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DECIMAL EQUIVALENTS

Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches
97	.0059	64	.0360	39	.0995	4.80mm	.1890	M	.2950
0.15mm	.0059	63	.0370	38	.1015	11	.1910	7.50mm	.2953
96	.0063	0.95mm	.0374	2.60mm	.1024	4.90mm	.1929	19/64	.2969
0.16mm	.0063	62	.0380	37	.1040	10	.1935	7.60mm	.2992
95	.0067	61	.0390	2.70mm	.1063	9	.1960	N	.3020
0.17mm	.0067	1.00mm	.0394	36	.1065	5.00mm	.1969	7.70mm	.3031
94	.0071	60	.0400	2.75mm	.1083	8	.1990	7.75mm	.3051
0.18mm	.0071	59	.0410	7/64	.1094	5.10mm	.2008	7.80mm	.3071
93	.0075	1.05mm	.0413	35	.1100	7	.2010	7.90mm	.3110
0.19mm	.0075	58	.0420	2.80mm	.1102	13/64	.2031	5/16	.3125
92	.0079	57	.0430	34	.1110	6	.2040	8.00mm	.3150
0.20mm	.0079	1.10mm	.0433	33	.1130	5.20mm	.2047	O	.3160
91	.0083	1.15mm	.0453	2.90mm	.1142	5	.2055	8.10mm	.3189
90	.0087	56	.0465	32	.1160	5.25mm	.2067	8.20mm	.3228
0.22mm	.0087	3/64	.0469	3.00mm	.1181	5.30mm	.2087	P	.3230
89	.0091	1.20mm	.0472	31	.1200	4	.2090	8.25mm	.3248
88	.0095	1.25mm	.0492	3.10mm	.1220	5.40mm	.2126	8.30mm	.3268
0.25mm	.0098	1.30mm	.0512	1/8	.1250	3	.2130	21/64	.3281
87	.0100	55	.0520	3.20mm	.1260	5.50mm	.2165	8.40mm	.3307
86	.0105	1.35mm	.0531	3.25mm	.1280	7/32	.2188	Q	.3320
85	.0110	54	.0550	30	.1285	5.60mm	.2205	8.50mm	.3346
0.28mm	.0110	1.40mm	.0551	3.30mm	.1299	2	.2210	8.60mm	.3386
84	.0115	1.45mm	.0571	3.40mm	.1339	5.70mm	.2244	R	.3390
0.30mm	.0118	1.50mm	.0591	29	.1360	5.75mm	.2264	8.70mm	.3425
83	.0120	53	.0595	3.50mm	.1378	1	.2280	11/32	.3438
82	.0125	1.55mm	.0610	28	.1405	5.80mm	.2283	8.75mm	.3445
0.32mm	.0126	1/16	.0625	9/64	.1406	5.90mm	.2323	8.80mm	.3465
81	.0130	1.60mm	.0630	3.60mm	.1417	A	.2340	S	.3480
80	.0135	52	.0635	27	.1440	15/64	.2344	8.90mm	.3504
0.35mm	.0138	1.65mm	.0650	3.70mm	.1457	6.00mm	.2362	9.00mm	.3543
79	.0145	1.70mm	.0669	26	.1470	B	.2380	T	.3580
0.38mm	.0150	51	.0670	3.75mm	.1476	6.10mm	.2402	9.10mm	.3583
1/64	.0156	1.75mm	.0689	25	.1495	C	.2420	23/64	.3594
0.40mm	.0157	50	.0700	3.80mm	.1496	6.20mm	.2441	9.20mm	.3622
78	.0160	1.80mm	.0709	24	.1520	D	.2460	9.25mm	.3642
0.42mm	.0165	1.85mm	.0728	3.90mm	.1535	6.25mm	.2461	9.30mm	.3661
0.45mm	.0177	49	.0730	23	.1540	6.30mm	.2480	U	.3680
77	.0180	1.90mm	.0748	5/32	.1562	E	.2500	9.40mm	.3701
0.48mm	.0189	48	.0760	22	.1570	1/4	.2500	9.50mm	.3740
0.50mm	.0197	1.95mm	.0768	4.00mm	.1575	6.40mm	.2520	3/8	.3750
76	.0200	5/64	.0781	21	.1590	6.50mm	.2559	V	.3770
75	.0210	47	.0785	20	.1610	F	.2570	9.60mm	.3780
0.55mm	.0217	2.00mm	.0787	4.10mm	.1614	6.60mm	.2598	9.70mm	.3819
74	.0225	2.05mm	.0807	4.20mm	.1654	G	.2610	9.75mm	.3839
0.60mm	.0236	46	.0810	19	.1660	6.70mm	.2638	9.80mm	.3858
73	.0240	45	.0820	4.25mm	.1673	17/64	.2656	W	.3860
72	.0250	2.10mm	.0827	4.30mm	.1693	6.75mm	.2657	9.90mm	.3898
0.65mm	.0256	2.15mm	.0846	18	.1695	H	.2660	25/64	.3906
71	.0260	44	.0860	11/64	.1719	6.80mm	.2677	10.00mm	.3937
0.70mm	.0276	2.20mm	.0866	17	.1730	6.90mm	.2717	X	.3970
70	.0280	2.25mm	.0886	4.40mm	.1732	I	.2720	10.20mm	.4016
69	.0292	43	.0890	16	.1770	7.00mm	.2756	Y	.4040
0.75mm	.0295	2.30mm	.0906	4.50mm	.1772	J	.2770	13/32	.4062
68	.0310	2.35mm	.0925	15	.1800	7.10mm	.2795	Z	.4130
1/32	.0312	42	.0935	4.60mm	.1811	K	.2810	10.50mm	.4134
0.80mm	.0315	3/32	.0938	14	.1820	9/32	.2812	27/64	.4219
67	.0320	2.40mm	.0945	13	.1850	7.20mm	.2835	10.80mm	.4252
66	.0330	41	.0960	4.70mm	.1850	7.25mm	.2854	11.00mm	.4331
0.85mm	.0335	2.45mm	.0965	4.75mm	.1870	7.30mm	.2874	7/16	.4375
65	.0350	40	.0980	3/16	.1875	L	.2900	11.20mm	.4409
0.90mm	.0354	2.50mm	.0984	12	.1890	7.40mm	.2913	11.50mm	.4528

DECIMAL EQUIVALENTS—Continued

Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches
29/64	.4531	22.50mm.	.8858	36.00mm.	1.4173	49.50mm.	1.9488	63.00mm.	2.4803
11.80mm.	.4646	57/64	.8906	1 27/64	1.4219	1 61/64	1.9531	2 31/64	2.4844
15/32	.4688	23.00mm.	.9055	36.50mm.	1.4370	50.00mm.	1.9685	63.50mm.	2.5000
12.00mm.	.4724	29/32	.9062	1 7/16	1.4375	1 31/32	1.9688	2 1/2	2.5000
12.20mm.	.4803	59/64	.9219	1 29/64	1.4531	1 63/64	1.9844	2 33/64	2.5156
31/64	.4844	23.50mm.	.9252	37.00mm.	1.4567	50.50mm.	1.9882	64.00mm.	2.5197
12.50mm.	.4921	15/16	.9375	1 15/32	1.4688	2	2.0000	2 17/32	2.5312
1/2	.5000	24.00mm.	.9449	37.50mm.	1.4764	51.00mm.	2.0079	64.50mm.	2.5394
12.80mm.	.5039	61/64	.9531	1 31/64	1.4844	2 1/64	2.0156	2 35/64	2.5469
13.00mm.	.5118	24.50mm.	.9646	38.00mm.	1.4961	51.50mm.	2.0276	65.00mm.	2.5591
33/64	.5156	31/32	.9688	1 1/2	1.5000	2 1/32	2.0312	2 9/16	2.5625
13.20mm.	.5197	25.00mm.	.9843	1 33/64	1.5156	2 3/64	2.0469	2 37/64	2.5781
17/32	.5312	63/64	.9844	38.50mm.	1.5157	52.00mm.	2.0472	65.50mm.	2.5787
13.50mm.	.5315	1	1.0000	1 17/32	1.5312	2 1/16	2.0625	2 19/32	2.5938
13.80mm.	.5433	25.50mm.	1.0039	39.00mm.	1.5354	52.50mm.	2.0669	66.00mm.	2.5984
35/64	.5469	1 1/64	1.0156	1 35/64	1.5469	2 5/64	2.0781	2 39/64	2.6094
14.00mm.	.5512	26.00mm.	1.0236	39.50mm.	1.5551	53.00mm.	2.0866	66.50mm.	2.6181
14.25mm.	.5610	1 1/32	1.0312	1 9/16	1.5625	2 3/32	2.0938	2 5/8	2.6250
9/16	.5625	26.50mm.	1.0433	40.00mm.	1.5748	53.50mm.	2.1063	67.00mm.	2.6378
14.50mm.	.5709	1 3/64	1.0469	1 37/64	1.5781	2 7/64	2.1094	2 41/64	2.6406
37/64	.5781	1 1/16	1.0625	1 19/32	1.5938	2 1/8	2.1250	2 21/32	2.6562
14.75mm.	.5807	27.00mm.	1.0630	40.50mm.	1.5945	54.00mm.	2.1260	67.50mm.	2.6575
15.00mm.	.5906	1 5/64	1.0781	1 39/64	1.6094	2 9/64	2.1406	2 43/64	2.6719
19/32	.5938	27.50mm.	1.0827	41.00mm.	1.6142	54.50mm.	2.1457	68.00mm.	2.6772
15.25mm.	.6004	1 3/32	1.0938	1 5/8	1.6250	2 5/32	2.1562	2 11/16	2.6875
39/64	.6094	28.00mm.	1.1024	41.50mm.	1.6339	55.00mm.	2.1654	68.50mm.	2.6968
15.50mm.	.6102	1 7/64	1.1094	1 41/64	1.6406	2 11/64	2.1719	2 45/64	2.7031
15.75mm.	.6201	28.50mm.	1.1220	42.00mm.	1.6535	55.50mm.	2.1850	69.00mm.	2.7165
5/8	.6250	1 1/8	1.1250	1 21/32	1.6562	2 3/16	2.1875	2 23/32	2.7188
16.00mm.	.6299	1 5/64	1.1406	1 43/64	1.6719	2 13/64	2.2031	2 47/64	2.7344
16.25mm.	.6398	29.00mm.	1.1417	42.50mm.	1.6732	56.00mm.	2.2047	69.50mm.	2.7362
41/64	.6406	1 5/32	1.1562	1 11/16	1.6875	2 7/32	2.2188	2 3/4	2.7500
16.50mm.	.6496	29.50mm.	1.1614	43.00mm.	1.6929	56.50mm	2.2244	70.00mm.	2.7559
21/32	.6562	1 11/64	1.1719	1 45/64	1.7031	2 15/64	2.2344	2 49/64	2.7656
16.75mm.	.6594	30.00mm.	1.1811	43.50mm.	1.7126	57.00mm.	2.2441	70.50mm.	2.7756
17.00mm.	.6693	1 3/16	1.1875	1 23/32	1.7188	2 1/4	2.2500	2 25/32	2.7812
43/64	.6719	30.50mm.	1.2008	44.00mm.	1.7323	57.50mm.	2.2638	71.00mm.	2.7953
17.25mm.	.6791	1 13/64	1.2031	1 47/64	1.7344	2 17/64	2.2656	2 51/64	2.7969
11/16	.6875	1 7/32	1.2188	1 3/4	1.7500	2 9/32	2.2812	2 13/16	2.8125
17.50mm.	.6890	31.00mm.	1.2205	44.50mm.	1.7520	58.00mm.	2.2835	71.50mm.	2.8150
45/64	.7031	1 15/64	1.2344	1 49/64	1.7656	2 19/64	2.2969	2 53/64	2.8281
18.00mm.	.7087	31.50mm.	1.2402	45.00mm.	1.7717	58.50mm.	2.3031	72.00mm.	2.8346
23/32	.7188	1 1/4	1.2500	1 25/32	1.7812	2 5/16	2.3125	2 27/32	2.8438
18.50mm.	.7283	32.00mm.	1.2598	45.50mm.	1.7913	59.00mm.	2.3228	72.50mm.	2.8543
47/64	.7344	1 17/64	1.2656	1 51/64	1.7969	2 21/64	2.3281	2 55/64	2.8594
19.00mm.	.7480	32.50mm.	1.2795	46.00mm.	1.8110	59.50mm.	2.3425	73.00mm.	2.8740
3/4	.7500	1 9/32	1.2812	1 13/16	1.8125	2 11/32	2.3438	2 7/8	2.8750
49/64	.7656	1 13/64	1.2969	1 53/64	1.8281	2 23/64	2.3594	2 57/64	2.8906
19.50mm.	.7677	33.00mm.	1.2992	46.50mm.	1.8307	60.00mm.	2.3622	73.50mm.	2.8937
25/32	.7812	1 5/16	1.3125	1 27/32	1.8438	2 3/8	2.3750	2 29/32	2.9062
20.00mm.	.7874	33.50mm.	1.3189	47.00mm.	1.8504	60.50mm.	2.3819	74.00mm.	2.9134
51/64	.7969	1 21/64	1.3281	1 55/64	1.8594	2 25/64	2.3906	2 59/64	2.9219
20.50mm.	.8071	34.00mm.	1.3386	47.50mm.	1.8701	61.00mm.	2.4016	74.50mm.	2.9331
13/16	.8125	1 11/32	1.3438	1 7/8	1.8750	2 13/32	2.4062	2 15/16	2.9375
21.00mm.	.8268	34.50mm.	1.3583	48.00mm.	1.8898	61.50mm.	2.4213	75.00mm.	2.9528
53/64	.8281	1 23/64	1.3594	1 57/64	1.8906	2 27/64	2.4219	2 61/64	2.9531
27/32	.8438	1 3/8	1.3750	1 29/32	1.9062	2 7/16	2.4375	2 31/32	2.9688
21.50mm.	.8465	35.00mm.	1.3780	48.50mm.	1.9094	62.00mm.	2.4409	75.50mm.	2.9724
55/64	.8594	1 25/64	1.3906	1 59/64	1.9219	2 29/64	2.4531	2 63/64	2.9844
22.00mm.	.8661	35.50mm.	1.3976	49.00mm.	1.9291	62.50mm.	2.4606	76.00mm.	2.9921
7/8	.8750	1 13/32	1.4062	1 15/16	1.9375	2 15/32	2.4688	3	3.0000

TABLE OF CUTTING SPEEDS

NUMBER SIZE DRILLS

Ft./min.	10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
No. Size	Revolutions per Minute														
1	168	335	503	670	838	1005	1173	1340	1508	1675	1843	2010	2179	2346	2513
2	173	345	518	691	864	1037	1210	1382	1555	1728	1901	2074	2247	2420	2593
3	179	359	538	717	897	1076	1255	1434	1614	1793	1974	2152	2331	2511	2690
4	183	365	548	731	914	1097	1280	1462	1645	1828	2010	2193	2376	2560	2741
5	186	372	558	744	930	1115	1301	1487	1673	1859	2045	2230	2416	2602	2788
6	187	374	562	749	936	1123	1310	1498	1685	1872	2060	2247	2434	2621	2809
7	190	380	570	760	950	1140	1330	1520	1710	1900	2090	2281	2470	2660	2850
8	192	384	576	768	960	1151	1343	1535	1727	1919	2111	2303	2495	2687	2879
9	195	390	585	780	975	1169	1364	1559	1754	1949	2144	2339	2534	2728	2923
10	197	395	592	790	987	1184	1382	1579	1777	1974	2171	2369	2566	2764	2961
11	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3001
12	202	404	606	808	1010	1213	1415	1617	1819	2021	2223	2425	2627	2829	3032
13	206	413	620	826	1032	1239	1450	1652	1859	2065	2271	2479	2684	2891	3097
14	210	420	630	840	1050	1259	1469	1679	1889	2099	2309	2518	2728	2938	3148
15	213	425	638	851	1064	1276	1489	1702	1914	2127	2334	2546	2759	2971	3183
16	216	432	647	863	1079	1295	1511	1726	1942	2158	2374	2590	2806	3021	3237
17	221	442	662	883	1104	1325	1546	1766	1987	2208	2429	2650	2870	3091	3313
18	226	452	678	904	1130	1356	1582	1808	2034	2260	2479	2704	2930	3155	3380
19	230	460	690	920	1151	1381	1611	1841	2071	2301	2531	2761	2991	3222	3453
20	237	475	712	949	1186	1423	1660	1898	2135	2372	2610	2847	3084	3322	3559
21	240	480	721	961	1201	1441	1681	1922	2162	2402	2644	2883	3123	3363	3604
22	243	487	730	973	1217	1460	1703	1946	2190	2433	2676	2920	3164	3406	3649
23	248	496	744	992	1240	1488	1736	1984	2232	2480	2728	2976	3224	3472	3720
24	251	503	754	1005	1257	1508	1759	2010	2262	2513	2764	3016	3267	3518	3769
25	256	511	767	1022	1276	1533	1789	2044	2300	2555	2810	3066	3322	3577	3832
26	260	520	779	1039	1299	1559	1819	2078	2338	2598	2858	3118	3378	3638	3898
27	265	531	796	1061	1327	1592	1857	2122	2388	2653	2919	3183	3448	3714	3979
28	272	544	816	1088	1360	1631	1903	2175	2447	2719	2990	3262	3534	3806	4078
29	281	562	843	1124	1405	1685	1966	2247	2528	2809	3090	3370	3651	3932	4213
30	297	595	892	1189	1487	1784	2081	2378	2676	2973	3270	3567	3864	4162	4459
31	318	637	955	1273	1592	1910	2228	2546	2865	3183	3501	3821	4138	4456	4775
32	329	659	988	1317	1647	1976	2305	2634	2964	3293	3622	3951	4281	4610	4939
33	338	676	1014	1352	1690	2028	2366	2704	3042	3380	3718	4056	4394	4732	5070
34	344	688	1032	1376	1721	2065	2409	2753	3097	3442	3785	4129	4474	4818	5162
35	347	694	1042	1389	1736	2083	2430	2778	3125	3472	3821	4167	4514	4861	5209
36	359	717	1076	1435	1794	2152	2511	2870	3228	3587	3945	4304	4663	5021	5380
37	367	735	1102	1469	1837	2204	2571	2938	3306	3673	4040	4407	4775	5142	5509
38	376	753	1129	1505	1882	2258	2634	3010	3387	3763	4140	4516	4892	5269	5645
39	384	768	1152	1536	1920	2303	2687	3071	3455	3839	4222	4607	4991	5374	5758
40	390	780	1169	1559	1949	2339	2729	3118	3508	3898	4287	4677	5067	5457	5846

For speeds higher than tabulated, multiply all values by 10 or 100.
For speeds lower than tabulated, divide all values by 10.

TABLE OF CUTTING SPEEDS

NUMBER SIZE DRILLS—Continued

Ft./min.	10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
No. Size	Revolutions per Minute														
41	398	796	1194	1592	1990	2387	2785	3183	3581	3979	4377	4775	5172	5570	5968
42	408	817	1226	1634	2043	2451	2860	3268	3677	4085	4494	4902	5311	5719	6128
43	429	858	1288	1717	2146	2575	3004	3434	3863	4292	4721	5150	5579	6008	6438
44	444	888	1333	1777	2221	2665	3109	3554	3999	4442	4886	5330	5774	6218	6662
45	466	932	1397	1863	2329	2795	3261	3726	4192	4658	5124	5590	6056	6522	6987
46	472	943	1415	1886	2358	2830	3301	3773	4244	4716	5187	5659	6130	6602	7074
47	487	973	1460	1946	2433	2920	3406	3893	4379	4866	5352	5839	6326	6812	7299
48	503	1005	1508	2010	2513	3016	3518	4021	4523	5026	5528	6031	6534	7036	7539
49	523	1047	1570	2093	2617	3140	3663	4186	4710	5233	5756	6279	6808	7326	7849
50	546	1091	1637	2183	2729	3274	3820	4366	4911	5457	6002	6548	7094	7640	8185
51	570	1140	1710	2280	2851	3421	3991	4561	5131	5701	6271	6841	7413	7982	8552
52	602	1203	1805	2406	3008	3609	4211	4812	5414	6015	6619	7218	7820	8421	9023
53	641	1283	1924	2566	3207	3848	4490	5131	5773	6414	7062	7704	8346	8988	9630
54	694	1389	2084	2778	3473	4167	4862	5556	6251	6945	7639	8334	9028	9723	10417
55	735	1469	2204	2938	3673	4408	5142	5877	6611	7346	8080	8815	9549	10284	11028
56	821	1643	2465	3286	4108	4929	5751	6572	7394	8215	9036	9857	10678	11500	12322
57	888	1777	2671	3561	4452	5342	6232	7122	8013	8903	9771	10660	11548	12436	13325
58	910	1819	2729	3637	4547	5456	6367	7275	8186	9095	10004	10913	11823	12732	13642
59	932	1863	2795	3726	4658	5590	6521	7453	8388	9316	10248	11180	12111	13043	13975
60	955	1910	2865	3820	4775	5729	6684	7639	8594	9549	10504	11459	12414	13369	14324
61	979	1959	2938	3918	4897	5876	6856	7835	8815	9794	10774	11753	12732	13712	14691
62	1005	2010	3015	4020	5025	6030	7035	8040	9045	10050	11057	12060	13068	14073	15078
63	1032	2064	3096	4128	5160	6192	7224	8256	9288	10320	11366	12398	13421	14453	15485
64	1061	2122	3183	4244	5305	6366	7427	8488	9549	10610	11671	12732	13793	14854	15915
65	1091	2182	3273	4364	5455	6546	7637	8728	9819	10910	12005	13096	14187	15279	16370
66	1158	2316	3474	4632	5790	6948	8106	9264	10422	11580	12732	13890	15047	16205	17362
67	1194	2388	3582	4776	5970	7164	8358	9552	10746	11940	13130	14324	15517	16712	17905
68	1232	2465	3696	4928	6160	7392	8624	9856	11088	12320	13554	14786	16018	17250	18482
69	1308	2616	3918	5224	6530	7836	9142	10488	11754	13060	14389	15697	17006	18314	19622
70	1364	2729	4091	5456	6820	8184	9548	10912	12276	13640	15006	16370	17734	19099	20463
71	1469	2938	4419	5892	7365	8838	10311	11784	13257	14730	16160	17629	19099	20568	22037
72	1528	3056	4584	6112	7640	9168	10696	12224	13752	15280	16807	18335	19863	21390	22918
73	1592	3183	4776	6368	7960	9552	11144	12736	14328	15920	17507	19099	20690	22282	23873
74	1698	3396	5106	6808	8510	10212	11914	13616	15318	17020	18674	20372	22069	23767	25465
75	1819	3638	5457	7276	9095	10914	12733	14552	16371	18190	20008	21827	23646	25465	27284
76	1910	3820	5730	7640	9550	11460	13370	15280	17190	19100	21008	22918	24828	26738	28648
77	2122	4244	6366	8488	10610	12732	14854	16976	19098	21220	23343	25465	27587	29709	31831
78	2388	4775	7161	9548	11935	14322	16709	19096	21483	23870	26260	28648	31035	33422	35810
79	2634	5269	7902	10536	13170	15804	18438	21072	23706	26340	28988	31611	34246	36880	39514
80	2830	5659	8490	11320	14150	16980	19810	22640	25470	28300	31123	33953	36782	39612	42441

For speeds higher than tabulated, multiply all values by 10 or 100.
For speeds lower than tabulated, divide all values by 10.

TABLE OF CUTTING SPEEDS

FRACTION SIZE DRILLS

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

LETTER SIZE DRILLS

Ft./min.	10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
Size Letter	Revolutions per Minute														
A	163	326	491	654	818	982	1145	1309	1472	1636	1796	1959	2122	2285	2448
B	161	321	482	642	803	963	1124	1284	1445	1605	1765	1926	2086	2247	2407
C	158	316	473	631	789	947	1105	1262	1420	1578	1736	1894	2052	2210	2368
D	155	311	467	622	778	934	1089	1245	1400	1556	1708	1863	2018	2174	2329
E	153	306	458	611	764	917	1070	1222	1375	1528	1681	1834	1968	2139	2292
F	149	297	446	594	743	892	1040	1189	1337	1486	1635	1784	1932	2081	2229
G	146	293	440	585	732	878	1024	1170	1317	1463	1610	1756	1903	2049	2195
H	144	287	430	574	718	862	1005	1149	1292	1436	1580	1723	1867	2010	2154
I	140	281	421	562	702	842	983	1123	1264	1404	1545	1685	1826	1966	2106
J	138	276	414	552	690	827	965	1103	1241	1379	1517	1655	1793	1930	2068
K	136	272	408	544	680	815	951	1087	1223	1359	1495	1631	1767	1903	2039
L	132	263	395	527	659	790	922	1054	1185	1317	1449	1581	1712	1844	1976
M	129	259	389	518	648	777	907	1036	1166	1295	1424	1554	1683	1813	1942
N	126	253	380	506	633	759	886	1012	1139	1265	1391	1518	1644	1771	1897
O	121	242	363	484	605	725	846	967	1088	1209	1330	1450	1571	1692	1813
P	118	237	355	473	592	710	828	946	1065	1183	1301	1419	1537	1657	1774
Q	115	230	345	460	575	690	805	920	1035	1150	1266	1384	1496	1611	1726
R	113	225	338	451	564	676	789	902	1014	1127	1239	1355	1465	1577	1690
S	110	220	329	439	549	659	769	878	988	1098	1207	1317	1427	1537	1646
T	107	213	320	426	533	640	746	853	959	1066	1173	1280	1387	1494	1600
U	104	208	311	415	519	623	727	830	934	1038	1142	1246	1349	1453	1557
V	101	203	304	405	507	608	709	810	912	1013	1114	1219	1317	1418	1520
W	99	198	297	396	495	594	693	792	891	989	1088	1188	1286	1385	1484
X	96	192	289	385	481	576	672	769	865	962	1058	1155	1251	1347	1443
Y	95	189	284	378	473	567	662	756	851	945	1040	1135	1229	1324	1418
Z	92	185	277	370	462	555	647	740	832	925	1017	1110	1202	1295	1387

For speeds higher than tabulated, multiply all values by 10 or 100.
For speeds lower than tabulated, divide all values by 10.

TAP DRILL SIZES

and PERCENTAGES OF THREADS

FORMULA FOR OBTAINING TAP DRILL SIZES

$$\text{Outside Diam. of Thread} - \frac{.01299 \times \text{Amt. of percentage of full thread}}{\text{No. of threads per inch}} = \text{Drilled Hole Size}$$

Note: Select nearest commercial stock drill.

PERCENTAGE OF FULL THREAD FOR OTHER DRILL SIZES

$$\text{No. of Threads per Inch} \times \left(\frac{\text{Outside Diam. of Thread} - \text{Selected Drill Diam.}}{.01299} \right) = \text{Percentage of Full Thread}$$

Tap Nom. Size	Tap Thrds. per Inch	Tap Drill	Decimal Equiv. of Tap Drill	Theoret. % of Thread	Probable Oversize (Mean)	Probable 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
		49	.0730	56	.0017	.0747	49
2	64	50	.0700	79	.0017	.0717	70
		49	.0730	64	.0017	.0747	56
3	48	5/64	.0781	77	.0019	.0800	70
		47	.0785	76	.0019	.0804	69
		46	.0810	67	.0019	.0829	60
3	56	46	.0810	78	.0019	.0829	69
		45	.0820	73	.0019	.0839	65
		44	.0860	56	.0019	.0879	48
4	40	43	.0890	71	.0020	.0910	65
		42	.0935	57	.0020	.0955	51
4	48	42	.0935	68	.0020	.0955	61
		3/32	.0938	68	.0020	.0958	60
5	40	39	.0995	79	.0023	.1018	71
		38	.1015	72	.0023	.1038	65
5	44	38	.1015	79	.0023	.1038	72
		37	.1040	71	.0023	.1063	63
6	32	36	.1065	78	.0026	.1091	71
		7/64	.1094	70	.0026	.1120	64
		35	.1100	69	.0026	.1126	63
6	40	33	.1130	77	.0026	.1156	69
		32	.1160	68	.0026	.1186	60
8	32	29	.1360	69	.0029	.1389	62
		28	.1405	58	.0029	.1434	51
8	36	29	.1360	78	.0029	.1389	70
		28	.1405	68	.0029	.1434	57
		9/64	.1406	68	.0029	.1435	57
10	24	25	.1495	75	.0032	.1527	69
		24	.1520	70	.0032	.1552	64
		23	.1540	67	.0032	.1572	61
10	32	22	.1570	81	.0032	.1602	73
		21	.1590	76	.0032	.1622	68
		20	.1610	71	.0032	.1642	64
12	24	17	.1730	79	.0035	.1765	73
		16	.1770	72	.0035	.1805	66
		15	.1800	67	.0035	.1835	60
12	28	15	.1800	78	.0035	.1835	70
		14	.1820	73	.0035	.1855	66
		13	.1850	67	.0035	.1885	59
1/4	20	7	.2010	75	.0038	.2048	70
		13/64	.2031	72	.0038	.2069	66
		6	.2040	71	.0038	.2078	65
		5	.2055	69	.0038	.2093	63
1/4	24	4	.2090	76	.0038	.2128	69
1/4	28	7/32	.2188	67	.0038	.2226	59
		2	.2210	63	.0038	.2248	55
1/4	32	7/32	.2188	77	.0038	.2226	67
5/16	18	F	.2570	77	.0038	.2608	72
		G	.2610	71	.0041	.2651	66
		17/64	.2656	65	.0041	.2697	59
5/16	20	17/64	.2656	72	.0041	.2697	66
5/16	24	I	.2720	75	.0041	.2761	67
		J	.2770	66	.0041	.2811	58
5/16	32	9/32	.2812	77	.0044	.2856	66
3/8	16	5/16	.3125	77	.0044	.3169	72
		O	.3160	73	.0044	.3204	68
		P	.323	64	.0044	.3274	59
3/8	20	21/64	.3281	72	.0044	.3325	65
3/8	24	Q	.3320	79	.0044	.3364	71
		R	.3390	67	.0044	.3434	58
3/8	32	11/32	.3437	77	.0046	.3483	66

TAP DRILL SIZES

and PERCENTAGES OF THREADS—Continued

Tap Nom. Size	Tap Thrds. per Inch	Tap Drill	Decimal Equiv. of Tap Drill	Theoret. % of Thread	Probable Oversize (Mean)	Probable Hole Size	% of Thread
7/16	14	U	.3680	75	.0046	.3726	70
		3/8	.3750	67	.0046	.3796	62
		V	.3770	65	.0046	.3816	60
7/16	20	W	.3860	79	.0046	.3906	72
		25/64	.3906	72	.0046	.3952	65
7/16	24	X	.3970	75	.0046	.4016	66
7/16	28	Y	.4040	72	.0047	.4087	62
1/2	13	27/64	.4219	78	.0047	.4266	73
		7/16	.4375	63	.0047	.4422	58
1/2	20	29/64	.4531	72	.0047	.4578	65
1/2	24	29/64	.4531	87	.0047	.4578	78
1/2	28	15/32	.4688	67	.0048	.4736	57
9/16	12	15/32	.4688	87	.0048	.4736	82
		31/64	.4844	72	.0048	.4892	68
9/16	18	1/2	.500	87	.0048	.5048	80
		33/64	.5156	65	.0048	.5204	58
9/16	24	33/64	.5156	87	.0048	.5204	78
5/8	11	17/32	.5313	79	.0049	.5362	75
		35/64	.5469	66	.0049	.5518	62
5/8	12	35/64	.5469	72	.0049	.5518	68
5/8	18	9/16	.5625	87	.0049	.5674	80
		37/64	.5781	65	.0049	.5831	58
5/8	24	37/64	.5781	87	.0049	.5831	77
11/16	12	39/64	.6094	72	.0050	.6144	68
11/16	24	41/64	.6406	87	.0050	.6456	77
3/4	10	41/64	.6406	84	.0050	.6456	80
		21/32	.6563	72	.0050	.6613	68
3/4	12	43/64	.6719	72	.0050	.6769	68
3/4	16	11/16	.6875	77	.0050	.6925	71
3/4	20	45/64	.7031	72	.0052	.7083	64
13/16	12	47/64	.7344	72	.0052	.7396	67
13/16	16	3/4	.7500	77	.0052	.7552	71
13/16	20	49/64	.7656	72	.0052	.7708	64
7/8	9	49/64	.7656	76	.0052	.7708	72
		25/32	.7812	65	.0052	.7864	61
7/8	12	51/64	.7969	72	.0052	.8021	67
7/8	14	51/64	.7969	84	.0052	.8021	79
		13/16	.8125	67	.0052	.8177	62
7/8	16	13/16	.8125	77	.0052	.8177	71
7/8	20	53/64	.8281	72	.0059	.8340	63
15/16	12	55/64	.8594	72	.0059	.8653	67
15/16	16	7/8	.8750	77	.0059	.8809	70
15/16	20	57/64	.8906	72	.0059	.8965	63
1	8	7/8	.875	77	.0059	.8809	73
		57/64	.8906	67	.0059	.8965	64
1	12	59/64	.9219	72	.0060	.9279	67
		15/16	.9375	58	.0060	.9435	52
1	14	59/64	.9219	84	.0060	.9279	78
		15/16	.9375	67	.0060	.9435	61
1	16	15/16	.9375	77	.0060	.9435	70
1	20	61/64	.9531	72	.0062	.9593	63
1 1/8	7	63/64	.9844	76	.0067	.9911	72
		1	1.000	67	.0070	1.007	64
1 1/8	12	1 1/32	1.0313	87	.0071	1.0384	80
		1 3/64	1.0469	72	.0072	1.0541	66
1 1/8	16	1 1/16	1.0625	77			
1 1/8	18	1 1/16	1.0625	87			
1 1/4	7	1 3/32	1.0938	84			
		1 7/64	1.1094	76			
		1 1/8	1.125	67			
1 1/4	12	1 5/32	1.1563	87			
		1 11/64	1.1719	72			
1 1/4	16	1 3/16	1.1875	77			
1 1/4	18	1 3/16	1.1875	87			
1 3/8	6	1 3/16	1.1875	87			
		1 13/64	1.2031	79			
		1 7/32	1.2188	72			
		1 15/64	1.2344	65			
1 3/8	12	1 9/32	1.2813	87			
		1 19/64	1.2969	72			
1 3/8	16	1 5/16	1.3125	77			
1 3/8	18	1 5/16	1.3125	87			
1 1/2	6	1 5/16	1.3125	87			
		1 21/64	1.3281	79			
		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			
1 1/2	16	1 7/16	1.4375	77			
1 1/2	18	1 7/16	1.4375	87			
1 3/4	16	1 11/16	1.6875	77			
2	16	1 15/16	1.9375	77			
2 1/4	16	2 3/16	2.1875	77			
2 1/2	16	2 7/16	2.4375	77			
2 3/4	16	2 11/16	2.6875	77			
3	16	2 15/16	2.9375	77			

Reaming Recommended

METRIC TAP DRILL SIZES

and PERCENTAGES OF THREADS

METRIC THREAD FORMULAE

$$\text{O.D. of thread} - \frac{\%\ \text{thread} \times \text{pitch (mm)}}{76.980} = \text{Drilled hole size}$$

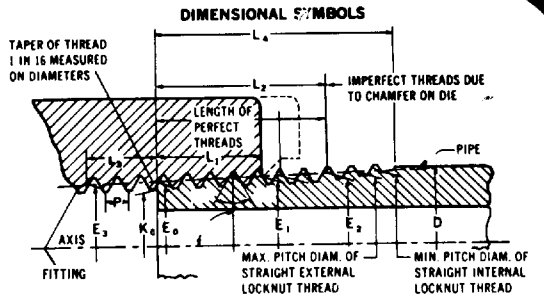
$$\frac{76.980}{\text{pitch (mm)}} \times (\text{O.D. of thread} - \text{Drilled hole size}) = \%\ \text{of thread}$$

(All above dimensions are in millimeters.)

Tap		Tap Drill (Nominal)	Tap Drill (Dec. Equiv.)	Theor. % Thrd.	Prob. O'size (Mean)	Prob. Hole Size (Inches)	% of Thrd.
1.6	0.35	1.25mm	.0492	77	.0015	.0507	69
1.8	0.35	1.45mm	.0571	77	.0015	.0586	69
2	0.4	1.60mm	.0630	77	.0017	.0647	69
		#52	.0635	74	.0017	.0652	66
2.2	0.45	1.75mm	.0689	77	.0017	.0706	70
2.5	0.45	2.05mm	.0807	77	.0019	.0826	69
		#45	.80200	71	.0019	.0839	63
3	0.5	2.50mm	.0984	77	.0023	.1007	68
		#39	.0995	73	.0023	.1018	64
3.5	0.6	2.90mm	.1142	77	.0026	.1168	68
		#32	.1160	71	.0026	.1186	63
4	0.7	3.30mm	.1299	77	.0029	.1328	69
4.5	0.75	3.70mm	.1457	82	.0032	.1489	74
		#25	.1495	72	.0032	.1527	64
5	0.8	4.20mm	.1654	77	.0032	.1686	69
6	1	5.00mm	.1968	77	.0038	.2006	70
		#8	.1990	73	.0038	.2028	65
7	1	6.00mm	.2362	77	.0038	.2400	70
		B	.2380	74	.0038	.2418	66
8	1.25	6.80mm	.2677	74	.0041	.2718	68
8	1	7.00mm	.2756	77	.0041	.2797	69
		J	.2770	74	.0041	.2811	66
10	1.5	8.50mm	.3346	77	.0044	.3390	71
10	1.25	8.70mm	.3425	80	.0046	.3471	73
		11/32"	.3438	78	.0046	.3483	71
12	1.75	10.30mm	.4055	75	.0046	.4101	70
		13/32"	.4062	74	.0047	.4109	69
12	1.25	10.80mm	.4252	74	.0047	.4299	67
		27/64"	.4219	79	.0047	.4266	72
14	2	12.00mm	.4724	77	.0048	.4772	72
14	1.5	12.50mm	.4921	77	.0048	.4969	71
16	2	14.00mm	.5512	77	.0049	.5561	72
16	1.5	14.50mm	.5709	77	.0049	.5758	71
18	2.5	15.50mm	.6102	77	.0050	.6152	73
18	1.5	16.50mm	.6496	77	.0050	.6546	70
20	2.5	17.50mm	.6890	77	.0052	.6942	73
20	1.5	18.50mm	.7283	77	.0052	.7335	70
22	2.5	19.50mm	.7677	77	.0052	.7729	73
22	1.5	20.50mm	.8071	77	.0052	.8123	70
24	3	21.00mm	.8268	77	.0059	.8327	73
24	2	22.00mm	.8661	77	.0059	.8720	71
27	3	24.00mm	.9449	77	.0062	.9511	73
27	2	25.00mm	.9843	77	.0070	.9913	70
		63/64"	.9844	77	.0070	.9914	70
30	3.5	26.50mm	1.0433	77			
30	2	28.00mm	1.1024	77			
		1 7/64"	1.1094	70			
33	3.5	29.50mm	1.1614	77			
		1 11/64"	1.1719	71			
33	2	31.00mm	1.2205	77			
36	4	32.00mm	1.2598	77			
36	3	1 19/64"	1.2969	78			
39	4	35.00mm	1.3780	77			
		1 3/8"	1.3750	78			
39	3	36.00mm	1.4173	77			
		1 27/64	1.4219	74			

Reaming Recommended

BASIC DIMENSIONS FOR AMERICAN NATIONAL STANDARD and DRYSEAL TAPER PIPE THREADS



Nominal Pipe Size Inches	Outside Diameter of Pipe Inches	Threads per Inch	Pitch of Thread	Pitch Diameter at Gaging Notch Basic Inches	Thickness of American Std. Thin Ring Gage and Distance from Small End to Gaging Notch Inches	Effective Thread External Inches	Wrench Take Up Inches	Total Length of Thread Inches	Pitch Dia. at Small End of Internal Effective Thread Inches	Pitch Dia. at end of Pipe Inches	Minor Diameter at End of Pipe Inches	*Tap Drill Size		Minimum Hole Depth for Std Pipe Tap
	D	n	p	E_1	L_1	L_2	L_3	L_4	E_3	E_0	K_0	NPT	NPTF	
1/16	.3125	27	.03704	.28118	.160	.2611	.1111	.3896	.26424	.27118	.2416	D	D	9/16
1/8	.405	27	.03704	.37360	.1615	.2639	.1111	.3924	.35656	.36351	.3339	Q	R	19/32
1/4	.540	18	.05556	.49163	.2278	.4018	.1667	.5946	.46697	.47739	.4329	7/16	7/16	13/16
3/8	.675	18	.05556	.62701	.240	.4078	.1667	.6006	.60160	.61201	.5676	9/16	37/64	13/16
1/2	.840	14	.07143	.77843	.320	.5337	.2143	.7815	.74504	.75843	.7013	45/64	45/64	11/32
3/4	1.050	14	.07143	.98887	.339	.5457	.2143	.7935	.95429	.96768	.9105	29/32	59/64	11/32
1	1.315	11½	.08696	1.23863	.400	.6828	.2609	.9845	1.19733	1.21363	1.1441	19/64	15/32	1¼
1¼	1.660	11½	.08696	1.58338	.420	.7068	.2609	1.0085	1.54083	1.55713	1.4876	131/64	1½	19/32
1½	1.900	11½	.08696	1.82234	.420	.7235	.2609	1.0252	1.77978	1.79609	1.7265	147/64	147/64	15/16
2	2.375	11½	.08696	2.29627	.436	.7565	.2609	1.0582	2.25272	2.26902	2.1995	213/64	27/32	19/32
2½	2.875	8	.12500	2.76216	.682	1.1375	.250(1)	1.5712	2.70391(1)	2.71953	2.6195	2⅝	241/64	127/32
3	3.500	8	.12500	3.38850	.766	1.2000	.250(2)	1.6337	3.32500(2)	3.34062	3.2406	—	317/64	129/32
3½	4.000	8	.12500	3.88881	.821	1.2500	.250	1.6837	3.82188	3.83750	3.7375	—	—	2
4	4.500	8	.12500	4.38712	.844	1.3000	.250	1.7337	4.31875	4.33438	4.2344	—	—	21/16
5	5.563	8	.12500	5.44929	.937	1.4063	.250	1.8400	5.37511	5.39073	5.2907	—	—	—
6	6.625	8	.12500	6.50597	.958	1.5125	.250	1.9462	6.43047	6.44609	6.3461	—	—	—
8	8.625	8	.12500	8.50003	1.063	1.7125	.250	2.1462	8.41797	8.43359	8.3336	—	—	—
10	10.750	8	.12500	10.62094	1.210	1.9250	.250	2.3587	10.52969	10.54531	10.4453	—	—	—
12	12.750	8	.12500	12.61781	1.360	2.1250	.250	2.5587	12.51719	12.53281	12.4328	—	—	—

(1) 2½" NPTF and ANPT L_3 = .375, E_3 = 2.69609; (2) 3" NPTF and ANPT L_3 = .375, E_3 = 3.31719

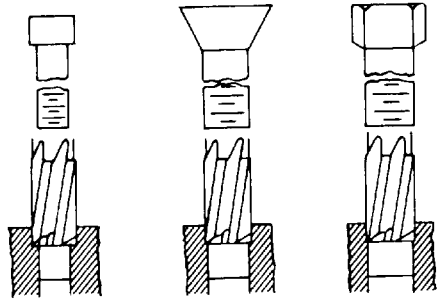
*Methods of inspection vary. Care should be taken to use a tap drill or taper reamer which can meet thread specifications. Sizes given permit direct tapping without reaming the hole, but only give a full thread for the first two or three threads. See columns K_0 and L_3.

CONSTANTS FOR FINDING PITCH DIAMETER AND MINOR DIAMETER OF SCREW THREADS

To find the basic pitch diameter or basic minor diameter of any screw thread, subtract the constant for the number of threads per inch from the basic major diameter.

Threads Per Inch	Pitch		Constant for Finding Basic Pitch Diameter		Constant for Finding Basic Minor Diameter	
	Inches	Millimeters	Unified	ISO	Unified	ISO
—	.0079	0.2	—	.00511	—	.01022
—	.0088	0.225	—	.00575	—	.01150
—	.0098	0.25	—	.00639	—	.01278
—	.0118	0.3	—	.00767	—	.01534
80	.0125	—	.00812	—	.01624	—
—	.0138	0.35	—	.00895	—	.01790
72	.0139	—	.00902	—	.01804	—
64	.0156	—	.01015	—	.02030	—
—	.0157	0.4	—	.01023	—	.02046
—	.0177	0.45	—	.01151	—	.02302
56	.0178	—	.01160	—	.02320	—
—	.0197	0.5	—	.01279	—	.02558
48	.0208	—	.01353	—	.02706	—
44	.0227	—	.01476	—	.02952	—
—	.0236	0.6	—	.01534	—	.03068
40	.0250	—	.01624	—	.03248	—
—	.0275	0.7	—	.01790	—	.03580
36	.0278	—	.01804	—	.03608	—
—	.0295	0.75	—	.01918	—	.03836
32	.0312	—	.02030	—	.04060	—
—	.0315	0.8	—	.02046	—	.04092
28	.0357	—	.02320	—	.04640	—
27	.0370	—	.02406	—	.04812	—
—	.0394	1	—	.02557	—	.05114
24	.0417	—	.02706	—	.05412	—
—	.0492	1.25	—	.03196	—	.06392
20	.0500	—	.03248	—	.06496	—
18	.0555	—	.03608	—	.07216	—
—	.0590	1.5	—	.03836	—	.07672
16	.0625	—	.04060	—	.08120	—
—	.0689	1.75	—	.04475	—	.08950
14	.0714	—	.04639	—	.09278	—
13	.0769	—	.04996	—	.09992	—
—	.0787	2	—	.05114	—	.10228
12	.0833	—	.05413	—	.10826	—
11.5	.0869	—	.05648	—	.11296	—
11	.0909	—	.05905	—	.11810	—
—	.0984	2.5	—	.06393	—	.12786
10	.1000	—	.06495	—	.12990	—
9	.1111	—	.07217	—	.14434	—
—	.1181	3	—	.07672	—	.15344
8	.1250	—	.08119	—	.16238	—
—	.1378	3.5	—	.08950	—	.17900
7	.1428	—	.09279	—	.18558	—
—	.1575	4	—	.10229	—	.20458
6	.1667	—	.10825	—	.21650	—
—	.1772	4.5	—	.11507	—	.23014
—	.1968	5	—	.12786	—	.25572
5	.2000	—	.12990	—	.25980	—
—	.2165	5.5	—	.14064	—	.28128
4.5	.2222	—	.14434	—	.28868	—
—	.2362	6	—	.15343	—	.30686
4	.2500	—	.16238	—	.32476	—

COUNTERBORE SIZES FOR CAP SCREWS



Screw Size	Threads/in.		Tap Drill Size		Body Drill Size	Pilot Body	Pilot Tap Hole		Socket Head Cap Screws 1960 Series Counterbore Diameter		82° Flat Head Cap Screws Counterbore Body Diameter		Hexagon Head Cap Screws Counterbore Body Diameter		Screw Size
	UNC	UNF	UNC	UNF			UNC	UNF	Wide	Close	Wide	Close	Wide	Close	
0	—	80	—	3/64	#51	.059	—	.040	1/8	.110	5/64	#51	—	—	0
1	64	72	#53	#53	#46	.072	.052	.052	5/64	.133	3/32	#46	—	—	1
2	56	64	#50	#50	3/32	.085	1/16	1/16	11/64	.155	7/64	3/32	—	—	2
3	48	56	#47	#45	#36	.098	.072	.076	3/16	.175	1/8	#36	—	—	3
4	40	48	#43	#42	#31	.111	5/64	5/64	7/32	.198	1/8	#31	—	—	4
5	40	44	#38	#37	9/64	.124	3/32	3/32	1/4	.222	5/32	9/64	—	—	5
6	32	40	#36	#33	#23	.137	.098	.102	9/32	.242	11/64	#23	—	—	6
8	32	36	#29	#29	#15	.163	1/8	1/8	5/16	.285	3/16	#15	—	—	8
10	24	32	#25	#21	#5	3/16	9/64	.149	3/8	.329	7/32	#5	—	—	10
1/4	20	28	#7	#3	17/64	1/4	3/16	13/64	13/32	25/64	9/32	17/64	—	17/64	1/4
5/16	18	24	F	I	21/64	5/16	15/64	1/4	9/16	31/64	11/32	21/64	11/32	21/64	5/16
3/8	16	24	5/16	Q	25/64	3/8	19/64	5/16	5/8	37/64	13/32	25/64	13/32	25/64	3/8
7/16	14	20	U	25/64	29/64	7/16	11/32	23/64	23/32	43/64	15/32	29/64	15/32	29/64	7/16
1/2	13	20	27/64	29/64	33/64	1/2	25/64	27/64	13/16	25/32	17/32	33/64	17/32	33/64	1/2
5/8	11	18	17/32	37/64	41/64	5/8	1/2	35/64	1	31/32	21/32	41/64	21/32	41/64	5/8
3/4	10	16	21/32	11/16	49/64	3/4	5/8	21/32	1 3/16	1 11/64	25/32	49/64	25/32	49/64	3/4
7/8	9	14	49/64	13/16	57/64	7/8	47/64	25/32	1 3/8	1 23/64	29/32	57/64	29/32	57/64	7/8
1	8	14	7/8	15/16	1 1/64	1	27/32	29/32	1 9/16	1 35/64	1 1/32	1 1/64	1 1/16	1 1/32	1

DRILLING SPEEDS AND FEEDS

SPEEDS

THE subject of the speed at which a drill should run and the feed per revolution is one upon which no rule can be given. The following recommended speeds and feeds should be considered as guides only, due to the variations in materials, methods and other operating conditions. The correct speeds and feeds should be determined by good, sound judgment for each particular case.

SUGGESTED SPEEDS FOR HIGH SPEED DRILLS

	Speed in F.P.M.
Aluminum and its Alloys	200-300
Brass and Bronze (ordinary)	150-300
Bronze (High Tensile)	70-150
Die Castings (Zinc Base)	300-400
Iron—Cast (soft)	100-150
Cast (medium hard)	70-100
Hard Chilled	30- 40
Malleable	80- 90
Magnesium and its Alloys	250-400
Monel Metal or High-Nickel Steel	30- 50
Plastics or Similar Materials (Bakelite)	100-300
Steel—Mild .2 carbon to .3 carbon	80-110
Steel .4 carbon to .5 carbon	70- 80
Tool 1.2 carbon	50- 60
Forgings	40- 50
Alloy—300 to 400 Brinell	20- 30

	Speed in F.P.M.
High Tensile (Heat Treated)	
35 to 40 Rockwell C	30- 40
40 to 45 Rockwell C	25- 35
45 to 50 Rockwell C	15- 25
50 to 55 Rockwell C	7- 15
Stainless Steel	
Free Machining Grades	30- 80
Work Hardening Grades	15- 50
Titanium Alloy Sheet	50- 60
Titanium Alloys	
Ti—75A (Commercially Pure)	50- 60
Ti-6AL-4VA BR. 310-350	20- 35
Inconel Alloy BR. 200-400	15- 20
Hastelloy (Wrought) BR. 140-310	15- 20
Hastelloy (Cast) BR. 200-375	5- 7
Rene BR. 225-400	12- 20
Zirconium Alloys BR. 140-280	55
Wood	300-400

FEEDS

Feeds are governed by the size of the drill and the material drilled. The general rule is—use a feed of .001 to .002 inch per revolution for drills smaller than ⅛ inch, .002 to .004 inch for drills ⅛ to ¼ inch, .004 to .007 inch for drills ¼ to ½ inch, .007 to .015 inch for drills ½ inch to 1 inch, and .015 to .025 inch for drills larger than 1 inch. Alloy and hard steels should be drilled at a lighter feed than given above while cast iron, brass and aluminum may usually be drilled with a heavier feed than given above.

INDICATION OF EXTREME SPEEDS AND FEEDS A drill split up the web is evidence of too much feed or insufficient lip clearance at the center due to improper grinding. The rapid wearing away of the extreme outer corners of the cutting edges indicates that the speed is too high. The best results will be obtained when the effect of the work on the tool is somewhere between the above conditions. A drill chipping or breaking out at the cutting edges indicates that either the feed is too heavy or the drill has been ground with too much lip clearance.

When drilling abrasive or work hardening materials, too light a feed will result in excessive wear of the cutting edges. In other materials too light a feed may sometimes give a very flexible chip which refuses to break up and packs in the flutes.

LUBRICANTS

Lubricants have many uses. To cool the tool cutting edges and the workpiece, direct as large a volume of the coolant as possible on the cutting edges. On thin-walled work, allow coolant to flow onto and around the workpiece. Lubricating chips aids in chip clearance. High lubricant pressures will force the chips back from the cutting edges and out of the flutes of oil feed drills. Lubricants improve the workpiece finish materially when carefully selected and applied. Refer lubrication problems to a reputable manufacturer of cutting oils. The following are suggested lubricant uses for various materials.

Materials		Brinell	SFM	Coolant*
Ferrous Materials				
Carbon Steels:	Low	85-125	80-95	S
	Medium	125-175	70-85	S
	High	175-225	45-65	S
Steels, Alloyed		< 200	60-90	S
		200-300	40-70	S
		over 300	20-30	S
Steel Drop Forgings, Heat Treated		330-370	30-40	C
		370-420	20-30	C
		>420	10-20	C
Gray Cast Iron:	Soft	125	140-150	D
	Medium	120-200	50-80	S
	Hard	up to 350	25-40	S
Titanium Alloys:	(Ti)-75A	300-440	50-60	C
	Ti-150A, RS-120	300-440	40-50	C
	Ti-140A, RC 130B	300-440	30-40	C
	Ti-6AL-4V	300-440	20-30	C
Stainless Steels:	300 Series	120-200	20-40	C
	400 Series	200-300	40-70	C
	Martensitic 416, 420F416 Plus K, 400F, 4165SE, 440F	135-185	40-50	C
	Precipitation Hardening	325-375	30	C
	Cast	400-450	20	C

Materials		Brinell	SFM	Coolant*
Steel, Heat Resisting		175-225	10-25	C
Nimonic Alloys		200-300	10-20	C
Manganese 12-14% min		125-220	10-12	C
Spring Steels		402	15-30	S
Armor Plate		200-250	40	S
		250-300	35	S
		300-350	30	C
Nonferrous Materials				
Aluminums:	Pure	140-350	130-200	S
	Alloys	140-330	150-300	S
	Leaded	40-100	200-325	S
	Silicon Alloy Die Cast	40-100	25-50	S
Brass		190-210	200-250	S or C
Bronze		150-200	200-250	S
Copper, Nickel & Copper Tin Alloy		65-100	140-200	S or C
Copper Aluminum Alloys		30-100	120-200	S or C
Magnesium Alloys:	Wrought	50-90	140-330	S or C
	Cast	50-90	140-365	S or C
Nickel Alloys Wrought & Cast Monel		80-170	70	S or C
		115-240	55	S or C
Beryllium Nickel		200-250	12	S
Zinc Alloy		112-126	200-250	S

*S = Soluble Oil; C = Cutting Oil, D = Dry

SUGGESTIONS FOR REGRINDING DRILLS

TO get the maximum efficiency and full life of a drill, it is absolutely essential that it be properly ground at the point. The two cutting edges must be (1st) of exactly the same length, (2nd) of the same inclination to the axis of the drill. 59° is recommended as the best angle for ordinary purposes (see Fig. 1).

Another important consideration in grinding drill points is the angle of lip relief, or the proper backing off of the cutting edges. This angle should be measured immediately back of the cutting edge as shown in Fig. 2. The angle varies according to the drill diameter:

Drill Size	Lip Relief
1/32	25°
1/16	22°
1/8	18°
1/4	16°
1/2	11°
1	8°
2	7°
3	6°

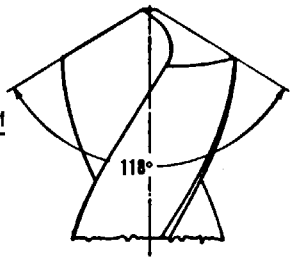


Figure 1

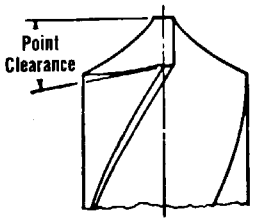


Figure 2

The relief angle, however, should be gradually increased as the center of the drill is approached, until the line across the center of the web stands at an angle with the cutting edges of approximately 123±5°, as shown in Fig. 3.

For a heavy feed in soft material the angle of lip relief may be increased slightly, but care should be taken that the angle at the center is given a corresponding increase. The failure to give sufficient angle of lip relief at the center of the drill is the principal cause of splitting drills up the web.

If you are having trouble with your drills examine the grinding of the points.

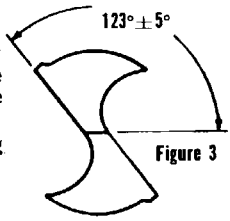


Figure 3

THE LITTLE DOCTOR
A FIRST AID FOR DRILL PRESS OPERATORS

SYMPTOMS	PROBABLE CAUSE	REMEDY
BREAKING of drill.	Spring or back lash in press or work. Too little lip relief. Too low speed in proportion to the feed. Dull drill. Improper chip clearing by drill.	Test press and work for rigidity and alignment. Regrind properly. Increase speed or decrease feed. Sharpen drill. Correct application.
BREAKING down of outer corners of cutting edges.	Material being drilled has hard spots, scale or sand inclusions. Too much speed. Improper cutting compound. No lubricant at point of drill. Improper chip clearing by drill.	Reduce speed. Use proper cutting compound. Correct application.
BREAKING of drill when drilling brass or wood.	Chips clog up flutes.	Increase speed. Use drills designed for these materials.
BROKEN TANG.	Imperfect fit of taper shank in the socket—due to nicks, dirt, burrs, or worn out socket.	Get a new socket or ream old one to prevent recurrence.
CHIPPING of margin.	Oversize jig bushing.	Use proper size bushing.
CHIPPING of lip or cutting edges.	Too much feed. Too much lip relief.	Reduce feed—see table on previous page. Regrind properly.
CHIPPING or checking of a high speed drill.	Heated and cooled too quickly while grinding or while drilling. Too much feed.	Warm slowly before using. Do not throw cold water on hot drill while grinding or drilling. Reduce feed.
HOLE too large.	Unequal angle or length of the cutting edges—or both. Loose spindle.	Regrind properly. Test spindle for rigidity.
ONLY one lip cutting.	Unequal length or angle of cutting lips or both.	Regrind drill properly.
SPLITTING up center.	Too little lip relief. Too much feed.	Regrind with proper lip relief. Reduce feed.
ROUGH HOLE.	Dull or improperly ground drill. Lack of lubricant or wrong lubricant. Improper set-up. Too much feed.	Regrind properly. Lubricate or change lubricant. Reduce feed.

REAMING HINTS

REAMING SPEEDS—Speeds for machine reaming may vary considerably depending in part on the material to be reamed, type of machine, and required finish and accuracy. In general most machine reaming is done at about ⅔ the speed used for drilling the same material. Speeds for drilling are shown on page 13.

REAMING FEEDS—Feeds for reaming are usually much higher than those used for drilling, often running 200 to 300% of drill feeds. Too low a feed may result in excessive reamer wear. At all times it is necessary that the feed be high enough to permit the reamer to cut rather than to rub or burnish. Too high a feed may tend to reduce the accuracy of the hole and may also lower the quality of the finish. The basic idea is to use as high a feed as possible and still produce the required finish and accuracy.

STOCK TO BE REMOVED—For the same reason, insufficient stock for reaming may result in a burnishing rather than a cutting action. It is very difficult to generalize on this phase as it is tied in closely with type of material, feed, finish required, depth of hole, and chip capacity of the reamer. For machine reaming, .010" on a ¼" hole, .015" on a ½" hole, up to .025" on a 1½" hole, seems a good starting point. For hand reaming, stock allowances are much smaller, partly because of the difficulty in forcing the reamer through greater stock. A common allowance is .001" to .003".

ALIGNMENT—In the ideal reaming job, the spindle, reamer, bushing, and hole to be machined are all in perfect alignment. Any variation from this tends to increase reamer wear and detracts from the accuracy of the hole. Tapered, oversize, or bell-mouthed holes should call for a check of alignment. Sometimes the bad effects of misalignment can be reduced through the use of floating or adjustable holder. Quite often if the user will grind a slight back taper on the reamer it will be of help in overcoming the effects of misalignment.

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

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

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

COOLANT—In reaming, the emphasis is usually on finish and a coolant is normally chosen for this purpose rather than for cooling. Quite often this means a change from that recommended for drilling as shown on page 13 but in general this list will be found satisfactory.

REAMER REGRINDING—In obtaining maximum economy from reamers the same principles apply as in the case of most other cutting tools. One of these principles is not to allow a tool to become too dull. It is best practice to regrind the chamfer on a reamer long before it exhibits excessive wear or refuses to cut. This sharpening is usually restricted to the entering taper or chamfer. It can be done on almost any tool and cutter grinder. Care must be taken so that each flute is ground exactly even or the tool is apt to cut oversize.

Sharpening the chamfer on a reamer by hand is not recommended as it is practically impossible to keep the cutting edges even.

The following figures show three common types of grinds used on reamers:

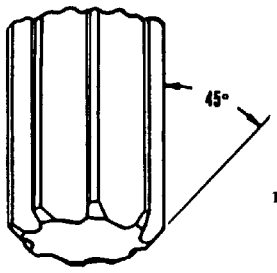


Figure A
Ordinary reamer point for most jobs.

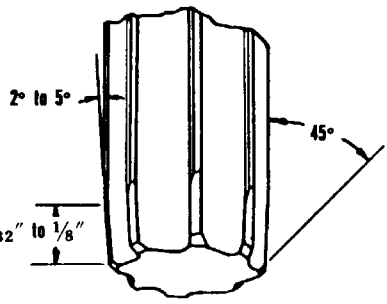


Figure B
Hand reamer grind also used on some machine reamer applications to obtain required finish or tolerance.

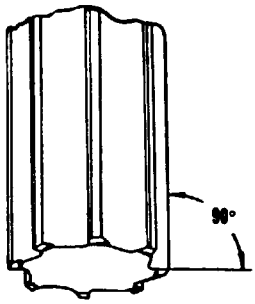
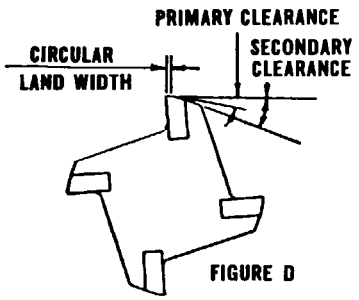


Figure C
Semi finish reamer grind to straighten out bent or misaligned holes. Corners must be kept sharp.

In grinding down a reamer to special size it is usually necessary to relieve or clear the lands. No hard or fast rule may be given as to the amount of this clearance but the following table may be of help:

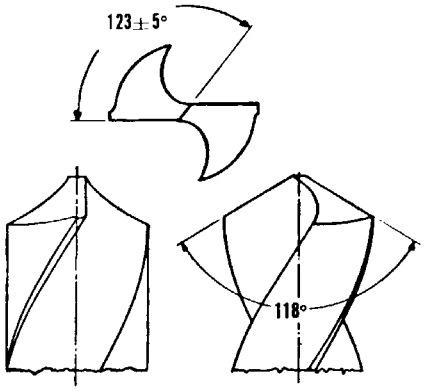
Size of Reamer	Circular Land Width	Primary Clearance
¼"	.007	14°
½"	.009	11°
1"	.013	9°
1½"	.016	7°
2"	.023	7°

CARE OF REAMERS—Reamers are precision tools and careful treatment of their cutting edges will pay big dividends in smooth accurate holes and long life. The use of racks, containers, or boxes will be of great help in preventing nicks along the cutting edges.



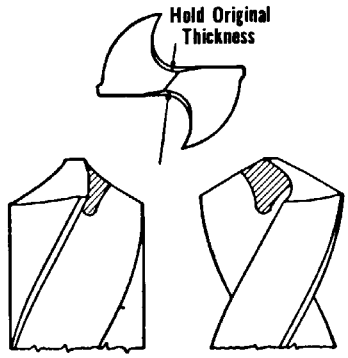
A secondary clearance is often ground on reamers as shown in Fig. D. This clearance is only to insure the back of the land being well away from the wall of the reamed hole in order to prevent rubbing.

METHODS OF POINTING AND THINNING DRILLS



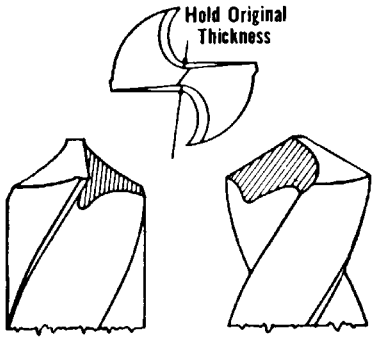
REGULAR DRILL POINT

Standard Point for a General Use.



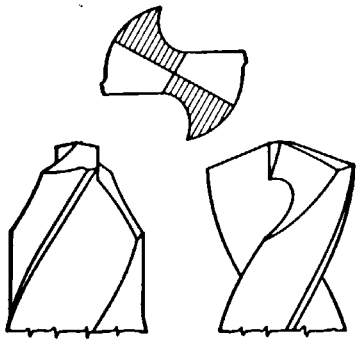
THINNED POINT

Usual method of thinning the point of a drill when the web has become too thick because of repeated re-pointing.



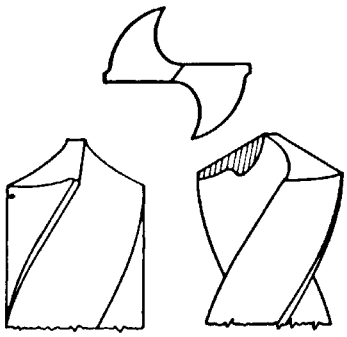
UNDERCUT THINNED POINT

Another common method of web thinning. If properly done this type of thinning will produce a fine curled chip.



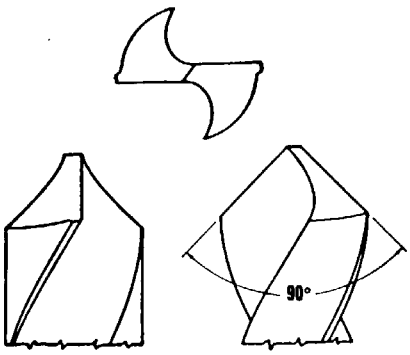
OFFSET POINT

General method of thinning and pointing heavy web drills.



REDUCED RAKE POINT

The added strength of the cutting edge is of help in drilling very hard material. Also used for shallow holes in any material to prevent "grabbing" when breaking through the bottom of the hole.



LONG POINT

Often used in softer materials such as plastics, wood, cast-iron, etc.