MAX MACHINING

Sheet Gauge Chart

Gauge to decimal thickness. Carbon steel, galvanized steel, stainless steel, aluminum. Inches with millimeters.

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Gauge to decimal

INCHES WITH MILLIMETERS

GAUGE	CARBON STEEL Mfrs. Std. Gauge	GALVANIZED STEEL Mfrs. Std. Gauge	STAINLESS STEEL U.S. Standard	ALUMINUM Brown and Sharpe
3	.2391 6.07 mm	·	·	.2294 5.83 mm
4	.2242 5.69 mm	·	·	.2043 5.19 mm
5	.2092 5.31 mm	·	·	.1819 4.62 mm
6	.1943 4.94 mm	·	·	.1620 4.11 mm
7	.1793 4.55 mm	·	.1875 4.76 mm	.1443 3.67 mm
8	.1644 4.18 mm	.1681 4.27 mm	.1719 4.37 mm	.1285 3.26 mm
9	.1495 3.80 mm	.1532 3.89 mm	.1563 3.97 mm	.1144 2.91 mm
10	.1345 3.42 mm	.1382 3.51 mm	.1406 3.57 mm	.1019 2.59 mm
11	.1196 3.04 mm	.1233 3.13 mm	.1250 3.17 mm	.0907 2.30 mm
12	.1046 2.66 mm	.1084 2.75 mm	.1094 2.78 mm	.0808 2.05 mm
13	.0897 2.28 mm	.0934 2.37 mm	.0938 2.38 mm	.0720 1.83 mm
14	.0747 1.90 mm	.0785 1.99 mm	.0781 1.98 mm	.0641 1.63 mm
15	.0673 1.71 mm	.0710 1.80 mm	.0703 1.79 mm	.0571 1.45 mm
16	.0598 1.52 mm	.0635 1.61 mm	.0625 1.59 mm	.0508 1.29 mm
17	.0538 1.37 mm	.0575 1.46 mm	.0563 1.43 mm	.0453 1.15 mm
18	.0478 1.21 mm	.0516 1.31 mm	.0500 1.27 mm	.0403 1.02 mm
19	.0418 1.06 mm	.0456 1.16 mm	.0438 1.11 mm	.0359 0.91 mm
20	.0359 0.91 mm	.0396 1.01 mm	.0375 0.95 mm	.0320 0.81 mm
21	.0329 0.84 mm	.0366 0.93 mm	.0344 0.87 mm	.0285 0.72 mm
22	.0299 0.76 mm	.0336 0.85 mm	.0313 0.80 mm	.0253 0.64 mm
23	.0269 0.68 mm	.0306 0.78 mm	.0281 0.71 mm	.0226 0.57 mm
24	.0239 0.61 mm	.0276 0.70 mm	.0250 0.64 mm	.0201 0.51 mm
25	.0209 0.53 mm	.0247 0.63 mm	.0219 0.56 mm	.0179 0.45 mm
26	.0179 0.45 mm	.0217 0.55 mm	.0188 0.48 mm	.0159 0.40 mm
28	.0149 0.38 mm	.0187 0.47 mm	.0156 0.40 mm	.0126 0.32 mm
30	.0120 0.30 mm	.0157 0.40 mm	.0125 0.32 mm	.0100 0.25 mm

Common aluminum sheet

DECIMAL, NOT GAUGE

THICKNESS in	METRIC	NEAREST GAUGE
.0250	0.64 mm	22 ga (.0253)
.0320	0.81 mm	20 ga (.0320)
.0400	1.02 mm	18 ga (.0403)
.0500	1.27 mm	16 ga (.0508)
.0630	1.60 mm	14 ga (.0641)
.0800	2.03 mm	12 ga (.0808)
.0900	2.29 mm	11 ga (.0907)
.1000	2.54 mm	10 ga (.1019)
.1250	3.17 mm	8 ga (.1285)
.1600	4.06 mm	6 ga (.1620)
.1900	4.83 mm	no gauge match
.2500	6.35 mm	no gauge match

NOTE

Aluminum is ordered by decimal thickness, not gauge. Steel gauge numbers follow the Manufacturers' Standard Gauge; stainless uses the U.S. Standard gauge, which runs slightly heavier. Mill tolerance applies to every value. For a part that cares about thickness, call out the decimal and the tolerance on the print.

MAX MACHINING

Inch Tap Drill Chart

Unified coarse and fine, #0 to 1 inch. Tap drills at about 75 percent thread with close and free fit clearance drills.

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HOW TO READ IT

Tap drill gives about 75 percent of full thread, the usual shop target. **Close fit** clearance holes are for located hardware, **free fit** for easy assembly. Decimals are nominal drill sizes; the hole a drill actually cuts runs a little larger. Formula: `drill = major - 0.01299 x percent / TPI`

THREAD	TPI	MAJOR in	TAP DRILL 75% thread	CLOSE FIT clearance	FREE FIT clearance
#0-80 UNF	80	.0600	3/64 .0469 1.19 mm	#52 .0635 1.61 mm	#50 .0700 1.78 mm
#1-64 UNC	64	.0730	#53 .0595 1.51 mm	#48 .0760 1.93 mm	#46 .0810 2.06 mm
#1-72 UNF	72	.0730	#53 .0595 1.51 mm	#48 .0760 1.93 mm	#46 .0810 2.06 mm
#2-56 UNC	56	.0860	#50 .0700 1.78 mm	#43 .0890 2.26 mm	#41 .0960 2.44 mm
#2-64 UNF	64	.0860	#50 .0700 1.78 mm	#43 .0890 2.26 mm	#41 .0960 2.44 mm
#3-48 UNC	48	.0990	#47 .0785 1.99 mm	#37 .1040 2.64 mm	#35 .1100 2.79 mm
#3-56 UNF	56	.0990	#45 .0820 2.08 mm	#37 .1040 2.64 mm	#35 .1100 2.79 mm
#4-40 UNC	40	.1120	#43 .0890 2.26 mm	#32 .1160 2.95 mm	#30 .1285 3.26 mm
#4-48 UNF	48	.1120	#42 .0935 2.37 mm	#32 .1160 2.95 mm	#30 .1285 3.26 mm
#5-40 UNC	40	.1250	#38 .1015 2.58 mm	#30 .1285 3.26 mm	#29 .1360 3.45 mm
#5-44 UNF	44	.1250	#37 .1040 2.64 mm	#30 .1285 3.26 mm	#29 .1360 3.45 mm
#6-32 UNC	32	.1380	#36 .1065 2.71 mm	#27 .1440 3.66 mm	#25 .1495 3.80 mm
#6-40 UNF	40	.1380	#33 .1130 2.87 mm	#27 .1440 3.66 mm	#25 .1495 3.80 mm
#8-32 UNC	32	.1640	#29 .1360 3.45 mm	#18 .1695 4.31 mm	#16 .1770 4.50 mm
#8-36 UNF	36	.1640	#29 .1360 3.45 mm	#18 .1695 4.31 mm	#16 .1770 4.50 mm
#10-24 UNC	24	.1900	#25 .1495 3.80 mm	#9 .1960 4.98 mm	#7 .2010 5.11 mm
#10-32 UNF	32	.1900	#21 .1590 4.04 mm	#9 .1960 4.98 mm	#7 .2010 5.11 mm
#12-24 UNC	24	.2160	#16 .1770 4.50 mm	#2 .2210 5.61 mm	#1 .2280 5.79 mm
#12-28 UNF	28	.2160	#14 .1820 4.62 mm	#2 .2210 5.61 mm	#1 .2280 5.79 mm
1/4-20 UNC	20	.2500	#7 .2010 5.11 mm	F .2570 6.53 mm	H .2660 6.76 mm
1/4-28 UNF	28	.2500	#3 .2130 5.41 mm	F .2570 6.53 mm	H .2660 6.76 mm
5/16-18 UNC	18	.3125	F .2570 6.53 mm	P .3230 8.20 mm	Q .3320 8.43 mm
5/16-24 UNF	24	.3125	I .2720 6.91 mm	P .3230 8.20 mm	Q .3320 8.43 mm
3/8-16 UNC	16	.3750	5/16 .3125 7.94 mm	W .3860 9.80 mm	X .3970 10.08 mm
3/8-24 UNF	24	.3750	Q .3320 8.43 mm	W .3860 9.80 mm	X .3970 10.08 mm
7/16-14 UNC	14	.4375	U .3680 9.35 mm	29/64 .4531 11.51 mm	15/32 .4688 11.91 mm
7/16-20 UNF	20	.4375	25/64 .3906 9.92 mm	29/64 .4531 11.51 mm	15/32 .4688 11.91 mm
1/2-13 UNC	13	.5000	27/64 .4219 10.72 mm	33/64 .5156 13.10 mm	17/32 .5312 13.49 mm
1/2-20 UNF	20	.5000	29/64 .4531 11.51 mm	33/64 .5156 13.10 mm	17/32 .5312 13.49 mm
9/16-12 UNC	12	.5625	31/64 .4844 12.30 mm	37/64 .5781 14.68 mm	19/32 .5938 15.08 mm
9/16-18 UNF	18	.5625	33/64 .5156 13.10 mm	37/64 .5781 14.68 mm	19/32 .5938 15.08 mm
5/8-11 UNC	11	.6250	17/32 .5312 13.49 mm	41/64 .6406 16.27 mm	21/32 .6562 16.67 mm
5/8-18 UNF	18	.6250	37/64 .5781 14.68 mm	41/64 .6406 16.27 mm	21/32 .6562 16.67 mm
3/4-10 UNC	10	.7500	21/32 .6562 16.67 mm	49/64 .7656 19.45 mm	25/32 .7812 19.84 mm
3/4-16 UNF	16	.7500	11/16 .6875 17.46 mm	49/64 .7656 19.45 mm	25/32 .7812 19.84 mm
7/8-9 UNC	9	.8750	49/64 .7656 19.45 mm	57/64 .8906 22.62 mm	29/32 .9062 23.02 mm
7/8-14 UNF	14	.8750	13/16 .8125 20.64 mm	57/64 .8906 22.62 mm	29/32 .9062 23.02 mm
1-8 UNC	8	1.0000	7/8 .8750 22.22 mm	1-1/64 1.0156 25.80 mm	1-1/32 1.0312 26.19 mm
1-12 UNF	12	1.0000	59/64 .9219 23.42 mm	1-1/64 1.0156 25.80 mm	1-1/32 1.0312 26.19 mm

MAX MACHINING

Metric Tap Drill Chart

M1.6 to M24, coarse and fine pitch. Tap drill at about 75 percent thread, clearance drills, nearest inch drill.

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THREAD	PITCH mm	MAJOR mm	TAP DRILL 75% thread	NEAREST INCH DRILL	CLOSE FIT clearance	MEDIUM FIT clearance
M1.6 × 0.35	0.35	1.6	**1.25 mm** 0.0492 in	3/64 .0469 1.19 mm	1.7 mm	1.8 mm
M2 × 0.4	0.40	2.0	**1.60 mm** 0.0630 in	1/16 .0625 1.59 mm	2.2 mm	2.4 mm
M2.5 × 0.45	0.45	2.5	**2.05 mm** 0.0807 in	#46 .0810 2.06 mm	2.7 mm	2.9 mm
M3 × 0.5	0.50	3.0	**2.50 mm** 0.0984 in	#40 .0980 2.49 mm	3.2 mm	3.4 mm
M3.5 × 0.6	0.60	3.5	**2.90 mm** 0.1142 in	#33 .1130 2.87 mm	3.7 mm	3.9 mm
M4 × 0.7	0.70	4.0	**3.30 mm** 0.1299 in	#30 .1285 3.26 mm	4.3 mm	4.5 mm
M5 × 0.8	0.80	5.0	**4.20 mm** 0.1654 in	#19 .1660 4.22 mm	5.3 mm	5.5 mm
M6 × 1.0	1.00	6.0	**5.00 mm** 0.1969 in	#9 .1960 4.98 mm	6.4 mm	6.6 mm
M8 × 1.25	1.25	8.0	**6.80 mm** 0.2677 in	H .2660 6.76 mm	8.4 mm	9.0 mm
M8 × 1.0 fine	1.00	8.0	**7.00 mm** 0.2756 in	J .2770 7.04 mm	8.4 mm	9.0 mm
M10 × 1.5	1.50	10.0	**8.50 mm** 0.3346 in	Q .3320 8.43 mm	10.5 mm	11.0 mm
M10 × 1.25 fine	1.25	10.0	**8.80 mm** 0.3465 in	S .3480 8.84 mm	10.5 mm	11.0 mm
M10 × 1.0 fine	1.00	10.0	**9.00 mm** 0.3543 in	T .3580 9.09 mm	10.5 mm	11.0 mm
M12 × 1.75	1.75	12.0	**10.20 mm** 0.4016 in	Y .4040 10.26 mm	13.0 mm	13.5 mm
M12 × 1.5 fine	1.50	12.0	**10.50 mm** 0.4134 in	Z .4130 10.49 mm	13.0 mm	13.5 mm
M12 × 1.25 fine	1.25	12.0	**10.80 mm** 0.4252 in	27/64 .4219 10.72 mm	13.0 mm	13.5 mm
M14 × 2.0	2.00	14.0	**12.00 mm** 0.4724 in	15/32 .4688 11.91 mm	15.0 mm	15.5 mm
M14 × 1.5 fine	1.50	14.0	**12.50 mm** 0.4921 in	31/64 .4844 12.30 mm	15.0 mm	15.5 mm
M16 × 2.0	2.00	16.0	**14.00 mm** 0.5512 in	35/64 .5469 13.89 mm	17.0 mm	17.5 mm
M16 × 1.5 fine	1.50	16.0	**14.50 mm** 0.5709 in	37/64 .5781 14.68 mm	17.0 mm	17.5 mm
M18 × 2.5	2.50	18.0	**15.50 mm** 0.6102 in	39/64 .6094 15.48 mm	19.0 mm	20.0 mm
M20 × 2.5	2.50	20.0	**17.50 mm** 0.6890 in	11/16 .6875 17.46 mm	21.0 mm	22.0 mm
M20 × 1.5 fine	1.50	20.0	**18.50 mm** 0.7283 in	47/64 .7344 18.65 mm	21.0 mm	22.0 mm
M24 × 3.0	3.00	24.0	**21.00 mm** 0.8268 in	53/64 .8281 21.03 mm	25.0 mm	26.0 mm

HOW TO READ IT

Coarse pitch is the default; fine pitches are marked. The **nearest inch drill** column is for when the metric drill is not in the cabinet; check the thread percentage before committing. Formula: `drill = major - pitch x percent / 76.98`

MAX MACHINING

Helical Insert Tap Drill Chart

STI drill sizes for wire thread inserts (screw thread insert), inch and metric.

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Inch UNIFIED COARSE AND FINE

THREAD insert size	STI TAP DRILL
#2-56	#44 .0860 2.18 mm
#4-40	#33 .1130 2.87 mm
#4-48	#32 .1160 2.95 mm
#6-32	#26 .1470 3.73 mm
#6-40	#28 .1405 3.57 mm
#8-32	#17 .1730 4.39 mm
#8-36	#18 .1695 4.31 mm
#10-24	#5 .2055 5.22 mm
#10-32	#6 .2040 5.18 mm
1/4-20	17/64 .2656 6.75 mm
1/4-28	G .2610 6.63 mm
5/16-18	Q .3320 8.43 mm
5/16-24	21/64 .3281 8.33 mm
3/8-16	X .3970 10.08 mm
3/8-24	25/64 .3906 9.92 mm
7/16-14	29/64 .4531 11.51 mm
7/16-20	29/64 .4531 11.51 mm
1/2-13	33/64 .5156 13.10 mm
1/2-20	33/64 .5156 13.10 mm
9/16-12	37/64 .5781 14.68 mm
9/16-18	37/64 .5781 14.68 mm
5/8-11	41/64 .6406 16.27 mm
5/8-18	41/64 .6406 16.27 mm
3/4-10	49/64 .7656 19.45 mm
3/4-16	49/64 .7656 19.45 mm
7/8-9	57/64 .8906 22.62 mm
1-8	1-1/64 1.0156 25.80 mm

Metric COARSE

THREAD insert size	STI TAP DRILL	NEAREST INCH DRILL
M3 × 0.5	3.20 mm 0.1260 in	1/8 .1250
M4 × 0.7	4.20 mm 0.1654 in	#19 .1660
M5 × 0.8	5.20 mm 0.2047 in	#6 .2040
M6 × 1.0	6.30 mm 0.2480 in	E .2500
M8 × 1.25	8.40 mm 0.3307 in	Q .3320
M10 × 1.5	10.50 mm 0.4134 in	Z .4130
M12 × 1.75	12.50 mm 0.4921 in	31/64 .4844
M14 × 2.0	14.50 mm 0.5709 in	37/64 .5781
M16 × 2.0	16.50 mm 0.6496 in	21/32 .6562
M20 × 2.5	20.75 mm 0.8169 in	13/16 .8125

CAUTION

These holes are oversize on purpose. They take an **STI tap** for the same thread, never a standard tap. Insert makers publish their own drill sizes and they vary slightly by brand and tolerance class. Verify against the data for the insert you stock before cutting.

WHY INSERTS

Full strength threads in aluminum, magnesium and plastics, and a clean repair for a stripped hole. Drill, tap with the STI tap, install the insert, break the tang.

MAX MACHINING

Form Tap Drill Chart

Roll form (thread forming) tap drills at 65 percent thread, inch and metric, with the thread percentage each standard drill gives.

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Inch 65 PERCENT THREAD

THREAD	TPI	MAJOR in	65% DRILL calculated	USE THIS DRILL nearest, inch or metric	THREAD YOU GET
#4-40	40	.1120	.1009	**#38** .1015 2.58 mm	62%
#6-32	32	.1380	.1242	**1/8** .1250 3.17 mm	61%
#8-32	32	.1640	.1502	**#25** .1495 3.80 mm	68%
#10-24	24	.1900	.1716	**11/64** .1719 4.37 mm	64%
#10-32	32	.1900	.1762	**#16** .1770 4.50 mm	61%
1/4-20	20	.2500	.2279	**#1** .2280 5.79 mm	65%
1/4-28	28	.2500	.2342	**15/64** .2344 5.95 mm	64%
5/16-18	18	.3125	.2879	**7.30 mm** .2874	66%
5/16-24	24	.3125	.2941	**M** .2950 7.49 mm	62%
3/8-16	16	.3750	.3474	**S** .3480 8.84 mm	64%
3/8-24	24	.3750	.3566	**T** .3580 9.09 mm	60%
7/16-14	14	.4375	.4059	**13/32** .4062 10.32 mm	64%
7/16-20	20	.4375	.4154	**Z** .4130 10.49 mm	72%
1/2-13	13	.5000	.4660	**11.80 mm** .4646	68%
1/2-20	20	.5000	.4779	**12.10 mm** .4764	69%

Metric 65 PERCENT THREAD

THREAD	PITCH mm	MAJOR mm	65% DRILL calculated	USE THIS DRILL nearest, metric or inch	THREAD YOU GET
M3 × 0.5	0.50	3.0	2.78	**2.80 mm** .1102 in	59%
M4 × 0.7	0.70	4.0	3.69	**3.70 mm** .1457 in	63%
M5 × 0.8	0.80	5.0	4.65	**#14** .1820 4.62 mm	69%
M6 × 1.0	1.00	6.0	5.56	**7/32** .2188 5.56 mm	65%
M8 × 1.25	1.25	8.0	7.45	**7.40 mm** .2913 in	71%
M10 × 1.5	1.50	10.0	9.34	**U** .3680 9.35 mm	64%
M12 × 1.75	1.75	12.0	11.23	**11.20 mm** .4409 in	67%

THE RULE

`drill = major - 0.442 x pitch` gives 65 percent thread, the usual form tap target. We list the nearest standard drill, inch or metric, and the thread percentage it actually gives. Where the nearest drill lands far from 65 percent, ask us or the tap maker for the hole size window.

CAUTION

Form taps make no chips, so blind holes stay clean and the thread is stronger. The trade: the hole size window is tight, and only ductile materials roll well. Aluminum, brass, copper and low carbon steel are good. Stainless works with the right tap and lubricant. Cast iron and hardened steel do not. Confirm with the tap maker's chart.

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Drill Size Chart

Number drills #80 to #1, letter drills A to Z, fractional drills 1/64 to 1 inch. Decimal inch and millimeter, in size order.

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DRILL	INCH	MM	DRILL	INCH	MM	DRILL	INCH	MM	DRILL	INCH	MM	DRILL	INCH	MM
#80	.0135	0.34	#50	.0700	1.78	#22	.1570	3.99	G	.2610	6.63	31/64	.4844	12.30
#79	.0145	0.37	#49	.0730	1.85	#21	.1590	4.04	17/64	.2656	6.75	1/2	.5000	12.70
1/64	.0156	0.40	#48	.0760	1.93	#20	.1610	4.09	H	.2660	6.76	33/64	.5156	13.10
#78	.0160	0.41	5/64	.0781	1.98	#19	.1660	4.22	I	.2720	6.91	17/32	.5312	13.49
#77	.0180	0.46	#47	.0785	1.99	#18	.1695	4.31	J	.2770	7.04	35/64	.5469	13.89
#76	.0200	0.51	#46	.0810	2.06	11/64	.1719	4.37	K	.2810	7.14	9/16	.5625	14.29
#75	.0210	0.53	#45	.0820	2.08	#17	.1730	4.39	9/32	.2812	7.14	37/64	.5781	14.68
#74	.0225	0.57	#44	.0860	2.18	#16	.1770	4.50	L	.2900	7.37	19/32	.5938	15.08
#73	.0240	0.61	#43	.0890	2.26	#15	.1800	4.57	M	.2950	7.49	39/64	.6094	15.48
#72	.0250	0.64	#42	.0935	2.37	#14	.1820	4.62	19/64	.2969	7.54	5/8	.6250	15.88
#71	.0260	0.66	3/32	.0938	2.38	#13	.1850	4.70	N	.3020	7.67	41/64	.6406	16.27
#70	.0280	0.71	#41	.0960	2.44	3/16	.1875	4.76	5/16	.3125	7.94	21/32	.6562	16.67
#69	.0292	0.74	#40	.0980	2.49	#12	.1890	4.80	O	.3160	8.03	43/64	.6719	17.07
#68	.0310	0.79	#39	.0995	2.53	#11	.1910	4.85	P	.3230	8.20	11/16	.6875	17.46
1/32	.0312	0.79	#38	.1015	2.58	#10	.1935	4.91	21/64	.3281	8.33	45/64	.7031	17.86
#67	.0320	0.81	#37	.1040	2.64	#9	.1960	4.98	Q	.3320	8.43	23/32	.7188	18.26
#66	.0330	0.84	#36	.1065	2.71	#8	.1990	5.05	R	.3390	8.61	47/64	.7344	18.65
#65	.0350	0.89	7/64	.1094	2.78	#7	.2010	5.11	11/32	.3438	8.73	3/4	.7500	19.05
#64	.0360	0.91	#35	.1100	2.79	13/64	.2031	5.16	S	.3480	8.84	49/64	.7656	19.45
#63	.0370	0.94	#34	.1110	2.82	#6	.2040	5.18	T	.3580	9.09	25/32	.7812	19.84
#62	.0380	0.97	#33	.1130	2.87	#5	.2055	5.22	23/64	.3594	9.13	51/64	.7969	20.24
#61	.0390	0.99	#32	.1160	2.95	#4	.2090	5.31	U	.3680	9.35	13/16	.8125	20.64
#60	.0400	1.02	#31	.1200	3.05	#3	.2130	5.41	3/8	.3750	9.52	53/64	.8281	21.03
#59	.0410	1.04	1/8	.1250	3.17	7/32	.2188	5.56	V	.3770	9.58	27/32	.8438	21.43
#58	.0420	1.07	#30	.1285	3.26	#2	.2210	5.61	W	.3860	9.80	55/64	.8594	21.83
#57	.0430	1.09	#29	.1360	3.45	#1	.2280	5.79	25/64	.3906	9.92	7/8	.8750	22.22
#56	.0465	1.18	#28	.1405	3.57	A	.2340	5.94	X	.3970	10.08	57/64	.8906	22.62
3/64	.0469	1.19	9/64	.1406	3.57	15/64	.2344	5.95	Y	.4040	10.26	29/32	.9062	23.02
#55	.0520	1.32	#27	.1440	3.66	B	.2380	6.05	13/32	.4062	10.32	59/64	.9219	23.42
#54	.0550	1.40	#26	.1470	3.73	C	.2420	6.15	Z	.4130	10.49	15/16	.9375	23.81
#53	.0595	1.51	#25	.1495	3.80	D	.2460	6.25	27/64	.4219	10.72	61/64	.9531	24.21
1/16	.0625	1.59	#24	.1520	3.86	E	.2500	6.35	7/16	.4375	11.11	31/32	.9688	24.61
#52	.0635	1.61	#23	.1540	3.91	1/4	.2500	6.35	29/64	.4531	11.51	63/64	.9844	25.00
#51	.0670	1.70	5/32	.1562	3.97	F	.2570	6.53	15/32	.4688	11.91	1	1.0000	25.40

LEGEND

Number drills #80 to #1, **letter drills** A to Z, **fractional drills** 1/64 to 1 inch, in order of size. Metric values are exact conversions of the nominal inch size.

MAX MACHINING

Hole and Hardware Chart

Countersinks, counterbores, PEM self clinching hole sizes, NPT pipe tap drills.

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Countersinks THEORETICAL SHARP Ø, 82°

SCREW	FLAT HEAD MACHINE SCREW ASME B18.6.3, 82°	FLAT SOCKET HEAD CAP SCREW ASME B18.3, 82°
#2	.1720 4.37 mm	.1970 5.00 mm
#3	.1990 5.05 mm	.2260 5.74 mm
#4	.2250 5.71 mm	.2550 6.48 mm
#5	.2520 6.40 mm	.2810 7.14 mm
#6	.2790 7.09 mm	.3070 7.80 mm
#8	.3320 8.43 mm	.3590 9.12 mm
#10	.3850 9.78 mm	.4110 10.44 mm
#12	.4380 11.13 mm	·
1/4	.5070 12.88 mm	.5310 13.49 mm
5/16	.6350 16.13 mm	.6560 16.66 mm
3/8	.7620 19.35 mm	.7810 19.84 mm
7/16	.8120 20.62 mm	.8440 21.44 mm
1/2	.8750 22.22 mm	.9380 23.83 mm
5/8	1.1250 28.57 mm	1.1880 30.18 mm
3/4	1.3750 34.92 mm	1.4380 36.53 mm

COUNTERSINK CALLOUT

Diameters are the theoretical sharp corner of the head. A head sits flush when the countersink is at or a few thousandths over this value. Flat head machine screws and flat socket heads differ, so pick the right column. Typical callout: ⌵ Ø.385 X 82°

Metric countersinks ISO 10642, 90°

SCREW	FLAT SOCKET HEAD ISO 10642, 90°
M3	6.72 mm 0.265 in
M4	8.96 mm 0.353 in
M5	11.20 mm 0.441 in
M6	13.44 mm 0.529 in
M8	17.92 mm 0.706 in
M10	22.40 mm 0.882 in
M12	26.88 mm 1.058 in
M16	33.60 mm 1.323 in
M20	40.32 mm 1.587 in

Counterbores, metric ASME B18.3.1M

SCREW SHCS	COUNTERBORE Ø	DEPTH head height	CLOSE FIT HOLE	MEDIUM FIT HOLE
M3	6.5 mm 0.256 in	3.0 mm	3.2 mm	3.4 mm
M4	8.0 mm 0.315 in	4.0 mm	4.3 mm	4.5 mm
M5	10.0 mm 0.394 in	5.0 mm	5.3 mm	5.5 mm
M6	11.0 mm 0.433 in	6.0 mm	6.4 mm	6.6 mm
M8	15.0 mm 0.591 in	8.0 mm	8.4 mm	9.0 mm
M10	18.0 mm 0.709 in	10.0 mm	10.5 mm	11.0 mm
M12	20.0 mm 0.787 in	12.0 mm	13.0 mm	13.5 mm
M16	26.0 mm 1.024 in	16.0 mm	17.0 mm	17.5 mm
M20	33.0 mm 1.299 in	20.0 mm	21.0 mm	22.0 mm

Counterbores, inch SOCKET HEAD CAP SCREWS, ASME B18.3

SCREW SHCS	COUNTERBORE Ø	DEPTH head height	CLOSE FIT HOLE	FREE FIT HOLE
#2	.1880 4.78 mm	.0860 2.18 mm	#43 .0890 2.26 mm	#41 .0960 2.44 mm
#4	.2190 5.56 mm	.1120 2.84 mm	#32 .1160 2.95 mm	#30 .1285 3.26 mm
#5	.2500 6.35 mm	.1250 3.17 mm	#30 .1285 3.26 mm	#29 .1360 3.45 mm
#6	.2810 7.14 mm	.1380 3.51 mm	#27 .1440 3.66 mm	#25 .1495 3.80 mm
#8	.3120 7.92 mm	.1640 4.17 mm	#18 .1695 4.31 mm	#16 .1770 4.50 mm
#10	.3750 9.52 mm	.1900 4.83 mm	#9 .1960 4.98 mm	#7 .2010 5.11 mm
1/4	.4380 11.13 mm	.2500 6.35 mm	F .2570 6.53 mm	H .2660 6.76 mm
5/16	.5310 13.49 mm	.3120 7.92 mm	P .3230 8.20 mm	Q .3320 8.43 mm
3/8	.6250 15.88 mm	.3750 9.52 mm	W .3860 9.80 mm	X .3970 10.08 mm
7/16	.7190 18.26 mm	.4380 11.13 mm	29/64 .4531 11.51 mm	15/32 .4688 11.91 mm
1/2	.8120 20.62 mm	.5000 12.70 mm	33/64 .5156 13.10 mm	17/32 .5312 13.49 mm
5/8	1.0000 25.40 mm	.6250 15.88 mm	41/64 .6406 16.27 mm	21/32 .6562 16.67 mm
3/4	1.1880 30.18 mm	.7500 19.05 mm	49/64 .7656 19.45 mm	25/32 .7812 19.84 mm
1	1.6250 41.27 mm	1.0000 25.40 mm	1-1/64 1.0156 25.80 mm	1-1/32 1.0312 26.19 mm

COUNTERBORE CALLOUT

Depth equals the head height so the head sits flush. Add a few thousandths for a washer or coating. Typical callout: Ø.2660 THRU, ⌴ Ø.438 ↧ .250

PEM self clinching hardware HOLE SIZE IN SHEET, FROM THE PENNENGINEERING DATA SHEETS

Nuts, S / SS / CLS / CLSS, inch

THREAD (CODE)	HOLE IN SHEET in	MIN SHEET -0 in	MIN SHEET -1 in	MIN SHEET -2 in	MIN SHEET -3 in
#4-40 (440)	.1660 +.003 / -.000	.0300	.0400	.0560	.0900
#6-32 (632)	.1875 +.003 / -.000	.0300	.0400	.0560	.0900
#8-32 (832)	.2130 +.003 / -.000	.0300	.0400	.0560	.0900
#10-32 (032)	.2500 +.003 / -.000	.0300	.0400	.0560	.0900
1/4-20 (0420)	.3440 +.003 / -.000	.0470	.0560	.0900	.1250
5/16-18 (0518)	.4130 +.003 / -.000	·	.0560	.0900	.1250
3/8-16 (0616)	.5000 +.003 / -.000	·	.0900	.1250	.2500

Nuts, S / SS / CLS / CLSS, metric

THREAD	HOLE IN SHEET mm	MIN SHEET -00 mm	MIN SHEET -0 mm	MIN SHEET -1 mm	MIN SHEET -2 mm
M3	4.22 mm +0.08	·	0.80	1.00	1.40
M4	5.41 mm +0.08	·	0.80	1.00	1.40
M5	6.35 mm +0.08	·	0.80	1.00	1.40
M6	8.75 mm +0.08	0.92	1.20	1.40	2.29
M8	10.50 mm +0.08	·	·	1.40	2.29
M10	14.00 mm +0.08	·	·	2.29	3.18

Pipe tap drills, NPT, no reamer

PIPE THREAD NPT	TPI	TAP DRILL no reamer
1/16-27	27	D .2460 6.25 mm
1/8-27	27	R .3390 8.61 mm
1/4-18	18	7/16 .4375 11.11 mm
3/8-18	18	37/64 .5781 14.68 mm
1/2-14	14	23/32 .7188 18.26 mm
3/4-14	14	59/64 .9219 23.42 mm
1-11.5	11.5	1-5/32 1.1562 29.37 mm
1-1/4-11.5	11.5	1-1/2 1.5000 38.10 mm
1-1/2-11.5	11.5	1-47/64 1.7344 44.05 mm
2-11.5	11.5	2-7/32 2.2188 56.36 mm

Flush head studs, FH / FHS

THREAD FH / FHS	HOLE IN SHEET in	MIN SHEET in
#4-40	.1110 +.003 / -.000	.0400
#6-32	.1370 +.003 / -.000	.0400
#8-32	.1630 +.003 / -.000	.0400
#10-32	.1890 +.003 / -.000	.0400
1/4-20	.2490 +.003 / -.000	.0620
5/16-18	.3110 +.003 / -.000	.0930

THREAD FH / FHS	HOLE IN SHEET mm	MIN SHEET mm
M3	3.00 mm +0.08	1.0 mm
M3.5	3.50 mm +0.08	1.0 mm
M4	4.00 mm +0.08	1.0 mm
M5	5.00 mm +0.08	1.0 mm
M6	6.00 mm +0.08	1.6 mm
M8	8.00 mm +0.08	2.4 mm

Thru threaded standoffs, SO / SOS / SOA

THREAD SO / SOS / SOA	HOLE IN SHEET in	MIN SHEET in
#4-40	.1660 +.003 / -.000	.0400
#6-32	.2130 +.003 / -.000	.0400
#8-32	.2810 +.003 / -.000	.0500
#10-32	.2810 +.003 / -.000	.0500

THREAD SO / SOS / SOA	HOLE IN SHEET mm	MIN SHEET mm
M3	4.22 mm +0.08 / -0.13	1.00 mm
M3.5	5.41 mm +0.08 / -0.13	1.00 mm
M4	7.14 mm +0.08 / -0.13	1.27 mm
M5	7.14 mm +0.08 / -0.13	1.27 mm

CAUTION

Hole sizes and minimum sheet thickness are from the PennEngineering data sheets for the **S, SS, CLS, FH, FHS and SO** families. Other brands and other families (stainless sheet types, miniature, floating) differ. Hole size is a maximum as well as a minimum: oversize and the hardware spins. Verify the exact part number against its data sheet before you cut.

PIPE THREADS

Drill, then taper ream for the cleanest NPT thread; these drill sizes are for tapping without a reamer. Tap depth sets the fit: gage with an L1 ring or plug. NPTF (dryseal) uses the same drills and needs a reamer.

MAX MACHINING

Tolerance and Finish Chart

ISO 2768 general tolerances, surface roughness, thread classes, and the Max Machining laser cut tolerance guide.

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ISO 2768-1 general tolerances LINEAR DIMENSIONS, MM, PLUS OR MINUS

CLASS	0.5 TO 3 mm	3 TO 6 mm	6 TO 30 mm	30 TO 120 mm	120 TO 400 mm	400 TO 1000 mm	1000 TO 2000 mm	2000 TO 4000 mm
f (fine)	±0.05	±0.05	±0.1	±0.15	±0.2	±0.3	±0.5	·
m (medium)	±0.1	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2
c (coarse)	±0.2	±0.3	±0.5	±0.8	±1.2	±2	±3	±4
v (very coarse)	·	±0.5	±1	±1.5	±2.5	±4	±6	±8

External radii and chamfer heights (mm)

CLASS	0.5 TO 3 mm	3 TO 6 mm	OVER 6 mm
f and m	±0.2	±0.5	±1
c and v	±0.4	±1	±2

Angular, by length of the shorter side (mm)

CLASS	UP TO 10 mm, shorter side	10 TO 50 mm, shorter side	50 TO 120 mm, shorter side	120 TO 400 mm, shorter side	OVER 400 mm, shorter side
f and m	±1°	±0°30'	±0°20'	±0°10'	±0°5'
c	±1°30'	±1°	±0°30'	±0°15'	±0°10'
v	±3°	±2°	±1°	±0°30'	±0°20'

HOW TO CALL IT OUT

`ISO 2768-mK` on the title block means medium linear tolerances and class K geometric tolerances for everything not dimensioned otherwise. Inch prints usually carry a block instead: `.X ±.030 .XX ±.010 .XXX ±.005 ANGLES ±0°30'` . Both are fine. Say which.

ISO 2768-2 general geometric tolerances MM

Straightness and flatness, by length

CLASS	UP TO 10 mm	10 TO 30 mm	30 TO 100 mm	100 TO 300 mm	300 TO 1000 mm	1000 TO 3000 mm
H	0.02	0.05	0.1	0.2	0.3	0.4
K	0.05	0.1	0.2	0.4	0.6	0.8
L	0.1	0.2	0.4	0.8	1.2	1.6

Perpendicularity, by shorter side

CLASS	UP TO 100 mm	100 TO 300 mm	300 TO 1000 mm	1000 TO 3000 mm
H	0.2	0.3	0.4	0.5
K	0.4	0.6	0.8	1
L	0.6	1	1.5	2

Symmetry, by length

CLASS	UP TO 100 mm	100 TO 300 mm	300 TO 1000 mm	1000 TO 3000 mm
H	0.5	0.5	0.5	0.5
K	0.6	0.6	0.8	1
L	0.6	1	1.5	2

Circular runout

CLASS	CIRCULAR RUNOUT mm
H	0.1
K	0.2
L	0.5

Surface roughness RA, WITH THE PROCESS THAT MAKES IT

GRADE ISO 1302	RA µm	RA µin	TYPICAL PROCESS	WHERE YOU SEE IT
N12	50	2000	Flame cutting, rough sawing	Raw stock faces
N11	25	1000	Sand casting, hot rolling, rough turning	Casting skin, hot rolled plate
N10	12.5	500	Rough milling, sawing, laser cut edge as cut (thick)	Non-critical faces
N9	6.3	250	Milling and turning, roughing passes, laser cut edge as cut	Default when nothing is specified
N8	3.2	125	Milling, turning, drilling, laser cut edge deburred	The common "125" callout on machined parts
N7	1.6	63	Fine milling and turning, reaming, boring	Sealing faces, bearing shoulders, cosmetic machined surfaces
N6	0.8	32	Fine turning, fine boring, grinding, reaming	Static seal faces, press fits
N5	0.4	16	Grinding, honing, fine reaming	Dynamic seals, bearing journals
N4	0.2	8	Honing, lapping, polishing	Gage surfaces, hydraulic spools
N3	0.1	4	Lapping, superfinishing	Valve seats, optical mounts
N2	0.05	2	Lapping, polishing	Mirror finishes
N1	0.025	1	Superfinishing	Gage blocks

ON THE PRINT

Ra 125 µin (3.2 µm) is the common machined default. Ra 63 is a fine machined finish without grinding. Below Ra 32 you are paying for grinding, honing or lapping, so call it out only where a seal or bearing needs it.

Thread class guide UNIFIED AND METRIC

CLASS	FIT	ALLOWANCE	USE
1A / 1B	Loose	Yes (1A)	Quick assembly, dirty or coated threads, field hardware. Rare on prints.
2A / 2B	Standard	Yes (2A)	The commercial default. Most fasteners, most tapped holes. Assumed when the print is silent.
3A / 3B	Close	None	Aerospace fasteners, socket set screws, anything that must not rattle. Costs more to gage and hold.
6g / 6H	Medium (metric)	Yes (6g)	The metric default, equivalent to 2A / 2B.
4g6g / 4H5H	Close (metric)	Small	Metric close fit, equivalent to 3A / 3B.
8g / 7H	Loose (metric)	Yes	Hot dip galvanized or heavy coated threads.

Laser cut tolerance guide MAX MACHINING, 12 KW FIBER LASER

Typical tolerance by thickness

MATERIAL THICKNESS in	TYPICAL TOLERANCE
up to .060	**±.0050** ±0.13 mm
.061 to .125	**±.0080** ±0.20 mm
.126 to .250	**±.0120** ±0.30 mm
.251 to .500	**±.0150** ±0.38 mm
over .500	**±.0250** ±0.64 mm

Edge finish options

EDGE FINISH	WHAT YOU GET
As cut	Fastest, lowest cost. Visible edge texture, small burr possible.
Deburred	Smooth, safe edges. The most common choice.
Tumbled	Uniform matte, softened edges. A cosmetic step up.
Brushed	Directional grain. Premium appearance for visible panels.
Powder coated	Final product finish. Durable and corrosion resistant, RAL colors.

Minimum hole size, 60 percent of thickness

THICKNESS in	MINIMUM HOLE 60% of thickness
.0600	**.0360** 0.91 mm
.1250	**.0750** 1.90 mm
.1870	**.1120** 2.84 mm
.2500	**.1500** 3.81 mm
.3750	**.2250** 5.71 mm
.5000	**.3000** 7.62 mm

WATCH FOR

Holes under 60 percent of thickness (drill them after). Expecting a cosmetic edge without specifying one. Tight tolerances on laser-only features: anything tighter than the table gets machined after cutting. Ignoring edge condition on parts that get handled or coated.