

TABLES and FORMULAS for the Automotive Engineer

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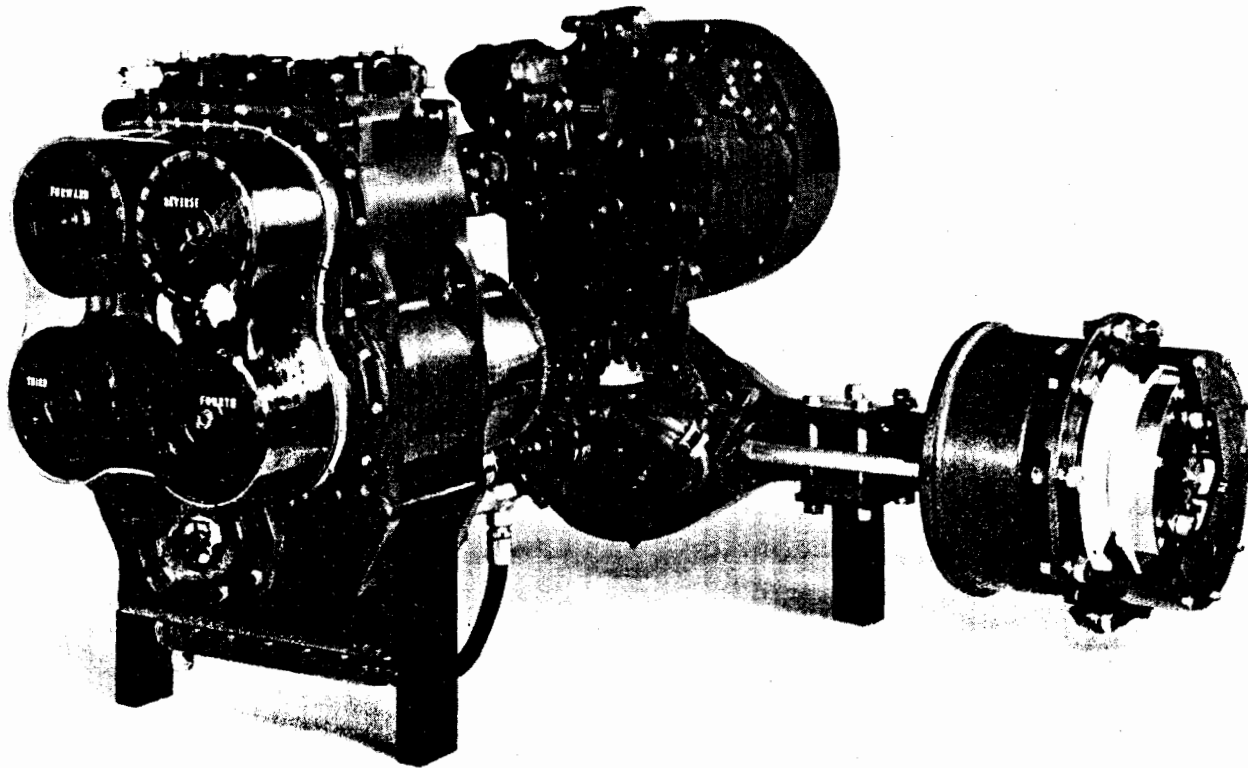
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**CLARK
EQUIPMENT**

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S.A.E. HORSEPOWER

The S.A.E. horsepower of a gasoline engine can be obtained by multiplying the number of cylinders by the square of the bore and dividing this sum by 2.5.

$$\text{S.A.E. HP} = \frac{N \times B^2}{2.5}$$

Where: S.A.E. HP = S.A.E. horsepower.

N = Number of cylinders.

B = Bore of cylinders in inches.

EXAMPLE: Find the S.A.E. horsepower of a 6 cylinder engine where the bore is 3 $\frac{1}{8}$.

$$\text{S.A.E. HP} = \frac{6 \times 3.625^2}{2.5} = 31.5 \text{ HP}$$

BRAKE HORSEPOWER

The brake horsepower of a gasoline engine can be obtained by multiplying the torque by the revolutions per minute and dividing this sum by 5252.

$$\text{BHP} = \frac{T \times \text{RPM}}{5252}$$

BHP = Brake horsepower.

Where: T = Torque in lbs.-feet.

RPM = Revolutions per minute.

EXAMPLE: Find the brake horsepower of an engine developing a torque of 100 lbs. feet at 2600 revolutions per minute.

$$\text{BHP} = \frac{100 \times 2600}{5252} = 49.5 \text{ BHP}$$

FRICTION HORSEPOWER

The friction horsepower of a gasoline engine can be obtained by multiplying the friction torque by the revolutions per minute and dividing this sum by 5252.

$$\text{FHP} = \frac{T \times \text{RPM}}{5252}$$

Where: FHP = Friction horsepower.

T = Friction torque in lbs.-feet.

RPM = Revolutions per minute.

EXAMPLE: Find the friction horsepower of a gasoline engine where the friction torque is 35 lbs. ft. at 3000 R.P.M.

$$\text{FHP} = \frac{35 \times 3000}{5252} = 20 \text{ FHP}$$

NOTE: In the preceding calculations "net" values should be used for torque or horsepower. These values are the actual output at the engine flywheel after suitable deductions have been made for the power requirements of engine driven accessories.

MAXIMUM NET ENGINE TORQUE

Where torque curves are not available the following formula can be used for an approximation.

$$.7 \times \text{cu. in. piston displacement.}$$

The .7 is based on an analysis of a number of torque curves.

EXAMPLE: Find the maximum net torque of an engine with 241 cu. in. displacement.

$$.7 \times 241 = 168.7 \text{ lbs.-feet.}$$

ENGINE TORQUE

The output of a motor can be expressed in either torque or horsepower. In automotive calculations, it is customary to use the torque value since it simplifies the calculations. The relationship between torque and horsepower is given by the formula.

$$T = \frac{5252 \times \text{HP}}{\text{RPM}}$$

Where: T = Torque in pounds feet.

HP = Horsepower.

RPM = Engine speed in revolutions per minute.

EXAMPLE: What is the torque of an engine that develops 80 H.P. at 2500 R.P.M.?

$$T = \frac{5252 \times 80}{2500} = 168 \text{ lbs.-feet.}$$

AXLE TORQUE

The torque available at the driving axle is the engine torque multiplied by gear reduction through the transmission and axle.

$$T_a = T \times R_t \times R_{ta} \times R_a$$

T_a = Axle torque.

R_t = Gear reduction through transmission for the particular gears engaged. In direct R_t equals 1.

R_a = Axle gear reduction.

R_{ta} = Gear reduction through auxiliary transmission.

T = Engine torque.

EXAMPLE: What is the rear axle torque in high gear on a vehicle having 168 lb.-ft. engine torque with a transmission ratio of 1:1, an auxiliary ratio of 1:1, and an axle ratio of 5.14:1.

$$T_a = 168 \times 1 \times 1 \times 5.14 = 864 \text{ lb.-ft.}$$

EXAMPLE: What is the rear axle torque on the same vehicle in low gear with a transmission ratio of 6.8:1 and an auxiliary ratio of 1.5:1.

$$T_a = 168 \times 6.8 \times 1.5 \times 5.14 = 8808 \text{ lb.-ft.}$$

ENGINE TORQUE REQUIRED TO SLIP WHEELS

The torque required to slip the wheels is the vehicle weight over the driving tires times the coefficient of friction of the driving tires on rolling surface times the rolling radius of tires divided by the overall gear reduction times the efficiency of power train.

$$ST = \frac{VW \times u \times r}{R \times e}$$

Where: VW = Vehicle weight over driving tires.

u = Coefficient of friction of tires on average road surface, generally 0.6

r = Rolling radius of loaded driving tire in inches.

R = Overall gear reduction in both axle and transmission.

e = Mechanical efficiency of drive line, generally 0.85.

EXAMPLE:

What is the engine torque required to slip wheels of a vehicle where the weight over the driving tire is 3000#, the coefficient of friction of the tires is 0.6, the rolling radius is 19.5 inches. The total reduction of power train is 10.

$$ST = \frac{3000 \times .6 \times 19.5}{10 \times .85} = 4129 \text{ lb.-in.}$$

ENGINE SPEED

The engine speed is obtained by multiplying 168 by the ratio of each unit in the power train by the miles per hour and dividing this sum by the rolling radius of the tire.

$$RPM = \frac{168 \times R \times MPH}{r}$$

- 168 = Factor.
 - RPM = Revolutions per minute of engine.
 - r = Rolling radius of loaded driving tire in inches.
 - R = Overall gear reduction including both axle and transmission.
 - MPH = Vehicle speed in miles per hour.
- EXAMPLE: Find the engine speed where the overall gear reduction is 10, vehicle speed is 15 M.P.H. and rolling radius of driving tire is 19.5 inches.

$$RPM = \frac{168 \times 10 \times 15}{19.5} = 1292 \text{ RPM}$$

MILES PER HOUR

Vehicle speed in miles per hour is the rolling radius of loaded driving tire multiplied by the engine R.P.M. and divided by 168 times the overall gear reduction of the power train.

$$MPH = \frac{RPM \times r}{168 \times R}$$

- 168 = Factor.
 - RPM = Revolutions per minute of engine.
 - r = Rolling radius of loaded driving tire in inches.
 - R = Overall gear reduction including both axle and transmission.
 - MPH = Vehicle speed in miles per hour.
- EXAMPLE: Find the M.P.H. of a vehicle where the engine speed is 1292 R.P.M., the rolling radius of loaded driving tire is 19.5 inches and the overall gear reduction is 10.

$$MPH = \frac{1292 \times 19.5}{168 \times 10} = 15 \text{ miles per hour.}$$

TRACTIVE EFFORT

The tractive effort is obtained by multiplying the torque by the total ratio of power train by the efficiency of the power train and dividing this sum by the rolling radius of the driving tires.

$$TE = \frac{T \times R \times e \times C \times 12}{r}$$

- Where: T = Gross engine torque in lb.-ft.
- C = Correction factor for engine torque to determine net torque available at flywheel. Generally 0.85.
- R = Overall gear reduction including both axle and transmission.
- e = Mechanical efficiency of drive line. Generally 0.85.
- r = Rolling radius of loaded driving tire in inches.
- 12 = A constant converting lb.-ft. to lb.-in.

EXAMPLE:

Find the tractive effort where the rolling radius of driving tires is 19.5 inches, the total ratio of power train is 10, the gross engine torque is 265 lb.-ft.

$$TE = \frac{265 \times 10 \times .85 \times .85 \times 12}{19.5} = 1178 \text{ pounds}$$

OVERALL GEAR REDUCTION

The overall gear reduction is the R.P.M. times the rolling radius of the loaded driving tire divided by 168 times the vehicle speed in miles per hour.

$$R = \frac{RPM \times r}{168 \times MPH}$$

- 168 = Factor.
 - RPM = Revolutions per minute of engine.
 - r = Rolling radius of loaded driving tire in inches.
 - R = Overall gear reduction including both axle and transmission.
 - MPH = Vehicle speed in miles per hour.
- EXAMPLE: Find the overall gear reduction of a vehicle where the engine speed is 1292 R.P.M., the rolling radius of loaded driving tire is 19.5 inches and the M.P.H. is 15.

$$R = \frac{1292 \times 19.5}{168 \times 15} = 10 \text{ to } 1$$

ROLLING RADIUS OF LOADED DRIVING TIRE

The rolling radius of loaded driving tire is 168 times the overall gear reduction times the miles per hour divided by the engine speed.

$$r = \frac{168 \times R \times MPH}{RPM}$$

- 168 = Factor.
 - RPM = Revolutions per minute of engine.
 - r = Rolling radius of loaded driving tire in inches.
 - R = Overall gear reduction including both axle and transmission.
 - MPH = Vehicle speed in miles per hour.
- EXAMPLE: Find the rolling radius of loaded driving tire of a vehicle where the overall gear reduction is 10, the miles per hour 15 and the engine speed 1292 R.P.M.

$$r = \frac{168 \times 10 \times 15}{1292} = 19.5 \text{ inches}$$

DRAW BAR PULL

The torque on the driving axle creates a force between the tires and the road which is used to propel the vehicle. This gross force is termed the tractive effort and the net force, that is, gross force minus rolling resistances is the drawbar pull.

$$DP = \frac{T \times R \times .85}{r} - RR$$

- DP = Drawbar pull in lbs.
- T = Engine torque in lb.-in.
- R = Overall gear reduction including both axle and transmission.
- r = Rolling radius of loaded driving tire in inches.
- .85 = A constant for efficiency of transmission and axle.
- RR = Road rolling resistance in pounds.
- GVW = Gross vehicle weight of motive vehicle.

EXAMPLE: What is the drawbar pull of a vehicle with an engine torque of 2400 lb.-in., an overall gear reduction of 8.00:1, and rolling radius of the driving tire is 20 inches and a G.V.W. of 20,000 lbs. over good concrete.

$$DP = \frac{2400 \times 8 \times .85}{20} - .015 \times 20,000 = 516 \text{ lbs.}$$

ROAD ROLLING RESISTANCE:

The road rolling resistance is the force required to push a vehicle over the surface it is rolling over and may be expressed in several ways. One, in terms of pounds resistance per thousand pounds of gross weight. Other methods are derived from this basic expression. Following is a table of rolling resistances in pounds per thousand pounds of gross weight of various road surfaces.

Concrete, excellent.....	10 lbs.
Concrete, good.....	15 lbs.
Concrete, poor.....	20 lbs.
Asphalt, good.....	12 lbs.
Asphalt, fair.....	17 lbs.
Asphalt, poor.....	22 lbs.
Macadam, good.....	15 lbs.
Macadam, fair.....	22 lbs.
Macadam, poor.....	37 lbs.
Cobbles, ordinary.....	55 lbs.
Cobbles, poor.....	85 lbs.
Snow, 2 inch.....	25 lbs.
Snow, 4 inch.....	37 lbs.
Dirt, smooth.....	25 lbs.
Dirt, sandy.....	37 lbs.
Mud.....	37 lbs. to 150 lbs.
Sand, level soft sand.....	60 lbs. to 150 lbs.
Sand, dune.....	160 lbs. to 300 lbs.

Rolling resistance is the gross vehicle weight in lbs. times the rolling resistance of the surface divided by 1000.

$$RR = \frac{GVW \times R}{1000}$$

- Where: RR = Road rolling resistance in pounds.
 GVW = Gross vehicle weight in pounds.
 R = Rolling resistance in pounds per thousand pounds vehicle weight.
 1000 = A constant to determine number of thousand pounds in vehicle.

EXAMPLE:

What is the rolling resistance of a vehicle having a gross weight of 7000 pounds on poor asphalt?

$$RR = \frac{7000 \times 22}{1000} = 154 \text{ lbs.}$$

Many formulas are arranged to use the rolling resistances in the above table as a factor. To set the table data up in factor form divide the resistance in lbs. by 1000.

$$Q = \frac{R}{1000}$$

- Where: Q = Rolling resistance factor per pound of gross vehicle weight.
 R = Rolling resistance in pounds per thousand pounds vehicle weight.

EXAMPLE:

What is the rolling resistance factor per pound of gross vehicle weight on good concrete?

$$Q = \frac{15}{1000} = .015$$

Another method of expressing road rolling resistance is in percent of grade. To express rolling resistance in percent of grade multiply rolling resistance per thousand pounds vehicle by 100 and divide by 1000.

$$RR \% \text{ Grade} = \frac{R \times 100}{1000}$$

ROAD ROLLING RESISTANCE: (Continued)

Where: RR % Grade = Road rolling resistance in percent of grade.

- R = Rolling resistance in pounds per thousand pounds vehicle weight.
 100 = A constant to express percent.

EXAMPLE:

What is the road rolling resistance expressed in percent of grade of a vehicle on good concrete?

$$RR \% \text{ Grade} = \frac{15 \times 100}{1000} = 1.5\%$$

GRADEABILITY

Obviously, the tractive effort available at the wheels must be greater than the sum of the rolling resistances encountered. If this is not so, the transmission must be shifted to a lower gear in order to increase the tractive effort. The percentage of grade which can be negotiated is given by the formula:

$$G = \frac{1200 \times T \times e \times C \times R}{r \times GVW} - RR$$

Where: 1200 = A constant expressing percentage grade and feet.

- T = Gross engine torque in lb.-ft.
 e = Mechanical efficiency of drive line. Generally 0.85.
 C = Correction factor for gross engine torque to determine net torque available at flywheel. Generally 0.85.
 R = Overall gear reduction including both axle and transmission.
 r = Rolling radius of loaded driving tire in inches.

GVW = Gross vehicle weight in pounds.

RR = Rolling resistance expressed in percentage grade.

EXAMPLE:

What percentage grade can be negotiated by a vehicle having a gross engine torque of 265 ft.-lbs., an overall gear reduction in high of 4.12 to 1, a tire rolling radius of 19.2 inches and a gross vehicle weight of 30,000 lbs.?

$$G = \frac{1200 \times 265 \times .85 \times .85 \times 4.12}{19.2 \times 30,000} - 1.5\%$$

$$G = 0.14\% \text{ grade.}$$

GRADE RESISTANCE

The grade resistance of a vehicle is .01 times the gross weight times the percentage grade.

$$GR = .01 \times G.V.W. \times \% \text{ grade.}$$

- Where: GR = grade resistance.
 GVW = Gross vehicle weight.

EXAMPLE: What is the grade resistance of a vehicle having a gross weight of 7000 lbs. on a 5% grade?

$$GR = .01 \times 7000 \times 5 = 350 \text{ lbs.}$$

AUTOMOTIVE VEHICLE PERFORMANCE FORMULAS

AIR RESISTANCE

The air resistance against a vehicle is a force in lbs. equal to .0025 times the miles per hour squared times the frontal area.

$$AR = .0025 \text{ MPH}^2 \times FA$$

AR = Air resistance in lbs.

MPH = Speed in miles per hour.

FA = Frontal area of vehicle in square feet.

EXAMPLE: What is the air resistance of a vehicle traveling 40 miles per hour and having a frontal area of 80 square feet.

$$AR = .0025 \times (40)^2 \times 80 = 320 \text{ lbs.}$$

HORSEPOWER REQUIRED TO OVERCOME AIR RESISTANCE

The horsepower required to overcome air resistance is the speed in miles per hour, cubed, times the frontal area in square feet divided by 150,000.

$$HP = \frac{\text{MPH}^3 \times FA}{150,000}$$

MPH = Speed in miles per hour.

FA = Frontal area in square feet.

HP = Horsepower.

150,000 = A conversion constant.

EXAMPLE: What is the horsepower required to overcome air resistance of a vehicle traveling 40 miles per hour and having a frontal area of 80 square feet.

$$HP = \frac{40^3 \times 80}{150,000} = 34.13 \text{ HP}$$

CLUTCH TORQUE CAPACITY

Clutch torque capacity is the sum of friction surfaces times coefficient of friction of linings, times the total effective pressure on linings times the radius of gyration of linings.

$$T = N \times f \times P \times K$$

Where: T = Torque in lbs. feet.

N = Number of friction surfaces.

f = Coefficient of friction of linings.

.25 average slipping.

.3 average breakaway.

P = Total effective pressure on linings.

K = Radius of gyration of lining in feet.

EXAMPLE:

What is the torque capacity of a clutch having a driven disc 15.5" O.D. and 9" I.D. The disc has two working surfaces. Pressure on disc is 5,000 lbs. and coefficient of friction .25 and K = .5281.

$$T = 2 \times .25 \times 5000 \times .5281 = 1320 \text{ lbs.-feet.}$$

GENERAL FORMULA FOR SPEEDOMETER GEAR RATIO

The basic formula for the speedometer gear ratio is the propeller shaft revolutions per mile divided by 1000.

$$\text{SGR} = \frac{\text{RPMps}}{1000}$$

Where: SGR = Speedometer gear ratio.

RPMps = Revolutions per mile of propeller shaft.

1000 = A constant.

In most instances it is necessary to use another formula to convert known factors into the propeller shaft revolutions per mile. This can be obtained by multiplying the inches per mile by the rear axle ratio and dividing by 6283.2 times the tire static loaded radius.

$$\text{SGR} = \frac{63,360 \times Ra}{6283.2 \times r}$$

Where: SGR = Speedometer gear ratio.

63,360 = Inches per mile, a constant.

Ra = Axle gear reduction.

6283.2 = A constant for converting to revolutions per mile.

r = Rolling radius of loaded driving tire in inches.

EXAMPLE:

What is the speedometer gear ratio for a vehicle with a rear axle ratio of 6.54 to 1 and 11.00-20 tires with a 20.1 rolling radius?

$$\text{SGR} = \frac{63360 \times 6.54}{6283.2 \times 20.1} = 3.281$$

GROUND SPEED OF TRACK LAYING VEHICLE

The ground speed of a track laying vehicle is the engine revolutions per minute times the circumference of the driving sprocket divided by 168 times 2 times 3.1416 times the overall gear reduction of the power train.

$$V = \frac{\text{RPM} \times C}{168 \times 2 \times 3.1416 \times R}$$

Where: V = Ground speed in M.P.H.

RPM = Rev. per min. of engine

C = Circumference

C = N × L

N = No. of teeth in sprocket.

L = Length of links in inches.

R = Overall gear reduction.

EXAMPLE:

Find the ground speed in miles per hour where the engine speed is 1800 R.P.M., the number of teeth in the sprocket is 41, the length of link 8", and the total reduction of power train is 61 to 1.

$$C = 41 \times 8 = 328$$

$$V = \frac{1800 \times 328}{168 \times 2 \times 3.1416 \times 61} = 9.169 \text{ MPH}$$

CIRCUMFERENCES AND AREAS OF CIRCLES
From 1/64 to 50, Diameter

Dia.	Circum.	Area	Dia.	Circum.	Area	Dia.	Circum.	Area	Dia.	Circum.	Area
1/64	.04909	.00019	6	18.8496	28.2743	13	40.8407	132.732	20	62.8319	314.159
1/32	.09818	.00077	6 1/2	19.2423	29.4647	13 1/2	41.2334	135.297	20 1/2	63.2246	318.099
1/16	.19635	.00307	6 3/4	19.6350	30.6796	13 3/4	41.6261	137.886	20 3/4	63.6173	322.062
3/32	.39270	.01227	6 7/8	20.0277	31.9191	13 7/8	42.0188	140.500	20 7/8	64.0100	326.051
1/8	.78540	.02761	6 7/8	20.4204	33.1831	13 7/8	42.4115	143.139	20 7/8	64.4027	330.064
3/16	.98175	.04909	6 7/8	20.8131	34.4716	13 7/8	42.8042	145.802	20 7/8	64.7954	334.101
1/4	1.1781	.11045	6 7/8	21.2058	35.7847	13 7/8	43.1969	148.489	20 7/8	65.1881	338.163
5/16	1.3744	.15033	6 7/8	21.5985	37.1223	13 7/8	43.5896	151.201	20 7/8	65.5808	342.250
3/8	1.5708	.19635	7	21.9912	38.4845	14	43.9823	153.938	21	65.9735	346.361
7/16	1.7671	.24850	7 1/2	22.3839	39.8712	14 1/2	44.3750	156.699	21 1/2	66.3662	350.496
1/2	1.9635	.30680	7 3/4	22.7765	41.2825	14 3/4	44.7677	159.485	21 3/4	66.7589	354.656
5/8	2.1598	.37122	7 3/4	23.1692	42.7183	14 3/4	45.1604	162.295	21 3/4	67.1516	358.841
3/4	2.3562	.44179	7 3/4	23.5619	44.1787	14 3/4	45.5531	165.130	21 3/4	67.5442	363.050
7/8	2.5525	.51849	7 3/4	23.9546	45.6636	14 3/4	45.9458	167.989	21 3/4	67.9369	367.284
1 1/8	2.7489	.60132	7 3/4	24.3473	47.1730	14 3/4	46.3385	170.873	21 3/4	68.3296	371.542
1 1/4	2.9452	.69029	7 3/4	24.7400	48.7069	14 3/4	46.7312	173.782	21 3/4	68.7223	375.825
1 1/2	3.1416	.78540	8	25.1327	50.2655	15	47.1239	176.715	22	69.1150	380.133
1 3/4	3.3379	.88690	8 1/4	25.5254	51.8485	15 1/4	47.5166	179.672	22 1/4	69.5077	384.465
1 7/8	3.5343	.99402	8 1/4	25.9181	53.4562	15 1/4	47.9094	182.654	22 1/4	69.9004	388.821
2	3.7307	1.10777	8 1/4	26.3108	55.0883	15 1/4	48.3020	185.661	22 1/4	70.2931	393.203
2 1/4	3.9270	1.22722	8 1/2	26.7035	56.7450	15 1/4	48.6947	188.692	22 1/4	70.6858	397.608
2 1/2	4.1234	1.35267	8 1/2	27.0962	58.4262	15 1/4	49.0874	191.748	22 1/4	71.0785	402.038
2 3/4	4.3197	1.48412	8 1/2	27.4889	60.1321	15 1/4	49.4801	194.828	22 1/4	71.4712	406.493
2 7/8	4.5161	1.62157	8 1/2	27.8816	61.8624	15 1/4	49.8728	197.933	22 1/4	71.8639	410.972
3	4.7124	1.76502	9	28.2743	63.6173	16	50.2655	201.062	23	72.2566	415.476
3 1/4	4.9087	1.91447	9 1/4	28.6670	65.3967	16 1/4	50.6582	204.216	23 1/4	72.6493	420.004
3 1/2	5.1051	2.06992	9 1/4	29.0597	67.2007	16 1/4	51.0509	207.394	23 1/4	73.0420	424.557
3 3/4	5.3014	2.23137	9 1/4	29.4524	69.0292	16 1/4	51.4436	210.597	23 1/4	73.4347	429.134
3 7/8	5.4978	2.39882	9 1/2	29.8451	70.8822	16 1/4	51.8363	213.825	23 1/4	73.8274	433.736
4	5.6941	2.57227	9 1/2	30.2378	72.7597	16 1/4	52.2290	217.077	23 1/4	74.2201	438.363
4 1/4	5.8905	2.75172	9 1/2	30.6305	74.6619	16 1/4	52.6217	220.353	23 1/4	74.6128	443.014
4 1/2	6.0869	2.93717	9 1/2	31.0232	76.5886	16 1/4	53.0144	223.654	23 1/4	75.0055	447.689
4 3/4	6.2832	3.12862	10	31.4159	78.5398	17	53.4071	226.980	24	75.3982	452.389
4 7/8	6.4796	3.32607	10 1/4	31.8086	80.5156	17 1/4	53.7998	230.330	24 1/4	75.7909	457.114
5	6.6759	3.52952	10 1/4	32.2013	82.5159	17 1/4	54.1925	233.705	24 1/4	76.1836	461.863
5 1/4	6.8723	3.73897	10 3/4	32.5940	84.5408	17 3/4	54.5852	237.104	24 3/4	76.5763	466.637
5 1/2	7.0686	3.95442	10 3/4	32.9867	86.5902	17 3/4	54.9779	240.528	24 3/4	76.9690	471.435
5 3/4	7.2649	4.17587	10 3/4	33.3794	88.6641	17 3/4	55.3706	243.977	24 3/4	77.3617	476.258
5 7/8	7.4613	4.40332	10 3/4	33.7721	90.7626	17 3/4	55.7633	247.450	24 3/4	77.7544	481.106
6	7.6576	4.63677	10 3/4	34.1648	92.8856	17 3/4	56.1560	250.947	24 3/4	78.1471	485.977
6 1/4	7.8540	4.87622	11	34.5575	95.0332	18	56.5487	254.469	25	78.5398	490.874
6 1/2	8.0503	5.12167	11 1/4	34.9502	97.2053	18 1/4	56.9414	258.016	25 1/4	78.9325	495.795
6 3/4	8.2467	5.37312	11 1/4	35.3429	99.4020	18 1/4	57.3341	261.587	25 1/4	79.3252	500.740
6 7/8	8.4430	5.63057	11 1/4	35.7356	101.623	18 1/4	57.7268	265.182	25 1/4	79.7179	505.711
7	8.6394	5.89402	11 1/2	36.1283	103.869	18 1/2	58.1195	268.803	25 1/2	80.1106	510.705
7 1/4	8.8357	6.16347	11 1/2	36.5210	106.139	18 1/2	58.5122	272.447	25 1/2	80.5033	515.724
7 1/2	9.0321	6.43892	11 1/2	36.9137	108.434	18 1/2	58.9049	276.117	25 1/2	80.8960	520.768
7 3/4	9.2284	6.72037	11 1/2	37.3064	110.753	18 1/2	59.2976	279.810	25 1/2	81.2887	525.836
7 7/8	9.4247	7.00782	12	37.6991	113.097	19	59.6903	283.529	26	81.6814	530.929
8	9.6210	7.30127	12 1/4	38.0918	115.466	19 1/4	60.0830	287.272	26 1/4	82.0741	536.047
8 1/4	9.8173	7.60072	12 1/4	38.4845	117.859	19 1/4	60.4757	291.039	26 1/4	82.4668	541.188
8 1/2	10.0136	7.90617	12 1/2	38.8772	120.276	19 1/2	60.8684	294.831	26 1/2	82.8595	546.355
8 3/4	10.2099	8.21762	12 1/2	39.2699	122.718	19 1/2	61.2611	298.648	26 1/2	83.2522	551.546
8 7/8	10.4062	8.53507	12 3/4	39.6626	125.185	19 3/4	61.6538	302.489	26 3/4	83.6449	556.761
9	10.6025	8.85852	12 3/4	40.0553	127.676	19 3/4	62.0465	306.354	26 3/4	84.0376	562.002
9 1/4	10.7988	9.18797	12 3/4	40.4480	130.191	19 3/4	62.4392	310.245	26 3/4	84.4303	567.266

CIRCUMFERENCES AND AREAS OF CIRCLES (Continued)

Dia.	Circum.	Area	Dia.	Circum.	Area	Dia.	Circum.	Area	Dia.	Circum.	Area
27	84.8230	572.555	33	103.6726	855.299	39	122.5221	1194.591	45	141.3717	1590.431
27 1/4	85.2157	577.869	33 1/4	104.0653	861.791	39 1/4	122.9148	1202.261	45 1/4	141.7644	1599.279
27 1/2	85.6084	583.207	33 1/2	104.4580	868.307	39 1/2	123.3075	1209.955	45 1/2	142.1571	1608.152
27 3/4	86.0011	588.570	33 3/4	104.8507	874.848	39 3/4	123.7002	1217.674	45 3/4	142.5498	1617.049
28	86.3938	593.957	34	105.2434	881.413	39 1/2	124.0929	1225.418	45 1/2	142.9425	1625.971
28 1/4	86.7865	599.369	34 1/4	105.6361	888.003	39 1/4	124.4856	1233.186	45 1/4	143.3352	1634.917
28 1/2	87.1792	604.806	34 1/2	106.0288	894.618	39 1/2	124.8783	1240.978	45 1/2	143.7279	1643.888
28 3/4	87.5719	610.267	34 3/4	106.4215	901.257	39 3/4	125.2710	1248.796	45 3/4	144.1206	1652.883
28	87.9646	615.752	34	106.8142	907.920	40	125.6637	1256.637	46	144.5133	1661.903
28 1/4	88.3573	621.262	34 1/4	107.2069	914.609	40 1/4	126.0564	1264.503	46 1/4	144.9060	1670.947
28 1/2	88.7500	626.797	34 1/2	107.5996	921.321	40 1/2	126.4491	1272.394	46 1/2	145.2987	1680.016
28 3/4	89.1427	632.356	34 3/4	107.9923	928.058	40 3/4	126.8418	1280.310	46 3/4	145.6914	1689.109
28 1/2	89.5354	637.940	34 1/2	108.3850	934.820	40 1/2	127.2345	1288.249	46 1/2	146.0841	1698.227
28 3/4	89.9281	643.548	34 3/4	108.7777	941.607	40 3/4	127.6272	1296.214	46 3/4	146.4768	1707.370
28 3/4	90.3208	649.181	34 3/4	109.1704	948.417	40 3/4	128.0199	1304.203	46 3/4	146.8695	1716.537
28 3/4	90.7135	654.838	34 3/4	109.5631	955.253	40 3/4	128.4126	1312.216	46 3/4	147.2622	1725.729
29	91.1062	660.520	35	109.9558	962.113	41	128.8053	1320.254	47	147.6549	1734.945
29 1/4	91.4989	666.226	35 1/4	110.3485	968.997	41 1/4	129.1980	1328.317	47 1/4	148.0476	1744.185
29 1/2	91.8916	671.957	35 1/2	110.7412	975.906	41 1/2	129.5907	1336.404	47 1/2	148.4403	1753.451
29 3/4	92.2843	677.713	35 3/4	111.1339	982.840	41 3/4	129.9834	1344.516	47 3/4	148.8330	1762.740
29 1/2	92.6770	683.493	35 1/2	111.5266	989.798	41 1/2	130.3761	1352.652	47 1/2	149.2257	1772.055
29 3/4	93.0697	689.297	35 3/4	111.9193	996.781	41 3/4	130.7688	1360.813	47 3/4	149.6184	1781.394
29 3/4	93.4624	695.127	35 3/4	112.3119	1003.788	41 3/4	131.1615	1368.998	47 3/4	150.0111	1790.757
29 3/4	93.8551	700.980	35 3/4	112.7046	1010.820	41 3/4	131.5542	1377.208	47 3/4	150.4038	1800.145
30	94.2478	706.858	36	113.0973	1017.876	42	131.9469	1385.443	48	150.7965	1809.558
30 1/4	94.6405	712.761	36 1/4	113.4900	1024.957	42 1/4	132.3396	1393.701	48 1/4	151.1892	1818.995
30 1/2	95.0332	718.689	36 1/2	113.8827	1032.062	42 1/2	132.7323	1401.985	48 1/2	151.5819	1828.456
30 3/4	95.4259	724.640	36 3/4	114.2754	1039.192	42 3/4	133.1250	1410.293	48 3/4	151.9746	1837.942
30 3/4	95.8186	730.617	36 3/4	114.6681	1046.347	42 3/4	133.5177	1418.626	48 3/4	152.3673	1847.453
30 3/4	96.2113	736.618	36 3/4	115.0608	1053.526	42 3/4	133.9104	1426.983	48 3/4	152.7600	1856.988
30 3/4	96.6040	742.643	36 3/4	115.4535	1060.729	42 3/4	134.3031	1435.364	48 3/4	153.1527	1866.548
30 3/4	96.9967	748.693	36 3/4	115.8462	1067.958	42 3/4	134.6958	1443.771	48 3/4	153.5454	1876.132
31	97.3894	754.768	37	116.2389	1075.210	43	135.0885	1452.201	49	153.9381	1885.741
31 1/4	97.7821	760.867	37 1/4	116.6316	1082.487	43 1/4	135.4812	1460.657	49 1/4	154.3308	1895.375
31 1/2	98.1748	766.990	37 1/2	117.0243	1089.789	43 1/2	135.8739	1469.137	49 1/2	154.7235	1905.033
31 3/4	98.5675	773.139	37 3/4	117.4170	1097.115	43 3/4	136.2666	1477.641	49 3/4	155.1162	1914.715
31 1/2	98.9602	779.311	37 1/2	117.8097	1104.466	43 1/2	136.6593	1486.170	49 1/2	155.5089	1924.422
31 3/4	99.3529	785.509	37 3/4	118.2024	1111.842	43 3/4	137.0520	1494.723	49 3/4	155.9016	1934.154
31 3/4	99.7456	791.731	37 3/4	118.5951	1119.242	43 3/4	137.4447	1503.301	49 3/4	156.2943	1943.910
31 3/4	100.1383	797.977	37 3/4	118.9878	1126.666	43 3/4	137.8374	1511.904	49 3/4	156.6870	1953.690
32	100.5310	804.248	38	119.3805	1134.115	44	138.2301	1520.531	50	157.0797	1963.496
32 1/4	100.9237	810.543	38 1/4	119.7732	1141.589	44 1/4	138.6228	1529.183			
32 1/2	101.3164	816.863	38 1/2	120.1659	1149.087	44 1/2	139.0155	1537.859			
32 3/4	101.7091	823.208	38 3/4	120.5586	1156.609	44 3/4	139.4082	1546.560			
32 1/2	102.1018	829.577	38 1/2	120.9513	1164.157	44 1/2	139.8009	1555.285			
32 3/4	102.4945	835.971	38 3/4	121.3440	1171.728	44 3/4	140.1936	1564.035			
32 3/4	102.8872	842.389	38 3/4	121.7367	1179.325	44 3/4	140.5863	1572.809			
32 3/4	103.2799	848.831	38 3/4	122.1294	1186.945	44 3/4	140.9790	1581.608			

MULTIPLICATION FACTOR FOR LENGTHS OF CIRCULAR ARCS

DEGREES

1	.017453	21	.366519	41	.715585	61	1.064651	81	1.413717	101	1.762783	121	2.111849	141	2.460914	161	2.809980
2	.034907	22	.383972	42	.733038	62	1.082104	82	1.431170	102	1.780236	122	2.129302	142	2.478368	162	2.827434
3	.052360	23	.401426	43	.750492	63	1.099558	83	1.448623	103	1.797689	123	2.146755	143	2.495821	163	2.844887
4	.069813	24	.418879	44	.767945	64	1.117011	84	1.466077	104	1.815143	124	2.164208	144	2.513274	164	2.862340
5	.087266	25	.436332	45	.785398	65	1.134464	85	1.483530	105	1.832596	125	2.181662	145	2.530728	165	2.879794
6	.104720	26	.453786	46	.802852	66	1.151917	86	1.500983	106	1.850049	126	2.199115	146	2.548181	166	2.897247
7	.122173	27	.471239	47	.820305	67	1.169371	87	1.518437	107	1.867502	127	2.216568	147	2.565634	167	2.914700
8	.139626	28	.488692	48	.837758	68	1.186824	88	1.535890	108	1.884956	128	2.234022	148	2.583088	168	2.932153
9	.157080	29	.506146	49	.855211	69	1.204277	89	1.553343	109	1.902409	129	2.251475	149	2.600541	169	2.949607
10	.174533	30	.523599	50	.872665	70	1.221731	90	1.570796	110	1.919862	130	2.268928	150	2.617994	170	2.967060
11	.191986	31	.541052	51	.890118	71	1.239184	91	1.588250	111	1.937316	131	2.286382	151	2.635447	171	2.984513
12	.209440	32	.558505	52	.907571	72	1.256637	92	1.605703	112	1.954769	132	2.303835	152	2.652901	172	3.001967
13	.226893	33	.575959	53	.925025	73	1.274090	93	1.623156	113	1.972222	133	2.321288	153	2.670354	173	3.019420
14	.244346	34	.593412	54	.942478	74	1.291544	94	1.640610	114	1.989676	134	2.338741	154	2.687807	174	3.036873
15	.261799	35	.610865	55	.959931	75	1.308997	95	1.658063	115	2.007129	135	2.356195	155	2.705261	175	3.054326
16	.279253	36	.628319	56	.977384	76	1.326450	96	1.675516	116	2.024582	136	2.373648	156	2.722714	176	3.071780
17	.296706	37	.645772	57	.994838	77	1.343904	97	1.692970	117	2.042035	137	2.391101	157	2.740167	177	3.089233
18	.314159	38	.663225	58	1.012291	78	1.361357	98	1.710423	118	2.059489	138	2.408555	158	2.757620	178	3.106686
19	.331613	39	.680678	59	1.029744	79	1.378810	99	1.727876	119	2.076942	139	2.426008	159	2.775074	179	3.124140
20	.349066	40	.698132	60	1.047198	80	1.396264	100	1.745329	120	2.094395	140	2.443461	160	2.792527	180	3.141593

MINUTES

1	.000291	11	.003200	21	.006109	31	.009018	41	.011926	51	.014835
2	.000582	12	.003491	22	.006400	32	.009308	42	.012217	52	.015126
3	.000873	13	.003782	23	.006690	33	.009599	43	.012508	53	.015417
4	.001164	14	.004072	24	.006981	34	.009890	44	.012799	54	.015708
5	.001454	15	.004363	25	.007272	35	.010181	45	.013090	55	.015999
6	.001745	16	.004654	26	.007563	36	.010472	46	.013381	56	.016290
7	.002036	17	.004945	27	.007854	37	.010763	47	.013672	57	.016581
8	.002327	18	.005236	28	.008145	38	.011054	48	.013963	58	.016872
9	.002618	19	.005527	29	.008436	39	.011345	49	.014254	59	.017162
10	.002909	20	.005818	30	.008727	40	.011636	50	.014544	60	.017453

EXAMPLE OF DETERMINING LENGTHS OF CIRCULAR ARCS BY USE OF MULTIPLICATION FACTOR

$$\text{Multiplication Factor} = \frac{3.141593}{180} \times \text{number of degrees}$$

$$\text{Length of Arc} = \text{Radius} \times \text{Multiplication Factor}$$

EXAMPLE: To find the length of arc of a circular sector of 33° 15' having a 20 inch radius:

$$\begin{aligned} \text{Factor for } 33^\circ &= .575959 \\ \text{Factor for } 15' &= .004363 \\ \hline &= .580322 \end{aligned}$$

$$.580322 \times 20 = 11.6064 \text{ inches.}$$

SAFE TORQUE—(LBS.-FT.)
For Bolts, Cap Screws, Studs and Nuts

Material	Steel	S.A.E.—1010 S.A.E.—1020 S.A.E.—1112	S.A.E.—1038	S.A.E.—1050	S.A.E.—3135
	Brass	S.A.E.—73 S.A.E.—72	.....	.....	.....
Heat Treat		None	R.C. 20—28	R.C. 28—39	R.C. 32—37
Tensile Strength		55,000 P.S.I.	100,000 P.S.I.	130,000 P.S.I.	150,000 P.S.I.
Yield Point—80%		22,000 P.S.I.	56,000 P.S.I.	70,400 P.S.I.	108,800 P.S.I.

THE FOLLOWING TORQUE IS APPLIED WITH DRY THREADS
 For oiled bolts and nuts the Torque required is approximately 30—40% less than that indicated in this table.

Coarse Threads	¼—20	2	5	6	9
	⅜—18	4	10	13	20
	½—16	7	18	23	36
	⅝—14	12	33	38	59
	¾—13	19	47	59	91
	⅞—12	27	68	85	132
	1—11	37	95	119	181
	1¼—10	69	175	219	340
	1½—9	113	286	359	555
	1¾—8	169	428	541	836
	2—7	238	605	760	1175
	2¼—7	345	878	1106	1705
	2½—6	497	1265	1575	2455
3—6	610	1551	1950	3011	
Fine Threads	¼—28	2	6	8	12
	⅜—24	5	13	16	25
	½—24	9	24	30	47
	⅝—20	15	37	48	74
	¾—20	23	60	76	117
	⅞—18	34	86	108	166
	1—18	49	124	155	240
	1¼—16	86	218	274	424
	1½—14	137	344	439	679
	1¾—14	214	545	686	1058
	2—12	303	768	967	1494
	2¼—12	427	1080	1368	2115
	2½—12	643	1635	2055	3180
3—12	775	1972	2475	3830	

Theoretical torque in inch pounds required on the nut of a bolt to produce either 1000# tension or 60,000# per sq. inch stress in the bolt. Based on coefficient of friction, between bolt and nut, of .15.

Bolt Dia.	Number of Threads	Required 1000 Lb. Tension	Torque for 60,000 Lb. Stress	Number of Threads	Required 1000 Lb. Tension	Torque for 60,000 Lb. Stress
¼	28	53	98	20	55	87
⅜	24	67	199	18	68	178
½	24	79	356	16	81	319
⅝	20	93	565	14	93	501
¾	20	105	864	13	107	771
⅞	18	118	1234	12	121	1124
1	18	128	1688	11	134	1538
1¼	16	156	3015	10	160	2730
1½	14	182	4768	9	186	4371
2	14	206	7276	8	212	6554
2¼	12	233	10325	7	239	9295
2½	12	257	14202	7	264	13086
3	12	307	25102	6	315	22686



CARBON BAR STEEL Weight per Lineal Foot in Pounds

Size	Round	Square	Octagon	Hexagon	Size	Round	Square	Octagon	Hexagon
1/16	.010	.013	.011	.....	4	42.73	54.40	45.15	47.13
1/8	.042	.053	.044	.046	4 1/16	44.07	56.11	46.57	.....
3/16	.094	.119	.099	.10	4 1/8	45.44	58.75	48.02	.....
1/4	.167	.212	.177	.18	4 3/16	46.83	59.62	49.48	.....
5/16	.261	.333	.276	.29	4 1/2	48.24	61.41	50.97	53.21
3/8	.375	.478	.397	.41	4 5/8	49.66	63.23	52.48	.....
7/16	.511	.651	.540	.56	4 3/4	51.11	65.08	54.02	.....
1/2	.667	.850	.706	.74	4 7/8	52.58	66.95	55.57	.....
9/16	.845	1.076	.892	.93	4 1/2	54.07	68.85	57.15	59.64
5/8	1.043	1.328	1.102	1.15	4 9/16	55.59	70.78	58.75	.....
11/16	1.262	1.608	1.325	1.40	4 5/8	57.12	72.73	60.37	.....
3/4	1.502	1.913	1.588	1.66	4 3/4	58.67	74.70	62.00	.....
13/16	1.763	2.245	1.863	1.94	4 7/8	60.25	76.71	63.67	66.46
7/8	2.044	2.603	2.161	2.25	4 15/16	61.84	78.74	65.35	.....
1 1/16	2.347	2.989	2.481	2.59	4 1/2	63.46	80.81	67.07	.....
1	2.670	3.400	2.822	2.94	4 5/8	65.10	82.89	68.80	.....
1 1/16	3.014	3.838	3.186	3.32	5	66.76	85.00	70.55	73.54
1 1/8	3.379	4.303	3.572	3.73	5 1/16	68.44	87.14	72.33	.....
1 3/16	3.766	4.795	3.980	4.15	5 1/8	70.14	89.30	74.12	.....
1 1/4	4.173	5.312	4.409	4.60	5 3/16	71.86	91.49	75.94	.....
1 5/16	4.600	5.857	4.861	5.06	5 1/2	73.60	93.72	77.79	81.18
1 3/8	5.049	6.428	5.335	5.54	5 5/8	75.37	95.96	79.65	.....
1 7/16	5.518	7.026	5.832	6.06	5 3/4	77.15	98.23	81.53	.....
1 1/2	6.008	7.650	6.350	6.63	5 7/8	78.95	100.5	83.42	.....
1 5/8	6.520	8.301	6.890	7.17	5 1/2	80.77	102.8	85.32	89.09
1 3/4	7.051	8.978	7.452	7.78	5 9/16	82.62	105.2	87.31	.....
1 11/16	7.604	9.682	8.036	8.37	5 5/8	84.49	107.6	89.31	.....
1 3/4	8.178	10.41	8.640	9.02	5 11/16	86.38	110.0	91.30	.....
1 13/16	8.773	11.17	9.271	9.67	5 3/4	88.29	112.4	93.29	97.38
1 7/8	9.388	11.95	9.919	10.36	5 13/16	90.22	114.9	95.37	.....
1 15/16	10.02	12.76	10.59	11.05	5 3/4	92.17	117.4	97.44	.....
2	10.68	13.60	11.29	11.78	5 15/16	94.14	119.9	99.52	.....
2 1/16	11.36	14.46	12.00	12.51	6	96.14	122.4	101.6	106.04
2 1/8	12.06	15.35	12.74	13.30	6 1/16	98.14	125.0	103.8	.....
2 3/16	12.78	16.27	13.50	14.08	6 1/8	100.2	127.6	105.9	.....
2 1/4	13.52	17.22	14.29	14.91	6 3/16	102.2	130.2	108.1	.....
2 5/16	14.28	18.19	15.10	15.74	6 1/4	104.3	132.8	110.2	.....
2 3/8	15.07	19.18	15.92	16.62	6 5/16	106.4	135.5	112.5	.....
2 7/16	15.86	20.20	16.77	17.50	6 3/8	108.5	138.2	114.7	.....
2 1/2	16.69	21.25	17.64	18.41	6 1/2	110.7	140.9	116.9	.....
2 5/8	17.53	22.33	18.53	19.35	6 5/8	112.8	143.6	119.2	124.42
2 3/4	18.40	23.43	19.45	20.30	6 3/4	114.9	146.5	121.6	.....
2 11/16	19.29	24.56	20.38	21.28	6 7/8	117.2	149.2	123.8	.....
2 3/4	20.20	25.00	20.75	22.28	6 15/16	119.4	152.1	126.2	.....
2 13/16	21.12	26.90	22.33	23.30	6 1/2	121.7	154.9	128.6	.....
2 7/8	22.07	28.10	23.32	24.34	6 3/4	123.9	157.8	131.0	.....
2 15/16	23.04	29.34	24.35	25.40	6 7/8	126.2	160.8	133.5	.....
3	24.03	30.60	25.40	26.51	6 15/16	128.5	163.6	135.8	.....
3 1/16	25.04	31.89	26.47	27.89	7	130.9	166.6	138.3	144.38
3 1/8	26.08	33.20	27.56	28.77	7 1/16	133.2	169.6	140.8	.....
3 3/16	27.13	34.55	28.68	29.90	7 1/8	135.6	172.6	143.3	.....
3 1/4	28.20	35.92	29.81	31.10	7 3/16	137.9	175.6	145.7	.....
3 5/16	29.30	37.31	30.97	32.29	7 1/4	140.4	178.7	148.3	.....
3 3/8	30.42	38.73	32.15	33.75	7 5/16	142.8	181.8	150.8	.....
3 7/16	31.56	40.18	33.35	34.75	7 3/8	145.3	184.9	153.5	.....
3 1/2	32.71	41.65	34.57	36.08	7 1/2	147.7	188.1	156.1	.....
3 5/8	33.90	43.14	35.81	37.34	7 5/8	150.2	191.3	158.8	.....
3 3/4	35.09	44.68	37.08	38.70	7 3/4	155.2	197.7	164.2	.....
3 11/16	36.31	46.24	38.38	40.00	7 7/8	160.3	204.2	169.5	.....
3 3/4	37.56	47.82	39.69	41.43	7 1/2	165.6	210.8	175.0	.....
3 13/16	38.81	49.42	41.02	42.75	8	171.0	217.6	180.6	188.61
3 7/8	40.10	51.05	42.37	44.20	9	218.4	275.6	227.8	238.58
3 15/16	41.40	52.71	43.75	45.65	10	267.2	340.0	282.4	294.50
					11	323.0	411.2	340.6	356.38
					12	384.4	489.6	405.8	428.64



WEIGHT OF ROUND SHELBY SEAMLESS STEEL TUBING

Weight per Lineal Foot in Pounds

Outside Diam. in Inches	WALL THICKNESS																
	20 BWG .035"	18 BWG .049"	16 BWG .065"	13 BWG .095"	12 BWG .109"	11 BWG .120"	10 BWG .134"	¾" .188"	½" .250"	⅜" .313"	¼" .375"	⅛" .438"	1/16" .500"	3/32" .625"	1/8" .750"	3/64" .875"	1" 1.00"
	POUNDS PER FOOT																
½	.1738	.2360	.3020	.4109	.4552	.4870											
¾	.2205	.3014	.3888	.5377	.6007	.6472	.7027	.8774									
¾	.2673	.3668	.4755	.6646	.7462	.8074	.8816	1.128	1.335								
¾	.3140	.4323	.5623	.7914	.8917	.9676		1.379	1.669	1.879							
1	.3607	.4977	.6491	.9182	1.037	1.128	1.239	1.630	2.003	2.297							
1¼	.4074	.5631	.7359	1.045	1.183	1.288		1.881	2.336	2.714	3.004						
1½	.4542	.6285	.8226	1.172	1.328	1.448	1.597	2.132	2.670	3.132	3.504	3.798					
1¾	.5009	.6939	.9094	1.299	1.474	1.608	1.776	2.383	3.004	3.550	4.005		4.673				
1½	.5476	.7593	.9962	1.426	1.619	1.769	1.955	2.634	3.338	3.968	4.506	4.968	5.340				
1¾	.5943	.8248	1.083	1.552		1.929		2.885	3.671	4.386	5.006	5.553	6.008				
1¾	.6411	.8902	1.170	1.679	1.910	2.089	2.313	3.136	4.005	4.804	5.507	6.137	6.675	7.509			
1¾	.6878		1.257	1.806	2.056	2.249		3.387	4.339	5.222	6.008	6.722	7.343				
2	.7345	1.021	1.343	1.933	2.201	2.409	2.670	3.638	4.673	5.639	6.508	7.307	8.010	9.178	10.01		
2¼		1.086	1.430	2.060		2.570		3.889	5.006	6.057	7.009	7.892	8.678				
2¼	.8280	1.152	1.517	2.186	2.492	2.730	3.028	4.140	5.340	6.475	7.509	8.476	9.345	10.85			
2½			1.604	2.313		2.890		4.391	5.674	6.893	8.010	9.061	10.01	11.68			
2½		1.283	1.690	2.440	2.783	3.050	3.386	4.642	6.008	7.311	8.511	9.646	10.68	12.52	14.02		
2½			1.777	2.567		3.210		4.893	6.341	7.729	9.011	10.23	11.35	13.35			
2¾			1.864	2.694	3.074	3.371		5.144	6.675	8.147	9.512	10.82	12.02	14.18	16.02	17.52	
2¾			1.951		3.220	3.531		5.395	7.009	8.564	10.01	11.40	12.68	15.02			
3		1.544	2.037	2.947	3.365	3.691		5.646	7.343	8.982	10.51	11.98	13.35	15.85	18.02	19.86	21.36
3¼			2.211	3.201		4.011		6.148	8.010	9.818	11.51	13.15	14.69	17.52	20.03	22.19	24.03
3½			2.385	3.455		4.332	4.817	6.650	8.678	10.65	12.52	14.32	16.02	19.19	22.03	24.53	26.70
3¾			2.558	3.708		4.652		7.152	9.345	11.49	13.52	15.49	17.36	20.86	24.03	26.87	29.37
4			2.732	3.962		4.973	5.533	7.654	10.01	12.33	14.52	16.66	18.69	22.53	26.03	29.20	32.04
4¼			2.905	4.216		5.293		8.156	10.68	13.16	15.52	17.83	20.03	24.20	28.04	31.54	34.71
4½			3.079			5.613	6.248	8.658	11.35	14.00	16.52	19.00	21.36	25.87	30.04	33.88	37.38
4¾				4.723		5.934		9.160	12.02	14.83	17.52	20.17	22.70	27.53	32.04	36.21	40.05
5			3.426			6.254	6.964	9.662	12.68	15.67	18.52		24.03	29.20	34.04	38.55	42.72
5¼						6.575		10.16	13.35		19.52		25.37	30.87	36.05	40.88	45.39
5½						6.895	7.679	10.67	14.02	17.34	20.53	23.68	26.70	32.54	38.05	43.22	48.06
5¾						7.215		11.17	14.69		21.53		28.04	34.21	40.05	45.56	
6						7.536	8.395	11.67	15.35		22.53		29.37	35.88	42.05		53.40
6¼						7.856			16.02		23.53	27.19	30.71	37.55	44.06		56.07
6½						8.177		12.67			24.53		32.04		46.06		58.74
6¾									17.36		25.53		33.38		48.06		61.41
7								13.68	18.02		26.53		34.71		50.06		64.08
7¼											27.53		36.05		52.07		
7½									19.36		28.54		37.38	45.89	54.07		69.42
8									20.69		30.54		40.05		58.07		74.76
8½									22.03		32.54		42.72		62.08		
9									23.36				45.39				
10									26.03				50.73				

Weights shown are in pounds per foot for either hot finished or cold-drawn tubing.

The inside diameter is determined by subtracting twice the wall thickness from the outside diameter.

This table contains only such sizes as are considered stock items.



COMPARATIVE TABLE OF STANDARD GAGES

Gage Number	THICKNESS IN DECIMALS OF AN INCH						
	United States Steel Wire (STL. W. G.)	British Imperial Standard Wire (I. S. W. G.)	Browne & Sharpe (B. & S. G.)	Birmingham Wire (B. W. G.)	Standard Birmingham Sheet and Hoop (B. G.)	United States Standard (Revised) U. S. S. G.	
						Thickness Approx.	Weight Oz./Sq. Ft.
000000	.4900	.500			.6666		
000000	.4615	.464	.580000		.6250		
00000	.4305	.432	.516500	.500	.5883		
0000	.3938	.400	.460000	.454	.5416		
000	.3625	.372	.409642	.425	.5000		
00	.3310	.348	.364796	.380	.4452		
0	.3065	.324	.324861	.340	.3964		
1	.2830	.300	.289297	.300	.3532		
2	.2625	.276	.257627	.284	.3147		
3	.2437	.252	.229423	.259	.2804	.2391	160
4	.2253	.232	.204307	.238	.2500	.2242	150
5	.2070	.212	.181940	.220	.2225	.2092	140
6	.1920	.192	.162023	.203	.1981	.1943	130
7	.1770	.176	.144285	.180	.1764	.1793	120
8	.1620	.160	.128490	.165	.1570	.1644	110
9	.1483	.144	.114423	.148	.1398	.1494	100
10	.1350	.128	.101897	.134	.1250	.1345	90
11	.1205	.116	.090742	.120	.1113	.1196	80
12	.1055	.104	.080808	.109	.0991	.1046	70
13	.0915	.092	.071962	.095	.0882	.0897	60
14	.0800	.080	.064084	.083	.0785	.0749	50
15	.0720	.072	.057068	.072	.0699	.0673	45
16	.0625	.064	.050821	.065	.0625	.0598	40
17	.0540	.056	.045257	.058	.0556	.0538	36
18	.0475	.048	.040303	.049	.0495	.0478	32
19	.0410	.040	.035890	.042	.0440	.0418	28
20	.0348	.036	.031961	.035	.0392	.0359	24
21	.03175	.032	.028462	.032	.0349	.0329	22
22	.0286	.028	.025346	.028	.03125	.0299	20
23	.0258	.024	.022572	.025	.02782	.0269	18
24	.0230	.022	.020101	.022	.02476	.0239	16
25	.0204	.020	.017900	.020	.02204	.0209	14
26	.0181	.018	.015941	.018	.01961	.0179	12
27	.0173	.0164	.014195	.016	.01745	.0164	11
28	.0162	.0148	.012641	.014	.015625	.0149	10
29	.0150	.0136	.011257	.013	.0139	.0135	9
30	.0140	.0124	.010025	.012	.0123	.0120	8
31	.0132	.0116	.008928	.010	.0110	.0105	7
32	.0128	.0108	.007950	.009	.0098	.0097	6.5
33	.0118	.0100	.007060	.008	.0087	.0090	6
34	.0104	.0092	.006305	.007	.0077	.0082	5.5
35	.0095	.0084	.005615	.005	.0069	.0075	5
36	.0090	.0076	.005000	.004	.0061	.0067	4.5
37	.0085	.0068	.004453		.0054	.0064	4.25
38	.0080	.0060	.003965		.0048	.0060	4
39	.0075	.0052	.003531		.0043		
40	.0070	.0048	.003144		.0038		



WIRE AND SHEET METAL GAGES

1. United States Steel Wire Gage (STL.W.G.).

Also known as: National Wire, Standard Steel Wire, Steel Wire, American Steel & Wire Company, Roebling, Washburn and Moen Gages.

Used for bare wire of galvanized, black annealed, bright basic tinned or copper coated, iron or steel, spring steel wire. Not used for telephone and telegraph wire.

2. British Imperial Standard Wire Gage (I.S.W.G.) or (N.B.S.).

Also known as British Imperial Wire or English Legal Standard Gages.

Used for bare copper telephone wires in the U. S. and for all wires and aluminum sheets in England.

3. Browne & Sharpe Gage (B.& S.G.).

Also known as American or American Wire Gages.

Used for bare wire of brass, phosphor bronze, German silver, aluminum, zinc and copper (not for copper telephone or telegraph wire).

Also resistance wire of German silver and other alloys, and for insulated wire of aluminum and copper.

Also for rods of brass, copper, phosphor bronze and aluminum; sheets of copper, brass, phosphor bronze, aluminum and German silver; brazed brass and brazed copper tubing.

4. Birmingham Wire Gage (B.W.G.).

Also known as Birmingham, Stubs or Stubs Iron Wire Gages.

Used for iron and steel telephone and telegraph wire and strip steel, steel bands, hoop steel, crucible spring steel, round-edged flat wire, and with limited usage for copper sheets. Also for seamless brass, seamless copper, seamless steel, stainless steel and aluminum tubes, and for boiler tubes.

5. Standard Birmingham Sheet and Hoop Gage (B.G.).

Used in England for iron and steel sheets and hoops.

6. United States Standard (Revised) (U.S.S.G.).

Also known as U. S. Standard Sheet Metal or U. S. Standard for Steel and Iron Sheets and Plates Gages.

This is a gage based on the weight per square foot of sheets rather than on thickness. It is used for commercial iron and steel sheets and plates including planished, galvanized, tinned and terne plates, black sheet iron, blue annealed soft steel, steel plate, hot-rolled sheet steel, cold-rolled sheet steel, hot-rolled monel metal, cold-rolled monel metal.

Other gages in use:

Trenton Iron Company Gage.

Zinc gage for sheet zinc only.

Birmingham Metal Gage—in England for brass sheets.

American Steel and Wire Company's music wire gage.

Twist Drill and Steel Wire Gage for twist drill and steel drill rods.

HARDNESS CONVERSION TABLE
FOR UNHARDENED STEEL, STEEL OF SOFT TEMPER, GREY AND MALLEABLE CAST IRON
AND MOST NON-FERROUS METAL

SCALE											
B	F	G	15-T	30-T	45-T	E	K	A	Brinell		SHORE
Rockwell Hardness Tester			Rockwell Superficial†			Rockwell Hardness Tester			Standard Type		
Ball Penetrator											
1/16			1/8			1/4		Brale	10 m.m.		
Load (kg.)											
100	60	150	15	30	45	100	150	60	500	3000	
100	....	82.5	93.0	82.0	72.0	....	....	61.5	201	240	33
99	....	81.0	92.5	81.5	71.0	....	....	61.0	195	234	32
98	....	79.0	....	81.0	70.0	....	....	60.0	189	228	32
97	....	77.5	92.0	80.5	69.0	....	....	59.5	184	222	31
96	....	76.0	....	80.0	68.0	....	....	59.0	179	216	30
95	....	74.0	91.5	79.0	67.0	....	....	58.0	175	210	30
94	....	72.5	....	78.5	66.0	....	....	57.5	171	205	29
93	....	71.0	91.0	78.0	65.5	....	....	57.0	167	200	28
92	....	69.0	90.5	77.5	64.5	....	100	56.5	163	195	28
91	....	67.5	....	77.0	63.5	....	99.5	56.0	160	190	27
90	....	66.0	90.0	76.0	62.5	....	98.5	55.5	157	185	27
89	....	64.0	89.5	75.5	61.5	....	98.0	55.0	154	180	25
88	....	62.5	....	75.0	60.5	....	97.0	54.0	151	176	25
87	....	61.0	89.0	74.5	59.5	....	96.5	53.5	148	172	24
86	....	59.0	88.5	74.0	58.5	....	95.5	53.0	145	169	24
85	....	57.5	....	73.5	58.0	....	94.5	52.5	142	165	23
84	....	56.0	88.0	73.0	57.0	....	94.0	52.0	140	162	23
83	....	54.0	87.5	72.0	56.0	....	93.0	51.0	137	159	23
82	....	52.5	....	71.5	55.0	....	92.0	50.5	135	156	23
81	....	51.0	87.0	71.0	54.0	....	91.0	50.0	133	153	22
80	....	49.0	86.5	70.0	53.0	....	90.5	49.5	130	150	22
79	....	47.5	....	69.5	52.0	....	89.5	49.0	128	147	21
78	....	46.0	86.0	69.0	51.0	....	88.5	48.5	126	144	21
77	....	44.0	85.5	68.0	50.0	....	88.0	48.0	124	141	20
76	....	42.5	....	67.5	49.0	....	87.0	47.0	122	139	..
75	99.5	41.0	85.0	67.0	48.5	....	86.0	46.5	120	137	..
74	99.0	39.0	....	66.0	47.5	....	85.0	46.0	118	135	..
73	98.5	37.5	84.5	65.5	46.5	....	84.5	45.5	116	132	..
72	98.0	36.0	84.0	65.0	45.5	....	83.5	45.0	114	130	..
71	97.5	34.5	....	64.0	44.5	100	82.5	44.5	112	127	..
70	97.0	32.5	83.5	63.5	43.5	99.5	81.5	44.0	110	125	..
69	96.0	31.0	83.0	62.5	42.5	99.0	81.0	43.5	109	123	..
68	95.5	29.5	....	62.0	41.5	98.0	80.0	43.0	107	121	..
67	95.0	28.0	82.5	61.5	40.5	97.5	79.0	42.5	106	119	..
66	94.5	26.5	82.0	60.5	39.5	97.0	78.0	42.0	104	117	..
65	94.0	25.0	....	60.0	38.5	96.0	77.5	....	102	116	..
64	93.5	23.5	81.5	59.5	37.5	95.5	76.5	41.5	101	114	..
63	93.0	22.0	81.0	58.5	36.5	95.0	75.5	41.0	99	112	..
62	92.0	20.5	....	58.0	35.5	94.5	74.5	40.5	98	110	..
61	91.5	19.0	80.5	57.0	34.5	93.5	74.0	40.0	96	108	..
60	91.0	17.5	....	56.5	33.5	93.0	73.0	39.5	95	107	..
59	90.5	16.0	80.0	56.0	32.0	92.5	72.0	39.0	94	106	..
58	90.0	14.5	79.5	55.0	31.0	92.0	71.0	38.5	92	104	..
57	89.5	13.0	....	54.5	30.0	91.0	70.5	38.0	91	103	..
56	89.0	11.5	79.0	54.0	29.0	90.5	69.5	....	90	101	..
55	88.0	10.0	78.5	53.0	28.0	90.0	68.5	37.5	89	100	..
54	87.5	8.5	....	52.5	27.0	89.5	68.0	37.0	87	....	..
53	87.0	7.0	78.0	51.5	26.0	89.0	67.0	36.5	86	....	..
52	86.5	5.5	77.5	51.0	25.0	88.0	66.0	36.0	85	....	..
51	86.0	4.0	....	50.5	24.0	87.5	65.0	35.5	84	....	..
50	85.5	2.5	77.0	49.5	23.0	87.0	64.5	35.0	83	....	..

ROCKWELL B NUMBERS ABOVE 100‡

SCALE									
BRINELL		B	BRINELL		B	BRINELL		B	
Ball Dia.	Number	Rockwell	Ball Dia.	Number	Rockwell	Ball Dia.	Number	Rockwell	
3.15	375	110	3.40	321	108	3.65	277	104	
3.20	363	110	3.45	311	107	3.70	269	104	
3.25	352	109	3.50	302	107	3.75	262	103	
3.30	341	109	3.55	293	106	3.80	255	102	
3.35	331	108	3.60	285	105	3.85	248	101	

**CLARK
EQUIPMENT**

HARDNESS CONVERSION TABLE
FOR UNHARDENED STEEL, STEEL OF SOFT TEMPER, GREY AND MALLEABLE CAST IRON
AND MOST NON-FERROUS METAL (Continued)

SCALE									
B	F	15-T	30-T	45-T	E	H	K	A	Brinell
Rockwell Hardness Tester		Rockwell Superficial†			Rockwell Hardness Tester				
Ball Penetrator									
1/16		1/8			1/4			Brace	10 m.m.
Load (kg.)									
100	60	15	30	45	100	60	150	60	500
50	85.5	77.0	49.5	23.0	87.0	....	64.5	35.0	83
49	85.0	76.5	49.0	22.0	86.5	....	63.5	....	82
48	84.5	....	48.5	20.5	85.5	....	62.5	34.5	81
47	84.0	76.0	47.5	19.5	85.0	....	61.5	34.0	80
46	83.0	75.5	47.0	18.5	84.5	....	61.0	33.5	....
45	82.5	....	46.0	17.5	84.0	....	60.0	33.0	79
44	82.0	75.0	45.5	16.5	83.5	....	59.0	32.5	78
43	81.5	74.5	45.0	15.5	82.5	....	58.0	32.0	77
42	81.0	....	44.0	14.5	82.0	....	57.5	31.5	76
41	80.5	74.0	43.5	13.5	81.5	....	56.5	31.0	75
40	79.5	73.5	43.0	12.5	81.0	....	55.5	....	....
39	79.0	....	42.0	11.0	80.0	....	54.5	30.5	74
38	78.5	73.0	41.5	10.0	79.5	....	54.0	30.0	73
37	78.0	72.5	40.5	9.0	79.0	....	53.0	29.5	72
36	77.5	....	40.0	8.0	78.5	100	52.0	29.0	....
35	77.0	72.0	39.5	7.0	78.0	99.5	51.5	28.5	71
34	76.5	71.5	38.5	6.0	77.0	99.0	50.5	28.0	70
33	75.5	....	38.0	5.0	76.5	....	49.5	....	69
32	75.0	71.0	37.5	4.0	76.0	98.5	48.5	27.5	....
31	74.5	....	36.5	3.0	75.5	98.0	48.0	27.0	68
30	74.0	70.5	36.0	2.0	75.0	....	47.0	26.5	67
29	73.5	70.0	35.5	1.0	74.0	97.5	46.0	26.0	....
28	73.0	....	34.5	....	73.5	97.0	45.0	25.5	66
27	72.5	69.5	34.0	....	73.0	96.5	44.5	25.0	....
26	72.0	69.0	33.0	....	72.5	....	43.5	24.5	65
25	71.0	....	32.5	....	72.0	96.0	42.5	....	64
24	70.5	68.5	32.0	....	71.0	95.5	41.5	24.0	....
23	70.0	68.0	31.0	....	70.5	....	41.0	23.5	63
22	69.5	....	30.5	....	70.0	95.0	40.0	23.0	....
21	69.0	67.5	29.5	....	69.5	94.5	39.0	22.5	62
20	68.5	....	29.0	....	68.5	....	38.0	22.0	....
19	68.0	67.0	28.5	....	68.0	94.0	37.5	21.5	61
18	67.0	66.5	27.5	....	67.5	93.5	36.5	....	....
17	66.5	....	27.0	....	67.0	93.0	35.5	21.0	60
16	66.0	66.0	26.0	....	66.5	....	35.0	20.5	....
15	65.5	65.5	25.5	....	65.5	92.5	34.0	20.0	59
14	65.0	....	25.0	....	65.0	92.0	33.0	....	....
13	64.5	65.0	24.0	....	64.5	....	32.0	....	58
12	64.0	64.5	23.5	....	64.0	91.5	31.5	....	....
11	63.5	....	23.0	....	63.5	91.0	30.5	....	....
10	63.0	64.0	22.0	....	62.5	90.5	29.5	....	57
9	62.0	....	21.5	....	62.0	....	29.0	....	....
8	61.5	63.5	20.5	....	61.5	90.0	28.0	....	....
7	61.0	63.0	20.0	....	61.0	89.5	27.0	....	56
6	60.5	....	19.5	....	60.5	....	26.0	....	....
5	60.0	62.5	18.5	....	60.0	89.0	25.5	....	55
4	59.5	62.0	18.0	....	59.0	88.5	24.5	....	....
3	59.0	....	17.0	....	58.5	88.0	23.5	....	....
2	58.0	61.5	16.5	....	58.0	....	23.0	....	54
1	57.5	61.0	16.0	....	57.5	87.5	22.0	....	....
0	57.0	....	15.0	....	57.0	87.0	21.0	....	53

†The 15-T, 30-T, 45-T, 15-N, 30-N and 45-N values are in scales having lighter loads and more sensitive depth reading system, used where for one or another reason the indentation must be exceptionally shallow.

‡The Rockwell B numbers above 100, as shown, are somewhat above the practical range of usefulness, as the Rockwell B versus Brinell hardness curve is very steep in this section, making the Brinell differences per unit change in Rockwell B reading quite large and subject to appreciable inaccuracy.

Source: This tabulation is published from data of Wilson Mechanical Inst. Co., augmented by data of General Motors Research Corp.



HARDNESS CONVERSION TABLE
FOR HARDENED STEEL AND HARD ALLOYS

SCALE									
C	A	D	15-N	30-N	45-N		Brinell	G	
Rockwell Hardness Tester			Rockwell Superficial†				Hultgren 10 m.m. Ball	Rockwell Tester 1/8 Ball	
Penetrator						*VICKERS			SHORE
"Brale"			"N Brale"						
Load (kg.)									
150	60	100	15	30	45	10	3000	150	
80	92.0	86.5	96.5	92.0	87.0	1865	....	....	....
79	91.5	85.5	....	91.5	86.5	1787	....	....	....
78	91.0	84.5	96.0	91.0	85.5	1710	....	....	....
77	90.5	84.0	....	90.5	84.5	1633	....	....	....
76	90.0	83.0	95.5	90.0	83.5	1556	....	....	....
75	89.5	82.5	....	89.0	82.5	1478	....	....	....
74	89.0	81.5	95.0	88.5	81.5	1400	....	....	....
73	88.5	81.0	....	88.0	80.5	1323	....	....	....
72	88.0	80.0	94.5	87.0	79.5	1245	....	....	....
71	87.0	79.5	....	86.5	78.5	1160	....	....	....
70	86.5	78.5	94.0	86.0	77.5	1076	....	....	....
69	86.0	78.0	93.5	85.0	76.5	1004	....	....	....
68	85.5	77.0	....	84.5	75.5	942	....	....	96
67	85.0	76.0	93.0	83.5	74.5	894	....	....	94
66	84.5	75.5	92.5	83.0	73.0	854	....	....	....
65	84.0	74.5	92.0	82.0	72.0	820	....	....	92
64	83.5	74.0	....	81.0	71.0	789	....	....	....
63	83.0	73.0	91.5	80.0	70.0	763	....	....	89
62	82.5	72.5	91.0	79.0	69.0	739	....	....	86
61	81.5	71.5	90.5	78.5	67.5	716	....	....	....
60	81.0	71.0	90.0	77.5	66.5	695	614	....	84
59	80.5	70.0	89.5	76.5	65.5	675	600	....	....
58	80.0	69.0	....	75.5	64.0	655	587	....	81
57	79.5	68.5	89.0	75.0	63.0	636	573	....	....
56	79.0	67.5	88.5	74.0	62.0	617	560	....	78
55	78.5	67.0	88.0	73.0	61.0	598	547	....	75
54	78.0	66.0	87.5	72.0	59.5	580	534	....	....
53	77.5	65.5	87.0	71.0	58.5	562	522	....	73
52	77.0	64.5	86.5	70.5	57.5	545	509	....	....
51	76.5	64.0	86.0	69.5	56.0	528	496	....	71
50	76.0	63.0	85.5	68.5	55.0	513	484	....	68
49	75.5	62.0	85.0	67.5	54.0	498	472	....	....
48	74.5	61.5	84.5	66.5	52.5	485	460	....	66
47	74.0	60.5	84.0	66.0	51.5	471	448	....	64
46	73.5	60.0	83.5	65.0	50.0	458	437	....	62
45	73.0	59.0	83.0	64.0	49.0	446	426	....	....
44	72.5	58.5	82.5	63.0	48.0	435	415	....	60
43	72.0	57.5	82.0	62.0	46.5	424	404	....	58
42	71.5	57.0	81.5	61.5	45.5	413	393	....	56
41	71.0	56.0	81.0	60.5	44.5	403	382	....	54
40	70.5	55.5	80.5	59.5	43.0	393	372	....	....
39	70.0	54.5	80.0	58.5	42.0	383	362	....	52
38	69.5	54.0	79.5	57.5	41.0	373	352	....	51
37	69.0	53.0	79.0	56.5	39.5	363	342	....	49
36	68.5	52.5	78.5	56.0	38.5	353	332	....	48
35	68.0	51.5	78.0	55.0	37.0	343	322	....	46
34	67.5	50.5	77.0	54.0	36.0	334	313	....	45
33	67.0	50.0	76.5	53.0	35.0	325	305	....	....
32	66.5	49.0	76.0	52.0	33.5	317	297	....	43
31	66.0	48.5	75.5	51.5	32.5	309	290	....	42
30	65.5	47.5	75.0	50.5	31.5	301	283	92.0	41
29	65.0	47.0	74.5	49.5	30.0	293	276	91.0	40
28	64.5	46.0	74.0	48.5	29.0	285	270	90.0	38
27	64.0	45.5	73.5	47.5	28.0	278	265	89.0	37
26	63.5	44.5	72.5	47.0	26.5	271	260	88.0	36
25	63.0	44.0	72.0	46.0	25.5	264	255	87.0	35
24	62.5	43.0	71.5	45.0	24.0	257	250	86.0	34
23	62.0	42.5	71.0	44.0	23.0	251	245	84.5	33
22	61.5	41.5	70.5	43.0	22.0	246	240	83.5	32
21	61.0	41.0	70.0	42.5	20.5	241	235	82.5	32
20	60.5	40.0	69.5	41.5	19.5	236	230	81.0	31

*4 sided 136° Diamond Pyramid, 10 kg. Load. Measurement of 2 diagonals by microscope.

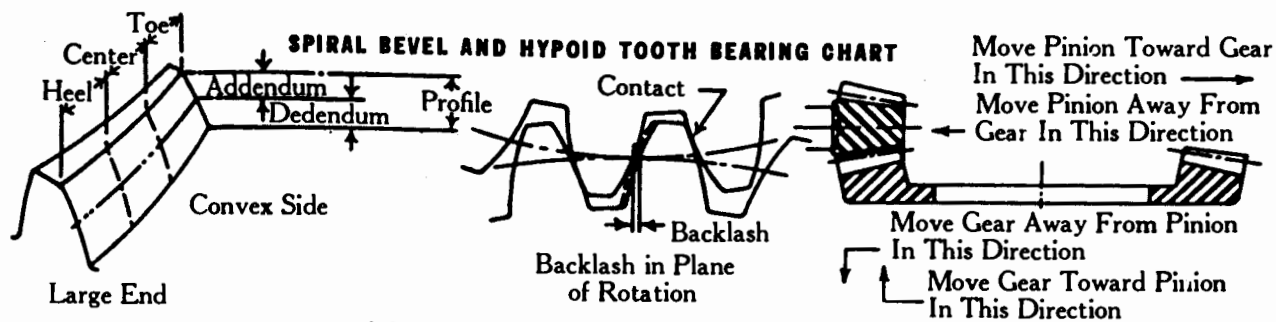


CONVERSION TABLE

Angstrom Unit	A° or A	Cubic Meter	cu m
0.0001 microns		1,000,000 cubic centimeters	
0.0000000001 or 10 ⁻¹⁰ meters		35.31 cubic feet	
0.003937 millionths of an inch		61023 cubic inches	
		264.2 gallons	
Atmosphere	atm	Degree (arc)	deg or °
76 centimeters of mercury at 0°C		60 minutes	
29.92 inches of mercury at 0°C		3600 seconds	
406.8 inches of water at 4°C		0.01745 radians	
14.7 pounds per square inch			
British Thermal Unit	Btu or B	Foot	ft
Amount of heat required to raise the temperature of one pound of water, one degree F.		12 inches	
252 calories		0.333 yards	
778.3 foot-pounds		0.30481 meters	
0.2928 watt-hours		Foot-Pound	ft-lb
		0.001285 Btu	
		1.356 joules	
Calorie	cal	Foot of Water	
Amount of heat required to raise the temperature of one gram of water one degree C		0.0295 atmospheres	
0.003969 Btu		62.43 pounds per square foot	
3.087 foot-pounds		0.4335 pounds per square inch	
0.001163 watt-hours		2.242 centimeters of mercury	
Centimeter	cm	Gallon	gal
0.010 meters		0.1337 cubic feet	
0.3937 inches		231 cubic inches	
		3.785 liters	
		8.336 pounds of water	
Circular Mil	cir mil	Grain	grain
Area of circle whose diameter is one mil or .001 inches		0.06481 grams	
0.000000785 square inches		0.002286 ounces	
0.000005067 square centimeters			
Cubic Centimeter	cc	Gram	g
0.000001 cubic meters		15.43 grains	
0.06102 cubic inches		0.03527 ounces	
0.00003531 cubic feet		0.002205 pounds	
Cubic Foot	cu ft	Gravity	g
1728 cubic inches		32.1740 feet per second per second	
0.0283 cubic meters		980.665 centimeters per second per second	
7.481 gallons			
28.32 liters		Horsepower	hp
62.4283 pounds of water		550 foot-pounds per second	
		33,000 foot-pounds per minute	
		42.41 Btu per minute	
		745.7 watts	
Cubic Inch	cu in.	Inch	in.
16.39 cubic centimeters		0.08333 feet	
0.0005787 cubic feet		2.54 centimeters	
0.00001639 cubic meters			
0.004329 gallons			

CONVERSION TABLE

<p>Inch of Water</p> <p>0.002458 atmospheres 5.204 pounds per square foot 0.03613 pounds per square inch 0.1868 centimeters of mercury</p>	<p>Miles per Hour mph</p> <p>1 mph = 1.467 feet per second 1 mph = 88 feet per minute 1 mph = 44.7 centimeters per second</p>
<p>Joule j</p> <p>1 watt-second 0.7376 foot-pounds 0.0009480 Btu</p>	<p>Ounce oz</p> <p>0.0625 pounds 28.35 grams 437.5 grains</p>
<p>Kilogram kg</p> <p>1000 grams 2.2046 pounds 35.274 ounces</p>	<p>Pound (Avoirdupois) lb</p> <p>16 ounces 0.4536 kilograms 7000 grains 1.2153 pounds Troy</p>
<p>Kilometer km</p> <p>1000 meters 0.6214 miles</p>	<p>Pounds per Square Inch lb/sq in.</p> <p>0.06804 atmospheres 5.171 centimeters of mercury 27.68 inches of water</p>
<p>Kilowatt kw</p> <p>1.341 horsepower 44,257 foot pounds per minute 56.89 Btu per minute</p>	<p>Quart qt</p> <p>2 pints 0.25 gallons 0.9464 liters 2.084 pounds of water</p>
<p>Liter l</p> <p>0.001 cubic meter 1.057 quarts 0.2642 gallons 0.03531 cubic feet</p>	<p>Radian radian</p> <p>57.296 degrees 57° 17' 44.81" 360° ÷ 2π</p>
<p>Meter m</p> <p>100 centimeters 1,000 millimeters 39.37 inches 3.2808 feet</p>	<p>Square Centimeter sq cm</p> <p>0.0001 square meters 0.155 square inches</p>
<p>Micron μ or mu</p> <p>0.001 millimeters 10,000 Angstrom units 39.37 millionths of an inch</p>	<p>Square Foot sq ft</p> <p>144 square inches 0.0929 square meters</p>
<p>Micro Inch μ in.</p> <p>0.000001 inches 0.0254 microns</p>	<p>Square Inch sq in.</p> <p>6.452 square centimeters 1,273,240 circular mils</p>
<p>Mil mil</p> <p>0.001 inches 25.4 microns 0.0254 millimeters</p>	<p>Square Meter sq m</p> <p>10000 square centimeters 10.764 square feet 1.196 square yards</p>
<p>Mile mile</p> <p>5280 feet 1760 yards 1.609 kilometers</p>	<p>Watt w</p> <p>44.26 foot-pounds per minute 0.001 kilowatts 0.00134 horsepower</p>



All bearings shown are on right hand spiral ring gear.
The drive is on the convex side of the tooth.

FIG. 1



Typical preferred bearing on both sides of tooth.



FIG. 2



Toe bearing on both sides of tooth—Gearset noisy. To move bearing toward heel increase backlash within limits by moving gear away from pinion. Cutting should be corrected. Also caused by pinion and gear axis not being at right angles.



FIG. 3



Heel bearing on both sides of tooth—Gearset noisy and could result in early gear failure. To move bearing toward toe decrease backlash within limits by moving gear toward pinion. Correct cutting. Also caused by pinion and gear axis not being at right angles.



FIG. 4



Low bearing on gear and high bearing on pinion. Correct by pulling pinion away from gear. (Increase cone distance.)



FIG. 5



High bearing on gear and low bearing on pinion. Correct by moving pinion in toward gear. (Decrease cone distance.)



FIG. 6



Lame bearing—High on one side of tooth and low on other. Correction cannot be made by adjusting in carrier, but must be made in the cutting.



FIG. 7



Toe bearing on drive and heel bearing on reverse side—Check carrier for low pinion. (Below center of gear axis.) Correct by installing gearset in carrier with high pinion bore. This applies to left hand pinions and right hand gears. For right hand pinions and left hand gears move in opposite direction.



FIG. 8



Heel bearing on drive and toe bearing on reverse side. Check carrier for high pinion bore. Correct by installing in carrier with lower pinion bore. This applies to left hand pinion and right hand gear. For right hand pinion and left hand gear move in opposite direction.



FIG. 9

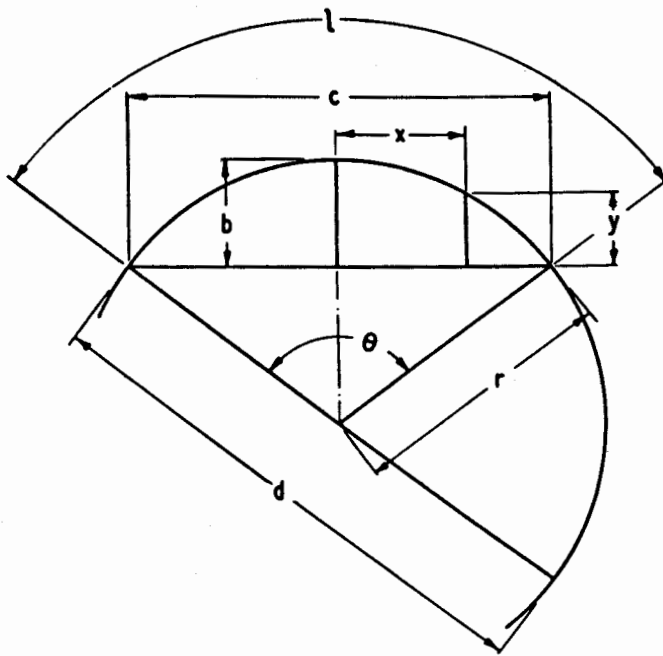


Bias bearing—not desirable. Under heavy load contact concentrates at top of gear tooth at heel on drive and on bottom on coast causing early failure. Correction must be made in cutting.



BACKLASH

Backlash should be measured with a dial indicator rigidly mounted with the stem perpendicular to the tooth surface at the extreme heel. The amount should vary from .007 to .012 depending upon the pitch of the gear. Fine pitches being near the low side and coarser pitches near the high side. In the case of 2:1 ratios and higher the gear may be moved axially for backlash with very little change in tooth bearing. However, in ratios less than 2:1 down to mitres, movement of the gear alone will affect tooth bearing. This can be compensated for by axial adjustment of the pinion in the opposite direction to that of the gear, the relative amount of the two being in proportion to the number of teeth.



PROPERTIES OF THE CIRCLE

Circumference of Circle of Diameter 1 = $\pi = 3.14159265$
 Circumference of Circle = $2\pi r = \pi d$
 Diameter of Circle = Circumference $\times 0.31831$
 Diameter of Circle of equal periphery as square = side $\times 1.27324$
 Side of Square of equal periphery as circle = diameter $\times 0.78540$
 Diameter of Circle circumscribed about square = side $\times 1.41421$
 Side of Square inscribed in Circle = diameter $\times 0.70711$

$$\text{Arc, } l = \frac{\pi r \theta^\circ}{180} = 0.017453 r \theta^\circ$$

$$\text{Angle, } \theta = \frac{180^\circ l}{\pi r} = 57.29578 \frac{l}{r}$$

$$\text{Radius, } r = \frac{4b^2 + c^2}{8b} \quad \text{Diameter, } d = \frac{4b^2 + c^2}{4b}$$

$$\text{Chord, } c = 2\sqrt{2br - b^2} = 2r \sin \frac{\theta}{2} = d \sin \frac{\theta}{2}$$

$$\text{Rise, } b = r - \frac{1}{2}\sqrt{4r^2 - c^2} = \frac{c}{2} \tan \frac{\theta}{4} = 2r \sin^2 \frac{\theta}{4}$$

$$\text{Rise, } b = r + y = \sqrt{r^2 - x^2}$$

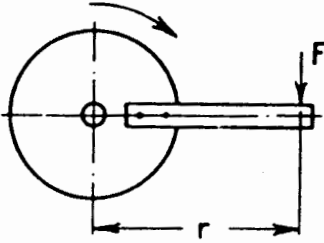
$$y = b - r + \sqrt{r^2 - x^2}$$

$$x = \sqrt{r^2 - (r + y - b)^2}$$

$\pi = 3.14159265$	$\log = 0.4971499$	$\pi^2 = 9.869604$	$\log = 0.994300$
$\frac{1}{\pi} = 0.318310$	$\log = 9.502850 - 10$	$\pi^3 = 31.006277$	$\log = 1.491450$
$\frac{2}{\pi} = 0.636620$	$\log = 9.803880 - 10$	$\frac{1}{\pi^2} = 0.101321$	$\log = 9.005700 - 10$
$\frac{180}{\pi} = 57.295780$	$\log = 1.758123$	$\frac{1}{\pi^3} = 0.032252$	$\log = 8.508557 - 10$
$\frac{\pi}{180} = 0.017453$	$\log = 8.241870 - 10$	$\sqrt{\pi} = 1.772454$	$\log = 0.248575$
		$1/\sqrt{\pi} = 0.564190$	$\log = 9.751425 - 10$
		$\sqrt[3]{\pi} = 1.464592$	$\log = 0.165717$
		$1/\sqrt[3]{\pi} = 0.682784$	$\log = 9.834283 - 10$

ENGINEERING FORMULAS

TORQUE AND HORSEPOWER



$$Q = F \times r$$

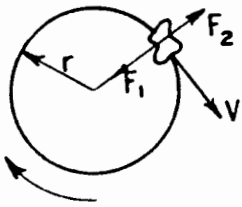
$$= \frac{63025 \text{ hp}}{\text{rpm}}$$

$$\text{hp} = \frac{Q \times \text{rpm}}{63025}$$

$$\text{rpm} = \frac{63025 \text{ hp}}{Q}$$

Q = Torque (inch-pounds)
 F = Force (pounds)
 r = Radius (inches)
 hp = Horsepower
 rpm = Revolutions per minute

CENTRIFUGAL AND CENTRIPETAL FORCE



$$F_1 = F_2 = \frac{WV^2}{32.16 R}$$

$$= 0.000341 WR (\text{rpm})^2$$

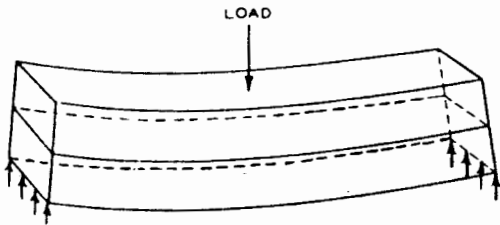
$$= 0.1023 Wr (\text{rps})^2$$

$$= 1.2276 WR (\text{rps})^2$$

$$= 0.0669 W \frac{(\text{mph})^2}{R}$$

F₁ = Centripetal force (pounds)
 F₂ = Centrifugal force (pounds)
 W = Weight of rotating body (pounds)
 V = Linear velocity (feet per second)
 mph = Linear velocity (miles per hour)
 rpm = Angular velocity (revolutions per minute)
 rps = Angular velocity (revolutions per second)
 r = Radius of rotation (inches)
 R = Radius of rotation (feet)

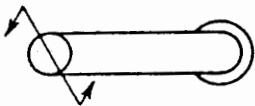
FIBER STRESS IN BENDING



$$S_T = \frac{Mc}{I}$$

S_T = Unit tensile or compressive stress in outer fibers.
 M = Bending moment at section.
 c = Distance from neutral axis to extreme fiber.
 I = Moment of inertia of cross section.

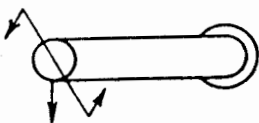
FIBER STRESS IN TORSION



$$S_s = \frac{16Q}{\pi d^3}$$

S_s = Unit shear stress in outer fiber.
 Q = Torsional moment.
 d = Shaft diameter.

COMBINED STRESS

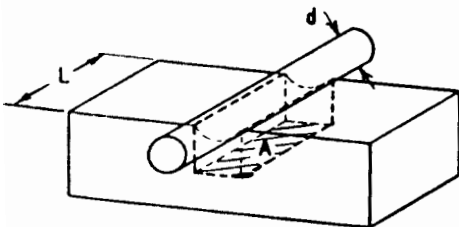


$$S'_T = \frac{S_T}{2} + \sqrt{S_s^2 + \left(\frac{S_T}{2}\right)^2}$$

$$S'_s = \sqrt{S_s^2 + \left(\frac{S_T}{2}\right)^2}$$

S'_T = Maximum unit fiber stress in tension or compression due to combined bending and torsion.
 S'_s = Maximum fiber stress in shear due to combined bending and torsion.

BEARING PROJECTED AREA



$$A = L \times d$$

A = Bearing projected area.
 L = Length of bearing.
 d = Diameter of shaft.



The Gates Rubber Company
999 South Broadway
P.O. Box 5887
Denver, Colorado 80217
(303) 744-1911

Thank you for your inquiry on Gates Hydraulic Pressure Drop Chart.

To help solve your pressure drop problem, here is an instruction sheet, a sample problem plotted on the chart and a viscosity chart page. Work your problem on the blank chart included. The chart will save you several minutes time on every pressure drop problem you calculate.

If you would like extra blank charts, need further information, or would like to consult with your local Gates representative, just fill out the enclosed postage-free card. He will help solve pressure drop problems and assist in selecting the proper hose assembly for your application.

Sincerely,

A handwritten signature in black ink that reads "Paul Athey". The signature is written in a cursive style with a large initial "P".

Paul Athey
Manager
Hydraulics Products Marketing

ih

INSTRUCTIONS

for using

Gates Hydraulic Pressure Drop Problem Analyzer

Gates problem analyzer chart was devised to speed your pressure drop calculations for hydraulic hose applications. Here's a step-by-step example to show you how it works.

Fluid data:
Viscosity—20 centistokes
Velocity—32 ft/sec
Specific gravity, γ —0.8

Hose data:
ID— $\frac{1}{2}$ in.
Length, L—10 ft.

Procedure:

Step:

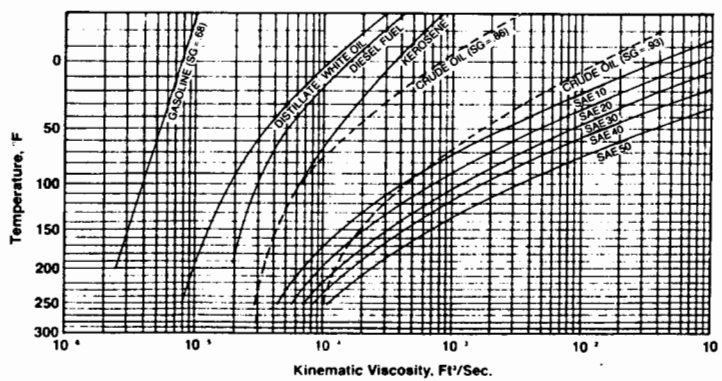
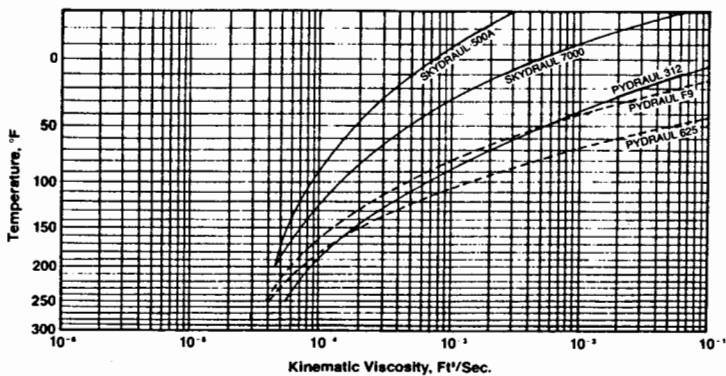
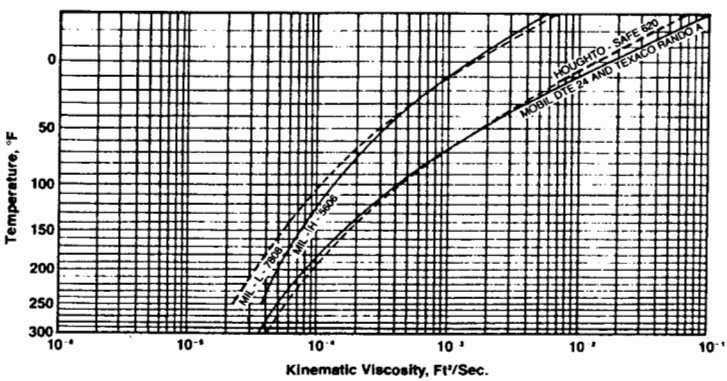
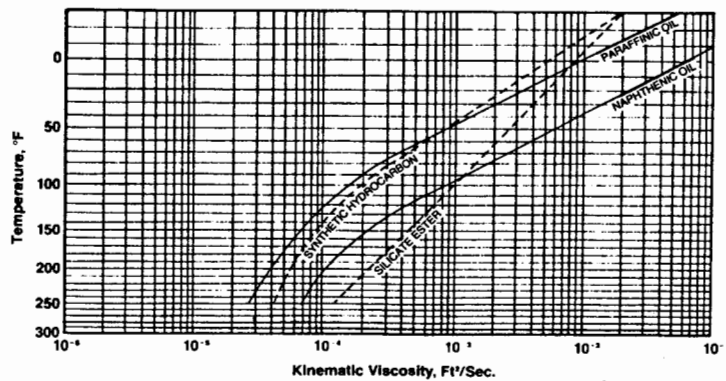
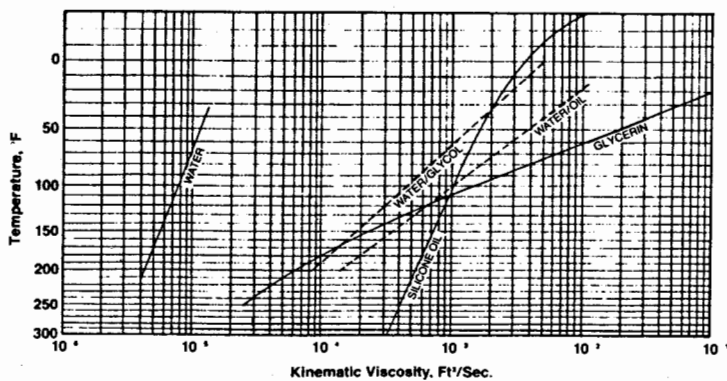
1. Use the formula, $1.0 \text{ stoke} = 0.001076 \text{ ft}^2/\text{sec}$, to convert viscosity of 20 centistokes to $2.15 \times 10^{-4} \text{ ft}^2/\text{sec}$. Find this value on the bottom **viscosity** axis and draw line **A** perpendicular to the axis.
2. Find velocity of 32 ft/sec on the lower left-hand **velocity** axis. Project this value to its intersection with the **index** line. Draw line **B** through this point and parallel to the **base** line.
3. Find 0.5 on the lower left-hand **hose diameter** axis. From this point, draw line **C** perpendicular to the axis.
4. From the intersection of lines **B** and **C**, draw horizontal line **D** to intersect line **A**.
5. From this point, project line **E** to read the Reynold's Number.
6. Find the point where line **E** intersects the **Moody Diagram** curve. Project line **F** from this point to the **friction factor** axis.
7. Now move to the upper left-hand **velocity** axis. Project 32 ft/sec to its intersection with the **index** line. Draw line **G** through this point and parallel to the **base** line.
8. Find 0.5 on the upper left-hand **hose diameter** axis. Draw line **H** to its intersection with line **G**.
9. From this point, project line **I** to intersect with line **F**.
10. From this final intersection, project horizontal line **J** to the right-hand vertical axis. Read the value of $\Delta p / \gamma L$ for this example as 5.7 on the axis.
11. Transposing: $\Delta p = 5.7 \gamma L$. Substituting $\gamma = 0.8$ and $L = 10$: $\Delta p = 45.6 \text{ psi}$.

To find flow, move to the upper right-hand graph. Project horizontal line **K** from 32 on the **velocity** axis to its intersection with the **index** line. Draw line **L** through the intersection point and parallel to the **base** line. Project vertical line **M** from 0.5 on the **hose diameter** axis to its intersection with line **L**. From this intersection point, read horizontally left to the flow axis. The answer for this example is 20 gpm.



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P.O. Box 5887
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Viscosity Chart Locator



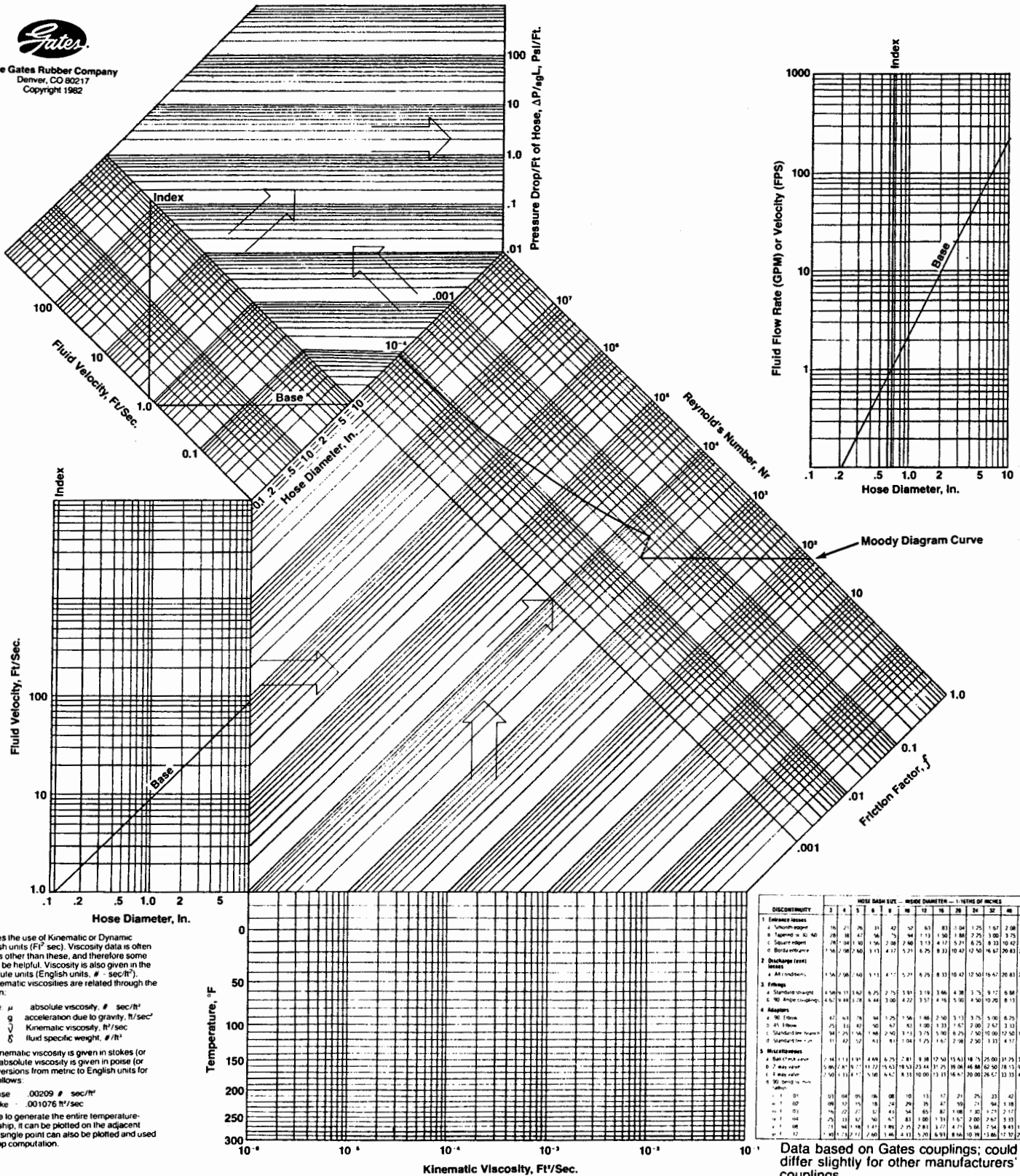
How To Use These Charts

1. Find the chart which lists the fluid being conveyed.
2. Locate on this line the maximum temperature in your system from the scale on the left side of the chart.
3. This point gives you the Kinematic Viscosity in feet squared, per second.
4. Put this point on the scale at the bottom of Hydraulic Pressure Drop Problem Analyzer Chart and begin to solve your specific pressure drop problem.

HYDRAULIC PRESSURE DROP PROBLEM ANALYZER



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Denver, CO 80217
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VISCOSITY:
This chart requires the use of Kinematic or Dynamic viscosity in English units (Ft²/sec). Viscosity data is often presented in units other than these, and therefore some conversions may be helpful. Viscosity is also given in the literature in absolute units (English units, # - sec/ft²). Absolute and Kinematic viscosities are related through the following equation:

$$\mu_g \frac{\rho}{g} = \nu$$

where μ = absolute viscosity, # - sec/ft²
 ρ = acceleration due to gravity, ft/sec²
 ν = Kinematic viscosity, ft²/sec
 δ = fluid specific weight, #/ft³

In metric units, Kinematic viscosity is given in stokes (or centistokes) and absolute viscosity is given in poise (or centipoise). Conversions from metric to English units for viscosity are as follows:

1 poise = 0.0209 # - sec/ft²
 1 stoke = 0.01076 ft²/sec

If data is available to generate the entire temperature-viscosity relationship, it can be plotted on the adjacent graph. Data for a single point can also be plotted and used for a pressure drop computation.

DISCRETENESS	HOSE DASH SIZE - HOSE DIAMETER - 1/16TH OF INCHES															
	3	4	5	6	8	10	12	16	20	24	32	40	48			
1. Standard sizes	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8			
2. Discharge (cent in)	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2			
3. Frittings	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2			
4. Hoopings	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2			
5. Miscellaneous	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2			

Data based on Gates couplings; could differ slightly for other manufacturers' couplings.

COMPRESSIVE STRESS IN A SPHERE WHEN LOADED BY A FLAT PLATE

Compressive stress in a sphere when loaded by a flat plate is .616 times the cube root of the quantity (total load times modulus of elasticity squared) divided by the quantity (diameter of sphere squared).

$$S_c = .616 \sqrt[3]{\frac{P E^2}{D^2}}$$

Where: S_c = compressive stress in sphere.
 P = total load.
 E = modulus of elasticity of sphere.
 D = diameter of sphere.

EXAMPLE:

Find the compressive stress in a .25" diameter steel ball carrying 75 lb. load between two steel plates.

$$S_c = .616 \sqrt[3]{\frac{75 \times (30,000,000)^2}{(.25)^2}} = 632,000 \text{ P.S.I.}$$

COMPRESSIVE STRESS IN A ROLLER LOADED BY A FLAT PLATE

Compressive stress in a roller due to pressure between the roller and a flat plate is .59 times the square root of the quantity (load per unit length of roller times modulus of elasticity of material divided by diameter of roller).

$$S_c = .59 \sqrt{\frac{P E}{D}}$$

Where: S_c = compressive stress in roller.
 p = load per unit length of roller.
 E = modulus of elasticity of roller and plate material.
 D = diameter of roller.

EXAMPLE:

Find the compressive stress in a 0.5" diameter steel roller 2" long carrying 3000 lb. load between two flat steel surfaces.

$$\frac{3000}{2} = 1500 \text{ lb. per inch of roller length.}$$

$$S_c = .59 \sqrt{\frac{1500 \times 30,000,000}{.5}} = 177,000 \text{ P.S.I.}$$

RADIUS OF GYRATION IN FEET FOR A FLAT CIRCULAR RING, AXIS THRU CENTER OF RING

Radius of gyration in feet for a flat circular ring with axis through center of ring is .7071 times the square root of (radius to outside in inches squared) plus (radius to inside in inches squared) divided by 12.

$$K = \frac{.7071 \sqrt{R^2 + r^2}}{12}$$

Where: K = Radius of gyration in feet.
 R = Radius to outside in inches.
 r = Radius to inside in inches.

EXAMPLE:

What is the radius of gyration of a flat circular ring having an outside diameter of 17" and an inside diameter of 8.6 inches.

$$R = 8.5$$

$$r = 4.30$$

$$K = \frac{.7071 \sqrt{8.5^2 + 4.30^2}}{12} = .5613 \text{ feet.}$$

CENTRIFUGAL FORCE

Centrifugal force in pounds is .0003409 times the weight of a revolving body in lbs. times the radius of gyration times the square of the number of revolutions per minute.

$$F = .0003409 \times W \times K \times N^2$$

Where: F = Centrifugal force in pounds.
 W = Weight of revolving body in pounds.
 K = Radius of gyration, in feet.
 N = Number of revolutions per minute.

EXAMPLE:

Find the centrifugal force of a flywheel where the outside diameter is 17" and the base or inside diameter is 8.6" and the thickness is 1.8" and $W = 79\#$, $K = .5613$, $N = 4000$

$$F = .0003409 \times 79 \times .5613 \times 4000^2 = 241863 \text{ lbs.}$$

POTENTIAL ENERGY OF REVOLVING FLYWHEEL

The potential energy of a revolving flywheel is the weight of wheel in lbs. times the square of the velocity at radius of gyration in feet per second divided by the sum of 2 times the acceleration due to gravity.

$$E = \frac{W \times V^2}{2 \times g}$$

Where: E = Potential energy in lbs. feet.
 W = Weight of wheel in lbs.
 V = Velocity at radius of gyration in feet per second.
 g = Acceleration due to gravity (32.16 ft. per second).

EXAMPLE:

Find the potential energy of a flywheel where $W = 79 \text{ lb.}$ V is 126.4 and g is 32.16.

$$E = \frac{79 \times 126.4^2}{2 \times 32.16} = 19623 \text{ lbs.-ft.}$$

TORSIONAL SHAFT STRESS

Torsional shaft stress is the torque in pound-inches divided by the sum of .1963 times shaft dia. cubed.

$$S = \frac{T}{.1963 \times D^3}$$

Where: S = Torsional shaft stress in P.S.I.
 T = Torque in lbs.-inches
 D = Dia. of shaft in inches
 .1963 = Factor

EXAMPLE: What is the torsional stress of a shaft whose dia. is 1½ and the torque is 20000 lb.-in.

$$S = \frac{20000}{.1963 \times 1.50^3} = 30189 \text{ P.S.I.}$$

SHAFT TORQUE

Torque is the product of the stresses times .1963 times the cube of shaft dia.

$$T = S \times .1963 \times D^3$$

EXAMPLE: What is the torque of a shaft whose dia. is 1.5 and the stress is 30189 P.S.I.

$$T = 30189 \times .1963 \times 1.50^3 = 20000 \text{ lb.-in.}$$

SHAFT DIAMETER

Shaft dia. is the cube root of the torque divided by the sum of .1963 times the stress.

$$D = \sqrt[3]{\frac{T}{.1963 \times S}}$$

EXAMPLE: What is the shaft diameter where the torque is 20000# and the torsional stress is 30189 P.S.I.

$$D = \sqrt[3]{\frac{20000}{.1963 \times 30189}} = 1.5 \text{ inches}$$

APPROXIMATE SQUARE ROOTS

Divide number by nearest root you know and average the divisor and quotient.

EXAMPLES:

$$\text{Sq. Rt. of } 10 = \begin{array}{l} 3\frac{1}{2} \\ 3 \overline{)10} \end{array} \quad \frac{3 + 3\frac{1}{2}}{2} = 3\frac{1}{4} = 3.166 \\ \text{Actual} = 3.163$$

$$\text{Sq. Rt. of } 20 = \begin{array}{l} 5 \\ 4 \overline{)20} \end{array} \quad \frac{4 + 5}{2} = 4.500 \\ \text{Actual} = 4.472$$

$$\text{Sq. Rt. of } 30 = \begin{array}{l} 6 \\ 5 \overline{)30} \end{array} \quad \frac{5 + 6}{2} = 5.500 \\ \text{Actual} = 5.477$$

$$\text{Sq. Rt. of } 40 = \begin{array}{l} 6\frac{1}{2} \\ 6 \overline{)40} \end{array} \quad \frac{6 + 6\frac{1}{2}}{2} = 6.333 \\ \text{Actual} = 6.325$$

$$\text{Sq. Rt. of } 50 = \begin{array}{l} 7\frac{1}{4} \\ 7 \overline{)50} \end{array} \quad \frac{7 + 7.1428}{2} = 7.0714 \\ \text{Actual} = 7.0711$$

NOTE: The process can be repeated using the new root to get closer values.

EXAMPLE:

$$\text{Sq. Rt. of } 20 = 4.5 \overline{)20} \begin{array}{l} 4.444 \\ 4.5 + 4.4444 \\ \hline 2 \end{array} = 4.4722 \\ \text{Actual} = 4.47214$$

APPROXIMATE WEIGHT OF SEAMLESS STEEL TUBING

The weights obtained are a very close approximation for seamless steel tubing.

To find the weight per ft. of a seamless steel tube subtract the wall thickness from the O.D. and multiply the result by the wall thickness, then multiply the result by 10.68. Expressed (O.D. - T) × T × 10.68.

Where: O.D. = Outside Dia.
T = Wall Thickness.
10.68 = Constant.

EXAMPLE: Find the weight per ft. of a seamless steel tube of 1/2" out dia. and a wall thickness of .035.

$$(.5 - .035) \times .035 \times 10.68 = .1738\#$$

EXAMPLE: Find the weight per ft. of a seamless steel tube of 8" out dia. and 1/2" wall thickness.

$$(8 - .5) \times .5 \times 10.68 = 40.05\#$$

APPROXIMATE WEIGHTS OF ROUND CARBON STEEL BARS

The weights obtained by the following formula are a very close approximation for all sizes of stock.

Square the number of quarter-inches in the bar diameter and divide by six.

EXPRESSED:

$$W = \frac{(D \times 4)^2}{6}$$

Where: W = Weight per ft.

D = Dia. of bar

$$\text{Sample } W = \frac{(3.75 \times 4)^2}{6}$$

$$= \frac{15^2}{6} \\ = \frac{225}{6} \\ = 37.50$$

$$W = \frac{(1.125 \times 4)^2}{6}$$

$$= \frac{(4.5)^2}{6} \\ = \frac{20.25}{6} \\ = 3.375$$

From chart = 3.379

EXAMPLES:

Bar Dia.	Computation	By Formula	By Machinery Handbook
1/8	$\frac{.5 \times .5}{6}$	.042	.042
1/4	$\frac{2 \times 2}{6}$	.666	.668
3/8	$\frac{4.25 \times 4.25}{6}$	3.010	3.015
1/2	$\frac{7 \times 7}{6}$	8.167	8.178
5/8	$\frac{9.25 \times 9.25}{6}$	14.26	14.28
3/4	$\frac{11.75 \times 11.75}{6}$	23.01	23.04
7/8	$\frac{15 \times 15}{6}$	37.50	37.55

PRODUCT INFORMATION

For information or assistance concerning axle housings, steer axles, planetary drive, drive-steer or bogie axles, call Buchanan, Michigan, (616) 697-8000.

For your requirements on manual or power-shift transmissions, torque converters, log skidder winches, and agricultural units, call Jackson, Michigan, (517) 764-6000.

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