List Of Abbreviations

Abbreviations conform to the practice of the American Standard Abbreviations for Scientific and Engineering Terms, ASA Z10.1

abs ..... Absolute
AGA ..... American Gas Association
AISI ..... American Iron and Steel Institute
Amer Std ..... American Standard
API ..... American Petroleum Institute
ASA ..... American Standards Association
Ashve ..... American Society of Heating and Ventilation Engineers
ASME ..... American Society of Mechanical Engineers
ASTM ..... American Society for Testing Materials
AWWA ..... American Water Works Association
B & S ..... Bell and spigiot or Brown & Sharpe (gauge)
bbl ..... Barrel
Btu ..... British thermal unit(s)
C ..... Centigrade
cfm ..... Cubic feet per minute
cfs ..... Cubic feet per second
CI ..... Cast iron
CS ..... Cast steel
Comp ..... Companion
C to F ..... Center to face
°C ..... Degrees Centigrade
°F ..... Degrees Fahrenheit
diam ..... Diameter
dwg ..... Drawing
ex-hy ..... Extra-heavy
F & D ..... Faced and drilled
F ..... Fahrenheit
F to F ..... Face to face
flg ..... Flange or flanges
flgd ..... Flanged
g ..... Gage or gauge

hex ..... Hexagonal
hg ..... mercury
IBBM ..... Iron body bronze (or brass) mounted
ID ..... Inside diameter
kw ..... Kilowatt(s)
MI ..... Malleable iron
max ..... Maximum
min ..... Minimum
mtd ..... Mounted
MSS ..... Manufactures Standardization Society (of Value and Fittings Industry)
NEWWA ..... New England Water Works Association
NPS ..... Nominal pipe size (formerly IPS for iron pipe size)
OD ..... Outside diameter
OS&Y ..... Outside screw and yoke
OWG ..... Oil, water, gas (see WOG)
psig ..... Pounds per square inch, gage
red ..... Reducing
sch or sched ..... Schedule
scd ..... Screwed
SF ..... Semifinished
Spec ..... Specification
SSP ..... Steam service pressure
SSU ..... Seconds Saybolt Universal
Std ..... Standard
Trans ..... Transactions
WOG ..... Water, oil, gas (see OWG)
WWP ..... Working water pressure
XS ..... Extra strong
XXS ..... Double extra strong

Decimal Equivalents Of Fractions

1/64	0.015625	33/64	0.515625
1/32	0.03125	17/32	0.53125
3/64	0.046875	35/64	0.546875
1/16	0.0625	9/16	0.5625
5/64	0.078125	37/64	0.578125
3/32	0.09375	19/32	0.59375
7/64	0.109375	39/64	0.609375
1/8	0.125	5/8	0.625
9/64	0.140625	41/64	0.640625
5/32	0.15625	21/32	0.65625
11/64	0.171875	43/64	0.671875
3/16	0.1875	11/16	0.6875
13/64	0.203125	45/64	0.703125
7/32	0.21875	23/32	0.71875
15/64	0.234375	47/64	0.734375
1/4	0.25	3/4	0.75
17/64	0.265625	49/64	0.765625
9/32	0.28125	25/32	0.78125
19/64	0.296875	51/64	0.796875
5/16	0.3125	13/16	0.8125
21/64	0.328125	53/64	0.828125
11/32	0.34375	27/32	0.84375
23/64	0.359375	55/64	0.859375
3/8	0.375	7/8	0.875
25/64	0.390625	57/64	0.890625
13/32	0.40625	29/32	0.90625
27/64	0.421875	59/64	0.921875
7/16	0.4375	15/16	0.9375
29/64	0.453125	61/64	0.953125
15/32	0.46875	31/32	0.96875
31/64	0.484375	63/64	0.984375
1/2	0.5	1	1

Decimal Degree Equivalents Of Minutes

Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.
1	0.0167	16	0.2667	31	0.5167	46	0.7667
2	0.0333	17	0.2833	32	0.5333	47	0.7833
3	0.0500	18	0.3000	33	0.5500	48	0.8000
4	0.0667	19	0.3167	34	0.5667	49	0.8167
5	0.0833	20	0.3333	35	0.5833	50	0.8333
6	0.1000	21	0.3500	36	0.6000	51	0.8500
7	0.1167	22	0.3667	37	0.6167	52	0.8667
8	0.1333	23	0.3833	38	0.6333	53	0.8833
9	0.1500	24	0.4000	39	0.6500	54	0.9000
10	0.1667	25	0.4167	40	0.6667	55	0.9167
11	0.1833	26	0.4333	41	0.6833	56	0.9333
12	0.2000	27	0.4500	42	0.7000	57	0.9500
13	0.2167	28	0.4667	43	0.7167	58	0.9667
14	0.2333	29	0.4833	44	0.7333	59	0.9833
15	0.2500	30	0.5000	45	0.7500	60	1.0000

Decimal Equivalents Of Fractions

1/64	0.015625	33/64	0.515625
1/32	0.03125	17/32	0.53125
3/64	0.046875	35/64	0.546875
1/16	0.0625	9/16	0.5625
5/64	0.078125	37/64	0.578125
3/32	0.09375	19/32	0.59375
7/64	0.109375	39/64	0.609375
1/8	0.125	5/8	0.625
9/64	0.140625	41/64	0.640625
5/32	0.15625	21/32	0.65625
11/64	0.171875	43/64	0.671875
3/16	0.1875	11/16	0.6875
13/64	0.203125	45/64	0.703125
7/32	0.21875	23/32	0.71875
15/64	0.234375	47/64	0.734375
1/4	0.25	3/4	0.75
17/64	0.265625	49/64	0.765625
9/32	0.28125	25/32	0.78125
19/64	0.296875	51/64	0.796875
5/16	0.3125	13/16	0.8125
21/64	0.328125	53/64	0.828125
11/32	0.34375	27/32	0.84375
23/64	0.359375	55/64	0.859375
3/8	0.375	7/8	0.875
25/64	0.390625	57/64	0.890625
13/32	0.40625	29/32	0.90625
27/64	0.421875	59/64	0.921875
7/16	0.4375	15/16	0.9375
29/64	0.453125	61/64	0.953125
15/32	0.46875	31/32	0.96875
31/64	0.484375	63/64	0.984375
1/2	0.5	1	1

Decimal Degree Equivalents Of Minutes

Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.
1	0.0167	16	0.2667	31	0.5167	46	0.7667
2	0.0333	17	0.2833	32	0.5333	47	0.7833
3	0.0500	18	0.3000	33	0.5500	48	0.8000
4	0.0667	19	0.3167	34	0.5667	49	0.8167
5	0.0833	20	0.3333	35	0.5833	50	0.8333
6	0.1000	21	0.3500	36	0.6000	51	0.8500
7	0.1167	22	0.3667	37	0.6167	52	0.8667
8	0.1333	23	0.3833	38	0.6333	53	0.8833
9	0.1500	24	0.4000	39	0.6500	54	0.9000
10	0.1667	25	0.4167	40	0.6667	55	0.9167
11	0.1833	26	0.4333	41	0.6833	56	0.9333
12	0.2000	27	0.4500	42	0.7000	57	0.9500
13	0.2167	28	0.4667	43	0.7167	58	0.9667
14	0.2333	29	0.4833	44	0.7333	59	0.9833
15	0.2500	30	0.5000	45	0.7500	60	1.0000

Standard Pipe Data

Nom. Pipe Dia. Inches	Actual Inside Dia. Inches	Actual Outside Dia. Inches	Wt./Ft. Pounds	Length Containing One Cu. Ft. Feet	Gallons per Lineal Ft. Gallons
1/8	0.269	0.405	0.244	2,526.000	0.0030
1/4	0.364	0.540	0.424	1,383.800	0.0054
3/8	0.493	0.675	0.567	754.360	0.0099
1/2	0.622	0.840	0.850	473.910	0.0158
3/4	0.824	1.050	1.130	270.030	0.0277
1	1.049	1.315	1.678	166.620	0.0449
1 1/4	1.380	1.660	2.272	96.275	0.0777
1 1/2	1.610	1.900	2.717	70.733	0.1058
2	2.067	2.375	3.652	49.913	0.1743
2 1/2	2.469	2.875	5.793	30.077	0.2487
3	3.068	3.500	7.575	19.479	0.3840
3 1/2	3.548	4.000	9.109	14.565	0.5136
4	4.026	4.500	10.790	11.312	0.6613
4 1/2	4.560	5.000	12.538	9.030	0.8284
5	5.047	5.563	14.617	7.198	1.0393
6	6.065	6.625	18.974	4.984	1.5008
8	7.981	8.625	28.554	2.878	2.5988
10	10.020	10.750	40.483	1.826	4.0963

Barlow's Formula

Barlow's Formula is a safe, easy method for finding the relationship between internal fluid pressure and stress in the pipe wall. The formula predicts bursting pressures that have been found to be safely within the actual test bursting pressures.

It is interesting to note that the formula uses the "Outside Diameter" of pipe and is sometimes referred to as the "Outside Diameter Formula."

$$P = (2 \cdot t \cdot S) / D$$

Where:

P = internal units pressure, in psi
S = unit stress, in psi
D = outside diameter of pipe, in inches
t = wall thickness, in inches

Standard Pipe Data

Nom. Pipe Dia. Inches	Actual Inside Dia. Inches	Actual Outside Dia. Inches	Wt./Ft. Pounds	Length Containing One Cu. Ft. Feet	Gallons per Lineal Ft. Gallons
1/8	0.269	0.405	0.244	2,526.000	0.0030
1/4	0.364	0.540	0.424	1,383.800	0.0054
3/8	0.493	0.675	0.567	754.360	0.0099
1/2	0.622	0.840	0.850	473.910	0.0158
3/4	0.824	1.050	1.130	270.030	0.0277
1	1.049	1.315	1.678	166.620	0.0449
1 1/4	1.380	1.660	2.272	96.275	0.0777
1 1/2	1.610	1.900	2.717	70.733	0.1058
2	2.067	2.375	3.652	49.913	0.1743
2 1/2	2.469	2.875	5.793	30.077	0.2487
3	3.068	3.500	7.575	19.479	0.3840
3 1/2	3.548	4.000	9.109	14.565	0.5136
4	4.026	4.500	10.790	11.312	0.6613
4 1/2	4.560	5.000	12.538	9.030	0.8284
5	5.047	5.563	14.617	7.198	1.0393
6	6.065	6.625	18.974	4.984	1.5008
8	7.981	8.625	28.554	2.878	2.5988
10	10.020	10.750	40.483	1.826	4.0963

Barlow's Formula

Barlow's Formula is a safe, easy method for finding the relationship between internal fluid pressure and stress in the pipe wall. The formula predicts bursting pressures that have been found to be safely within the actual test bursting pressures.

It is interesting to note that the formula uses the "Outside Diameter" of pipe and is sometimes referred to as the "Outside Diameter Formula."

$$P = (2 \cdot t \cdot S) / D$$

Where:

P = internal units pressure, in psi
S = unit stress, in psi
D = outside diameter of pipe, in inches
t = wall thickness, in inches

Commercial Pipe Sizes and Wall Thicknesses

This table lists standard pipe sizes and wall thicknesses, or specifically:

1. Traditional standard weight, extra strong and durable extra strong pipe.
2. Pipe wall thickness in American Standard B36.10 for carbon steel.
3. Pipe wall thickness in ASTM Specification A409 and American Standard B36.19 and applicable only to corrosion resistant materials.

Note: All dimensions in inches and thicknesses are nominal or average wall thickness. Actual thickness may be as much as 12.5% under nominal due to mill tolerance.

Nom. Pipe Size	Outside Dia.	Nominal Wall Thickness For Sch 5S*	Sch 10S*	Sch 10	Sch 20	Sch 30	Sch Std.†
1/8	0.405	–	0.049	–	–	–	0.068
1/4	0.540	–	0.650	–	–	–	0.088
3/8	0.675	–	0.065	–	–	–	0.091
1/2	0.840	0.065	0.083	–	–	–	0.109
3/4	1.050	0.065	0.083	–	–	–	0.113
1	1.315	0.065	0.109	–	–	–	0.133
1 1/4	1.660	0.065	0.109	–	–	–	0.140
1 1/2	1.900	0.065	0.109	–	–	–	0.145
2	2.375	0.065	0.109	–	–	–	0.540
2 1/2	2.875	0.083	0.120	–	–	–	0.203
3	3.500	0.083	0.120	–	–	–	0.216
3 1/2	4.000	0.083	0.120	–	–	–	0.226
4	4.500	0.083	0.120	–	–	–	0.237
5	5.563	0.109	0.134	–	–	–	0.258
6	6.625	0.109	0.134	–	–	–	0.280
8	8.625	0.109	0.148	–	0.250	0.277	0.322
10	10.750	0.134	0.165	–	0.250	0.307	0.365
12	12.750	0.156	0.180	–	0.250	0.330	0.375
14 O.D.	14.000	0.156	0.188	0.250	0.312	0.375	0.375
16 O.D.	16.000	0.165	0.188	0.250	0.312	0.375	0.375
18 O.D.	18.000	0.165	0.188	0.250	0.312	0.438	0.375
20 O.D.	20.000	0.188	0.218	0.250	0.375	0.500	0.375
22 O.D.	22.000	0.188	0.218	0.250	0.375	0.500	0.375
24 O.D.	24.000	0.218	–	0.250	0.375	0.562	0.375
26 O.D.	26.000	–	–	0.312	0.500	–	0.375
28 O.D.	28.000	–	–	0.312	0.500	0.625	0.375
30 O.D.	30.000	0.250	0.312	0.312	0.500	0.625	0.375
32 O.D.	32.000	–	–	0.312	0.500	0.625	0.375
34 O.D.	34.000	–	–	0.312	0.500	0.625	0.375
36 O.D.	36.000	–	–	0.312	0.500	0.625	0.375
42 O.D.	42.000	–	–	–	0.375	–	–

Note: Thicknesses shown in light face for Schedule 60 and heavier pipe are not currently supplied by the mills unless a certain minimum tonnage is ordered.

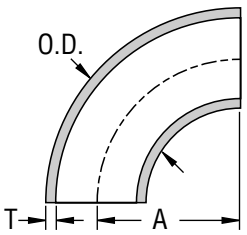
*Schedule 5S and 10S are available in corrosion resistant material and Schedule 10S is available in carbon steel in sizes up to 12"

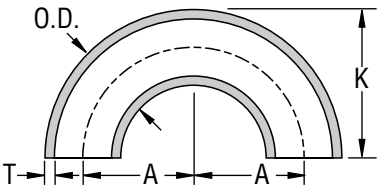
†Thickness shown in italics are available in stainless steel as Sch. 40S

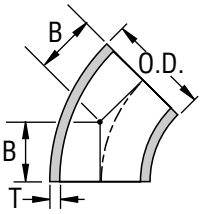
‡Thickness shown in italics are available in stainless stell as Sch. 80S

Nominal Wall Thickness For								
Sch 40	Sch 60	Extra Strong‡	Sch 80	Sch 100	Sch 120	Sch 140	Sch. 160	XX Strong
0.068	–	0.095	0.095	–	–	–	–	–
0.088	–	0.119	0.119	–	–	–	–	–
0.091	–	0.126	0.126	–	–	–	–	–
0.109	–	0.147	0.147	–	–	–	0.188	0.294
0.113	–	0.154	0.154	–	–	–	0.219	0.308
0.133	–	0.179	0.179	–	–	–	0.250	0.358
0.140	–	0.191	0.191	–	–	–	0.250	0.382
0.145	–	0.200	0.200	–	–	–	0.281	0.400
0.540	–	0.218	0.218	–	–	–	0.344	0.436
0.203	–	0.276	0.276	–	–	–	0.375	0.552
0.216	–	0.300	0.300	–	–	–	0.438	0.600
0.226	–	0.318	0.318	–	–	–	–	–
0.237	–	0.337	0.337	–	0.438	–	0.531	0.674
0.258	–	0.375	0.375	–	0.500	–	0.625	0.750
0.280	–	0.432	0.432	–	0.562	–	0.719	0.864
0.322	0.406	0.500	0.500	0.594	0.719	0.812	0.906	0.875
0.365	0.500	0.500	0.594	0.719	0.844	1.000	1.125	1.000
0.406	0.562	0.500	0.688	0.844	1.000	1.125	1.312	1.000
0.438	0.594	0.500	0.750	0.938	1.094	1.250	1.406	–
0.500	0.656	0.500	0.844	1.031	1.219	1.438	1.594	–
0.562	0.750	0.500	0.938	1.156	1.375	1.562	1.781	–
0.594	0.812	0.500	1.031	1.281	1.500	1.750	1.969	–
–	0.875	0.500	1.125	1.375	1.625	1.875	2.125	–
0.688	0.969	0.500	1.218	1.531	1.812	2.062	2.344	–
–	–	0.500	–	–	–	–	–	–
–	–	0.500	–	–	–	–	–	–
–	–	0.500	–	–	–	–	–	–
0.688	–	0.500	–	–	–	–	–	–
0.688	–	0.500	–	–	–	–	–	–
0.750	–	0.500	–	–	–	–	–	–
–	–	0.500	–	–	–	–	–	–

Weld Fitting ——90° Elbow, 180° Return, 45° Elbow

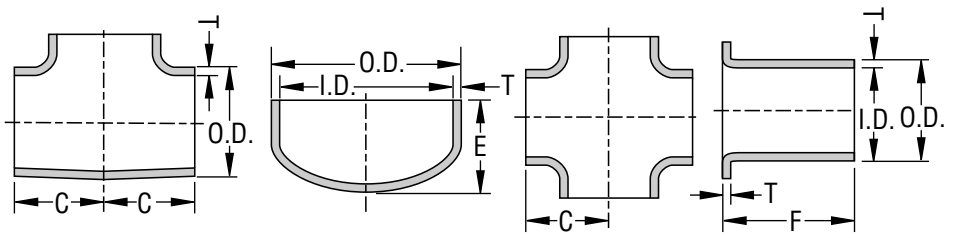






Nom. Pipe Size	90° Elbows Long R A	90° Elbows Short R A	180° Returns Long R K	180° Returns Short R K	45° Elbow B
½	1½	–	1⅞	–	⅝
¾	1⅛	–	1 11/16	–	7/16
1	1½	1	2 3/16	1⅝	⅞
1¼	1⅞	1¼	2¾	2 1/16	1
1½	1¼	1½	3¼	2 7/16	1⅛
2	3	2	4 3/16	3 3/16	1⅜
2½	3¾	2½	5 3/16	3 15/16	1¾
3	4½	3	6¼	4¾	2
3½	5¼	3½	7¼	5½	2¼
4	6	4	8¼	6¼	2½
5	7½	5	10 5/16	7¾	3⅛
6	9	6	12 5/16	9 5/16	3¾
8	12	8	16 5/16	12 5/16	5
10	15	10	20⅜	15⅜	6¼
12	18	12	24⅜	18⅜	7½
14	21	14	28	21	8¾
16	24	16	32	24	10
18	27	18	36	27	11¼
20	30	20	40	30	12½
22	33	–	44	–	13½
24	36	24	48	36	15
26	39	–	52	–	16
30	45	30	60	45	18½
34	51	–	–	–	21
36	54	36	–	54	22¼
42	63	48	–	–	26

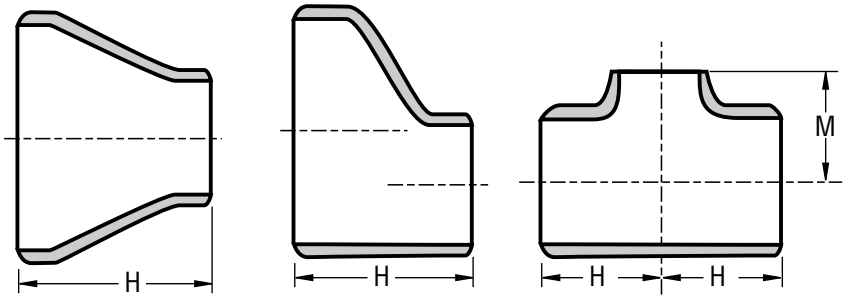
*Dimensions apply to STD and XS only.



NOM. PIPE SIZE	TEES C	CAPS E	CROSSES C	STUB ENDS F	STUB ENDS G
½	1	1	–	3	1⅜
¾	1⅛	1	–	3	1 11⁄16
1	1½	1½	–	4	2
1¼	1⅞	1½	1⅞	4	2½
1½	2¼	1½	2¼	4	2⅞
2	2½	1½*	2½	6	3⅝
2½	3	1½*	3	6	4¼
3	3⅜	2*	3⅜	6	5
3½	3¾	2½*	3¾	6	5½
4	4⅛	2½*	4⅛	6	6 3⁄16
5	4⅞	3*	4⅞	8	7 5⁄16
6	5⅝	3½*	5⅝	8	8½
8	7	4*	7	8	10⅝
10	8½	5*	8½	10	12¾
12	10	6*	10	10	15
14	11	6½*	11	12	16¼
16	12	7*	12	12	18½
18	13½	8*	13½	12	21
20	15	9*	15	12	23
22	16½	10	16½	–	–
24	17	10½	17	12	27¼
26	19½	10½	–	–	–
30	22	10½	–	–	–
34	25	10½	–	–	–
36	26½	10½	–	–	–
42	–	12	–	–	–

*Dimensions apply to STD and XS only.

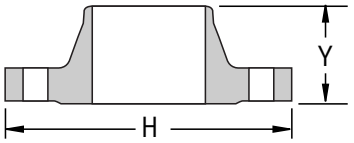
Weld Fitting —— Reducers and Reducing Outlet Tees



H: Concentric and Eccentric Reducers **C, M:** Reducing Outlet Tees

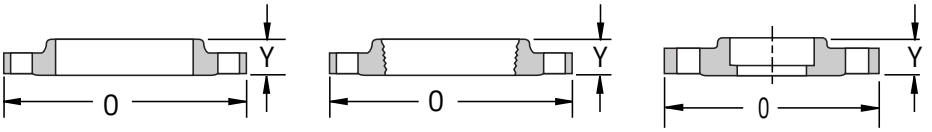
Nom. Pipe Size	H	C	M
½ X ¼	–	1	1
⅜			1
¾ X ⅜	1½	1⅛	1⅛
½			1⅛
1 X ⅜	2	1½	1½
½			1½
¾			1½
1¼ X ½	2	1⅞	1⅞
¾			1⅞
1			1⅞
1½ X ½	2½	2¼	2¼
¾			2¼
1			2¼
1¼			2¼
2 X ¾	3	2½	1¾
1			2
1¼			2¼
1½			2⅜
2½ X 1	3½	3	2¼
1¼			2½
1½			2⅝
2			2¾
3 X 1	–		2⅝
1¼	3½	3⅜	2¾
1½			2⅞
2			3
2½			3¼
3½ X 1¼	4	–	–
1½		3¾	3⅛
2			3¼
2½			3½
3			3⅝

Nom. Pipe Size	H	C	M
4 X 1½	4	4⅛	3⅜
2			3½
2½			3¾
3			3⅞
3½			4
5 X 2	5	4⅞	4⅛
2½			4¼
3			4⅜
3½			4½
4			4⅝
6 X 2½	5½	5⅝	4¾
3			4⅞
3½			5
4			5⅛
5			5⅜
8 X 3	–	7	6
3½	6		6
4			6⅛
5			6⅜
6			6⅝
10 X 4	7	8½	7¼
5			7½
6			7⅝
8			8
12 X 5	8	10	8½
6			8⅝
8			9
10			9½
14 X 6	13	11	9⅜
8			9¼
10			10⅛
12			10⅝



NOM. PIPE SIZE	150 LB. O	150 LB. Y(1)	300 LB. O	300 LB. Y(1)	400 LB. O	400 LB. Y(2)	600 LB. O	600 LB. Y(2)
½	3½	1⅞	3¾	2 1/16	For		3¾	2 1/16
¾	3⅞	2 1/16	4⅝	2¼	sizes		4⅝	2¼
1	4¼	2 3/16	4⅞	2 7/16	3½		4⅞	2 7/16
1¼	4⅝	2¼	5¼	2 9/16	and		5¼	2⅝
1½	5	2 7/16	6⅛	2 11/16	smaller		6⅛	2¾
2	6	2½	6½	2¾	use		6½	2⅞
2½	7	2¾	7½	3	600 LB.		7½	3⅛
3	7½	2¾	8¼	3⅛	Standard		8¼	3¼
3½	8½	2 13/16	9	3 3/16			9	3⅜
4	9	3	10	3⅜	10	3½	10¾	4
5	10	3½	11	3⅞	11	4	13	4½
6	11	3½	12½	3⅞	12½	4 1/16	14	4⅝
8	13½	4	15	4⅜	15	4⅝	16½	5¼
10	16	4	17½	4⅝	17½	4⅞	20	6
12	19	4½	20½	5¼	20½	5⅜	22	6⅛
14	21	5	23	5⅝	23	5⅞	23¾	6½
16	23½	5	25½	5¾	25½	6	27	7
18	25	5½	28	6¼	28	6½	29¼	7¼
20	27½	5 11/16	30½	6⅜	30½	6⅝	32	7½
22	29½	5⅞	33	6½	33	6¾	34¼	7¾
24	32	6	36	6⅝	36	6⅞	37	8
26	34¼	5	38¼	7¼	38¼	7⅝	40	8¾
30	38¾	5⅛	43	8¼	43	8⅝	44½	9¾
34	43¾	5 5/16	47½	9⅛	47½	9½	49	10⅝
36	46	5⅜	50	9½	50	9⅞	51¾	11⅛
42	53	5⅝	57	10⅞	57	11⅜	58¾	12¾

(1) The 1/16" raised face **is** included in length thru Hub, "Y".
(2) The 1/16" raised face **is not** included in length thru Hub, "Y".



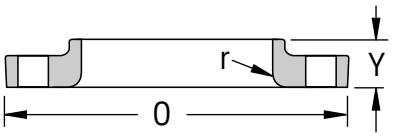
NOM. PIPE SIZE	150 LB. O	150 LB. Y(1)	300 LB. O	300 LB. Y(1)	400 LB. O	400 LB. Y(2)	600 LB. O	600 LB. Y(2)
½	3½	5/8	3¾	7/8	For	3¾	7/8	
¾	3 7/8	5/8	4 5/8	1	sizes	4 5/8	1	
1	4¼	1 1/16	4 7/8	1 1/16	3½	4 7/8	1 1/16	
1¼	4 5/8	1 3/16	5¼	1 1/16	and	5¼	1⅛	
1½	5	7/8	6⅛	1 3/16	smaller	6⅛	1¼	
2	6	1	6½	1 5/16	use	6½	1 7/16	
2½	7	1⅛	7½	1½	600 LB.	7½	1 5/8	
3	7½	1 3/16	8¼	1 11/16	Standard	8¼	1 13/16	
3½	8½	1¼	9	1¾			9	1 15/16
4	9	1 5/16	10	1 7/8	10	2†	10¾	2⅛†
5	10	1 7/16	11	2†	11	2⅛†	13	2⅜*
6	11	1 9/16	12½	2 1/16†	12½	2¼†	14	2 5/8†
8	13½	1¾	15	2 7/16†	15	2 11/16†	16½	3†
10	16	1 15/16	17½	2 5/8†	17½	2 7/8†	20	3⅜†
12	19	2 3/16	20½	2 7/8†	20½	3⅛†	22	3 5/8†
14	21	2¼	23	3†	23	3 5/16†	23¾	3 11/16†
16	23½	½	25½	3¼†	25½	3 11/16†	27	4 3/16†
18	25	2 11/16	28	3½†	28	3 7/8†	29¼	4 5/8†
20	27½	2 7/8	30½	3¾†	30½	4†	32	5†
22	29½	3⅛ *†	33	4*†	33	4¼*†	34¼	5¼*†
24	32	3¼	36	4 3/16†	36	4½†	37	5½†
26	34¼	3⅜*†	38¼	7¼*†	38¼	7 5/8*†	40	8¾*†
30	38¾	3½*†	43	8¼*†	43	8 5/8*†	44½	9¾*†
34	43¾	3 11/16*†	47½	9⅛*†	47½	9½*†	49	10 5/8*†
36	46	3¾*†	50	9½*†	50	9 7/8*†	51¾	11⅛*†
42	53	4*†	57	10 7/8*†	57	11 3/8*†	58¾	12¾*†

* Not available in Threaded type

† Not available in Socket type

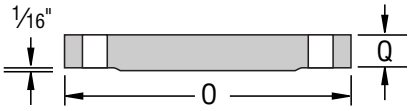
(1) The 1/16" raised face **is** included in length thru Hub, "Y".

(2) The 1/16" raised face **is not** included in length thru Hub, "Y".



NOM. PIPE SIZE	150 LB. O	150 LB. Y(1)	300 LB. O	300 LB. Y(1)	400 LB. O	400 LB. Y(2)	600 LB. O	600 LB. Y(2)
½	3½	5/8	3¾	7/8	For	3¾	7/8	
¾	3⅞	5/8	4⅝	1	sizes	4⅝	1	
1	4¼	1 1/16	4⅞	1 1/16	3½	4⅞	1 1/16	
1¼	4⅝	1 3/16	5¼	1 1/16	and	5¼	1⅛	
1½	5	7/8	6⅛	1 3/16	smaller	6⅛	1¼	
2	6	1	6½	1 5/16	use	6½	1 7/16	
2½	7	1⅛	7½	1½	600 LB.	7½	1⅝	
3	7½	1 3/16	8¼	1 11/16	Standard	8¼	1 13/16	
3½	8½	1¼	9	1¾			9	1 15/16
4	9	1 5/16	10	1⅞	10	2	10¾	2⅛
5	10	1 7/16	11	2	11	2⅛	13	2⅜
6	11	1 9/16	12½	2 1/16	12½	2¼	14	2⅝
8	13½	1¾	15	2 7/16	15	2 11/16	16½	3
10	16	1 15/16	17½	3¾	17½	4	20	4⅜
12	19	2 3/16	20½	4	20½	4¼	22	4⅝
14	21	3⅛	23	4⅜	23	4⅝	23¾	5
16	23½	3 7/16	25½	4¾	25½	50	27	5½
18	25	3 13/16	28	5⅛	28	5⅜	29¼	6
20	27½	4 1/16	30½	5½	30½	5¾	32	6½
24	32	4⅜	36	6	36	6¼	37	7¼

(1) The 1/16" raised face **is** included in length thru Hub, "Y".
(2) The 1/16" raised face **is not** included in length thru Hub, "Y".



NOM. PIPE SIZE	150 LB. O	150 LB. Y(1)	300 LB. O	300 LB. Y(1)	400 LB. O	400 LB. Y(2)	600 LB. O	600 LB. Y(2)
1/2	3 1/2	7/16	3 3/4	9/16	For	3 3/4	9/16	
3/4	3 7/8	1/2	4 5/8	5/8	sizes	4 5/8	5/8	
1	4 1/4	9/16	4 7/8	1 1/16	3 1/2	4 7/8	1 1/16	
1 1/4	4 5/8	5/8	5 1/4	3/4	and	5 1/4	1 3/16	
1 1/2	5	1 1/16	6 1/8	1 3/16	smaller	6 1/8	7/8	
2	6	3/4	6 1/2	7/8	use	6 1/2	1	
2 1/2	7	7/8	7 1/2	1	600 LB.	7 1/2	1 1/8	
3	7 1/2	15/16	8 1/4	1 1/8	Standard	8 1/4	1 1/4	
3 1/2	8 1/2	15/16	9	1 3/16		9	1 3/8	
4	9	15/16	10	1 1/4	10	1 3/8	10 3/4	1 1/2
5	10	15/16	11	1 3/8	11	1 1/2	13	1 3/4
6	11	1	12 1/2	1 7/16	12 1/2	1 5/8	14	1 7/8
8	13 1/2	1 1/8	15	1 5/8	15	1 7/8	16 1/2	2 3/16
10	16	1 3/16	17 1/2	1 7/8	17 1/2	2 1/8	20	2 1/2
12	19	1 1/4	20 1/2	2	20 1/2	1/4	22	2 5/8
14	21	1 3/8	23	2 1/8	23	2 3/8	23 3/4	2 3/4
16	23 1/2	1 7/16	25 1/2	2 1/4	25 1/2	2 1/2	27	3
18	25	1 9/16	28	2 3/8	28	2 5/8	29 1/4	3 1/4
20	27 1/2	1 11/16	30 1/2	2 1/2	30 1/2	2 3/4	32	3 1/2
22	29 1/2	1 13/16	33	2 5/8	33	2 7/8	34 1/4	3 3/4
24	32	1 7/8	36	2 3/4	36	3	37	4
26	34 1/4	2	38 1/4	3 1/8	38 1/4	3 1/2	40	4 1/4
30	38 3/4	2 1/8	43	3 5/8	43	4	44 1/2	4 1/2
34	43 3/4	2 5/16	47 1/2	4	47 1/2	4 3/8	49	4 3/4
36	46	2 3/8	50	4 1/8	50	4 1/2	51 3/4	4 7/8
42	53	2 5/8	57	4 5/8	57	5 1/8	58 3/4	5 1/2

(1) The 1/16" raised face **is** included in Thickness, "Q".
(2) The 1/4" raised face **is not** included in Thickness, "Q".

– Bolting Dimensions for 150 to 300 Lb. Steel Flange

	125/150 Lb. Flange					250/300 Lb. Flange				
Nom. Pipe Size	Bolt Circle Dia.	Bolt Dia.	No. of Bolts	*Stud Len.	Bolt Len.	Bolt Circle Dia.	Bolt Dia.	No. of Bolts	*Stud Len.	Bolt Len.
1/2	2 3/8	1/2	4	2 1/4	1 3/4	2 5/8	1/2	4	2 1/2	2
3/4	2 3/4	1/2	4	2 1/4	2	3 1/4	5/8	4	2 3/4	2 1/2
1	3 1/8	1/2	4	2 1/2	2	3 1/2	5/8	4	3	2 1/2
1 1/4	3 1/2	1/2	4	2 1/2	2 1/4	3 7/8	5/8	4	3	2 3/4
1 1/2	3 7/8	1/2	4	2 3/4	2 1/4	4 1/2	3/4	4	3 1/2	3
2	4 3/4	5/8	4	3	2 3/4	5	5/8	8	3 1/4	3
2 1/2	5 1/2	5/8	4	3 1/4	3	5 7/8	3/4	8	3 3/4	3 1/4
3	6	5/8	4	3 1/2	3	6 5/8	3/4	8	4	3 1/2
3 1/2	7	5/8	8	3 1/2	3	7 1/4	3/4	8	4 1/4	3 3/4
4	7 1/2	5/8	8	3 1/2	3	7 7/8	3/4	8	4 1/4	3 3/4
5	8 1/2	3/4	8	3 3/4	3 1/4	9 1/4	3/4	8	4 1/2	4
6	9 1/2	3/4	8	3 3/4	3 1/4	10 5/8	3/4	12	4 3/4	4 1/4
8	11 3/4	3/4	8	4	3 1/2	13	7/8	12	5 1/4	4 3/4
10	14 1/8	7/8	12	4 1/2	3 3/4	15 1/4	1	16	6	5 1/4
12	17	7/8	12	4 1/2	4	17 3/4	1 1/8	16	6 1/2	5 3/4
14	18 3/4	1	12	5	4 1/4	20 1/4	1 1/8	20	6 3/4	6
16	21 1/4	1	16	5 1/4	4 1/2	22 1/2	1 1/4	20	7 1/4	6 1/2
18	22 3/4	1 1/8	16	5 3/4	4 3/4	24 3/4	1 1/4	24	7 1/2	6 3/4
20	25	1 1/8	20	6	5 1/4	27	1 1/4	24	8	7
22	27 1/4	1 1/4	20	6 1/2	5 1/2	29 1/4	1 1/2	24	8 3/4	7 1/2
24	29 1/2	1 1/4	20	6 3/4	5 3/4	32	1 1/2	24	9	7 3/4
26	31 3/4	1 1/4	24	7	6	34 1/2	1 5/8	28	10	8 3/4
30	36	1 1/4	28	7 1/4	6 1/4	39 1/4	1 3/4	28	11 1/4	10
34	40 1/2	1 1/2	32	8	7	43 1/2	1 7/8	28	12 1/4	10 3/4
36	42 3/4	1 1/2	32	8 1/4	7	46	2	32	12 3/4	11 1/4
42	49 1/2	1 1/2	36	8 3/4	7 1/4	52 3/4	2	36	13 3/4	13 1/2

*1/16" Raised Face

Stud lengths for lap joint flanges are equal to lengths shown plus the thickness of two laps of the stub ends.

Bolting Dimensions for 400 Lb./600Lb. Steel Flange

	400 LB. Steel Flanges ——				600 LB. Steel Flanges			
Nom Pipe Size	Diam of Bolt Circle	Diam of Bolts	No. of Bolts	Length of Studs ¼" Raised Face	Diam of Bolt Circle	Diam of Bolts	No of Bolts	Length of Studs ¼" Raised Face
½	2⅝	½	4	3	2⅝	½	4	3
¾	3¼	⅝	4	3¼	3¼	⅝	4	3¼
1	3½	⅝	4	3½	3½	⅝	4	3½
1¼	3⅞	⅝	4	3¾	3⅞	⅝	4	3¾
1½	4½	¾	4	4	4½	¾	4	4
2	5	⅝	8	4	5	⅝	8	4
2½	5⅞	¾	8	4½	5⅞	¾	8	4¼
3	6⅝	¾	8	4¾	6⅝	¾	8	4¾
3½	7¼	⅞	8	5¼	7¼	⅞	8	5¼
4	7⅞	⅞	8	5¼	8½	⅞	8	5½
5	9¼	⅞	8	6½	10½	1	8	6¼
6	10⅝	⅞	12	5¾	11½	1	12	6½
8	13	1	12	6½	13¾	1⅛	12	7½
10	15¼	1⅛	16	7¼	17	1¼	16	8¼
12	17¾	1¼	16	7¾	19¼	1¼	20	8½
14	20¼	1¼	20	8	20¾	1⅜	20	9
16	22½	1⅜	20	8½	23¾	1½	20	9¾
18	24¾	1⅜	24	8¾	25¾	1⅝	20	10½
20	27	1½	24	9½	28½	1⅝	24	11¼
22	29¼	1⅝	24	10	30⅝	1¾	24	12
24	32	1¾	24	10½	33	1⅞	24	12¾
26	34½	1¾	28	11½	36	1⅞	28	13¼
30	39¼	2	28	13	40¼	2	28	14
34	43½	2	28	13¾	44½	2¼	28	15
36	46	2	32	14	47	2½	28	15¾
42	52¾	2½	32	16¼	53¾	2¾	28	17½

Stud lengths for lap joint flanges are equal to lengths shown minus ½" plus the thickness of two laps of the stub ends.

—— Standard Cast Iron Companion Flanges and Bolts

(for working pressures up to 125 psi steam, 175 psi WOG)

Size	Flange Dia.	Bolt Circle	No. Bolts	Bolt Size	Bolt Length
3/4	3 1/2	2 1/2	4	3/8	1 3/8
1	4 1/4	3 1/8	4	1/2	1 1/2
1 1/4	4 5/8	3 1/2	4	1/2	1 1/2
1 1/2	5	3 7/8	4	1/2	1 3/4
2	6	4 3/4	4	5/8	2
2 1/2	7	5 1/2	4	5/8	2 1/4
3	7 1/2	6	4	5/8	2 1/2
3 1/2	8 1/2	7	8	5/8	2 1/2
4	9	7 1/2	8	5/8	2 3/4
5	10	8 1/2	8	3/4	3
6	11	9 1/2	8	3/4	3
8	13 1/2	11 3/4	8	3/4	3 1/4
10	16	14 1/4	12	7/8	3 1/2
12	19	17	12	7/8	3 3/4
14	21	18 3/4	12	1	4 1/4
16	23 1/2	21 1/4	16	1	4 1/4

– Extra Heavy Cast Iron Companion Flanges and Bolts

(for working pressures up to 250 psi steam, 400 psi WOG)

Size	Flange Dia.	Bolt Circle	No. Bolts	Bolt Size	Bolt Length
1	4 7/8	3 1/2	4	5/8	2 1/4
1 1/4	5 1/4	3 7/8	4	5/8	2 1/2
1 1/2	6 1/8	4 1/2	4	3/4	2 1/2
2	6 1/2	5	8	5/8	2 1/2
2 1/2	7 1/2	5 7/8	8	3/4	3
3	8 1/4	6 5/8	8	3/4	3 1/4
3 1/2	9	7 1/4	8	3/4	3 1/4
4	10	7 7/8	8	3/4	3 1/2
5	11	9 1/4	8	3/4	3 3/4
6	12 1/2	10 5/8	12	3/4	3 3/4
8	15	13	12	7/8	4 1/4
10	17 1/2	15 1/4	16	1	5
12	20 1/2	17 3/4	16	1 1/8	5 1/2
14 O.D.	23	20 1/4	20	1 1/8	5 3/4
16 O.D.	25 1/2	22 1/2	20	1 1/4	6
18 O.D.	28	24 3/4	24	1 1/4	6 1/4
20 O.D.	30 1/2	27	24	1 1/4	6 3/4
24 O.D.	36	32	24	1 1/2	7 1/2
30 O.D.	43	39 1/4	28	1 3/4	8 1/2
36 O.D.	50	46	32	2	9 1/2
42 O.D.	57	52 3/4	36	2	10
48 O.D.	65	60 3/4	40	2	11

—— Standard Cast Iron Companion Flanges and Bolts

(for working pressures up to 125 psi steam, 175 psi WOG)

Size	Flange Dia.	Bolt Circle	No. Bolts	Bolt Size	Bolt Length
3/4	3 1/2	2 1/2	4	3/8	1 3/8
1	4 1/4	3 1/8	4	1/2	1 1/2
1 1/4	4 5/8	3 1/2	4	1/2	1 1/2
1 1/2	5	3 7/8	4	1/2	1 3/4
2	6	4 3/4	4	5/8	2
2 1/2	7	5 1/2	4	5/8	2 1/4
3	7 1/2	6	4	5/8	2 1/2
3 1/2	8 1/2	7	8	5/8	2 1/2
4	9	7 1/2	8	5/8	2 3/4
5	10	8 1/2	8	3/4	3
6	11	9 1/2	8	3/4	3
8	13 1/2	11 3/4	8	3/4	3 1/4
10	16	14 1/4	12	7/8	3 1/2
12	19	17	12	7/8	3 3/4
14	21	18 3/4	12	1	4 1/4
16	23 1/2	21 1/4	16	1	4 1/4

– Extra Heavy Cast Iron Companion Flanges and Bolts

(for working pressures up to 250 psi steam, 400 psi WOG)

Size	Flange Dia.	Bolt Circle	No. Bolts	Bolt Size	Bolt Length
1	4 7/8	3 1/2	4	5/8	2 1/4
1 1/4	5 1/4	3 7/8	4	5/8	2 1/2
1 1/2	6 1/8	4 1/2	4	3/4	2 1/2
2	6 1/2	5	8	5/8	2 1/2
2 1/2	7 1/2	5 7/8	8	3/4	3
3	8 1/4	6 5/8	8	3/4	3 1/4
3 1/2	9	7 1/4	8	3/4	3 1/4
4	10	7 7/8	8	3/4	3 1/2
5	11	9 1/4	8	3/4	3 3/4
6	12 1/2	10 5/8	12	3/4	3 3/4
8	15	13	12	7/8	4 1/4
10	17 1/2	15 1/4	16	1	5
12	20 1/2	17 3/4	16	1 1/8	5 1/2
14 O.D.	23	20 1/4	20	1 1/8	5 3/4
16 O.D.	25 1/2	22 1/2	20	1 1/4	6
18 O.D.	28	24 3/4	24	1 1/4	6 1/4
20 O.D.	30 1/2	27	24	1 1/4	6 3/4
24 O.D.	36	32	24	1 1/2	7 1/2
30 O.D.	43	39 1/4	28	1 3/4	8 1/2
36 O.D.	50	46	32	2	9 1/2
42 O.D.	57	52 3/4	36	2	10
48 O.D.	65	60 3/4	40	2	11

ASTM Carbon Steel Pipe and Flange Specifications

Pipe and Tubing Description and Applications	Spec No.	ASTM or Type	Grade Strength PSI
Seamless milled steel pipe for high-temperature service, suitable for bending, flanging and similar forming operations	(1) A106	A	48,000
As above, except use Grade A for close coiling, cold bending or forge welding.	(1) A106	B	60,000
Black or hot-dip galvanize seamless or res-welded steel pipe suitable for coiling, bending, flanging, and other special purposes, suitable for welding	A 53	A	48,000
As above, except use Grade A for close coiling, cold bending or forge welding.	A 53	B	60,000
Black or hot-dip galvanize seamless or res. welded steel pipe suitable for ordinary uses. (When tension, flattening or bend test required, order to A-53)	A 120 (obsolete)	–	–
Resistance welded steel pipe for liquid, gas or vapor	A 135	A	48,000
As above, except use Grade A for flanging and bending	A 135	B	60,000
Electric-fusion-welded strait- or spiral-seam pipe for liquid, gas or vapor frommill grades of plate	A 139	A	48,000
As above	A 139	B	60,000
Forged Pipe, Flanges Description and Applications			
Forged or rolled steel pipe flanges, fittings (6) values and parts for high temperature service. Heat treatment required; may be annealed or normalized	A105	I	60,000
As above	A 105	II	70,000
As above except for general service. Heat treatment is not required	A 181	I	60,000
As above	A 181	II	70,000

(1) 0.10% silicon minimum.

(2) Open hearth, 0.13 max for ⅛" and ¼" size resistance welded pipe only

(3) Seamless: open hearth 0.048 max, acid bessemar 0.11 max;
Res. welded: open hearth 0.050 max.

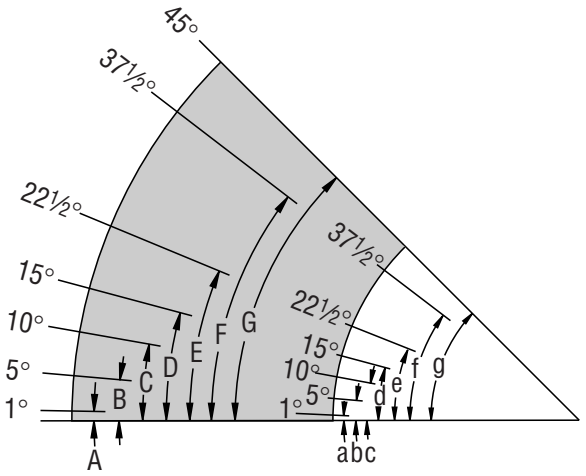
(4) Longitudinal or transverse direction of test specimen with respect to pipe axis

Yield Point or Strength PSI	Elongation (% in 2") STD Round	Rectangular t	5/16"	5/16"	Chemical Composition, % C	MN	P	S
30,000	28 long. OR (4) 20 trans.	17.5+ or 12.5+	56t 40t	35 . 25	.25 max	.27 to .93	.048 max	.058 max
35,000	28 long. OR (4) 12 trans.	17.5+ or 6.5+	56t . 32t	35 16.5	30 max	.27 to 1.06	.048 max	.058 max
30,000	28	17.5+	56t	35	(2)	–	(3)	-
35,000	22	15+	48t	30	(2)	–	(3)	-
–	–	–	–	–	–	–	–	
30,000	–	17.5+	56t	35	–	–	.050 max	.060 max
35,000	–	15+	48t	30	–	–	.05 max	.060 max
30,000	–	17.5+	56t	35	–	.30 to 1.00	.040 max	.050 max
35,000	–	15+	48t	30	.30 max	.30 to 1.00	.040 max	.050 max
30,000	25		–	–	.35 (5) max	.90 max	.05 max	.05 max
36,000	22		–	–	.35 (5) max	.90 max	.05 max	.05 max
30,000	22		–	–	.35 (5) max	.90 max	.05 max	.05 max
36,000	18		–	–	.35 (5) max	.90 max	.05 max	.05 max

(5) When flanges will be subject to fusion welding, carbon content shall be ≤0.35%. If carbon is ≤0.35%, it may be necessary to add silicon to meet required tensile properties. The silicon content shall be ≤0.35%.

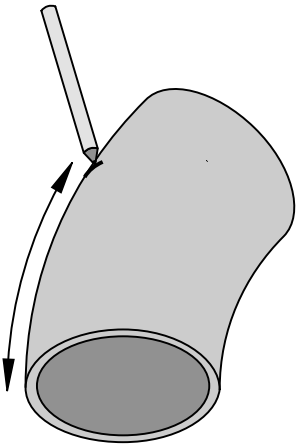
(6) Factor-made Wrought Carbon Steel and Ferritic Alloy Steel Welding Fitting Specifications are covered under ASTM A234.

How to Cut Odd-Angle Elbows

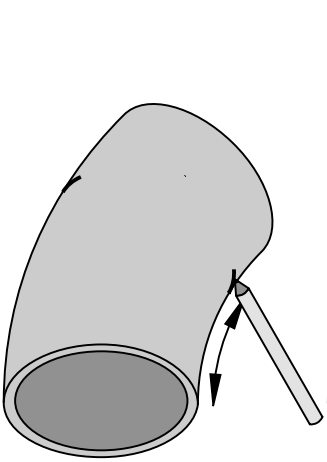


Nom Size	Outside Arc A	B	C	D	E	F	G
2	5/32	3/8	23/32	13/32	1 21/32	2 3/4	3 9/32
2½	3/32	7/16	29/32	1 11/32	2 1/32	3 3/8	4 1/16
3	7/32	9/16	1 1/8	1 5/8	2 15/32	4 3/32	4 29/32
3½	1/8	5/8	1 9/32	1 29/32	2 27/32	4 3/4	5 11/16
4	9/32	23/32	1 7/16	2 5/32	3 1/4	5 13/32	6 15/32
5	3/16	29/32	1 25/32	2 11/16	4 1/32	6 23/32	8 1/16
6	7/32	1 1/16	2 5/32	3 7/32	4 27/32	8 1/16	9 21/32
8	9/32	1 7/16	2 27/32	4 9/32	6 13/32	10 11/16	12 13/16
10	1 1/32	1 25/32	3 9/16	5 11/32	8	13 11/32	16
12	7/16	2 1/8	4 1/4	6 3/8	9 9/16	15 31/32	19 5/32
14	1/2	2 7/16	4 7/8	7 5/16	11	18 5/16	22
16	9/16	2 13/16	5 19/32	8 3/8	12 9/16	20 15/16	25 1/8
18	5/8	3 1/8	6 9/32	9 7/16	14 1/8	23 9/16	28 9/32
20	1 1/16	3 1/2	7	10 15/32	15 23/32	26 3/16	31 13/32
22	3/4	3 27/32	7 11/16	11 17/32	17 9/32	28 13/16	34 9/16
24	2 7/32	4 3/16	8 3/8	12 9/16	18 27/32	31 13/32	37 11/16
26	2 9/32	4 17/32	9 3/32	13 5/8	20 13/32	34 1/32	40 27/32
30	1 1/32	5 1/4	10 15/32	15 3/4	23 9/16	39 1/4	47 1/8
34	1 5/32	5 29/32	11 27/32	17 13/16	26 23/32	44 17/32	53 3/8
36	1 7/32	6 1/4	12 17/32	18 7/8	28 7/32	47	56 17/32
42	1 7/16	7 5/16	14 5/8	22	32 31/32	54 31/32	65 15/16

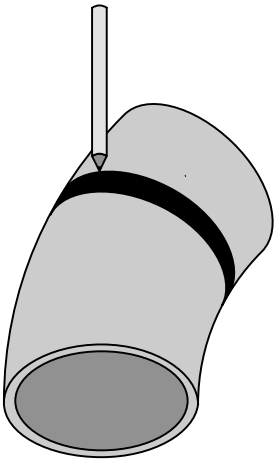
How to Cut Odd-Angle Elbows



Step1
Measure distance on outside arc using the values from the table on the previous page and make a mark.



Step2
Measure distance on inside arc using the values from the table below and make a mark.



Step1
Wrap tape around elbow and mark cutting line

Nom	Inside Arc						
SIZE	AA	BB	CC	DD	EE	FF	GG
2	1/32	5/32	5/16	1 5/32	2 3/32	1 3/16	1 7/16
2 1/2	3/32	3/16	1 3/32	1 9/32	2 9/32	1 1/2	1 13/16
3	3/32	1/4	1/2	2 3/32	1 3/32	1 13/16	2 5/32
3 1/2	1/16	9/32	9/16	2 7/32	1 9/32	2 1/8	2 9/16
4	1/16	5/16	2 1/32	3 1/32	1 15/32	2 7/16	2 15/16
5	5/32	1 3/32	1 3/16	1 1/4	1 27/32	3 3/32	3 23/32
6	3/32	1/2	1	1 1/2	2 7/32	3 23/32	4 15/32
8	1/8	1 1/16	1 11/32	2	3 1/32	5 1/32	6 1/32
10	5/32	2 7/32	1 11/16	2 17/32	3 25/32	6 5/16	7 9/16
12	7/32	1	2 1/32	3 1/16	4 9/16	7 19/32	9 1/8
14	1/4	1 7/32	2 7/16	3 21/32	5 1/2	9 5/32	11
16	9/32	1 13/32	2 13/16	4 3/16	6 3/16	10 15/32	12 5/8
18	5/16	1 9/16	3 1/8	4 23/32	7 1/16	11 25/32	14 1/8
20	1 1/32	1 3/4	3 1/2	5 1/4	7 27/32	13 3/32	15 11/16
22	3/8	1 29/32	3 27/32	5 3/4	8 5/8	14 3/8	17 9/32
24	1 3/32	2 3/32	4 3/16	6 9/32	9 7/16	15 11/16	18 27/32
26	1 5/32	2 9/32	4 17/32	6 13/16	10 7/32	17 1/32	20 13/32
30	1 7/32	2 5/8	5 1/4	7 7/8	11 25/32	19 5/8	23 9/16
34	1 9/32	2 31/32	5 29/32	8 29/32	13 3/8	22 9/32	26 11/16
36	5/8	2 13/16	6 1/4	9 7/16	14 1/8	23 5/8	28 1/4
42	2 3/32	3 21/32	7 5/16	10 19/32	16 1/2	26 3/8	32 31/32

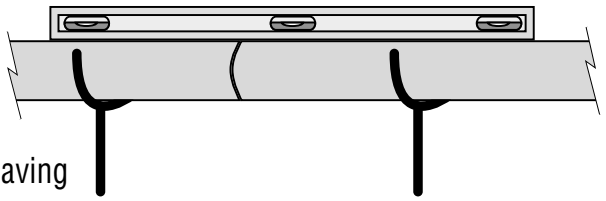
Alignment of Pipe

Proper alignment is important if a piping system is to be correctly fabricated.

Poor alignment may result in welding difficulties and a system that does not function properly.

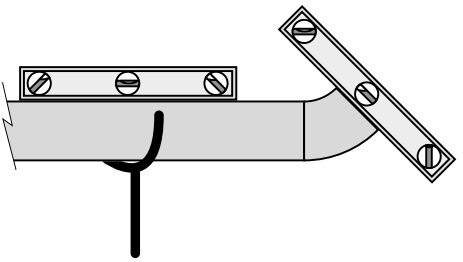
Welding rings may be employed to assure proper alignment as well as the correct welding gap. In addition to using welding rings, some simple procedures can be followed to assist the pipe fitter. Below and on the following page are alignment procedures commonly used by today's craftsmen.

PIPE–TO–PIPE



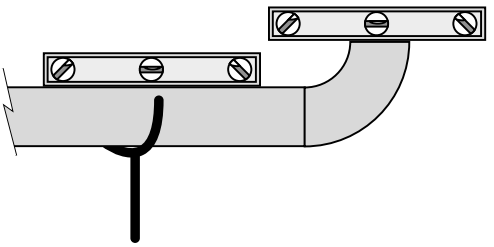
1. Level one length of pipe using spirit level
2. Bring lengths together leaving only small welding gap
3. Place spirit level over both pipes as shown and maneuver unpositioned length until both are level
4. Tack weld top and bottom
5. Rotate pipe 90°
6. Repeat procedure

45° ELBOW-TO-PIPE



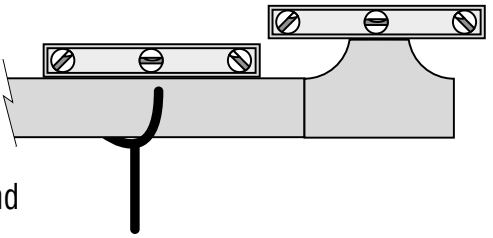
1. Level pipe using spirit level
2. Place fitting to pipe leaving small welding gap
3. Place 45" spirit level on face of elbow and maneuver elbow until bubble is centered
4. Tack weld in place

90° ELBOW.TO-PIPE



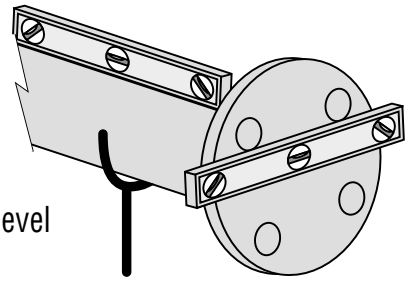
1. Level pipe using spirit level
2. Place fitting to pipe leaving small welding gap
3. Place spirit level on face of elbow and maneuver elbow until level
4. Tack weld in place

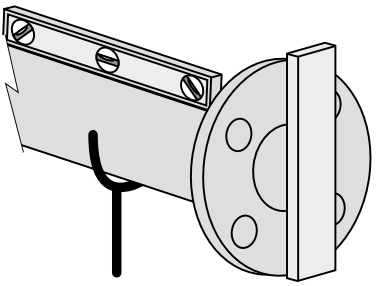
TEE-TO-PIPE



1. Level pipe using spirit level
2. Place tee to pipe leaving small welding gap
3. Place spirit level on face of tee and maneuver tee until level
4. Tack weld in place

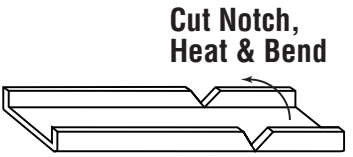
FLANGE-TO-PIPE





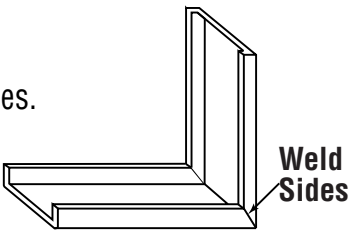
1. Bring flange to pipe end leaving smal welding gop
2. Align toptwo holes of flange with spirit level
3. Tack weld in place
4. Center square on face of flange as shown
5. Tack weld in place
6. Check sides in same way

JIG FOR SMALL DIAMETER PIPING

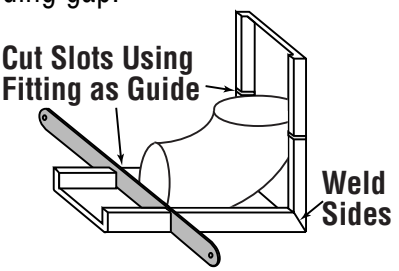


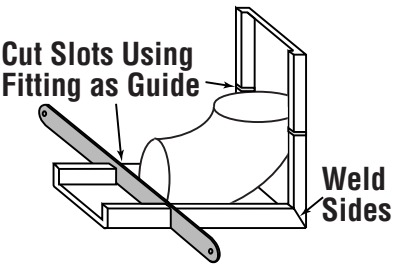
The jig is made from channel iron 3' 9" long. Use 1/8" x 1½" for pipe sizes 1¼" thru 3"; 1/8" x ¾" for Sizes 1" or smaller.

1. Cut out 90° notches about 9" from end.
2. Heat bottom of notch with torch.
3. Bend channel iron to 90° angle and weld sides.



4. Place elbow in jig and saw half thru sides of channel iron as shown. Repeat this step with several elbows so jig may be used for different operations.
5. A used hack saw blade placed in notch as shown will provide proper welding gap.





Drill Sizes For Pipe Tapes

Tap Size	Threads/In.	Drill Diameter
1/8	27	11/32
1/4	18	7/16
3/8	18	37/32
1/2	14	23/32
3/4	14	59/32
1	11 1/2	15/32
1 1/4	11 1/2	1 1/2
1 1/2	11 1/2	1 49/32
2	11 1/2	2 3/16
2 1/2	8	2 9/16
3	8	3 3/16
3 1/2	8	3 11/16
4	8	4 3/16
4 1/2	8	4 3/4
5	8	5 5/16
6	8	6 5/16

Tap And Drill Sizes (American Standard Coarse)

Drill Size	Tap Size	Threads/In.
7	1/4	20
F	5/16	18
5/16	3/8	16
U	7/16	14
27/32	1/2	13
31/32	9/16	12
17/32	5/8	11
19/32	11/16	11
21/32	3/4	10
23/32	13/16	10
49/32	7/8	9
53/32	15/16	9
7/8	1	8
63/32	1 1/8	7
17/32	1 1/4	7
1 13/32	1 3/8	6
1 11/32	1 1/2	6
1 29/32	1 5/8	5 1/2
1 9/16	1 3/4	5
1 11/16	1 7/8	5
1 25/32	2	4 1/2

Drill Sizes For Pipe Tapes

Tap Size	Threads/In.	Drill Diameter
1/8	27	11/32
1/4	18	7/16
3/8	18	37/32
1/2	14	23/32
3/4	14	59/32
1	11 1/2	15/32
1 1/4	11 1/2	1 1/2
1 1/2	11 1/2	1 49/32
2	11 1/2	2 3/16
2 1/2	8	2 9/16
3	8	3 3/16
3 1/2	8	3 11/16
4	8	4 3/16
4 1/2	8	4 3/4
5	8	5 5/16
6	8	6 5/16

Tap And Drill Sizes (American Standard Coarse)

Drill Size	Tap Size	Threads/In.
7	1/4	20
F	5/16	18
5/16	3/8	16
U	7/16	14
27/32	1/2	13
31/32	9/16	12
17/32	5/8	11
19/32	11/16	11
21/32	3/4	10
23/32	13/16	10
49/32	7/8	9
53/32	15/16	9
7/8	1	8
63/32	1 1/8	7
17/32	1 1/4	7
1 13/32	1 3/8	6
1 11/32	1 1/2	6
1 29/32	1 5/8	5 1/2
1 9/16	1 3/4	5
1 11/16	1 7/8	5
1 25/32	2	4 1/2

Pipe And Water Weight/Foot

Nom. Pipe Size	Weight STD Pipe	Water	Weight XS Pipe	Water
½	0.851	0.132	1.088	0.101
¾	1.131	0.231	1.474	0.187
1	1.679	0.374	2.172	0.311
1¼	2.273	0.648	2.997	0.555
1½	2.718	0.882	3.632	0.765
2	3.653	1.453	5.022	1.278
2½	5.794	2.073	7.622	1.835
3	7.580	3.200	10.250	2.860
3½	9.110	4.280	12.510	3.850
4	10.790	5.510	14.990	4.980
5	14.620	8.660	20.780	7.880
6	18.980	12.510	28.580	11.290
8	28.560	21.680	43.400	19.800
10	40.500	34.100	54.700	32.300
12	49.600	49.000	65.400	47.000
14	54.600	59.700	72.100	57.500
16	62.600	79.100	82.800	76.500
18	70.600	101.200	93.500	98.300
20	78.600	126.000	104.100	122.800
24	94.600	183.800	125.500	179.900
30	118.700	291.000	157.600	286.000

Weight/Foot - Seamless Brass And Copper Pipe

Nominal Pipe Size	Regular Yellow Brass	Red Brass	Copper	Extra Strong Yellow Brass	Red Brass	Copper
½	0.91	0.93	0.96	1.19	1.23	1.25
¾	1.23	1.27	1.30	1.62	1.67	1.71
1	1.73	1.78	1.82	2.39	2.49	2.51
1¼	2.56	2.63	2.69	3.29	3.39	3.46
1½	3.04	3.13	3.20	3.99	4.10	4.19
2	4.01	4.12	4.22	5.51	5.67	5.80

Pipe And Water Weight/Foot

Nom. Pipe Size	Weight STD Pipe	Water	Weight XS Pipe	Water
½	0.851	0.132	1.088	0.101
¾	1.131	0.231	1.474	0.187
1	1.679	0.374	2.172	0.311
1¼	2.273	0.648	2.997	0.555
1½	2.718	0.882	3.632	0.765
2	3.653	1.453	5.022	1.278
2½	5.794	2.073	7.622	1.835
3	7.580	3.200	10.250	2.860
3½	9.110	4.280	12.510	3.850
4	10.790	5.510	14.990	4.980
5	14.620	8.660	20.780	7.880
6	18.980	12.510	28.580	11.290
8	28.560	21.680	43.400	19.800
10	40.500	34.100	54.700	32.300
12	49.600	49.000	65.400	47.000
14	54.600	59.700	72.100	57.500
16	62.600	79.100	82.800	76.500
18	70.600	101.200	93.500	98.300
20	78.600	126.000	104.100	122.800
24	94.600	183.800	125.500	179.900
30	118.700	291.000	157.600	286.000

Weight/Foot - Seamless Brass And Copper Pipe

Nominal Pipe Size	Regular Yellow Brass	Red Brass	Copper	Extra Strong Yellow Brass	Red Brass	Copper
½	0.91	0.93	0.96	1.19	1.23	1.25
¾	1.23	1.27	1.30	1.62	1.67	1.71
1	1.73	1.78	1.82	2.39	2.49	2.51
1¼	2.56	2.63	2.69	3.29	3.39	3.46
1½	3.04	3.13	3.20	3.99	4.10	4.19
2	4.01	4.12	4.22	5.51	5.67	5.80

Water Pressure To Feet Head

Lbs./ Sq.In.	Feet Head
1	2.31
2	4.62
3	6.93
4	9.24
5	11.54
6	13.85
7	16.16
8	18.47
9	20.78
10	23.09
15	34.63
20	46.18
25	57.72
30	69.27

Lbs./ Sq.In.	Feet Head
40	92.36
50	115.45
60	138.54
70	161.63
80	184.72
90	207.81
100	43.31
110	47.64
120	51.97
130	56.30
140	60.63
150	64.96
160	69.29
170	73.63

Lbs./ Sq.In.	Feet Head
180	77.96
200	86.62
250	108.27
300	129.93
350	151.58
400	173.24
500	216.55
600	259.85
700	303.16
800	346.47
900	389.78
1,000	433.00

Feet Head To Water Pressure

Feet Head	Lbs./ Sq.In.
1	0.43
2	0.87
3	1.30
4	1.73
5	2.17
6	2.60
7	3.03
8	3.46
9	3.90
10	4.33
15	6.50
20	8.66
25	10.83
30	12.99

Feet Head	Lbs./ Sq.In.
40	17.32
50	21.65
60	25.99
70	30.32
80	34.65
90	38.98
100	43.31
110	47.64
120	51.97
130	56.30
140	60.63
150	64.96
160	69.29
170	73.63

Feet Head	Lbs./ Sq.In.
180	77.96
200	86.62
250	108.27
300	129.93
350	151.58
400	173.24
500	216.55
600	259.85
700	303.16
800	346.47
900	389.78
1,000	433.00

Note: One foot of water at 62°F equals 0.433 pound pressure per square inch. To find the pressure per square inch for any feet head not given in the table above, multiply the feet head by 0.433.

Water Pressure To Feet Head

Lbs./ Sq.In.	Feet Head
1	2.31
2	4.62
3	6.93
4	9.24
5	11.54
6	13.85
7	16.16
8	18.47
9	20.78
10	23.09
15	34.63
20	46.18
25	57.72
30	69.27

Lbs./ Sq.In.	Feet Head
40	92.36
50	115.45
60	138.54
70	161.63
80	184.72
90	207.81
100	43.31
110	47.64
120	51.97
130	56.30
140	60.63
150	64.96
160	69.29
170	73.63

Lbs./ Sq.In.	Feet Head
180	77.96
200	86.62
250	108.27
300	129.93
350	151.58
400	173.24
500	216.55
600	259.85
700	303.16
800	346.47
900	389.78
1,000	433.00

Feet Head To Water Pressure

Feet Head	Lbs./ Sq.In.
1	0.43
2	0.87
3	1.30
4	1.73
5	2.17
6	2.60
7	3.03
8	3.46
9	3.90
10	4.33
15	6.50
20	8.66
25	10.83
30	12.99

Feet Head	Lbs./ Sq.In.
40	17.32
50	21.65
60	25.99
70	30.32
80	34.65
90	38.98
100	43.31
110	47.64
120	51.97
130	56.30
140	60.63
150	64.96
160	69.29
170	73.63

Feet Head	Lbs./ Sq.In.
180	77.96
200	86.62
250	108.27
300	129.93
350	151.58
400	173.24
500	216.55
600	259.85
700	303.16
800	346.47
900	389.78
1,000	433.00

Note: One foot of water at 62°F equals 0.433 pound pressure per square inch. To find the pressure per square inch for any feet head not given in the table above, multiply the feet head by 0.433.

Boiling Points Of Water At Various Pressures

Vacuum, in Inches of Mercury	Boiling Point
29	76.62
28	99.93
27	114.22
26	124.77
25	133.22
24	140.31
23	146.45
22	151.87
21	156.75
20	161.19
19	165.24
18	169.00
17	172.51
16	175.80
15	178.91
14	181.82
13	184.61
12	187.21
11	189.75
10	192.19
9	194.50
8	196.73
7	198.87
6	200.96
5	202.25
4	204.85
3	206.70
2	208.50
1	210.25

Pressure Gauge Lbs	Boiling Point
0	212.0
1	215.6
2	218.5
4	224.4
6	229.8
8	234.8
10	239.4
15	249.8
25	266.8
50	297.7
75	320.1
100	337.9
125	352.9
200	387.9

Flow Conversion Chart

The accompanying chart provides fast answers to many problems that may confront the pipe fitter. Procedures for using the chart are as follows:

Note that there are three sets of figures shown in connection with the extreme left-hand column **A**.

"Standard" gives the internal diameter of standard pipe (somewhat greater than 1" for 1 in. standard pipe).

"Exact" gives the exact diameter.

"Extra Heavy" gives the internal diameter of extra heavy pipe.

EXAMPLE:

How much water is passing through a pipe with parameters:

I.D. of exactly 1 in.
Velocity of the water being 3 F.P.S.

To apply the chart to the problem locate 1 in. in column **"A"** using the scale "**Exact**" and run a straight line from the point through the 3 in column "**C**". From the intersection of this line with column "**B**". run a straight line horizontally to column "**G**". The intersection of this line at columns "**D**", "**E**" and "**F**" gives the following information:

"**D**" shows the cubic feet/minute flowing through the pipe.

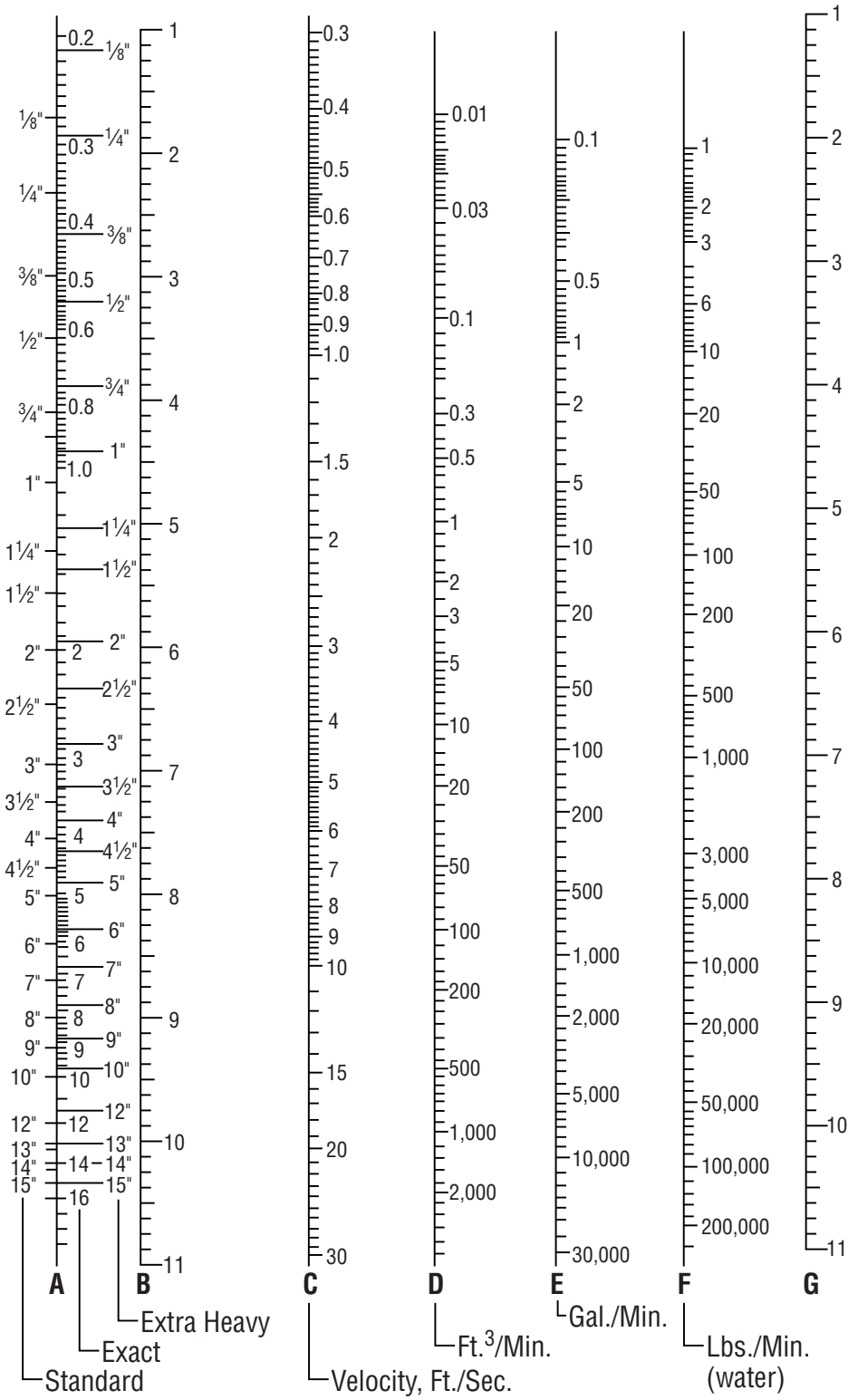
"**E**" shows the volume of flow in gallons/minute

"**F**" gives the weight of the water in pounds/minute.
(For liquids other tharn water. multiply the value of column "**F**" by the specific gravity of the liquid for accurate weight conversion.)

If a quantity in columns "**D**", "**E**" and "**F**" is known then velocity may be determined by reversing the procedure. Draw a horizontal line from the known point to column "**G**". From this intersection draw a line to the exact I.D. of the pipe in column "**A**" and extend this line to cross column "**C**". The intersection with column "**C**" gives the velocity in feet/second.

The chart can be used as a.conversion chart to determine the number of gallons in a certain number of cubic feet of liquid. The horizontal line already drawn to determine answers in columns "**C**" and "**D**" will provide the answer to the conversion in column "**E**".

A little practice will prove this chart to be a real time-saver.


A
B
C
D
E
F
G
Standard
Exact
Extra Heavy
Velocity, Ft./Sec.
Ft.3/Min.
Gal./Min.
Lbs./Min.
(water)

Heat Losses From Horizontal Bare Steel Pipe

(BTU per hour per linear foot at 70°F room temperature)

Pipe Nom. Pipe Size	Hot Water (180°F)	Steam 5 PSIG (20 PSIA)
½	60	96
¾	73	118
1	90	144
1¼	112	179
1½	126	202
2	155	248
2½	185	296
3	221	355
3½	244	401
4	279	448

Total Thermal Expansion of Piping Material (Inches Per 100 Ft. Above 32°F)

Temp °F	Carbon and Carbon Molly Steel	Cast Iron	Copper	Brass and Bronze	Wrought Iron
32	0.0	0.0	0.0	0.0	0.0
100	0.5	0.5	0.8	0.8	0.5
150	0.8	0.8	1.4	1.4	0.9
200	1.2	1.2	2.0	2.0	1.3
250	1.7	1.5	2.7	2.6	1.7
300	2.0	1.9	3.3	3.2	2.2
350	2.5	2.3	4.0	3.9	2.6
400	2.9	2.7	4.7	4.6	3.1
450	3.4	3.1	5.3	5.2	3.6
500	3.8	3.5	6.0	5.9	4.1
550	4.3	3.9	6.7	6.5	4.6
600	4.8	4.4	7.4	7.2	5.2
650	5.3	4.8	8.2	7.9	5.6
700	5.9	5.3	9.0	8.5	6.1
750	6.4	5.8	–	–	6.7
800	7.0	6.3	–	–	7.2
850	7.4	–	–	–	–
900	8.0	–	–	–	–
950	8.5	–	–	–	–
1000	9.1	–	–	–	–

Weights of Metals

Material	Chemical Symbol	Weight in Pounds Per Cubic Inch	Weight in Pounds Per Cubic Foot
Aluminum	Al	0.093	160
Antimony	Sb	0.2422	418
Brass	–	0.303	524
Bronze	–	0.32	552
Chromium	Cr	0.2348	406
Copper	Cu	0.323	558
Gold	Au	0.6975	1,205
Iron (cast)	Fe	0.26	450
Iron (wrought)	Fe	0.2834	490
Lead	Pb	0.4105	710
Maganese	Mn	0.2679	463
Mercury	Hg	0.491	849
Molybdenum	Mo	0.309	534
Monel	–	0.318	550
Platinum	Pt	0.818	1,413
Steel (mild)	–	0.2816	490
Steel (stainless)	–	0.277	484
Tin	Sn	0.265	459
Titanium	Ti	0.1278	221
Zinc	Zn	0.258	446

Colors And Approximate Temperature For Carbon Steel

Black Red	990°F
Dark Blood Red	1,050°F
Dark Cherry Red	1,175°F
Medium Cherry Red	1,250°F
Full Cherry Red	1,375°F
Light Cherry, Scalding	1,550°
Salmon, Free Scalding	1,650°F
Light Salmon	1,725°F
Yellow	1,825°F
Light Yellow	1,975°F
White	2,220°F

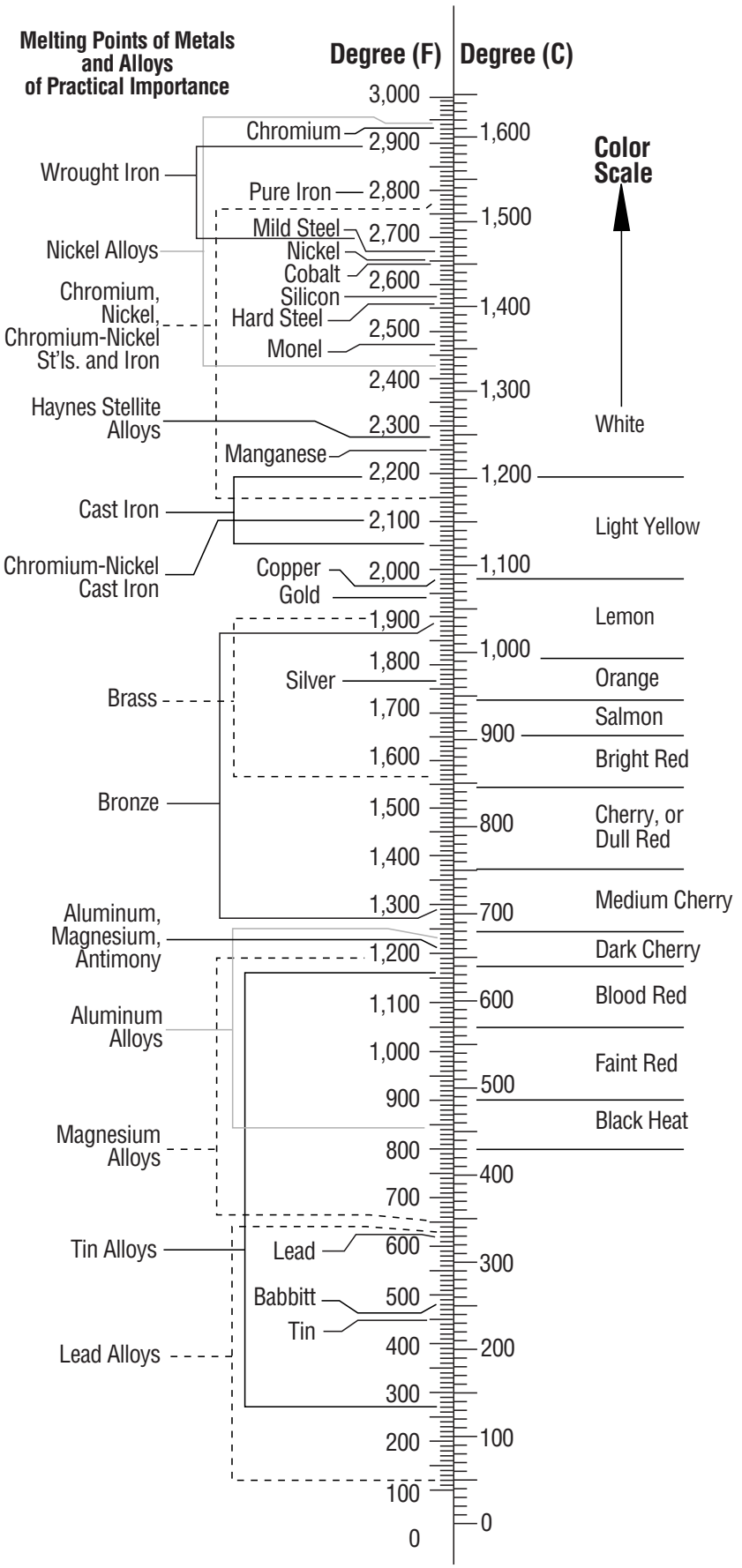
Weights of Metals

Material	Chemical Symbol	Weight in Pounds Per Cubic Inch	Weight in Pounds Per Cubic Foot
Aluminum	Al	0.093	160
Antimony	Sb	0.2422	418
Brass	–	0.303	524
Bronze	–	0.32	552
Chromium	Cr	0.2348	406
Copper	Cu	0.323	558
Gold	Au	0.6975	1,205
Iron (cast)	Fe	0.26	450
Iron (wrought)	Fe	0.2834	490
Lead	Pb	0.4105	710
Maganese	Mn	0.2679	463
Mercury	Hg	0.491	849
Molybdenum	Mo	0.309	534
Monel	–	0.318	550
Platinum	Pt	0.818	1,413
Steel (mild)	–	0.2816	490
Steel (stainless)	–	0.277	484
Tin	Sn	0.265	459
Titanium	Ti	0.1278	221
Zinc	Zn	0.258	446

Colors And Approximate Temperature For Carbon Steel

Black Red	990°F
Dark Blood Red	1,050°F
Dark Cherry Red	1,175°F
Medium Cherry Red	1,250°F
Full Cherry Red	1,375°F
Light Cherry, Scalding	1,550°
Salmon, Free Scalding	1,650°F
Light Salmon	1,725°F
Yellow	1,825°F
Light Yellow	1,975°F
White	2,220°F

Melting Point of Metals



Spcific Gravity Of Gases

Dry Air (1 cu. Ft. at 60°F. and 29.92" Hg. Weighs .07638 pound)		1.000
Acetylene	C_2H_2	0.91
Ethane	C_2H_4	1.05
Methane	CH_4	0.554
Ammonia	NH_3	0.596
Carbon-dioxide	CO_2	1.53
Carbon_monoxide	CO	0.967
Butane	C_4H_{10}	2.067
Butene	C_4H_8	1.93
Chlorine	Cl_2	2.486
Helium	He	0.138
Hydrogen	H_2	0.0696
Nitrogen	N_2	0.9718
Oxygen	O2	1.1053

Spcific Gravity Of Liquids

Liquid	Temp °F	Specific Gravity
Water (1 cu.-ft. weights 62.41 lb.)	50	1.00
Brine (Sodium Chloride 25%)	32	1.20
Pennsylvania Crude Oil	80	0.85
Fuel Oil No. 1 and 2	85	0.95
Gasoline	80	0.74
Kerosene	85	0.82
Lubricating Oil SAE 10-20-30	115	0.94

Typcial BTU Values Of Fuels

ASTM RANK SOLIDS	BTU VALUES PER POUND
Anthracite Class I	11,230
Bitiminous Class II Group 1	14,100
Bitiminous Class II Group 3	13,080
Sub-Bituminous Class III Group 1	10,810
Sub-Bituminous Class III Group 2	9,670
LIQUIDS	**BTU VALUES PER GALLON**
Fuel Oil No. 1	136,000
Fuel Oil No. 2	138,000
Fuel Oil No. 4	145,000
Fuel Oil No. 5	148,000
Fuel Oil No. 6	152,000
GASES	**BTU VALUES PER CU. FT.**
Natural Gas	935 to 1132
Producers Gas	163
Illuminating Gas	534
Mixed (Coke oven and water gas)	545

Spcific Gravity Of Gases

Dry Air (1 cu. Ft. at 60°F. and 29.92" Hg. Weighs .07638 pound)		1.000
Acetylene	C_2H_2	0.91
Ethane	C_2H_4	1.05
Methane	CH_4	0.554
Ammonia	NH_3	0.596
Carbon-dioxide	CO_2	1.53
Carbon_monoxide	CO	0.967
Butane	C_4H_{10}	2.067
Butene	C_4H_8	1.93
Chlorine	Cl_2	2.486
Helium	He	0.138
Hydrogen	H_2	0.0696
Nitrogen	N_2	0.9718
Oxygen	O2	1.1053

Spcific Gravity Of Liquids

Liquid	Temp °F	Specific Gravity
Water (1 cu.-ft. weights 62.41 lb.)	50	1.00
Brine (Sodium Chloride 25%)	32	1.20
Pennsylvania Crude Oil	80	0.85
Fuel Oil No. 1 and 2	85	0.95
Gasoline	80	0.74
Kerosene	85	0.82
Lubricating Oil SAE 10-20-30	115	0.94

Typcial BTU Values Of Fuels

ASTM RANK SOLIDS	BTU VALUES PER POUND
Anthracite Class I	11,230
Bitiminous Class II Group 1	14,100
Bitiminous Class II Group 3	13,080
Sub-Bituminous Class III Group 1	10,810
Sub-Bituminous Class III Group 2	9,670
LIQUIDS	**BTU VALUES PER GALLON**
Fuel Oil No. 1	136,000
Fuel Oil No. 2	138,000
Fuel Oil No. 4	145,000
Fuel Oil No. 5	148,000
Fuel Oil No. 6	152,000
GASES	**BTU VALUES PER CU. FT.**
Natural Gas	935 to 1132
Producers Gas	163
Illuminating Gas	534
Mixed (Coke oven and water gas)	545

Spcific Gravity Of Gases

Dry Air (1 cu. Ft. at 60°F. and 29.92" Hg. Weighs .07638 pound)		1.000
Acetylene	C_2H_2	0.91
Ethane	C_2H_4	1.05
Methane	CH_4	0.554
Ammonia	NH_3	0.596
Carbon-dioxide	CO_2	1.53
Carbon_monoxide	CO	0.967
Butane	C_4H_{10}	2.067
Butene	C_4H_8	1.93
Chlorine	Cl_2	2.486
Helium	He	0.138
Hydrogen	H_2	0.0696
Nitrogen	N_2	0.9718
Oxygen	O2	1.1053

Spcific Gravity Of Liquids

Liquid	Temp °F	Specific Gravity
Water (1 cu.-ft. weights 62.41 lb.)	50	1.00
Brine (Sodium Chloride 25%)	32	1.20
Pennsylvania Crude Oil	80	0.85
Fuel Oil No. 1 and 2	85	0.95
Gasoline	80	0.74
Kerosene	85	0.82
Lubricating Oil SAE 10-20-30	115	0.94

Typcial BTU Values Of Fuels

ASTM RANK SOLIDS	BTU VALUES PER POUND
Anthracite Class I	11,230
Bitiminous Class II Group 1	14,100
Bitiminous Class II Group 3	13,080
Sub-Bituminous Class III Group 1	10,810
Sub-Bituminous Class III Group 2	9,670
LIQUIDS	**BTU VALUES PER GALLON**
Fuel Oil No. 1	136,000
Fuel Oil No. 2	138,000
Fuel Oil No. 4	145,000
Fuel Oil No. 5	148,000
Fuel Oil No. 6	152,000
GASES	**BTU VALUES PER CU. FT.**
Natural Gas	935 to 1132
Producers Gas	163
Illuminating Gas	534
Mixed (Coke oven and water gas)	545

Useful Definitions

ALLOY STEEL: A Steel which owes its distinctive properties to elements other than carbon.

AREA OF A CIRCLE: The measurement of the surface within a circle. To find the area of a circle, multiply the product of the radius times the radius by Pi (3.142). Commonly written $A = \pi r^2$.

BRAZE WELD OR BRAZING: A process of joining metals using a nonferrous filler metal or alloy, the melting point of which is higher than 800°F but lower than that of the metals to be joined.

BUTT WELD: A circumferential weld in pipe fusing the abutting pipe walls completely from inside wall to outside wall.

CARBON STEEL: A steel which owes its distinctive properties chiefly to the various percentages of carbon (as distinguished from the other elements) which it contains.

CIRCUMFERENCE OF A CIRCLE: The measurement around the perimeter of a circle. To find the circumference, multiply Pi (3.142) by the diameter. (Commonly written as πd).

COEFFICIENT OF EXPANSION: A number indicating the degree of expansion or contraction of a substance.

The coefficient of expansion is not constant and varies with changes in temperature. For linear expansion it is expressed as the change in length of one unit of length of a substance having one degree rise in temperature.

CORROSION: The gradual destruction or alteration of a metal or alloy caused by direct chemical attack or by electrochemical reaction.

CREEP: The plastic flow of pipe within a system; the permanent set in metal caused by stresses at high temperatures. Generally associated with a time rate of deformation.

DIAMETER OF A CIRCLE: A straight line drawn through the center of a circle from one extreme edge to the other. Equal to twice the radius.

DUCTILITY: The property of elongation, above the elastic limit, but under the tensile strength.

A measure of ductility is the percentage of elongation of the fractured piece over its original length.

ELASTIC LIMIT: The greatest stress which a material can withstand without a permanent deformation after release of the stress.

EROSION: The gradual destruction of metal or other material by the abrasive action of liquids, gases, solids or mixtures thereof.

RADIUS OF A CIRCLE: A straight line drawn from the center to the extreme edge of a circle.

SOCKET FITTING: A fitting used to join pipe in which the pipe is inserted into the fitting. A fillet weld is then made around the edge of the fitting and the outside wall of the pipe.

SOLDERING: A method of joining metals using fusible alloys, usually tin and lead, having melting points under 700°F

STRAIN: Change of shape or size of a body produced by the action of a stress.

STRESS: The intensity of the internal, distributed forces which resist a change in the form of a body. When external forces act on a body they are resisted by reactions within the body which are termed stresses.

TENSILE STRESS: One that resists a force tending to pull a body apart.

COMPRESSIVE STRESS: One that resists a force tending to crush a body.

SHEARING STRESS: One that resists a force tending to make one layer of a body slide across another layer.

TORSIONAL STRESS: One that resists forces tending to twist a body.

TENSILE STRENGTH: The maximum tensile stress which a material will develop. The tensile strength is usually considered to be the load in pounds per square inch at which a test specimen ruptures.

TURBULENCE: Any deviation from parallel flow in a pipe due to rough inner walls, obstructions or directional changes.

VELOCITY: Time rate of motion in a given direction and sense, usually expressed in feet per second.

VOLUME OF A PIPE: The measurement of the space within the walls of the pipe. To find the volume of a pipe, multiply the length (or height) of the pipe by the product of the inside radius times the inside radius by Pi (3.142). Commonly written as $V = h\pi r^2$.

WELDING: A process of joining metals by heating until they are fused together, or by heating and applying pressure until there is a plastic joining action. Filler metal may or may not be used.

YIELD STRENGTH: The stress at which a material exhibits a specified limiting permanent set.

Unit Conversions

FLOW		
1 gpm	=	0.134 cu. ft. per min
	=	500 lb.per hr. x sp. gr.
500 lb. Per hr.	=	1 gpm / sp. gr.
1 cu. Ft. per min. (cfm)	=	448.8 gal. per hr. (gph)
POWER		
l Btu per hr.	=	0.293 watt
	=	12.96 ft. lb. per min.
	=	0.00039 hp
1 ton refrigeration (U.S.)	=	288,000 Btu per 24 hr.
	=	12,000 Btu per hr.
	=	200 Btu per min.
	=	83.33 lb. ice melted per 24 hr. from and at 32°F.
	=	2,000 lb. ice melted per 24 hr. from and at 32°F
1 hp	=	550 ft. lb. per sec.
	=	746 watt
	=	2,545 Btu per hr.
1 boiler hp	=	33,480 Btu per hr.
	=	34.5 lb. water evap. per hr. from and at 212°F
	=	9.8 kw.
1 kw.	=	3,413 Btu per hr.
MASS		
1 lb. (avoir.)	=	16 oz. (avoir.)
	=	7,000 grain
1 ton (short)	=	2,000 lb.
1 ton (long)	=	2,240 lb.
PRESSURE		
1 lb. Per sq. in.	=	3.13 ft. water at 60°F
	=	2.04 in. hg at 60°F
1 ft. water at 60°F	=	.433 lb. per sq. in.
	=	.884 in. hg at 60°F
l in. Hg at 60°F	=	.49 lb. per sq. in.
	=	1.13 ft. water at 60°F
l lb. Per sq. in.	=	lb. per sq. in gauge (psig)
Absolute (psia)	=	14.7

TEMPERATURE		
°C	=	(°F-32) x 5/9
VOLUME		
l gal. (U.S.)	=	128 fl. oz. (U.S.)
	=	231 cu. in.
	=	.833 gal. (Brit.)
1 cu. ft.	=	7.48 gal. (U.S.)
WEIGHT OF WATER		
1 cu. ft. at 50°F.	=	62.41 lb.
l gal. at 50°F.	=	8.34 lb.
1 cu. ft. of ice	=	57.2 lb.
1 cu. ft. at 39.2°F.	=	62.43 lb. Note: Water is at its greatest density at 39.2°F
WEIGHT OF LIQUID		
1 gal. (U.S.)	=	8.34 lb. x sp. gr.
l cu. ft.	=	62.4 lb. x sp. gr.
1 lb.	=	.12 U.S. gal. / sp. gr.
	=	.016 cu. ft. / sp. gr.
WORK		
1 Btu (mean)	=	778 ft. lb.
	=	.293 watt hr.
	=	1/180 of heat required to change temp of 1 lb. water from 32°F to 212°F
1 hp-hr	=	2545 Btu (mean)
	=	.746 kwhr
1 Kwhr	=	3413 Btu (mean)
	=	1.34 hp-hr

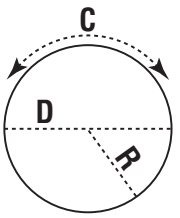
Geometry Formulas

A = Area **A1** = Surface area of solids **V** = Volume
C = Circumference π = Pi (3.14159)

Circle

$A = \pi \bullet R \bullet R$ $C = \pi \bullet D$

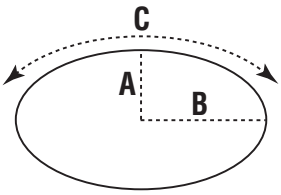
$R = D / 2$ $D = 2 \bullet R$



Ellipse

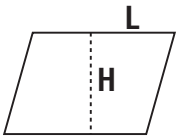
$A = \pi \bullet A \bullet B$

$C = 2 \bullet \pi \bullet \sqrt{\frac{A^2 + B^2}{2}}$



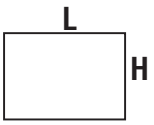
Parallelogram

$A = H \bullet L$



Rectangle

$A = W \bullet L$



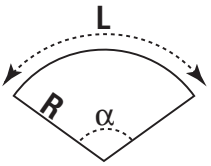
Sector of Circle

$A = (\pi \bullet R^2 \bullet \alpha) / 360$

$L = (\pi \bullet R \bullet \alpha) / 180$

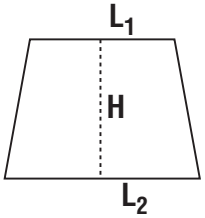
$\alpha = (L \bullet 180) / (\pi \bullet R)$

$R = (L \bullet 180) / (\pi \bullet \alpha)$



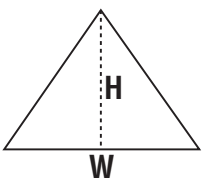
Trapezoid

$A = H \bullet (L_1 + L_2) / 2$



Triangle

$A = (W \bullet H) / 2$

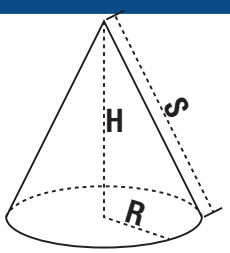


A = Area **A1** = Surface area of solids **V** = Volume
C = Circumference π = Pi (3.14159)

CONE

$A1 = (\pi \bullet R \bullet S) + (\pi \bullet R^2)$

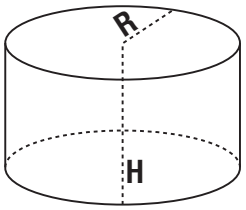
$V = (\pi \bullet R^2 \bullet H) / 3$



CYLINDER

$A1 = (2 \bullet \pi \bullet R^2) + (2 \bullet \pi \bullet R \bullet H)$

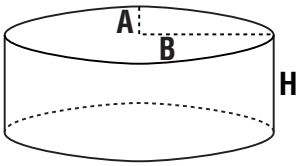
$V = \pi \bullet R^2 \bullet H$



ELLIPTICAL TANKS

$$A1 = 2 \bullet \pi \bullet \sqrt{\frac{A^2 + B^2}{2}} \bullet H = (2 \bullet \pi A \bullet B)$$

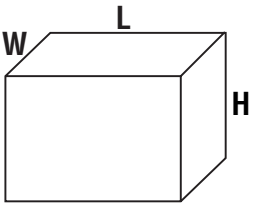
$V = \pi \bullet A \bullet B \bullet H$



RECTANGULAR SOLID

$A1 = 2 \bullet [(W \bullet L) + (L \bullet H) + (H \bullet W)]$

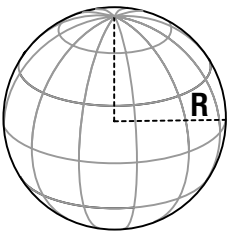
$V = W \bullet L \bullet H$



SPHERE

$A1 = 6 \bullet \pi \bullet R^2$

$V = (4 \bullet \pi \bullet R^3) / 3$



CAPACITY IN GALLONS

For the above contains, capacity in gallons (**G**) is:

$G = (V / 231)$; when V is in cubic inches

$G = (V \bullet 7.48)$; when V is in cubic feet

SIMPLE FLOW RATE

Q = K P 0.5 , where

Q = flow rate (GPM)
K = discharge coefficient of pipe
P = pressure (PSI)

GENERAL VOLUMETRIC FLOW RATE

Q = flow rate (GPM)

D = outlet diameter (Inches)
Cd = discharge coefficient based on outlet geometry
P = pressure (PSI)
Q = 29.8 D 2 Cd P 0.5 , where

PRESSURE TANK SIZING (TANK ABOVE SPRINKLERS)

P = (30/A) - 15, where

P = air pressure in tank (PSI)
A = proportion of air in the tank

PRESSURE TANK SIZING (TANK BELOW SPRINKLERS)

P = [(30/A) - 15] + (0.43 H/A), where

P = air pressure carried in tank (PSI)
A = proportion of air in the tank
H = height of highest sprinkler above tank bottom (Ft)

PRESSURE TANK SIZING (HYDRAULICALLY CALCULATED)

Pi = [(Pf = 15)/A] - 15, where

Pi = tank air pressure to use (PSI)
A = proportion of air in the tank
Pf = system pressure req'd per hydraulic calc. (PSI)

DARCY-WEISBACH FORMULA FOR FRICTION LOSS:

HL = f v 2 /2 g D, where

HL = friction loss (Ft)
Re = Reynolds number
f = friction factor (f=64/Re)
v = water velocity (Ft/Sec)
g = gravitational constant (Ft/Sec^2)
D = pipe diameter (Ft)

HAZEN-WILLIAMS FORMULA FOR PRESSURE LOSS

P = 4.52 Q 1.85 /C 1.85 D 4.87 , where:]

P = pressure loss (PSI) per lineal ft.
Q = flow rate (GPM)
C = friction factor of pipe (constant)
D = internal diameter of pipe (Inches)

Typical "C" values:

Unlined cast or ductile iron 100
Black steel (dry sys.incl.preaction) 100
Black steel (wet sys.incl.deluge) 120
Galvanized (all) 120
Plastic (listed)– all 150
Cement lined cast or ductile iron 140
Copper tube or stainless steel 150

HAZEN-WILLIAMS FORMULA FOR PRESSURE LOSS (IN SI UNITS):

P = 10 5 (6.05) Q 1.85 /C 1.85 D 4.87 , where

P = pressure loss (Bars) per lineal ft
Q = flow rate (Litre/Min)
C = friction factor of pipe (constant)
D = internal diameter of pipe (mm)

PRESSURE VELOCITY:

Pv = 0.001123 Q 2 /D 4 , where

Pv = pressure velocity (PSI)
Q = upstream flow rate (GPM)
D = internal dia. of pipe (Inches)

ESTIMATE – DRY PIPE TRIP TIME:

t = 0.0352 (Vt/An TO 0.5) In(pao/pa), where

t = time (seconds)
Vt = dry volume of sprinkler system(Cu. Ft)
An = flow area of open sprinklers (Sq. Ft)
TO = air temperature (Degrees Rankine)
pao = initial air pressure (absolute)
pa = trip pressure (absolute)

Standard Conversions

To Change	To	Multiply By
Inches	Feet	0.0833
Inches	Millimeters	25.4
Feet	Inches	12
Feet	Yards	0.3333
Yards	Feet	3
Square Inches	Square feet	0.00694
Square feet	Square inches	144
Square feet	Square yards	0.11111
Square yards	Square feet	9
Cubic Inches	Cubic feet	0.00058
Cubic feet	Cubic inches	1728
Cubic feet	Cubic yards	0.03703
Cubic yards	Cubic feet	27
Cubic Inches	Gallons	0.00433
Cubic feet	Gallons	7.48
Gallons	Cubic inches	231
Gallons	Cubic feet	0.1337
Gallons	Pounds of water	8.33
Pounds of water	Gallons	0.12004
Ounces	Pounds	0.0625
Pounds	Ounces	16
Inches of water	Pounds per square inch	0.0361
Inches of water	Inches of mercury	0.0735
Inches of water	Ounces per square inch	0.578
Inches of water	Pounds per square foot	5.2
Inches of mercury	Inches of water	13.6
Inches of mercury	Feet of water	1.1333
Inches of mercury	Pounds per square inch	0.4914
Ounces per square inch	Inches of mercury	0.127
Ounces per square inch	Inches of water	1.733
Pounds per square inch	Inches of water	27.72
Pounds per square inch	Feet of water	2.31
Pounds per square inch	Inches of mercury	2.04
Pounds per square inch	Atmospheres	0.0681
Feet of water	Pounds per square inch	0.434
Feet of water	Pounds per square foot	62.5
Feet of water	Inches of mercury	0.8824
Atmospheres	Pounds per square inch	14.696
Atmospheres	Inches of mercury	29.92
Atmospheres	Feet of water	34
Long tons	Pounds	2240
Short tons	Pounds	2000
Short tons	Long tons	0.89285

Hardness Conversion Numbers

(1) Brinell Indentation Diameter, MM.
(2) Standard or Tungsten Carbide Ball Brinell Hardness No. – 10MM. Ball 3000–KG. Load
(3) Diamond Pyramid Hardness Number. 50-KG. Load
(4) Rockwell Hardness Number B-Scale 100-KG. Load; 1⁄16" Diameter Ball
(5) Rockwell Hardness Number C-Scale 150-KG. Load Brale Penetrator
Rockwell Superficial Hardness Number Superficial Brale Penetrator:
(6) 15-N Scale 15-KG. Load
(7) 30-N Scale 30-KG. Load
(8) 45-N Scale 45-KG. Load
(9) Shore Scleroscope Hardness Number
(10) Tensile Strength (Approx.) 1000 PSI.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2.95	429	455	–	45.7	83.4	64.6	49.9	61	217
3.00	415	440	–	44.5	82.8	63.5	48.4	59	210
3.05	401	425	–	43.1	82.0	62.3	46.9	58	202
3.10	388	410	–	41.8	81.4	61.1	45.3	56	195
3.15	375	396	–	40.4	80.6	59.9	43.6	54	188
3.20	363	383	–	39.1	80.0	58.7	42.0	52	182
3.25	352	372	(110.0)	37.9	79.3	57.6	40.5	51	176
3.30	341	360	(109.0)	36.9	78.6	56.4	39.1	50	170
3.35	331	350	(108.5)	35.5	78.0	55.4	37.8	48	166
3.40	321	339	(108.0)	34.3	77.3	54.3	36.4	47	160
3.45	311	328	(107.5)	33.1	76.7	53.3	34.4	46	155
3.50	302	319	(107.0)	32.1	76.1	52.2	33.8	45	150
3.55	293	309	(106.0)	30.9	75.5	51.2	32.4	43	145
3.60	285	301	(105.5)	29.9	75.0	50.3	31.2	–	141
3.65	277	292	(104.5)	28.8	74.4	49.3	29.9	41	137
3.70	269	284	(104.0)	27.6	73.7	48.3	28.5	40	133
3.75	262	276	(103.0)	26.6	73.1	47.3	27.3	39	129
3.80	255	269	(102.0)	25.4	72.5	46.2	26.0	38	126
3.85	248	261	(101.0)	24.2	71.7	45.1	24.5	37	122
3.90	241	253	100.0	22.8	70.9	43.9	22.8	36	118
3.95	235	247	99.0	21.7	70.3	42.9	21.5	35	115
4.00	229	241	98.2	20.5	69.7	41.9	20.1	34	111
4.05	223	234	97.3	(18.8)	–	–	–	–	-
4.10	217	228	96.4	(17.5)	–	–	–	33	105
4.15	212	222	95.5	(16.0)	–	–	–	–	102
4.20	207	218	94.6	(15.2)	–	–	–	32	100
4.25	201	212	93.8	(13.8)	–	–	–	31	98
4.30	197	207	92.8	(12.7)	–	–	–	30	95
4.35	192	202	91.9	(11.5)	–	–	–	29	93
4.40	187	196	90.7	(10.0)	–	–	–	–	90
4.45	183	192	90.0	(9.0)	–	–	–	28	89
4.50	179	188	89.0	(8.0)	–	–	–	27	87
4.55	174	182	87.8	(6.4)	–	–	–	–	85
4.60	170	178	86.8	(5.4)	–	–	–	26	83
4.65	167	175	86.0	(4.4)	–	–	–	–	81
4.70	163	171	85.0	(3.3)	–	–	–	25	79
4.80	156	163	82.9	(0.9)	–	–	–	–	76
4.90	149	156	80.8	–	–	–	–	23	73
5.00	143	150	78.7	–	–	–	–	22	71
5.10	137	143	76.4	–	–	–	–	21	67
5.20	131	137	74.0	–	–	–	–	–	65
5.30	126	132	72.0	–	–	–	–	20	63
5.40	121	127	69.8	–	–	–	–	19	60
5.50	116	122	67.6	–	–	–	–	18	58
5.60	111	117	65.7	–	–	–	–	15	56

Note: Values in () are beyond normal range; given for information only.

Coated Arc Welding Electrodes - Types & Styles

A. W. S.
Classification

E60**10** — **Direct Current, Reverse polarity, All Positions.**
All purpose. Moderately smooth finish. Good penetration. This is the electrode used for most carbon steel pipe welding.

E60**11** — **Alternating Current, All Positions.**
All purpose. Moderately smooth finish. Good penetration.

E60**12** — **Direct Current, Straight Polarity, All Positions.**
High bead. Smooth. Fast. "Cold rod".

E60**13** — **Alternating Current, All Positions.**
High bead. Smooth. Fast. "Cold rod".

E60**15** — **Direct Current, Reverse polarity, All Positions.**
"Low hydrogen" electrode.

E60**16** — **Direct Current or Alternating Current, All Positions**
"Low hydrogen" electrode.

E60**18** — **Direct Current, All Positions**
"Low hydrogen" iron powder electrodes

E60**20** — **Direct Current, Straight Polarity, Flat Position Only.**
Flat bead. Smooth. Fast. Deep penetration. Can be used with A.C. also. "Hot rod".

E60**24** and E60**27** — **Direct Current, Straight Polarity or Alternating and Current, Flat Position Only. Flat bead. Smooth. Fast. Deep penetration.**
"Iron powder electrodes".

NOTE: This information also applies to E70, E80, E90, and E100 Series.

The last two numbers (in bold type) designate the types or styles and the first two numbers the minimum specified tensile strength in 1,000 psi of the weld deposit as welded.

Physical Properties of E60 & E70 Series Electrodes

TYPICAL VALUES				
AWS ASTM Electrode	Tensile Strength	Yield Strength	Elongation	Red. in Area Min. %
E6010	62,000–70,000	52,000–58,000	22 to 28%	35
E6011	62,000–73,000	52,000–61,000		
E6012	68,000–78,000	55,000–65,000	17 to 22%	25

MINIMUM VALUES			
AWS ASTM Electrode	Tensile Strength	Yield Strength	Elongation
E7010	70,000	57,000	22
E7011	70,000	57,000	22
E7015	70,000	57,000	22
E7016	70,000	57,000	22
E7020	70,000	52,000	25

WELDING AND BRAZING TEMPERATURES	
Carbon Steel Welding	2700–2790°F
Stainless Steel Welding	2490–2730°F
Cast Iron Welding	1920–2500°F
Copper Welding and Brazing	1980°F
Brazing Copper-Silicon with Phosphor-Bronze	1850–1900°F
Brazing Naval Bronze with Manganese Bronze	1600–1700°F
Silver Solder	1175–1600°F
Low Temperature Brazing	1175–1530°F
Soft Solder	200–730°F
Wrought Iron	2700–2750°F

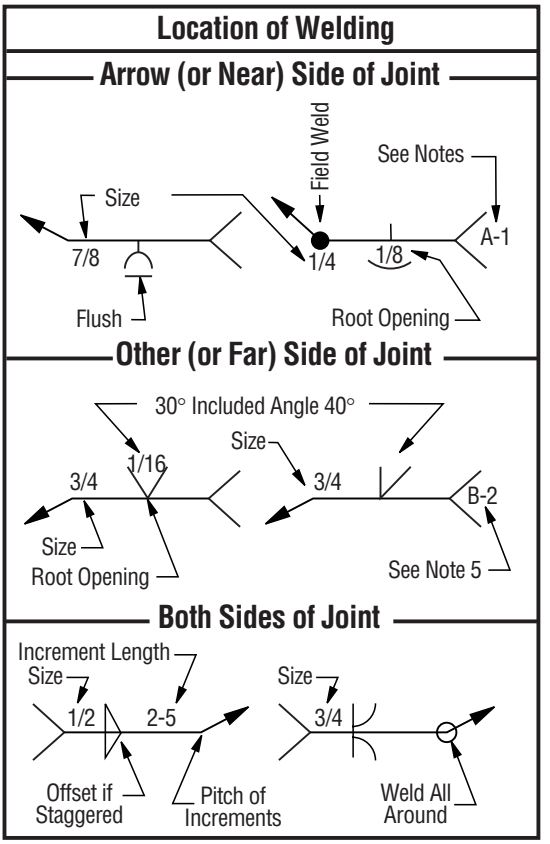
Trouble Shooting Arc Welding Equipment

Problem: Welder will not start (Starter not operating)	
Cause:	Power circuit dead.
Remedy:	Check voltage.
Cause:	Broken power lead.
Remedy:	Repair.
Cause:	Wrong supply voltage.
Remedy:	Check nameplate against supply.
Cause:	Open power switches
Remedy:	Close.
Cause:	Blown fuses.
Remedy:	Replace.
Cause:	Overload relay tripped.
Remedy:	Let set cool. Remove cause of overloading.
Cause:	Open circuit to starter button.
Remedy:	Repair.
Cause:	Defective operating coil.
Remedy:	Replace.
Cause:	Mechanical obstruction in contactor.
Remedy:	Remove.
Problem: Welder will not start (Starter operating)	
Cause:	Wrong motor connections.
Remedy:	Check connection diagram.
Cause:	Wrong supply voltage.
Remedy:	Check nameplate against supply.
Cause:	Rotor stuck.
Remedy:	Try turning by hand.
Cause:	Power circuit single-phased.
Remedy:	Replace fuse; repair open line.
Cause:	Starter single-phased.
Remedy:	Check contact of starter tips.
Cause:	Poor motor connection.
Remedy:	Tighten.
Cause:	Open circuit in windings.
Remedy:	Repair.
Problem: Starter operates and blows fuse	
Cause:	Fuse too small.
Remedy:	Should be two to three times rated motor current.
Cause:	Short circuit in motor connections.
Remedy:	Check starter and motor leads for insulation from around and from each other.

Problem: Welder runs but soon stops	
Cause:	Wrong relay heaters
Remedy:	Renewal part recommendations
Cause:	Welder overloaded
Remedy:	Considerable overlaod can be carried only for a short time
Cause:	Duty cycle too high
Remedy:	Do not operate continually at overload currents
Cause:	Leads too long or too narrow in cross section
Remedy:	Should be large enough to carry welding current without excessive voltage drop
Cause:	Power circuit single-phased
Remedy:	Check for one dead fuse or line
Cause:	Ambient temperature too high
Remedy:	Operate at reduced loads where temperature exceeds 100° F
Cause:	Ventilation blocked
Remedy:	Check air inlet and exhaust openings
Problem: Welding arc is loud and spatters excessively	
Cause:	Current setting too high
Remedy:	Check setting and output with ammeter
Cause:	Polarity wrong
Remedy:	Check polarity, try reversing, or an electrode of opposite polarity
Problem: Welding arc sluggish	
Cause:	Current too low
Remedy:	Check output, and current recommended for electrode being used
Cause:	Poor connections
Remedy:	Check all electrode-holder, cable and ground-cable connections. Strap iron is poor ground return
Cause:	Cable long or too small
Remedy:	Check cable voltage drop and change cable
Problem: Touching set gives shock	
Cause:	Frame not grounded
Remedy:	Ground solidly
Problem: Generator control fails to vary current	
Cause:	Any part of field circuit may be short circuited or open circuited
Remedy:	Find faulty contact and repair

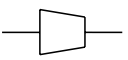
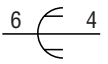
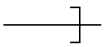
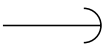
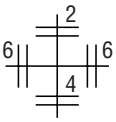
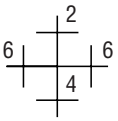
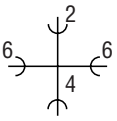
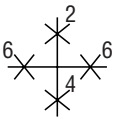
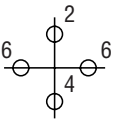
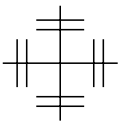
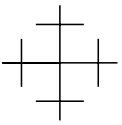
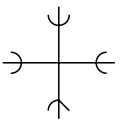
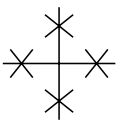
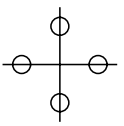
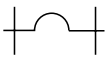
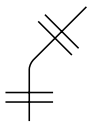
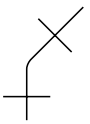
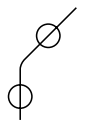
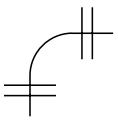
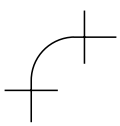
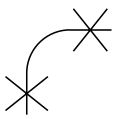
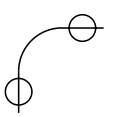
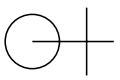
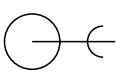
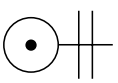
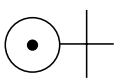
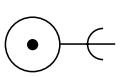
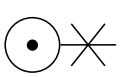
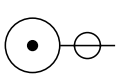
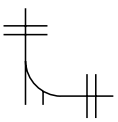
Problem:	**Welder starts but will not deliver welding current**
Cause:	Wrong direction of rotation
Remedy:	See INITIAL STARTING
Cause:	Brushes worn or missing
Remedy:	Check that all brushes bear on commutator with sufficient tension
Cause:	Brush connections loose
Remedy:	Tighten
Cause:	Open field circuit
Remedy:	Check connection to rheostat, resistor, and auxiliary brush studs
Cause:	Series field and armature circuit open
Remedy:	Check with test lamp or bell ringer
Cause:	Wrong driving speed
Remedy:	Check name plate against speed of motor or belt drive
Cause:	Dirt, grounding field coils
Remedy:	Clean and reinsulate
Cause:	Welding terminal shorted
Remedy:	Electrode holder or cable grounded
Problem:	**Welder generating but current falls off when welding**
Cause:	Electrode or ground connection loose
Remedy:	Clean and tighten all connections
Cause:	Poor ground
Remedy:	Check ground-return circuit
Cause:	Brushes worn worn off
Remedy:	Replace with recommended grade. Sand to fit. Blow out carbon dust.
Cause:	Weak brush spring pressure.
Remedy:	Replace or readjust brush springs
Cause:	Brush not properly fitted
Remedy:	Sand brushes to fit
Cause:	Brushes in backwards
Remedy:	Reverse
Cause:	Wrong brushes used
Remedy:	Renewal part recommendations
Cause:	Brush pigtails damaged
Remedy:	Replace brushes
Cause:	Rough or dirty commutator
Remedy:	Turn down or clean commutator
Cause:	Motor connection single-phased
Remedy:	Check all connections

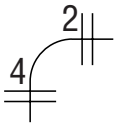
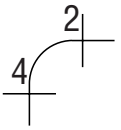
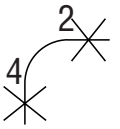
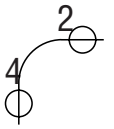
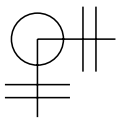
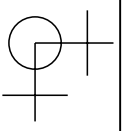
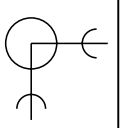
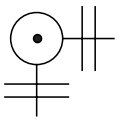
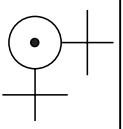
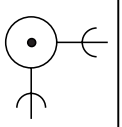
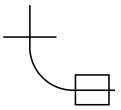
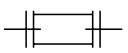
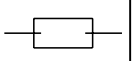
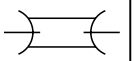
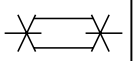
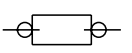
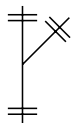
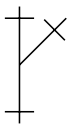
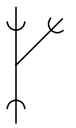
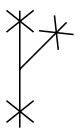
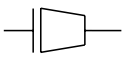
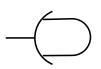
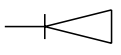
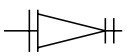
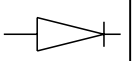
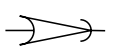
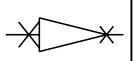
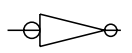
Type of Weld			
Groove Bead	Groove Fillet	Groove Square	Groove "V"
Groove Bevel	Groove "U"	Groove "J"	Plug & Slot
Field Weld	Weld All Around	Flush	



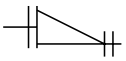
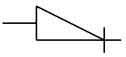
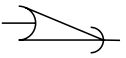
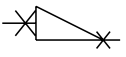
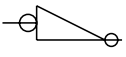
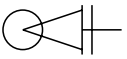
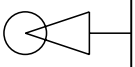
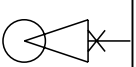
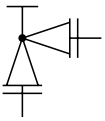
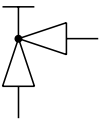
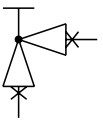
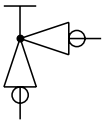
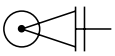
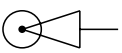
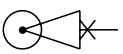
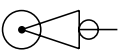
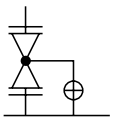
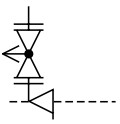
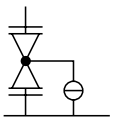
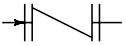
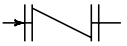
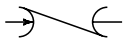
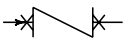
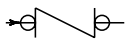
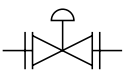
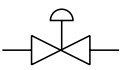
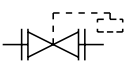
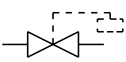
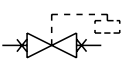
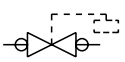
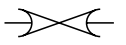
1. In plan or elevation, near, far, and both sides, locations refer to nearest member parallel to plane of drawing and not to others farther behind.
2. In section or end views only, when weld is not drawn, the side to which arrow points is considered near side.
3. Welds on both sides are of same size unless otherwise shown.
4. Symbols govern to break in continuity of structure or to extent of hatching or dimension lines.
5. Tail of arrow used for specification reference.
6. All welds are continuous and of user's standard propertions and all except V-grooved and bevel-grooved welds are closed unless otherwise shown.
7. When welds are drawn in section or end views, obvious information is not given by symbol.
8. In joints in which one member only is to be grooved, arrows point to that member.

Symbols For Pipe Fittings

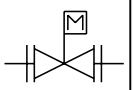
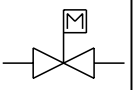
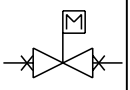
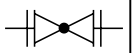
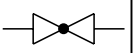
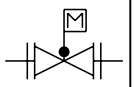
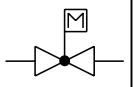
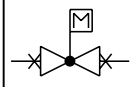
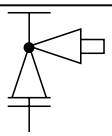
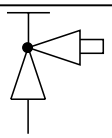
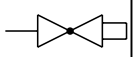
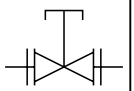
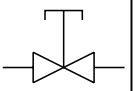
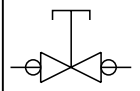
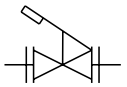
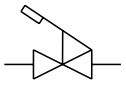
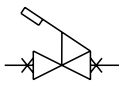
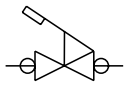
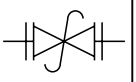
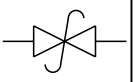
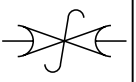
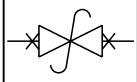
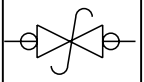
	Flanged	Screwed	Bell And Spigot	Welded	Soldered
Bushing					
Cap					
Cross (Reducing)					
Cross (Straight)					
Crossover					
Elbow - 45°					
Elbow - 90°					
Elbow - Turned Down					
Elbow - Turned Up					
Elbow - Base					
Elbow - Double Branch					
Elbow - Long Radius					

	Flanged	Screwed	Bell And Spigot	Welded	Soldered
Elbow - Reducing					
Elbow - Side Outlet (Outlet Down)					
Elbow - Side Outlet (OutletUp)					
Elbow - Street					
Joint - Conn. Pipe					
Joint - Expansion					
Lateral					
Orifice Plate					
Reducing Flange					
Plug - Bull					
Plug - Pipe					
Reducer - Concentric					

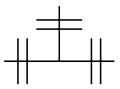
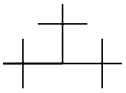
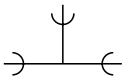
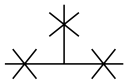
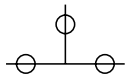
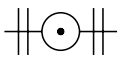
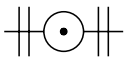
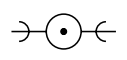
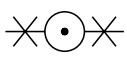
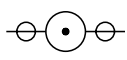
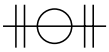
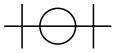
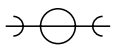
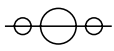
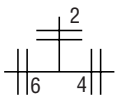
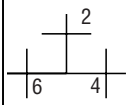
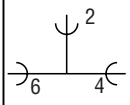
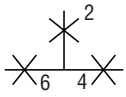
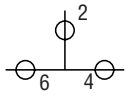
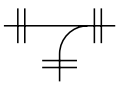
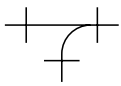
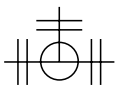
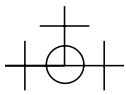
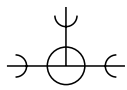
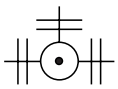
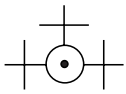
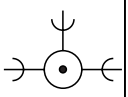
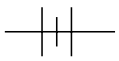
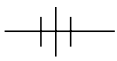
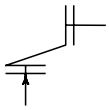
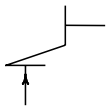
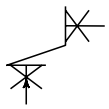
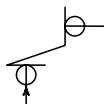
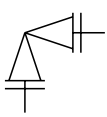
Symbols For Pipe Fittings

	Flanged	Screwed	Bell And Spigot	Welded	Soldered
Reducer - Eccentric					
Valve - Gate Angle Gate (Plan)					
Valve - Globe Angle Globe (Elevation)					
Valve - Globe (Plan)					
Valve (Auto)- B-Pass					
Valve (Auto)- Governor Oper.					
Valve - Reducing					
Valve - Check (Straight Way)					
Valve - Cock					
Valve - Diaphragm					
Valve - Float					
Valve - Gate*					

*Also used for General Stop Valve when amplified by specification.

	Flanged	Screwed	Bell And Spigot	Welded	Soldered
Valve - Gate Motor Operated					
Valve - Globe					
Valve - Globe Motor Operated					
Valve - Angle Hose Angle					
Valve - Hose Gate					
Valve - Hose Globe					
Valve - Lockshield					
Valve - Quick Opening					
Valve - Saftey					
Sleeve					

Symbols For Pipe Fittings

	Flanged	Screwed	Bell And Spigot	Welded	Soldered
Tee - Straight					
Tee - Outlet Up					
Tee - Outlet Down					
Tee - Double Sweep					
Tee - Reducing					
Tee - Single Sweep					
Tee - Side Outlet (Outlet Down)					
Tee - Side Outlet (Outlet Up)					
Union					
Angle Valve Check					
Angle Valve Gate					

OVERVIEW

Strength of wire ropes vary, depending on the material from which the individual strands are made and the method used in forming the cable, ranging between 30 and 100 tons per square inch. Primarily there are 3 classes of wire rope:

(1) Iron – Iron wire is soft with low tensile strength of 30 to 40 tons per square inch. Commonly used for drum type elevator cables and to some extent for derrick guys; being replaced by low-carbon steel wire in these uses.

(2) Cast Steel – May have a tensile strength up to 90 tons per square inch and because of its greater strength is generally used for hoisting purposes. To check quickly whether a piece of wire is iron or cast steel, bend it. Iron will bend easily and take a long time to regain its original shape, while cast steel will be harder to bend and will snap back to its original shape very quickly.

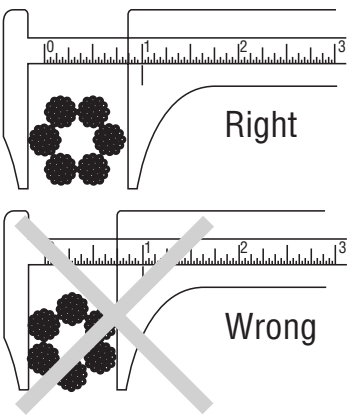
(3) Plow Steel - Plow steel wire rope is made from high grade, open hearth furnace steel and has an average tensile strength of 110 tons per square inch. This is the best and safest wire rope for cranes, derricks, dredges and slings or straps for heavy loads.

LUBRICATION — WIRE ROPE

All wire rope, whether used indoors or out, should be considered as a group of moving wires constantly rubbing against one another. The resulting friction causes incessant wear on the moving parts of the wire rope or cable and will shorten its life very rapidly unless lubricants are used to overcome the friction. Lubrication also prevents rusting.

Lubricating intervals will depend on the types and amount of work encountered. Under average conditions, if worked steadily on equipment, wire rope or cable will require lubrication once every 3 weeks. Where heavy abrasive dusts exist, more frequent lubrication is in order. Rusty ropes may break without warning.

Wire rope is usually larger than the nominal diameter and may exceed the nominal diameter by the amounts shown in the U.S. Federal Specification for Wire Rope.



SHEAVES

The life of wire rope or cable is directly affected by the condition and size of the sheaves over which it is used. Sheaves should be at least 16 x the diameter of the rope or cable that is used over them. In passing over a sheave, the inside portion of the cable, which is against the sheave, is shortened and compression is developed in that section of the cable. The outside portion (away from the sheave) is lengthened or stretched, causing tension in that section. These compressive and tensional stresses

combine to create bending stresses which increase rapidly as the diameter of the sheaves decrease. As these bending stresses cause much undue wear and directly shorten the safe working life of the rope or cable, the ratio mention between sheaves and rope should be maintained.

New wire rope may be damaged and not work properly in sheaves that have become worn or in which the grooves have become irregular in shape. When sheaves are worn or damaged, it is more economical to renew the sheaves rather than to allow excessive wear on the cable.

One cause of very severe wear in wire rope or cables is reverse bending, which will shorten the life of the rope by approximately ½. Reverse bending refers to the bending of a cable or rope over sheaves, first in one direction then in another.

Another cause of severe rope wear is twisting of the fall rope. When the fall rope is twisted and a hoist is made, the wear produced is equal to more than that resulting from weeks of normal use. The person in charge of lifting operations should guard against twisting of the fall rope and should not allow a lift to be made if the fall rope is twisted.

Handling Cable or Wire Rope

Cable or wire rope must not be coiled or uncoiled like manila rope. Cable or wire rope must be taken off the reel in a straight line, avoiding kinking. The reel may be mounted on a heavy pipe or roller to facilitate unwinding. If space is limited, the cable as it comes off the reel may be layed out in a figure 8, after which it can be reeved into the line for which it is intended.

Clamp Fastenings

When it is necessary to make a short bend. as in attaching wire rope or when it is to be looped. thimbles should always be used.

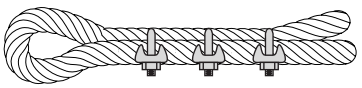
In clamping a strap or an eye, the loose or “dead” end is clamped against the main part of the rope with the damps spaced apart a distance equal to 6 x diameter of the rope. Clamp fastenings seldom develop more than 4⁄5 of rope strength at best.

The point of greatest fatigue and/or wear in a rope usually develops at or near the end where it is clamped around the boom or where attached to the becket on the block. Clamps should be inspected at least once weekly and tightened if they show signs of loosening. All clamped or spliced fastenings, especially those on cranes or derricks, should be shifted and changed at least once every six months.

No. of Crosby or Safety Clips and Dist. Between Clips Needed for Safety

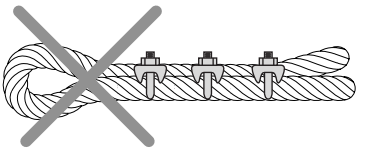
Rope Dia. Inches	No. of Clips	Dist. Between Clips, Inches
1/4 –3/8	3	2 1/4
7/16 –5/8	3	3 3/4
3/4 – 1 1/8	4	6 3/4
1 1/4 – 1 1/2	5	9
1 5/8 – 1 3/4	6	10 1/2
2 and over	7	6 x diam. of cable

U BOLTS OF ALL CLAMPS MUST BE ON THE DEAD END OF THE ROPE

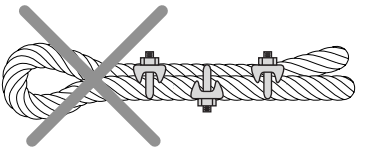


CORRECT - U-Bolts on short end of rope. (No distortion on live end of rope.)

INCORRECT - U-Bolts on live end of rope. (Causes mashed spots on live end of rope.)

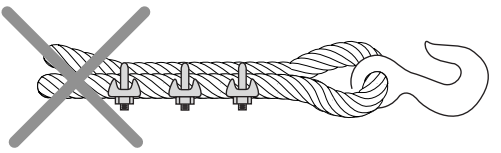


INCORRECT - Staggered clips. (Causes a mashed spot in live end of rope due to incorrect position of center clip.)

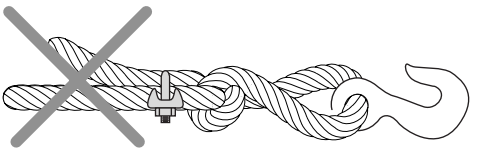


CORRECT

INCORRECT - Thimble should be used to increase strength of eye and reduce wear on rope.



INCORRECT - Wire rope knot with clip efficiency 50% or less



SAFE LOAD (IN POUNDS) ON IMPROVED PLOW STEEL WIRE ROPE
(6 STRANDS. 19 OR 37 WIRES PER STRAND. HEMPCORE)

DIA. INCHES	CIRCUM. INCHES	SINGLE VERTICLE WIREROPE	TWO PART SLING 60°	TWO PART SLING 45°	TWO PART SLING 30°	WT./FT. LBS.	BREAKING STRENGTH TONS (2000 LBS)
1/4	3/4	1,100	1,900	1,550	1,100	0.10	2.74
3/8	1 1/8	2,500	4,230	3,460	2,450	0.23	6.1
1/2	1 1/2	4,300	7,450	6,080	4,300	0.40	10.7
5/8	2	6,600	11,600	9,430	6,670	0.63	16.7
3/4	2 1/4	9,400	16,500	13,450	9,520	0.90	23.8
7/8	2 3/4	12,800	22,300	18,200	12,800	1.23	32.2
1	3	16,000	29,000	23,690	16,790	1.60	41.8
1 1/8	3 1/2	21,000	36,450	29,780	21,040	2.03	52.6
1 1/4	4	26,000	44,700	36,570	25,870	2.50	64.6
1 3/8	4 1/4	31,000	53,800	43,900	31,050	3.03	77.7
1 1/2	4 3/4	37,000	63,700	52,000	36,800	3.60	92.0
1 5/8	5	43,000	74,400	60,700	42,900	4.23	107.0
1 3/4	5 1/2	49,600	86,000	70,260	49,700	4.90	124.0
2	6 1/4	64,000	110,700	90,400	64,000	6.40	160.0
2 1/8	6 5/8	63,000	125,200	102,200	72,200	7.22	181.0
2 1/4	7 1/8	81,000	140,300	114,600	79,000	8.10	202.0
2 1/2	7 7/8	98,000	170,000	139,100	98,400	10.00	246.0
2 3/4	8 5/8	117,600	203,500	166,700	117,700	12.10	294.0