

For Classes 2, 3, 1B, 2B and 3B Unified and American National Screw Threads

Size	THREADS PER INCH		RECOMMENDED TAP LIMITS				INTERNAL THREAD PITCH DIAMETER LIMITS				
	NC UNC	NF UNF	Class 2	Class 3	Class 2B	Class 3B	Min. /All Classes (Basic)	Max Class 2	Max Class 3	Max Class 2B	Max Class 3B
0		80	G H1	G H1	G H2	G H1	.0519	.0536	.0532	.0542	.0536
1	64		G H1	G H1	G H2	G H1	.0629	.0648	.0643	.0655	.0648
1		72	G H1	G H1	G H2	G H1	.0640	.0658	.0653	.0665	.0659
2	56		G H1	G H1	G H2	G H1	.0744	.0764	.0759	.0772	.0765
2		64	G H1	G H1	G H2	G H1	.0759	.0778	.0773	.0786	.0779
3	48		G H1	G H1	G H2	G H1	.0855	.0877	.0871	.0885	.0877
3		56	G H1	G H1	G H2	G H1	.0874	.0894	.0889	.0902	.0895
4	40		G H2	G H1	G H2	G H2	.0958	.0982	.0975	.0991	.0982
4		48	G H1	G H1	G H2	G H1	.0985	.1007	.1001	.1016	.1008
5	40		G H2	G H1	G H2	G H2	.1088	.1112	.1105	.1121	.1113
5		44	G H1	G H1	G H2	G H1	.1102	.1125	.1118	.1134	.1126
6	32		G H2	G H1	G H3	G H2	.1177	.1204	.1196	.1214	.1204
6		40	G H2	G H1	G H2	G H2	.1218	.1242	.1235	.1252	.1243
8	32		G H2	G H1	G H3	G H2	.1437	.1464	.1456	.1475	.1465
8		36	G H2	G H1	G H2	G H2	.1460	.1485	.1478	.1496	.1487
10	24		G H3	G H1	G H3	G H3	.1629	.1662	.1653	.1672	.1661
10		32	G H2	G H1	G H3	G H2	.1697	.1724	.1716	.1736	.1726
12	24		G H3	G H1	G H3	G H3	.1889	.1922	.1913	.1933	.1922
12		28	G H3	G H1	G H3	G H3	.1928	.1959	.1950	.1970	.1959
1/4	20		G H3	G H2	G H5	G H3	.2175	.2211	.2201	.2223	.2211
1/4		28	G H3	G H1	G H4	G H3	.2268	.2299	.2290	.2311	.2300
5/16	18		G H3	G H2	G H5	G H3	.2764	.2805	.2794	.2817	.2803
5/16		24	G H3	G H1	G H4	G H3	.2854	.2887	.2878	.2902	.2890
3/8	16		G H3	G H2	G H5	G H3	.3344	.3389	.3376	.3401	.3387
3/8		24	G H3	G H1	G H4	G H3	.3479	.3512	.3503	.3528	.3516
7/16	14		G H5	G H3	G H5	G H3	.3911	.3960	.3947	.3972	.3957
7/16		20	G H3	G H1	G H5	G H3	.4050	.4086	.4076	.4104	.4091
1/2	13		G H5	G H3	G H5	G H3	.4500	.4552	.4537	.4565	.4548
1/2		20	G H3	G H1	G H5	G H3	.4675	.4711	.4701	.4731	.4717
9/16	12		G H5	G H3	G H5	G H3	.5084	.5140	.5124	.5152	.5135
9/16		18	G H3	G H2	G H5	G H3	.5264	.5305	.5294	.5323	.5308
5/8	11		G H5	G H3	G H5	G H3	.5660	.5719	.5702	.5732	.5714
5/8		18	G H3	G H2	G H5	G H3	.5889	.5930	.5919	.5949	.5934
3/4	10		G H5	G H3	G H5	G H5	.6850	.6914	.6895	.6927	.6907
3/4		16	G H3	G H2	G H5	G H3	.7094	.7139	.7126	.7159	.7143
7/8	9		G H6	G H4	G H6	G H4	.8028	.8098	.8077	.8110	.8089
7/8		14	G H4	G H2	G H6	G H4	.8286	.8335	.8322	.8356	.8339
1	8		G H6	G H4	G H6	G H4	.9188	.9264	.9242	.9276	.9254
1		12	G H4	G H2	G H6	G H4	.9459	.9515	.9499	.9535	.9516
1		14 NS	G H4	G H2	G H6	G H4	.9536	.9585	.9572	.9609	.9590
1-1/8	7		G H8	G H4	G H8	G H4	1.0322	1.0407	1.0381	1.0416	1.0393
1-1/8		12	G H4	G H4	G H6	G H4	1.0709	1.0765	1.0749	1.0787	1.0768
1-1/4	7		G H8	G H4	G H8	G H4	1.1572	1.1657	1.1631	1.1668	1.1644
1-1/4		12	G H4	G H4	G H6	G H4	1.1959	1.2015	1.1999	1.2039	1.2019
1-3/8	6		G H8	G H4	G H8	G H4	1.2667	1.2768	1.2738	1.2771	1.2745
1-3/8		12	G H4	G H4	G H6	G H4	1.3209	1.3265	1.3249	1.3291	1.3270
1-1/2	6		G H8	G H4	G H8	G H4	1.3917	1.4018	1.3988	1.4022	1.3996
1-1/2		12	G H4	G H4	G H6	G H4	1.4459	1.4515	1.4499	1.4542	1.4522

NOTES: **Class 1B:** Tapped holes can be produced with cut thread taps. **Class 2B:** Cut thread taps may be used under normal conditions and in average materials for producing tapped holes to this classification. The above recommended taps normally produce the class of thread indicated in average materials when used with reasonable care. However, if the tap specified does not give a satisfactory gage fit in the work, a choice of some other limit tap will be necessary.

Tap breakage:

- The tap is dull.
- The wrong type of tap is used.
- The tap is incorrectly ground.
- The tap drill is too small.
- The drilled hole is too shallow.
- The tap is misaligned with the hole.
- The wrong machine is used.
- An incorrect fixture or holding device is used.
- Work hardened material.
- There is a lack of lubricant, or the wrong type is used.

Tap failure on reversal:

- The tap is cutting too tightly. The cutting face angle should be increased.
- The tap is galling. The face angle on the back of the land should be increased.
- Chips are wedged between the flutes.

Chips clogging flutes:

- The wrong type of tap is used.
- The chamfer is insufficient.
- The cutting face angle is incorrect.
- The flutes are rough.
- The flutes are improperly reground.
- There is a lack of lubricant, or the wrong type is used.

Stripped or chipped tap threads:

- The tap is misaligned.
- The tap is carelessly handled.
- The tap is dull.
- The tap is too hard.
- The tap is improperly sharpened.
- A surface treated tap is used in the wrong application.

Torn threads in tapped part:

- The cutting face angle is incorrect; usually, the angle is too small.
- The tap drill is too small.
- Chips are clogging the flutes.
- The tap has broken threads.
- The tap is improperly resharpened.
- There is a lack of lubricant, or the wrong type is used.

Tap sticking or binding:

- The tap drill is too small.
- The tap lands are too wide.
- The cutting face angle is incorrect.
- There is a lack of lubricant, or the wrong type is used.
- A surface treatment (lubricant) is required.

Excessive tap wear:

- The material is abrasive, or inclusions are present. A surface treated tap is required.
- The tap is misaligned.

Cutting face breakdown:

- The cutting face angle is incorrect.
- A surface treatment is required.

Tap overheating:

- The land width is excessive.
- There is a lack of lubricant, or the wrong type is used.
- The tap is dull.
- There is excessive flank contact. Pitch diameter relief is required.
- The tap is used at excessive speeds.

Poor finish on thread in tapped part:

- Pitch diameter relief is required.
- The face angle is incorrect; usually, the angle is too small.
- The tap drill is too small.
- There are an insufficient number of chamfered threads.
- The tap is dull.
- There is a lack of lubricant, or the wrong type is used.

Excessive frictional drag and power requirement:

- Pitch diameter relief is required.
- The point size on the tap is too small.
- The tap is dull.
- The cutting face angle is incorrect.
- The tapping speed is incorrect.
- There is a lack of lubricant, or the wrong type is used.
- The equipment used is incorrect or inadequate.
- The tap is misaligned.

Fractional Sizes

Feet per Minute

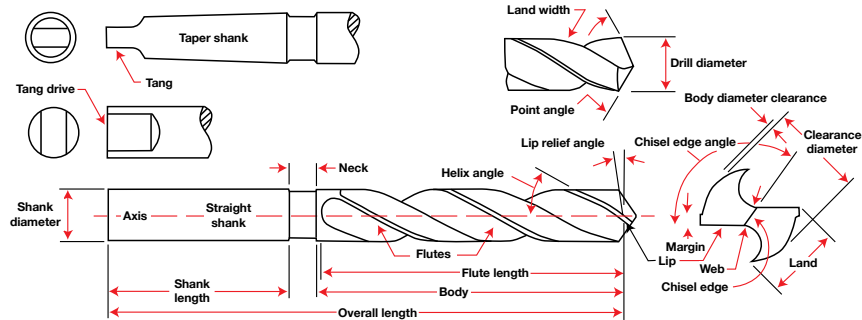
Drill Size		10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
Fraction	Decimal	Revolutions per Minute														
1/16	.0625	611	1222	1833	2445	3056	3667	4278	4889	5500	6111	6722	7334	7945	8556	9167
1/8	.1250	306	611	917	1222	1528	1833	2139	2445	2750	3056	3361	3667	3973	4278	4584
3/16	.1875	204	407	611	815	1019	1222	1426	1630	1833	2037	2241	2445	2648	2852	3056
1/4	.2500	153	306	458	611	764	917	1070	1222	1375	1528	1681	1833	1986	2139	2292
5/16	.3125	122	244	367	489	611	733	856	978	1100	1222	1345	1467	1589	1711	1833
3/8	.3750	102	204	306	407	509	611	713	815	917	1019	1120	1222	1324	1426	1528
7/16	.4375	87	175	262	349	437	524	611	698	786	873	960	1048	1135	1222	1310
1/2	.5000	76	153	229	306	382	458	535	611	688	764	840	917	993	1070	1146
5/8	.6250	61	122	183	244	306	367	428	489	550	611	672	733	794	856	917
3/4	.7500	51	102	153	203	255	306	357	407	458	509	560	611	662	713	764
7/8	.8750	44	87	131	175	218	262	306	349	393	436	480	524	568	611	655
1	1.0000	38	76	115	153	191	229	267	306	344	382	420	458	497	535	573
1-1/8	1.1250	34	68	102	136	170	204	238	272	306	340	373	407	441	475	509
1-1/4	1.2500	31	61	92	122	153	183	214	244	275	306	336	367	397	428	458
1-3/8	1.3750	28	56	83	111	139	167	194	222	250	278	306	333	361	389	417
1-1/2	1.5000	26	51	76	102	127	153	178	204	229	255	280	306	331	357	382
1-5/8	1.6250	24	47	70	94	117	141	165	188	212	235	259	282	306	329	353
1-3/4	1.7500	22	44	65	87	109	131	153	175	196	218	240	262	284	306	327
1-7/8	1.8750	20	41	61	81	102	122	143	163	183	204	224	244	265	285	306
2	2.0000	19	38	57	76	95	115	134	153	172	191	210	229	248	267	287
2-1/4	2.2500	17	34	51	68	85	102	119	136	153	170	187	204	221	238	255
2-1/2	2.5000	15	31	46	61	76	92	107	122	137	153	168	183	199	214	229
2-3/4	2.7500	14	28	42	56	69	83	97	111	125	139	153	167	181	194	208
3	3.0000	13	25	38	51	64	76	89	102	115	127	140	153	166	178	191

Letter Sizes

Feet per Minute

Drill Size		10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
Letter	Decimal	Revolutions per Minute														
A	.2340	163	326	491	654	818	982	1145	1309	1472	1636	1796	1959	2122	2285	2448
B	.2380	161	321	482	642	803	963	1124	1284	1445	1605	1765	1926	2086	2247	2407
C	.2420	158	316	473	631	789	947	1105	1262	1420	1578	1736	1894	2052	2210	2368
D	.2460	155	311	467	622	778	934	1089	1245	1400	1556	1708	1863	2018	2174	2329
E	.2500	153	306	458	611	764	917	1070	1222	1375	1528	1681	1834	1986	2139	2292
F	.2570	149	297	446	594	743	892	1040	1189	1337	1486	1635	1784	1932	2081	2229
G	.2610	146	293	440	585	732	878	1024	1170	1317	1463	1610	1756	1903	2049	2195
H	.2660	144	287	430	574	718	862	1005	1149	1292	1436	1580	1723	1867	2010	2154
I	.2720	140	281	421	562	702	842	983	1123	1264	1404	1545	1685	1826	1966	2106
J	.2770	138	276	414	552	690	827	965	1103	1241	1379	1517	1655	1793	1930	2068
K	.2810	136	272	408	544	680	815	951	1087	1223	1359	1495	1631	1767	1903	2039
L	.2900	132	263	395	527	659	790	922	1054	1185	1317	1449	1581	1712	1844	1976
M	.2950	129	259	389	518	648	777	907	1036	1166	1295	1424	1554	1683	1813	1942
N	.3020	126	253	380	506	633	759	886	1012	1139	1265	1391	1518	1644	1771	1897
O	.3160	121	242	363	484	605	725	846	967	1088	1209	1330	1450	1571	1692	1813
P	.3230	118	237	355	473	592	710	828	946	1065	1183	1301	1419	1537	1657	1774
Q	.3320	115	230	345	460	575	690	805	920	1035	1150	1266	1384	1496	1611	1726
R	.3390	113	225	338	451	564	676	789	902	1014	1127	1239	1355	1465	1577	1690
S	.3480	110	220	329	439	549	659	769	878	988	1098	1207	1317	1427	1537	1646
T	.3580	107	213	320	426	533	640	746	853	959	1066	1173	1280	1387	1494	1600
U	.3680	104	208	311	415	519	623	727	830	934	1038	1142	1246	1349	1453	1557
V	.3770	101	203	304	405	507	608	709	810	912	1013	1114	1219	1317	1418	1520
W	.3860	99	198	297	396	495	594	693	792	891	989	1088	1188	1286	1385	1484
X	.3970	96	192	289	385	481	576	672	769	865	962	1058	1155	1251	1347	1443
Y	.4040	95	189	284	378	473	567	662	756	851	945	1040	1135	1229	1324	1418
Z	.4130	92	185	277	370	462	555	647	740	832	925	1017	1110	1202	1295	1387

Taper Shank – in accordance with American National Standard B5.10. Machine Tapers



Axis: The imaginary straight line forming the longitudinal center line of the drill.

Back Taper: A slight decrease in diameter from front to back of the drill body.

Body: The portion of the drill extending from the shank or neck to the outer corners of the cutting lips.

Body Diameter Clearance: The portion of the land that has been cut away to prevent rubbing against the walls of the hole.

Chip Packing: The failure of chips to pass through the flute during the cutting action. Generally results in tool failure.

Chipping: The breakdown at a cutting lip or margin by loss of fragments broken away during the cutting action.

Chisel Edge: The edge at the end of the web that connects the cutting lips.

Chisel Edge Angle: The angle included between the chisel edge and the cutting lip, as viewed from the end of the drill.

Clearance: The space provided to eliminate undesirable contact between the drill and the work piece.

Clearance Diameter: The diameter over the cut away portion of the drill lands.

Cutting Lips: The cutting edges of a two flute drill, extending from the chisel edge to the periphery. In core drills, the cutting edges extending from the bottom of the chamfer to the periphery.

Drill Diameter: The diameter over the margins of the drill, measured at the point.

Flutes: Helical or straight grooves cut or formed in the body of the drill; these provide cutting lips, permit removal of chips, and allow cutting fluid to reach the cutting lips.

Flute Length: The length from the outer corners of the cutting lips to the extreme back end of the flutes. This includes the sweep of the tool used to generate the flutes. Does not indicate the useable length of the flutes.

Heel: The trailing edge of the land.

Helical Flutes: Flutes which are formed in a helical path around the axis.

Helix Angle: The angle made by the leading edge of the land with a plane containing the axis of the drill.

Land: The peripheral portion of the body between adjacent flutes.

Land Clearance: The preferred term is body diameter clearance; see above.

Land Width: The distance between the leading edge and the heel of the land, measured at a right angle to the leading edge.

Length of Twist: The preferred term is flute length; see left.

Lip Relief: The axial relief angle at the outer corner of the lip. It is measured by projection into a plane tangent to the periphery at the outer corner of the lip.

Margin: The cylindrical portion of the land which is not cut away to provide clearance.

Overall Length (OAL): The length from the extreme end of the shank to the outer corners of the cutting lips. Does not include the conical shank end often used on straight shank drills. Does not include the conical cutting point used on both straight and taper shank drills. In core drills, the overall length of drills with an external center on the cutting end is the same as for two flute drills. Drills with an internal center on the cutting end are measured from the extreme ends of the tool.

Point: The cutting end of a drill, made up of the ends of the lands and the web. Resembles a cone, but departs from a true cone to furnish clearance behind the cutting lips.

Point Angle: The angle included between the cutting lips, projected upon a plane parallel to the drill axis and the two cutting lips.

Relief: The result of the removal of tool material behind or adjacent to the cutting lip and leading edge of the land to provide clearance and prevent rubbing (also known as heel drag).

Shank: The part of the drill by which it is held and driven.

Straight Flutes: Flutes which form lands lying in an axial plane.

Straight Shank Drills: Drills with cylindrical shanks which may be the same or different diameter than the body of the drill. The shank may be made with or without driving flats, tang, grooves or threads.

Tang: The flattened end of a taper shank, intended to fit into a driving slot in a socket.

Tang Drive: Two opposite parallel driving flats on the extreme end of a straight shank.

Taper Shank Drills: Drills with conical shanks suitable for direct fitting into tapered holes in machine spindles, driving sleeves or sockets. Tapered shanks generally have a tang.

Twist Drill: A rotary end cutting tool with one or more cutting lips, having one or more helical or straight flutes for the passage of chips and the admission of a cutting fluid.

Web: The central portion of the body that joins the lands. The extreme end of the web forms the chisel edge on a two flute drill.

Web Thickness: The thickness of the web at the point, unless another specific location is indicated.

Drilling Recommendations for Various Materials

Recommended Surface Feet per Minute (SFM) and Coolant by Material Application

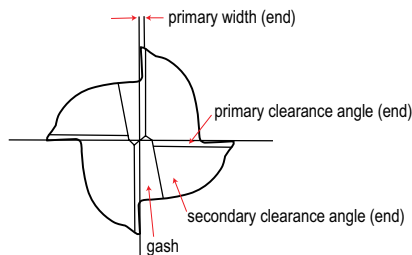
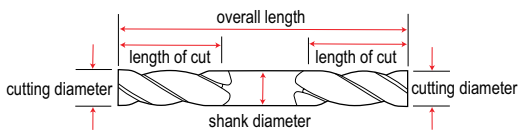
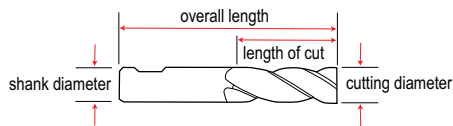
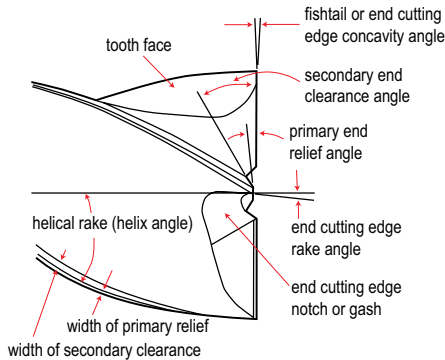
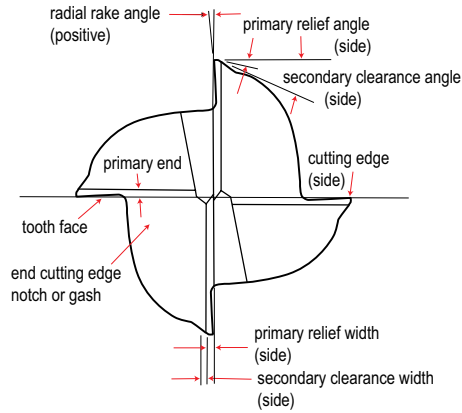
Ferrous Materials

Materials	Brinell Hardness	Geometry	SFM	Coolant
Low Carbon Steel	85 - 125	general purpose	80 - 95	Soluble oil
Medium Carbon Steel	125 - 175	general purpose	70 - 85	Soluble oil
High Carbon Steel	175 - 225	heavy duty	45 - 65	Soluble oil
Steel Alloys	Under 200	general purpose	60 - 90	Soluble oil
	200 - 300	heavy duty	40 - 70	Soluble oil
	Over 300	cobalt	20 - 30	Soluble oil
Steel Drop Forgings (heat treated)	330 - 370		30 - 40	Cutting oil
	370 - 420		20 - 30	Cutting oil
	Over 420		10 - 20	Cutting oil
Grey Cast Iron (soft)	125	general purpose	140 - 150	Dry
Grey Cast Iron (medium)	120 - 200	heavy duty	50 - 80	Soluble oil
Grey Cast Iron (hard)	Up to 350	heavy duty	25 - 40	Soluble oil
Titanium Alloys (Ti)-75A	300 - 440	cobalt	50 - 60	Cutting oil
Ti-150A, RS-120	300 - 440	cobalt	40 - 50	Cutting oil
Ti140A, RC 130B	300 - 440	cobalt	30 - 40	Cutting oil
Ti-6AL-4V	300 - 440	cobalt	20 - 30	Cutting oil
300 Series Stainless	120 - 200	cobalt	20 - 40	Cutting oil
400 Series Stainless	200 - 300	cobalt	40 - 70	Cutting oil
Martensitic 416, 420, F416, Plus K, 400F, 416SSE, 440F	135 - 185	cobalt	40 - 50	Cutting oil
Precipitation Hardening	325 - 375	cobalt	30	Cutting oil
Stainless Steel (cast)	400 - 450	cobalt	20	Cutting oil
Heat Resisting Steels	175 - 225	cobalt	10 - 25	Cutting oil
Nimonic Alloys	200 - 300	cobalt	10 - 20	Cutting oil
Manganese, 12-14% min	125 - 220	heavy duty	10 - 12	Cutting oil
Spring Steels	402	cobalt	15 - 30	Soluble oil
Armor Plate	200 - 250	cobalt	40	Soluble oil
	250 - 300	cobalt	35	Soluble oil
	300 - 350	cobalt	30	Cutting oil

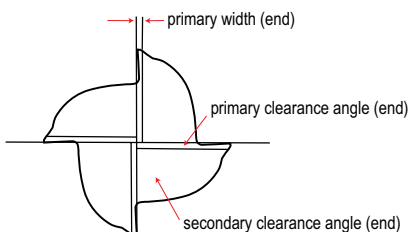
Non-Ferrous Materials

Materials	Brinell Hardness	Geometry	SFM	Coolant
Aluminum (pure)	140 - 350	fast spiral*	130 - 200	Soluble oil
Aluminum Alloys	140 - 330	fast spiral*	150 - 300	Soluble oil
Aluminum (lead)	40 - 100	fast spiral*	200 - 325	Soluble oil
Aluminum Silicon Alloy (die cast)	40 - 100	fast spiral*	25 - 50	Soluble oil
Brass	190 - 210	slow spiral*	200 - 250	Cutting or soluble oil
Bronze	150 - 200	slow spiral*	200 - 250	Soluble oil
Copper (nickel & copper tin alloy)	65 - 100	general purpose*	140 - 200	Cutting or soluble oil
Copper (aluminum alloys)	30 - 100	general purpose*	120 - 200	Cutting or soluble oil
Magnesium Alloys (wrought)	50 - 90	general purpose*	140 - 330	Cutting or soluble oil
Magnesium Alloys (cast)	50 - 90	general purpose*	140 - 365	Cutting or soluble oil
Nickel Alloys (wrought & cast)	80 - 170	general purpose	70	Cutting or soluble oil
Nickel Alloys (Monel)	115 - 240	general purpose	55	Cutting or soluble oil
Nickel Alloys (Beryllium nickel)	200 - 250	general purpose	12	Cutting or soluble oil
Zinc Alloy	112 - 126	general purpose	200 - 250	Soluble oil

*bright only



Center Cutting End View



Non-Center Cutting End View

An end mill is a straight or tapered shank milling cutter, which extends or projects from the milling machine spindle unobstructed. It is one of the most versatile and most-used of the cutting tools in any machine shop. It is capable of milling, drilling, reaming, planning, shaping, contour cutting and more. Improvements in cutting efficiency through both design and material changes have only increased the use of this style of tool.

Axial Relief: The relief, measured in the axial direction, between a plane perpendicular to the axis at the cutting edge and the relieved surface.

Clearance (Secondary Relief): The additional space provided behind the relieved land. Eliminates undesirable contact between the mill and the workpiece.

Cutting Edge: The leading edge of the cutter tooth.

Flute: The chip space between the back of one tooth and the face of the following tooth.

Gash: The secondary cuts on a mill. Provides chip room.

Heel: The back edge of the relieved land.

Helical Rake: The angle between the tool axis and a tangent plane at a given point on the flute face.

Helix Angle: The cutting edge angle made by a helical cutting edge with a plane containing the axis of a cylindrical mill. When viewed from the cutter end of the mill, the flute will move clockwise for a right hand helix.

Hook: A concave condition of a tooth face. The rake of a hooked tooth face must be determined at a given point.

Land: Used to define the width of a specified surface.

Left Hand Cut: When viewed from the cutting end of the mill, a clockwise rotation of the mill is required to cut.

Length of Cut: The effective axial length of the relieved peripheral cutting edge.

Radial Rake: The angle between the tooth face and a radial line passing through the cutting edge in a plane perpendicular to the cutting axis.

Rake: The angular relationship between a reference plane or line and the tooth face or a tangent to the tooth face at a given point.

Relief: The result of the removal of tool material behind or adjacent to the cutting edge. Provides clearance and prevents rubbing.

Relief Angle: The angle formed between a relieved surface and a point on the cutting edge, or a given plane tangent to the axis.

Right Hand Cut: When viewed from the cutting end of the mill, a counterclockwise rotation is required to cut. Most end mills are right hand cut.

Shank: The projecting portion of a cutter which locates and drives the cutter from the machine spindle.

Tooth Face: The surface of the tooth on which the chip forms.

Problem	Solution
Tool breakage	<ul style="list-style-type: none"> • Reduce feed rate • Decrease width and depth of cut • Hold shank deeper or use shorter end mill • Regrind at an earlier stage
Excessive wear	<ul style="list-style-type: none"> • Increase feed and speed • Decrease spindle speed • Use another coolant • Use end mill with coating (TiN, TiCN, TiAlN, AlTiN) • Change tool to correct helix angle • Change to smaller relief angle • Change chip size or clear chips with more coolant or air pressure
Reduced tool life	<ul style="list-style-type: none"> • Use end mill with coating (TiN, TiCN, TiAlN, AlTiN) • Change to correct helix angle and primary relief • Regrind at an earlier stage
Chipped cutting edges	<ul style="list-style-type: none"> • Reduce feed rate on first cut • Use better machine or tool holder • Change parameters of machine or tool holder • Hold shank deeper or use shorter end mill • Decrease primary relief and cutting angle • Reduce radial width of cut
Chip packing	<ul style="list-style-type: none"> • Decrease width and depth of cut • Use an end mill with fewer flutes • Use higher coolant pressure and reposition nozzle to point of cut or use air pressure
Work piece burrs	<ul style="list-style-type: none"> • Correct cutting parameters • Change to correct cutting angle • Regrind at an earlier stage
Rough surface finish	<ul style="list-style-type: none"> • Reduce feed rate • Increase RPM • Grind concave angle on bottom teeth • Change chip size or clear chips with coolant or air pressure • Regrind at an earlier stage
Squealing and chattering	<ul style="list-style-type: none"> • Correct feed and speed • Use better machine or tool holder • Change parameters of machine or tool holder • Improve clamping rigidity • Decrease width and depth of cut • Hold shank deeper or use shorter end mill • Decrease relief angle
Side wall taper in workpiece	<ul style="list-style-type: none"> • Reduce feed rate • Hold shank deeper or use shorter end mill • Use multiflute end mill • Use end mill with higher rigidity
No dimensional accuracy	<ul style="list-style-type: none"> • Decrease width and depth of cut • Repair machine or tool holder • Change machine or tool holder • Change parameters of machine or tool holder • Use multiflute end mill • Use end mill with higher rigidity

Tap Size	Pitch	75% Thread		70% Thread		65% Thread		60% Thread	
		Theoretical Hole Size	Nearest Drill Size	Theoretical Hole Size	Nearest Drill Size	Theoretical Hole Size	Nearest Drill Size	Theoretical Hole Size	Nearest Drill Size
2	56	.0769	1.95	.0774	1.95	.0781	5/64	.0787	47
2	64	.0780	5/64	.0785	47	.0791	2.0	.0796	2.0
3	48	.0884	2.25	.0890	43	.0898	43	.0905	2.3
3	56	.0899	43	.0904		.0911	2.3	.0917	2.3
4	40	.0993	2.5	.1000	39	.1010	39	.1018	38
4	48	.1014	38	.1020	38	.1028	2.6	.1035	2.6
5	40	.1123	34	.1130	33	.1140	33	.1148	2.9
5	44	.1134	33	.1141	2.9	.1150	2.9	.1157	
6	32	.1221	3.1	.1230	3.1	.1242		.1252	1/8
6	40	.1253	1/8	.1260	3.2	.1270	3.2	.1278	3.25
8	32	.1481	3.75	.1490		.1502	25	.1512	3.8
8	36	.1498	25	.1507	3.8	.1517	24	.1526	24
10	24	.1688		.1700	18	.1716	11/64	.1729	11/64
10	32	.1741	17	.1750	=	.1762		.1772	16
12	24	.1948	10	.1960	9	.1976	5.0	.1989	8
12	28	.1978	5.0	.1989	8	.2002	8	.2014	7
1/4	20	.2245	5.7	.2260		.2279	1	.2295	1
1/4	28	.2318		.2329	5.9	.2342	A	.2354	15/64
5/16	18	.2842	7.2	.2861	7.25	.2879	7.3	.2898	L
5/16	24	.2912	7.4	.2927		.2941	M	.2955	7.5
3/8	16	.3431	11/32	.3452	8.75	.3474	S	.3495	8.9
3/8	24	.3537	9.0	.3552	9.0	.3566		.3580	T
7/16	14	.4011		.4035	Y	.4059	13/32	.4084	
7/16	20	.4120	Z	.4137	10.5	.4154		.4171	
1/2	13	.4608		.4634		.4660		.4686	15/32
1/2	20	.4745	12.0	.4762		.4779		.4796	
9/16	12	.5200		.5229		.5257		.5285	17/32
9/16	18	.5342	13.5	.5361		.5380		.5398	

FORMULA FOR TAP / DRILL SIZES FOR DECIMAL / INCH TAPS:

$$\text{HOLE SIZE} = \text{Basic Tap O.D.} - \left(\frac{.0068 \times \% \text{ of Thread}^*}{\text{Threads per Inch}} \right)$$

For example:

To determine drill size for a 1/4-20 thread forming tap at 65% of thread: $.250 - \left(\frac{.0068 \times 65}{20} \right) = .2279$

*Use whole number for % of thread... for 65%, use 65 (not .65).

FORMULA FOR TAP / DRILL SIZES FOR METRIC TAPS:

$$\text{HOLE SIZE (mm)} = \text{Basic Tap O.D. (mm)} - \left(\frac{\% \text{ of Thread} \times \text{mm Pitch}}{147.06} \right)$$

*Use whole number for % of thread... for 65%, use 65 (not .65).

Probable Percentage of Full Thread Produced in Tapped Hole Using Stock Sizes of Drill

TAP	Tap Drill	Decimal Equiv.	Theoretical % of Thread	Probable Oversize (Mean)	Hole Size	% of Thread
0-80	56	.0465	83	.0015	.0480	74
	3/64	.0469	81	.0015	.0484	71
1-64	54	.0550	89	.0015	.0565	81
	53	.0595	67	.0015	.0610	59
1-72	53	.0595	75	.0015	.0610	67
	1/16	.0625	58	.0015	.0640	50
2-56	51	.0670	82	.0017	.0687	74
	50	.0700	69	.0017	.0717	62
2-56	49	.0730	56	.0017	.0747	49
	50	.0700	79	.0017	.0717	70
2-64	49	.0730	64	.0017	.0747	56
	48	.0760	85	.0017	.0779	78
3-48	5/64	.0781	77	.0019	.0800	70
	47	.0785	76	.0019	.0804	69
3-48	46	.0810	67	.0019	.0829	60
	45	.0820	63	.0019	.0839	56
3-56	46	.0810	78	.0019	.0829	69
	45	.0820	73	.0019	.0839	65
4-40	44	.0860	56	.0019	.0879	48
	44	.0860	80	.0020	.0880	74
4-40	43	.0890	71	.0020	.0910	65
	42	.0935	57	.0020	.0955	51
4-40	3/32	.0938	56	.0020	.0958	50
	4-48	42	.0935	68	.0020	.0955
3/32		.0938	68	.0020	.0958	60
4-48	41	.0960	59	.0020	.0980	52
	5-40	40	.0980	83	.0023	.1003
39		.0995	79	.0023	.1018	71
5-40	38	.1015	72	.0023	.1038	65
	37	.1040	65	.0023	.1063	58
5-44	38	.1015	79	.0023	.1038	72
	37	.1040	71	.0023	.1063	63
6-32	36	.1065	63	.0023	.1088	55
	6-32	37	.1040	84	.0023	.1063
36		.1065	78	.0026	.1091	71
6-32	7/64	.1094	70	.0026	.1120	64
	35	.1100	69	.0026	.1126	63
6-32	34	.1110	67	.0026	.1136	60
	33	.1130	62	.0026	.1156	55
6-40	34	.1110	83	.0026	.1136	75
	33	.1130	77	.0026	.1156	69
8-32	32	.1160	68	.0026	.1186	60
	8-32	29	.1360	69	.0029	.1389
28		.1405	58	.0029	.1434	51
8-36	29	.1360	78	.0029	.1389	70
		.1405	68	.0029	.1434	57
8-36	9/64	.1406	68	.0029	.1435	57
	10-24	27	.1440	85	.0032	.1472
26		.1170	79	.0032	.1502	74
10-24	25	.1495	75	.0032	.1527	69
	24	.1520	70	.0032	.1552	64
10-24	23	.1540	67	.0032	.1572	61
	5/32	.1563	62	.0032	.1595	56
10-32	22	.1570	61	.0032	.1602	55
	5/32	.1563	83	.0032	.1595	75
10-32	22	.1570	81	.0032	.1602	73
	21	.1590	76	.0032	.1622	68
10-32	20	.1610	71	.0032	.1642	64
	19	.1660	59	.0032	.1692	51
12-24	11/64	.1719	82	.0035	.1754	75
	17	.1730	79	.0035	.1765	73
12-24	16	.1770	72	.0035	.1805	66
	15	.1800	67	.0035	.1835	60
12-28	14	.1820	63	.0035	.1855	56
	12-28	16	.1770	84	.0035	.1805
15		.1800	78	.0035	.1835	70
12-28	14	.1820	73	.0035	.1855	66
	13	.1850	67	.0035	.1885	59
1/4-20	3/16	.1875	61	.0035	.1910	54
	1/4-20	9	.1960	83	.0038	.1998
8		.1990	79	.0038	.2028	73
1/4-20	7	.2010	75	.0038	.2048	70
		.2031	72	.0038	.2069	66
1/4-20	6	.2040	71	.0038	.2078	65
	5	.2055	69	.0038	.2093	63
1/4-20	4	.2090	63	.0038	.2128	57

TAP	Tap Drill	Decimal Equiv.	Theoretical % of Thread	Probable Oversize (Mean)	Hole Size	% of Thread
1/4-28	3	.2130	80	.0038	.2168	72
	7/32	.2188	67	.0038	.2226	59
5/16-18	2	.2210	63	.0038	.2248	55
	F	.2570	77	.0038	.2608	72
5/16-18	G	.2610	71	.0041	.2651	66
	5/16-18	17/64	.2656	65	.0041	.2697
H		.2660	64	.0041	.2701	59
5/16-24	H	.2660	86	.0041	.2701	78
	I	.2720	75	.0041	.2761	67
3/8-16	J	.2770	66	.0041	.2811	58
	3/8-16	5/16	.3125	77	.0044	.3169
O		.3160	73	.0044	.3204	68
3/8-24	P	.3230	64	.0044	.3274	59
	3/8-24	21/64	.3281	87	.0044	.3325
Q		.3320	79	.0044	.3364	71
7/16-14	R	.3390	67	.0044	.3434	58
	7/16-14	T	.3580	86	.0046	.3626
23/64		.594	84	.0046	.3640	79
7/16-14	U	.3680	75	.0046	.3726	70
	3/8	.3750	67	.0046	.3796	62
7/16-20	V	.3770	65	.0046	.3816	60
	7/16-20	W	.3860	79	.0046	.3906
25/64		.3906	72	.0046	.3952	65
1/2-13	X	.3970	62	.0046	.4016	55
	1/2-13	27/64	.4219	78	.0047	.4266
7/16		.4375	63	.0047	.4422	58
1/2-20	29/64	.4531	72	.0047	.4578	65
9/16-12	15/32	.4688	87	.0048	.4736	82
	31/64	.4844	72	.0048	.4892	68
9/16-18	1/2	.5000	87	.0048	.5048	80
	33/64	.5156	65	.0048	.5204	58
5/8-11	17/32	.5313	79	.0049	.5362	75
	35/64	.5469	66	.0049	.5518	62
5/8-18	9/16	.5625	87	.0049	.5674	80
	37/64	.5781	65	.0049	.5831	58
3/4-10	41/64	.6406	84	.0050	.6456	80
	21/32	.6563	72	.0050	.6613	68
3/4-16	11/16	.6875	77	.0050	.6925	71
7/8-9	49/64	.7656	76	.0052	.7708	72
	25/32	.7812	65	.0052	.7864	61
7/8-14	51/64	.7969	84	.0052	.8021	79
	13/16	.8125	67	.0052	.8177	62
1"-8	55/64	.8594	87	.0059	.8653	83
	7/8	.8750	77	.0059	.8809	73
1"-8	57/64	.8906	67	.0059	.8965	64
	29/32	.9063	58	.0059	.9122	54
1"-12	29/32	.9063	87	.0060	.9123	81
	59/64	.9219	72	.0060	.9279	67
1"-14	15/16	.9375	58	.0060	.9435	52
	59/64	.9219	84	.0060	.9279	78
1-1/8 - 7	15/16	.9375	67	.0060	.9435	61
	31/32	.9688	84	.0062	.9750	81
1-1/8 - 7	63/64	.9844	76	.0067	.9911	72
	1	1.0000	67	.0070	1.0070	64
1-1/8 - 12	1-1/64	1.0156	59	.0070	1.0226	55
	1-1/32	1.0313	87	.0071	1.0384	80
1-1/4 - 7	1-3/64	1.0469	72	.0072	1.0541	66
	1-3/32	1.0938	84			
1-1/4 - 12	1-7/64	1.1094	76			
	1-1/8	1.1250	67			
1-3/8 - 6	1-5/32	1.1563	87			
	1-11/64	1.1719	72			
1-3/8 - 6	1-3/16	1.1875	87			
	1-13/64	1.2031	79			
1-3/8 - 12	1-7/32	1.2188	72			
	1-15/64	1.2344	65			
1-1/2 - 6	1-9/32	1.2813	87			
	1-19/64	1.2969	72			
1-1/2 - 6	1-5/16	1.3125	87			
	1-21/64	1.3281	79			
1-1/2 - 12	1-11/32	1.3438	72			
	1-23/64	1.3594	65			
1-1/2 - 12	1-13/32	1.4063	87			
	1-27/64	1.4219	72			

**REAMING
RECOMMENDED**

Note: These speeds are based on 2/3 speeds rated for drilling.

Fractional Sizes

Drill Size		Feet per Minute														
Fraction	Decimal	10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
		Revolutions per Minute														
1/16	.0625	403	807	1210	1614	2017	2420	2823	3227	3663	4033	4437	4840	5244	5647	6050
1/8	.1250	202	403	605	807	1008	1210	1412	1614	1815	2017	2218	2420	2622	2823	3025
3/16	.1875	135	269	403	538	673	807	941	1076	1210	1344	1479	1614	1748	1882	2017
1/4	.2500	101	202	302	403	504	605	706	807	908	1008	1109	1210	1311	1412	1513
5/16	.3125	81	161	242	323	403	484	565	645	726	807	888	968	1049	1129	1210
3/8	.3750	67	135	202	269	336	403	471	538	605	673	739	807	874	941	1008
7/16	.4375	57	116	173	230	288	346	403	461	519	576	634	692	749	807	865
1/2	.5000	50	101	151	202	252	302	353	403	454	504	554	605	655	706	756
5/8	.6250	40	81	121	161	202	242	282	323	363	403	444	484	524	565	605
3/4	.7500	34	67	101	134	168	202	236	269	302	336	370	403	437	471	504
7/8	.8750	29	57	86	116	144	173	202	230	259	288	317	346	375	403	432
1	1.0000	25	50	76	101	126	151	176	202	227	252	277	302	328	353	378
1-1/8	1.1250	22	45	67	90	112	135	157	180	202	224	246	269	291	314	336
1-1/4	1.2500	20	40	61	81	101	121	141	161	182	202	222	242	262	282	302
1-3/8	1.3750	18	37	55	73	92	110	128	147	165	183	202	220	238	257	275
1-1/2	1.5000	17	34	50	67	84	101	117	135	151	168	185	202	218	236	252
1-5/8	1.6250	16	31	46	62	77	93	109	124	140	155	171	186	202	217	233
1-3/4	1.7500	15	29	43	57	72	86	101	116	129	144	158	173	187	202	216
1-7/8	1.8750	13	27	40	53	67	81	94	108	121	135	148	161	175	188	202
2	2.0000	13	25	38	50	63	76	88	101	114	126	139	151	164	176	189
2-1/4	2.2500	11	22	34	45	56	67	79	90	101	112	123	135	146	157	168
2-1/2	2.5000	10	20	30	40	50	61	71	81	90	101	111	121	131	141	151
2-3/4	2.7500	9	18	28	37	46	55	64	73	83	92	101	110	119	128	137
3	3.0000	9	17	25	34	42	50	59	67	76	84	92	101	110	117	126

Note: These speeds are based on 2/3 speeds rated for drilling.

Letter Sizes

Drill Size		Feet per Minute														
Letter	Decimal	10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
		Revolutions per Minute														
A	.2340	108	215	324	432	540	648	756	864	972	1080	1185	1293	1401	1508	1616
B	.2380	106	212	318	424	530	636	742	847	954	1059	1165	1271	1377	1483	1589
C	.2420	104	209	312	416	521	625	729	833	937	1041	1146	1250	1354	1459	1563
D	.2460	102	205	308	411	513	616	719	822	924	1027	1127	1230	1332	1435	1537
E	.2500	101	202	302	403	504	605	706	807	908	1008	1109	1210	1299	1412	1513
F	.2570	98	196	294	392	490	589	686	785	882	981	1079	1177	1275	1373	1471
G	.2610	96	193	290	386	483	579	676	772	869	966	1063	1159	1256	1352	1449
H	.2660	95	189	284	379	474	569	663	758	853	948	1043	1137	1232	1327	1422
I	.2720	92	185	278	371	463	556	649	741	834	927	1020	1112	1205	1298	1390
J	.2770	91	182	273	364	455	546	637	728	819	910	1001	1092	1183	1274	1365
K	.2810	90	180	269	359	449	538	628	717	807	897	987	1076	1166	1256	1346
L	.2900	87	174	261	348	435	521	609	696	782	869	956	1043	1130	1217	1304
M	.2950	85	171	257	342	428	513	599	684	770	855	940	1026	1111	1197	1282
N	.3020	83	167	251	334	418	501	585	668	752	835	918	1002	1085	1169	1252
O	.3160	80	160	240	319	399	479	558	638	718	798	878	957	1037	1117	1197
P	.3230	78	156	234	312	391	469	546	624	703	781	859	937	1014	1094	1171
Q	.3320	76	152	228	304	380	455	531	607	683	759	836	913	987	1063	1139
R	.3390	75	149	223	298	372	446	521	595	669	744	818	894	967	1041	1115
S	.3480	73	145	217	290	362	435	508	579	652	725	797	869	942	1014	1086
T	.3580	71	141	211	281	352	422	492	563	633	704	774	845	915	986	1056
U	.3680	69	137	205	274	343	411	480	548	616	685	754	822	890	959	1028
V	.3770	67	134	201	267	335	401	468	535	602	669	735	805	869	936	1003
W	.3860	65	131	196	261	327	392	457	523	588	653	718	784	849	914	979
X	.3970	63	127	191	254	317	380	444	508	571	635	698	762	826	889	952
Y	.4040	63	125	187	249	312	374	437	499	562	624	686	749	811	874	936
Z	.4130	61	122	183	244	305	366	427	488	549	611	671	733	793	855	915

Reamer Speeds and Feeds in Ferrous Materials

Ferrous Materials

FEED (IPR) for MILL DIAMETER

Material		Speed (SFM)	≤ 1/16	> 1/16 - 1/8	> 1/8 - 1/4	> 1/4 - 1/2	> 1/2 - 1	> 1
Steel	under 200 BHN	55 - 80	.0005 - .003	.002 - .006	.004 - .010	.006 - .015	.010 - .030	.020 - .050
	200 - 300 BHN	30 - 55	.005 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020	.020 - .040
	300 - 400 BHN	20 - 30	.0002 - .001	.001 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020
	400 - 500 BHN	10 - 20	.0002 - .001	.001 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020
	500 BHN +	-	.0002 - .001	.001 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020
Cast Iron	Soft (Ferritic)	50 - 100	.001 - .003	.003 - .006	.006 - .010	.010 - .015	.015 - .030	.030 - .050
	Medium (Pearlitic)	25 - 50	.0002 - .002	.001 - .004	.002 - .006	.004 - .010	.006 - .020	.010 - .040
	Hard (Martensitic or Acicular)	15 - 25	.0002 - .001	.001 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020
Stainless Steel	Free machining and 400 Ann	40 - 60	.0005 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020	.020 - .040
	300 Series	20 - 30	.0005 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020	.020 - .040
	PH and HT 400 Series	15 - 25	.0002 - .002	.001 - .004	.002 - .006	.004 - .010	.006 - .020	.010 - .040
High-Temp Alloys	Nickel-base	10 - 20	.0002 - .001	.001 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020
	Cobalt-base	10 - 15	.0002 - .001	.001 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020
Titanium	Pure	35 - 50	.0005 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020	.020 - .040
	Alloys	10 - 20	.0002 - .002	.001 - .004	.002 - .006	.004 - .010	.006 - .020	.010 - .040

Reamer Speeds and Feeds in Non-Ferrous Materials

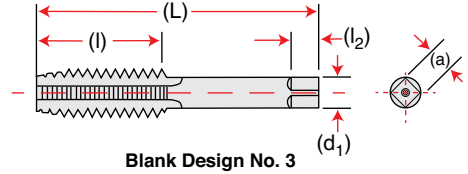
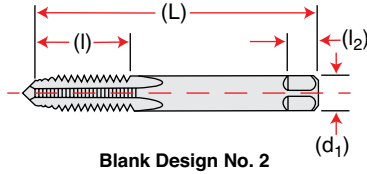
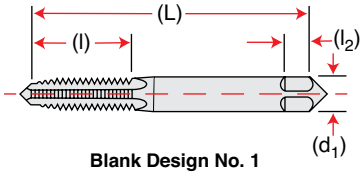
Non-Ferrous Materials

FEED (IPR) for MILL DIAMETER

Material		Speed (SFM)	≤ 1/16	> 1/16 - 1/8	> 1/8 - 1/4	> 1/4 - 1/2	> 1/2 - 1	> 1
Aluminum		150 - 300	.0005 - .003	.002 - .006	.004 - .010	.006 - .015	.010 - .030	.020 - .050
Brass and Bronze	Free Machining Tough	125 - 200	.0005 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020	.020 - .040
		75 - 125	.0005 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020	.020 - .040
Copper and Hard Bronze		50 - 75	.0002 - .001	.001 - .002	.002 - .004	.004 - .006	.006 - .010	.010 - .020
Magnesium		200 - 400	.0005 - .003	.002 - .006	.004 - .010	.006 - .015	.010 - .030	.020 - .050

Speed and Feed Data for Regular HSS and Cobalt HSS End Mills in Selected Materials

Material	Heat-resistant cobalt base alloys, High tensile steels (50-55C)		Heat-resistant austenitic alloys, High tensile steels (46-50C)		Heat-resistant nickel base alloys, High strength stainless steels, High strength titanium alloys		High strength stainless steels, High tensile steels (46-46C) Medium strength titanium alloys		Heat-resistant ferritic base alloys, Medium strength Stainless steels, Unalloyed titanium tool steels (30-40C)	
	Cobalt HSS HSS 2 or more flute		Cobalt HSS HSS 2 or more flute		Cobalt HSS HSS 2 or more flute		Cobalt HSS HSS 2 or more flute		HSS 2 or more flute	
Speed (all dia.) Mill Diameter	5-10 SFM		10-15 SFM		15-20 SFM		20-40 SFM		40-60 SFM	
	Speed (RPM)	Feed (Chip Load per Tooth)	Speed (RPM)	Feed (Chip Load per Tooth)	Speed (RPM)	Feed (Chip Load per Tooth)	Speed (RPM)	Feed (Chip Load per Tooth)	Speed (RPM)	Feed (Chip Load per Tooth)
1/16	*	*	*	*	*	*	1222 - 2444	.0002 - .0005	2444 - 3667	.0002 - .0005
3/32	*	*	*	*	611 - 815	.0002 - .0005	815 - 1629	.0002 - .0005	1629 - 2750	.0002 - .0005
1/8	*	*	*	*	456 - 611	.0002 - .0005	611 - 1222	.0002 - .0005	1222 - 1833	.0002 - .0005
3/16	*	*	204 - 306	.0002 - .0005	306 - 407	.0002 - .0005	407 - 815	.0002 - .0005	815 - 1222	.0002 - .0005
1/4	76 - 153	.0002 - .0010	153 - 230	.0002 - .0010	229 - 306	.0002 - .0010	306 - 611	.0002 - .0010	611 - 917	.0002 - .0010
5/16	61 - 122	.0002 - .0010	122 - 183	.0002 - .0010	183 - 244	.0002 - .0010	244 - 489	.0002 - .0010	489 - 733	.0002 - .0010
3/8	51 - 102	.0002 - .0010	102 - 153	.0002 - .0010	153 - 203	.0002 - .0010	203 - 407	.0005 - .0020	407 - 611	.0005 - .0020
7/16	44 - 88	.0005 - .0010	88 - 132	.0005 - .0010	131 - 175	.0005 - .0020	175 - 349	.0005 - .0020	349 - 524	.0005 - .0020
1/2	38 - 76	.0005 - .0010	76 - 115	.0005 - .0010	115 - 153	.0005 - .0020	153 - 306	.0005 - .0030	306 - 458	.0010 - .0030
9/16	34 - 68	.0005 - .0020	68 - 104	.0005 - .0020	104 - 136	.0005 - .0020	136 - 272	.0005 - .0030	272 - 412	.0010 - .0030
3/8	31 - 61	.0005 - .0020	61 - 92	.0005 - .0020	92 - 122	.0005 - .0020	122 - 244	.0010 - .0040	244 - 367	.0010 - .0040
11/16	28 - 56	.0005 - .0020	56 - 84	.0005 - .0020	84 - 111	.0005 - .0020	111 - 222	.0010 - .0040	222 - 337	.0010 - .0040
3/4	26 - 51	.0005 - .0020	51 - 76	.0005 - .0020	76 - 102	.0010 - .0040	102 - 203	.0010 - .0040	203 - 306	.0010 - .0040
13/16	24 - 47	.0010 - .0030	47 - 71	.0010 - .0030	71 - 94	.0010 - .0040	94 - 189	.0010 - .0040	189 - 284	.0010 - .0040
7/8	22 - 44	.0010 - .0030	44 - 65	.0010 - .0030	65 - 87	.0010 - .0040	87 - 175	.0010 - .0040	175 - 262	.0020 - .0060
15/16	20 - 40	.0010 - .0030	40 - 62	.0010 - .0030	62 - 81	.0010 - .0040	81 - 163	.0010 - .0040	163 - 246	.0020 - .0060
1	19 - 38	.0010 - .0030	38 - 58	.0010 - .0030	58 - 76	.0010 - .0040	76 - 153	.0020 - .0060	153 - 229	.0020 - .0060
1-1/8	34	.0015 - .0040	34 - 51	.0015 - .0040	51 - 68	.0015 - .0050	68 - 136	.0020 - .0060	136 - 204	.0020 - .0060
1-1/4	31	.0015 - .0040	31 - 46	.0015 - .0040	46 - 61	.0015 - .0050	61 - 122	.0020 - .0060	122 - 183	.0020 - .0060
1-3/8	28	.0015 - .0040	28 - 42	.0015 - .0040	42 - 55	.0015 - .0050	55 - 111	.0020 - .0060	111 - 167	.0030 +
1-1/2	26	.0015 - .0040	26 - 38	.0015 - .0040	38 - 51	.0020 +	51 - 102	.0030 +	102 - 153	.0030 +
1-5/8	24	.0020 +	35	.0020 +	35 - 47	.0020 +	47 - 94	.0030 +	94 - 141	.0030 +
1-3/4	22	.0020 +	32	.0020 +	32 - 43	.0020 +	43 - 87	.0030 +	87 - 131	.0030 +
1-7/8	20	.0020 +	30	.0020 +	30 - 40	.0030 +	40 - 81	.0030 +	81 - 122	.0030 +
2	19	.0020 +	29	.0030 +	29 - 38	.0030 +	38 - 76	.0030 +	76 - 115	.0030 +
2-1/8	18	.0030 +	28	.0030 +	36	.0030 +	36 - 72	.0030 +	72 - 108	.0030 +
2-1/4	17	.0030 +	26	.0030 +	34	.0030 +	34 - 68	.0030 +	68 - 102	.0030 +
2-3/8	16	.0030 +	25	.0030 +	32	.0030 +	32 - 64	.0030 +	64 - 97	.0030 +
2-1/2	15	.0030 +	23	.0030 +	30	.0030 +	30 - 61	.0030 +	61 - 92	.0030 +
2-5/8	15	.0030 +	22	.0030 +	29	.0030 +	29 - 58	.0030 +	58 - 88	.0030 +
2-3/4	14	.0030 +	21	.0030 +	28	.0030 +	28 - 56	.0030 +	56 - 83	.0030 +
2-7/8	14	.0030 +	20	.0030 +	27	.0030 +	27 - 53	.0030 +	53 - 80	.0030 +
3	13	.0030 +	19	.0030 +	26	.0030 +	26 - 51	.0030 +	51 - 76	.0030 +



Nominal Diameter Range Inches Over to (inc.)	Machine Screw Size Number Inches	Nominal Fractional Diameter Inches	Nominal Metric Diameter Millimeters, Inches	Blank Design No.	Overall Length L	Thread Length l	Square Length l ₂	Shank Diameter d ₁	Square Size a
.052 .065	0 (.0600)		M1.6 (.0630)	1	1.63	.31	.19	.1410	.110
.065 .078	1 (.0730)		M1.8 (.0709)	1	1.69	.38	.19	.1410	.110
.078 .091	2 (.0860)		M2 (.0787), M2.2 (.0866)	1	1.75	.44	.19	.1410	.110
.091 .104	3 (.0990)		M2.5 (.0984)	1	1.81	.50	.19	.1410	.110
.104 .117	4 (.1120)			1	1.88	.56	.19	.1410	.110
.117 .130	5 (.1250)		M3 (.1181)	1	1.94	.63	.19	.1410	.110
.130 .145	6 (.1380)		M3.5 (.1378)	1	2.00	.69	.19	.1410	.110
.145 .171	8 (.1640)		M4 (.1575)	1	2.13	.75	.25	.1680	.131
.171 .197	10 (.1900)		M4.5 (.1772), M5 (.1969)	1	2.38	.88	.25	.1940	.152
.197 .223	12 (.2160)			1	2.38	.94	.28	.2200	.165
.223 .260		1/4 (.2500)	M6 (.2362)	2	2.50	1.00	.31	.2550	.191
.260 .323		5/16 (.3125)	M7 (.2756), M8 (.3150)	2	2.72	1.13	.38	.3180	.238
.323 .395		3/8 (.3750)	M10 (.3937)	2	2.94	1.25	.44	.3810	.286
.395 .448		7/16 (.4375)		3	3.16	1.44	.41	.3230	.242
.448 .510		1/2 (.5000)	M12 (.4724)	3	3.38	1.66	.44	.3670	.275
.510 .573		9/16 (.5625)	M14 (.5512)	3	3.59	1.66	.50	.4290	.322
.573 .635		5/8 (.6250)	M16 (.6299)	3	3.81	1.81	.56	.4800	.360
.635 .709		11/16 (.6875)	M18 (.7087)	3	4.03	1.81	.63	.5420	.406
.709 .760		3/4 (.7500)		3	4.25	2.00	.69	.5900	.442
.760 .823		13/16 (.8125)	M20 (.7874)	3	4.47	2.00	.69	.6520	.489
.823 .885		7/8 (.8750)	M22 (.8661)	3	4.69	2.22	.75	.6970	.523
.885 .948		15/16 (.9375)	M24 (.9449)	3	4.91	2.22	.75	.7600	.570
.948 1.010		1 (1.0000)	M25 (.9843)	3	5.13	2.50	.81	.8000	.600
1.010 1.073		1-1/16 (1.0625)	M27 (1.0630)	3	5.13	2.50	.88	.8960	.672
1.073 1.135		1-1/8 (1.1250)		3	5.44	2.56	.88	.8960	.672
1.135 1.198		1-3/16 (1.1875)	M30 (1.1811)	3	5.44	2.56	1.00	1.0210	.766
1.198 1.260		1-1/4 (1.2500)		3	5.75	2.56	1.00	1.0210	.766
1.260 1.323		1-5/16 (1.3125)	M33 (1.2992)	3	5.75	2.56	1.06	1.1080	.831
1.323 1.385		1-3/8 (1.3750)		3	6.06	3.00	1.06	1.1080	.830
1.358 1.448		1-7/16 (1.4375)	M36 (1.4173)	3	6.06	3.00	1.13	1.2230	.925
1.448 1.510		1-1/2 (1.5000)		3	6.38	3.00	1.13	1.2230	.925
1.510 1.635		1-5/8 (1.6250)	M39 (1.5354)	3	6.69	3.19	1.13	1.3050	.979
1.635 1.760		1-3/4 (1.7500)	M42 (1.6535)	3	7.00	3.19	1.25	1.4300	1.072
1.760 1.885		1-7/8 (1.8750)		3	7.31	3.56	1.25	1.5190	1.139
1.885 2.010		2 (2.0000)	M48 (1.8898)	3	7.63	3.56	1.38	1.6440	1.233
2.010 2.135		2-1/8 (2.1250)		3	8.00	3.56	1.38	1.7690	1.327
2.135 2.260		2-1/4 (2.2500)	M56 (2.2047)	3	8.25	3.56	1.44	1.8940	1.420
2.260 2.385		2-3/8 (2.3750)		3	8.50	4.00	1.44	2.0190	1.514
2.385 2.510		2-1/2 (2.5000)		3	8.75	4.00	1.50	2.1000	1.575
2.510 2.635		2-5/8 (2.6250)	M64 (2.5197)	3	8.75	4.00	1.50	2.2250	1.669
2.635 2.760		2-3/4 (2.7500)		3	9.25	4.00	1.56	2.3500	1.762
2.760 2.885		2-7/8 (2.8750)	M72 (2.8346)	3	9.25	4.00	1.56	2.4750	1.856
2.885 3.010		3 (3.0000)		3	9.75	4.56	1.63	2.5430	1.907
3.010 3.135		3-1/8 (3.1250)		3	9.75	4.56	1.63	2.6680	2.001
3.135 3.260		3-1/4 (3.2500)	M80 (3.1496)	3	10.00	4.56	1.75	2.7930	2.095
3.260 3.385		3-3/8 (3.3750)		3	10.00	4.56	1.75	2.8830	2.162
3.385 3.510		3-1/2 (3.5000)		3	10.25	4.94	2.00	3.0080	2.256
3.510 3.635		3-5/8 (3.6250)	M90 (3.5433)	3	10.25	4.94	2.00	3.1330	2.350
3.635 3.760		3-3/4 (3.7500)		3	10.50	5.31	2.13	3.2170	2.413
3.760 3.885		3-7/8 (3.8750)		3	10.50	5.31	2.13	3.3420	2.506
3.885 4.010		4 (4.0000)	M100 (3.9370)	3	10.75	5.31	2.25	3.4670	2.600

FRACTIONAL • WIRE • LETTER • METRIC

TAP DRILL SIZES

Tap Size	Tap Drill Size	m/m	Decimal Equiv. of Tap Drill	Probable % of Thread
0-80	56		.0465	74
	3/64	1.20	.0469	72
1-64	54	1.40	.0550	81
	53	1.50	.0595	59
1-72	53	1.50	.0595	67
	1/16		.0625	50
2-56	51		.0670	75
	50	1.75	.0700	62
2-64	50	1.80	.0700	71
	49		.0730	56
3-48	48	2.00	.0760	79
	5/64		.0781	71
3-56	46	2.10	.0810	71
	45		.0820	66
4-40	44		.0860	75
	43	2.25	.0890	66
	42		.0935	51
	3/32		.0938	50
4-48	42	2.35	.0935	62
	3/32		.0938	60
5-40	39		.0995	73
	38	2.60	.1015	67
5-44	38		.1015	74
	37	2.60	.1040	65
6-32	36	2.70	.1065	73
	7/64		.1095	66
6-40	33	2.90	.1130	72
	32		.1160	62
8-32	29	3.40	.1360	64
8-36	29	3.50	.1360	72
	9/64		.1406	60
10-24	25	3.80	.1495	71
10-32	5/32		.1563	78
	21	4.00	.1590	72
12-24	11/64		.1719	78
	17	4.50	.1730	76
12-28	16		.1770	80
	15	4.60	.1800	73
1/4-20	9		.1960	80
	7	5.10	.2010	72
	13/64		.2031	69
1/4-28	3		.2130	75
	7/32	5.50	.2188	59
5/16-18	F	6.50	.2570	74
	G		.2610	68
5/16-24	H		.2660	78
	I	6.90	.2720	70
3/8-16	5/16	8.00	.3125	74
	O		.3160	69

Tap Size	Tap Drill Size	m/m	Decimal Equiv. of Tap Drill	Probable % of Thread
3/8-24	Q	8.50	.3320	75
	R		.3390	58
7/16-14	23/64	9.30	.3594	81
	U		.3680	70
7/16-20	W		.3860	75
	25/64	9.90	.3906	68
1/2-13	27/64	10.75	.4219	75
	7/16		.4375	58
1/2-20	29/64	11.50	.4531	67
9/16-12	15/32		.4688	84
	31/64	12.00	.4844	69
9/16-18	1/2		.5000	82
	33/64	13.00	.5156	60
5/8-11	17/32	13.50	.5313	76
	35/64		.5469	63
5/8-18	9/16		.5625	82
	37/64	14.50	.5781	60
3/4-10	41/64		.6406	81
	21/32	16.50	.6563	69
3/4-16	11/16	17.50	.6875	72
7/8-9	49/64	18.50	.7656	73
	25/32		.7813	62
7/8-14	51/64		.7969	79
	13/16	20.50	.8125	62
1-8	7/8	22.50	.8750	74
	57/64		.8906	64
1-12	29/32		.9063	82
	59/64	23.50	.9219	68
1-14	59/64		.9219	79
	15/16	23.50	.9375	62
1-1/8-7	63/64	25.00	.9844	73
	1		1.0000	65
1-1/8-12	1-1/32		1.0313	82
	1-3/64	26.50	1.0469	67
1-1/4-7	1-3/32		1.0938	81
	1-7/64	28.00	1.1094	73
	1-1/8		1.1250	64
1-1/4-12	1-5/32		1.1563	81
	1-11/64	29.50	1.1719	67
1-3/8-6	1-13/64		1.2031	77
	1-7/32	31.00	1.2188	69
	1-15/64		1.2344	62
1-3/8-12	1-9/32		1.2813	81
	1-19/64	33.00	1.2969	66
1-1/2-6	1-11/32	34.00	1.3438	69
	1-23/64		1.3594	62
1-1/2-12	1-13/32		1.4063	80
	1-27/64	36.00	1.4219	66

PIPE TAP DRILL SIZES

Tap Size	NPT Tap Drill		NPS Tap Drill	
	Inches	m/m	Inches	m/m
1/16 - 27	D	6.25	1/4	6.35
1/8 - 27	Q	8.50	11/32	8.75
1/4 - 18	7/16	11.00	7/16	11.50
3/8 - 18	9/16	14.50	37/64	15.00
1/2 - 14	45/64	18.00	23/32	18.50
3/4 - 14	29/32	23.00	59/64	23.50
1 - 11 1/2	1 9/64	29.00	1 5/32	29.50
1 1/4 - 11 1/2	1 31/64	38.00	1 1/2	38.50
1 1/2 - 11 1/2	1 47/64	44.00	1 3/4	44.50
2 - 11 1/2	2 13/64	56.00	2 1/32	57.00
2 1/2 - 8	2 5/8	66.68	2 21/32	67.47

METRIC TAP, DRILL SIZES

Tap Size	Tap Drill Size	Tap Size	Tap Drill Size
1.50 x .35	1.10	12.00 x 1.25	11.00
2.00 x .40	1.60	12.00 x 1.50	10.50
2.00 x .45	1.50	12.00 x 1.75	10.50
2.00 x .50	1.50	13.00 x 1.50	11.50
2.30 x .40	1.90	13.00 x 1.75	11.50
2.50 x .45	2.00	13.00 x 2.00	11.00
2.60 x .45	2.10	14.00 x 1.25	13.00
3.00 x .50	2.50	14.00 x 1.75	12.50
3.00 x .60	2.40	14.00 x 2.00	12.00
3.00 x .75	2.25	15.00 x 1.75	13.50
3.50 x .60	2.90	15.00 x 2.00	13.00
4.00 x .70	3.30	16.00 x 2.00	14.00
4.00 x .75	3.25	17.00 x 2.00	15.00
4.50 x .75	3.75	18.00 x 1.50	16.50
5.00 x .75	4.25	18.00 x 2.00	16.00
5.00 x .80	4.20	18.00 x 2.50	15.50
5.00 x .90	4.10	19.00 x 2.50	16.50
5.00 x 1.00	4.00	20.00 x 2.00	18.00
5.50 x .75	4.75	20.00 x 2.50	17.50
5.50 x .90	4.60	22.00 x 2.50	19.50
6.00 x 1.00	5.00	24.00 x 3.00	21.00
6.00 x 1.25	4.80	26.00 x 3.00	23.00
7.00 x 1.00	6.00	27.00 x 3.00	24.00
7.00 x 1.25	5.80	28.00 x 3.00	25.00
8.00 x 1.00	7.00	30.00 x 3.50	26.50
8.00 x 1.25	6.80	32.00 x 3.50	28.50
9.00 x 1.00	8.00	33.00 x 3.50	29.50
9.00 x 1.25	7.80	34.00 x 3.50	30.50
10.00 x 1.25	8.80	36.00 x 4.00	32.00
10.00 x 1.50	8.60	38.00 x 4.00	34.00
11.00 x 1.50	9.60		

Recommended tap drill sizes for approximately 75% depth of thread.

Inch Sizes (all measurements in inches)

Tap Size and Pitch	Cutting Taps		Forming Taps	
	Drill Size	Decimal Equiv.	Drill Size	Decimal Equiv.
0-80	3/64	.0469	54	.0550
1-64	53	.0595	51	.0670
1-72	53	.0595	51	.0670
2-56	50	.0700	5/64	.0781
2-64	50	.0700	47	.0785
3-48	47	.0785	43	.0890
3-56	46	.0810	2.30	.0905
4-40	43	.0890	38	.1015
4-48	42	.0935	2.60	.1024
5-40	38	.1015	33	.1130
5-44	37	.1040	2.90	.1142
6-32	36	.1065	1/8	.1250
6-40	33	.1130	3.25	.1280
8-32	29	.1360	25	.1495
8-36	29	.1360	24	.1520
10-24	26	.1470	11/64	.1719
10-32	21	.1590	16	.1770
12-24	16	.1770	8	.1990
12-28	15	.1800	7	.2010
1/4-20	7	.2010	1	.2280
1/4-28	3	.2130	15/64	.2340
5/16-18	F	.2570	L	.2900
5/16-24	I	.2720	M	.2950
3/8-16	5/16	.3125	S	.3480
3/8-24	Q	.3320	T	.3580
7/16-14	U	.3680	Y	.4040
7/16-20	25/64	.3906	Z	.4130
1/2-13	27/64	.4219	15/32	.4682
1/2-20	29/64	.4531	12.25	.4823
9/16-12	31/64	.4844	17/32	.5312
9/16-18	33/64	.5156	13.50	.5315
5/8-11	17/32	.5312	14.75	.5807
5/8-18	37/64	.5781	15.25	.6004
3/4-10	21/32	.6562	45/64	.7031
3/4-16	11/16	.6875	23/32	.7188
7/8-9	49/64	.7656	*	*
7/8-14	13/16	.8125	*	*
1-8	7/8	.8750	*	*
1-12	59/64	.9219	*	*
1-1/8 - 7	63/64	.9844	*	*
1-1/8 - 12	1-3/64	1.0469	*	*
1-1/4 - 7	1-7/64	1.1094	*	*
1-1/4 - 12	1-11/64	1.1719	*	*
1-3/8 - 6	1-7/32	1.2188	*	*
1-3/8 - 12	1-19/64	1.2969	*	*
1-1/2 - 6	1-11/32	1.3438	*	*
1-1/2 - 12	1-27/64	1.4219	*	*

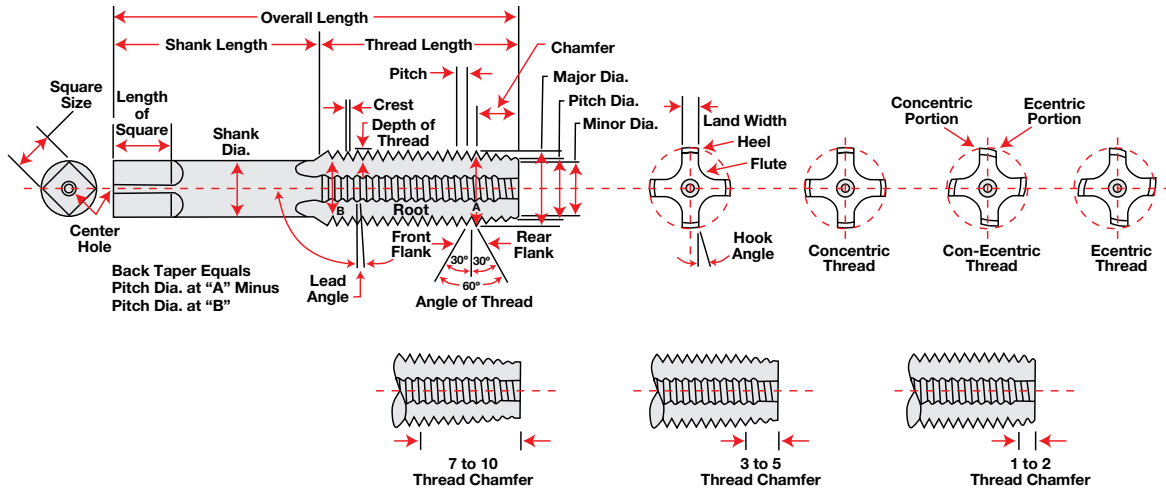
*Contact Technical Service for recommendations.
Hole sizes shown may not suit UNJ and MJ hole requirements.

Metric Sizes

Tap Size and Pitch mm	Cutting Taps		Forming Taps	
	Drill Size mm	Decimal Equiv. in.	Drill Size mm / in.	Decimal Equiv. in.
M1.6 x 0.35	1.25	.0492	1.45	.0571
M1.8 x 0.35	1.45	.0571	1.65	.0650
M2 x 0.40	1.60	.0630	1.80	.0709
M2.2 x 0.45	1.75	.0689	2.00	.0787
M2.5 x 0.45	2.05	.0807	2.30	.0906
M3 x 0.50	2.50	.0984	7/64	.1094
M3.5 x 0.60	2.90	.1142	3.20	.1260
M4 x 0.70	3.30	.1299	3.70	.1476
M4.5 x 0.75	3.70	.1476	4.10	.1614
M5 x 0.80	4.20	.1654	14	.1820
M6 x 1.00	5.00	.1969	7/32	.2188
M7 x 1.00	6.00	.2362	F	.2570
M8 x 1.25	6.70	.2638	7.40	.2913
M8 x 1.00	7.00	.2756	19/64	.2969
M10 x 1.50	8.50	.3346	U	.3680
M10 x 1.25	8.70	.3425	9.40	.3701
M12 x 1.75	10.20	.4016	11.20	.4409
M12 x 1.25	10.80	.4252	11.50	.4528
M14 x 2.00	12.00	.4724	33/64	.5156
M16 x 2.00	14.00	.5512	19/32	.5938
M16 x 1.50	14.50	.5709	15.25	.6004
M18 x 2.50	15.50	.6102	39/64	.6094
M18 x 1.50	16.50	.6496	17.25	.6791
M20 x 2.50	17.50	.6890	*	*
M20 x 1.50	18.50	.7283	*	*
M22 x 2.50	19.50	.7677	*	*
M22 x 1.50	20.50	.8071	*	*
M24 x 3.00	21.00	.8268	*	*
M24 x 2.00	22.00	.8661	*	*
M27 x 3.00	24.00	.9449	*	*
M27 x 2.00	25.00	.9843	*	*
M30 x 3.50	26.50	1.0433	*	*
M30 x 2.00	28.00	1.1024	*	*
M33 x 3.50	29.50	1.1614	*	*
M33 x 2.00	31.00	1.2205	*	*
M36 x 4.00	32.00	1.2598	*	*
M36 x 3.00	33.00	1.2992	*	*
M39 x 4.00	35.00	1.3780	*	*
M39 x 3.00	36.00	1.4173	*	*

Pipe Tap Sizes (measurements in millimeters & inches)

Nominal Pipe Tap Size	NPT & NPTF		NPSM	NPSC	NPSF
	Without Reamer	With Reamer			
1/16-27	C .242	A .234	—	.250	D .246
1/8-27	Q .332	21/64	T .358	Q .332	R .339
1/4-18	7/16	27/64	15/32	7/16	7/16
3/8-18	9/16	9/16	.603 (special)	37/64	37/64
1/2-14	45/64	11/16	19 mm	18 mm	18 mm
3/4-14	29/32	57/64	61/64	59/64	59/64
1 - 11-1/2	1-9/64	1-1/8	1-13/64	1-5/32	1-5/32
1-1/4 - 11-1/2	1-31/64	1-15/32	1-35/64	1-1/2	—
1-1/2 - 11-1/2	1-23/32	1-45/64	1-25/32	1-47/64	—
2 - 11-1/2	2-3/16	2-11/64	2-1/4	2-13/64	—



Angle of Thread: The angle included between the flanks of the thread, measured in an axial plane.

Back Taper: A slight axial relief of the tap that makes the pitch diameter of the thread near the shank slightly smaller than the pitch diameter of the thread near the chamfered end.

Basic: The theoretical or nominal standard size from which all variations are made.

Chamfer: The tapering of the threads at the front end of each land. Done by cutting away and relieving the crest of the first few teeth, which distributes the cutting action over several teeth. When the tapering amounts to 7 to 10 threads, the tap is called a "taper" tap; 3 to 5 threads is called a "plug" tap; and 1 to 2 threads is called a "bottoming" tap.

Chamfer Relief: The gradual decrease in height of the lands from cutting edge to heel on the chamfered portion. Provides clearance for the cutting action as the tap advances.

Crest: The top surface joining the two flanks of a thread. The crest of an external thread is at its major diameter, while the crest of an internal thread is at its minor diameter.

Cutting Face: The leading side of the land in the direction of rotation for cutting, on which the chip impinges.

Dryseal: A pipe threaded fuel connection designed for use where the assembled product must withstand high fluid or gas pressures without the use of a sealing compound. Suitable for both external and internal applications.

Flutes: Longitudinal channels formed in a tap to create cutting edges on the thread profile. Provides chip spaces and cutting fluid passages.

Height of Thread: The distance between the crest and the base of a thread, measured normal to the axis.

Helical Flute: A flute with uniform axial lead and constant helix in a helical path around the axis of a cylindrical tap.

Hook Face: A concave cutting face. Usually specified either as chordal hook or tangential hook.

Chordal Hook Angle: The angle between the chord passing through the root and crest of a thread at the cutting face and a radial line through the crest at the cutting edge.

Tangential Hook Angle: The angle between a line tangent to a hook cutting face at the cutting edge and a radial line to the same point.

Interrupted Thread: A tap with an odd number of lands. Every other tooth along the thread helix is removed.

Lead: The distance a screw thread advances axially in one complete turn. On a single lead screw or tap, the lead and pitch are identical. On a double lead screw or tap, the lead is twice the pitch, and so on for higher lead screws or taps.

Pitch: The distance from any point on a screw or tap thread to a corresponding point on the next thread, measured parallel to the axis. The pitch equals on divided by the number of threads per inch.

Pitch Diameter: On straight threads, the pitch diameter is the diameter of an imaginary coaxial cylinder. The surface of this cylinder would pass through the thread profile at points which would make the width of threads and the width of the spaces cut by the surface of the cylinder equal. On taper threads, the pitch diameter is the diameter at a given distance from a reference plane perpendicular to the axis of an imaginary coaxial cone. The surface of this cone would pass through the thread profile at points which would make the width of the threads and the width of the spaces cut by the surface of the cone equal.

Rake: Deviation of a straight cutting face of the tooth from a radial line. Positive rake means the crest of the cutting face is angularly advanced ahead of the balance of the face of the tooth. Negative rake means the crest of the cutting face is angularly behind the balance of the face of the tooth. Zero rake means the cutting face is directly on the center line.

Root: The bottom surface joining the flanks of two adjacent threads. The root of an external thread is at its minor diameter. The root of an internal thread is at its major diameter.

Spiral Point: A supplemental angular fluting cut in the cutting face of the land at the chamfer end. Slightly longer than the chamfer on the tap and the opposite hand to that of rotation. Also known as a "chip driver."

Threads Per Inch: The number of threads in one inch of length.

Thread relief: The clearance produced by removing metal from behind the cutting edge. When the thread angle is relieved from the heel to the cutting edge, it is called an "eccentric" relief. When the thread angle is relieved from the heel to a portion of the land width only, it is called a "con-eccentric" relief.

MATERIAL TO BE TAPPED	LUBRICANT / COOLANT	SPEED - (SFM)
Aluminum (wrought)	Soluble, light base or lard oil	90 - 150
Aluminum die casting	Soluble or lard oil	65 - 75
Aluminum bronze	Mineral oil with lard or light oil	20 - 60
Bakelite (hard plastic)	Dry or air jet	25 - 40
Beryllium copper	Soluble light base oil	50 - 90
Brass	Soluble light base oil	100 - 200
Bronze (free-machine)	Soluble light base oil	80 - 150
Cast brass	Soluble light base oil	100 - 200
Cast iron (gray)	Dry or soluble oil	20 - 80
Copper	Soluble light base oil	80 - 150
Copper - nickel	Soluble light base oil	10 - 20
Delrin	Dry, air jet or water soluble	65 - 100
Ductile iron	Soluble or sulphur based oils	30 - 50
Duralumin	Soluble or lard oil	50 - 90
Ferro-Tic	Anti-seize compound	8 - 20
Fiberglass	Dry or air jet	25 - 40
Hastelloy	Sulphur based oils	8 - 20
Inconel	Sulphur based oils	8 - 20
Magnesium	Soluble light base oil	100 - 150
Malleable iron	Soluble or sulphur based oils	30 - 50
Manganese	Sulphur based oils	8 - 20
Manganese bronze	Soluble light base oil	20 - 60
Molybdenum	Sulphur based oils	20 - 45
Monel	Sulphur based oils	8 - 20
Naval brass	Soluble light base oil	100 - 200
Naval bronze	Soluble light base oil	80 - 150
Nickel silver	Sulphur based oils	20 - 60
Nickel (pure)	Soluble light base oil	5 - 25
Nitralloy	Sulphur based oils	8 - 20
Nitronic (*no guarantee)	Sulphur based oils	8 - 20
Nylon	Dry, air jet or water soluble	65 - 100
Plastics:		
Thermoplastic (soft) ABS, Delrin, nylon, PVC, etc.	Dry, air jet or water soluble	65 - 100
Thermosetting (hard) Bakelite, laminates, Phenolic, polyesters, etc.	Dry or air jet	25 - 40
Powdered metal (sintered)	Soluble light base oil	25 - 80
Rubber, hard	Dry	50 - 200
Silicon bronze	Soluble light base oil	20 - 60
Steel:		
Carbon steel	Sulphur based oil	40 - 90
Cold-rolled steel (1018, etc.)	Sulphur based oil	40 - 90
Forged	Sulphur based oil	20 - 50
Leaded (12L14, etc.)	Sulphur based oil	40 - 90
Stainless		
Free machining	Sulphur based oil	20 - 40
Precip. Hardening	Sulphur based oil	8 - 20
Tool	Sulphur based oil	20 - 50
Titanium	Sulphur based oil	20 - 50
Tungsten	Sulphur based oil	8 - 20
Turcite (soft plastic)	Dry, air jet or water soluble	65 - 100
Zamak (zinc die cast)	Soluble light base oil	50 - 200
Zinc	Soluble light base oil	50 - 200

- Speeds shown are suggested starting points only. Speeds may be increased or decreased depending on the actual material and machining conditions. Begin at lowest possible speed and increase until the machining cycle is optimized.
- Tap speeds may be increased for coated taps, spiral point taps, fine pitch taps and when the percentage of thread is decreased.
- It may be necessary to decrease tap speeds for uncoated taps, spiral flute taps, coarse pitch taps, bottoming taps, difficult materials, longer thread inserts and when the percentage of thread is increased.
- Generally, thread forming taps form threads more efficiently at higher speeds. Suggested speeds are up to 50% to 100% higher than the suggested speeds for cutting taps in similar applications.
- Pipe tap speeds should be between ½ and ¾ of the speeds of taps of comparable diameter and pitch.

UNC/UNF and NPT/NPTF Sizes

UNC UNF Tap Size	NPT NPTF Taper Pipe	Surface Feet per Minute (SFM)																	
		5'	10'	15'	20'	25'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
0		318	637	955	1273	1592	1910	2546	3183	3820	4456	5093	5729	6366	7003	7639	8276	8913	9549
1		273	546	819	1046	1308	1570	2093	2617	3140	3663	4186	4710	5233	5756	6279	6805	7326	1849
2		212	424	637	888	1110	1333	1777	2221	2665	3109	3554	3999	4442	4886	5330	5774	6218	6662
3		191	382	573	772	964	1157	1543	1929	2315	2701	3086	3472	3858	4244	4629	5015	5401	5787
4		174	347	521	682	853	1023	1364	1705	2046	2387	2728	3069	3411	3751	4092	4434	4775	5115
5		147	294	441	611	764	917	1222	1528	1833	2139	2445	2750	3056	3361	3667	3973	4278	4584
6		136	273	409	553	691	829	1106	1382	1859	1935	2212	2488	2766	3042	3318	3595	3871	4148
8		119	239	358	466	583	699	932	1165	1398	1631	1864	2097	2330	2563	2796	3029	3262	3495
10		101	201	302	402	502	603	804	1005	1205	1406	1607	1808	2009	2210	2411	2612	2813	3014
12		87	174	260	354	442	531	707	884	1061	1238	1415	1592	1769	1945	2122	2300	2476	2653
1/4		76	153	229	306	382	458	611	764	917	1070	1222	1375	1528	1681	1833	1986	2139	2292
5/16		62	123	185	245	306	367	489	611	733	856	978	1100	1222	1345	1467	1589	1711	1833
3/8		50	101	151	204	255	305	407	509	611	713	815	917	1019	1120	1222	1324	1426	1528
7/16	1/8	43	87	130	175	219	262	349	437	524	611	698	786	873	960	1048	1135	1222	1310
1/2	—	38	76	115	153	191	229	305	382	458	535	611	688	764	840	917	993	1070	1146
9/16	1/4	34	68	102	137	172	206	274	342	410	478	547	616	683	752	820	888	952	1020
5/8	—	32	64	96	122	153	183	244	306	367	428	489	550	611	672	733	794	856	917
11/16	3/8	28	55	83	111	138	167	222	278	333	389	444	500	556	611	667	722	778	833
3/4	—	25	51	76	102	128	153	203	255	305	357	407	458	509	560	611	662	713	764
7/8	1/2	22	43	65	87	109	131	175	218	262	306	350	392	437	480	524	568	611	655
1	—	19	38	57	76	96	115	153	191	230	268	305	344	382	420	458	497	535	573
1-1/8	3/4	17	34	51	68	84	102	136	170	204	238	272	306	340	373	407	441	475	509
1-1/4	—	15	31	46	61	76	92	122	153	183	214	244	275	305	336	367	397	428	458
1-3/8	1	14	28	42	56	69	83	111	139	167	194	222	250	278	306	333	361	389	417
1-1/2	—	13	25	38	51	63	76	102	127	153	178	204	229	255	280	305	331	356	382
1-5/8		12	23	35	47	59	71	94	118	141	165	188	212	235	259	282	306	329	353
1-3/4		11	22	33	44	55	65	87	109	131	153	175	196	218	240	262	284	306	327
1-7/8		10	20	30	41	51	61	81	102	122	143	163	183	204	224	244	265	285	306
2		9	19	29	38	48	57	76	96	115	134	153	172	191	210	229	248	267	287

Alfa Tools 7845 N Merrimac Ave., Morton Grove, IL 60053 p. 847-470-9595 f. 847-470-9696

Metric Sizes

Tap Size	Surface Feet per Minute (SFM)																	
	5'	10'	15'	20'	25'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
M1	490	979	1469	1959	2449	2938	3918	4897	5877	6856	7836	8815	9795	10774	11754	12733	13713	14692
M2	242	484	725	967	1209	1451	1934	2418	2901	3385	3868	4352	4835	5319	5803	6286	6770	7253
M3	162	324	486	647	809	971	1295	1619	1942	2266	2590	2914	3237	3561	3885	4208	4532	4856
M3.5	138	277	415	554	692	830	1107	1384	1661	1938	2214	2491	2768	3045	3322	3599	3875	4152
M4	122	243	365	487	608	730	973	1217	1460	1703	1946	2190	2433	2676	2920	3163	3406	3650
M5	97	194	291	388	485	582	776	970	1163	1357	1551	1745	1939	2133	2327	2521	2715	2905
M6	81	162	243	324	405	486	647	809	971	1133	1295	1457	1619	1781	1942	2104	2266	2428
M7	69	138	208	277	346	415	554	692	830	969	1107	1246	1384	1522	1661	1799	1938	2076
M8	61	121	182	243	303	364	485	606	728	849	970	1091	1213	1334	1455	1577	1698	1819
M10	48	97	145	194	242	291	388	485	582	679	776	873	970	1067	1163	1260	1357	1454
M12	40	81	121	162	202	243	324	405	486	567	647	728	809	890	971	1052	1133	1214
M14	35	69	104	139	173	208	277	347	416	485	555	624	693	763	832	901	971	1040
M16	30	61	91	121	152	182	243	303	364	424	485	546	606	667	728	788	849	910
M18	27	54	81	108	135	162	216	269	323	377	431	485	539	593	647	700	754	808
M20	24	49	73	97	121	146	194	243	291	340	388	437	485	534	582	631	680	728
M22	22	44	66	88	110	132	176	221	265	309	353	397	441	485	529	573	618	662
M24	20	40	61	81	101	121	162	202	243	283	323	364	404	445	485	526	566	606
M27	18	36	54	72	90	108	144	180	216	252	287	323	359	395	431	467	503	539
M30	16	32	49	65	81	97	129	162	194	226	259	291	323	356	388	420	453	485