

Useful Tables, Charts, and Formulas

Contents

- | | | | |
|---------------|--|----------------|---|
| 17.0.0 | Nails: penny designation (“d”) and lengths (U.S. and metric) | 17.10.0 | Volume of vertical cylindrical tanks (in gallons per foot of depth) |
| 17.1.0 | Stainless steel sheets (thicknesses and weights) | 17.11.0 | Volume of rectangular tank capacities (in U.S. gallons per foot of depth) |
| 17.2.0 | Comparable thicknesses and weights of stainless steel, aluminum, and copper | 17.12.0 | Capacity of horizontal cylindrical tanks |
| 17.3.0 | Wire and sheetmetal gauges and weights | 17.13.0 | Round-tapered tank capacities |
| 17.4.0 | Weights and specific gravities of common materials | 17.14.0 | Circumferences and areas of circles |
| 17.5.0 | Useful formulas | 17.15.0 | Tap drill sizes for fractional size threads |
| 17.6.0 | Decimal equivalents of inches in feet and yards | 17.16.0 | Common material R-values |
| 17.7.0 | Conversion of fractions to decimals | 17.17.0 | Conversion factors—power, pressure, energy |
| 17.7.1 | Decimals of a foot for each $\frac{1}{32}$ inch | 17.18.0 | Useful engineering tables—Schedule 40 pipe dimensions, diameter of circles, and drill sizes |
| 17.7.2 | Decimal of an inch for each $\frac{1}{64}$ inch, with millimeter equivalents | 17.19.0 | Thermal expansion of various materials |
| 17.8.0 | Solutions of the right triangle | 17.20.0 | Miscellaneous tables of weights, measures, and other information |
| 17.9.0 | Areas and other formulas | | |

17.0.0 Nails: Penny Designation ("d") and Lengths (U.S. and Metric)

Nail—penny size	Length in inches	Length in millimeters
2d	1	25.40
3d	1 1/4	31.75
4d	1 1/2	38.10
5d	1 3/4	44.45
6d	2	50.80
7d	2 1/4	57.15
8d	2 1/2	63.50
9d	2 3/4	69.85
10d	3	76.20
12d	3 1/4	82.55
16d	3 1/2	88.90
20d	3 3/4	95.25
30d	4 1/2	114.30
40d	5	127.00
50d	5 1/2	139.70
60d	6	152.40

17.1.0 Stainless Steel Sheets (Thicknesses and Weights)

Gauge	Thickness		Weight	
	inches	mm.	lb/ft ²	kg/m ²
8	0.17188	4.3658	7.2187	44.242
10	0.14063	3.5720	5.9062	28.834
11	0.1250	3.1750	5.1500	25.6312
12	0.10938	2.7783	4.5937	22.427
14	0.07813	1.9845	3.2812	16.019
16	0.06250	1.5875	2.6250	12.815
18	0.05000	1.2700	2.1000	10.252
20	0.03750	0.9525	1.5750	7.689
22	0.03125	0.7938	1.3125	6.409
24	0.02500	0.6350	1.0500	5.126
26	0.01875	0.4763	0.7875	3.845
28	0.01563	0.3970	0.6562	3.1816
Plates				
3/16"	0.1875	4.76	7.752	37.85
1/4"	0.25	6.35	10.336	50.46
5/16"	0.3125	7.94	12.920	63.08
3/8"	0.375	9.53	15.503	75.79
1/2"	0.50	12.70	20.671	100.92
5/8"	0.625	15.88	25.839	126.15
3/4"	0.75	19.05	31.007	151.38
1"	1.00	25.4	41.342	201.83

17.2.0 Comparable Thicknesses and Weights of Stainless Steel, Aluminum, and Copper

STAINLESS STEEL			ALUMINUM			COPPER		
Thickness (Inch)	Gauge (U.S. Standard)	Lb/sq ft	Thickness (Inch)	Gauge (B&S)	Lb/sq ft	Thickness (Inch)	Oz sq ft	Lb/sq ft
.010	32	.420	.010	30	.141	.0108	8	.500
.0125	30	.525	.0126	28	.177	.0121	9	.563
						.0135	10	.625
.0156	28	.656	.0156		.220	.0148	11	.688
			.0179	25	.253	.0175	13	.813
.0187	26	.788						
.0219	25	.919	.020	24	.282	.021	16	1.000
.025	24	1.050	.0253	22	.352			
						.027	20	1.250
.031	22	1.313	.0313	—	.441	.032	24	1.500
.0375	20	1.575	.032	20	.451	.0337	28	1.750
			.0403	18	.563	.0431	32	2.000
			.0453	17	.100			
.050	18	2.100	.0506	16	.126			

Note that U.S. Standard Gauge (stainless sheet) is not directly comparable with the B&S Gauge (aluminum). A 20-gauge stainless averages .0375" thick; while a 20-gauge aluminum averages .032" thick; and 20-ounce copper is .027" thick. The higher strength of stainless steel permits use of thinner gauges than required for aluminum or copper, which makes stainless more competitive with

aluminum on a weight-to-coverage basis and provides stainless with a substantial weight saving compared to copper. For example, 100 sq ft of .032" aluminum will weigh about 45 pounds, .021" (16-ounce) copper will weigh about 100 pounds, and .015" stainless will weigh about 66 pounds.

17.3.0 Wire and Sheetmetal Gauges and Weights

Name of Gage	*United States Standard Gage		The United States Steel Wire Gage	American or Brown & Sharpe Wire Gage	New Birmingham Standard Sheet & Hoop Gage	British Imperial or English Legal Standard Wire Gage	Birmingham or Stubs Iron Wire Gage	Name of Gage
Principal Use	Uncoated Steel Sheets and Light Plates		Steel Wire except Music Wire	Non-Ferrous Sheets and Wire	Iron and Steel Sheets and Hoops	Wire	Strips, Bands, Hoops and Wire	Principal Use
Gage No.	Weight Oz. per Sq. Ft.	Approx. Thickness Inches	Thickness, Inches				Gage No.	
7/0's			.4900		.6666	.500		7/0's
6/0's			.4615	.5800	.625	.464		6/0's
5/0's			.4305	.5165	.5883	.432	.550	5/0's
4/0's			.3938	.4600	.5416	.400	.454	4/0's
3/0's			.3625	.3648	.500	.372	.425	3/0's
2/0's			.3310	.3249	.4452	.348	.380	2/0's
1/0			.3065	.2893	.3964	.324	.340	1/0
1			.2830	.2576	.3532	.300	.300	1
2			.2625	.2294	.3147	.276	.284	2
3	160	.2391	.2437	.2043	.2804	.252	.259	3
4	150	.2242	.2253	.1819	.250	.232	.238	4
5	140	.2092	.2070	.1620	.2225	.212	.220	5
6	130	.1943	.1920	.1443	.1981	.192	.203	6
7	120	.1793	.1770	.1285	.1764	.176	.180	7
8	110	.1644	.1620	.1144	.1570	.160	.165	8
9	100	.1495	.1483	.1019	.1398	.144	.148	9
10	90	.1345	.1350	.0907	.1250	.128	.134	10
11	80	.1195	.1205	.0808	.1113	.116	.120	11
12	70	.1046	.1055	.0720	.0991	.104	.109	12
13	60	.0897	.0915	.0641	.0882	.092	.095	13
14	50	.0747	.0800	.0571	.0785	.080	.083	14
15	45	.0673	.0720	.0508	.0699	.072	.072	15
16	40	.0598	.0625	.0453	.0625	.064	.065	16
17	36	.0538	.0540	.0403	.0556	.056	.058	17
18	32	.0478	.0475	.0359	.0495	.048	.049	18
19	28	.0418	.0410	.0320	.0440	.040	.042	19
20	24	.0359	.0348	.0285	.0392	.036	.035	20
21	22	.0329	.0317	.0253	.0349	.032	.032	21
22	20	.0299	.0286	.0226	.0313	.028	.028	22
23	18	.0269	.0258	.0201	.0278	.024	.025	23
24	16	.0239	.0230	.0179	.0248	.022	.022	24
25	14	.0209	.0204	.0159	.0220	.020	.020	25
26	12	.0179	.0181	.0142	.0196	.018	.018	26
27	11	.0164	.0173	.0126	.0175	.0164	.016	27
28	10	.0149	.0162	.0113	.0156	.0148	.014	28
29	9	.0135	.0150	.0100	.0139	.0136	.013	29
30	8	.0120	.0140	.0089	.0123	.0124	.012	30
31	7	.0105	.0132	.0080	.0110	.0116	.010	31
32	6.5	.0097	.0128	.0071	.0098	.0108	.009	32
33	6	.0090	.0118	.0063	.0087	.0100	.008	33
34	5.5	.0082	.0104	.0056	.0077	.0092	.007	34
35	5	.0075	.0095	.0050	.0069	.0084	.005	35
36	4.5	.0067	.0090	.0045	.0061	.0076	.004	36
37	4.25	.0064	.0085	.0040	.0054	.0068		37
38	4	.0060	.0080	.0035	.0048	.0060		38
39			.0075	.0031	.0043	.0052		39
40			.0070		.0039	.0048		40

* U.S. Standard Gage is officially a weight gage, in oz per sq ft as tabulated. The Approx. Thickness shown is the "Manufacturers' Standard" of the American Iron and Steel Institute, based on steel as weighing 501.81 lb per cu ft (489.6 true weight plus 2.5 percent for average over-run in area and thickness).

17.4.0 Weights and Specific Gravities of Common Materials

Substance	Weight Lb per Cu Ft	Specific Gravity	Substance	Weight Lb per Cu Ft	Specific Gravity
METALS, ALLOYS, ORES			TIMBER, U. S. SEASONED		
Aluminum, cast, hammered.....	165	2.55-2.75	Moisture Content by Weight:		
Brass, cast, rolled.....	534	8.4-8.7	Seasoned timber 15 to 20%		
Bronze, 7.9 to 14% Sn.....	509	7.4-8.9	Green timber up to 50%		
Bronze, aluminum.....	481	7.7	Ash, white, red.....	40	0.62-0.65
Copper, cast, rolled.....	556	8.8-9.0	Cedar, white, red.....	22	0.32-0.38
Copper ore, pyrites.....	262	4.1-4.3	Chestnut.....	41	0.66
Gold, cast, hammered.....	1205	19.25-19.3	Cypress.....	30	0.48
Iron, cast, pig.....	450	7.2	Fir, Douglas spruce.....	32	0.51
Iron, wrought.....	485	7.6-7.9	Fir, eastern.....	25	0.40
Iron, spiegel-eisen.....	468	7.5	Elm, white.....	45	0.72
Iron, ferro-silicon.....	437	6.7-7.3	Hemlock.....	29	0.42-0.52
Iron ore, hematite.....	325	5.2	Hickory.....	49	0.74-0.84
Iron ore, hematite in bank.....	160-180	-----	Locust.....	46	0.73
Iron ore, hematite loose.....	130-160	-----	Maple, hard.....	43	0.68
Iron ore, limonite.....	237	3.6-4.0	Maple, white.....	33	0.53
Iron ore, magnetite.....	315	4.9-5.2	Oak, chestnut.....	54	0.86
Iron slag.....	172	2.5-3.0	Oak, live.....	59	0.95
Lead.....	710	11.37	Oak, red, black.....	41	0.65
Lead ore, galena.....	465	7.3-7.6	Oak, white.....	46	0.74
Magnesium, alloys.....	112	1.74-1.83	Pine, Oregon.....	32	0.51
Manganese.....	475	7.2-8.0	Pine, red.....	30	0.48
Manganese ore, pyrolusite.....	259	3.7-4.6	Pine, white.....	26	0.41
Mercury.....	849	13.6	Pine, yellow, long-leaf.....	44	0.70
Monel Metal.....	556	8.8-9.0	Pine, yellow, short-leaf.....	38	0.61
Nickel.....	565	8.9-9.2	Poplar.....	30	0.48
Platinum, cast, hammered.....	1330	21.1-21.5	Redwood, California.....	26	0.42
Silver, cast, hammered.....	656	10.4-10.6	Spruce, white, black.....	27	0.40-0.46
Steel, rolled.....	490	7.85	Walnut, black.....	38	0.61
Tin, cast, hammered.....	459	7.2-7.5	Walnut, white.....	26	0.41
Tin ore, cassiterite.....	418	6.4-7.0			
Zinc, cast, rolled.....	440	6.9-7.2			
Zinc ore, blende.....	253	3.9-4.2			
VARIOUS SOLIDS			VARIOUS LIQUIDS		
Cereals, oats.....bulk	32	-----	Alcohol, 100%.....	49	0.79
Cereals, barley.....bulk	39	-----	Acids, muriatic 40%.....	75	1.20
Cereals, corn, rye.....bulk	48	-----	Acids, nitric 91%.....	94	1.50
Cereals, wheat.....bulk	48	-----	Acids, sulphuric 87%.....	112	1.80
Hay and Straw.....bales	20	-----	Lye, soda 66%.....	106	1.70
Cotton, Flax, Hemp.....	93	1.47-1.50	Oils, vegetable.....	58	0.91-0.94
Fats.....	58	0.90-0.97	Oils, mineral, lubricants.....	57	0.90-0.93
Flour, loose.....	28	0.40-0.50	Water, 4°C. max. density.....	62.428	1.0
Flour, pressed.....	47	0.70-0.80	Water, 100°C.....	59.830	0.9584
Glass, common.....	156	2.40-2.60	Water, ice.....	56	0.88-0.92
Glass, plate or crown.....	161	2.45-2.72	Water, snow, fresh fallen.....	8	.125
Glass, crystal.....	184	2.90-3.00	Water, sea water.....	64	1.02-1.03
Leather.....	59	0.86-1.02			
Paper.....	58	0.70-1.15			
Potatoes, piled.....	42	-----			
Rubber, caoutchouc.....	59	0.92-0.96			
Rubber goods.....	94	1.0-2.0			
Salt, granulated, piled.....	48	-----			
Salt peter.....	67	-----			
Starch.....	96	1.53			
Sulphur.....	125	1.93-2.07			
Wool.....	82	1.32			
			GASES		
			Air, 0°C. 760 mm.....	.08071	1.0
			Ammonia.....	.0478	0.5920
			Carbon dioxide.....	.1234	1.5291
			Carbon monoxide.....	.0781	0.9673
			Gas, illuminating.....	.028-.036	0.35-0.45
			Gas, natural.....	.038-.039	0.47-0.48
			Hydrogen.....	.00559	0.0693
			Nitrogen.....	.0784	0.9714
			Oxygen.....	.0892	1.1056

The specific gravities of solids and liquids refer to water at 4°C, those of gases to air at 0°C and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

17.4.0 Weights and Specific Gravities of Common Materials—Continued

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Hay and Straw.....bales	20	-----	Lye, soda 66%.....	106	1.70
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Saltpeter.....	67	-----			
Starch.....	96	1.53			
Sulphur.....	125	1.93-2.07			
Wool.....	82	1.32			
			GASES		
			Air, 0°C. 760 mm.....	.08071	1.0
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17.5.0 Useful Formulas

Circumference of a circle = $\pi \times \text{diameter}$ or $3.1416 \times \text{diameter}$

Diameter of a circle = $\text{circumference} \times 0.31831$

Area of a square = $\text{length} \times \text{width}$

Area of a rectangle = $\text{length} \times \text{width}$

Area of a parallelogram = $\text{base} \times \text{perpendicular height}$

Area of a triangle = $\frac{1}{2} \text{base} \times \text{perpendicular height}$

Area of a circle = $\pi \text{ radius squared}$ or $\text{diameter squared} \times 0.7854$

Area of an ellipse = $\text{length} \times \text{width} \times 0.7854$

Volume of a cube or rectangular prism = $\text{length} \times \text{width} \times \text{height}$

Volume of a triangular prism = $\text{area of triangle} \times \text{length}$

Volume of a sphere = $\text{diameter cubed} \times 0.5236$ ($\text{diameter} \times \text{diameter} \times \text{diameter} \times 0.5236$)

Volume of a cone = $\pi \times \text{radius squared} \times \frac{1}{3} \text{height}$

Volume of a cylinder = $\pi \times \text{radius squared} \times \text{height}$

Length of one side of a square $\times 1.128 = \text{diameter of an equal circle}$

Doubling the diameter of a pipe or cylinder increases its capacity 4 times

Pressure (in lb/sq in.) of a column of water = $\text{height of the column}$ (in feet) $\times 0.434$

Capacity of a pipe or tank (in U.S. gallons) = diameter squared (in inches) $\times \text{length}$ (in inches) $\times 0.0034$

1 gal water = $8\frac{1}{2}$ lb = 231 cu in.

1 cu ft water = $62\frac{1}{2}$ lb = $7\frac{1}{2}$ gal.

17.6.0 Decimal Equivalents of Inches in Feet and Yards

Inches	Feet	Yards
1	.0833	.0278
2	.1667	.0556
3	.2500	.0833
4	.333	.1111
5	.4166	.1389
6	.5000	.1667
7	.5833	.1944
8	.6667	.2222
9	.7500	.2500
10	.8333	.2778
11	.9166	.3056
12	1.000	.3333

17.7.0 Conversion of Fractions to Decimals

Fractions	Decimal	Fractions	Decimal
1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	38/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.1719	43/64	.67187
3/16	.1875	11/16	.6875
13/64	.2031	45/64	.70312
7/32	.2188	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/10	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.398625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	60/64	.921875
7/16	.4375	15/16	.9375
20/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.50	1"	1.000000

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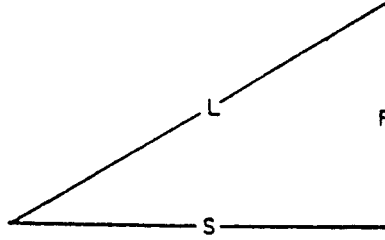
17.7.1 Decimals of a Foot for Each $\frac{1}{32}$ "

Inch	0	1	2	3	4	5
0	0	.0833	.1667	.2500	.3333	.4167
$\frac{1}{32}$	.0026	.0859	.1693	.2526	.3359	.4193
$\frac{1}{16}$	.0052	.0885	.1719	.2552	.3385	.4219
$\frac{3}{32}$	.0078	.0911	.1745	.2578	.3411	.4245
$\frac{7}{8}$	.0104	.0938	.1771	.2604	.3438	.4271
$\frac{9}{32}$	.0130	.0964	.1797	.2630	.3464	.4297
$\frac{5}{16}$	.0156	.0990	.1823	.2656	.3490	.4323
$\frac{7}{32}$	.0182	.1016	.1849	.2682	.3516	.4349
$\frac{1}{4}$	.0208	.1042	.1875	.2708	.3542	.4375
$\frac{5}{32}$	.0234	.1068	.1901	.2734	.3568	.4401
$\frac{3}{8}$	.0260	.1094	.1927	.2760	.3594	.4427
$\frac{11}{32}$	.0286	.1120	.1953	.2786	.3620	.4453
$\frac{3}{8}$	.0313	.1146	.1979	.2812	.3646	.4479
$\frac{13}{32}$	.0339	.1172	.2005	.2839	.3672	.4505
$\frac{7}{16}$	.0365	.1198	.2031	.2865	.3698	.4531
$\frac{15}{32}$	.0391	.1224	.2057	.2891	.3724	.4557
$\frac{1}{2}$	.0417	.1250	.2083	.2917	.3750	.4583
$\frac{17}{32}$	.0443	.1276	.2109	.2943	.3776	.4609
$\frac{9}{16}$	.0469	.1302	.2135	.2969	.3802	.4635
$\frac{19}{32}$	.0495	.1328	.2161	.2995	.3828	.4661
$\frac{5}{8}$	.0521	.1354	.2188	.3021	.3854	.4688
$\frac{21}{32}$	.0547	.1380	.2214	.3047	.3880	.4714
$\frac{11}{16}$	.0573	.1406	.2240	.3073	.3906	.4740
$\frac{23}{32}$	.0599	.1432	.2266	.3099	.3932	.4766
$\frac{3}{4}$	.0625	.1458	.2292	.3125	.3958	.4792
$\frac{25}{32}$	.0651	.1484	.2318	.3151	.3984	.4818
$\frac{13}{16}$	.0677	.1510	.2344	.3177	.4010	.4844
$\frac{27}{32}$	.0703	.1536	.2370	.3203	.4036	.4870
$\frac{7}{8}$	.0729	.1563	.2396	.3229	.4063	.4896
$\frac{29}{32}$	.0755	.1589	.2422	.3255	.4089	.4922
$\frac{15}{16}$	.0781	.1615	.2448	.3281	.4115	.4948
$\frac{31}{32}$	.0807	.1641	.2474	.3307	.4141	.4974

17.7.2 Decimals of in inch for Each $\frac{1}{64}$ ", with Millimeter Equivalents

Fraction	$\frac{1}{64}$ ths	Decimal	Millimeters (Approx.)	Fraction	$\frac{1}{64}$ ths	Decimal	Millimeters (Approx.)
...	1	.015625	0.397	...	33	.515625	13.097
$\frac{1}{32}$	2	.03125	0.794	$\frac{17}{32}$	34	.53125	13.494
...	3	.046875	1.191	...	35	.546875	13.891
$\frac{1}{16}$	4	.0625	1.588	$\frac{9}{16}$	36	.5625	14.288
...	5	.078125	1.984	...	37	.578125	14.684
$\frac{3}{32}$	6	.09375	2.381	$\frac{19}{32}$	38	.59375	15.081
...	7	.109375	2.778	...	39	.609375	15.478
$\frac{1}{8}$	8	.125	3.175	$\frac{5}{8}$	40	.625	15.875
...	9	.140625	3.572	...	41	.640625	16.272
$\frac{5}{32}$	10	.15625	3.969	$\frac{21}{32}$	42	.65625	16.669
...	11	.171875	4.366	...	43	.671875	17.066
$\frac{3}{16}$	12	.1875	4.763	$\frac{11}{16}$	44	.6875	17.463
...	13	.203125	5.159	...	45	.703125	17.859
$\frac{7}{32}$	14	.21875	5.556	$\frac{23}{32}$	46	.71875	18.256
...	15	.234375	5.953	...	47	.734375	18.653
$\frac{1}{4}$	16	.250	6.350	$\frac{3}{4}$	48	.750	19.050
...	17	.265625	6.747	...	49	.765625	19.447
$\frac{9}{32}$	18	.28125	7.144	$\frac{25}{32}$	50	.78125	19.844
...	19	.296875	7.541	...	51	.796875	20.241
$\frac{5}{16}$	20	.3125	7.938	$\frac{13}{16}$	52	.8125	20.638
...	21	.328125	8.334	...	53	.828125	21.034
$\frac{11}{32}$	22	.34375	8.731	$\frac{27}{32}$	54	.84375	21.431
...	23	.359375	9.128	...	55	.859375	21.828
$\frac{3}{8}$	24	.375	9.525	$\frac{7}{8}$	56	.875	22.225
...	25	.390625	9.922	...	57	.890625	22.622
$\frac{13}{32}$	26	.40625	10.319	$\frac{29}{32}$	58	.90625	23.019
...	27	.421875	10.716	...	59	.921875	23.416
$\frac{7}{16}$	28	.4375	11.113	$\frac{15}{16}$	60	.9375	23.813
...	29	.453125	11.509	...	61	.953125	24.209
$\frac{15}{32}$	30	.46875	11.906	$\frac{31}{32}$	62	.96875	24.606
...	31	.484375	12.303	...	63	.984375	25.003
$\frac{1}{2}$	32	.500	12.700	1	64	1.000	25.400

17.8.0 Solutions of the Right Triangle



To find side	When you know side	Multiply side	For 45 Ells-By	For 22 1/2 Ells-By	For 67 1/2 Ells-By	For 72 Ells-By	For 60 Ells-By	For 80 Ells-By
L	S	S	1.4142	2.6131	1.08	1.05	1.1547	2.00
S	L	L	.707	.3826	.92	.95	.866	.50
R	S	S	1.000	2.4142	.414	.324	.5773	.1732
S	R	R	1.000	.4142	2.41	3.07	1.732	.5773
L	R	R	1.4142	1.0824	2.61	3.24	2.00	1.1547
R	L	L	.7071	.9239	.38	.31	.50	.866

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17.9.0 Area and Other Formulas

<i>Parallelogram</i>	$\text{Area} = \text{base} \times \text{distance between the two parallel sides}$
<i>Pyramid</i>	$\text{Area} = \frac{1}{2} \text{perimeter of base} \times \text{slant height} + \text{area of base}$ $\text{Volume} = \text{area of base} \times \frac{1}{3} \text{of the altitude}$
<i>Rectangle</i>	$\text{Area} = \text{length} \times \text{width}$
<i>Rectangular prisms</i>	$\text{Volume} = \text{width} \times \text{height} \times \text{length}$
<i>Sphere</i>	$\text{Area of surface} = \text{diameter} \times \text{diameter} \times 3.1416$ $\text{Side of inscribed cube} = \text{radius} \times 1.547$ $\text{Volume} = \text{diameter} \times \text{diameter} \times \text{diameter} \times 0.5236$
<i>Square</i>	$\text{Area} = \text{length} \times \text{width}$
<i>Triangle</i>	$\text{Area} = \text{one half of height times base}$
<i>Trapezoid</i>	$\text{Area} = \text{one half of the sum of the parallel sides} \times \text{height}$
<i>Cone</i>	$\text{Area of surface} = \text{one half of circumference of base} \times \text{slant height} + \text{area of base}$ $\text{Volume} = \text{diameter} \times \text{diameter} \times 0.7854 \times \text{one third of the altitude}$
<i>Cube</i>	$\text{Volume} = \text{width} \times \text{height} \times \text{length}$
<i>Ellipse</i>	$\text{Area} = \text{short diameter} \times \text{long diameter} \times 0.7854$
<i>Cylinder</i>	$\text{Area of surface} = \text{diameter} \times 3.1416 \times \text{length} + \text{area of the two bases}$ $\text{Area of base} = \text{diameter} \times \text{diameter} \times 0.7854$ $\text{Area of base} = \text{volume} \div \text{length}$ $\text{Length} = \text{volume} \div \text{area of base}$ $\text{Volume} = \text{length} \times \text{area of base}$ $\text{Capacity in gallons} = \text{volume in inches} \div 231$ $\text{Capacity of gallons} = \text{diameter} \times \text{diameter} \times \text{length} \times 0.0034$ $\text{Capacity in gallons} = \text{volume in feet} \times 7.48$
<i>Circle</i>	$\text{Circumference} = \text{diameter} \times 3.1416$ $\text{Circumference} = \text{radius} \times 6.2832$ $\text{Diameter} = \text{radius} \times 2$ $\text{Diameter} = \text{square root of } (\text{area} \div 0.7854)$ $\text{Diameter} = \text{square root of area} \times 1.1283$

17.10.0 Volume of Vertical Cylindrical Tanks (in Gallons per Foot of Depth)

Diameter in		U. S. Gallons	Diameter in		U. S. Gallons	Diameter in		U. S. Gallons
Feet	Inches		Feet	Inches		Feet	Inches	
1	0	5.875	3	6	71.97	6	0	211.5
1	1	6.895	3	7	75.44	6	3	220.5
1	2	7.997	3	8	78.99	6	6	248.2
1	3	9.180	3	9	82.62	6	9	267.7
1	4	10.44	3	10	86.33	7	0	287.9
1	5	11.79	3	11	90.13	7	3	308.8
1	6	13.22	4	0	94.00	7	6	330.5
1	7	14.73	4	1	97.96	7	9	352.9
1	8	16.32	4	2	102.0	8	0	376.0
1	9	17.99	4	3	106.1	8	3	399.9
1	10	19.75	4	4	110.3	8	6	424.5
1	11	21.58	4	5	114.6	8	9	449.8
2	0	23.50	4	6	119.0	9	0	475.9
2	1	25.50	4	7	123.4	9	3	502.7
2	2	27.58	4	8	127.9	9	6	530.2
2	3	29.74	4	9	132.6	9	9	558.5
2	4	31.99	4	10	137.3	10	0	587.5
2	5	34.31	4	11	142.0	10	3	617.3
2	6	36.72	5	0	146.9	10	6	647.7
2	7	39.21	5	1	151.8	10	9	679.0
2	8	41.78	5	2	156.8	11	0	710.9
2	9	44.43	5	3	161.9	11	3	743.6
2	10	47.16	5	4	167.1	11	6	777.0
2	11	49.98	5	5	172.4	11	9	811.1
3	0	52.88	5	6	177.7	12	0	846.0
3	1	55.86	5	7	183.2	12	3	881.6
3	2	58.92	5	8	188.7	12	6	918.0
3	3	62.06	5	9	194.2	12	9	955.1
3	4	65.28	5	10	199.9			
3	5	68.58	5	11	205.7			

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17.11.0 Volume of Rectangular Tank Capacities (in U.S. Gallons per Foot of Depth)

Width Feet	LENGTH OF TANK — IN FEET						
	2	2 1/2	3	3 1/2	4	4 1/2	5
2	29.92	37.40	44.88	52.36	59.84	67.32	74.81
2 1/2	—	46.75	56.10	65.45	74.81	84.16	93.51
3	—	—	67.32	78.55	89.77	101.0	112.2
3 1/2	—	—	—	91.64	104.7	117.8	130.9
4	—	—	—	—	119.7	134.6	149.6
4 1/2	—	—	—	—	—	151.5	168.3
5	—	—	—	—	—	—	187.0
	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2
2	82.29	89.77	97.25	104.7	112.2	119.7	127.2
2 1/2	102.9	112.2	121.6	130.9	140.3	149.6	159.0
3	123.4	134.6	145.9	157.1	168.3	179.5	190.8
3 1/2	144.0	157.1	170.2	183.3	196.4	209.5	222.5
4	164.6	179.5	194.5	209.5	224.4	239.4	254.3
4 1/2	185.1	202.0	218.8	235.6	252.5	269.3	286.1
5	205.7	224.4	243.1	261.8	280.5	299.2	317.9
5 1/2	226.3	246.9	267.4	288.0	308.6	329.1	349.7
6	—	269.3	291.7	314.2	336.6	359.1	381.5
6 1/2	—	—	316.1	340.4	364.7	389.0	413.3
7	—	—	—	366.5	392.7	418.9	445.1
7 1/2	—	—	—	—	420.8	448.8	476.9
8	—	—	—	—	—	478.8	508.7
8 1/2	—	—	—	—	—	—	540.5
	9	9 1/2	10	10 1/2	11	11 1/2	12
2	134.6	142.1	149.6	157.1	164.6	172.1	179.5
2 1/2	168.3	177.7	187.0	196.4	205.7	215.1	224.4
3	202.0	213.2	224.4	235.6	246.9	258.1	269.3
3 1/2	235.6	248.7	261.8	274.9	288.0	301.1	314.2
4	269.3	284.3	299.2	314.2	329.1	344.1	359.1
4 1/2	303.0	319.8	336.6	353.5	370.3	387.1	403.9
5	336.6	355.3	374.0	392.7	411.4	430.1	448.8
5 1/2	370.3	390.9	411.4	432.0	452.6	473.1	493.7
6	403.9	426.4	448.8	471.3	493.7	516.2	538.6
6 1/2	437.6	461.9	486.2	510.5	534.9	559.2	583.5
7	471.3	497.5	523.6	549.8	576.0	602.2	628.4
7 1/2	504.9	533.0	561.0	589.1	617.1	645.2	673.2
8	538.6	568.5	598.4	628.4	658.3	688.2	718.1
8 1/2	572.3	604.1	635.8	667.6	699.4	731.2	763.0
9	605.9	639.6	673.2	706.9	740.6	774.2	807.9
9 1/2	—	675.1	710.6	746.2	781.7	817.2	852.8
10	—	—	748.1	785.5	822.9	860.3	897.7
10 1/2	—	—	—	824.7	864.0	903.3	942.5
11	—	—	—	—	905.1	946.3	987.4
11 1/2	—	—	—	—	—	989.3	1032.0
12	—	—	—	—	—	—	1077.0

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17.12.0 Capacity of Horizontal Cylindrical Tanks

% Depth Filled	% of Capacity	% Depth Filled	% of Capacity	% Depth Filled	% of Capacity	% Depth Filled	% of Capacity
1	.20	26	20.73	51	51.27	76	81.50
2	.50	27	21.86	52	52.55	77	82.60
3	.90	28	23.00	53	53.81	78	83.68
4	1.34	29	24.07	54	55.08	79	84.74
5	1.87	30	25.31	55	56.34	80	85.77
6	2.45	31	26.48	56	57.60	81	86.77
7	3.07	32	27.66	57	58.86	82	87.76
8	3.74	33	28.84	58	60.11	83	88.73
9	4.45	34	30.03	59	61.36	84	89.68
10	5.20	35	31.19	60	62.61	85	90.60
11	5.98	36	32.44	61	63.86	86	91.50
12	6.80	37	33.66	62	65.10	87	92.36
13	7.64	38	34.90	63	66.34	88	93.20
14	8.50	39	36.14	64	67.56	89	94.02
15	9.40	40	37.36	65	68.81	90	94.80
16	10.32	41	38.64	66	69.97	91	95.50
17	11.27	42	39.89	67	71.16	92	96.26
18	12.24	43	41.14	68	72.34	93	96.93
19	13.23	44	42.40	69	73.52	94	97.55
20	14.23	45	43.66	70	74.69	95	98.13
21	15.26	46	44.92	71	75.93	96	98.66
22	16.32	47	46.19	72	77.00	97	99.10
23	17.40	48	47.45	73	78.14	98	99.50
24	18.50	49	48.73	74	79.27	99	99.80
25	19.61	50	50.00	75	80.39	100	100.00

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17.13.0 Round-Tapered Tank Capacities

$$Volume = \frac{h^3}{3} \frac{[Area_{Top} + Area_{Base}] + \sqrt{(Area_{Top} + Area_{Base})}}{231}$$

If inches are used.

$$Volume = \frac{h}{3} [(Area_{Base} + Area_{Top}) + \sqrt{(Area_{Base} + Area_{Top})}] \times 7.48$$

If feet are used.

Sample Problem

Let d be 12" (2 ft)

D be 36" (3 ft)

h be 48" (4 ft)

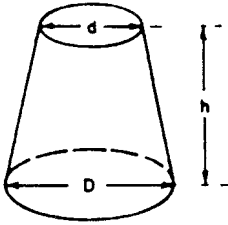
Find volume in gallons.

$$Volume = \frac{48}{3} \frac{[(\pi \times 12^2) + (\pi \times 18^2) + \sqrt{\pi \times 12^2 \times 18^2}]}{231}$$

Where dimensions are in inches

$$Volume = \frac{4}{3} [(\pi \times 12^2) + (\pi \times 1\frac{1}{2}^2) + \sqrt{(\pi \times 1^2) \times \frac{1}{2}^2}] \times 7.48$$

Where dimensions are in feet



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17.14.0 Circumferences and Areas of Circles

Fract.	Of One Inch				Of Inches or Feet				
	Decimal	Circ.	Area	Dia.	Circ.	Area	Dia.	Circ.	Area
1/64	.015625	.04909	.00019	1	3.1416	.7854	64	201.06	3216.99
1/32	.03125	.09818	.00077	2	6.2832	3.1416	65	204.20	3318.31
3/64	.046875	.14726	.00173	3	9.4248	7.0686	66	207.34	3421.19
1/16	.0625	.19635	.00307	4	12.5664	12.5664	67	210.49	3525.65
5/64	.078125	.24545	.00479	5	15.7080	19.635	68	213.63	3631.68
3/32	.09375	.29452	.00690	6	18.850	28.274	69	216.77	3739.28
7/64	.109375	.34363	.00939	7	21.991	38.485	70	219.91	3848.45
1/8	.125	.39270	.01227	8	25.133	50.266	71	223.05	3959.19
9/64	.140625	.44181	.01553	9	28.274	63.617	72	226.19	4071.50
5/32	.15625	.49087	.01917	10	31.416	78.540	73	229.34	4185.50
11/64	.171875	.53999	.02320	11	34.558	95.033	74	232.48	4300.84
3/16	.1875	.58.905	.02761	12	37.699	113.1	75	235.62	4417.86
13/64	.203125	.63817	.03241	13	40.841	132.73	76	238.76	4536.46
7/32	.21875	.68722	.03757	4	43.982	153.94	77	241.90	4656.63
15/64	.234375	.73635	.04314	15	47.124	176.71	78	245.04	4778.36
1/4	.25	.78540	.04909	16	50.265	201.06	79	248.19	4901.67
17/64	.265625	.83453	.05542	17	53.407	226.98	80	251.33	5026.55
9/32	.28125	.88357	.06213	18	56.549	254.47	81	254.47	5153.0
10/64	.296875	.93271	.06922	19	59.690	283.53	82	257.61	5281.02
5/16	.3125	.98175	.07670	20	63.832	314.16	83	260.75	5410.61
21/64	.328125	1.0309	.08456	21	65.973	346.36	84	263.89	5541.77
11/32	.34375	1.0799	.09281	22	69.115	380.13	85	267.04	5674.50
23/64	.35975	1.1291	.10144	23	72.257	415.48	86	270.18	5808.80
3/8	.375	1.1781	.11045	24	75.398	452.39	87	273.32	5944.68
25/64	.390625	1.2273	.11984	25	78.540	490.87	88	276.46	6082.12
13/32	.40625	1.2763	.12962	26	81.681	530.93	89	279.60	6221.14
27/64	.421875	1.3254	.13979	27	84.823	572.56	90	282.74	6361.71
7/16	.4375	1.3744	.15033	28	87.965	615.75	91	258.88	6503.88
29/64	.453125	1.4236	.16126	29	91.106	660.52	92	289.03	6647.61
15/32	.46875	1.4726	.17257	30	94.248	706.86	93	292.17	6792.91
31/64	.484375	1.5218	.18427	31	97.389	754.77	94	295.31	6939.78
1/2	.5	1.5708	.19635	32	100.53	804.25	95	298.45	7088.22

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17.14.0 Circumferences and Areas of Circles—Continued

Fract.	Decimal	Of One Inch			Of Inches or Feet				
		Circ.	Area	Dia.	Circ.	Area	Dia.	Circ.	Area
33/64	.515625	1.6199	.20880	33	103.67	855.30	96	301.59	7238.23
17/32	.53125	1.6690	.22166	34	106.81	907.92	97	304.73	7339.81
35/64	.546875	1.7181	.23489	35	109.96	962.11	98	307.88	7542.96
9/16	.5625	1.7671	.24850	36	113.10	1017.88	99	311.02	7697.69
37/64	.578125	1.8163	.26248	37	116.24	1075.21	100	314.16	7853.98
19/32	.59375	1.8653	.27688	38	119.38	1134.11	101	317.30	8011.85
30/64	.609375	1.9145	.29164	39	122.52	1194.59	102	320.44	8171.28
5/8	.625	1.9635	.30680	40	125.66	1256.64	103	323.58	8332.29
41/64	.640625	2.0127	.32232	41	128.81	1320.25	104	326.73	8494.87
21/32	.65625	2.0617	.33824	42	131.95	1385.44	105	327.87	8659.01
43/64	.671875	2.1108	.35453	43	135.09	1452.20	106	333.01	8824.73
11/16	.6875	2.1598	.37122	44	138.23	1520.53	107	336.15	1992.02
45/64	.703125	2.2090	.38828	45	141.37	1590.43	108	339.29	9160.88
23/32	.71875	2.2580	.40574	46	144.51	1661.90	109	342.43	9331.32
47/64	.734375	2.3072	.42356	47	147.65	1734.94	110	345.58	9503.32
3/4	.75	2.3562	.44179	48	150.80	1809.56	111	348.72	9676.89
49/64	.765625	2.4050	.45253	49	153.94	1885.74	112	351.86	9853.03
23/32	.78125	2.4544	.47937	50	157.08	1963.50	113	355.0	10028.75
51/64	.796875	2.5036	.49872	51	160.22	2042.82	114	358.14	10207.03
13/16	.8125	2.5525	.51849	52	163.36	2123.72	115	361.28	10386.89
53/64	.828125	2.6017	.53862	53	166.50	2206.18	116	364.42	10568.32
27/32	.84375	2.6507	.55914	54	169.65	2290.22	117	367.57	10751.32
55/64	.859375	2.6999	.58003	55	172.79	2375.83	118	370.71	10935.88
7/8	.875	2.7489	.60123	56	175.93	2463.01	119	373.85	11122.02
57/64	.890625	2.7981	.62298	57	179.07	2551.76	120	376.99	11309 '3
29/32	.90625	2.8471	.64504	58	182.21	2642.08	121	380.13	11499 01
59/64	.921875	2.8963	.66746	59	185.35	2733.97	122	383.27	11689.07
15/16	.9375	2.9452	.69029	60	188.50	2827.43	123	386.42	11882.29
61/64	.953125	2.9945	.71349	61	191.64	2922.47	124	389.56	12076.28
31/32	.96875	3.0434	.73708	62	194.78	3019.07	125	392.70	12271.85
63/64	.984375	3.0928	.76097	63	197.92	3117.25	126	395.84	12468.98

(By permission of Cast Iron Soil Pipe Institute.)

17.15.0 Tap Drill Sizes for Fractional Size Threads

Approximately 65% Depth Thread / AMERICAN NATIONAL THREAD FORM

Tap Size	Threads per Inch	Hole Diameter	Drill	Tap Size	Threads per Inch	Hole Diameter	Drill
1/16	72	.049	3/64	1/2	20	.451	29/64
1/16	64	.047	3/64	1/2	13	.425	27/64
1/16	60	.046	56	1/2	12	.419	27/64
5/64	72	.065	52	9/16	27	.526	17/32
5/64	64	.063	1/16	9/16	18	.508	33/64
5/64	60	.062	1/16	9/16	12	.481	31/64
5/64	56	.061	53	5/8	27	.589	19/32
3/32	60	.077	5/64	5/8	18	.571	37/64
3/32	56	.076	48	5/8	12	.544	35/64
3/32	50	.074	49	5/8	11	.536	17/32
3/32	48	.073	49	11/16	16	.627	5/8
7/64	56	.092	42	11/16	11	.599	19/32
7/64	50	.090	43	3/4	27	.714	23/32
7/64	48	.089	43	3/4	16	.689	11/16
1/8	48	.105	36	3/4	12	.669	43/64
1/8	40	.101	38	3/4	10	.653	21/32
1/8	36	.098	40	13/16	12	.731	47/64
1/8	32	.095	3/32	13/16	10	.715	23/32
9/64	40	.116	32	7/8	27	.839	27/32
9/64	36	.114	33	7/8	18	.821	53/64
9/64	32	.110	35	7/8	14	.805	13/16
5/32	40	.132	30	7/8	12	.794	51/64
5/32	36	.129	30	7/8	9	.767	49/64
5/32	32	.126	1/8	15/16	12	.856	55/64
11/64	36	.145	27	15/16	9	.829	53/64
11/64	32	.141	9/64	1	27	.964	31/32
3/16	36	.161	20	1	14	.930	15/16
3/16	32	.157	22	1	12	.919	59/64
3/16	30	.155	23	1	8	.878	7/8
3/16	24	.147	26	1 1/16	8	.941	15/16
13/64	32	.173	17	1 1/8	12	1.044	1 3/64
13/64	30	.171	11/64	1 1/8	7	.986	63/64
13/64	24	.163	20	1 3/16	7	1.048	1 3/64
7/32	32	.188	12	1 1/4	12	1.169	1 11/64
7/32	28	.184	13	1 1/4	7	1.111	1 7/64
7/32	24	.178	16	1 5/16	7	1.173	1 11/64
15/64	32	.204	6	1 3/8	12	1.294	1 19/64
15/64	28	.200	8	1 3/8	6	1.213	1 7/32
15/64	24	.194	10	1 1/2	12	1.419	1 27/64
1/4	32	.220	7/32	1 1/2	6	1.338	1 11/32
1/4	28	.215	3	1 5/8	5 1/2	1.448	1 29/64
1/4	27	.214	3	1 3/4	5	1.555	1 9/16
1/4	24	.209	4	1 7/8	5	1.680	1 11/16
1/4	20	.201	7	2	4 1/2	1.783	1 25/32
5/16	32	.282	9/32	2 1/8	4 1/2	1.909	1 29/32
5/16	27	.276	J	2 1/4	4 1/2	2.034	2 1/32
5/16	24	.272	I	2 3/8	4	2.131	2 1/8
5/16	20	.264	17/64	2 1/2	4	2.256	2 1/4
5/16	18	.258	F	2 5/8	4	2.381	2 3/8
3/8	27	.339	R	2 3/4	4	2.506	2 1/2
3/8	24	.334	Q	2 7/8	3 1/2	2.597	2 19/32
3/8	20	.326	21/64	3	3 1/2	2.722	2 23/32
3/8	16	.314	5/16	3 1/8	3 1/2	2.847	2 27/32
7/16	27	.401	Y	3 1/4	3 1/2	2.972	2 31/32
7/16	24	.397	X	3 3/8	3 1/4	3.075	3 1/16
7/16	20	.389	25/64	3 1/2	3 1/4	3.200	3 3/16
7/16	14	.368	U	3 5/8	3 1/4	3.325	3 5/16
1/2	27	.464	15/32	3 3/4	3	3.425	3 7/16
1/2	24	.460	29/64	4	3	3.675	3 11/16

17.16.0 Common Material R-Values

R-value is a unit of measure for the rate of heat flow through a given thickness material(s) by conduction. It can include a cavity that incorporates air space reflective insulation. It is measured by the temperature difference between outside surfaces required to cause one **BTU** to flow through one square hour. A **BTU**, (British Thermal Unit), is the amount of heat required to raise temperature of one pound of water 1°F.

MATERIAL	R-value	MATERIAL	R-value	MATERIAL	R-value
1" mineral wool	3.70	3½" fiberglass	13.48	3" honeycomb	2.59
1/2" gypsum	0.45	½" mineral tile	1.19	3" isocyanurate	22.5
1/2" plywood	0.02	1" isocyanurate	7.50	3" polystyrene	12.0
1/8" floor tile	0.05	1" polystyrene	4.00	3" polyurethane	17.6
1/8" hardboard	0.09	1" wood core door	1.96	8" con. block	1.11
3/16" hardboard	0.14	6" fiberglass	19.00	insulated glass	1.65
5/8" gypsum	0.56	1" polyurethane	5.88	single glass pane	0.94

17.17.0 Conversion Factors—Power, Pressure, Energy

Power		
Multiply	By	To Get
Boiler hp	33.472	Btu/hr
		lbs H ₂ O evap. at 212°F
Boiler hp	34.5	Btu/hr
Horsepower	2.540	Btu/hr
Horsepower	550	ft-lb/sec
Horsepower	33.000	ft-lb/min
Horsepower	42.42	Btu/min
Horsepower	0.7457	Kilowatts
Kilowatts	3.415	Btu/hr
Kilowatts	56.92	Btu/min
Watts	44.26	ft-lb/min
Watts	0.7378	ft-lb/sec
Watts	0.05692	Btu/min
Tons refriger.	12.000	Btu/hr
Tons refriger.	200	Btu/min
Btu/hr	0.0002986	Boiler hp
lb H ₂ O evap. at 212°F	0.0290	Boiler hp
Btu/hr	0.000393	Horsepower
ft-lb/sec	0.00182	Horsepower
ft-lb/min	0.0000303	Horsepower
Btu/min	0.0236	Horsepower
Kilowatts	1.341	Horsepower
Btu/hr	0.000293	Kilowatts
Btu/min	0.01757	Kilowatts
ft-lb/min	0.02259	Watts
ft-lb/sec	1.355	Watts
Btu/min	1.757	Watts
Btu/hr	0.0000633	Tons refriger.
Btu/min	0.005	Tons refriger.

Energy		
Multiply	By	To Get
Btu	778	ft-lb
Btu	0.000393	hp-hr
Btu	0.000293	kw-hr
		(lbs H ₂ O evap. at 212°F)
Btu	0.0010307	Watt-hr
Btu	0.293	Watt-hr
ft-lb	0.3765	Watt-hr
Latent heat) of ice	143.33	Btu/lb H ₂ O
lb H ₂ O evap.) at 212°F	0.284	kw-hr
lb H ₂ O evap.) at 212°F	0.381	hp-hr
ft-lb	0.001287	Btu
hp-hr	2.540	Btu
kw-hr	3.415	Btu
lb H ₂ O evap.) at 212°F	970.4	Btu
Watt-hr	3.415	Btu
Watt-hr	2.656	ft-lb
		(Latent heat of ice)
Btu/lb H ₂ O	0.006977	(lb H ₂ O evap. at 212°F)
kw-hr	3.52	(lb H ₂ O evap. at 212°F)
hp-hr	2.63	(lb H ₂ O evap. at 212°F)

Pressure		
Multiply	By	To Get
atmospheres	29.92	(in Mercury at 62°F)
atmospheres	406.8	(in H ₂ O at 62°F)
atmospheres	33.90	(ft. H ₂ O at 62°F)
atmospheres	14.70	lb/in ²
atmospheres	1.058	ton/ft ²
in. H ₂ O) (at 62°F)	0.0737	(in. Mercury at 62°F)
ft H ₂ O) (at 62°F)	0.881	(in. Mercury at 62°F)
ft H ₂ O) (at 62°F)	0.4335	lb/in ²
ft H ₂ O) (at 62°F)	62.37	lb/ft ²
in. Mercury) (at 62°F)	70.73	lb/ft ²
in. Mercury) (at 62°F)	0.4912	lb/in ²
in. Mercury) (at 62°F)	0.03342	atmospheres
in. H ₂ O) (at 62°F)	0.002458	atmospheres
ft. H ₂ O) (at 62°F)	0.0295	atmospheres
lb/in ²	0.0680	atmospheres
ton/ft ²	0.945	atmospheres
in. Mercury) (at 62°F)	13.57	(in. H ₂ O at 62°F)
in. Mercury) (at 62°F)	1.131	(ft H ₂ O at 62°F)
lb/in ²	2.309	(ft H ₂ O at 62°F)
lb/ft ²	0.01603	(ft H ₂ O at 62°F)
lb/ft ²	0.014138	(in. Mercury at 62°F)
lb/in ²	2.042	(in. Mercury at 62°F)
lb/in ²	0.0689	Bar
lb/in ²	0.0703	kg/cm ²

Velocity of Flow		
Multiply	By	To Get
ft/min	0.01139	miles/hr
ft/min	0.01667	ft/sec
cu ft/min	0.1247	gal/sec
cu ft/sec	448.8	gal/min
miles/hr	88	ft/min
ft/sec	60	ft/min
gal/sec	8.02	cu ft/min
gal/min	0.002228	cu ft/sec

Heat Transmission		
Multiply	By	To Get
Btu/in)		(Btu/ft
/sq ft	0.0833	/sq ft
/hr/°F		/hr/°F
Btu/ft)		(Btu/in
/sq ft	12	/sq ft
/hr /°F		/hr/ °F

Weight		
Multiply	By	To Get
lb	7.000	grains
lb H ₂ O (60°F)	0.01602	cu ft H ₂ O (60°F)
lb H ₂ O (60°F)	0.1198	gal H ₂ O (60°F)
tons (long)	2.240	lb
tons (short)	2.000	lb
grains	0.000143	lb
cu ft H ₂ O	62.37	lb H ₂ O (60°F)
gal H ₂ O	8.3453	lb H ₂ O (60°F)
lb	0.000446	tons (long)
lb	0.000500	tons (short)

Circular Measure		
Multiply	By	To Get
Degrees	0.01745	Radians
Minutes	0.00029	Radians
Diameter	3.142	Circumference
Radians	57.3	Degrees
Radians	3.438	Minutes
Circumference	0.3183	Diameter

Volume		
Multiply	By	To Get
Barrels (oil)	42	gal (oil)
cu ft	1.726	cu in
cu ft	7.48	gal
cu in	0.00433	gal
gal (oil)	0.0238	barrels (oil)
cu in	0.000579	cu ft
gal	0.1337	cu ft
gal	231	cu in

Temperature	
F =	(°C x 1.8) + 32
C =	(°F - 32) + 1.8

Fractions and Decimals		
Multiply	By	To Get
Sixty-fourths	0.015625	Decimal
Thirty-seconds	0.03125	Decimal
Sixteenths	0.0625	Decimal
Eighths	0.125	Decimal
Fourths	0.250	Decimal
Halves	0.500	Decimal
Decimal	64	Sixty-fourths
Decimal	32	Thirty-seconds
Decimal	16	Sixteenths
Decimal	8	Eighths
Decimal	4	Fourths
Decimal	2	Halves

Gallons shown are U.S. standard.

17.18.0 Useful Engineering Tables—Schedule 40 Pipe Dimensions, Diameter of Circles, and Drill Sizes

Schedule 40 Pipe, Standard Dimensions

Size (in)	Diameters			Circumference		Transverse Areas			Length of Pipe per sq ft		Length of Pipe Containing One Cubic Foot	Nominal Weight per foot		Number Threads per inch of Screw
	External (in)	Approximate Internal (in)	Nominal Thickness (in)	External (in)	Internal (in)	External (sq in)	Internal (sq in)	Metal (sq in)	External Surface	Internal Surface		Plain Ends	Threaded and Coupled	
									Feet	Feet	Feet			
1/4	0.540	0.364	0.088	1.696	1.114	0.229	0.104	0.125	7.073	10.493	1383.789	0.424	0.425	18
1/4	0.675	0.493	0.091	2.121	1.549	0.358	0.191	0.167	5.658	7.747	754.360	0.567	0.568	18
1/2	0.640	0.622	0.109	2.639	1.954	0.554	0.304	0.250	4.547	6.141	473.906	0.850	0.852	14
3/4	1.050	0.824	0.113	3.299	2.589	0.866	0.533	0.333	3.637	4.635	270.034	1.130	1.134	14
1	1.315	1.049	0.133	4.131	3.296	1.358	0.864	0.494	2.904	3.641	166.618	1.678	1.684	11 1/2
1 1/4	1.660	1.380	0.140	5.215	4.335	2.164	1.495	0.669	2.301	2.767	96.275	2.272	2.281	11 1/2
1 1/2	1.900	1.610	0.145	5.969	5.058	2.835	2.036	0.799	2.010	2.372	70.733	2.717	2.731	11 1/2
2	2.375	2.067	0.154	7.461	6.494	4.430	3.355	1.075	1.608	1.847	42.913	3.652	3.678	11 1/2
2 1/2	2.675	2.469	0.203	9.032	7.757	6.492	4.788	1.704	1.328	1.547	30.077	5.793	5.819	8
3	3.500	3.068	0.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	19.479	7.575	7.576	8
3 1/2	4.000	3.548	0.226	12.566	11.146	12.566	9.886	2.680	0.954	1.076	14.565	9.109	9.202	8
4	4.500	4.026	0.237	14.137	12.648	15.904	12.730	3.174	0.848	0.948	11.312	10.790	10.899	8
5	5.563	5.047	0.258	17.477	15.856	24.306	20.006	4.300	0.686	0.756	7.198	14.617	14.810	8
6	6.625	6.065	0.280	20.813	19.054	34.472	28.891	5.581	0.576	0.629	4.984	18.974	19.185	8
8	8.625	7.981	0.322	27.096	25.073	58.426	50.027	8.399	0.442	0.478	2.878	28.554	28.809	8
10	10.750	10.020	0.365	33.772	31.479	90.763	78.855	11.908	0.355	0.381	1.826	40.483	41.132	8
12	12.750	11.938	0.406	40.055	37.699	127.640	111.900	15.740	0.299	0.318	1.288	53.600	—	—
14	14.000	13.125	0.437	43.982	41.217	153.940	135.300	18.640	0.272	0.280	1.069	63.000	—	—
16	16.000	15.000	0.500	50.265	47.123	201.050	176.700	24.350	0.238	0.254	0.817	78.000	—	—
18	18.000	16.874	0.563	56.548	52.998	254.850	224.000	30.850	0.212	0.226	0.643	105.000	—	—
20	20.000	18.814	0.593	62.831	59.093	314.150	278.000	36.150	0.191	0.203	0.519	123.000	—	—
24	24.000	22.626	0.687	75.398	71.063	452.400	402.100	50.300	0.159	0.169	0.358	171.000	—	—

Equivalent Length of Pipe to be Added for Fittings—Schedule 40 Pipe

Pipe Size (in)	Length in Feet to be Added Run				
	Standard Elbow	Side Outlet Tee	Gate Valve*	Globe Valve*	Angle Valve*
1/2	1.3	3	0.3	14	7
3/4	1.8	4	0.4	18	10
1	2.2	5	0.5	23	12
1 1/4	3.0	6	0.6	29	15
1 1/2	3.5	7	0.8	34	16
2	4.3	8	1.0	46	22
2 1/2	5.0	11	1.1	54	27
3	6.5	13	1.4	66	34
3 1/2	8.0	15	1.6	80	40
4	9.0	18	1.9	92	45
5	11.0	22	2.2	112	56
6	13.0	27	2.8	136	67
8	17.0	35	3.7	180	92
10	21.0	45	4.6	230	112
12	27.0	53	5.5	270	132

Thermal Expansion of Pipe

*From Piping Handbook, by Walker and Crocker, by special permission.

This table gives the expansion from -20°F to temperature in question. To obtain the amount of expansion between any two temperatures take the difference between the figures in the table for those temperatures. For example, if cast iron pipe is installed at a temperature of 80°F and is operated at 240°F , the expansion would be $1.780 - 0.649 = 1.131$ in.

*Valve in full open position

Temp (°F)	Elongation in Inches per 100 Ft from -20°F Up			
	Cast Iron Pipe	Steel Pipe	Wrought Iron Pipe	Copper Pipe
-20	0.000	0.000	0.000	0.000
0	0.127	0.145	0.152	0.204
20	0.255	0.293	0.306	0.442
40	0.390	0.430	0.465	0.655
60	0.518	0.593	0.620	0.888
80	0.649	0.725	0.780	1.100
100	0.787	0.898	0.939	1.338
120	0.926	1.055	1.110	1.570
140	1.051	1.209	1.265	1.794
160	1.200	1.368	1.427	2.008
180	1.345	1.526	1.597	2.255
200	1.495	1.691	1.778	2.500
240	1.780	2.020	2.110	2.960
280	2.085	2.350	2.465	3.422
320	2.395	2.690	2.800	3.900
360	2.700	3.029	3.175	4.380
400	3.008	3.375	3.521	4.870
500	3.847	4.296	4.477	6.110
600	4.725	5.247	5.455	7.388

Diameters and Areas of Circles and Drill Sizes

Drill Size	Dia.	Area	Drill Size	Dia.	Area	Drill Size	Dia.	Area	Drill Size	Dia.	Area
3/64	.0469	.00173	27	.1440	.01629	C	.2420	.04600	27/64	.4219	.13920
55	.0520	.00212	26	.1470	.01697	D	.2460	.04753	7/16	.4375	.15033
54	.0550	.00238	25	.1495	.01705	1/4	.2500	.04909	29/64	.4531	.16117
53	.0595	.00278	24	.1520	.01815	E	.2500	.04909	15/32	.4688	.17257
1/16	.0625	.00307	23	.1540	.01863	F	.2570	.05187	31/64	.4844	.18398
52	.0635	.00317	5/32	.1562	.01917	G	.2610	.05350	1/2	.5000	.19635
51	.0670	.00353	22	.1570	.01936	17/64	.2656	.05515	33/64	.5156	.20831
50	.0700	.00385	21	.1590	.01986	H	.2660	.05557	17/32	.5313	.22166
49	.0730	.00419	20	.1610	.02036	I	.2720	.05811	9/16	.5625	.24850
48	.0760	.00454	19	.1660	.02164	J	.2770	.06026	19/32	.5937	.27688
5/64	.0781	.00479	18	.1695	.02256	K	.2810	.06202	5/8	.6250	.30680
47	.0785	.00484	11/64	.1719	.02320	9/32	.2812	.06213	21/32	.6562	.33824
46	.0810	.00515	17	.1730	.02351	L	.2900	.06605	11/16	.6875	.37122
45	.0820	.00528	16	.1770	.02461	M	.2950	.06835	23/32	.7187	.40574
44	.0860	.00581	15	.1800	.02545	19/64	.2969	.06881	3/4	.7500	.44179
43	.0890	.00622	14	.1820	.02602	N	.3020	.07163	25/32	.7812	.47937
42	.0935	.00687	13	.1850	.02688	5/16	.3125	.07670	13/16	.8125	.51849
3/32	.0938	.00690	3/16	.1875	.02761	O	.3160	.07843	27/32	.8437	.55914
41	.0960	.00724	12	.1890	.02806	P	.3230	.08194	7/8	.8750	.60132
40	.0980	.00754	11	.1910	.02865	21/64	.3281	.08449	29/32	.9062	.64504
39	.0995	.00778	10	.1935	.02941	Q	.3320	.08657	15/16	.9375	.69029
38	.1015	.00809	9	.1960	.03017	R	.3390	.09026	31/32	.9687	.73708
37	.1040	.00850	8	.1990	.03110	11/32	.3438	.09281	1	1.0000	.78540
36	.1065	.00891	7	.2010	.03173	S	.3480	.09511	1-1/16	1.0625	.86664
7/64	.1094	.00940	13/64	.2031	.03241	T	.3580	.10066	1-1/8	1.1250	.99402
35	.1100	.00950	6	.2040	.03268	23/64	.3594	.10122	1-3/16	1.1875	1.1075
34	.1110	.00968	5	.2055	.03317	U	.3680	.10636	1-1/4	1.2500	1.2272
33	.1130	.01003	4	.2090	.03431	3/8	.3750	.11045	1-5/16	1.3125	1.3530
32	.1160	.01039	3	.2130	.03563	V	.3770	.11163	1-3/8	1.3750	1.4859
31	.1200	.01131	7/32	.2188	.03758	W	.3860	.11702	1-7/16	1.4375	1.6230
1/8	.1250	.01227	2	.2210	.03836	25/64	.3906	.11946	1-1/2	1.5000	1.7671
30	.1285	.01242	1	.2280	.04083	X	.3970	.12379	1-5/8	1.6250	2.0739
29	.1360	.01453	A	.2340	.04301	Y	.4040	.12819	1-3/4	1.7500	2.4053
28	.1405	.01550	15/64	.2344	.04314	13/32	.4062	.12962	1-7/8	1.8750	2.7612
9/64	.1406	.01553	8	.2380	.0449	Z	.4130	.13396	2	2.0000	3.1416

17.19.0 Thermal Expansion of Various Materials

Material	Inches per inch 10 ⁶ X per °F	Inches per 100' of pipe per 100°F.	Ratio-assuming cast iron equals 1.00
Cast iron	6.2	0.745	1.00
Concrete	5.5	0.66	.89
Steel (mild)	6.5	0.780	1.05
Steel (stainless)	7.8	0.940	1.26
Copper	9.2	1.11	1.49
PVC (high impact)	55.6	6.68	8.95
ABS (type 1A)	56.2	6.75	9.05
Polyethylene (type 1)	94.5	11.4	15.30
Polyethylene (type 2)	83.3	10.0	13.40

Here is the *actual* increase in length for 50 feet of pipe and 70° temperature rise.

Cast Iron			.261	
Concrete	↑	Building Materials	.231	
Mild Steel			2.73	
Copper	↑	Other Materials	.388	
PVC (high Impact)			Plastics	2.338
ABS (type 1A)				2.362
Polyethylene (type 1)				3.990
Polyethylene (type 2)				3.500

17.20.0 Miscellaneous Tables of Weights, Measures, and Other Information

Square Measure

144 inches	1 square foot
9 square feet.....	1 square yard
30¼ sq. yds. 272¼ sq. ft.	1 square rod
160 square rods.....	1 acre
640 acres.....	1 square mile

Cubic Measure

1728 cubic inches.....	1 cubic foot
1 cubic foot.....	7.4805 gallons
27 cubic feet.....	1 cubic yard
128 cubic feet.....	1 cord

Dry Measure

2 pints.....	1 quart
8 quarts	1 peck
4 pecks	1 bushel
1 bushel	1.24 cu. feet
1 bushel	2150.42 cu inches

Liquid Measure

4 gills	1 pint
2 pints.....	1 quart
4 quarts.....	1 gallon
31½ gallons.....	1 barrel
2 barrels.....	1 hogshead

Linear Measure

12 inches.....	1 foot
3 feet	1 yard
16½ feet.....	1 rod or pole
5½ yards.....	1 rod or pole
40 rods or poles.....	1 furlong
8 furlongs.....	1 statute mile
320 rods.....	1 mile
5280 feet	1 mile
4 inches.....	1 hand
7.92 inches	1 link
18 inches	1 cubit
1.15156 miles	1 knot or 1 nautical mile

Weight – Avoirdupois or Commercial

437.5 grains	1 ounce
16 ounces	1 pound
112 pounds	1 hundredweight
2000 pounds.....	1 net ton or 1 short ton
20 hundredweight.....	1 gross or long ton
20 hundredweight	2240 pounds
2204.6 pounds.....	1 metric ton