11.9	8.0	2.5
No.5 Morse	0.63151	44.399	6.5	29.0	120.5	149.5	156.0	35.70	15.9	12.0	3.0
No.6 Morse	0.62565	63.348	8.0	40.0	170.0	210.0	218.0	51.00	19.0	18.0	4.0

In Accordance With B.S. 1660 Part 1:1192, ISO 296:1991

Useful Tapers

Taper "Cone Of"	Taper Per Foot	Included Angle			Angle with Centreline		
		deg	mins	secs	deg	mins	secs
1 in 96	1/8"	0°	35'	49"	0°	17'	54"
1 in 60	0.200	0°	57'	18"	0°	28'	39"
Metric Hand Taper Pin Reamers							
1 in 50	0.240	1°	8'	47"	0°	34'	23"
Imperial Hand Taper Pin Reamers							
1 in 48	1/4"	1°	11'	37"	0°	35'	48"
1 in 38.4	5/16"	1°	29'	31"	0°	44'	46"
1 in 32	3/8"	1°	47'	25"	0°	53'	42"
1 in 25	0.480"	2°	17'	29"	1°	8'	45"
1 in 24	1/2"	2°	23'	13"	1°	11'	36"
Morse 1	0.59858	2°	51'	27"	1°	25'	43"
Morse 2	0.59941	2°	51'	41"	1°	25'	50"
1 in 20	0.600"	2°	51'	51"	1°	25'	55"
Morse 3	0.60235	2°	52'	31"	1°	26'	16"
Morse 4	0.62326	2°	58'	31"	1°	2'	15"
Morse 0	0.6246	2°	58'	54"	1°	29'	27"
1 in 19.2	5/8"	2°	59'	0"	1°	29'	30"
Morse 6	0.62565	3°	59'	12"	1°	29'	36"
Morse 5	0.63151	3°	0'	52"	1°	30'	26"
Reamers For BSPT & NPT Threads							
1 in 16	3/4"	3°	34'	47"	1°	47'	24"
1 in 15	0.800	3°	49'	6"	1°	54'	33"
1 in 13.7143	7/8"	4°	10'	33"	2°	5'	17"
1 in 12	1"	4°	46'	19"	2°	23'	9"
Bridge Reamer Lead Taper							
1 in 10	1.200	5°	43'	29"	2°	52'	45"
1 in 9.6	1-1/4"	5°	57'	46"	2°	58'	53"
1 in 8	1-1/2"	7°	9'	9"	3°	34'	35"
1 in 6	2"	9°	31'	38"	4°	45'	49"
1 in 5	2.400"	11°	25'	16"	5°	42'	38"
1 in 4	3"	14°	15'	0"	7°	7'	30"
Milling Machine Shanks ISO 30, 40, 45, 50							
ISO 7/24	3 1/2"	16°	35'	39"	8°	17'	50"
1 in 3	4"	18°	55'	20"	9°	27'	44"

Hardness Conversion Table

VPN Vickers Hardness N°	HBN Brinell Hardness N°	Rc Rockwell Hardness C Scale	Tensile Strength		
			Tons / Sq. Inch	Kilos / Sq. mm	Newtons Per Sq. mm.
940	745	68.0			
920	735	67.5			
900	725	67.0			
883	718	66.5			
865	712	66.0			
848	695	65.5			
832	682	65.0	150	236	2314
817	675	64.5	147	231	2265
800	668	64.0	145	228	2235
787	660	63.5	142	223	2186
772	652	63.0	140	220	2157
756	644	62.5	138	218	2137
746	626	62.0	137	215	2108
733	620	61.5	135	212	2079
720	614	61	133	209	2049
697	601	60	129	203	1990
674	590	59	126	198	1941
653	588	58	123	193	1892
633	576	57	120	189	1853
613	552	56	117	184	1804
595	545	55	114	179	1755
577	529	54	112	176	1726
560	510	53	109	171	1676
544	500	52	107	168	1647
528	487	51	104	163	1598
513	475	50	102	160	1569
498	464	49	100	157	1539
484	450	48	98	154	1510
471	442	47	96	151	1480
458	432	46	94	148	1451
446	421	45	92	145	1422
434	410	44	90	142	1392
423	401	43	88	139	1363

Not a practical method of test in this range.

Hardness Conversion Table

VPN Vickers Hardness N°	HBN Brinell Hardness N°	Rc Rockwell Hardness C Scale	Tensile Strength		
			Tons / Sq. Inch	Kilos / Sq. mm	Newtons Per Sq. mm.
412	390	42	86	135	1323
402	381	41	85	134	1314
392	371	40	83	132	1294
382	362	39	81	129	1265
372	353	38	80	126	1235
363	344	37	78	123	1206
354	336	36	76	120	1176
345	327	35	74	117	1147
336	319	34	72	113	1108
327	311	33	70	110	1072
318	301	32	68	107	1049
310	294	31	67	105	1030
302	286	30	65	103	1010
294	279	29	64	101	990
286	273	28	62	98	960
279	267	27	61	96	941
272	261	26	59	93	912
266	258	25	58	91	892
260	253	24	57	90	882
254	248	23	55	88	863
248	243	22	54	85	833
243	239	21	53	84	823
238	235	20	52	82	804
228	226	98B	50	79	774
217	216	96B	47	74	725
207	206	94B	45	71	696
196	195	92B	43	68	666
187	187	91B	41	65	637
176	176	88B	39	61	598
165	165	86B	37	58	568
145	145	79B	33	52	510
131	131	72B	30	47	464

Use "B" scale in this range.



Conversion Factors

To Convert	Multiply By
Imperial - Metric	
Inches to Millimetres	25.4
Feet to Metres	0.3048
Yards to Metres	0.9144
Miles to Kilometres	1.60934
Square Inches to Square Centimetres	6.4516
Square Feet to Square Metres	0.092903
Square Yards to Square Metres	0.0836127
Square Miles to Square Kilometres	2.58999
Acre (4840 Sq.Yds, 10sq Chains) to Hectare	0.4047
Cubic Inches to Cubic Centimetres	16.3871
Cubic Feet to Cubic Metres	0.028317
Cubic Yards to Cubic Metres	0.764555
Pints to Litres	0.568261
IMP.Gallons to Litres	4.54609
Ounces to Grams	28.3495
Pounds to Kilograms	0.453592
Tons (2240lbs) to Tonnes (1000kg)	1.01605
lbs. / Sq. Inch to Kg / cm ²	0.070307
Fahrenheit to Centigrade	°C x 9 / 5 + 32
Metric - Imperial	
Millimetres to Inches	0.0393701
Metres to Feet	3.28084
Metres to Yards	1.09361
Kilometres to Miles	0.621371
Square Centimetres to Square Inches	0.155
Square Metres to Square Feet	10.76391
Square Metres to Square Yards	1.19599
Square Kilometres to Square Miles	0.3861
Hectares (100m x 100m) to Acres	2.471
Cubic Centimetres to Cubic Inches	0.061024
Cubic Metres to Cubic Feet	35.3147
Cubic Metres to Cubic Yards	1.30795
Litres to Pints	1.76
Litres to Gallons (Imperial)	0.22
Grams to Ounces	0.035274
Kilograms to Pounds	2.2-462
Tonnes to Tons (Long Ton British)	0.984207
Kg / cm ² to lb. / sq. in.	14.2233
Centigrade (Celsius) to Fahrenheit	5/9 (°F - 32)