PRESTO®

Engineers Cutting Tools

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International UK Ltd

Quality Since 1843

COUNSELLOR

Twist Drills Reamers Taps & Dies Milling Cutters

PRESTO

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®PRESTO

DECIMAL EQUIVALENTS

Stocked items in Bold.

Gauge and Letter sizes are not now recommended.

Metric	Fract	Gauge	Inch
0.30			.0118
0.32			.0126
0.343		**80**	.0135
0.35			.0138
0.368		**79**	.0145
0.38			.0150
0.397	**1/64"**		.0156
0.40			.0157
0.406		**78**	.0160
0.42			.0165
0.45			.0177
0.457		**77**	.0180
0.48			.0189
0.50			.0197
0.508		**76**	.0200
0.52			.0205
0.533		**75**	.0210
0.55			.0217
0.572		**74**	.0225
0.58			.0228
0.60			.0236
0.61		**73**	.0240
0.62			.0244
0.635		**72**	.0250
0.65			.0256
0.660		**71**	.0260
0.68			.0268
0.7			.0276
0.711		**70**	.0280
0.72			.0283
0.742		**69**	.0292
0.75			.0295
0.78			.0307
0.787		**68**	.0310
0.794	**1/32"**		.0312
0.8			.0315
0.813		**67**	.0320

Metric	Fract	Gauge	Inch
0.82			.0323
0.838		**66**	.0330
0.85			.0335
0.88			.0346
0.889		**65**	.0350
0.9			.0354
0.914		**64**	.0360
0.92			.0362
0.940		**63**	.0370
0.95			.0374
0.965		**62**	.0380
0.98			.0386
0.991		**61**	.0390
1.00			.0394
1.016		**60**	.0400
1.041		**59**	.0410
1.05			.0413
1.067		**58**	.0420
1.092		**57**	.0430
1.10			.0433
1.15			.0453
1.181		**56**	.0465
1.191	**3/64"**		.0469
1.20			.0472
1.25			.0492
1.30			.0512
1.321		**55**	.0520
1.35			.0531
1.397		**54**	.0550
1.40			.0551
1.45			.0571
1.50			.0591
1.511		**53**	.0595
1.55			.0610
1.588	**1/16"**		.0625
1.60			.0630
1.613		**52**	.0635

Number drill diameters are listed to ANSI standard diameters. Although often referred to as Wire Gauge this is the high speed steel wire, which they are made from and not to any British wire sizes. For reference to British SWG used on sheet metal, see page 55.

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Metric	Fract	Gauge	Inch
1.65			.0650
1.70			.0669
1.702		**51**	.0670
1.75			.0689
1.778		**50**	.0700
1.80			.0709
1.85			.0728
1.854		**49**	.0730
1.90			.0748
1.930		**48**	.0760
1.95			.0768
1.984	**5/64"**		.0781
1.994		**47**	.0785
2.00			.0787
2.05			.0807
2.057		**46**	.0810
2.083		**45**	.0820
2.10			.0827
2.15			.0846
2.184		**44**	.0860
2.2			.0866
2.25			.0886
2.261		**43**	.0890
2.30			.0906
2.35			.0925
2.375		**42**	.0935
2.381	**3/32"**		.0938
2.40			.0945
2.438		**41**	.0960
2.45			.0965
2.489		**40**	.0980
2.50			.0984
2.527		**39**	.0995
2.55			.1004
2.578		**38**	.1015
2.60			.1024
2.642		**37**	.1040
2.65			.1043
2.70			.1063
2.705		**36**	.1065
2.75			.1083
2.778	**7/64"**		.1094

Metric	Fract	Gauge	Inch
2.794		**35**	.1100
2.80			.1102
2.819		**34**	.1110
2.85			.1122
2.870		**33**	.1130
2.90			.1142
2.946		**32**	.1160
2.95			.1161
3.00			.1181
3.048		**31**	.1200
3.10			.1220
3.175	**1/8"**		.1250
3.20			.1260
3.25			.1280
3.264		**30**	.1285
3.30			.1299
3.40			.1339
3.454		**29**	.1360
3.5			.1378
3.569		**28**	.1405
3.572	**9/64"**		.1406
3.6			.1417
3.658		**27**	.1440
3.70			.1457
3.734		**26**	.1470
3.75			.1476
3.797		**25**	.1495
3.80			.1496
3.861		**24**	.1520
3.90			.1535
3.912		**23**	.1540
3.969	**5/32"**		.1562
3.988		**22**	.1570
4.00			.1575
4.039		**21**	.1590
4.089		**20**	.1610
4.10			.1614
4.20			.1654
4.216		**19**	.1660
4.25			.1673
4.30			.1693
4.305		**18**	.1695

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DECIMAL EQUIVALENTS

Metric	Fract	Gauge	Inch
4.366	**11/64"**		.1719
4.394		**17**	.1730
4.40			.1732
4,496		**16**	.1770
4.50			.1772
4.572		**15**	.1800
4.60			.1811
4.623		**14**	.1820
4.70		**13**	.1850
4.75			.1870
4.762	**3/16"**		.1875
4.80		**12**	.1890
4.851		**11**	.1910
4.90			.1929
4.915		**10**	.1935
4.978		**9**	.1960
5.00			.1969
5.055		**8**	.1990
5.10			.2008
5.105		**7**	.2010
5.159	**13/64"**		.2031
5.182		**6**	.2040
5.20			.2047
5.220		**5**	.2055
5.25			.2067
5.30			.2087
5.309		**4**	.2090
5.40			.2126
5.410		**3**	.2130
5.50			.2165
5.556	**7/32"**		.2188
5.60			.2205
5.613		**2**	.2210
5.70			.2244
5.75			.2264
5.791		**1**	.2280
5.80			.2283
5.90			.2323
5.944		**A**	.2340
5.953	**15/64"**		.2344
6.00			.2362
6.045		**B**	.2380

Metric	Fract	Letter	Inch
6.10			.2402
6.147		**C**	.2420
6.20			.2441
6.248		**D**	.2460
6.25			.2461
6.30			.2480
6.35	**1/4"**	**E**	.2500
6.40			.2520
6.50			.2559
6.528		**F**	.2570
6.60			.2598
6.629		**G**	.2610
6.70			.2638
6.747	**17/64"**		.2656
6.75			.2657
6.756		**H**	.2660
6.80			.2677
6.90			.2717
6.909		**I**	.2720
7.00			.2756
7.036		**J**	.2770
7.10			.2795
7.137		**K**	.2810
7.144	**9/32"**		.2812
7.20			.2835
7.25			.2854
7.30			.2874
7.366		**L**	.2900
7.40			.2913
7.493		**M**	.2950
7.50			.2953
7.541	**19/64"**		.2969
7.60			.2992
7.671		**N**	.3020
7.70			.3031
7.75			.3051
7.80			.3071
7.90			.3110
7.938	**5/16"**		.3125
8.00			.3150
8.026		**O**	.3160
8.10			.3189

DECIMAL EQUIVALENTS

Metric	Fract	Letter	Inch
8.20			.3228
8.204		**P**	.3230
8.25			.3248
8.30			.3268
8.334	**21/64"**		.3281
8.40			.3307
8.433		**Q**	.3320
8.50			.3346
8.60			.3386
8.611		**R**	.3390
8.70			.3425
8.731	**11/32"**		.3438
8.75			.3445
8.80			.3465
8.839		**S**	.3480
8.90			.3504
9.00			.3543
9.093		**T**	.3580
9.10			.3583
9.128	**23/64"**		.3594
9.20			.3622
9.25			.3642
9.30			.3661
9.347		**U**	.3680
9.40			.3701
9.50			.3740
9.525	**3/8"**		.3750
9.576		**V**	.3770
9.60			.3780
9.70			.3819
9.75			.3839
9.80			.3858
9.804		**W**	.3860
9.90			.3898
9.922	**25/64"**		.3906
10.00			.3937
10.084		**X**	.3970
10.10			.3976
10.20			.4016
10.25			.4035
10.262		**Y**	.4040
10.30			.4055

Metric	Fract	Letter	Inch
10.319	**13/32"**		.4062
10.40			.4094
10.490		**Z**	.4130
10.50			.4134
10.60			.4173
10.70			.4213
10.716	**27/64"**		.4219
10.75			.4232
10.80			.4252
10.90			.4291
11.00			.4331
11.10			.4370
11.112	**7/16"**		.4375
11.20			.4409
11.25			.4429
11.30			.4449
11.40			.4488
11.50			.4528
11.509	**29/64"**		.4531
11.60			.4567
11.70			.4606
11.75			.4626
11.80			.4646
11.90			.4685
11.906	**15/32"**		.4688
12.00			.4724
12.10			.4764
12.20			.4803
12.25			.4823
12.30			.4843
12.303	**31/64"**		.4844
12.40			.4882
12.50			.4921
12.60			.4961
12.70	**1/2"**		.5000
12.75			.5020
12.80			.5039
12.90			.5079
13.00			.5118
13.097	**33/64"**		.5156
13.10			.5157
13.20			.5197

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DECIMAL EQUIVALENTS

Metric	Fract	Inch
13.25		.5217
13.30		.5236
13.40		.5276
13.494	**17/32"**	.5313
13.50		.5315
13.60		.5354
13.70		.5394
13.75		.5413
13.80		.5433
13.891	**35/64"**	.5469
13.90		.5472
14.00		.5512
14.25		.5610
14.288	**9/16"**	.5625
14.50		.5709
14.684	**37/64"**	.5781
14.75		.5807
15.00		.5906
15.081	**19/32"**	.5937
15.25		.6004
15.478	**39/64"**	.6094
15.50		.6102
15.75		.6201
15.875	**5/8"**	.6250
16.00		.6299
16.25		.6398
16.272	**41/64"**	.6406
16.50		.6496
16.669	**21/32"**	.6563
16.75		.6594
17.00		.6693
17.066	**43/64"**	.6719
17.25		.6791
17.462	**11/16"**	.6875
17.50		.6890
17.75		.6988
17.859	**45/64"**	.7031
18.00		.7087
18.25		.7185
18.256	**23/32"**	.7187
18.50		.7283
18.653	**47/64"**	.7344

Metric	Fract	Inch
18.75		.7382
19.00		.7480
19.050	**3/4"**	.7500
19.25		.7579
19.447	**49/64"**	.7656
19.50		.7677
19.75		.7776
19.844	**25/32"**	.7813
20.00		.7874
20.241	**51/64"**	.7969
20.25		.7972
20.50		.8071
20.638	**13/16"**	.8125
20.75		.8169
21.00		.8268
21.034	**53/64"**	.8281
21.25		.8366
21.431	**27/32"**	.8437
21.50		.8465
21.75		.8563
21.828	**55/64"**	.8594
22.00		.8661
22.225	**7/8"**	.8750
22.25		.8760
22.50		.8858
22.622	**57/64"**	.8906
22.75		.8957
23.00		.9055
23.019	**29/32"**	.9063
23.25		.9154
23.416	**59/64"**	.9219
23.50		.9252
23.75		.9350
23.812	**15/16"**	.9375
24.00		.9449
24.209	**61/64"**	.9531
24.25		.9547
24.5		.9646
24.606	**31/32"**	.9687
24.75		.9744
25.00		.9843
25.003	**63/64"**	.9844

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DECIMAL EQUIVALENTS

Metric	Fract	Inch
25.25		**.9941**
25.400	**1"**	1.0000
25.50		1.0039
25.75		1.0138
25.797	**1-1/64"**	1.0156
26.00		1.0236
26.194	**1-1/32"**	1.0313
26.25		1.0335
26.50		1.0433
26.591	**1-3/64"**	1.0469
26.75		1.0531
26.988	**1-1/16"**	1.0625
27.00		1.0630
27.25		1.0728
27.384	**1-5/64"**	1.0781
27.50		1.0827
27.75		1.0925
27.781	**1-3/32"**	1.0937
28.00		1.1024
28.178	**1-7/64"**	1.1094
28.25		1.1122
28.50		1.1220
28.575	**1-1/8"**	1.1250
28.75		1.1319
28.972	**1-9/64"**	1.1406
29.00		1.1417
29.25		1.1516
29.369	**1-5/32"**	1.1563
29.50		1.1614
29.75		1.1713
29.766	**1-11/64"**	1.1719
30.000		1.1811
30.162	**1-3/16"**	1.1875
30.25		1.1909
30.50		1.2008
30.559	**1-13/64"**	1.2031
30.75		1.2106
30.956	**1-7/32"**	1.2187
31.00		1.2205
31.250		1.2303
31.353	**1-15/64"**	1.2344
31.50		1.2402

Metric	Fract	Inch
31.750	**1-1/4"**	1.2500
32.00		1.2598
32.147	**1-17/64"**	1.2656
32.5		1.2795
32.544	**1-9/32"**	1.2813
32.941	**1-19/64"**	1.2969
33.00		1.2992
33.338	**1-5/16"**	1.3125
33.50		1.3189
33.734	**1-21/64"**	1.3281
34.00		1.3386
34.131	**1-11/32"**	1.3437
34.50		1.3583
34.528	**1-23/64"**	1.3594
34.925	**1-3/8"**	1.3750
35.00		1.3780
35.322	**1-25/64"**	1.3906
35.50		1.3976
35.719	**1-13/32**	1.4063
36.00		1.4173
36.116	**1-27/64"**	1.4219
36.50		1.4370
36.512	**1-7/16"**	1.4375
36.909	**1-29/64"**	1.4531
37.00		1.4567
37.306	**1-15/32"**	1.4687
37.50		1.4764
37.703	**1-31/64"**	1.4844
38.00		1.4961
38.100	**1-1/2"**	1.5000
38.497	**1-33/64"**	1.5156
38.50		1.5157
38.894	**1-17/32"**	1.5313
39.00		1.5354
39.291	**1-35/64"**	1.5469
39.50		1.5551
39.688	**1-9/16"**	1.5625
40.00		1.5748
40.084	**1-37/64**	1.5781
40.481	**1-19/32"**	1.5937
40.50		1.5945
40.878	**1-39/64"**	1.6094

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DECIMAL EQUIVALENTS

Metric	Fract	Inch
41.00		1.6142
41.275	**1-5/8"**	1.6250
41.50		1.6339
41.672	**1-41/64"**	1.6406
42.00		1.6535
42.069	**1-21/32"**	1.6563
42.466	**1-43/64"**	1.6719
42.50		1.6732
42.862	**1-11/16"**	1.6875
43.00		1.6929
43.259	**1-45/64"**	1.7031
43.50		1.7126
43.656	**1-23/32"**	1.7187
44.00		1.7323
44.053	**1-47/64"**	1.7344
44.450	**1-3/4"**	1.7500
44.50		1.7520
44.847	**1-49/64"**	1.7656
45.00		1.7717
45.244	**1-25/32"**	1.7813
45.50		1.7913
45.641	**1-51/64"**	1.7969
46.00		1.8110
46.038	**1-13/16"**	1.8125
46.434	**1-53/64"**	1.8281
46.50		1.8307
46.831	**1-27/32"**	1.8437
47.00		1.8504
47.228	**1-55/64"**	1.8594
47.50		1.8701
47.625	**1-7/8"**	1.8750
48.00		1.8898
48.022	**1-57/64"**	1.8906
48.419	**1-29/32"**	1.9063
48.50		1.9094
48.816	**1-59/64"**	1.9219
49.00		1.9291
49.212	**1-15/16"**	1.9375
49.50		1.9488
49.609	**1-61/64"**	1.9531
50.00		1.9685
50.006	**1-31/32"**	1.9687

Metric	Fract	Inch
50.403	**1-63/64"**	1.9844
50.50		1.9882
50.800	**2"**	2.0000
51.00		2.0079
51.594	**2-1/32"**	2.0313
52.00		2.0472
52.388	**2-1/16"**	2.0625
53.00		2.0866
53.181	**2-3/32"**	2.0937
53.975	**2-1/8"**	2.1250
54.00		2.1260
54.769	**2-5/32"**	2.1563
55.00		2.1654
55.562	**2-3/16"**	2.1875
56.00		2.2047
56.356	**2-7/32"**	2.2187
57.00		2.2441
57.150	**2-1/4"**	2.2500
57.944	**2-9/32"**	2.2813
58.00		2.2835
58.738	**2-5/16"**	2.3125
59.00		2.3228
59.531	**2-11/32"**	2.3437
60.00		2.3622
60.325	**2-3/8"**	2.3750
61.00		2.4016
61.119	**2-13/32"**	2.4063
61.912	**2-7/16"**	2.4375
62.00		2.4409
62.706	**2-15/32"**	2.4687
63.00		2.4803
63.500	**2-1/2"**	2.5000
64.00		2.5197
64.294	**2-17/32"**	2.5313
65.00		2.5591
65.088	**2-9/16"**	2.5625
65.881	**2-19/32"**	2.5937
66.00		2.5984
66.675	**2-5/8"**	2.6250
67.00		2.6378
67.469	**2-21/32"**	2.6563
68.00		2.6772

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DECIMAL EQUIVALENTS

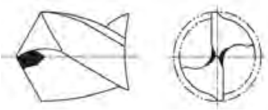
Metric	Fract	Inch
68.262	**2-11/16"**	2.6875
69.00		2.7165
69.056	**2-23/32"**	2.7187
69.850	**2-3/4"**	2.7500
70.00		2.7559
70.644	**2-25/32"**	2.7813
71.00		2.7953
71.438	**2-13/16"**	2.8125
72.00		2.8346
72.231	**2-27/32"**	2.8437
73.00		2.8740
73.025	**2-7/8"**	2.8750
73.819	**2-29/32"**	2.9063
74.00		2.9134
74.612	**2-15/16"**	2.9375
75.00		2.9528
75.406	**2-31/32"**	2.9687
76.00		2.9921
76.200	**3"**	3.0000
76.994	**3-1/32"**	3.0313
77.00		3.0315
77.788	**3-1/16"**	3.0625
78.00		3.0709
78.581	**3-3/32"**	3.0937
79.00		3.1102
79.375	**3-1/8"**	3.1250
80.00		3.1496
80.169	**3-5/32"**	3.1563
80.962	**3-3/16"**	3.1875
81.00		3.1890
81.756	**3-7/32"**	3.2187
82.00		3.2283
82.550	**3-1/4"**	3.2500
83.00		3.2677

Metric	Fract	Inch
83.344	**3-9/32"**	3.2813
84.00		3.3071
84.138	**3-5/16"**	3.3125
84.931	**3-11/32"**	3.3437
85.00		3.3465
85.725	**3-3/8"**	3.3750
86.00		3.3858
86.519	**3-13/32"**	3.4063
87.00		3.4252
87.312	**3-7/16"**	3.4375
88.00		3.4646
88.106	**3-15/32"**	3.4687
88.900	**3-1/2"**	3.5000
89.00		3.5039
90.00		3.5433
90.488	**3-9/16"**	3.5625
91.00		3.5827
92.00		3.6220
92.075	**3-5/8"**	3.6250
93.00		3.6614
93.662	**3-11/16"**	3.6875
94.00		3.7008
95.00		3.7402
95.250	**3-3/4"**	3.7500
96.00		3.7795
96.838	**3-13/16"**	3.8125
97.00		3.8189
98.00		3.8583
98.425	**3-7/8"**	3.8750
99.00		3.8976
100.00		3.9370
100.012	**3-15/16"**	3.9375
101.600	**4"**	4.0000

®PRESTO

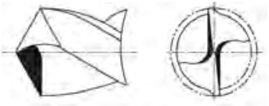
DRILL POINTS, According to DIN 1412

DIN 1412 Form A Point Thinning



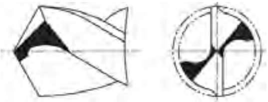
Form ‘A’ point thinning - Reduction of the chisel edge length. Thinning of the web helps the drill to self-centre and decreases the amount of force required to penetrate material.

DIN 1412 Form B



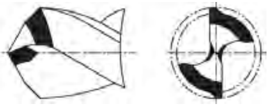
For edge correction or to reduce cutting edge rake to suit brittle / hard materials.

DIN 1412 Form C & ANSI Split Point



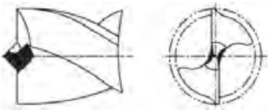
Drills with split points have better penetration capabilities, improved starting / self centering ability and improved hole accuracy.

DIN 1412 Form D
Double Angle Point



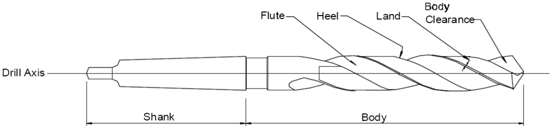
Point for cast iron, the outer corner stops frittering of the iron on break-through, and resists abrasive wear.

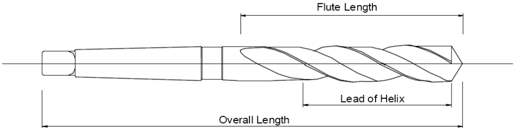
DIN 1412 Form E Spot Weld Point

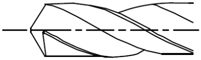


Special drill point for removing spot welds in sheet metal.

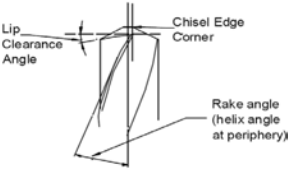
TWIST DRILL NOMENCLATURE

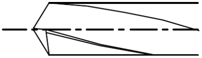




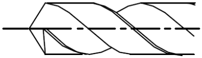


STANDARD SPIRAL OR HELIX ANGLE 25° - 31°

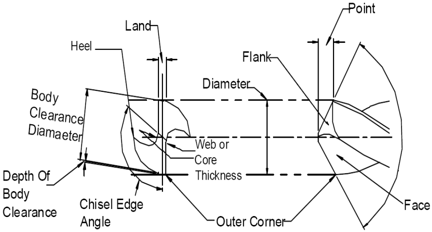


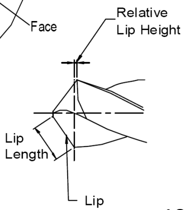


SLOW SPIRAL OR HELIX ANGLE 11° - 18°



QUICK SPIRAL OR HELIX ANGLE 35° - 40°





®PRESTO

DRILLING PRACTICE

The flute form, web thickness and helix angle of the standard drill are suitable for most materials producing semi-continuous chips.

Drilling sizes of 13mm and smaller in soft materials which produce continuous chips, e.g. copper**,** aluminium, a bright finish fast helix drill may be required to remove the swarf more effectively. Conversely on materials producing discontinuous chips like brass, gunmetal and some plastics, a slow spiral is preferable.

For effective drilling, the rigidity of the drill and work piece are most important. The shorter the flute length the more rigid the drill. Long drills must be adequately supported to reduce vibration, or stage drill as opposite.

Heavy duty thick web drills may be necessary on the more difficult materials, or when work lacks rigidity. These drills must be point thinned or have split points (see page 17).

The following are important in drill use:

1 Clamp the work-piece securely.

2 Select the correct speed and feed.

3 Use an appropriate coolant and lubrication.

4 When using a taper shank drill use a soft face hammer or wood block for insertion.

5 Ensure the shank is securely held. Avoid using worn sockets or drill chucks as the drill may slip during use.

6 Regrind the point before it dulls, do not force a worn drill.

7 Deep hole drilling, withdraw frequently to clear the chips**.** Deep holes start at 4 times diameter.

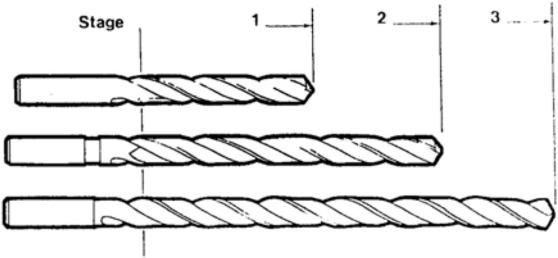
8 Opening out existing hole, **do not use** a 2 flute twist drill, use a 3 or 4 flute core drill. Pilot holes should be 1.5 times the chisel edge length.

9 Stainless, Manganese and high tensile steels, use an automatic feed throughout the drilling cycle. Do not allow the drill to dwell as it will cause work-hardening; use a slower speed and heavier feed than on easier machined materials.

DEEP HOLE SERIES DRILLING

Holes deeper than nominally three times the drill diameter may need special methods to clear the swarf especially when drilling horizontally with standard flute design.

SERIES DRILLING



A series of longer drills may be used successively.

FIRST DRILL

This should be either a stub drill or a jobber drill used down to the flute length and pecking at intervals after 3 times diameter in depth to clear the swarf. Alignment of the first drill is very important as all subsequent drills will wander further from this location.

SECOND DRILL

A long series drill to be used as above with pecking about every diameter in depth.

THIRD & SUCCESSIVE DRILLS

Extra length drill of increasing flute lengths may be used successively to the required depth, pecking may be required at only half the diameter on extreme depth.

PARABOLIC FLUTE DRILLS

Are specifically designed for deep hole drilling and clearing the swarf without pecking down to 10 times the diameter on materials that produce long continuous swarf. Parabolic drills are stocked from stub to extra length drills.

®PRESTO

RESHARPENING OF TWIST DRILLS

Unless a drill is correctly re-sharpened the efficiency is greatly reduced. The general features to be observed are:

1. Re-sharpen before the drill becomes too dull

2 Maintain

a. The correct point angle

b. Correct lip clearance

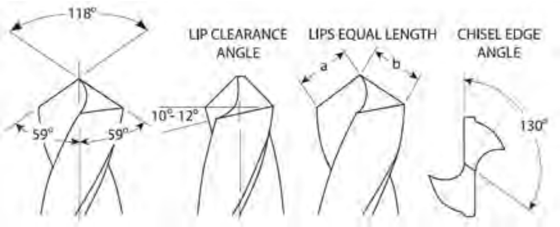
c. Equal cutting edge length

d. Equal cutting edge angles

e. Correct web thickness

f. Relative lip height to a close tolerance

g. Never quench the drill in water to cool it. Never grind using a trickle of water. These two methods are likely to produce hair line surface cracks owing to the local heating and quenching. Grind either under a gush of water, or perfectly dry and allow to air cool.



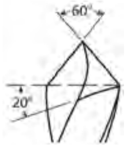
Web Thinning

The thickness of the web increases from the point back to the flute run out. As the drill is pointed back the web should be thinned to approx. 10% of the drill diameter using a grinding wheel of half the flute width. Excessive thinning may weaken the drill causing splitting up the web.

Chipbreaking

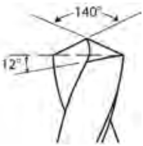
A thin radiused wheel can be used to grind grooves across the cutting face which assists chipbreaking. Reducing the peripheral speed and increasing the feed rate, where conditions allow, can also produce a discontinuous chip.

Acute Point Angle



Point angles down to 60° can be used to reduce the tendency of brittle materials such as Bakelite, to flake away on the undersurface as the drill breaks through. The acute angles when applied to standard drills result in convex cutting edges, see point correction.

More Obtuse Point angle



A flatter point angle up to 140° inclusive can be advantageous on high tensile steel and work hardening materials. This angle causes the cutting lips to become concave which weakens the outer corners. It is preferable to use specially designed drills for more difficult materials.

Point Correction

The face of the flute along the cutting lip is ground to reduce the helix angle for brittle materials. A similar technique can be used to correct convex cutting edges. It is important that the circular land is not ground away.

This flat cutting edge will assist when using a two flute drill to open out an existing hole.

Double Angle Point

The standard 118° point is maintained on the drill for half the lip length. The outer half is then ground at 90° to give a reinforced cutting edge, thus ensuring the corner is not destroyed in abrasive materials, such as cast iron.

Split Point

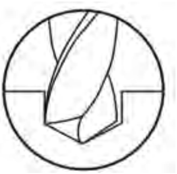
On thick web heavy duty drills, the chisel edge may be too wide to use web thinning, consequently a split point is required to produce an additional cutting edge at the centre.

Specialist drills for most materials are available, please consult the catalogue.

PRESTO®

COMMON REASONS FOR DRILL FAILURE

1. OVERSIZE HOLE



a. Lips of unequal length, one lip doing all the work. Suggest: Re-grinding the drill.
b. Chisel edge not central. Suggest: Re-grinding the drill.
c. Machine spindle out of true. Check for damage to chuck or spindle.

2. UNEQUAL CHIPS

a. Lips of unequal length as in 1a. Long chip from one side indicates that it is doing all the work. Suggest: Re-grinding the drill.
b. Drill point angle is off; low on one side and high on the other consequently the chisel edge will be off centre.
c. Relative lip height; too great a difference.

3. SPLITTING UP THE WEB

a. Insufficient lip clearance. Suggest re-grinding drill.
b. Too high a feed rate. Check recommended conditions.
c. Striking drill point with hard object.
d. Ejecting drill onto machine base. Both c. & d. cause bruising to the chisel edge, which will show up under use as a fracture.
e. Surface cracks on the flanks can be caused by overheating when grinding and then quenching see item 2g on page 16.

4. BROKEN TANG

The tang is for ejection purposes only. Allowing the torque to be taken by the tang will result in breakage's. Always ensure that the taper socket is free from foreign matter and damage, So that friction alone drives through the taper. The positive helix angle of the drill, will, when opening out an existing hole pull the Morse taper out of contact, which will result in a broken tang. Pilot holes should only be 1.5 times the chisel edge.

5. BREAKING DOWN OF OUTER CORNERS

a. Peripheral speed too high burning out the corners.
b. Inadequate lubrication / coolant.
c. Interrupted feed on work hardening materials.
d. Work not supported adequately.
e. Opening out existing holes.

6. CHIPPING OF LIPS

a. Lip clearance too great.
b. Feed rate too high.
c. Drill surging on break through.
d. Quenching drill on re-grinding.

7. BREAKING OF DRILLS

a. Drill worn or improperly point ground.
b. Drill slipping in drive.
c. Drill flutes choking in swarf.
d. Insufficient lip clearance.
e. Work not rigid.
f. Feed rate too high or drill pulling through on breakthrough.

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DRILL CUTTING SPEEDS

MATERIAL	HARD'S	SPEEDS & (FEEDS)		
Steel		Stub	Jobber	Long S
Leaded Free Cutting	120Hb	36 (5)	33 (4)	22 (3)
Low Carbon	150Hb	32 (5)	27 (4)	20 (3)
Medium Carbon	250Hb	27 (4)	22 (3)	17 (3)
Alloy Steel	250Hb	21 (4)	18 (3)	16 (2)
Alloy Steal Treated	300Hb	14 (3)	11 (2)	9 (2)
Alloy Steel Treaded	350Hb	9 (2)	7 (2)	6 (2)
Stainless Steel				
Free Cutting	250Hb	16 (4)	14 (2)	12 (2)
Austenitic Non-Mag	250Hb	9 (4)	7 (4)	6 (3)
Duplex Alloys	300Hb	12 (3)	9 (3)	7 (2)
Cast Irons				
Plain Grey Cast	150Hb	35 (4)	33 (4)	25 (3)
SG & Malleable	250Hb	30 (4)	22 (4)	20 (3)
Alloy Cast	300Hb	19 (4)	17 (3)	15 (3)
Titanium				
Pure Titanium	200Hb	28 (4)	18 (4)	15 (3)
Titanium Alloys	300Hb	9 (2)	7 (2)	6 (2)
Nickel				
Pure Nickel	200Hb	12 (4)	14 (4)	10 (3)
Nimonics 75, Hasteloy	300Hb	10 (4)	9 (4)	7 (3)
Inconel 718	300Hb	7 (3)	5 (3)	3 (2)
Copper Alloys				
Pure Copper	100Hb	42 (5)	40 (4)	30 (3)
Brass Soft Yellow	150Hb	40 (5)	40 (5)	
Brass Tough Red	200Hb	37 (5)	37 (5)	
Hi-tensile Bronze	250Hb	28 (4)	25 (4)	23 (3)
Aluminium				
Soft & Extruded	100Hb	55 (7)	50 (6)	40 (5)
Wrought & Treated	150Hb	45 (5)	40 (5)	30 (3)
Cast 5% Si	120Hb	40 (5)	35 (4)	30 (3)
Cast 10% Si	150Hb	33 (4)	30 (4)	27 (3)

Speeds given in Meters / min. Feeds In brackets(4).

Use cobalt drills, or H.S.S. at reduced speed of 66%.

Specialist drills are available for most material or difficult applications please consult catalogue for application orientated drills.

Use quick spiral Bright finish on aluminium, copper.
Use slow spiral Bright finish on brasses.

If quick or slow spiral not available, bright finish is a good alternative for non ferrous materials.

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SPEED CHART

Diameter	**1/8"**	**3/16"**	**1/4"**	**5/16"**	**3/8"**	**1/2"**	**5/8"**	**3/4"**
Meters/min	**3**	**5**	**6**	**8**	**10**	**12**	**16**	**19**
5	530	318	265	199	159	133	99	84
7	743	446	371	279	223	186	139	117
9	955	573	477	358	286	239	179	151
12	1273	764	637	477	382	318	239	201
15	1591	955	796	597	477	398	298	251
20	2122	1273	1061	796	637	530	398	335
22	2334	1401	1167	875	700	584	438	369
25	2652	1591	1326	995	796	663	497	419
27	**2865**	**1719**	**1432**	**1074**	**859**	**716**	**537**	**452**
30	3183	1910	1591	1194	955	796	597	503
35	3713	2228	1857	1393	1114	928	696	586
40	4244	2546	2122	1591	1273	1061	796	670
45	4774	2865	2387	1790	1432	1194	895	754
50	5305	3183	2652	1989	1591	1326	995	838

FEED CHART

Diameter	**3**	**5**	**6**	**8**	**10**	**12**	**16**	**19**
Feed Code	Feed per revolution in mm's							
(1)	0.030	0.035	0.045	0.055	0.062	0.070	0.085	0.110
(2)	0.045	0.060	0.065	0.070	0.100	0.110	0.130	0.160
(3)	**0.062**	**0.080**	**0.095**	**0.120**	**0.140**	**0.150**	**0.160**	**0.210**
(4)	0.085	0.110	0.120	0.160	0.190	0.200	0.240	0.280
(5)	0.120	0.150	0.170	0.220	0.260	0.280	0.320	0.360
(6)	0.150	0.190	0.210	0.280	0.330	0.350	0.400	0.450
(7)	0.180	0.230	0.250	0.330	0.390	0.420	0.460	0.520

Feeds in Brackets (4) from speed chart above.

Figure in **bold** are the best general purpose speed and feed for use on steel as a good starting point .

To convert Meters / Minute peripheral speed to RPM use formula:

$$\text{RPM} = \frac{\text{Meters Per Minute} \times 1000}{3.1416\ (\pi) \times \text{Diameter in MM's}}$$

Penetration rate = RPM x Feed per revolution.

Speeds and Feeds are given as starting points, the design of the drill can effect the performance and life.

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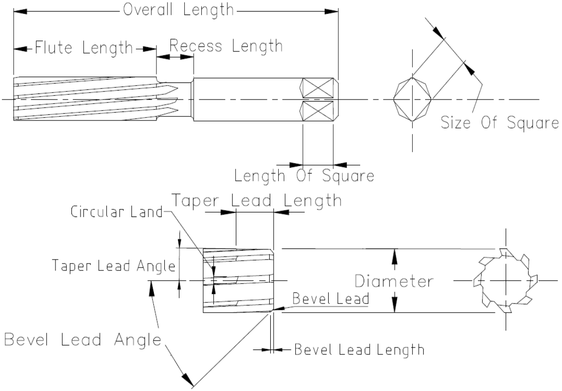
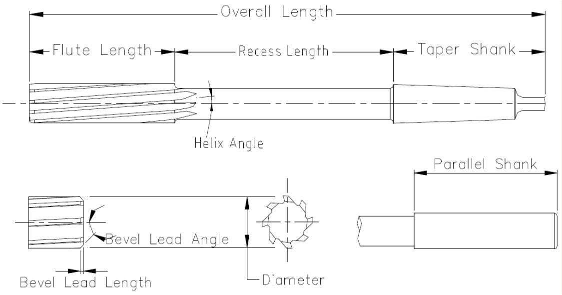
REAMERS NOMENCLATURE

Parallel Hand Reamer, Right-hand Rotation - Left hand Helical Flutes



Machine/Chucking Reamer, Right hand Rotation Left Hand Helical Flutes



Machine reamers are made in both straight shank and taper shank. The DIN standard are all chucking types with short flutes and are offered in straight flutes, 6° left hand spiral, and quick spiral. British Standard Machine reamers with long flutes are made in both taper shanks and parallel shanks all 6° L.H. Spiral.

Note that Din Quick Spiral machine reamers have a 2° lead for approximately 1/2 of the diameter in length, and a 45° bevel. They cannot ream to a blind hole without leaving this step.

REAMING PRACTICE

All reamers are now made to cut an H7 tolerance on both British and Din Standard. Many users expect this to be exact, this is not practicable and they are made slightly oversize. The chart lists both the hole size and the reamers tolerance.

Diameter	H7 Hole Tolerance		Reamer Tolerance	
0 - 3mm	+ 0.01 max	+ 0 min	+ 0.008 max	+ 0.002 min
over 3 - 6	+ 0.012	+ 0	+ 0.010,	+ 0.004mm
>6 -10mm	+ 0.015	+ 0	+ 0.012	+ 0.004mm
>10 - 18	+ 0.018	+ 0	+ 0.015	+ 0.006mm
>18 - 30	+ 0.021	+ 0	+ 0.017	+ 0.009mm
>30 - 50	+ 0.025	+ 0	+ 0.021	+ 0.012mm

Reaming Allowance

Diameter	Machine	Hand
up to 6mm	0.2mm	0.15mm or 0.006"
>6 - 12	0.2 to 0.3mm	0.5mm or 1/64"
>12 - 25	0.3 to 0.5mm	0.5mm or 1/64"
>25 - 50	0.4 to 0.8mm	0.8mm or 1/32"

Reaming allowance is dependant on the material being cut. Harder materials will require less allowance and very soft steel may require more as the drill may have torn the bore.

Speeds and Feeds
General practice is to use half the drilling speed and double the feed per rev as used in drilling. It is always stated that reaming is a slow process, but at these conditions it has the same cycle time as drilling.

Lubricants
Good lubrication is required as the material being cut will gall or pick up on the cutting edges, giving oversize holes and scored bores.
Use the above notes as a guide, in practice adjust the recommendations to suit the job until optimum results are obtained.

Re-sharpening
This must be done by skilled personnel on proper machine tools, on no account must free hand grinding be done: When regrinding remember that the lead performs the cutting action. For correct lands and clearances copy those on a new reamer.

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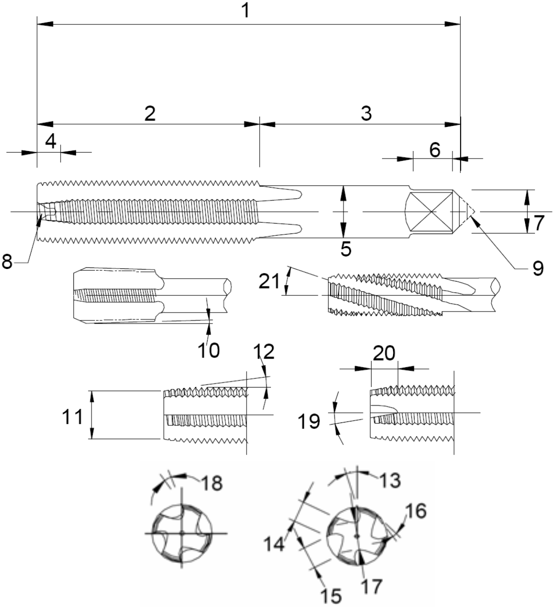
TAP NOMENCLATURE



Key:	
1. Overall Length	12. Chamfer Angle
2. Thread Length (Including Chamfer)	13. Rake Angle
3. Shank Length (Including Square)	14. Width of Land
4. Chamfer Length	15. Width of Flute
5. Shank Diameter	16. Radial Thread Relief
6. Length Of Driving Square	17. Web Diameter
7. Size Across Flars of Square	18. Spiral Point Rake Angle
8. Internal Centre (Female)	19. Spiral Point Angle
9. External Centre	20. Spiral Point Length
10. Back Taper	21. Angle of Spiral
11. Point Diameter (Chamfer)	(Spiral Flute)

Basic Sizes and Tolerances for Taps

If taps were manufactured to basic sizes they would have a very short life. The screw thread has a plus tolerance and the standard allows the taps to be made within this tolerance.

If you measure the outside diameter of a tap it will be approximately 1% larger than the nominal size i.e. a 10mm tap will measure 10.1mm. It can be misleading to measure the outside diameter of the bolt as it will be 2% smaller. The two cannot be compared.

The size of the tap cannot be judged by measuring the major diameter.

Limits of Tolerance

Tolerance is the amount of variation permitted in the manufacture of the tap and takes the form of a further addition to the minimum diameters.

The tolerances of the major and the minor diameters are not given in the tap standards, but the effective diameter is regarded as the most important element and thus the tolerance is rigidly specified.

Example for an M10 tap applying Class 2 thread tolerance.

Basic Effective (Pitch) Diameter	= 9.026
Minimum Oversize	= 0.042
Minimum Effective Diameter	= 9.06
Tap Tolerance	= 0.028
Maximum Effective Diameter	= 9.096
Basic Major Diameter	= 10.000
Minimum Oversize	= 0.056
Minimum Major Diameter	= 10.056

Maximum major is not specified, common practice is to leave a small flat crest and not out to a sharp point.

Tapping Practice

Tap Drill Size

In the thread charts that follow the correct tapping size is given in the information. We also give the alternative maximum size, as with good modern drills the drilled hole can be small. On tough materials like stainless steel we recommend you take advantage of the extra allowance. It is especially important in deep holes of 2 times diameter and greater (drill sizes from BS1157 appendix "A").

TAPPING PRACTICE

LUBRICANTS

First class tapping can only be done with a copious supply of proper lubricant. Use of the correct lubricants is as important as the decision to use it, it must be kept clean and carefully directed into the hole being tapped, an ample supply is needed on the cutting edges, not only to disperse heat, but to aid in the formation and removal of chips.

SPEEDS

Efficient tapping has its optimum speed, see page 29 for an initial recommendation and guide. Exact figures cannot be given because of the variables such as machinability of the material being tapped, condition of the machine, depth, pitch and length of the thread, holding fixture or tapping attachment. From practical application adjust our recommendations up or down until optimum results are obtained.

When starting a tap do not force or retard the tap, or a bell mouthed hole will be produced with thin threads. Allow the tap to establish its own pitch.

During tapping of a deep hole, avoid the flutes becoming clogged with chips - breakage is inevitable in these circumstances, consider a fluteless tap for very deep holes.

Chip disposal is a large problem on taps of 12mm and smaller where flute space is restricted, see description on spiral point and spiral flute taps below.

HAND TAPS

For hand tapping, the conventional set of 3 taps with straight flutes is recommended. It is essential that the tap is presented squarely to the work and that the taps are correctly aligned. When taps are used in a machine it is usual to use only the second lead. Using the bottom tap only can cause problems and will significantly reduce the life of the tool.

SERIAL FORM HAND TAPS

These are also hand taps. The roughing tap takes out half the thread area it is marked with a ring on the shank for identification. The Mid-Rougher will take out to 75% of the area of the thread, it is marked with two rings on the shank. Only the plain shanked Finish tap cuts SIZE. This form of hand tap is recommended for materials like stainless steel and large taps over 25mm in diameter make it possible to hand tap right up to 52mm. Only two taps are supplied for fine pitch threads.

SPIRAL POINT TAPS

These taps are sometimes called GUN-Nosed and are made with a special leading flute ground at an angle to the tap axis. This left hand flute at the lead pushes the swarf ahead of the tap threads thus allowing the use of smaller flutes since chip clearance is not required. The result is therefore stronger taps which are suitable for through hole tapping in most materials. Blind hole tapping should only be attempted where there is sufficient room at the bottom of the hole to accommodate the swarf.

SPIRAL FLUTE TAPS

These taps have a continuous spiral flute the same hand as the thread, thus forcing the swarf up the hole. The most suitable applications are on blind holes in ductile materials with long continuous chips. Slower 15° spiral may be used on tougher materials.

PIPE TAPS

There are three types of ISO component Pipe Taps Threads:

1. **G** series threads (BSPF) this is a parallel fastening thread for BS2779 where pressure tight joints are not required.

2. **Rc** series (BSPT) threads where pressure tight joints are required. These taps are made to BS949 with ISO shanks and squares. Taper reamers are an advantage on tapping these threads and we stock 1:16 taper reamers for this application. Interrupted thread taps are also available for stainless and other work hardening materials.

3. **Rp** or **BSPPL** are undersize Parallel taps for use on BS21 gas tight application, they have tapered plugs assembled into the parallel hole and are destructively dry sealing. We only supply these to order. Details are given on page 37.

AMERICAN PIPE TAPS

NPS taps can be used for NPSC & NPSM parallel threads. NPSC threads are internal couplings and may be used with sealant for low pressure pipe work.

NPSM is used as a mechanical fastening thread.

NPSF are parallel undersize threads with truncated crests for dryseal use with tapered fitting.

NPT are standard taper taps and can be assembled with jointing for low pressure work. We can supply tapered pipe reamers to aid tapping, and interrupted thread taps for stainless and other work hardening materials.

NPTF similar to above but with truncated crests to effect a dryseal. We recommend the use of the tapered reamer when tapping this thread.

®PRESTO

FLUTELESS ROLL (Cold Forming) TAPS

Fluteless or cold forming taps can be used in a wide variety of materials from steel, aluminium, copper and soft ductile brasses but will also cut stainless's and titanium and nickel materials. As these materials may tear rather than cut cleanly, they tend to clog the flutes of conventional taps. The fluteless tap offers an alternative forming by displacing the material instead of cutting. It should be noted that the biggest change is the requirement of a larger tapping drill, (see thread charts on page 30) the fluteless tap also can tap faster than a standard tap (see speed chart on page 29) Lubrication is of the utmost importance in thread forming, with an extreme pressure additive is advisable in soluble oils.

SOME COMMON REASONS FOR TAP FAILURES

Tap Cuts Oversize

1. Tap out of alignment with the hole or tap not running true.
2. Feed pressure on tap producing thin or deformed threads.
3. Drilled core hole too small, see thread charts.
4. Incorrect tap for the material e.g.:
   (a) Cutting rake too great,
   (b) Incorrect thread relief,
   (c) Chamfer lead too short.
5. Incorrect sharpening e.g. chamfer relief uneven or to excessive.

Tap Cutting Edges Chip

6. Tap hitting the bottom of a blind hole.
7. Tap reversing with swarf trapped.
8. Lubrication lacking or wrong quality or specification.
9. Material too hard, or abrasive for the tap type.

Rapid Tap Wear

10. Speed too fast also consider items 3, 4, and 8.

Poor Thread Finish

11. Tap has reached the extent of its life. Consider type of tap used, or items 3, 4, and 8.

Tap Breaks

12. Tap blocked with swarf, is it the correct type of tap? look at items 1, 3, 4c, 5, 6, 7, 8, 9, 10, and 11.

®PRESTO

TAPPING SPEEDS

MATERIAL	Hardness Hb	Straight Flute M/min	Through Holes Spiral M/min	Blind Holes Spiral M/min	Fluteless M/Min
CARBON & ALLOY STEEL					
Mild Steel	<120	12 - 24	15 - 28	12 - 24	20 - 40
Low/Medium Carbon Steel	<200	11 - 20	16 - 24	10 - 18	18 - 35
Higher Carbon Steel	<250	8 - 12	10 - 16	8 - 12	12 - 25
Low Alloy Engineering Steel	<250	6 - 10	8 -12	6 - 10	8 - 16
Alloy Steel - Heat Treated	>300		3 - 9	3 - 5	
Alloy Steel - Heat Treated	>350		3 - 7	2 - 5	
STAINLESS STEEL					
Free Cutting (magnetic) Ferritic	<250	6 - 10	8 - 12	5 - 9	10 - 16
Austenitic (Non Magnetic)	<250		5 - 9	4 - 7	8 - 14
Martensitic / Maraging Duplex Alloys	>300		4 - 6	2 - 5	5 - 8
CAST IRON					
Plain Grey Iron-Ferritic Malleable	<150	9 - 15	10 - 16		
Plain SG Iron-Pearlitic Malleable	<250	6 - 12	5 - 9		
Alloy SG Iron NiHard	>250	3 - 5	4 - 8		
TITANIUM					
Pure Titanium	<200	6 - 12	8 - 10	5 - 8	10 -15
Titanium Alloys	>300		3 - 6	3 - 6	6 - 12
NICKEL					
Pure Nickel	<300	5 - 9	7 - 11	5 - 8	15 -22
Nickel, Nimonic 75 Hasteloy Alloys	>300		3 - 7		
Nickel, Inconel718 Alloys	<350		1 - 4		
COPPER					
Pure Copper	<100	6 - 12		9 - 15	14 - 20
Alpha Brass (soft yellow)	<200	24 - 30			20 - 30
Beta Brass	>200	18 - 24			
High Tensile Bronze	<350	8 - 16	9 - 18b	8 - 16	
ALUMINIUM					
Wrought (soft) & Extruded	<150	15-25	25 - 35b	18 - 30	30 - 50
Wrought & Treated	>150	12-20	20 - 35b	16 -25	25 - 40
Cast Low Silicon 5%	<150	10-15	15 - 22b	12 - 18	20 - 30
Cast High Silicon 10%	>150	8 - 12	10 - 18b	8 - 16	

b = Bright Finish Spiral Point Taps available on request.

Where no speed is given in Straight Flutes, we suggest use of serial form taps when hand tapping.

$$\text{Speed in RPM} = \frac{\text{Peripheral Meters/Min} \times 1000}{3.1416\ (\pi) \times \text{Diameter}}$$

NOTE: Fluteless taps have special opening drill sizes, listed in the tap and thread tables from page 30 onwards.

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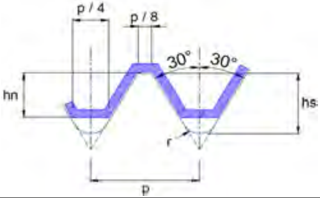
ISO METRIC COARSE M



Thread Form 60° ISO

Basic Radius "r" = 0.1443P

Height Int Thread "hn"= 0.54127P

Height Ext Thread "hs" = 0.61344P

Triangular Height H = 0.866025P

Nom Dia. mm	Pitch mm	Effective Dia. mm	Nut Max Core Dia. mm	Flutless Tapping Drill Size mm	Tapping Drill Size mm	Clearance Drill Size mm
M1	0.25	0.838	0.785		0.75	1.05
M1.1	0.25	0.938	0.885		0.85	1.15
M1.2	0.25	1.038	0.985		0.95	1.25
M1.4	0.30	1.205	1.160		1.10	1.45
M1.6	0.35	1.373	1.321		1.25	1.65
M1.8	0.35	1.573	1.521		1.45	1.85
M2	0.40	1.740	1.679	1.80	1.60	2.05
M2.2	0.45	1.908	1.838		1.75	2.25
M2.5	0.45	2.208	2.138	2.30	2.05	2.60
M3	0.50	2.675	2.599	2.80	2.50	3.10
M3.5	0.60	3.110	3.010	3.20	2.90	3.60
M4	0.70	3.545	3.422	3.70	3.30	4.10
M5	0.80	4.480	4.334	4.60	4.20	5.10
M6	1.00	5.350	5.153	5.60	5.00	6.10
M7	1.00	6.350	6.153	6.50	6.00	7.20
M8	1.25	7.188	6.912	7.40	6.80	8.20
M9	1.25	8.188	7.912		7.80	9.20
M10	1.50	9.026	8.676	9.30	8.50	10.20
M12	1.75	10.026	10.441	11.20	10.20	12.20
M14	2.00	12.701	12.210		12.00	14.25
M16	2.00	14.701	14.210		14.00	16.25
M18	2.50	16.376	15.744		15.50	18.25
M20	2.50	18.376	17.774		17.50	20.25
M22	2.50	20.376	19.774		19.50	22.25
M24	3.00	22.051	21.252		21.00	24.25
M27	3.00	25.051	24.252		24.00	27.25
M30	3.50	27.727	26.771		26.50	30.50
M33	3.50	30.727	29.771		29.50	33.40
M36	4.00	33.402	32.270		32.00	36.50
M39	4.00	36.402	35.270		35.00	39.50
M42	4.50	39.077	37.799		37.50	42.50
M45	4.50	42.077	40.799		40.50	45.50
M48	5.00	44.752	43.297		43.00	48.50
M52	5.00	48.752	47.297		47.00	53.00
M56	5.50	52.428	50.796		50.50	57.00

Max core given for a 6H fit.

ISO METRIC FINE THREADS

Thread form as **M** above.

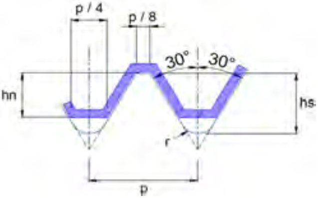
Mf or **M** may be used for identification, always include pitch Mf4 x 0.5.

Including Sparkplug, and Conduit. Preferred ISO Metric Fine are marked *

Nom Dia mm	Pitch mm	Effective Dia Nominal mm	Max Core Diameter mm	Tapping Drill mm	Clearance Drill mm
Mf3 *	0.35	2.773	2.721	2.65	3.10
Mf3.5	0.35	3.273	3.221	3.15	3.60
Mf4 *	0.50	3.675	3.599	3.50	4.10
Mf4.5	0.50	4.175	4.099	4.00	4.60
Mf5	0.50	4.675	4.599	4.50	5.10
M5 (Special)	0.75	4.513	4.378	4.20	5.10
Mf6	0.50	5.675	5.099	5.50	6.10
Mf6 *	0.75	5.513	5.378	5.20	6.10
Mf7	0.75	6.513	6.378	6.25	7.10
Mf8	0.75	7.513	7.378	7.20	8.20
Mf8 *	1.00	7.735	7.153	7.00	8.20
Mf9	1.00	8.350	8.153	8.00	9.20
Mf10	0.75	9.513	9.378	9.20	10.20
Mf10S/plug	1.00	9.350	9.153	9.00	10.20
Mf10 *	1.25	9.188	8.912	8.80	10.20
Mf11	1.00	10.350	10.153	10.00	11.20
Mf12	1.00	11.350	11.153	11.00	12.20
Mf12 * S/plug	1.25	11.188	10.912	10.80	12.20
Mf12	1.50	11.026	10.676	10.50	12.20
Mf14	1.00	13.350	13.153	13.00	14.25
Mf14 S/plug	1.25	13.188	12.912	12.80	14.25
Mf14 *	1.50	13.026	12.676	12.50	14.25
Mf16	1.00	15.350	15.153	15.00	16.25
Mf16 * Conduit	1.50	15.026	14.676	14.50	16.25
Mf18	1.00	17.350	17.153	17.00	18.25
Mf18 * S/plug	1.50	17.026	16.676	16.50	18.25
Mf18	2.00	16.701	16.210	16.00	18.25
Mf20	1.00	19.350	19.153	19.00	20.25
Mf20 * Conduit	1.50	19.026	18.676	18.50	20.25
Mf20	2.00	18.701	18.210	18.00	20.25
Mf22 *	1.50	21.026	29.676	20.50	22.25
Mf22	2.00	20.701	20.210	20.00	22.25
Mf24	1.50	23.026	22.676	22.50	24.25
Mf24 *	2.00	22.701	22.210	22.00	24.25
Mf25 Conduit	1.50	24.026	23.676	23.50	25.25
Mf27	1.50	26.026	25.676	25.50	27.25
Mf27 *	2.00	25.701	25.210	25.00	27.25
Mf30	1.50	29.026	28.676	28.50	30.50
Mf30 *	2.00	28.701	28.210	28.00	30.50
Mf32 Conduit	1.50	31.026	30.676	30.50	32.50
Mf33	2.00	31.701	31.210	31.00	33.50
Mf40 Conduit	1.50	39.026	38.676	38.50	40.50

PRESTO®

Unified Coarse UNC, NC



Thread Form 60°

Basic Rad "r" = 0.1443P

Height Int Thread "hn"= 0.54127P

Height Ext Thread "hs" = 0.61344P

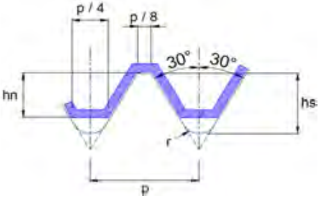
Triangular Height H = 0.866025P

p = Pitch = 1/TPI

Nom Size	T.P.I.	Nom Dia. inch	Basic Effective Dia inch	Max Core Dia mm	Fluteless Tapping Drill Size mm	Tapping Drill Size mm	Clear Drill Size mm
No1	64	0.0730	0.0629	1.582		1.55	1.95
No2	56	0.0860	0.0774	1.872	1.95	1.85	2.30
N03	48	0.0990	0.0855	2.146	2.25	2.10	2.65
No4	40	0.1120	0.0958	2.385	2.55	2.35	2.95
No5	40	0.1250	0.1088	2.697	2.85	2.65	3.30
No6	32	0.1380	0.1177	2.896	3.10	2.85	3.60
No8	32	0.1640	0.1437	3.531	3.80	3.50	4.30
No10	24	0.1900	0.1629	3.962	4.30	3.90	4.90
No12	24	0.2160	0.1889	4.597	4.90	4.50	5.60
1/4	20	0.2500	0.2175	5.268	5.80	5.10	6.50
5/16	18	0.3125	0.2764	6.734	7.30	6.60	8.10
3/8	16	0.3750	0.3344	8.164	8.80	8.00	9.70
7/16	14	0.4375	0.3911	9.550		9.40	11.30
1/2	13	0.5000	0.4500	11.01	11.90	10.80	13.00
9/16	12	0.5625	0.5084	10.40		12.20	14.50
5/8	11	0.6250	0.5660	14.33		13.50	16.25
3/4	10	0.7500	0.6850	16.83		16.50	19.25
7/8	9	0.8750	0.8028	19.75		19.50	22.50
1"	8	1.0000	0.9188	22.60		22.25	25.75
1-1/8	7	1.1250	1.0322	25.35		25.00	29.00
1-1/4	7	1.2500	1.1572	30.98		28.00	32.00
1-3/8	6	1.3750	1.2667	31.12		30.75	35.50
1-1/2	6	1.5000	1.3917	34.30		34.00	38.50
1-3/4	5	1.7500	1.6201	39.81		39.50	45.00
2"	4-1/2	2.0000	1.8557	45.60		45.00	51.00
2-1/4	4-1/2	2.2500	2.1057	51.95		52.00	58.00
2-1/2	4	2.5000	2.3376	57.58		57.00	65.00

Max core size given for a 2B fit.

Unified Fine UNF, UF



Thread Form 60°

Basic Radius "r" = 0.1443P

Height Int Thread "hn"= 0.54127P

Height Ext Thread "hs" = 0.61344P

Triangular Height H = 0.866025P

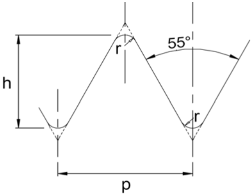
p = Pitch = 1/TPI

Nom Size	T.P.I.	Nom Dia. inch	Basic Effective Dia inch	Max. Core Dia mm	Fluteless Tapping Drill Size mm	Tapping Drill Size mm	Clear Drill Size mm
No0	80	0.0600	0.0519	1.3056	1.35	1.25	1.60
No1	72	0.0730	0.0640	1.6129	1.70	1.55	1.95
No2	64	0.0860	0.7590	1.9126	2.00	1.90	2.30
N03	56	0.0990	0.0874	2.1971	2.30	2.15	2.65
No4	48	0.1120	0.0985	2.4587	2.55	2.40	2.95
No5	44	0.1250	0.1102	2.7407	2.90	2.70	3.30
No6	40	0.1380	0.1218	3.0226	3.20	2.95	3.60
No8	36	0.1640	0.1460	3.6068	3.80	3.50	4.30
No10	32	0.1900	0.1697	4.1656	4.50	4.10	4.90
No12	28	0.2160	0.1928	4.7244		4.70	5.60
1/4	28	0.2500	0.2268	5.5804	5.90	5.50	6.50
5/16	24	0.3125	0.2854	7.0383	7.50	6.90	8.10
3/8	24	0.3750	0.3479	8.6258	9.00	8.50	9.70
7/16	20	0.4375	0.4050	10.030	10.50	9.90	11.30
1/2	20	0.5000	0.4675	11.618	12.20	11.50	13.00
9/16	18	0.5625	0.5264	13.084		12.90	14.50
5/8	18	0.6250	0.5889	14.676		14.50	16.25
3/4	16	0.7500	0.7094	17.689		17.50	19.25
7/8	14	0.8750	0.8289	20.663		20.40	22.50
1"	12	1.0000	0.9459	23.569		23.25	25.75
1-1/8	12	1.1250	1.0709	26.744		26.50	29.00
1-1/4	12	1.2500	1.1959	29.919		29.50	32.00
1-3/8	12	1.3750	1.3209	33.094		32.75	35.50
1-1/2	12	1.5000	1.4459	36.269		36.00	38.50

Max core size given for 2B fit.

®PRESTO

British Standard Whitworth BSW



Thread Form 55°

Basic Radius "r" = 0.137239P

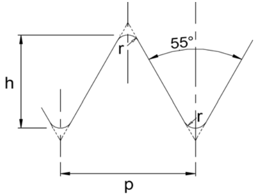
Basic Depth Of Thread = 0.640327P

p = Pitch = 1/TPI

Nom. Size	T.P.I.	Nominal Dia inch	Basic Effective Dia inch	Max Core Dia mm	Fluteless Tapping Drill Size mm	Tapping Drill Size mm
1/16	60	0.0625	0.0518	1.221		1.15
3/32	48	0.0938	0.0805	1.907		1.85
1/8	40	0.1250	0.1090	2.591	2.90	2.55
5/32	32	0.1562	0.1362	2.954		3.10
3/16	24	0.1875	0.1608	3.744	4.20	3.70
7/32	24	0.2188	0.1921	4.201		4.40
1/4	20	0.2500	0.2180	5.156	5.70	5.10
5/16	18	0.3125	0.2769	6.589	7.20	6.50
3/8	16	0.3750	0.3350	7.988	8.70	7.90
7/16	14	0.4375	0.3918	9.332		9.30
1/2	12	0.5000	0.4466	10.589		10.50
9/16	12	0.5625	0.5091	12.177		12.10
5/8	11	0.6250	0.5668	13.559		13.50
11/16	11	0.6875	0.6293	15.146		15.00
3/4	10	0.7500	0.6860	16.485		16.25
7/8	9	0.8750	0.8039	19.355		19.25
1"	8	1.0000	0.9200	22.149		22.00
1-1/8	7	1.1250	1.0335	24.831		24.75
1-1/4	7	1.2500	1.1585	28.006		28.00
1-3/8	6	1.3750	1.2683	29.505		30.50
1-1/2	6	1.5000	1.3933	33.703		33.50
1-3/4	5	1.7500	1.6219	39.136		39.00
2"	4½	2.0000	1.8577	44.877		44.50
2-1/4	4	2.2500	2.0899	50.465		51.00
2-1/2	4	2.5000	2.3399	56.815		57.00

Maximum core diameter given for medium fit.

British Standard Fine



BSF

Thread Form 55°

Basic Radius "r" = 0.137239P

Basic Depth Of Thread = 0.640327P

p = Pitch = 1/TPI

Nom Size	T.P.I.	Nom Dia inch	Basic Effective Dia inch	Max Core Dia mm	Fluteless Tapping Drill Size mm	Tapping Drill Size mm
3/16	32	0.1875	0.1675	4.006		4.00
7/32	28	0.2188	0.1959	4.676		4.60
1/4	26	0.2500	0.2254	5.398	5.90	5.30
5/16	22	0.3125	0.2834	6.817	7.40	6.80
3/8	20	0.3750	0.3430	8.331	9.00	8.30
7/16	18	0.4375	0.4019	9.764		9.70
1/2	16	0.5000	0.4600	11.163		11.10
9/16	16	0.5625	0.5225	12.751		12.70
5/8	14	0.6250	0.5793	14.094		14.00
11/16	14	0.6875	0.6418	15.682		15.50
3/4	12	0.7500	0.6966	16.939		16.75
7/8	11	0.8750	0.8168	19.909		19.75
1"	10	1.0000	0.9360	22.835		22.75
1-1/8	9	1.1250	1.0539	25.705		25.50
1-1/4	9	1.2500	1.1789	28.880		28.50
1-3/8	8	1.3750	1.2950	31.674		31.50
1-1/2	8	1.5000	1.4200	34.849		34.50
1-3/4	7	1.7500	1.6585	40.706		41.00
2"	7	2.0000	1.9085	47.056		47.00
2-1/4	6	2.2500	2.1433	52.753		53.00
2-1/2	6	2.5000	2.3933	59.103		58.00

Max core diameter given for medium fit.

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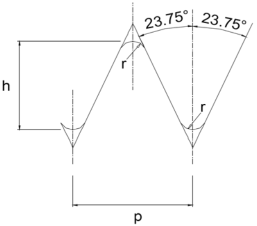
British Association BA

47½° Thread Angle



Thread Form

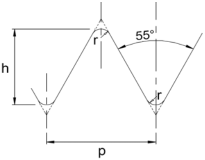
Basic Radius "r" = 0.1808346P

Basic Depth Of Thread = 0.6P

p = Pitch = 1/TPI

B.A. Num	Pitch mm	Nom Dia mm	Effective Dia Nominal mm	Max Core Dia mm	Fluteless Tapping Drill Size mm	Tapping Drill Size mm
14	0.23	1.00	0.8611	0.805		0.80
13	0.25	1.20	1.0490	0.995		0.98
12	0.28	1.30	1.1303	1.065		1.05
11	0.31	1.50	1.3157	1.245		1.20
10	0.35	1.70	1.4910	1.410	1.55	1.40
9	0.39	1.90	1.6662	1.575		1.55
8	0.43	2.20	2.4790	1.840	2.00	1.80
7	0.48	2.50	2.2098	2.100		2.05
6	0.53	2.80	2.4790	2.360	2.60	2.30
5	0.59	3.20	2.8448	2.710	2.95	2.65
4	0.66	3.60	3.2055	3.060	3.30	3.00
3	0.73	4.10	3.6601	3.495	3.80	3.40
2	0.81	4.70	4.2139	4.035	4.40	4.00
1	0.90	5.30	4.7600	4.560		4.50
0	1.00	6.00	5.3975	5.175	5.60	5.10

B.A. Threads are basically a metric thread based on 6mm With the diameter reducing by approx. 88% on each step and the pitch reducing by 90% to give a useful step to the next size for instrument, watch and clock use.



Thread Form 55° (Whitworth)

Basic Radius "r" = 0.137239P

Basic Depth Of Thread = 0.640327P

p = Pitch = 1/TPI

British Standard Pipe Fastener
“G” Series, BSPF, BSP (Medium Class)

Nom Size	T.P.I.	Major Basic Dia. mm	Effective Dia. Nominal mm	Max. Core Dia. mm	Fluteless Tapping Drill Size mm	Tapping Drill Size mm
1/16	28	7.722	7.142	6.843		6.80
1/8	28	9.728	9.147	8.848	9.25	8.80
1/4	19	13.157	12.301	11.890	12.60	11.80
3/8	19	16.662	15.806	15.395	16.10	15.25
1/2	14	20.955	19.794	19.172	20.00	19.00
5/8	14	22.911	21.750	21.128		21.00
3/4	14	26.441	25.279	24.658		24.50
7/8	14	30.201	29.040	28.418		28.25
1"	11	33.249	31.770	30.931		30.75
1-1/4	11	41.910	40.431	39.592		39.50
1-1/2	11	47.803	46.324	45.485		45.00
1-3/4	11	53.746	52.268	51.428		51.00
2"	11	59.614	58.135	57.296		57.00
2-1/4	11	65.710	64.232			62.75
2-1/2	11	75.184	73.705			72.50

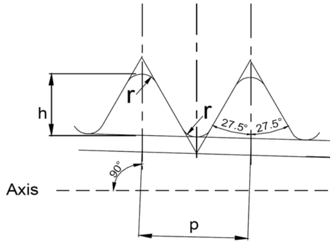
Rp (BSP Pl)
Reduced effective diameter for BS 21 Gas Fittings.

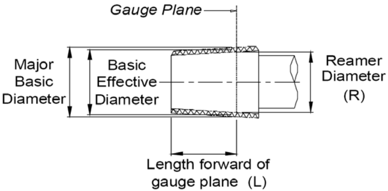
Nom Size	T.P.I.	Major Minimum Dia. mm	Special Effective Taper Gauge		Max. Core Dia. mm	Tapping Drill Size mm
			Nom mm	Turns of Gauge		
1/8	28	9.685	9.147	±1¼	8.637	8.60
1/4	19	13.094	12.301	±1¼	11.549	11.50
3/8	19	16.599	15.806	±1¼	15.054	15.00
1/2	14	20.869	19.794	±1¼	18.773	18.75
3/4	14	26.355	25.281	±1¼	24.259	24.25
1"	11	33.140	31.770	±1¼	30.471	30.40
1-1/4	11	41.801	40.432	±1¼	39.132	39.00
1-1/2	11	47.694	46.325	±1¼	45.025	45.00
2"	11	59.505	58.136	±1¼	56.836	56.75

Taps for Rp are supplied only to special order.
These are made to a negative tolerance on the nominal.
Parallel tapped hole - use tapered notch gauge.

British Standard Pipe Taper Rc (BSPT)

Thread Form 55°, Taper 1 in 16 on Diameter, Basic Radius "r" = 0.137278p, Basic Depth of Thread "h" = 0.640327p, "p" = 1/TPI





Nom Size	T.P.I.	Major Basic Dia. mm	Effective Dia. At Gauge P. mm	Position of Gauge "L" on tap mm	Ream Dia. (R) at "L" mm	Tapping Drill Size with Reamer mm	Tapping Drill Size without Reamer mm
1/16	28	7.723	7.142	10.1	6.56		6.40
1/8	28	9.728	9.147	10.1	8.57	8.00	8.40
1/4	19	13.157	12.301	15.0	11.45	10.80	11.20
3/8	19	16.662	15.806	15.4	14.95	14.25	14.75
1/2	14	20.955	19.793	20.5	18.63	17.75	18.25
3/4	14	26.441	25.279	21.8	24.12	23.00	23.75
1"	11	33.249	31.770	26.0	30.29	29.00	30.00
1-1/4	11	41.910	40.431	28.3	38.95	37.50	38.50
1-1/2	11	47.803	46.324	28.3	44.85	43.50	44.50
2"	11	59.614	58.135	32.7	56.65	55.00	56.00
2-1/2	11	75.184	73.705	37.1	72.23	70.00	71.00

Position of gauge plane "L" is ± one thread on the tap.
We strongly recommend the use of the reamer for Rc threads.
1:16 taper pipe reamers are available in the reamer section of the catalogue.

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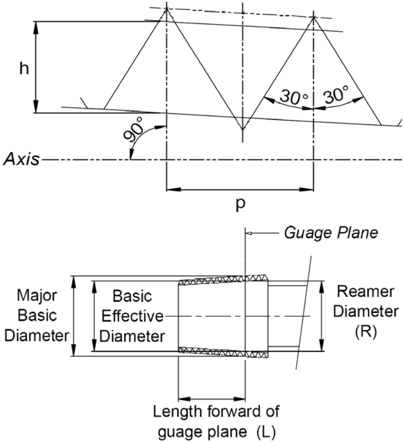
NPT National Pipe Taper (API, ANPT, Briggs Taper)

Thread Form 60°, Taper 1 in 16 on Diameter, Basic Depth of Thread "h" = 0.8p, Pitch "p" = 1/TPI



Nom Size	T.P.I.	Outside Pipe Dia. inch	Effective Dia. at Gauge inch	Position of Gauge "L" on Tap inch*	Ream Dia. (R) at "L" inch	Tapping Drill Size with Reamer mm	Tapping Drill Size without Reamer mm
1/16	27	0.313	0.2812	0.472	0.2515	6.00	6.30
1/8	27	0.405	0.3736	0.474	0.3440	8.40	8.70
1/4	18	0.540	0.4916	0.687	0.4472	10.70	11.10
3/8	18	0.675	0.6270	0.694	0.5826	14.25	14.50
1/2	14	0.840	0.7784	0.899	0.7213	17.50	18.00
3/4	14	1.050	0.9889	0.904	0.9317	22.75	23.25
1"	11½	1.315	1.2386	1.078	1.1691	28.50	29.00
1-1/4	11½	1.660	1.5834	1.106	1.5138	37.50	38.00
1-1/2	11½	1.900	1.8223	1.119	1.7528	43.50	44.00
2"	11½	2.375	2.2960	1.103	2.2267	55.00	56.00

*** up to 3 /4 ± 1/16", 1" and over ± 3/32"**

We strongly recommend the use of the reamer for NPT Threads.

1:16 taper pipe reamers are available in the reamer section of the catalogue.

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CIRCULAR DIES

BS Standard 1951 Inch

There are two types of dies in the range, the standard BS 1172 1951 style which are "inch" outside diameter and are of the split die type. The die stock is provided with 3 screws, the centre screw should just be touched into the vee split and the two side screws touching into the closing dimple. The centre screw should be retracted by 1/4 turn. The die is ready to cut a thread which should be size to a medium fit.

Adjusting the Die

Avoid trying to open out the die to cut an oversize thread as this will cause rubbing on the workpiece. Adjusting the die down should be done by 1/8 turn (45°) on the dimple screws and both screws adjusted alternately, and evenly.

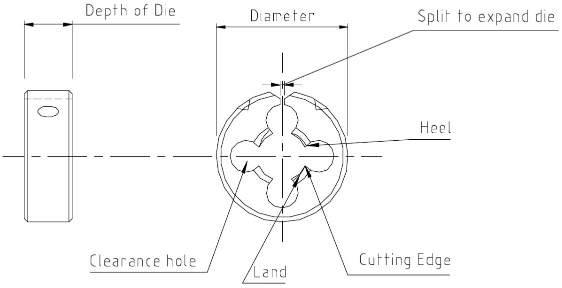
DIN 223, ISO 2568 B.S. Standard 1127 (1990)

These are solid dies with Metric outside diameters. They have no split for adjustment, they have Gun Nose geometry which throws the swarf forward of the tool, so that swarf does not fill the clearance holes.

The dies are designed to cut a 6g tolerance.

The Gun nose design is very effective for tough and work hardening materials like stainless steel.

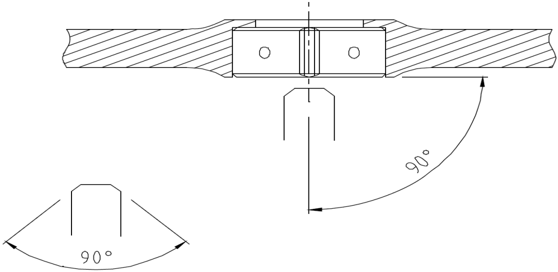
NOMENCLATURE



USE OF CIRCULAR DIES

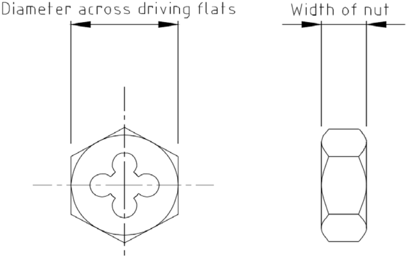
Prepare the workpiece by chamfering the end at 45°, 90° inclusive. This will allow the die to start cutting squarely to the rod or bolt. Failure to do this will put sudden loads onto the cutting edges, resulting in the thread cutting off-centre. Trying to straighten the cut will result in chipping. In extreme cases the one side of the split die will lift and the other drop, the die will split at the clearance hole opposite the vee groove.

Always ensure that the die is concentric and squarely presented to the work-piece.



HEXAGONAL DIENUTS

Hexagonal dienuts are normally used by hand, for reclaiming or cleaning of existing threads. They are generally used "On Site" and are more robustly constructed for this type of work. They have lower cutting rake, and are not suitable for cutting a new thread. We understand that it is often used in exceptional circumstances for this type of application, but extreme care must be exercised as it will tend to cut a wavering thread as there is no diestock to keep it square to the workpiece.



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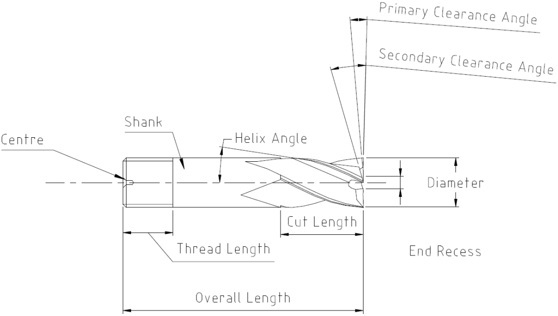
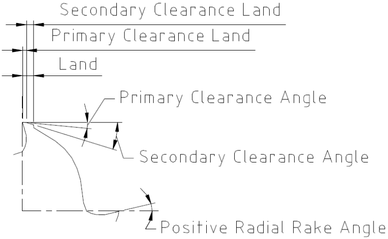
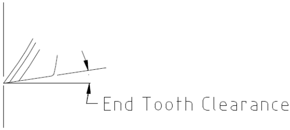
CUTTERS NOMENCLATURE

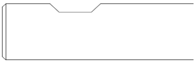






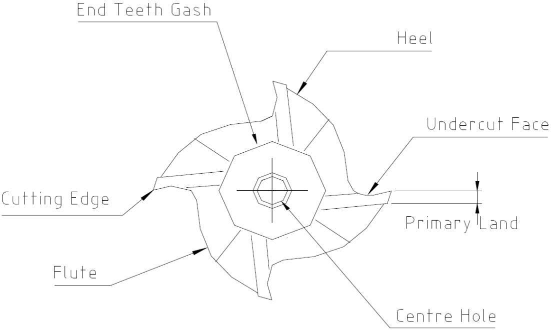
Shank Types

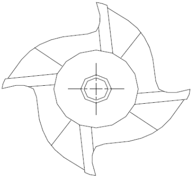
BS 122 Part 4
Screwed Shank
Suitable for use in
chucks



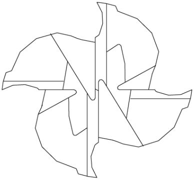
ISO
Plain Shank
Suitable for use
with collets

CUTTERS NOMENCLATURE

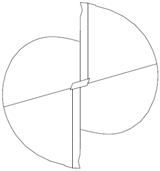




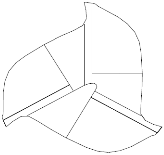
Standard End Mill
End teeth approx 1/4 of diameter in length.



End Mill Two Teeth Cut To Centre
End mills up to 12mm and ripping cutters up to 32mm.



Standard Slot Drill
One tooth cut through centre for plunge cutting in axial feed.



TRI-Cutter 3 Flute Slot Drill
One tooth ground to centre for plunge cutting in axial feed.

MILLING PRACTICE

The ease with which material can be milled is dependant on several factors including tensile strength and abrasion resistance. These may be assessed from the hardness tests, material composition and known heat treatment. Whilst hardness and / or strength is the usual criterion, wide variations in machinability can exist among materials showing very similar physical properties.

The cutting conditions used can be dependant upon requirements for tool life and surface finish and further restrictions, such as, tool rigidity, workpiece, lubrication and machine power available.

In general the harder the material the lower the cutting speed, but some materials of relatively low hardness contain abrasive constituents leading to rapid cutting edge wear at high speeds. Feed rates are governed by rigidity of set up, width of cut, i.e. volume of metal removed, surface finish required, and the available power. Conventional or climb milling can also effect the life and finish from the cutter.

Taking the above into account, therefore no one set of speeds and feeds is necessarily correct for a given material. It is usually preferable to set and maintain a constant surface speed for a given material and vary the feed rate within defined limits to obtain the desired life and finish.

Machine feed is measured in mm per minute and is the product of RPM x the number of teeth in the cutter x feed per tooth.

All machine feed should be worked back to the recommended feed per tooth. Too light a cut may fail to penetrate work hardening materials and cause edge breakdown, too heavy feeds will cause chipping and excessive heat generation. Slender and long shanked cutters are restricted in feed rate due to deflection of the cutter, where ever possible the largest and most robust tool should be used. This is particularly important to material over 250 Hb. Over 300Hb then Cobalt HSSE-Co8 cutters should be used. For softer materials Cobalt cutters may give increased output by increasing speeds and feeds up to 50%.

The following charts are a guide only and the final conditions should be established by application.

Formula For Milling Calculations

D = Diameter of cutter in mm
z = Number of teeth in cutter
n = Spindle speed in revolutions / min
V_f = Cutter feed or table traverse in mm
f_z = Feed per tooth in mm
V_c = Cutting speed in meters / minute
π = 3.1416

Cutting Speed $V_c = \frac{D \times \pi \times n}{1000}$ in meters / min

Spindle Speed $n = \frac{V_c \times 1000}{\pi \times D}$ in RPM

Feed Per Tooth $f_z = \frac{V_f}{z \times n}$ in mm

Cutter Feed or Table Traverse $V_f = f_z \times z \times n$ in mm

Feed Per Tooth For End Mills

The charts from page 48 give End Mill feeds per tooth (f_z) for 1/4 diameter radial cut with 1 diameter in axial depth.

To increase the axial depth to :

1½ diameters deep reduce feed to 70%.

2 diameters deep reduce feed by 50%.

To modify radial depth to :

1/2 Diameter reduce feed by 50%.

1/8 Diameter increase feed by 50%.

Feed Per Tooth For Slot Drills

The charts from page 50 give Slot Drill feed per tooth (f_z) for 1/2 diameter axial depth of cut full slot width.
To increase axial depth to full diameter reduce feed by 50%.

Feed per tooth for all long series cutters should be reduced by 50%.

Large axial and radial depths on small diameter or long cutters may cause deflection.

Hints On Milling

As in most machining operations optimum performance is controlled by the following:

(1) Rigidity of set up, use the most robust tool. Where this cannot be done, feeds and speeds must be reduced. Avoid large overhang of shank cutters. Adequately clamp cutter for both movement and chatter.

(2) Speeds, feeds and lubrication, consult the charts and adapt to suit workshop conditions, no coolant requires a reduction to the speed by up to 50%.

(3) Tool maintenance. Check tool shanks, machine chucks and arbor for dirt. Scoring or damage before mounting the tool. Tools with these faults will run eccentrically giving poor finish, inaccuracy, and poor tool life.

Milling Problems

1. Tool Breaks

(a) Incorrectly mounted or running eccentrically

(b) Excessive overhang, consider shorter tool

(c) Workpiece inadequately clamped

(d) Excessive feed or table running with cutter stalling

(e) Cutter chipped or worn. See page 47

(f) Swarf not clearing, consider different design or spiral of cutter

(g) Cutter too light for job

2. Short Tool Life

Consider items (a), (b), (c), (d)

(h) Speed too high, tool burning out

(i) Feed too light, tool rubbing (consider climb milling)

(j) Inadequate lubrication (no coolant, run at half speed)

3. Poor Size

Consider items (a), (b), (c), (g), (k).
Machine in poor condition.
If giving slot lean on slot drilling, try using a tri-cutter.

4. Poor Finish

Consider items (a), (b), (c), (d), (j), (k).

Look for one tooth doing all the work, consider climb milling.

Climb milling is where the cutter, cuts from the thick side of the chip to thin. The cutter tending to pull the workpiece into the cut, previously always avoided but modern machines can cope with this mode of cut.

Re-sharpening

Regular light re-sharpening is important for consistent performance. Shank type cutters are usually reconditioned by sharpening the end teeth relief and the clearance surfaces of the peripheral teeth. Up to 10mm diameter are considered disposable tools.

On slot drills it is necessary to remove all the wear by cutting back the end teeth to maintain the cutter size. The alternative is to lip glaze up the flute taking away the wear land as indicated below.

When regrinding relief on end teeth, angles should be restored to the original values. These are typically:

Primary 6° and Secondary 12°

Re-grinding body teeth the angles are typically:

up to 2mm	Primary 23° No secondary
over 2 up to 6mm	Primary 17° No secondary
over 6mm up to 10mm	Primary 14° optional 22°
over 10mm up to 16mm	Primary 12° secondary 25°
over 16mm	Primary 6° secondary 12°

or an archimedean cam relief can replace both.

When To Regrind

When a wear land appears on the cutter. Suggested amount:

0.10mm	(0.004") on up to 10mm (3/8") diameter cutters
0.15mm	(0.006") on up to 20mm (3/4") diameter cutters
0.20mm	(0.008") on up to 25mm (1") diameter cutters
0.025mm	(0.010") on 32mm (1-1/4") and over cutters

Greater than these wear lands may lead to broken cutters.

If the power consumption goes up, regrinding is required.

Size in a slot is lost (P9 tolerance).

When the surface finish starts to deteriorate.

Large burrs start to appear on edge of cut.

If the swarf starts to turn blue.

When noise and smoke start to appear it is usually too late to save the cutter for re-grinding.

H.S.S. End Mills, Feeds & Speeds

Depth of Cut = Diameter, Width of Cut = 1/4 Diameter

Material	**Aluminium**			**Brass**			**Cast Iron**			**Mild Steel** 120Hb			**Low Carbon Steel** 200Hb			**Alloy Steel** 250Hb			
*Speed **M***	**60 meters/min**			**55 meters/min**			**22 meters/min**			**30 meters/min**			**25 meters/min**			**15 meters/min**			
Dia.	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	Inch
2	9549	0.002	76	8754	0.002	70	3501	0.002	28	4775	0.002	38	3979	0.002	32	2387	0.002	19	5/64
3	6366	0.003	76	5836	0.003	70	2334	0.005	47	3183	0.006	76	2653	0.006	64	1592	0.004	25	1/8
5	3820	0.008	122	3501	0.007	98	1401	0.008	45	1910	0.020	153	1592	0.020	127	955	0.016	61	5/32
6	3183	0.011	140	2918	0.020	233	1167	0.021	98	1592	0.025	159	1326	0.025	133	796	0.020	64	1/4
8	2387	0.020	191	2188	0.030	263	875	0.032	112	1194	0.036	172	995	0.036	143	597	0.030	72	5/16
10	1910	0.030	229	1751	0.060	420	700	0.042	118	955	0.048	183	796	0.048	153	477	0.042	80	3/8
12	1592	0.050	318	1459	0.070	408	584	0.052	121	796	0.060	191	663	0.060	159	398	0.052	83	1/2
16	1194	0.080	382	1094	0.085	372	438	0.068	119	597	0.075	179	497	0.075	149	298	0.068	81	5/8
20	955	0.100	382	875	0.090	315	350	0.075	105	477	0.085	162	398	0.085	135	239	0.075	72	3/4
25	764	0.110	504	700	0.110	462	280	0.080	134	382	0.100	229	318	0.100	191	191	0.080	92	1"
32	597	0.125	448	547	0.110	361	219	0.090	118	298	0.100	179	249	0.100	149	149	0.085	76	1¼
40	477	0.130	372	438	0.130	341	175	0.100	105	239	0.110	158	199	0.110	131	119	0.095	68	1½
50	382	0.130	298	350	0.130	273	140	0.100	84	191	0.110	126	159	0.110	105	95	0.095	54	2"

Long series cutters use half the feed rates.
For 8% cobalt cutters use above at 1.33 x RPM and feed use same feed/tooth.

PRESTO ®

Cobalt 8% End Mills, Feeds & Speeds

Depth of Cut = Diameter, Width of Cut = 1/4 Diameter

Material	**Alloy Steel**			**Alloy Steel**			**Stainless** Free Cut Ferritic			**Stainless** Austenitic §			**Titanium Alloy** 300Hb §			**Nickel Alloy** Nimonic 250Hb §			
Speed M	**15** meters/min			**10** meters/min			**25** meters/min			**15** meters/min			**9** meters/min			**8** meters/min			
Dia.	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	Inch
2	2387	0.003	29	1592	0.003	19	3979	0.003	48	2387	0.003	29	1432	0.003	17	1273	0.002	10	5/64
3	1592	0.005	32	1061	0.005	21	2653	0.005	53	1592	0.005	32	955	0.005	19	849	0.004	14	1/8
5	955	0.010	38	637	0.010	25	1592	0.008	51	955	0.008	31	573	0.008	18	509	0.007	14	5/32
6	796	0.016	51	531	0.016	34	1326	0.021	111	796	0.018	57	477	0.018	34	424	0.012	20	1/4
8	597	0.025	60	398	0.025	40	995	0.032	127	597	0.027	64	358	0.027	39	318	0.018	23	5/16
10	477	0.035	67	318	0.035	45	796	0.042	134	477	0.037	71	286	0.037	42	255	0.026	26	3/8
12	398	0.045	72	265	0.045	48	663	0.052	138	398	0.045	72	239	0.045	43	212	0.035	30	1/2
16	298	0.060	72	199	0.060	48	497	0.068	135	298	0.060	72	179	0.060	43	159	0.050	32	5/8
20	239	0.070	67	159	0.070	45	398	0.075	119	239	0.072	69	143	0.072	41	127	0.058	30	3/4
25	191	0.070	80	127	0.070	53	318	0.080	153	191	0.080	92	115	0.080	55	102	0.065	40	1"
32	149	0.080	72	99	0.080	48	249	0.090	134	149	0.080	72	90	0.080	43	80	0.065	31	1¼
40	119	0.090	64	80	0.090	43	199	0.100	119	119	0.090	64	72	0.090	39	64	0.070	27	1½
50	95	0.090	52	64	0.090	34	159	0.100	95	95	0.090	52	57	0.090	31	51	0.070	21	2"

Long series cutters use half the feed rates.

§ Special PMC cutters with a higher spiral angle will give better results on difficult Stainless, Titanium and Nickel.

H.S.S. Slot Drills, Feeds & Speeds

Depth of Cut = 1/2 Diameter, Width of Cut = Diameter

Material	**Aluminium**			**Brass**			**Cast Iron**			**Mild Steel** 120Hb			**Low Carbon Steel** 200Hb			**Alloy Steel** 250Hb			
Speed M	**60** meters/min			**55** meters/min			**22** meters/min			**30** meters/min			**25** meters/min			**15** meters/min			
Dia.	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	Inch
2	9549	0.003	57	8754	0.003	53	3501	0.003	21	4775	0.003	29	3979	0.003	24	2387	0.002	10	5/64
3	6366	0.005	64	5836	0.005	58	2334	0.009	42	3183	0.007	45	2653	0.007	37	1592	0.005	16	1/8
5	3820	0.012	92	3501	0.011	77	1401	0.015	42	1910	0.015	57	1592	0.015	48	955	0.013	25	5/32
6	3183	0.032	204	2918	0.030	175	1167	0.027	63	1592	0.023	73	1326	0.023	61	796	0.021	33	1/4
8	2387	0.050	239	2188	0.045	197	875	0.042	74	1194	0.036	86	995	0.036	72	597	0.032	38	5/16
10	1910	0.085	325	1751	0.060	210	700	0.060	84	955	0.048	92	796	0.048	76	477	0.042	40	3/8
12	1592	0.100	318	1459	0.070	204	584	0.072	84	796	0.060	95	663	0.060	80	398	0.052	41	1/2
16	1194	0.125	298	1094	0.085	186	438	0.080	70	597	0.075	90	497	0.075	75	298	0.068	41	5/8
20	955	0.135	258	875	0.090	158	350	0.080	56	477	0.088	84	398	0.088	70	239	0.072	34	3/4
25	764	0.170	260	700	0.110	154	280	0.090	50	382	0.100	76	318	0.100	64	191	0.090	34	1"
32	597	0.175	209	547	0.110	120	219	0.090	39	298	0.100	60	249	0.100	50	149	0.090	27	1¼
40	477	0.180	172	438	0.130	114	175	0.100	35	239	0.110	53	199	0.110	44	119	0.100	24	1½
50	382	0.180	138	350	0.130	91	140	0.100	28	191	0.110	42	159	0.110	35	95	0.100	19	2"

Long series cutters use half the feed rates.
For 8% cobalt cutters use above at 1.33 x RPM and feed use same feed/tooth.

®PRESTO

Cobalt 8% Slot Drills, Feeds & Speeds

Depth of Cut = 1/2 Diameter, Width of Cut = Diameter

Material	**Alloy Steel** 300Hb			**Alloy Steel** 350Hb			**Stainless** Free Cut Ferritic			**Stainless** Austenitic §			**Titanium Alloy** 300Hb §			**Nickel Alloy** Nimonic 250Hb §			
Speed M	**15** meters/min			**10** meters/min			**25** meters/min			**15** meters/min			**9** meters/min			**8** meters/min			
Dia.	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	Inch
2	2387	0.003	14	1592	0.003	10	3979	0.003	24	2387	0.003	14	1432	0.003	9	637	0.003	4	5/64
3	1592	0.009	29	1061	0.009	19	2653	0.009	48	1592	0.009	29	955	0.007	13	424	0.007	6	1/8
5	955	0.017	32	637	0.017	22	1592	0.015	48	955	0.012	23	573	0.012	14	255	0.012	6	5/32
6	796	0.025	40	531	0.025	27	1326	0.027	72	796	0.018	29	477	0.020	19	212	0.020	8	1/4
8	597	0.040	48	398	0.040	32	995	0.042	84	597	0.020	24	358	0.030	21	159	0.030	10	5/16
10	477	0.050	48	318	0.050	32	796	0.060	95	477	0.040	38	286	0.037	21	127	0.037	9	3/8
12	398	0.060	48	265	0.060	32	663	0.072	95	398	0.055	44	239	0.045	21	106	0.045	10	1/2
16	298	0.075	45	199	0.075	30	497	0.080	80	298	0.072	43	179	0.060	21	80	0.060	10	5/8
20	239	0.080	38	159	0.080	25	398	0.080	64	239	0.080	38	143	0.072	21	64	0.072	9	3/4
25	191	0.090	34	127	0.090	23	318	0.090	57	191	0.080	31	115	0.080	18	51	0.080	8	1"
32	149	0.090	27	99	0.090	18	249	0.090	45	149	0.080	24	90	0.080	14	40	0.080	6	1¼
40	119	0.095	23	80	0.095	15	199	0.100	40	119	0.090	21	72	0.090	13	32	0.090	6	1½
50	95	0.095	18	64	0.095	12	159	0.100	32	95	0.090	17	57	0.090	10	25	0.090	5	2"

Long series cutters use half the feed rates.

§ Tri-Cutters with a higher spiral angle will give better results on difficult Stainless, Titanium and Nickel.

H.S.S. Slot Cutters, Feeds & Speeds

Nominal Bolt Size		Head	Teeth	Aluminium			Brass			Cast Iron			Mild Steel 120Hb, 450N/mm²			Low Carbon Steel 200Hb, 700N/mm²			Alloy Steel 250Hb, 850N/mm²		
		Speed M		**60** meters/min			**55** meters/min			**20** meters/min			**30** meters/min			**25** meters/min			**12** meters/min		
mm.	inch	Dia.	Z	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min
6		12.5	6	1528	0.010	92	1401	0.010	84	509	0.007	21	764	0.009	41	637	0.006	23	306	0.004	7
	1/4"	14.7	6	1299	0.010	78	1191	0.010	71	433	0.010	26	650	0.013	51	541	0.009	29	260	0.006	9
8		16	6	1194	0.010	72	1094	0.010	66	398	0.010	24	597	0.014	50	497	0.011	33	239	0.008	11
10	5/16"	19	6	1005	0.010	60	921	0.010	55	335	0.013	26	503	0.016	48	419	0.013	33	201	0.011	13
12	3/8"	22	6	868	0.020	104	796	0.020	95	289	0.016	28	434	0.020	52	362	0.018	39	174	0.016	17
14	7/16"	25	6	764	0.020	92	700	0.020	84	255	0.025	38	382	0.030	69	318	0.025	48	153	0.022	20
16	1/2"	28	8	682	0.020	109	625	0.020	100	227	0.025	45	341	0.030	82	284	0.025	57	136	0.022	24
18		32	8	597	0.030	143	547	0.030	131	199	0.030	48	298	0.035	84	249	0.030	60	119	0.027	26
	5/8"	34	8	562	0.030	135	515	0.030	124	187	0.030	45	281	0.037	83	234	0.032	60	112	0.030	27
20		36	8	531	0.030	127	486	0.030	117	177	0.030	42	265	0.037	79	221	0.032	57	106	0.030	25
	3/4"	39	8	496	0.030	119	455	0.030	109	165	0.035	46	248	0.037	73	207	0.032	53	99	0.030	24
22		40	8	477	0.030	115	438	0.030	105	159	0.035	45	239	0.037	71	199	0.032	51	95	0.030	23
	7/8"	43	8	441	0.030	106	404	0.030	97	147	0.035	41	221	0.037	65	184	0.032	47	88	0.030	21
	1"	50	8	382	0.030	92	350	0.030	84	127	0.038	39	191	0.037	57	159	0.032	41	76	0.033	20

Used to make "T"- Slots from pre-machined slots with not more than 0.1mm cut on bottom face.
Calculations are made on HEAD diameter and not the nominal BOLT SIZE.

H.S.S. Dovetail Cutters, Feeds & Speeds

Depth of Cut 80% of Flute Length, Width of Cut 25% of Diameter.

Material			Aluminium			Brass			Cast Iron			Mild Steel 120Hb			Low Carbon Steel 200Hb			Alloy Steel 250Hb		
*Speed **M***			**60** meters/min			**55** meters/min			**20** meters/min			**30** meters/min			**25** meters/min			**12** meters/min		
Dia. mm.	Dia. *inch*	*Teeth* Z	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min	RPM	Feed Per Tooth	Feed mm/min
13	*1/2"*	6	1469	0.020	176	1347	0.020	162	490	0.025	73	735	0.020	88	612	0.020	24	294	0.020	35
16		6	1194	0.020	143	1094	0.020	131	398	0.030	72	597	0.025	90	497	0.025	25	239	0.025	36
20	*3/4"*	6	955	0.030	172	875	0.030	158	318	0.035	67	477	0.030	86	398	0.030	24	191	0.030	34
22	*7/8"*	6	868	0.035	182	796	0.035	167	289	0.035	61	434	0.035	91	362	0.035	25	174	0.035	36
25	*1"*	6	764	0.035	160	700	0.035	147	255	0.040	61	382	0.040	92	318	0.040	25	153	0.040	37
28	*-1/8"*	6	682	0.040	164	625	0.040	150	227	0.040	55	341	0.040	82	284	0.040	23	136	0.040	33
32	*1-1/4"*	8	597	0.050	179	547	0.050	164	199	0.050	60	298	0.045	81	249	0.045	22	119	0.045	32
35	*1-3/8"*	8	546	0.055	180	500	0.055	165	182	0.055	60	273	0.055	90	227	0.050	23	109	0.050	33
38	*1-1/2"*	8	503	0.060	181	461	0.060	166	168	0.060	60	251	0.060	90	209	0.060	25	101	0.055	33

Cobalt Cutters use 1.3 x speeds and feed, maintain feed per tooth.

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

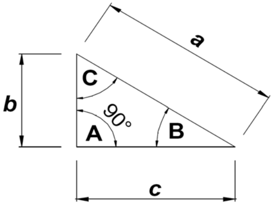
Using the larger drill size on thin materials will result in stripped threads. Using the smallest drill in thick materials will need very high torque values to drive the screw and can result in the head shearing off the screw.

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.

®PRESTO

SOLUTIONS OF TRIANGLES (Right Angled Triangles)

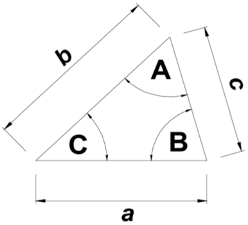


As shown in the sketch the sides of the right angled triangle are designated a, b, c.

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"

$$C = 180° - (A + B)$$

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

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

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

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

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

$$C = 180° - (A + B)$$

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

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

$$C = 180° - (A + B)$$

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

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

PRESTO®

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

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

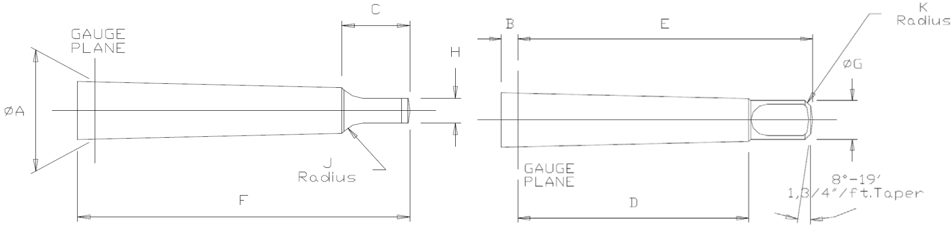
Manufacturing Tolerances To BS EN 20286-2, ISO286-2 (Old BS Standard 4500)

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



No. Of Morse Taper	Taper Per Foot On Dia.	A Dia. At Gauge Plane	B Overhang	C Tang Length	D Gauge Plane To Tang	E Gauge Plane To End Of Shank mm	F Overall Length	G Dia.	H Thickness	J Radius	K 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

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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	1-¼"	5°	57'	46"	2°	58'	53"
1 in 8	1-½"	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	3½"	16°	35'	39"	8°	17'	50"
1 in 3	4"	18°	55'	20"	9°	27'	44"

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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.

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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.

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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)

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