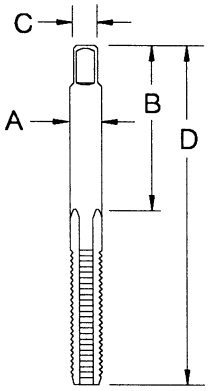
TAPS STANDARDS AND DIMENSIONS

A metric tap with an ANSI shank uses the same Z-Lock holder as an inch tap with the same shank diameter. To determine spindle size for application. Select spindle size at minimum centers or use the basic spindle size. (Ref. Pages 6-7.) Use the charts on this page and the following to specify the holder number.



Inch Series

Tap Size	Shank Dia. A (in.)	Shank Length B (in.)	Size of Square C (in.)	Overall Length D (in.)	Metric Tap Size w/ Inch Shank (mm)
#0-0(.047)					
#0 (.060)	.141	1.312	.110x.187	1.625	M1.6
#1 (.073)				1.687	M1.8
#2 (.086)				1.750	M2,M2.2
#3 (.099)				1.812	M2.5
#4 (.112)				1.875	
#5 (.125)				1.937	M3,M315
#6 (.138)	.141	1.312	.110	2.000	M3.5
#8 (.164)	.168	1.375	.131	2.125	M4
#10 (.190)	.194	1.500	.152	2.375	M4.5,M5
#12 (.216)	.220	1.438	.165	2.375	
1/4 (.250)	.255	1.500	.191	2.500	M6,M6.3
5/16 (.312)	.318	1.593	.238	2.718	M7,M8
3/8 (.375)	.381	1.687	.286	2.937	M10
7/16 (.437)	.323	1.720	.242	3.156	M10
1/2 (.500)	.367	1.720	.275	3.375	M12,M12.5
9/16 (.562)	.429	1.938	.322	3.594	M14
5/8 (.625)	.480	2.000	.360	3.812	M16
11/16 (.687)	.542	2.218	.406	4.031	M18
3/4 (.750)	.590	2.250	.442	4.250	
13/16 (.812)	.652	2.375	.489	4.500	M20
7/8 (.875)	.697	2.468	.523	4.688	M22
15/16 (.937)	.760	2.562	.570	4.875	M24
1 (1.000)	.800	2.625	.600	5.125	M25

Note: Customer to specify M10 shank dimensions.

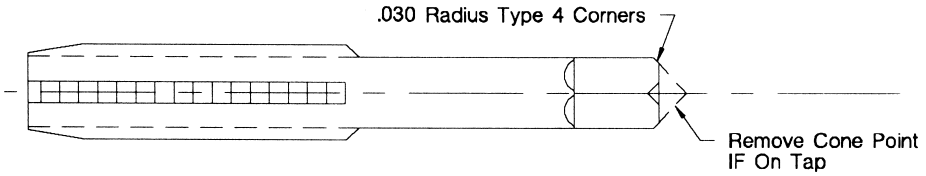
ISO Metric Series

Tap Size	Shank Dia. A	Shank Length B	Size of Square C	Overall Length D
M0.9	2.5 (.098")	17	2.1 x 5	25
M1		18		
M1.1				
M1.2		18		25
M1.4		21		28
M1.6		24		32
M1.7				
M1.8	2.5 (.098")	24		
M2	2.8 (.110")	23		
M2.2				
M2.3		23		32
M2.5		26		36
M2.6	2.8 (.110")	26	2.1 x 5	36
M3	3.5 (.138")	26	2.7 x 6	36
M3.5	4.0 (.157")	29	3.0 x 6	40
M4	4.5 (.177")	28	3.4 x 6	40
M4.5	6.0 (.236")	33	4.9 x 8	45
M5		31		45
M6		34		50
M7		34		50
M8	6.0 (.236")	38	4.9 x 8	56
M9	7.0 (.275")	38	5.5 x 8	56
M10	7.0 (.275")	43	5.5 x 8	63
M11	8.0 (.314")	41	6.2 x 9	63
M12	9.0 (.354")	48	7.0 x 10	70
M14	11.0 (.433")	45	9.0 x 12	70
M16	12.0 (.472")	42	9.0 x 12	70
M18	14.0 (.552")	48	11.0 x 14	80
M20	16.0 (.629")	48	12.0 x 15	80
M22	18.0 (.708")	58	14.5 x 17	90
M24	18.0 (.708")	68	14.5 x 17	100
M27	20.0 (.787")	64	16.0 x 19	100
M30	22.0 (.866")	70	18.0 x 21	110

PROCEDURE FOR GRINDING TAPS for ZLOCK AND SLIP LOCK TAP HOLDERS

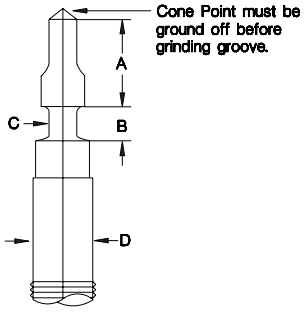
Before inserting taps into holders follow these steps:

(1) If taps have cone points on square, grind off flush with square.
(2) Hand grind and buff a .030 radius on the square end.
(3) Assemble taps into holder by twisting in counter-clockwise until square end engages square hole, then push straight in until tap bottoms.



TAP GROOVE DATA for Tension Tap Holder

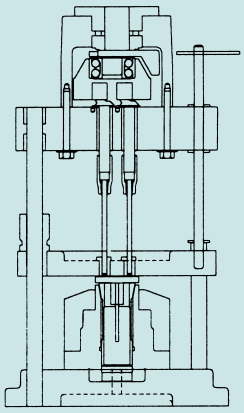
Tap Sz.	#0 (.060) thru #6 (.138)	#8 (.164)	#10 (.190)	#12 (.216)	1/4 (.250)	5/16 (.312)	3/8 (.375)	7/16 (.437)	1/2 (.500)
A	.56 14.22	.56 14.22	.56 14.22	.69 17.53	.66 16.76	.66 16.76	.66 16.76	.66 16.76	.66 16.76
B	.16 4.06	.16 4.06	.16 4.06	.16 4.06	.19 4.83	.19 4.83	.19 4.83	.19 4.83	.19 4.83
C	.090 2.29 .080 2.03	.120 3.05 .110 2.79	.150 3.81 .140 3.56	.175 4.45 .165 4.19	.205 5.21 .195 4.95	.265 6.73 .255 6.48	.325 8.26 .315 8.00	.265 6.73 .255 6.48	.325 8.26 .315 8.00
D	.141 3.58	.168 4.26	.194 4.83	.220 5.59	.255 6.48	.318 8.08	.381 9.68	.323 8.20	.367 9.32

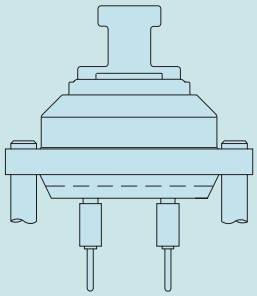


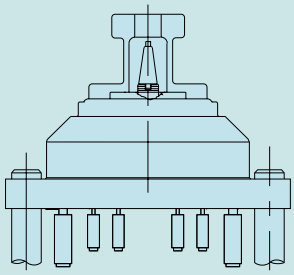
NOTE: Smaller numbers are metric conversions.

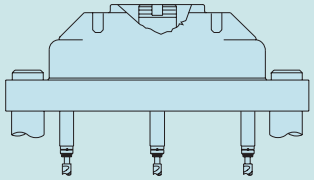
MULTIPLE SPINDLE Head Data Questionnaire

Zagar INCORPORATED
24000 Lakeland Boulevard
Cleveland, Ohio 44132 U.S.A.
216/731-0500 FAX 216/731-8591









Customer Information

Date _____ Zagar Sales Rep. _____

Name _____ Title _____

Company _____

Street _____

City _____ State _____ Zip _____

Phone _____ FAX _____

Part Information:

1. Part No. _____
2. Part Print Enclosed _____
3. Sample Part Submitted o Yes o No
4. Type of Material

o Aluminum	o Plastic
o Brass	o Stainless Steel
o Cast Iron	o Steel
o Magnesium	o _____

Drill Head Layout:

1. Use the appropriate Head Layout Form on Pages 2 or 3 to **show your hole pattern** in relation to head centerlines and guide rods. *We accept your Autocad layouts on disk.*
2. On Page 4 give make, model and complete specifications of drill press as applicable.

Drilling Information:

1. Operating R.P.M. (Zagar heads are 1:1 ratio) _____
2. Operation(s) Required

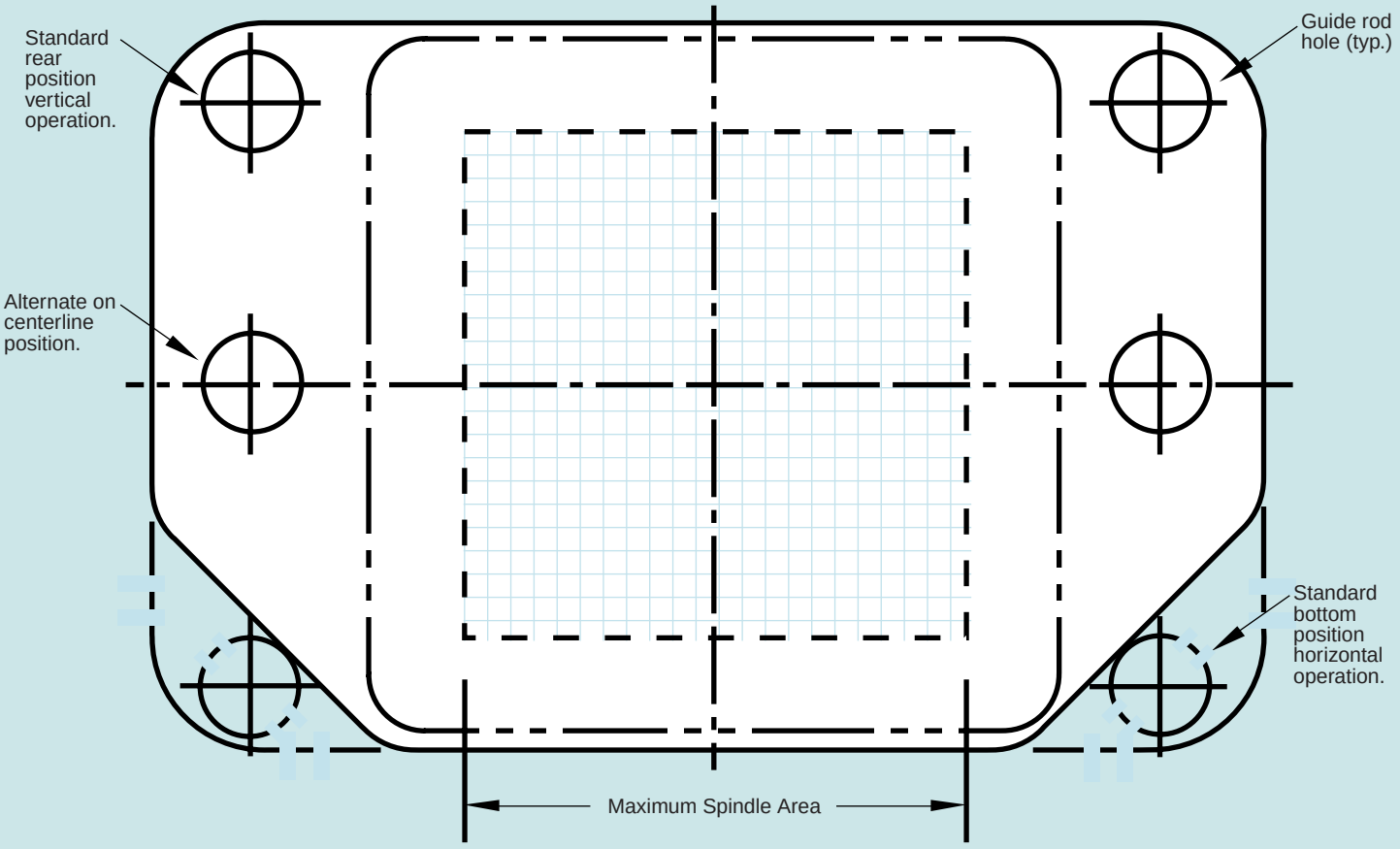
o Chamfer	o Ream
o Drill and Chamfer	o Spotface
o Countersink	o Tap
o Drill	o _____

3. How many holes? _____
4. Do you have a fixture for part? o Yes o No
   If not, see fixture information on Page 3.
   Note: Multiple-Spindle Heads require guide rod tie in of tooling. The Zagar standard distance is shown in Zagar's Multiple Spindle Drill Head Catalog, Page 10.
5. Head Operating Position
   - o Verticle spindles–pointing down.
   - o Horizontal spindles
   - o Inverted spindles–pointing up
   - o _____

Information given (by customer) on this Questionnaire is assumed correct and final for Head(s) being ordered. • Any changes after order is placed may result in additional charges. • Any omission on this questionnaire will cause a delay in the delivery of head(s).

Square Head

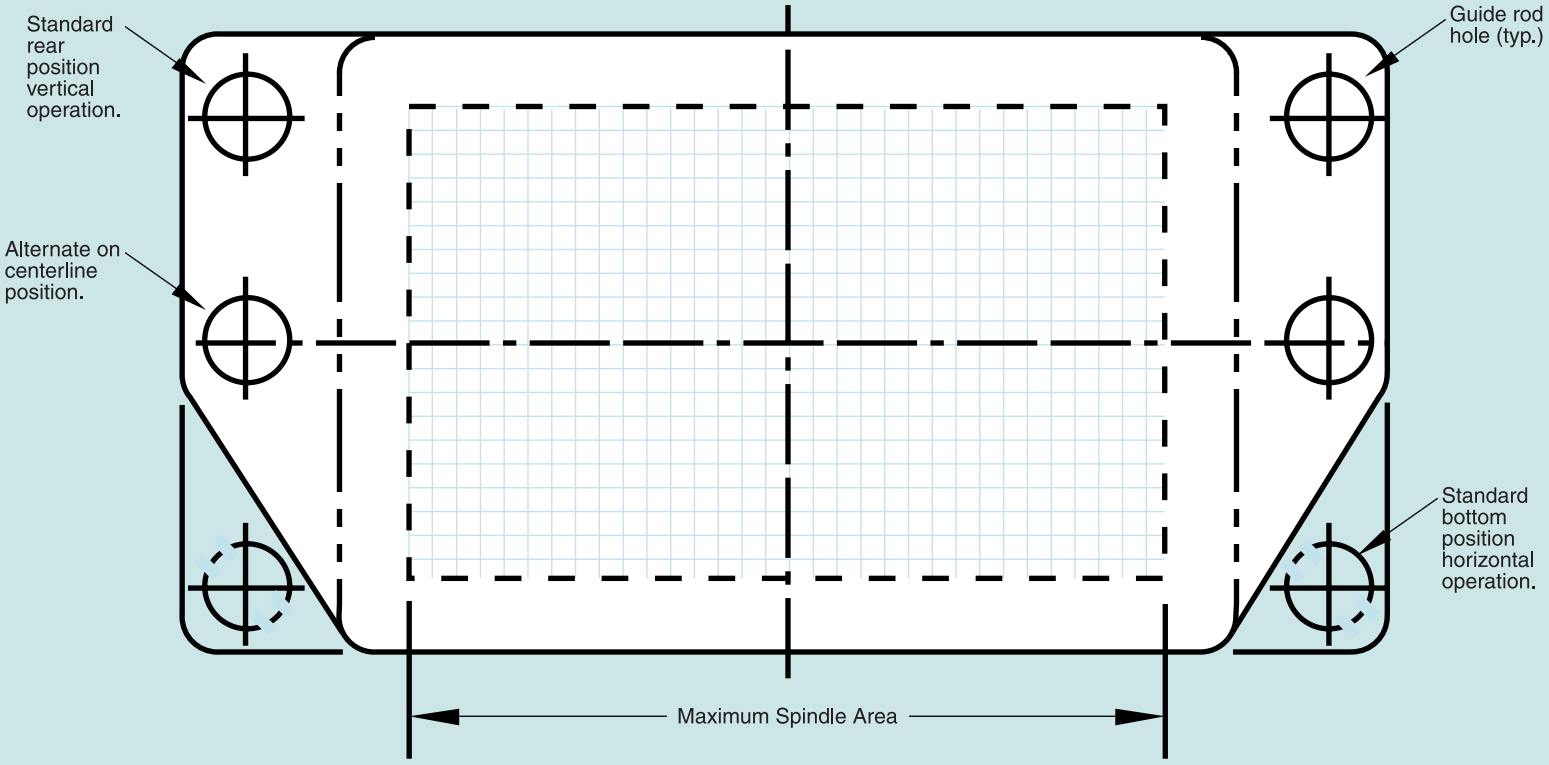
View looking thru TOP OF HEAD and not at the spindles.



See Zagar Multiple Spindle Heads Catalog Page 10.

Rectangle Head

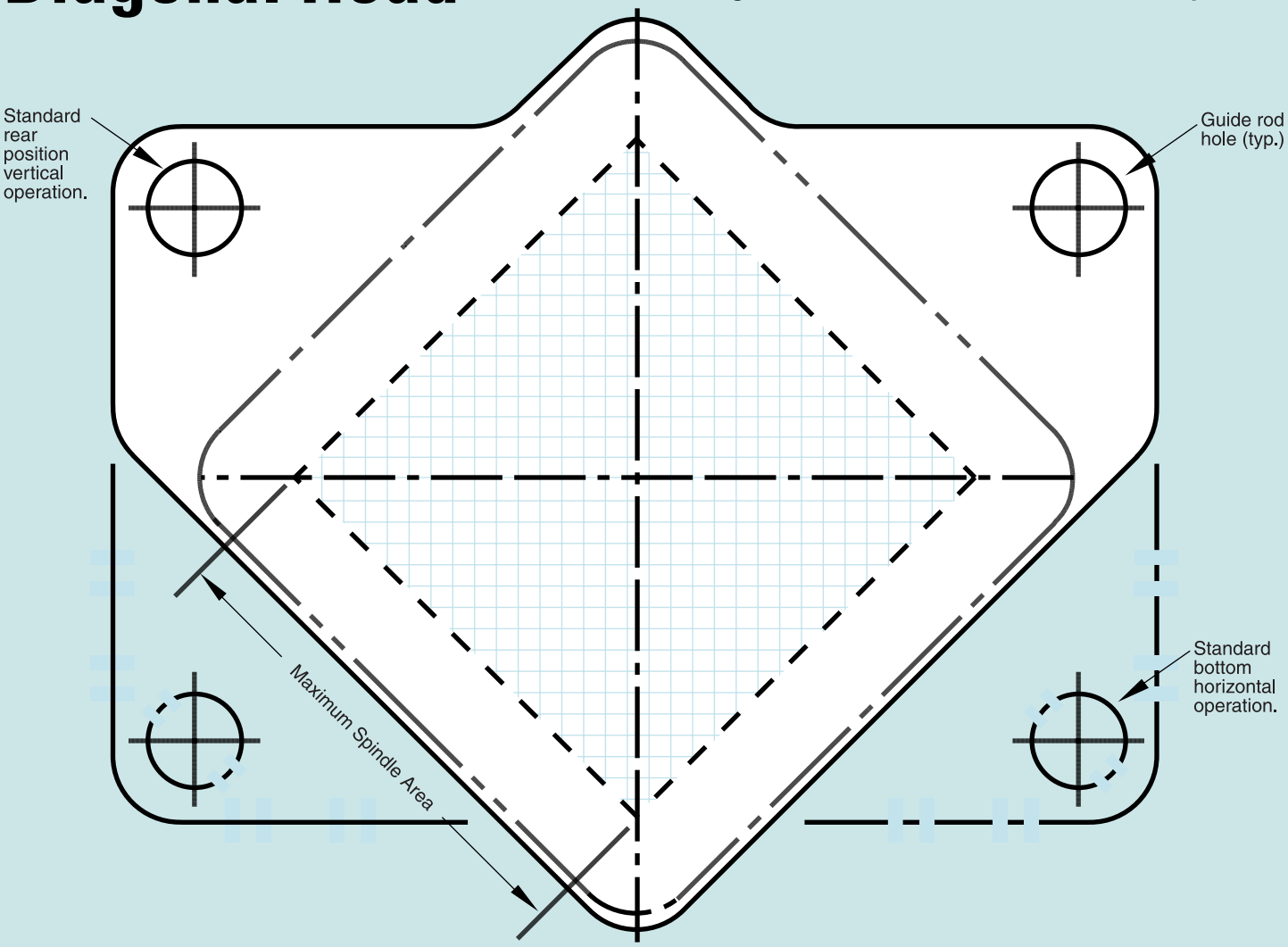
View looking thru TOP OF HEAD and not at the spindles.



See Zagar Multiple Spindle Heads Catalog Page 11.

Diagonal Head

View looking thru TOP OF HEAD and not at the spindles.



See Zagar Multiple Spindle Heads Catalog Page 10.

Typical Available Fixtures

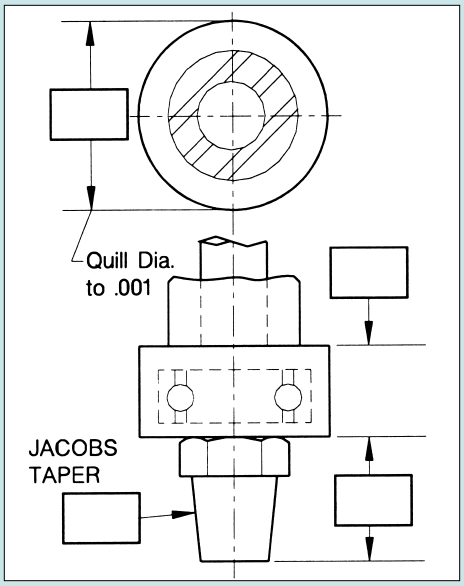
See Multiple Spindle Heads Technical Specifications Catalog, Page 26 for complete, partially complete and blank fixture assemblies and components. Autocad disk available to show these assemblies on your layouts.

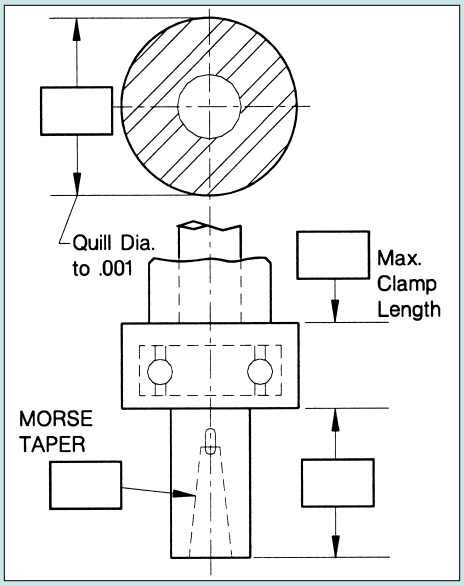
Complete

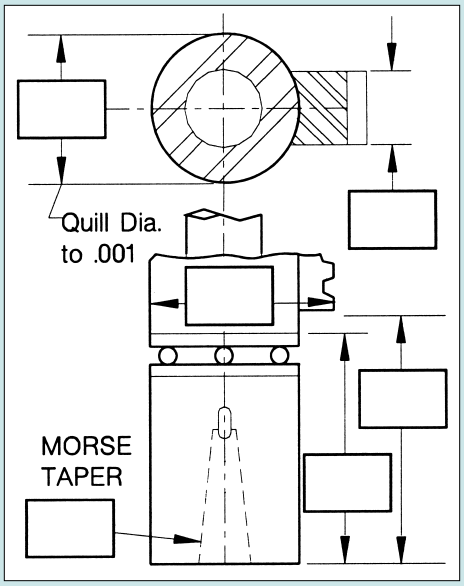
Partially Complete

Blank Assemblies

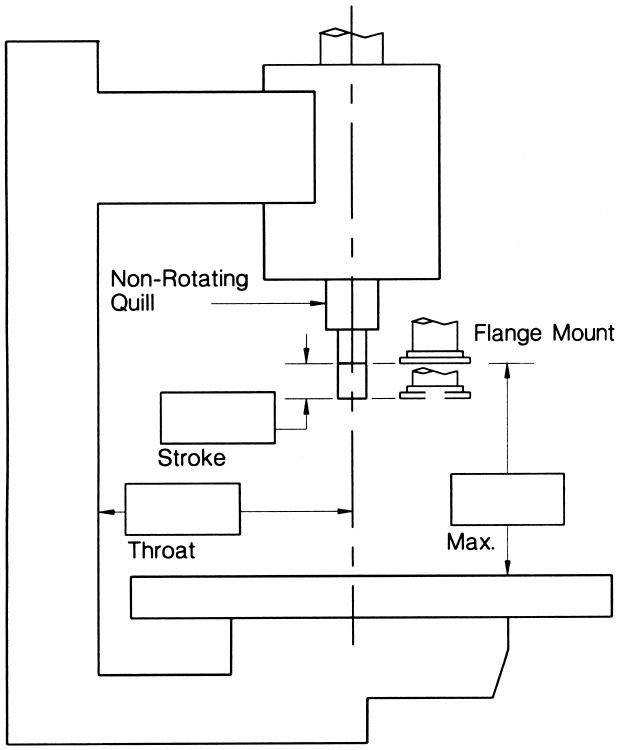
Quill & Spindle Specs.

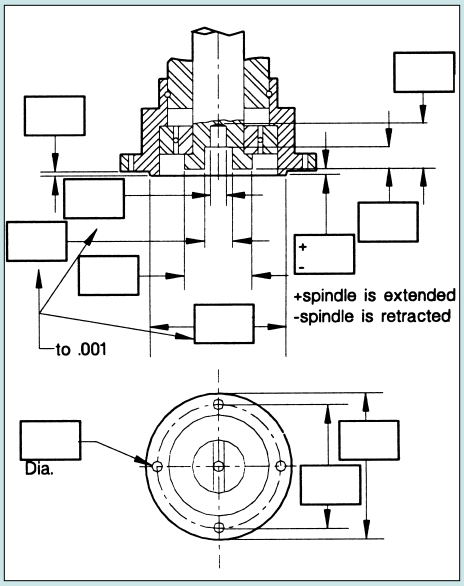






Drill Press Specs.





Make _____

Model _____

Comments _____

_____

_____

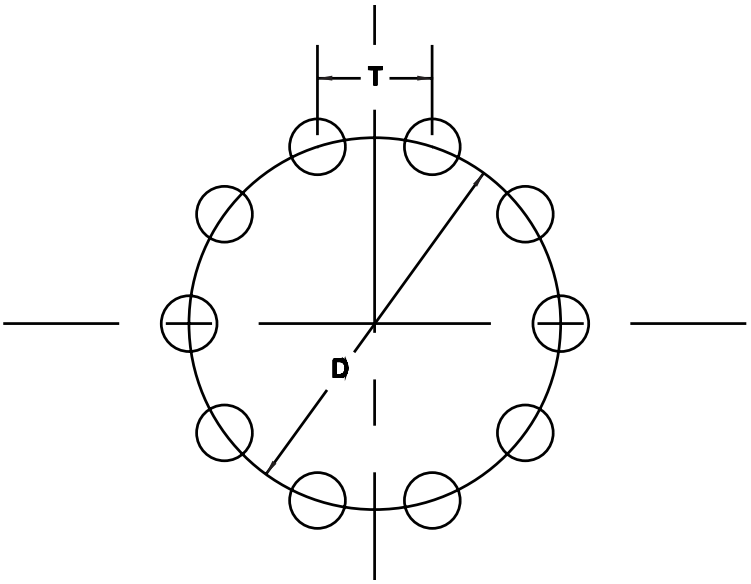
Logan
INCORPORATED

24000 Lakeland Boulevard
Cleveland, Ohio 44132 U.S.A.
216/731-0500 FAX 216/731-8591

LENGTH OF CHORDS

T = length of chord
D = diameter of circle
C = constant for each No. of divisions N

To obtain length of chord T, multiply the diameter of D by the constant C.



T = DC

N	C	N	C	N	C	N	C
3	.86603	28	.11196	53	.05924	78	.04027
4	.70711	29	.10812	54	.05814	79	.03976
5	.58779	30	.10453	55	.05709	80	.03926
6	.50000	31	.10117	56	.05607	81	.03878
7	.43388	32	.09802	57	.05509	82	.03830
8	.38268	33	.09506	58	.05414	83	.03784
9	.34202	34	.09227	59	.05322	84	.03739
10	.30902	35	.08964	60	.05234	85	.03695
11	.28173	36	.08716	61	.05148	86	.03652
12	.25882	37	.08481	62	.05065	87	.03610
13	.23932	38	.08258	63	.04985	88	.03569
14	.22252	39	.08047	64	.04907	89	.03529
15	.20791	40	.07846	65	.04831	90	.03490
16	.19509	41	.07655	66	.04758	91	.03452
17	.18375	42	.07473	67	.04687	92	.03414
18	.17365	43	.07300	68	.04618	93	.03377
19	.16459	44	.07134	69	.04551	94	.03341
20	.15643	45	.06976	70	.04486	95	.03306
21	.14904	46	.06824	71	.04423	96	.03272
22	.14231	47	.06679	72	.04362	97	.03238
23	.13617	48	.06540	73	.04302	98	.03205
24	.13053	49	.06407	74	.04244	99	.03173
25	.12533	50	.06279	75	.04188	100	.03141
26	.12054	51	.06156	76	.04132	101	.03110
27	.11609	52	.06038	77	.04079	102	.03080

Our applications engineering department evaluates production drilling and machining requirements and recommends the appropriate units for profitable operation. Sales engineers in major metalworking areas give you prompt, personal service without obligation.

Formulae are programmed into our computer. Send us data on your application for machining units for a free evaluation. Needed information includes: operations, S.A.E. equivalent of material and Brinell hardness (BHN) or Rockwell scale, depth and diameter of cut, and whether cutting tools are HSS or carbide.

The following procedures are recommended to determine specifications of machining unit.

I. Drill

Determine RPM, HP, Torque and Thrust as follows:

A. $\text{RPM} = \frac{3.82 \times \text{SFM}}{\text{O.D.}}$

B. Drill HP (cutting dia. up to 2 inches) = 1.5 x (actual feed) x drill dia. x SFM x MM (Table 4)

C. $\text{Torque (in. lbs.)} = \frac{\text{HP} \times 63{,}025}{\text{RPM}}$

D. Thrust =
Thrust (Table 2) x $\frac{\text{Actual Feed Rate} \times \text{MM (Table 4)}}{\text{Feed Rate (Table 2)}}$

Note:

If the hole is pre-drilled (dead center removed), the thrust value is approximately one-half that of the drill from solid. For diameters larger than Table 2, drill thrusts can be obtained from graph (Figure 1) on Page 46. Multiply graph value by MM if other than 1.

E. Cycle time =

$$60 \times \left(\frac{\text{Length of Drill Point} + \text{clearance} + \text{Hole Depth}}{\text{Feed Rate} \times \text{Cutting Tool RPM}}\right) + \text{Rapid Approach} + \text{Rapid Retract Time}$$

II. Ream, Bore, Counterbore, Countersink, Hollow Mill, Trepan, and Core Drill

Determine RPM, HP, Torque and Thrust as follows:

A. $\text{RPM} = \frac{3.82 \times \text{SFM}}{\text{O.D.}}$

B. HP (cutting dia. up to 2 inches) = 1.5 x

$$\text{Feed Rate} \times \frac{(\text{Cutting O.D.}^2 - \text{Cutting I.D.}^2) \times \text{SFM} \times \text{MM}}{\text{Cutting O.D.}}$$

C. $\text{Torque (in. lbs.)} = \frac{\text{HP} \times 63{,}025}{\text{RPM}}$

D. Reamer Thrust =

$$\frac{\text{Thrust of Equiv. Drill}}{2} \times \frac{\text{Reamer Feed}}{\text{Equiv. Drill Feed}} \times \text{MM}$$

Where equiv. drill = $\sqrt{\text{Reamer Dia.}^2 - \text{Rough Drill Dia.}^2}$
Thrust and feed of equiv. drill are taken from Table 2.

E. Unit cycle time =

$$60 \times \left(\frac{\text{Length of Drill Point} + \text{clearance} + \text{Hole Depth}}{\text{Feed Rate} \times \text{Cutting Tool RPM}}\right) + \text{Rapid Approach} + \text{Rapid Retract Time}$$

Horsepower Formula for Drilling, Reaming, Etc. Cutting Diameters of Two or More Inches.

For cutting operations that exceed two inches in diameter (solid or otherwise), calculate horsepower at the spindle based on one HP required to remove one cu. in. of average steel in one minute using applicable material factor "K":

HP = Area of metal removed x Feed Rate (in./min.) x K x 1.3 (30% dull tool factor)

Material Factor "K"

Aluminum	= .25	Iron Malleable	= .75
Bronze & Brass	= .25	Steel, Average	= 1.0
Iron, Cast	= .50	Steel, Hard	= 1.5

III. Tap

Determine RPM, HP and Torque; thrust is not a factor:

A. $\text{RPM} = \frac{3.82 \times \text{SFM}}{\text{O.D.}}$ $\quad \text{SFM} = \frac{\text{RPM} \times \text{O.D.}}{3.82}$

B. For HP values of material with MM other than 1 and SFM other than 100, use the following formula: (Applicable for straight threads and pipe taps.)

$$\text{H.P. (Actual)} = \frac{\text{HP (Table 3)} \times \text{Actual SFM} \times \text{MM}}{100}$$

C. For torque values of material with MM other than 1, multiply Table 3 value by actual MM. (Applicable for straight or taper threads.)

D. For HP of thread sizes not shown on Table 3, the following general formula prevails (for straight threads only):

$$\text{HP} = \frac{2.34 \times \left(\frac{.646}{\text{Major Dia.} - \text{T.P.I.}}\right) \times \text{SFM} \times \text{MM}}{\text{Major Dia.} \times (\text{T.P.I.})^2}$$

E. $\text{Torque (in. lbs.)} = \frac{\text{HP} \times 63{,}025}{\text{RPM}}$
Thrust is not a factor in tapping

F. $\text{Feed Rate} = \frac{1}{\text{T.P.I. of tap}}$

G. Unit cycle time =

$$\frac{120 \times (\text{Clearance} + \text{Hole Depth})}{\text{Feed Rate} \times \text{Tap RPM}} + \text{Rapid Approach} + \text{Rapid Retract Time}$$

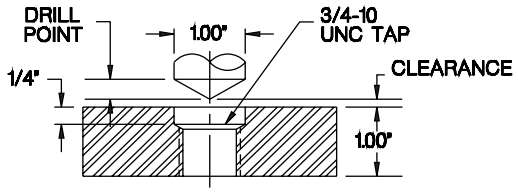
Note:

1. Feed rates are expressed in inches per revolution of the spindle. If necessary, convert this to inches per minute by multiplying the feed rate in inches per revolution by the RPM of the spindle.
2. Rapid approach and rapid retract rates are expressed in inches per minute. To determine the rapid approach time or rapid retract time when the length of these movements are known:

$$\text{R.A. or R.R. Time (seconds)} = \frac{60 \times \text{(Length of R.A. or R.R.)}}{\text{R.A. or R. R. Rate (IPM)}}$$

NOTE:
Power values are those required at the spindle of the machining unit for cutting metal. Additional horsepower must be allowed for actuation of the machining unit. Usually, air-hydraulic units require from 1/4 to 1 H.P.; mechanical units need from 1/2 to 5 H.P., depending upon the size of the unit, number of spindles, and the type of spindle gear reduction. Your Zagar sales engineer can advise you of the requirements.

EXAMPLE: 1020 carbon steel, 200 BHN hardness



I. Tap drill 21/32 inch diameter (.656) through:

1. SFM = 70 (Table No. 1 or other reference)
2. RPM = 409 (Table No. 6 or Formula IA.)
3. MM = 2.1 (Table No. 4)
4. Feed rate = .008 (Table No. 2 or other reference)
5. H.P. = 1.5 x .008 x .656 x 70 x 2.1 = 1.16 (Formula IB)
6. Torque = $\frac{1.16 \times 63{,}025}{409}$ = 178.5 in. lbs. (Formula IC)
7. Thrust = $\frac{597 \times .008 \times 2.1}{.009}$ = 1114 lbs. (Table No. 2, Formula ID)
8. Unit Cycle Time = $\frac{60 \times (.1972 + .062 + 1.000)}{.008 \times 409}$ + .5 sec. rapid approach
   +.5 sec. rapid retract = 24 seconds
   (Formula IE; approx. rapid approach and retract rates)

II. Countersink 1 inch diameter, 1/4 inch deep

1. SFM = 70 (Table No. 1 or other reference)
2. RPM = 268 (Table No. 6 or Formula IIA)
3. MM = 2.1 (Table No. 4)
4. Feed Rate = .012 (Table No. 2 or other reference)
5. H.P. = $\frac{1.5 \times .012 \times (1.000^2 - .656^2) \times 70 \times 2.1}{1.00}$
   = 1.5 (Formula IIB)
6. Torque = $\frac{1.5 \times 63{,}025}{267}$ = 354 in. lbs. (Formula IIC)
7. Thrust = $\frac{750}{2} \times \frac{.012}{.010} \times 2.1$
   = 945 lbs. (Formula IID)
8. Unit Cycle Time = $\frac{60 \times (.3005 + .062 + .250)}{.012 \times 267}$ + .5 sec. rapid approach
   +.5 sec. rapid retract = 12.5 seconds
   (Formula IIE approx. rapid approach and retract rates)

III. Tap 3/4* - 10 UNC through

1. SFM = 40 (Table No. 1 or other reference)
2. RPM = 203 (Table No. 6 or Formula IIIA)
3. MM = 2.1 (Table No. 4)
4. H.P. = 2.16 x $\frac{40}{100}$ x 2.1 = 1.8 (Formula IIIB)
5. Torque = 254.4 x 2.1 = 554 in. lbs. (Table No. 3; Formula IIIC)
6. Thrust is not a factor in tapping.
7. Feed Rate = 1/10 = .100 (Formula IIIF)
8. Unit Cycle Time = $\frac{120 \times (.125 + .750)}{.100 \times 203}$ + .5 sec. rapid approach
   +.5 sec. rapid retract = 6.14 seconds
   (Formula IIIG; approx. rapid approach and retract rates)

Cutting Tool Life
Use these formulas to calculate feeds and speeds as guidelines only. Test machine under production conditions to predict accurate tool life. Speeds and feeds shown are calculated on 60 minutes of actual cutting life for high speed steel tools; 45 minutes for re-usable carbide and 30 minutes for throw away carbide tools. Where a machine has an eight second cycle, 6 seconds is devoted to loading, transferring and unloading. Therefore, the tools are cutting for only two seconds per cycle or 15 minutes per hour. Thus, in the example, life of a high speed steel tool would be (4) hours of machine time.

Cutting Tool Failure
ZAGAR machining units help extend but do not control the life of the cutting tools. Excessive tool wear or breakage can usually be caused by one of the following:

1. Improper surface speed of tool.
2. Improper feed rates of tool
3. Improper cutting tool material
4. Excessively dull tools.
5. Hard spots; scale or sand in the materials.
6. Improper coolant or lubricants.
7. Lack of coolant or lubricant at the point of the cut.
8. No rigid tool guidance (overside drill bushings, guide rods, etc.)
9. Excessive deep cut and chip packing.
10. Improperly ground tools (clearance angles, rake angles, lip angles, rough finishes, etc.)

The above rates are recommendations only. The rate should be modified to best suite the machining environment.

Suggested Cutting Speeds with HSS Cutting Tools

Table No.1

MATERIAL	BRINELL (BHN)	DRILLS S.F.M.	TAPS - S.F.M. THREADS PER INCH			
			3-7 1/2	8-15	16-24	25 UP
Aluminum	99-101	200-250	50	100	150	200
Aluminum Bronze	170-187	60	12	25	45	60
Bakelite	—	80	50	100	150	200
Brass	192-202	200-250	50	100	150	200
Bronze, Common	166-183	200-250	40	80	100	150
Bronze, Phos.; 1/2 Hard	187-202	175-180	25	40	50	80
Bronze, Phos.; Soft	149-163	200-250	40	80	100	150
Celluloid	—	100	50	100	150	200
Copper	80-85	70	40	80	100	150
Copper, Mang.; 30% Min.	134	15	—	—	—	—
Duralumin	90-104	200	50	100	150	200
Everdur	179-207	60	20	30	40	50
Iron, Cast; Soft	126	140-150	30	60	90	140
Iron, Cast; Med. Soft	196	80-110	25	40	50	80
Iron, Cast; Hard	293-302	45-50	10	20	30	40
Iron, Cast; Chilled	402	15	5	5	10	10
Iron Malleable	112-126	85-90	20	30	40	50
Monel	149-170	50	8	10	15	20
Nickel, Pure	187-202	75	25	40	50	80
Nickel Steel; 3 1/2%	196-241	60	8	10	15	20
Rubber, Hard	—	100	50	100	150	200

MATERIAL	BRINELL (BHN)	DRILLS S.F.M.	TAPS-S.F.M. THREADS PER INCH			
			3-7 1/2	8-15	16-24	25 UP
Screw Stock; C.R.	170-196	110	20	30	40	50
Steel, Carbon	175-225	70	30	40	50	50
Steel, Drop Forged	170-196	60	12	25	45	60
Steel, Machinery	170-196	110	35	50	60	85
Steel, Magnet; Soft	241-302	35-40	20	40	50	75
Steel, Magnet; Hard	321-512	15	5	10	15	25
Steel, Mang.; 7-13%	187-217	15	15	20	25	30
Steel, Mild; .20-.30C	170-202	110-120	40	55	70	90
Steel, Molybdenum	196-235	55	20	30	35	45
Steel, Spring	402	20	10	10	15	15
Steel, Stainless	150-225	50	8	10	15	20
Steel, Stainless	460-520	20	8	10	15	20
Steel .40-.50C	170-196	80	20	30	40	50
Steel, Structural; A-36	160	110	40	55	70	90
Steel, Tool; S.A.E. and Forging	149	75	25	35	45	55
Steel, Tool; S.A.E. and Forging	241	50	15	15	25	25
Steel, Tool; S.A.E. and Forging	402	15	8	10	15	20
Zinc, Alloy	112-126	200-250	50	100	150	200

NOTE: 1) HSS reaming tools should be at approximately 2/3 of Drill RPM.
2) Carbide tools should be at approximately double above values.

Table No. 2
DRILL THRUST AND HORSEPOWER
MM of one (cast iron)

DRILL DIA.	DRILL POINT	FEED* IN./REV.	HP@ 100 S.F.M.	THRUST LBS.	TORQUE IN-LBS.
1/32	.009	.0008	.004	10	0.02
1/16	.019	.0015	.014	31	0.14
3/32	.028	.0020	.028	45	0.4
1/8	.037	.0025	.047	66	0.9
5/32	.047	.0035	.082	110	2.1
3/16	.056	.0040	.113	131	3.4
7/32	.066	.0045	.148	168	5.3
1/4	.075	.0050	.188	194	7.7
9/32	.084	.0050	.211	210	9.8
5/16	.094	.0050	.235	227	12.
11/32	.103	.0055	.284	261	16.
3/8	.113	.0060	.338	296	20.
13/32	.122	.0065	.396	333	26.
7/16	.131	.0070	.460	372	33.
15/32	.141	.0075	.526	413	40.
1/2	.150	.0080	.600	474	49.
17/32	.160	.0080	.637	503	56.
9/16	.169	.0080	.675	533	62.
19/32	.178	.0085	.757	569	74.
5/8	.188	.0090	.844	587	87.
21/32	.197	.0090	.885	597	96.
11/16	.206	.0090	.928	627	105.
23/32	.216	.0095	1.025	685	121.
3/4	.225	.0100	1.125	729	139.
25/32	.235	.0100	1.175	750	151.
13/16	.244	.0100	1.218	771	163.
27/32	.253	.0105	1.335	822	185.
7/8	.263	.0110	1.45	875	209.
29/32	.272	.0115	1.56	925	234.
15/16	.282	.0120	1.68	983	261.
31/32	.291	.0125	1.81	1097	291.
1	.300	.013	1.96	1164	322.
1 1/16	.319	.013	2.13	1180	364.
1 1/8	.338	.014	2.37	1266	439.
1 3/16	.357	.014	2.50	1360	490.
1 1/4	.376	.015	2.64	1440	581.
1 5/16	.394	.015	2.70	1490	641.
1 3/8	.413	.015	3.04	1540	704.
1 7/16	.432	.015	3.23	1590	769.
1 1/2	.451	.015	3.37	1640	837.
1 9/16	.469	.016	3.78	1730	969.
1 5/8	.488	.016	3.94	1820	1048
1 11/16	.507	.016	4.07	1870	1131.
1 3/4	.526	.016	4.35	1915	1216.
1 13/16	.544	.016	4.50	2005	1304.
1 7/8	.563	.017	4.75	2115	1483
1 15/16	.582	.017	4.95	2165	1584.
2	.601	.017	5.12	2211	1688.

With carbide drills decrease feed rate 10% and double drill RPM and HP.

Table No. 3 - Tapping, MM of one (cast iron)

SIZE	SERIES	TAP DRILL 75%	RPM @ 100 S.F.M.	HP @ 100 S.F.M.	TORQUE IN-LBS.
6-32	UNC	.1077	2775	.19	4.4
6-40	UNF	.1138	2775	.12	2.9
8-32	UNC	.1337	2335	.2	5.4
8-36	UNF	.137	2335	.16	4.3
10-24	UNC	.149	2016	.35	10.9
10-32	UNF	.1597	2016	.2	6.4
12-24	UNC	.175	1773	.36	12.6
12-28	UNF	.1813	1773	.27	9.5
1/4-20	UNC	.2115	1532	.51	21
1/4-28	UNF	.2153	1532	.27	11
5/16-18	UNC	.2589	1226	.64	33
5/16-24	UNF	.2715	1226	.37	19.1
3/8-16	UNC	.3144	1021	.82	50
3/8-24	UNF	.334	1021	.38	23.3
7/16-14	UNC	.3681	875.5	1.1	77
7/16-20	UNF	.3890	875.5	.54	39
1/2-13	UNC	.4251	766	1.25	102.6
1/2-20	UNF	.4515	766	.55	45
9/16-12	UNC	.4817	681	1.5	136
9/16-18	UNF	.5089	681	.68	62.5
5/8-11	UNC	.5365	613	1.75	180
5/8-18	UNF	.5714	613	.68	70
3/4-10	UNC	.6562	511	2.1	264
3/4-16	UNF	.6894	511	.87	107
7/8-9	UNC	.7667	438	2.7	382
7/8-14	UNF	.8056	438	1.1	163
1"-8	UNC	.8781	383	3.4	553
1-12	UNF	.9192	383	1.5	253
1 1/8-7	UNC	.9857	340	4.4	812
1 1/8-12	UNF	1.0442	340	1.6	286
1 1/4-7	UNC	1.1107	306	4.4	910
1 1/4-12	UNF	1.1692	306	1.6	320
1 3/8-6	UNC	1.2125	279	6	1356
1 3/8-12	UNF	1.2942	279	1.6	353
1 1/2-6	UNC	1.3375	255	6	1489
1 1/2-12	UNF	1.4192	255	1.6	387
1 3/4-5	UNC	1.5552	219	8.7	2496
2"-4 1/2	UNC	1.7836	191	10.7	3530
2 1/4-4 1/2	UNC	2.0336	170	10.8	4005
2 1/2-4	UNC	2.2565	153	13.7	5628
2 3/4-4	UNC	2.5065	139	13.8	6230
3"-4	UNC	2.7565	127	13.8	6831
3 1/4-4	UNC	3.0065	118	13.9	7433
3 1/2-4	UNC	3.2565	109	13.95	8035
3 3/4-4	UNC	3.5065	102	14	8636
4"-4	UNC	3.7565	96	14	9238
PIPE TAPS (TAPER)					
The following H.P. and Torque specs are based on tapered hole. If hole is straight, multiply by (3) three.					
1/8-27	NPT	R	948	.54	36
1/4-18	NPT	7/16	706	1.17	103
3/8-18	NPT	37/64	565	1.69	133
1/2-14	NPT	23/32	455	2.00	277
3/4-14	NPT	59/64	364	2.06	356
1-11 1/2	NPT	1 5/32	291	3.07	663
1 1/4-11 1/2	NPT	1 1/2	231	3.48	950
1 1/2-11 1/2	NPT	1 47/64	201	4.08	1280
2-11 1/2	NPT	2 7/32	161	5.31	2080

Table No. 4
MATERIAL MULTIPLIERS (MM)
RELATIVE MACHINABILITY BASED ON CAST IRON = 1

MATERIAL	BHN	MM	MATERIAL	BHN	MM
Aluminum		.38	Free Cutting (1111-1213)	140	1.10
Brass		.60	Alloy Steel(1330-8642)	175	1.50
Bronze		.60		190	1.60
Cast Iron		1.00		200	1.70
Copper		.72		203	1.80
Magnesium		.80		205	1.90
Malleable Iron		1.20		210	2.00
Stainless Steel		2.50		215	2.10
Titanium		2.25		220	2.20
Zinc		.60		230	2.30
Carbon Steel				240	2.40
(1008-1095)	90	1.60		250	2.50
	110	1.70		330	3.30
	140	1.80		390	3.90
	170	1.90		470	4.60
	190	2.00	Structural Steel (A-36)	160	1.50
	200	2.10			
	250	2.20			

DRILL THRUST; DIAMETERS OVER TWO INCHES
MM OF ONE (CAST IRON) 25% DULL DRILL FACTOR

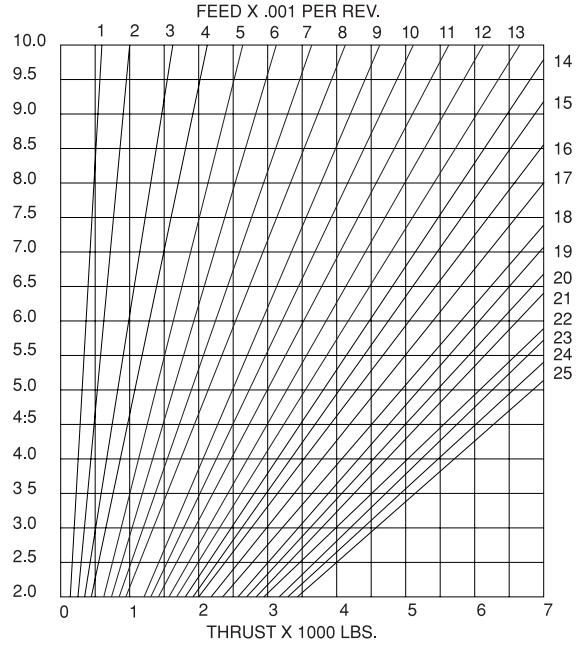
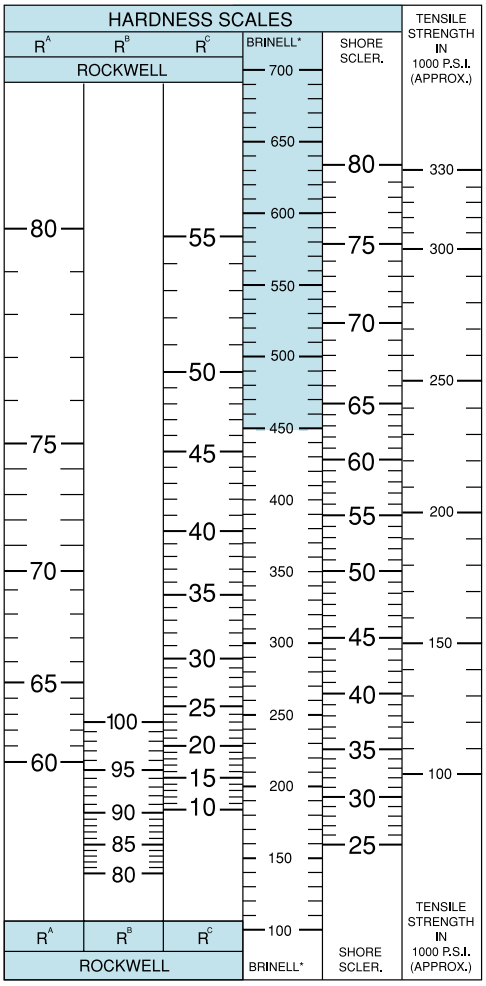


Table No. 5
HARDNESS CONVERSION

Hardness table compares the equivalent hardness of various scales. Brinell number 245 is equal to 62 Rockwell “A”, 100 Rockwell “B”, 23 Rockwell “C”, 37 shore and tensile strength of approximately 120,000 PSI. Shaded area above 450 Brinell indicates that values vary slightly depending on the type of hardness tester.



SPINDLE RPM FOR VARIOUS CUTTING DIAMETERS WITH GIVEN SURFACE SPEED. (For higher speeds, multiply 150' values by new 5FM/150.)

SFM	10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
DIAMETER INCHES	REVOLUTIONS PER MINUTE														
1/16	611	1222	1833	2445	3056	3667	4278	4889	5500	—	—	—	—	—	—
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

Suggested Drilling Feed Rates (inches per rev.)

MATERIAL	BRINELL HARDNESS	HOLE DIAMETER							
		1/16"	1/8	1/4	1/2	3/4	1	1 1/2	2
Aluminum	99-101	.001	.003	.007	.012	.016	.020	.025	.030
Aluminum Bronze	170-187	.001	.003	.004	.008	.010	.012	.015	.020
Balkelite	- -	.002	.005	.006	.008	.010	.012	.015	.015
Brass	192-202	.001	.003	.004	.008	.012	.018	.020	.022
Bronze, Common	166-183	.001	.003	.004	.008	.012	.018	.020	.022
Bronze Phos.; 1/2 Hard	187-202	.001	.003	.004	.008	.010	.012	.015	.020
Bronze Phos.; Soft	149-163	.001	.003	.004	.008	.012	.018	.020	.022
Celluloid	—	.002	.004	.005	.006	.006	.008	.008	.010
Copper	80-85	.001	.003	.004	.008	.010	.012	.015	.020
Copper Mang.; 30% Mn	134	.001	.003	.005	.007	.009	.012	.014	.016
Duralumin	90-104	.001	.003	.005	.010	.015	.018	.020	.025
Iron, Cast; Med Soft	196	.001	.003	.005	.008	.010	.012	.014	.015
Iron, Cast; Hard	293-302	—	.001	.003	.005	.007	.009	.012	.012
Iron, Cast; Chilled	402	—	.001	.003	.005	.007	.009	.011	.011
Iron, Malleable	112-126	—	.002	.004	.007	.010	.012	.015	.018
Monel	149-170	—	.002	.003	.006	.008	.010	.012	.015
Nickel, Pure	187-202	—	.002	.003	.006	.008	.015	.018	.020
Nickel, Steel; 3 1/2%	196-241	—	.002	.003	.006	.008	.010	.012	.015
Rubber, Hard	—	.005	.010	.012	.015	.018	.020	.025	.030
Screw Stock, C.R.	170-196	.001	.003	.004	.007	.010	.012	.015	.018
Stl, Carbon	175-225	.001	.003	.004	.007	.010	.012	.015	.018
Stl, Drop Forged	170-196	.001	.002	.004	.007	.010	.012	.015	.018
Stl, Machinery	170-196	.001	.003	.005	.009	.012	.013	.018	.022
Stl, Magnet; Soft	241-302	—	.002	.003	.006	.008	.009	.010	.011
Stl, Magnet; Hard	321-512	—	.0005	.001	.002	.002	.003	.003	.004
Stl, Mang.; 7-13%	187-217	—	.0005	.001	.002	.002	.003	.003	.004
Stl, Mild; .20-.30C	170-202	.001	.003	.005	.010	.015	.018	.020	.025
Stl, Molybdenum	196-235	—	.002	.004	.006	.010	.012	.015	.018
Stl, Spring	402	—	.002	.003	.005	.007	.009	.010	.010
Stl, Stainless	150-225	.001	.002	.004	.006	.008	.011	.013	.016
Stl, Stainless	460-520	—	.0005	.001	.002	.002	.003	.003	.004
Stl, .40-.50c	170-196	.001	.002	.004	.007	.010	.012	.015	.018
Stl, Struct; A-36	160	.001	.003	.005	.010	.015	.018	.020	.025
Stl Tool; SAE, Forged	149	—	.002	.003	.006	.009	.011	.014	.016
Stl, Tool; SAE, Forged	402	—	.0005	.001	.002	.002	.003	.003	.004
Zinc, Alloy	112-126	.002	.003	.007	.012	.016	.018	.020	.025

Drill Sizes in Decimal Equivalents

Inch	Decimal	Wire	mm	Inch	Decimal	Wire	mm	Inch	Decimal	Wire	mm	Inch	Decimal	Wire	mm	Inch	Decimal	Wire	mm	Inch	Decimal	Wire	mm
1/64	.0156			1/16	.0625				.1339		3.40		.2165		5.50		.3248		8.25	37/64	.5781		
	.0157		0.40		.0630		1.60		.1360	29		7/32	.2188				.3268		8.30		.5906		15.0
	.0160	78			.0635	52			.1378		3.50		.2205		5.60	21/64	.3281						
	.0165		0.42		.0650		1.65		.1405	28			.2210	2			.3307		8.40	19/32	.5938		
	.0173		0.44		.0669		1.70	9/64	.1406				.2244		5.70		.3320	Q		39/64	.6094		
	.0177		0.45		.0670	51			.1417		3.60		.2264		5.75		.3346		8.50		.6102		15.5
	.0180	77			.0689		1.75		.1440	27			.2280	1			.3386		8.60	5/8	.6250		
	.0181		0.46		.0700	50			.1457		3.70		.2283		5.80		.3390	R			.6299		16.0
	.0189		0.48		.0709		1.80		.1470	26			.2323		5.90		.3425		8.70	41/64	.6406		
	.0197		0.50		.0728		1.85		.1476		3.75		.2340	A		11/32	.3438				.6496		16.5
	.0200	76			.0730	49			.1495	25		15/64	.2344				.3445		8.75	21/32	.6562		
	.0210	75			.0748		1.90		.1496		3.80		.2362		6.00		.3465		8.80		.6693		17.0
	.0217		0.55		.0760	48			.1520	24			.2380	B			.3480	S		43/64	.6719		
	.0225	74			.0768		1.95		.1535		3.90		.2402		6.10		.3504		8.90	11/16	.6875		
	.0236		0.60	5/64	.0781				.1540	23			.2420	C			.3543		9.00		.6890		17.5
	.0240	73			.0785	47		5/32	.1562				.2441		6.20		.3580	T		45/64	.7031		
	.0250	72			.0787		2.00		.1570	22			.2460	D			.3583		9.10		.7087		18.0
	.0256		0.65		.0807		2.05		.1575		4.00		.2461		6.25	23/64	.3594			23/32	.7188		
	.0260	71			.0810	46			.1590	21			.2480		6.30		.3622		9.20		.7283		18.5
	.0276		0.70		.0820	45			.1610	20		1/4	.2500	E			.3642		9.25	47/64	.7344		
	.0280	70			.0827		2.10		.1614		4.10		.2520		6.40		.3661		9.30		.7480		19.0
	.0292	69			.0846		2.15		.1654		4.20		.2559		6.50		.3680	U		3/4	.7500		
	.0295		0.75		.0860	44			.1660	19			.2570	F			.3701		9.40	49/64	.7656		
	.0310	68			.0866		2.20		.1673		4.25		.2598		6.60		.3740		9.50		.7677		19.5
1/32	.0312				.0886		2.25		.1693		4.30		.2610	G		3/8	.3750			25/32	.7812		
	.0315		0.80		.0890	43			.1695	18			.2638		6.70		.3770	V			.7874		20.0
	.0320	67			.0906		2.30	11/64	.1719			17/64	.2656				.3780		9.60	51/64	.7969		
	.0330	66			.0925		2.35		.1730	17			.2657		6.75		.3819		9.70		.8071		20.5
	.0335		0.85		.0935	42			.1732		4.40		.2660	H			.3839		9.75	13/16	.8125		
	.0350	65		3/32	.0938				.1770	16			.2677		6.80		.3858		9.80		.8268		21.0
	.0354		0.90		.0945		2.40		.1772		4.50		.2717		6.90		.3860	W		53/64	.8281		
	.0360	64			.0960	41			.1800	15			.2720	I			.3898		9.90	27/32	.8438		
	.0370	63			.0965		2.45		.1811		4.60		.2756		7.00	25/64	.3906				.8465		21.5
	.0374		0.95		.0980	40			.1820	14			.2770	J			.3937		10.0	55/64	.8594		
	.0380	62			.0981		2.50		.1850	13			.2795		7.10		.3970	X			.8661		22.0
	.0390	61			.0995	39			.1850		4.70		.2810	K			.4040	Y		7/8	.8750		
	.0394		1.00		.1015	38			.1870		4.75	9/32	.2812			13/32	.4062				.8858		22.5
	.0400	60			.1024		2.60	3/16	.1875				.2835		7.20		.4130	Z		57/64	.8906		
	.0410	59			.1040	37			.1890		4.80		.2854		7.25		.4134		10.5		.9055		23.0
	.0413		1.05		.1063		2.70		.1890	12			.2874		7.30	27/64	.4219			29/32	.9062		
	.0420	58			.1065	36			.1910	11			.2900	L			.4331		11.0	59/64	.8906		
	.0430	57			.1083		2.75		.1929		4.90		.2913		7.40	7/16	.4375				.9252		23.5
	.0433		1.10	7/64	.1094				.1935	10			.2950	M			.4528		11.5	15/16	.9375		
	.0453		1.15		.1100	35			.1960	9			.2953		7.50	29/64	.4531				.9445		24
	.0465	56			.1102		2.80		.1969		5.00	19/64	.2969			15/32	.4688			61/64	.9531		
3/64	.0469				.1110	34			.1990	8			.2992		7.60		.4724		12.0		.9646		24.5
	.0472		1.20		.1130	33			.2008		5.10		.3020	N		31/64	.4844			31/32	.9688		
	.0492		1.25		.1142		2.90		.2010	7			.3031		7.70		.4921		12.5		.9843		25.0
	.0512		1.30		.1160	32		13/64	.2031				.3051		7.75	1/2	.5000			63/64	.9844		
	.0520	55			.1181		3.00		.2040	6			.3071		7.80		.5118		13.0	1"	1.000		
	.0531		1.35		.1200	31			.2047		5.20		.3110		7.90	33/64	.5156						
	.0550	54			.1220		3.10		.2055	5		5/16	.3125			17/32	.5312						
	.0551		1.40	1/8	.1250				.2067		5.25		.3150		8.00		.5315		13.5				
	.0571		1.45		.1260		3.20		.2087		5.30		.3160	O		35/64	.5469						
	.0591		1.50		.1280		3.25		.2090	4			.3189		8.10		.5512		14.0				
	.0595	53			.1285	30			.2126		5.40		.3228		8.20	9/16	.5625						
	.0610		1.55		.1299		3.30		.2130	3			.3230	P			.5709		14.5				

TAP DRILL SIZES FOR CUT AND FORMED THREADS

TAP SIZE	TAP DRILL SIZE				TAP SIZE	TAP DRILL SIZE				TAP SIZE	TAP DRILL SIZE			
	Cut Thread		Formed Thread			Cut Thread		Formed Thread			Cut Thread		Formed Thread	
0-80	3/64	.0469	54	.0545	8-32	29	.1360	25	.1495	7/16-14	U	.3680	13/32	.406
1-64	53	.0595	1.65 mm	.065	8-36	29	.1360	24	.1520	7/16-20	25/64	.3906	10.5 mm	.4134
1-72	53	.0595	1.7 mm	.0669	10-24	23	.1540	11/64	.1719	1/2-13	27/64	.4219	*	.466
2-56	50	.0700	5/64	.0781	10-32	20	.1610	16	.1770	1/2-20	29/64	.4531	*	.478
2-64	50	.0700	2 mm	.0787	12-24	15	.1800	5 mm	.1968	9/16-12	31/64	.4844	*	.525
3-48	46	.0810	43	.089	12-28	13	.1850	8	.1990	9/16-18	33/64	.5156	*	.538
3-56	45	.0820	2.3 mm	.0906	1/4-20	13/64	.2031	1	.2280	5/8-11	35/64	.5469	*	.584
4-40	43	.0890	39	.0995	1/4-28	7/32	.2187	A	.2340	5/8-18	37/64	.5781	*	.600
4-48	3/32	.0938	2.6 mm	.1024	5/16-18	G	.2610	7.3 mm	.2874	11/16-11	39/64	.6094	*	.646
5-40	38	.1015	33	.113	5/16-24	J	.2770	M	.2950	11/16-16	5/8	.6250	*	.660
5-44	37	.1040	2.9 mm	.1142	3/8-16	O	.3160	S	.3480	3/4-10	21/32	.6562	45/64	.7031
6-32	34	.1110	1/8	.125	3/8-24	R	.3390	T	.358	3/4-16	11/16	.6875	*	.722
6-40	32	.1160	3.2 mm	.1260										

NOTE: Cut thread tap drill sizes are for 2 B threads. Formed thread tap drill sizes are for approximately 65% thread. *Special drill sizes

Tap Size	Decimal Equivalent	PITCH (threads per in.)	MM Per Thread	Threads per mm	Tap Size	Decimal Equivalent	Threads Per In.	PITCH (mm per thread)	Threads per mm
.90 mm	.0354				1/4"	.2500	24		
1.0 mm	.0393	101.60	.25	4.000	1/4"	.2500	28		
1.1 mm	.0433	101.60	.25	4.000	1/4"	.2500	32		
1.2 mm	.0472	101.60	.25	4.000	7.0 mm	.2755	25.4	1.00	1.00
1.4 mm	.0551	84.66	.30	3.333	5/16"	.3120	18		
#0	.0600	80			5/16"	.3120	24		
1/16"	.0625	64			8.0 mm	.3149	20.32	1.25	.800
1.7 mm	.0669	72.56	.35	2.857	9.0 mm	.3543	20.32	1.25	.800
1.8 mm	.0708	72.56	.35	2.857	3/8"	.3750	16		
#1	.0730	64			3/8"	.3750	24		
#1	.0730	72			10.0 mm	.3937	16.93	1.50	.666
2.0 mm	.0787	63.50	.40	2.500	11.0 mm	.4330	16.93	1.50	.666
#2	.0860	64			7/16"	.4370	14		
2.3 mm	.0905	63.50	.40	2.500	7/16"	.4370	20		
3/32"	.0625	64			12.0 mm	.4724	14.51	1.75	.571
#3	.0990	48			1/2"	.5000	13		
#3	.0990	56			1/2"	.5000	20		
2.6 mm	.1023	56.43	.45	2.222	14.0 mm	.5510	12.70	2.00	.500
1/8"	.1250	40			5/8"	.6250	11		
#4	.1120	32			5/8"	.6250	18		
#4	.1120	36			16.0 mm	.6299	12.70	2.00	.500
#4	.1120	40			11/16"	.6870	11		
#4	.1120	48			11/16"	.6870	16		
3.0 mm	.1181	50.80	.50	2.000	18.0 mm	.7086	10.16	2.50	.400
#5	.1250	40			3/4"	.7500	10		
#5	.1250	44			3/4"	.7500	16		
3.5 mm	.1378	42.33	.60	1.666	20.0 mm	.7870	10.16	2.50	.400
#6	.1380	32			13/16"	.8120	12		
#6	.1380	40			13/16"	.8120	16		
5/32"	.1562	32			13/16"	.8120	20		
5/32"	.1562	36			13/16"	.8120	28		
4.0 mm	.1574	36.28	.70	1.428	13/16"	.8120	32		
#8	.1640	32			22.0 mm	.8666	10.16	2.50	.400
#8	.1640	36			7/8"	.8750	9		
#8	.1640	40			7/8"	.8750	14		
4.5 mm	.1771	33.86	.75	1.333	15/16"	.9370	12		
3/16"	.1870	24			15/16"	.9370	16		
3/16"	.1870	32			15/16"	.9370	20		
#10	.1900	24			15/16"	.9370	28		
#10	.1900	32			15/16"	.9370	32		
#10	.1900	30			24.0 mm	.9448	8.46	3.00	.333
5.0 mm	.1980	31.75	.80	1.250	1.00 “	1.0000	8		
#12	.2160	24			1.00 “	1.0000	12		
#12	.2160	28			1.00 “	1.0000	14		
#12	.2160	32			27.0 mm	1.0629	8.46	3.00	.333
7/32"	.2188	24			1-1/8"	1.1250	7		
7/32"	.2188	32			1-1/8"	1.1250	12		
6.0 mm	.2326	25.4	1.00	1.00	30.0 mm	1.1810	7.25	3.50	.285
#14	.2420	20			1-1/4"	1.2500	7		
#14	.2420	24			1-1/4"	1.2500	12		
1/4"	.2500	20			33.0 mm	1.2999	7.25	3.50	.285