HANDBOOK
OF
CAST IRON PIPE

CAST IRON PIPE RESEARCH ASSOCIATION

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CORRECTIONS

Handbook of Cast Iron Pipe

SINCE the publication of the Handbook in 1927 some typographical errors have been discovered and certain changes in standards have been made. For these reasons it has been deemed advisable to issue this pamphlet in order to bring the corrections to the attention of those to whom the handbook has been issued. The corrections are listed in the order in which they appear in the book. The holder of each book is advised to make the corrections in his copy preferably in red ink. In cases where an entire page is changed, the revised page will be found in the back of the pamphlet printed on one side only so that it can be pasted in the proper place in the book.

THE CAST IRON PIPE RESEARCH ASSOCIATION
122 S. Michigan Ave.
Chicago

Changes and Corrections

PAGE 5—First line under table of contents:

Change "Pages 330 to 335" to read "PAGES 329 To 336."

PAGE 36—Seventh line from bottom of page:

Change "left hand" to read "RIGHT HAND."

Sixth line from bottom of page:

Change "right" to read "LEFT."

PAGE 37—Under cut:

Change "patterns in place" to read "CORE IN PLACE READY FOR POURING" and change "core in place ready for pouring" to read "PATTERNS IN PLACE."

PAGE 50—Fourth line from top of page:

Change "Publicity Bureau" to read "RESEARCH ASSOCIATION."

PAGE 66—Fourth line from bottom of page:

Change "page 72" to read "PAGES 72 AND 74."

PAGE 68—Add following to table 1:

Nom. Dia. Inches	Dimensions, Inches									
	Class	A	B	C	D	E	F	G	T	W
72	D	77.74	78.99	88.99	2.25	5.50	3.09	.63	2.82	78.24
84	C	89.58	90.83	100.83	2.50	5.50	3.12	.63	2.74	90.08
84	D	90.58	91.83	102.83	2.50	5.50	3.62	.63	3.24	91.08

PAGE 69—Two new tables will replace the one on this page. Table 2 shows low pressure lugs and 2a high pressure lugs. These tables will be found on pages 9 and 11 of this pamphlet.

PAGE 70—Add following weights for 4″ 5-Meter Pipe:

Class A—19.8 lbs. per ft. 325 lbs. per length.

Class B—21.3 lbs. per ft. 350 lbs. per length.

PAGE 71—Add following weights for 4″ 5-Meter Pipe:

Class C—22.9 lbs. per ft. 375 lbs. per length.

Class D—24.4 lbs. per ft. 400 lbs. per length.

Add following dimensions for 84″ Class "C" Pipe:

Thickness, Inches	Weight of 12-ft. Length Foot	Length
2.74	2596.4	31,165

Add 72″ and 84″ Class "D" Pipe:

Size	Thickness, Inches	Weight of 12-ft. Length Foot	Length
72″	2.82	2260.9	27,137
84″	3.24	3084.6	37,023

PAGE 75—A table showing dimensions of 72″ and 84″ Bells is shown on page 13 of this pamphlet. This table should be cut out and pasted on page 75.

PAGE 76—Last line:

Change "page 83" to "PAGE 88."

PAGE 78—On cut of Base Ell show dimension H from bottom of base to center line of pipe.

To table of Base Ells add following:

BASE ELLS

Size of Fitting	H	X	Width of Base	Z
30	21.75	30	30	1.38
36	25.50	30	30	1.72
42	28.75	42	42	1.78
48	32.25	42	42	2.00
54	36.00	48	48	2.25
60	39.00	48	48	2.38

PAGE 79—Add following Y Branches to table:

Size	A	S	Size	A	S
48x24	62.00	13.50	60x24	78.00	12.00
54x24	74.00	14.00	60x30	84.00	15.00
54x30	78.00	18.00	60x36	88.00	19.00
54x36	82.00	21.00	60x42	93.00	24.00
54x42	87.00	24.00	60x48	96.00	29.00
54x48	91.00	34.00	60x54	101.00	32.00
54x54	97.00	39.00	60x60	106.00	36.00

PAGE 79—Fifth line from bottom:

Change "page 92" to read "PAGES 92 and 93."

PAGE 82—Last line:

Change "page 98" to "PAGES 97 and 98."

PAGE 83—Show diameter of manhole as 20".

Change dimensions A and S to read as follows:

Size	Blow-Off Branches With Manhole	Manhole Pipe Without Blow-Off Branches	
	A	A	S
30	21	21	36
36	21	21	36
42	21	21	36
48	21	21	36
54	28	28	46
60	28	28	46

Add line at bottom of page:

Approximate weight of 20" blind flange 227 lbs."

PAGE 85—Middle of page change (all classes) to read (CLASSES A TO D).

Change heading of last table on page from "Table No. 16 (continued)" to read "TABLE No. 16 A."

Change letter at top of fourth column of table 16 A from "S" to "N."

PAGE 112—First column:

Insert asterisk before 3" and at bottom of page have asterisk indicate this note:

"NO AMERICAN GAS ASSOCIATION STANDARD FOR 3" PIPE."

Change per foot weights of 4", 6" and 8" Pipe to read: 19.50, 30.58 and 42.42 respectively.

PAGE 113—Change per foot weights of 4", 6" and 8" Pipe to read:

19.5, 30.6 and 42.7 respectively.

PAGE 114—Paste page 15 of this pamphlet over this page.

PAGE 118—Insert note between drawings of Cap and Plug saying:

"LUG FURNISHED ON SIZES 20" To 48"."

PAGE 119—Change dimension C to read as indicated below:

16x12	- 24.5	24x20	- 26.0
20x10	- 50.0	30x20	- 50.5
20x12	- 41.5	48x36	- 59.0
20x16	- 25.5	48x42	- 35.0
24x16	- 42.0		

Last Line:

Change word "greater" to "LESS."

PAGE 140—Change caption under cut at top of pipe from "type 1" to "TYPE 2."

Change caption under cut at bottom of page from "type 2" to "TYPE 1."

Transpose type numbers in columns showing weight of lead per joint.

Substitute following weights in place of those shown on this page:

Size Inches	Class	Weight per Length Pounds	Size Inches	Class	Weight per Lenght Pounds
6	B	Weights will be furnished on application	16	D	Weights will be furnished on application
6	D		18	B	
8	B		18	D	
8	D		20	B	
10	B		20	D	
10	D		24	B	
12	B		24	D	
12	D		30	B	
14	B		30	D	
14	D		36	B	
16	B		36	D	

PAGE 141—Under cut at top of page, insert "TYPE 5."
Add 14″ size to table as follows:

Size Inches	Thickness Inches	Radius R Inches	Gib Screws Diameter Inches	Gib Screws Number	Weight Pounds
14	.82	9.50	13/16	16	1903

PAGE 147—Change lengths of bolts as follows:

Nominal Size Pipe

1¼″	Change length of bolt from 1¾″ to 1½″.
1½″	Change length of bolt from 2″ to 1¾″.
16″	Change length of bolt from 4″ to 4¼″.

PAGE 149—Change diameter of raised faces as follows:

Nominal Size Inches	Diameter of Raised Face Inches	Nominal Size Inches	Diameter of Raised Face Inches
1	2 11/16	10	14 1/16
1¼	3 1/16	12	16 7/16
1½	3 9/16	14 O. D.	18 15/16
2	4 3/16	16 O. D.	21 1/16
2½	4 15/16	18 O. D.	23 5/16
3	5 11/16	20 O. D.	25 9/16
3½	6 5/16	24 O. D.	30 5/16
4	6 15/16	30 O. D.	37 3/16
5	8 5/16	36 O. D.	43 11/16
6	9 11/16	42 O. D.	50 7/16
8	11 15/16	48 O. D.	58 7/16

Change length of bolts as follows:

Nominal Size Pipe

1″	Change length of bolt from 2″ to 2¼″
1¼″	Change length of bolt from 2¼″ to 2½″
2″	Change length of bolt from 3″ to 2½″
12″	Change length of bolt from 5¼″ to 5½″
14″	Change length of bolt from 5½″ to 5¾″

PAGE 151—Change diameter of raised faces as follows:

Size	Diameter of Raised Face M	Size	Diameter of Raised Face M
1	2 11/16	6	9 11/16
1¼	3 1/16	8	11 5/16
1½	3 9/16	10	14 1/16
2	4 3/16	12	16 7/16
2½	4 15/16	14	18 15/16
3	5 11/16	16	21 1/16
3½	6 5/16	18	23 5/16
4	6 15/16	20	25 9/16
5	8 5/16	24	30 5/16

PAGE 152—Make following changes in tables:

125 LB. STANDARD

Nominal Diameter	
3½″	Change number of bolts from 4 to 8
16″	Change size of bolts from 1x4 to 1x4¼

250 LB. STANDARD

Nominal Diameter	
2½″	Change number of bolts from 4 to 8
12″	Change size of bolts from 1⅛x5¼ to 1⅛x5½
14″	Change size of bolts from 1⅛x5½ to 1⅛x5¾
20″	Change size of bolts from 1⅜x6½ to 1¼x6½
24″	Change size of bolts from 1⅝x7½ to 1½x7½
20″	Change outside diameter of ring gasket from 25⅝ to 25¾
24″	Change outside diameter ring gasket from 30⅜ to 30½

PAGE 155—This entire page will be replaced by page 17 of this pamphlet. The revised page should be pasted over page 155 of the Handbook.

PAGE 157—Under cut:

Change "D = P(.80C − 6.8)" to read "D = P(.80C + 6.8)"

PAGE 158—Change External Diameter of 5″ Pipe from "5.363" to "5.563."

PAGE 164—Add following note:

"125 lb. and 250 lb. Flanged Standard have been adopted as Standard by the American Standards Association. The 25 lb. Flanged Standard has not yet been adopted, but in all probability the revised dimensions given in this correction pamphlet will be adopted."

PAGE 170—This entire page will be replaced by page 19 of this pamphlet. The revised page should be pasted over page 170 of the Handbook.

Laying dimensions of short body Tees and Crosses should be added. They are shown on page 21 of this pamphlet.

PAGE 172—Cross out entire paragraph entitled "Dimensions" American 25 lb. Standard.

PAGE 175—Remove asterisks in last column opposite following:

18x18x12
20x20x12
20x20x14
24x24x14
24x24x16

PAGE 176—Change size 5 x 6 x 3½ to read 5 x 5 x 3½.

PAGE 185—This entire page will be replaced by page 23 of this pamphlet. The revised page should be pasted over page 185 of the Handbook.

PAGE 186—Seventh column:

Change word "long" to "SHORT."

Add dimension A for 54″ and 60″ 90° Bends. This dimension is 60″ in both cases.

PAGE 188—Last column:

Change word "long" to "SHORT."

Add weights of 90° Bends (third column) as follows:

Size	Class	90° Bends	Size	Class	90° Bends
42	A	3835	54	A	7192
42	B	4294	54	B	8011
42	C	4960	54	C	9460
42	D	5584	54	D	10845
48	A	4930	60	A	8342
48	B	5393	60	B	9605
48	C	6237	60	C	11114
48	D	6981	60	D	12882

PAGE 212—Last line:

Change "96% lead, 5% tin and 2% antimony" to "95% LEAD, and 5% TIN."

PAGE 221—About middle of page:

Change "page 194" to "PAGE 210."

PAGE 234—The paragraph shown on page 13 of this pamphlet should be pasted on this page.

PAGES 246, 247, 248—CEMENT LINING SPECIFICATION:

For this entire specification substitute the one shown on pages 24 to 29 of this pamphlet.

PAGE 251—12th line from bottom:

Change "150+7.5" to read "150÷7.5."

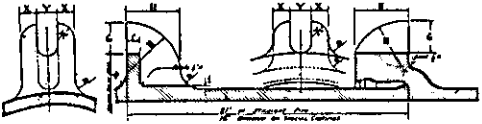
PAGE 258—Under 84″ Pipe:

Change Velocity in feet per second.

From 0.78 to 1.21	From 2.60 to 4.02
From 0.91 to 1.41	From 3.12 to 4.82
From 1.04 to 1.61	From 3.64 to 5.64
From 1.17 to 1.81	From 4.16 to 6.44
From 1.30 to 2.01	From 4.68 to 7.26
From 1.56 to 2.41	From 5.20 to 8.04
From 1.82 to 2.82	From 5.72 to 8.86
From 2.08 to 3.22	From 6.24 to 9.64
From 2.34 to 3.65	From 6.76 to 10.45

Cut along dotted lines

Standard Lugs for A. W. W. A.
Bell and Spigot Pipe and Fittings



Classes A to D

Table No. 2

Nominal Diameter Pipe	Class	Number of Lugs Each End	Dimensions Inches G	H	X	Y	Size of Bolt	Length of Bolt	Weight of Lugs, Pounds One Bell	One Spigot
8	AB	4	2½	4	1¼	1⅝	1⅝	24½	32	42
8	CD	4	2½	4	1¼	1⅝	1⅝	24½	32	43
10	AB	4	2½	4	1¼	1⅝	1⅝	24½	32	43
10	CD	4	2½	4	1¼	1⅝	1⅝	24½	32	44
12	AB	4	2½	4	1¼	1⅝	1⅝	24½	32	44
12	CD	4	2½	4	1¼	1⅝	1⅝	24½	32	45
14	AB	4	2½	4	1¼	1⅝	1⅝	24½	32	45
14	CD	4	2½	4	1¼	1⅝	1⅝	24½	32	46
16	AB	6	2½	4	1¼	1⅝	1⅝	24½	56	71
16	CD	6	2½	4	1¼	1⅝	1⅝	24½	56	73
18	AB	6	2½	4	1¼	1⅝	1⅝	24½	56	73
18	CD	6	2½	4	1¼	1⅝	1⅝	24½	56	76
20	AB	6	2½	4	1¼	1⅝	1⅝	24½	56	75
20	CD	6	2½	4	1¼	1⅝	1⅝	24½	56	80
24	AB	6	2½	4	1¼	1⅝	1⅝	24½	56	76
24	CD	6	2½	4	1¼	1⅝	1⅝	24½	56	83
30	A	6	3	4	1½	2	1¾	25½	80	116
30	B	6	3	4	1½	2	1¾	25½	80	116
30	C	6	3	4½	1½	2	1¾	25½	80	123
30	D	6	3	4½	1½	2	1¾	25½	80	133
36	A	6	3	4½	1½	2	1¾	25½	80	121
36	B	6	3	4½	1½	2	1¾	25½	80	128
36	C	6	3	4½	1½	2	1¾	25½	80	135
36	D	6	3	4½	1½	2	1¾	25½	80	142
42	A	8	3	5	1½	2	1¾	25½	111	186
42	B	8	3	5	1½	2	1¾	25½	111	193
42	C	8	3	5	1½	2	1¾	25½	111	207
42	D	8	3	5	1½	2	1¾	25½	111	221
48	A	8	3	5	1½	2	1¾	25½	114	194
48	B	8	3	5	1½	2	1¾	25½	114	203
48	C	8	3	5	1½	2	1¾	25½	114	221
48	D	8	3	5	1½	2	1¾	25½	114	234
54	A	8	3	5½	1½	2	1¾	25½	134	212
54	B	8	3	5½	1½	2	1¾	25½	134	232
54	C	8	3	5½	1½	2	1¾	25½	134	251
54	D	8	3	5½	1½	2	1¾	25½	134	271
60	A	8	3	5½	1½	2	1¾	25½	137	220
60	B	8	3	5½	1½	2	1¾	25½	137	234
60	C	8	3	5½	1½	2	1¾	25½	137	259
60	D	8	3	5½	1½	2	1¾	25½	137	283

Dimension 21 inches in above cut is for pipe; this dimension varies for fittings.

Two lugs are placed on the vertical axis of each bell, the others at equal distances around circumference.

Dimensions in inches.

Weights given in pounds. All weights approximate.

Pipe furnished with lugs only when specifically ordered.

Cut along dotted lines—Apply paste on back of space indicated by arrows only, and paste over new table 2

Lugs for High Pressure
Bell and Spigot Pipe and Fittings
Classes E to H

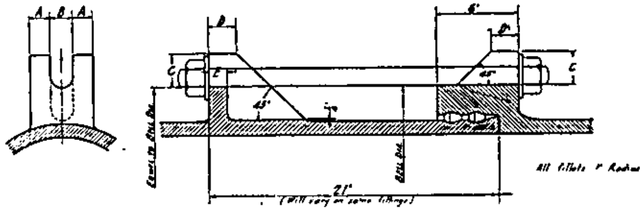


Table No. 2-A

Nominal Dia.	Class	Bell Dia.	No. of Lugs	Dimensions A	B	C	D	E	Size of Bolts Dia.	L'th	Weight of Lugs, Lbs. One Bell	One Spigot
6	EF / GH	11.52 / 11.88	4	1.50	1.25	2.25	1.50	.88	1	26	34	68
8	EF / GH	13.92 / 14.30	4	1.50	1.25	2.25	1.50	1.00	1	26	34	70
10	EF / GH	16.30 / 16.74	4	1.50	1.50	2.50	2.00	1.19	1¼	27	36	83
12	EF / GH	18.68 / 19.28	4	1.50	1.63	2.50	2.00	1.38	1⅜	27	38	88
14	EF / GH	21.08 / 21.82	6	1.50	1.63	2.50	2.00	1.50	1⅜	27	55	135
16	EF / GH	23.56 / 24.44	6	1.50	1.63	2.50	2.25	1.63	1⅜	27	56	141
18	EF / GH	26.04 / 27.08	6	1.62	1.75	3.00	2.25	1.88	1½	28	72	198
20	EF / GH	28.44 / 29.52	6	1.62	1.75	3.00	2.50	2.00	1½	28	73	200
24	EF / GH	33.40 / 34.86	6	1.75	2.00	3.25	2.75	2.00	1¾	28	89	240
30	E / F	40.60 / 41.46	8	1.75	2.00	3.25	2.75	2.00	1¾	28	121	371
36	E / F	48.00 / 49.04	12	1.75	2.00	3.25	2.75	2.25	1¾	28	191	613

Dimension 21 inches in above cut is for pipe; this dimension varies for fittings.

Two lugs are placed on the vertical axis of each bell, the others at equal distances around circumference.

Dimensions in inches.

Weights given in pounds. All weights approximate.

Pipe furnished with lugs only when specifically ordered.

Paste the following paragraph on page 234

Since the above was written, equipment has been developed for casting pipe horizontally which makes it possible to cast it in this way sufficiently uniform in thickness. New methods of gating, also, practically avoid the danger of slag and other impurities in the iron collecting in the wall of the pipe along top of the mold.

Apply paste on back of space indicated by arrows only and paste over lower part of table 6

Nom. Dia. Inches	Dimensions, Inches								
	Class	A	B	C	D	E	F	G	T
72	A	75.34	76.59	84.19	2.25	5.50	1.87	.63	1.62
72	B	76.00	77.25	85.65	2.25	5.50	2.20	.63	1.95
72	C	76.88	78.13	87.33	2.25	5.50	2.64	.63	2.39
72	D	77.74	78.99	88.99	2.25	5.50	3.07	.63	2.82
84	A	87.54	88.79	96.99	2.50	5.50	2.10	.63	1.72
84	B	88.54	89.79	98.79	2.50	5.50	2.60	.63	2.22
84	C	89.58	90.83	100.83	2.50	5.50	3.12	.63	2.74
84	D	90.58	91.83	102.83	2.50	5.50	3.62	.63	3.24

Cut along dotted lines

Cut along dotted lines

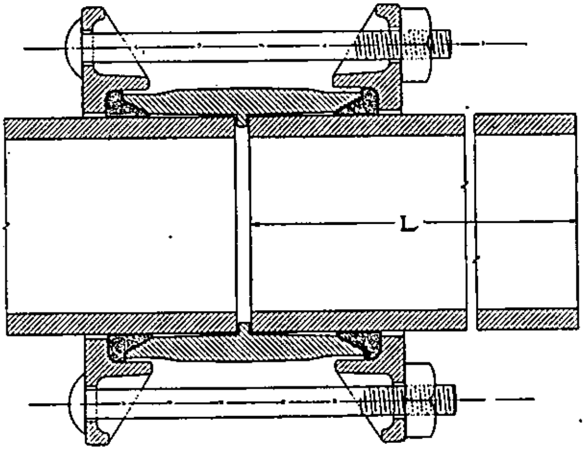


Table No. 31

Pipe Dimensions and Weights					Coupling Weights	
Nominal Diameter	Actual Outside Diameter	Actual Inside Diameter	Thickness	Weight Per Foot Pounds	Style 53 Cast See Above Fig.	Style 38 Steel See Fig. 10 Page 132
4	4.80	4.00	.40	17.25	29	22
6	6.90	6.04	.43	27.13	41	30
8	9.05	8.15	.45	38.06	48	40
10	11.10	10.12	.49	51.09	64	60
12	13.20	12.12	.54	67.21	78	84
16	17.40	16.16	.62	102.15	128	108
20	21.60	20.24	.68	139.70	176	138
24	25.80	24.28	.76	186.60	218	157
30	31.74	30.04	.85	257.30	These sizes furnished in Style 38 only.	225
36	37.96	36.06	.95	344.60		278
42	44.20	42.06	1.07	452.40		334
48	50.50	47.98	1.26	608.10		395

Couplings not furnished unless specifically ordered.
Pipe furnished in random lengths (L) from 11′-0″ to 12′-4″ overall.
Longer lengths can be furnished.
Couplings are also made for A.W.W.A. classes B, C and D pipe.
Dimensions in inches.

Cut along dotted lines

American Standard *Dimensions and Drilling Templates of Flanges for Cast Iron Pipe and Fittings for Maximum Working Saturated Steam Pressure of 25 Pounds per Square Inch

Table No. 59

Nominal Pipe Size	Diameter of Flange	Minimum Thickness of Flange[3, 4]	Diameter of Bolt Circle	Number of Bolts[1]	Diameter of Bolts	Diameter of Bolt Holes	Length of Bolts[2, 4]	Size of Ring Gasket
4	9	¾	7½	8	⅝	¾	2¼	4×6⅞
5	10	¾	8½	8	⅝	¾	2¼	5×7⅞
6	11	¾	9½	8	⅝	¾	2¼	6×8¾
8	13½	¾	11¾	8	⅝	¾	2¼	8×11
10	16	⅞	14¼	12	⅝	¾	2½	10×13⅜
12	19	1	17	12	⅝	¾	2¾	12×16⅛
14	21	1⅛	18¾	12	¾	⅞	3¼	14×18
16	23½	1⅛	21¼	16	¾	⅞	3¼	16×20½
18	25	1¼	22¾	16	¾	⅞	3½	18×22
20	27½	1¼	25	20	¾	⅞	3½	20×24¼
24	32	1⅜	29½	20	¾	⅞	3¾	24×28¾
30	38¾	1½	36	28	⅞	1	4¼	30×35⅛
36	46	1⅝	42¾	32	⅞	1	5	36×41⅞
42	53	1¾	49½	36	1	1⅛	5¼	42×48½
48	59½	2	56	44	1	1⅛	5½	48×55
54	66¼	2¼	62¾	44	1	1⅛	5¾	54×61¾
60	73	2¼	69¼	52	1⅛	1¼	6	60×68⅛
72	86½	2½	82½	60	1⅛	1¼	6¼	72×81¾
84	99¾	2¾	95½	64	1¼	1⅜	7¼	84×94½
96	113¼	3	108½	68	1¼	1⅜	7¾	96×107¼

All dimensions given in inches.

[1] Note: Drilling templates are in multiples of four, so that fittings may be made to face in any quarter, and bolt holes straddle the center line. Bolt holes are drilled ⅛ inch larger in diameter than the nominal diameter of the bolt.

[2] Note: The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 in. and larger may be spot faced or back faced to minimum thickness of flange with a plus tolerance of ⅛ inch, so that standard length bolts can be used.

[3] Note: All 25 lb. cast iron standard flanges have plain faces.

[4] Note: Screwed Companion Flanges "should not be thinner than the '125 lb. American Standard' thickness on sizes 24 in. and smaller. Other types of flanges may have thicknesses as given in the table above."

[5] Note: Bolts shall be of steel with standard "Rough Square Heads" and the hexagon nuts shall be of steel with "U. S. standard dimensions."

*See Note page 164.

Laying Dimensions of American Standard Flanged Fittings for 25 Pounds Steam Working Pressure

90 Deg. Elbow — 90 Deg. Long Radius Elbow — 45 Deg. Elbow — Straight Tee — Straight Cross

Table No. 63

Nominal Pipe Size	Center to Face Elbow Tee and Cross (A)	Center to Face Long Radius Elbow (B)	Center to Face 45 Deg. Elbow (C)	Diameter of Flange	Minimum Thickness of Flange	Minimum Metal Thickness of Body
4	6½	9	4	9	¾	.42
5	7½	10¼	4½	10	¾	.44
6	8	11½	5	11	¾	.44
8	9	14	5½	13½	¾	.46
10	11	16½	6½	16	⅞	.50
12	12	19	7½	19	1	.54
14	14	21½	7½	21	1⅛	.57
16	15	24	8	23½	1⅛	.60
18	16½	26½	8½	25	1¼	.64
20	18	29	9½	27½	1¼	.67
24	22	34	11	32	1⅜	.76
30	25	41½	15	38¾	1½	.88
36	28	49	18	46	1⅝	.99
42	31	56½	21	53	1¾	1.10
48	34	64	24	59½	2	1.26
54	39	71½	27	66¼	2⅛	1.35
60	44	79	30	73	2¼	1.39
72	53	94	36	86½	2⅜	1.62

See notes on pages 164, 171 and 172.

The flanged diameters, bolt circles and number of bolts are the same as the American 125 Lb. Standard with a reduction in the thickness of flanges and bolt diameters as shown in Table 59, thereby maintaining interchangeability between the two Standards.

The center to face dimensions for fittings are the same as the American 125 Lb. Standard cast iron flanged fittings.

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Laying Dimensions of American Standard Flanged Fittings for 25 Pounds Steam Working Pressure

Reducing Tees and Crosses (Short Body Patterns) [1,3,5]

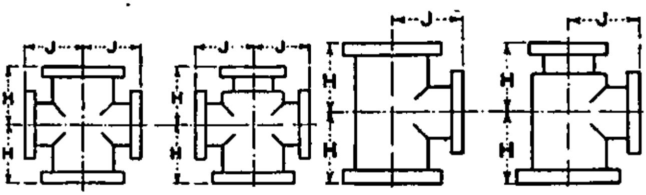


Table No. 63-A

Nominal Pipe Size[1]	Size of Outlet and Smaller[3], [4]	Center to Face Run H	Face to Face Run HH	Center to Face Outlet J
	All reducing fittings sizes 16 inches and smaller have same center to face dimensions as straight size fittings.			
18	12	13	26	15½
20	14	14	28	17
24	16	15	30	19
30	20	18	36	23
36	24	20	40	26
42	24	23	46	30
48	30	26	52	34
54	36	29	58	37
60	40	33	66	41
72	48	40	80	48

All dimensions given in inches.

[1] Short body patterns are used for sizes 18 inches and larger.

[2] Long body patterns are used when outlets are larger than given in above table, and, therefore, have the same dimensions as straight size fittings.

[3] Fittings reducing on the run only carry same dimensions center to face and face to face as straight size fittings corresponding to size of the larger opening. Tees increasing on outlet, known as Bull Head Tees, will have same center to face and face to face dimensions as a straight fitting of the size of the outlet. For example: a 12 × 12 × 18 inch tee will be governed by the dimensions of the 18 inch long body tee, given in Table 63; namely 16½ inches center to face of all openings and 33 inches face to face.

[4] Side outlet tees, with outlet at 90 degrees or any other angle, straight or reducing, carry same dimensions center to face and face to face as regular tees having same reductions.

[5] In a side outlet tee the larger of the two side outlets govern the center to face dimensions "J."

Cut along dotted lines—Apply paste on back of space indicated by arrows only and paste over new table 63

Cut along dotted lines

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 25 Pounds per Square Inch

Table No. 74

Nominal Pipe Size	90 Deg. Elbow	45 Deg. Elbow	90 Deg. Long Radius Elbow	Tees	Crosses
4	35	30	45	50	65
5					
6	55	50	65	85	100
8	80	65	105	120	150
10	135	100	160	185	225
12	185	160	245	270	325
14	250	195	330	370	450
16	340	240	425	450	550
18	385	285	530	550	670
20	465	350	665	660	780
24	695	490	950	960	1130
30	1050	840	1550	1500	1750
36	1620	1350	2480	2275	2600
42	2325	2000	3620	3200	3675
48	3205	2850	5300	4300	4880
54	4565	3970	7500	6250	6880
60	6000	5140	9675	8000	10250
72	9320	7525	14175	12150	13450

For dimensions see page 170.

NOTE: All weights listed are for fittings faced and drilled, based upon minimum thicknesses and dimensions given in preceding table without allowances for variation. Cast iron is considered to weigh 0.26 pound per cubic inch.

Tentative Specifications for Cement-Mortar Lined Cast Iron Pipe, and Fittings*

November, 1930

(In recommending these specifications, Sub-Committee 3C wishes to call attention to the fact that they are tentative only and subject to revision as additional information is obtained.)

Cement

1. The cement used for making cement mortar shall be Portland cement, complying in all respects with the standard specifications of the American Society for Testing Materials, Serial designation 6-9-21.

Sand

2. The sand for mortar shall consist of a clean, sharp, hard silicious sand, free from loam, clay, organic matter, or other foreign substance considered as deleterious for good mortar. The sand shall be well graded, and when tested by laboratory sieves, shall meet the following specifications:

Total passing 12 mesh sieve, 100%
Total passing 100 mesh sieve, not over 5%

*These *Tentative Specifications for Cement-Mortar Lined Cast Iron Pipe and Fittings* were adopted by Sub-Committee No. 3C (Inorganic Coatings) of the Sectional Committee on Specifications for Cast Iron Pipe (A-21) in March, 1930, except for the two amendments between triple star (***—***). These amendments were proposed at a meeting of Technical Committee 3, on March 25, 1930, were referred back to Sub-Committee 3C for consideration and were adopted by Sub-Committee 3C in November, 1930.

3. The cement mortar used for lining pipe shall be a mixture of the above specified sand and cement in such proportions as to obtain a good, hard, dense lining, reasonably well bonded to the pipe, and with a smooth interior surface. (A mixture which has been found to give very satisfactory results consists of three parts cement to one part sand, by volume.)

4. The cement mortar shall be thoroughly mixed, only sufficient water being added to form a workable mixture for placing in the pipe.

5. Only sufficient cement mortar shall be mixed for the immediate requirements of lining.

6. The water for tempering the cement mortar shall be free from harmful amounts of oil, acid, alkali, organic or vegetable matter.

Preparation of Pipe for Lining

7. Pipe to be lined with cement mortar shall not be coated inside with tar or other asphaltum products. Its interior surface shall be thoroughly cleaned of all core sand, mud, grease, foreign materials, or any sharp projections of iron which might project through the lining. Pipe shall be tested hydrostatically before being lined.

Method of Applying the Cement Mortar Lining

8. Sufficient cement mortar shall be introduced to produce the required thickness of lining and spread evenly over the interior surface of the pipe, by any suitable means. A careful examination shall be made after this

operation is completed to see that the inner surface of the pipe is completely covered with cement mortar.

9. The shoulder of the bell and the end of the spigot may be covered with cement mortar by applying with a brush.

10. Surplus cement mortar shall be removed from the interior of the bell so as not to interfere with proper keying of the joint.

11. The work of lining the pipe shall be done in a building where the product shall be protected from the direct rays of the sun, and from extreme weather conditions, such as rain, frost, etc. The product shall not be put on the yard until the cement has set sufficiently to avoid injury or damage thereto.

12. Patching of improperly lined pipe will not be permitted.

* * * Smoothness of Lining

13. The lining of straight pipe shall be smooth and substantially free from noticeable ridges, corrugations, projections or depressions. The lining of fittings shall be as smooth as practicable * * *

Outside Surface of Pipe

14. Unless otherwise specified, no coating shall be applied to the outside surface of cement mortar lined pipe and fittings.

Lining Fittings

15. The interior surface of fittings shall be lined by applying cement mortar as specified in previous paragraphs, evenly and uniformly * * * and as nearly as

practicable of the thicknesses specified for the corresponding sizes of pipe * * *

Thickness of Lining

16. The minimum thickness of lining for the various sizes pipe shall be as follows:

Nominal Size of Pipe	Minimum Thickness of Cement-Mortar Lining
4-inch	1/8 of an inch
6-inch	1/8 of an inch
8-inch	1/8 of an inch
10-inch	1/8 of an inch
12-inch	1/8 of an inch
14-inch	3/16 of an inch
16-inch	3/16 of an inch
18-inch	3/16 of an inch
20-inch	3/16 of an inch
24-inch	3/16 of an inch

17. A plus tolerance of 1/8″ in thickness of lining shall be permitted on all size pipe from 4″ to 24″. No minus tolerance to be allowed.

18. Linings of greater thickness will be furnished when specified.

19. The thickness of lining may be determined by means of spear measurement, using a hardened steel point not greater than 1/16″ in diameter. The inspector shall pierce the lining immediately after it is placed in the pipe, and before cement has set, at four diametrically opposite points of the pipe at bell and spigot ends, making two sets of measurements at each end. The first set shall not be greater than 4″ from the respective ends of the pipe and the second set shall be made as far into the interior of the pipe as can readily be obtained by reaching into the pipe without injuring the lining.

20. All measurements shall be within the limits as specified.

21. At the ends of the pipe where the lining naturally tends to taper off to a thin edge, the full thickness of lining shall extend to within one inch of end of pipe.

22. For linings of the above specified thickness, or of greater thickness, failure of the lining to completely adhere to the wall of the pipe shall not be cause of rejection, if the lining conforms to these specifications in all other respects (See Foot Notes).

Curing Cement Mortar Lining

23. Immediately after pipe is lined with cement mortar, it shall be protected in a suitable manner to prevent the too rapid withdrawal of moisture from the cement mortar, and if necessary, suitable means shall be provided to keeping lining damp for a period of at least twenty-four hours after lining.

24. No pipe shall be shipped until the lining is thoroughly set.

NOTES

The above tentative specification provides for thicker cement linings than have generally been used in American practice. In view of the unavoidable irregularities in the inner surface of cast iron pipe, of the known solvent action of many waters on the lime content of Portland cement, and the limited experience (only about seven years) with thin Portland cement linings in cast iron pipe, thicker linings are believed to be desirable as a matter of insurance.

In the present state of the art such thicker linings are more prone, when dry, to a minute separation from the wall of the pipe; when wet, however, slightly separated cement linings swell into close contact with the pipe. The

Committee believes that the thicker linings recommended will have longer life and will prevent tuberculation and maintain carrying capacity longer than thinner linings which may show somewhat less temporary separation from the pipe.

The Committee refrains from attempting, at this time, to specify the amount, or area, of the non-adherence of the lining which shall cause rejection. It is realized that the manufacturer will produce the best pipe he can and that it may require some little experimentation on each size and thickness of lining to secure the best adherence. The judgment and common sense of the inspector and the manufacturer's forces is relied upon to secure the best practicable results during this period of development, rather than an arbitrary limit to the permissible areas of non-adherence.

HOWARD BERKEL
C.E. '31
H.S.C.

HANDBOOK

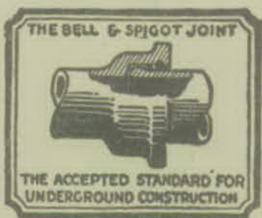
OF

CAST IRON PIPE

FOR

WATER, GAS, STEAM, AIR, CHEMICALS AND ABRASIVES

1927



CAST IRON PIPE RESEARCH ASSOCIATION
CHICAGO, ILLINOIS

PRICE $3.00

Printed in the United States of America

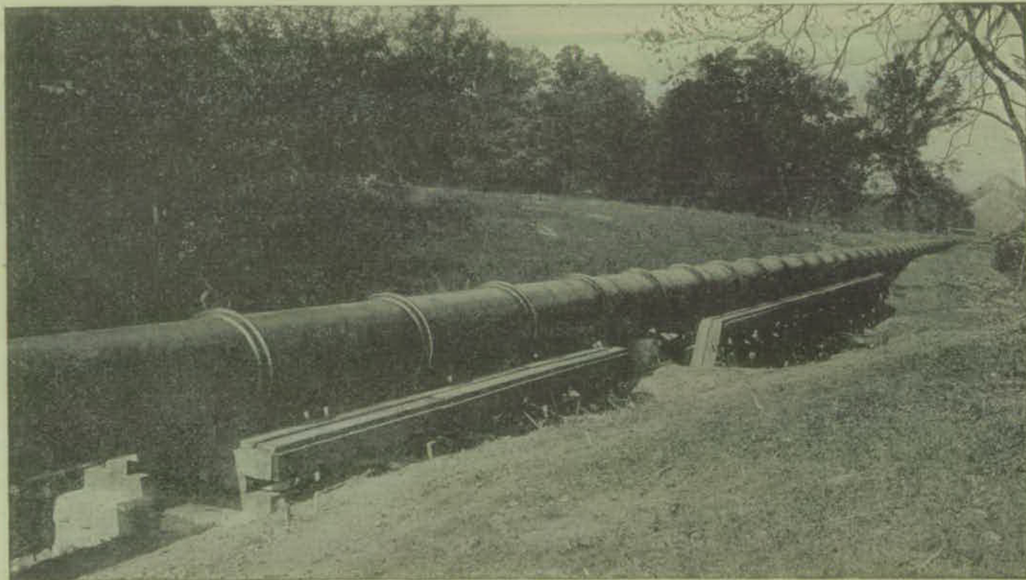
INTRODUCTION

CAST IRON PIPE needs no introduction to the Engineers of the Water Works and Gas Industries. Because of its dependable quality, resistance to corrosion, ease of installation and reasonable cost, it has become their standard conduit. Next to the air which we breathe, nothing is more essential to us than water, light and fuel. The excellent work of these engineers in design, operation, and the selection of materials, is well shown by these vital elements being the most dependable of the many Public Services that make possible our dense city life.

But since the establishment of specifications on Cast Iron Pipe and Fittings, by the various engineering associations, numerous new fittings have been developed on which complete standards have not been written. Required data regarding weights, dimensions and capacities, while available, is often scattered through several handbooks. Information regarding many of the problems arising in the field may be quite inaccessible to the engineer. With the hope that a new compilation of tables and chapters on these subjects may be of aid, not only to the water and gas Engineers, but to the many others to whom Cast Iron Pipe recommends itself, this book has been published.

CAST IRON PIPE RESEARCH ASSOCIATION

May, 1927.



48-Inch Cast Iron Pipe Laid on Top of the Ground

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(For Detailed Index, see Pages 330 to 335).

Long, Easy Curves Can be Laid with Full Length Bell and Spigot Cast Iron Pipe

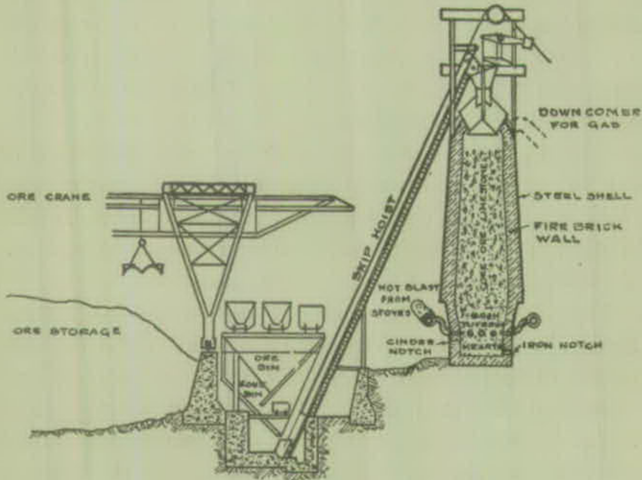
SECTION 1

THE PRODUCTION OF IRON

THE production of iron is one of the oldest of the arts, dating back to some unknown iron master five or six thousand years ago. But the ancient metallurgical methods were so wasteful of both material and labor, that the metal was never of great economic importance. The ores were reduced to a pasty metallic mass at a temperature below the melting point of the iron itself, and the clay and sand that were embedded in the ore were laboriously kneaded out by hammering. Our present metallurgy had its origin about the thirteenth century A. D. when furnaces were developed in Western Europe to produce iron in a molten condition.

The modern blast furnace is a round barrel shaped shaft about a hundred feet in height and twenty-five feet at its largest diameter, with thick fire brick walls jacketed and supported with steel plates. The bottom seven or eight feet is cylindrical, topped by a ring of openings for nozzles or tuyeres as they are called, through which the blast of air is forced. Immediately above this is a divergent conical section called the "Bosh." The "Bosh" is surmounted by another cylindrical section, then another cone and another cylinder at the top. A bell, drawn up tight against a ring seals the top and can be lowered at intervals to drop in fresh supplies of ore and coke. A "skip" or charging car periodically brings up fresh supplies of raw materials from the nearby stock house, which are dumped into the annular hopper around the bell.

In blast furnace practice, the raw materials are divided into three classes—ores, fuels and fluxes. The ores are the mineral sources of the metal, occurring in nature as rich deposits of the oxides of iron. They are mined by open cutting or tunnelling depending on local conditions, and are usually shipped to the furnace without other treatment than sizing. The fuels are used to produce the temperatures and also the gases that deoxidize the ores.



Cross Section of a Modern Blast Furnace

At present coke is the only one of commercial importance, though in the past much charcoal was consumed. The fluxes are minerals which combine with the coke ash and the impurities in the ore, to form an easily fusible slag. Generally these are the carbonates of calcium or magnesium, which are charged in the furnace as raw limestone or dolomite.

The reduction of the ore is accomplished by the removal of oxygen, through the agency of two chemical reactions, accompanied by heat. When air passes through a thick bed of incandescent coke or charcoal, incomplete combustion takes place and a gas called carbon monoxide or CO is formed. This gas has very active reducing properties so that at temperature above 600 degrees Fahrenheit, it will take up the oxygen in the ore, leaving metallic iron. There are several intermediate reactions, but the whole reducing process may be generalized as follows:

$$6\,C + 3\,O_2 = 6\,C\,O$$
$$2\,Fe_2\,O_3 + 6\,C\,O = 2\,Fe_2 + 6\,C\,O_2$$

The gases that pass off are high enough in heat value to be used under boilers and for heating the regenerative stoves for the blast. These stoves are steel shells about twenty feet in diameter by a hundred feet high, filled with brick checkerwork. They are alternately heated with the gas and then thrown in on the blast line. The cold air from the blowing engine for a time is heated to about 1300 degrees F. while passing through the checkerwork, but when the stove has cooled so that the blast is no longer as hot as desired, the air is passed through another stove and the cool one is again heated with the gas from the furnace. The heated blast is led through brick lined pipe to the tuyeres where it enters the furnace. The blast pressure in the more modern plants is from 20 to 25 pounds per square inch and is developed in large blowing engines or turbo blowers.

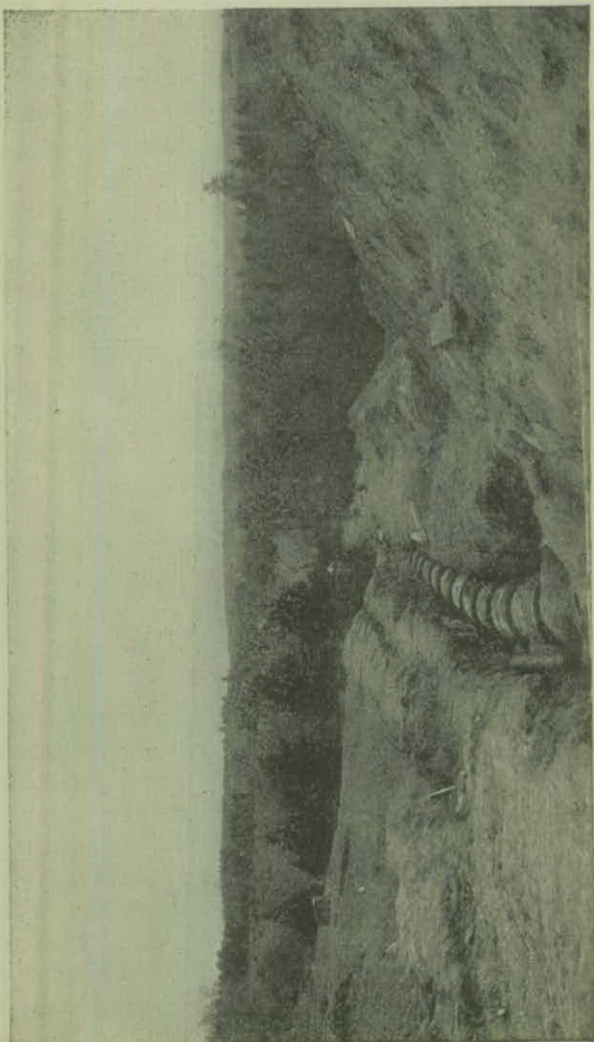
The furnace is kept nearly full of carefully proportioned charges of coke, ore and limestone. This column slowly travels downward as the coke below is consumed, being heated as it approaches the "Bosh" by the ascending gases. The ore is also acted on by the carbon monoxide so that most of it has been reduced by the time the combustion zone in the "Bosh" is reached. Here the heat is intense and the iron and slag melt and trickle down to collect in the hearth below the tuyeres.

Their great difference in specific gravity separates the iron and slag into layers, permitting the withdrawal of iron through a hole or notch at the bottom, and the slag through another notch higher up. Both of these notches are usually plugged but as often as the slag level rises to approach the tuyeres, the cinder notch is opened and the accumulation of slag flows out into a receiving vessel. At less frequent intervals, five or six times a day, the iron notch is opened and the furnace drained of iron. The molten metal is either caught in large ladles, to be carried to the steel plant or pig casting machine, or it is led out into a series of pig molds that have been made in a sand bed in front of the furnace. The arrangement of these molds, a long channel with shorter and narrower channels opening into it on one side, suggested a litter of pigs at lunch time to some old Englishman and his terms of sow for the main channel and pigs for the shorter ones, are current today. On solidifying the pigs and the sow are broken into convenient sizes for handling. The term "Pig Iron" is usually taken to mean the product of the blast furnace and "Cast Iron" the product of the foundry. These terms are used somewhat indiscriminately, though, and rightly so because the function of the foundry is not to alter the properties of the pig iron but to form it into useful shapes.

Iron has never been produced in an absolutely pure state except by the most careful laboratory conditions. At high temperatures, it has a strong tendency to alloy with many of the non-ferrous substances which are present in the fuel or ore and these naturally are retained in the cast iron. They are not to be regarded as injurious impurities because each has its peculiar modifying influence on the metal, and it is only through the intelligent control of these effects that the foundryman produces the desired qualities in his castings.

Steel and wrought iron, the two other commercial forms of iron, are both made by reducing the non-ferrous constituents of pig iron to a desired minimum. This elimination is accomplished through treatments that cause these elements to separate from the iron and form gas or a slag. In steel making these new substances are formed in a molten bath of metal and are either burned out or being lighter than iron, float to the surface to be skimmed off. For wrought iron, the slag is formed while the metal is at a pasty heat, and is removed from the resulting mass by kneading. Each of these metals exhibits distinct physical characteristics that are modified greatly by the presence of such non-ferrous elements as remain.

As compared with cast iron the most marked changes caused by these conversions are the increase in strength, ductility, and forging properties while losing the original granular structure. At the same time wrought iron completely loses its typical qualities if melted, and steel castings are only used in limited services. Cast iron readily lends itself to being formed into intricate shapes, and to this owes its chief value for the foundryman. Cast iron pipe has also shown a greater resistance to corrosion than has that of either steel or wrought iron, which is also a valuable asset where a permanent installation is desired.



Large Cast Iron Pipe Through the Open Country

SECTION 2

THE EVOLUTION OF PIPING

THE modern gas and water supply systems can trace the history of their development to pre-historic times. The use of gas, of course, is comparatively new, beginning during the last years of the eighteenth century but its close relation to the earlier experiments of the water-works engineer is in that both services need a cheap, strong and durable conduit. Cast Iron Pipe, the first material to meet these requirements, had become available through improvements and economies in metallurgy made during the eighteenth century. Its present popularity is due to the splendid service which these original and later lines are still giving.

The most ancient civilizations originated in the flat plains of the Euphrates and the Nile and extensive networks of canals were dug leading out from the rivers. Probably these channels were the earliest efforts toward diverting water from its natural course, though they seem to have been more for irrigation than for domestic supply. In the cities the populations were dependent on the water carrier, who filled his jars and skin bags from the springs, or wells around which the first inhabitants had settled. These conditions in defiance of all laws of sanitation must have caused many such epidemics as was prophesied by Moses for the Egyptians. A more apparent defect in such a system was the danger to which an insufficient water supply exposed the city during a long drought or a siege. With the advancement in culture we are not surprised at the heroic measures taken to assure adequate water at all times.

The manner in which these systems were built reflects not only the general knowledge of construction during each age but the state of development of many of the other crafts. The lack of any except the crudest pumping machines permitted only gravity lines which were first merely open ditches and dykes. Soon the increasing skill of the stone cutter and the mason were brought into play and by the time of the Phoenecians we find elevated stone aqueducts and tunnels in solid rock through which water was brought from distant points. The difficulties in driving such tunnels can hardly be exaggerated when it is remembered that until well into the times of the Grecians no harder tools were in general use than those made of bronze.

The potters art also came to the aid of the hydraulic engineer. The oldest pipe of which we know is a twin line of clay tubes found at Nippur in Mesopotamia. This was embedded in cement in the bottom of a low arched passage under the wall of the temple which it supplied. No doubt much trouble was experienced with breaks if the line was subjected to much pressure, but these were easily repaired through the passage way. A number of tees and bends lying nearby showed that they had also solved the problem of connections. A much more elaborate and later use of clay pipe was in the drainage system of the Palace of Minos at Cnossus (2000 B. C.). Provision for sewage disposal was made on the four floors of the building through pipe that were constantly flushed with water. The whole design resembles very much our modern plumbing practice and is greatly superior to similar work of the classical Greeks and Romans. The other forms of early conduit were pipe made of wood and lead, masonry channels, pierced stones and tunnels. Very good examples of the last two mentioned were found at Jerusalem dating from the time of the Judean kings. One of these, an inverted syphon across a marsh, is a series of masonry covered stone blocks through which fifteen-inch holes had been dug. The other is the seventeen-hundred-foot tunnel connecting the Virgins Pool with the upper Pool of Saloam. An old inscription on the tunnel wall states that it was driven from both ends. Though no mention is made of the fact, it was shown by recent examination that the two parties nearly missed each other.

In their distributing lines the Greeks and Romans both made use of pipe of the various materials and the more highly developed systems of the Latin cities contained large quantities of that made from both wood and lead. The short life of the wood pipe, the breaks in the clay lines and the high cost and poisoning where lead was used, must have given continuous trouble. But, representing as they did, the most suitable materials known to engineers, the use of each was an important step toward our modern practice.

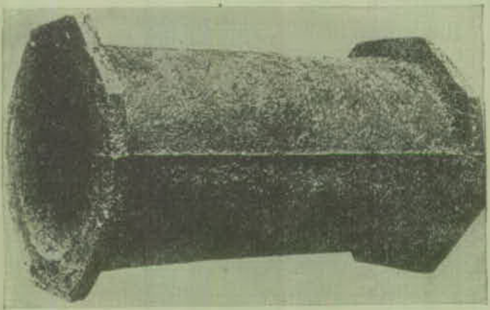
The best known achievements of any of the ancient water works engineers were the aqueducts leading into the Grecian and the Roman cities, both from the size of the undertakings and the present state of their ruins.

The Greeks used the tunnel almost exclusively and with great skill. Some of their most brilliant feats were the eight-foot-square tunnel, forty-two hundred feet long, which the engineer Polycrates drove through the solid rock at Samos, passing an Athenian tunnel twice under the

River Illissus and at one point carrying the conduit into Syracuse under the sea. The water usually flowed through the tunnels in clay pipe though channels in the rock floor were also used and occasionally a line of pierced stones cemented together. Little is known of the engineering methods employed in establishing the carefully adjusted grades and lines of these tunnels. Generally, shafts were dug at short intervals, possibly as guides to the working parties, as vents, or for decreasing the distance each face was driven.

The Roman engineers inherited the engineering experience of the Greeks and were able to carry it to a much higher state of perfection. The preference for vented tunnels was still marked, 304 miles of the 359 miles of conduit leading into Rome being under ground. A portion of this was of sheet lead pipe, which was coming into more common use, but the major portion was rock cut or masonry-lined tunnels. The systems stretched out to more distant water sources which called for much greater precision in establishing the grades. But it was in the manner in which the conduit spanned the subgrade areas that the greatest advancement was shown. Massive stone arches were built in tiers from hill to hill, surmounted by a water channel of well jointed stone blocks. This course or specus continued the gentle slope of the tunnels which it connected to make a constant gradient where inverted syphons would otherwise have been needed. On occasions such syphons of lead or bronze pipe were successfully used, but never to a proportion suggesting standard practice. The earlier aqueducts are rather heavy and clumsy, giving an impression of unnecessary mass of material. Many of the later ones show a graceful use of arches that leaves nothing to be desired and still stand as some of the most perfect monuments of the ancient designing engineer. The Pont du Garde at Nimes, which is often referred to as an excellent example of the ornamental effects which they achieved. Ruins of many such installations are scattered throughout the old Roman Empire, monuments to the thought and labor which they gave to their water supply. At convenient points in or near the city, the water from these systems discharged into reservoirs or pools and was carried in pipes from there to the point of use. The poorer people were supplied by neighborhood fountains, though the residences and palaces of the richer classes enjoyed an individual connection as we do today.

These are the various expedients that were tried by the water works engineers down through the first few centuries of our era. The cities that sprang up in Europe during the middle ages turned their attention more to distribution systems and extended the use of the networks of mains much as we use today. Pipe of the old Roman materials, clay, wood, lead and stone, were installed with varying success, but more extensively than ever before. The growing application of the principles of mechanics to the problems of every day life led to many improvements in pumping machines, driven by water wheels. This, with the increase of wealth of the common people, permitted expansions in residence supply lines and a general demand for more modern conveniences. London, typical of such cities, experimented with pipe of stone, wood, cast lead and "Red Earth, baked" as early as 1235. In 1609-1613 Sir Hugh Myddelton built his boarded aqueduct, the "New River," and laid over four hundred miles of new wooden mains in addition to the pipe already installed. A water power pumping plant had been built at London Bridge in 1582, and the city, no doubt, considered herself equipped with a highly efficient water system. Yet defective piping was giving constant trouble. The wooden pipe leading from the pumps could not withstand the pressure required to force water into the upper stories of many houses and its rapid deterioration gave it an average life of only twenty years. In addition, the great fire of



Section of a Pipe from the Distributing Mains at Versailles
After 250 Years of Service

1666 destroyed quantities of both lead and wood pipe at the time when it was most needed.

We can imagine, therefore, with what interest was watched the experiment with cast iron pipe that was being made at Versailles. Unfortunately, when this line was begun (1664) the production of iron in England and most of Europe was in the hands of a powerful group of furnace men. They controlled prices and production through ownership of the forest where charcoal was burned and had crushed Dudley's attempt to make cheaper iron with coke in 1619. So it was only after Darby had established a coke iron industry in 1738 that cast iron pipe could be afforded by the water works companies. Immediately cast iron mains began to be installed by many of the more progressive cities.

The joints of all these earliest lines were of the bolted type, with lead gaskets, and some trouble was experienced through the rusting of bolts. This difficulty was overcome by Thomas Simpson, engineer of the Chelsea Water Company, London, who, in 1785, invented the bell and spigot joint. It was used for the first time soon afterwards when that Company relaid a forty-five-year-old line whose joints had "perished." Thus was developed the bell and spigot cast iron pipe that has been used so extensively ever since. Many of the original lines are still in use, apparently good for many centuries more of service.

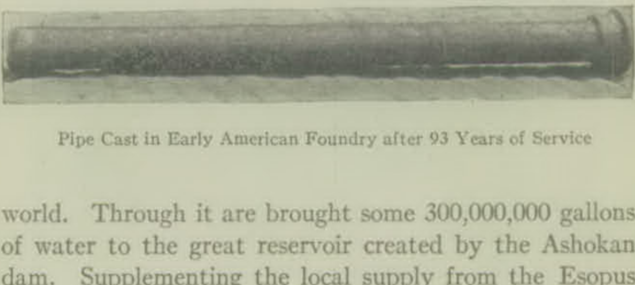
Most of the cities of this country are young enough to have planned their piping with modern materials and design. Some of the older towns went through very disagreeable experimental stages before building the finest type of systems in the world. Undoubtedly, New York has the greatest of these. A series of yellow fever epidemics following the Revolutionary War showed the necessity for more sanitary conditions. An unusually severe one in 1798 caused a group of the more prominent citizens, headed by Aaron Burr, to make plans for the water works installation which was chartered in 1799 as the Manhattan Company. Wells were dug at various points and the water was pumped through the city in bored pine logs. Philadelphia was also laying a log pipe system at the same time, but after a number of breaks ordered some cast iron pipe from England. Her experience with these were so satisfactory that New York followed her example and Baltimore imported Cast Iron Pipe for her new gas lines. Its superiority over other materials created such a demand for it that in 1834 a foundry was built at Millville, New Jersey, to supply the neighboring cities. This was the beginning of the important cast iron pipe industry of that district and the United States.

With its rapid growth, New York soon found the capacity of the local wells to be inadequate. Agitation

Flange from a Philadelphia Pipe Line Laid in 1817

for relief became so insistent that in 1834 a fifty foot dam was begun on the Croton River, some forty miles away from the city. An aqueduct was also built, largely of the cut and cover type. Cast iron pipe was used in portions of it, bringing the water over the stone arched "High Bridge" across the Harlem River and then on into the city. This system came into service in 1842, designed to supply 36,000,000 gallons daily.

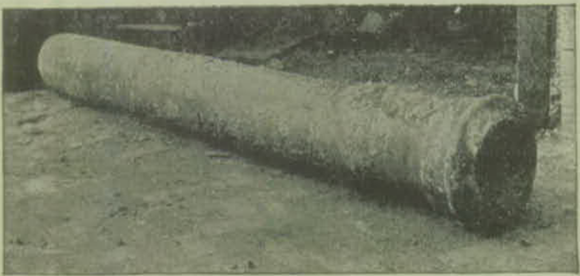
By 1880 the system was being forced to 95,000,000 gallons a day and additional water was needed. A second storage reservoir was built in the Croton water shed and another aqueduct, increasing the supply by 300,000,000 gallons daily. This relief again proved to be only temporary, and in 1905 the Catskill Aqueduct Commission was authorized to provide a new supply of water from the Catskill Mountains. Beginning at the Schoharie Reservoir the first eighteen miles of this system is spanned by the Shandaken Tunnel, the longest continuous tunnel in the



Pipe Cast in Early American Foundry after 93 Years of Service

world. Through it are brought some 300,000,000 gallons of water to the great reservoir created by the Ashokan dam. Supplementing the local supply from the Esopus Creek drainage area a reserve of 130 billion gallons is impounded here to be drawn off by the aqueduct to the Kensico Reservoir, ninety-two miles away. A large portion of this distance is traversed through a reinforced concrete channel, 241 square feet in section, the valleys being crossed by syphons or pressure tunnels. The most remarkable of these, the Storm King Tunnel, was driven three thousand feet through solid rock at a depth of eleven hundred feet below the Hudson River. From the Kensico Reservoir the water flows to the equalizing reservoir at Hill View and thence by deep pressure tunnels to the various boroughs of the city. This system has been in operation since 1917. It furnishes a dependable yield of 600,000,000 gallons per day.

Staten Island, in addition to ten or twelve million gallons from local sources, receives its supply of Catskill water through two lines of flexible joint cast iron pipe 36 inches and 42 inches in diameter, passing under the Narrows. The watershed on Long Island can furnish about 120,000,000 gallons for use in the Boroughs of Brooklyn and Queens. When all water works under con-



Earliest Cast Iron Gas Pipe after 80 Years of Service in Baltimore

struction are finally completed New York City will have a daily supply of over a billion gallons and a storage capacity of nearly three hundred billion gallons. While these figures and the cost of such projects are almost beyond conception, it has permitted New York's six million inhabitants to now have a per capita consumption of 131 gallons daily (789 million total), and at the rate of thirteen cents per thousand. The importance of cast iron pipe in such a development may be appreciated from the fact that at the end of 1921, exclusive of fire line piping, 3,067 miles of cast iron mains had been laid in the City of New York in sizes ranging from 4 inches to 60 inches.

A study of the coking process showed the possibilities of generating gas from coal, and in 1792 Murclock introduced it for lighting in London. The cheaper bored logs were first tried, but these were soon replaced with cast iron mains. Since then cast iron pipe has been used for

View of Early Pipe Foundry

nearly all the gas piping that has been laid in Europe or in the United States.

Since the introduction of Cast Iron Pipe, many substitutes of various materials have been offered. Some, after trial, have failed, some are accepted only as a cheap material and only a short life is expected, while others are still so recent that their life and performance cannot be judged as compared to the many old cast iron mains now in use. A specific comparison of these materials is covered in another chapter of this book. So far Cast

Iron has been the only material specified by the Standards of the American Water Works and American Gas Associations, and it has met in performance the exacting service which this implies.

SECTION 3

MANUFACTURE OF CAST IRON PIPE AND FITTINGS

THE manufacture of cast iron pipe had its origin about the year 1660, in some forgotten French foundry, for pipe lines to the fountains at Versailles. The underlying principal of the process, the introduction of molten cast iron into molds, where it solidifies into the desired shape, is the same today as it was then; but where formally hand labor was used exclusively and technical control was unknown, now the most modern machines of the electrical and the mechanical engineer are utilized and the whole operation is guided by one of the newest of sciences, metallurgy. An unusual type of plant design has been developed in the industry to permit the vertical casting of pipe twelve and sixteen feet long. This requires very heavy and expensive equipment, the cost of which is prohibitive unless used to maximum capacity; consequently, the manufacture of cast iron pipe is essentially a system of mass production ranking among the largest foundry operations in the iron industry.

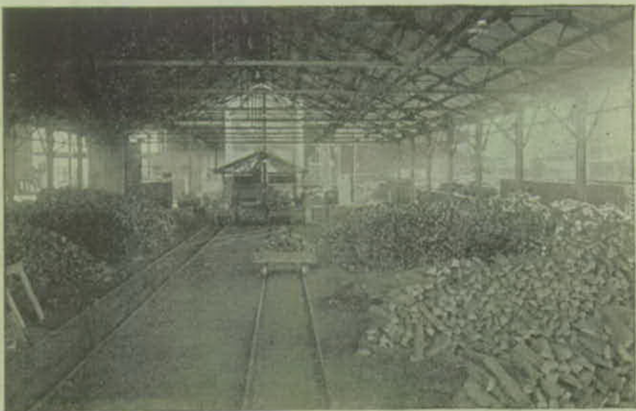
The heavy initial investment in such plants limits the manufacture of cast iron pipe to companies with large financial resources that can take advantage of economical developments and offset with more efficient machinery the constantly rising cost of labor. The sharp competition between modern plants has prevented the manufacturing extravagance and waste that often is passed on to the customer in the price, so that today water and gas pipes are the cheapest commodities made of cast iron to engineering specifications. To the users of cast iron pipe, the large units have also meant manufacturing capacities well able to meet the emergency demands of construction work, and an assurance of quality that comes only with supervision by a staff of metallurgists and engineers beyond the means of a smaller foundry.

The most striking feature of the industry that has persisted throughout its whole history is the unsurpassed fitness of cast iron pipe for conduits. It is often mentioned in the trade that the first cast iron pipe line has been in continuous use since its installation; but of even more importance to the manufacturer of cast iron pipe is the knowledge that through the long period since its introduction no substitute has yet been offered to check the increasing use of cast iron pipe, nor has any material given so satisfactory a combination of qualities to resist the conditions to which conduits are subjected.

With the fact established that cast iron pipe has an almost indeterminable life, the problem of the manufacturer for many years has been to produce pipe with the best combination of physical properties and to eliminate the causes of defective workmanship that arise wherever the human equation enters into the process.

Cast iron pipe was originally made in horizontally cast sections, four to five feet in length. The mold or cavity into which the molten iron was poured was formed in two boxes of damp sand, each containing an impression of half the outer circumference of the pipe, and by closing these two half molds around a core whose diameter was that of the pipe bore. The core was supported and held concentric by tight-fitting extensions of the mold proper, the shoulders formed by these extensions being the end walls of the mold. An opening was made at some point through which the metal could be poured. The core was a cylinder of sand, reinforced with iron rods, and, naturally, the limit in length of such molds was the extreme length at which the core would support itself without deflection. Any sagging in the middle of the core would cause eccentricity in the mold and a corresponding thin place in the pipe wall. Another objectionable feature of this method was that any sand or slag washed from the mold surface by the flowing iron would tend to float in the heavier metal and would collect in a streak at the highest point in the circumference of the pipe. But, with the limited experience of the early foundry men, this pouring position was used some hundred and fifty years until the advantages of pouring "on the bank" were discovered. In this method the mold was formed as before, but before pouring one end was raised so that the foreign substances would segregate at one end only, where their effect would not be so apparent. The tendency of the core to deflect was not so great in this position, and that permitted an increase in length to nine feet. The next change in pouring position came some fifty years later (about 1850), when the present method of vertical pouring came into use. By this means all tendency for the core to sag was removed, the elimination of sand and slag from the body of the pipe was made much more positive, and the commercial length of cast iron pipe was increased to twelve, and later, also, sixteen feet. In this way we may now cast iron pipe, knowing that they will be free from defects that were once, no doubt, quite common.

The control and improvement in the physical properties of cast iron were made possible through the discoveries within the past fifty years, that the strength, resistance to shock, machinability and other qualities of the castings are largely affected by the presence with the iron of non-ferrous elements. A study of these effects has been the chief activity of the foundry metallurgist, and by them he is able to select only such iron as is best suited



Storage of Pig Iron

for his class of work. As an example of the value of such research, it is well known that the presence of phosphorus is desirable within certain limits, but that an excess of this element causes the casting to be extremely brittle, and for that reason pipe with high phosphorus content is liable to breakage under the shocks incident to installation and service. Fortunately, most American pig irons are well within the margin of safety on phosphorus, and those that are too high are not used by the pipe maker. Experience has shown that phosphorus should not exceed one percent as a maximum.

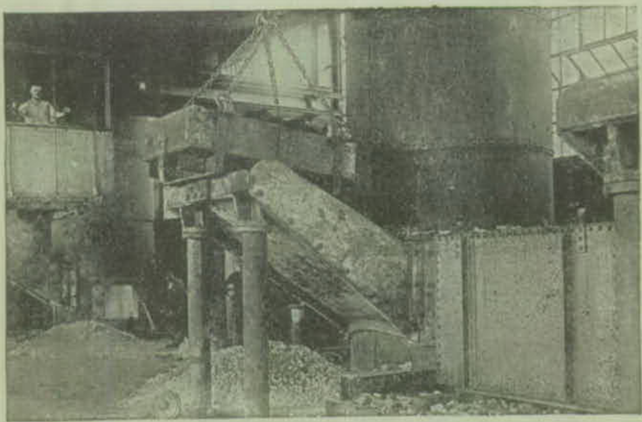
Crude cast iron is known as pig iron, from being cast into short bars or "pigs" at the blast furnace where it is reduced from the ore. It is graded by its content of non-ferrous elements, but as these commercial grades cover wider ranges of these elements than is permitted in foundry practice, it must be sorted at the foundry according to its analysis and blended to prevent excessive variations. The more important of these controlling elements are carbon, silicon, sulphur, manganese and phosphorus, all of which are in either the ore or the fuel, and are absorbed by the iron while being smelted in the blast furnace.

Carbon is taken up from the fuel, usually to the extent of about three and one-half percent in all grades. Silicon and sulphur are present in relatively large quantities, as impurities in the ore and the coke and the amount of their absorption is regulated in the blast furnace operation. These two elements are used for the commercial grading of pig iron, premiums being paid for higher silicons and lower sulphurs. The standard foundry grades range from one and a quarter percent to three and a quarter percent for silicon, and up to a maximum of about six-hundredth of one percent for sulphur. The manganese and phosphorus content of the iron is due to the occurrence of these elements in the ore, so their proportions are regulated through the ore supply. For foundry pig iron in general the amounts of each will fall between four-tenths and one percent, though, at any one furnace with uniform ores, the percentages of these two elements will be almost constant in all commercial grades.

As it cools and solidifies, these elements either break their chemical bond with the iron, and separate as non-ferrous masses in the metal, or remain as a combination with the iron similar to an alloy. Carbon may follow either of these courses, forming in flakes of graphite interspersed through the casting, or retaining its alloyed condition as a carbide of iron. With a separation of all the carbon as graphite, a soft granular metal is obtained, but so divided into cells by the graphite as to have little strength. Or, if the carbon all remains in the combined form, the castings will be too hard to be machined, and, therefore, only suitable for special classes of service. Between these extremes are the gradual changes in the ratio of the two carbon conditions, that give increase in strength and hardness as the proportion of graphite becomes smaller, accompanied by a decrease in the size of the graphite flakes themselves.

One of the most effective agencies in determining these final proportions is the rate at which the casting is cooled. Bulky, slow-cooling castings have a much more open grain and larger percentage of graphitic carbon than smaller castings of the same analysis. In special cases, such as chilled car wheels, all of the carbon in wearing surfaces of the castings may be retained in the combined state by using metal blocks in parts of the mold to cause quicker cooling than would be obtained with sand. But as the size of the casting is determined by its purpose, as well as the extent to which strength, hardness, elasticity, and ease of machining must be given relative importance, other means must usually be used to influence the carbon condition and the physical properties of the metal. This is accomplished largely through the amounts of silicon and sulphur present in the pig iron; increases in silicon causing increases in the tendency for graphitic carbon to form, and increases in sulphur producing the opposite effect. By balancing these two effects against the nature of the casting itself, similar properties may be given to different castings, though widely varying in size. Manganese and phosphorus have somewhat more complex reactions. Manganese has a strong affinity for sulphur and will unite with it to form a manganese sulphide that is without influence on the state of the carbon. In this way, by decreasing the amount of active sulphur, manganese has an indirect effect of increasing the graphitic carbon. But as its direct effect is to toughen the metal and to increase the combined carbon, the amount of manganese present must be considered in determining the silicon-sulphur ratio. Phosphorus is usually considered more for its influence on the fluidity of the molten metal and the brittleness of the casting. Rapid pouring is essential so that the metal will not begin to solidify before the mold is filled, and this is facilitated by the increase in fluidity given by phosphorus. With excessively high phosphorus, though, the iron is liable to be brittle, with a resulting low resistance to shocks. For this reason, while its presence is desirable within limits, pig iron must be selected that will not exceed a desired maximum.

The actual pipe casting operation is divided into three departments: melting, casting, and cleaning and inspection, so the plant is designed with this in view. The principal building is the foundry, a one-story structure to support the heavy cranes and to house the equipment and molding pits. At one end or side is the two-story cupola house in which are located the cupolas used to melt the pig iron as it is brought from the adjacent storage yard. The cupolas themselves are just at the edge of the foundry so that the molten metal can be lead from them through gutters into ladles that are served by the foundry cranes. As soon as the pipe is cast, it is rolled out at other points around the foundry into the cleaning sheds, where it is cleaned, coated and tested. These three departments are



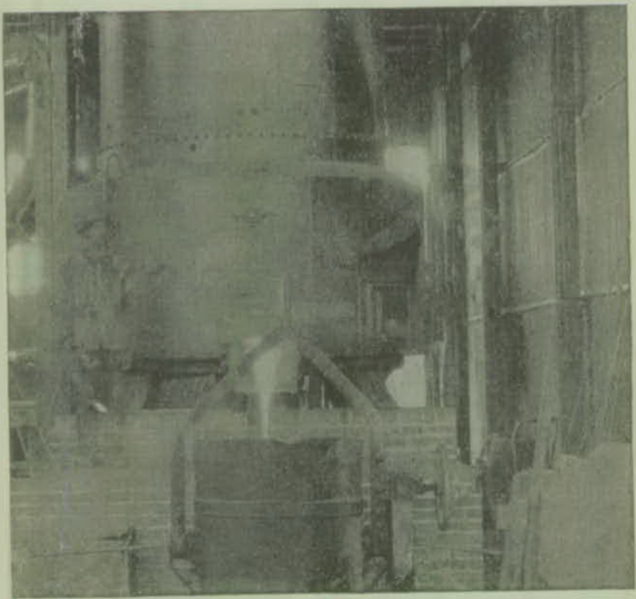
Cupola Charging Floor

under the supervision of the metallurgist, the foundry superintendent, and the chief inspector, respectively; though, naturally, there is a great overlapping of duties and co-operation between these department heads.

The cupola is a steel shell, usually about eight feet in diameter, and forty feet high, lined with a twelve inch fire-brick wall. The bottom is sealed and a hole through the wall just above it opens into the gutter for the escape of the iron as it melts. A short distance higher another hole is pierced for the removal of the slag, and still higher, about three feet above the bottom, a full circle of openings are arranged through which the blast of air is forced. At about half its height, a door in the cupola opens on the second story of the building for the charges of raw materials. Above this point, the cupola serves as a draft stack to prevent the hot gases blowing out through the door.

After a bed of coke several feet thick has been thrown in and ignited, the cupola is filled to the door with alternate charges of coke, pig iron and limestone. The blast of air is lead from a low-pressure blower through the openings near the bottom, and in a short time the molten iron begins to flow out. As the coke is consumed and the iron at the bottom is removed, the column of iron and fuel is replenished through the door until a sufficient quantity has been charged. The charges are made up from weighed fractions from the various piles of pig iron, and are usually brought to the cupola platform one at a time, as needed. A proportion of scrap cast iron is mixed with the pig, originating either from defective castings and runners in the foundry or from outside sources. When used so that the proper analysis of the metal is obtained, scrap iron has no injurious effects on the quality of the castings, as the function of the cupola is merely to melt the iron and not to change its properties. Limestone is charged with the pig iron to render more fluid the pasty mass of slag formed from the ash in the coke and the foreign matter adhering to the iron, and to permit its easier removal at the slag hole. Up until the last few years, all charging was done by hand, but of late many foundries have installed mechanical charging machines with excellent results.

The floor plan of the foundry is divided into rectangular or circular pits, in which the molds are rammed and



Tapping a Cupola

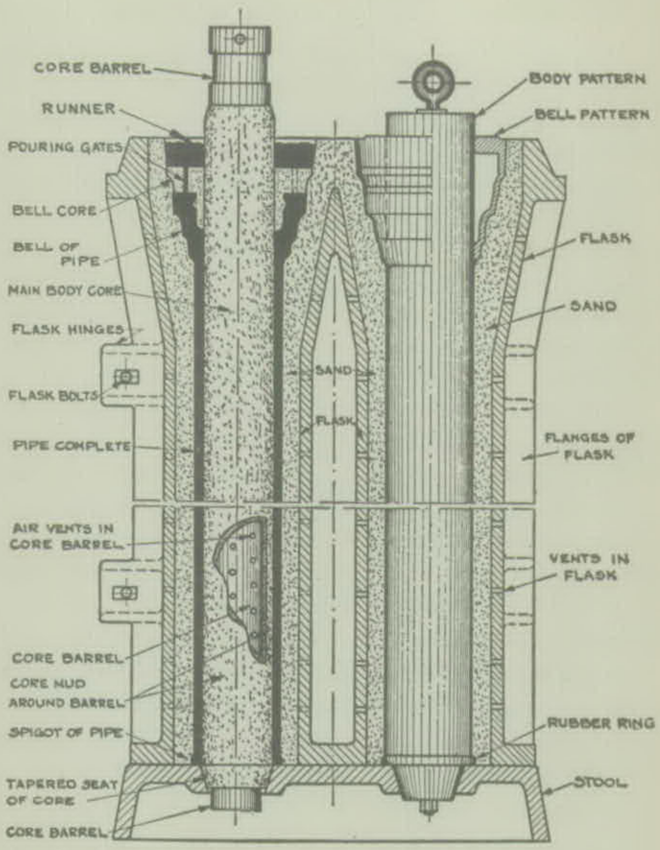
poured. These trenchlike units vary considerably in size in various shops, but to give some idea as to their dimensions, they may be said to average about a hundred feet in length, eight to ten feet in width, and to have a capacity of fifty to seventy tons of pipe per day. Their depth is such that only about three feet of the mold length extends above the floor level, which permits the floor to be used as a working platform convenient to the top of the long flasks. The shape of the pit is made to conform to the movement of the crane; circular pits being used with revolving jib cranes, and rectangular pits with bridge type travelers.

Two variations in molding practice, the "up socket" and the "down socket," are now in general use, so named

Interior of a Modern Pipe Foundry

from the position of the socket or bell in the mold. Engineering Society specifications require all pipe larger in diameter than sixteen inches to be cast with the bell down, the smaller sizes being cast up socket or down socket at the manufacturer's discretion. The high temperature of molten iron has a tendency to destroy the cohesiveness of the sand mold and to cause it to disintegrate. This cutting action is not apparent with smaller volumes of metal, and the more rapid solidification in the thin sections of lighter pipe. So no preference is stated for sizes in which experience has shown either method to be safe. In heavier pipe, though, spongy, dirty castings might occur from sand having been entrapped in the metal and floating to the upper portion of the mold. This danger is eliminated by making an extension in the spigot end of the pipe, which is then removed to leave a perfect casting. The molding methods are so nearly identical for both bell positions that only a description of the "up socket" will be given here.

The molds for cast iron pipe are made in cylindrical containers or flasks, whose interior walls are shaped somewhat like the pipe itself. Two side castings are bolted or clamped together to form one, two or three vertical chambers, depending on the size of the pipe, which are open at the top but partially closed at the bottom by a third casting called the chill plate. In the picture a single flask is suspended from the crane, and double flasks are shown in the pit. The section of the double flask opposite has the patterns in place with the sand rammed around them in the left-hand chamber, and the cores assembled in the mold as for pouring on the right. A conical hole is machined in the chill plate for each mold chamber to support the barrel pattern and aline it concentrically with the flask walls. The barrel pattern is a straight metal cylinder with a tapered seat at one end to fit the chill plate, and handling rings at the other.



Patterns in Place Core in Place Ready for Pouring

Section of Cast Iron Pipe Mold

All patterns and mold dimensions are made about one percent larger than the finished size of the casting to allow for the shrinkage of the metal as it cools.

Usually some one point on the pit is used as a ramming station, to which the empty flasks and molding sand are brought to be rammed. Rubber rings are slipped around the lower ends of the patterns to form the bead contour, and the patterns, one to each chamber, are lowered through the flask onto the chill plate. Damp sand is then thrown in at the top between the pattern and the flask and is packed firmly in place to give a mold wall some three or four times the thickness of the pipe section. Numerous mechanical means for packing the sand are in use, to replace the older method of hand ramming, but as all of these produce the same results, no especial merit can be assigned to any one method so far as the finish of the pipe is concerned. When the flask has been rammed nearly to the top, the bell pattern is positioned over the barrel pattern and more sand is rammed around it until the mold is full. The barrel patterns are withdrawn by the crane, leaving the bell patterns and bead rings in the mold. These are removed, and the mold surface is covered with a wash of coke or coal dust, which prevents the sand being in direct contact with the metal and fusing to it. The completed mold is then carried to the drying oven and an empty flask takes its place at the ramming station.

These ovens are built in the bottom of the pits with heavy cast iron covers on which the molds are placed. Hot gases pass up through holes in the cover plate and chill plate and bake the mold until it is thoroughly dry.

The molds are then quite hard, sufficiently so to withstand the attrition and pressure of the fluid metal.

While the molds are being rammed and dried in the pits, the cores are being prepared in another part of the building. A pipe, drilled at close intervals with small vent holes, is supported horizontally by bearings at each end, and is given a coating of coarse paper, straw or excelsior, while being slowly revolved. On this coating a layer of clay and sand is daubed, and then brought to a cylindrical shape by turning against a knife edge. It is painted with a wash similar to that put on the mold and is placed in an oven to dry. The head core for the inside of the bell and the top of the mold, is made of a mixture of sand, clay and some adhesive substances like molasses or tar. It is formed in a box which can be removed, and after being blacked, is also baked.

After the mold and cores are dry they are ready for assembling. The barrel core is lowered through the mold carefully so as not to injure the surfaces of the mold or core and is seated in the conical opening in the chill plate. One end of the core has been made to fit there so that it not only supports the weight of the core, but also insures the core being centrally located with the mold as well as preventing any leakage of the molten iron. The bell core is then placed over the barrel core and brought down against a shoulder molded for it by the bell pattern. This forms the upper end of the pipe and holds the barrel core concentric at the top, as does the conical seat at the bottom. A runner basin is formed at the top of the flask by the mold walls extending above the head core. When pouring, this basin is kept full of metal, so that the iron may be fed into the mold from the bottom of the basin and any slag or sand will float on the surface without entering the pipe. Small holes are made around the head core for this purpose. The iron solidifying in the runner is removed from the pipe and remelted the following day.

As soon as a group of molds and cores are assembled, iron is brought from the cupola in a ladle and the molds are poured. In a short time the iron solidifies, while at

Core Making Showing Core Bar with Paper Wrapping

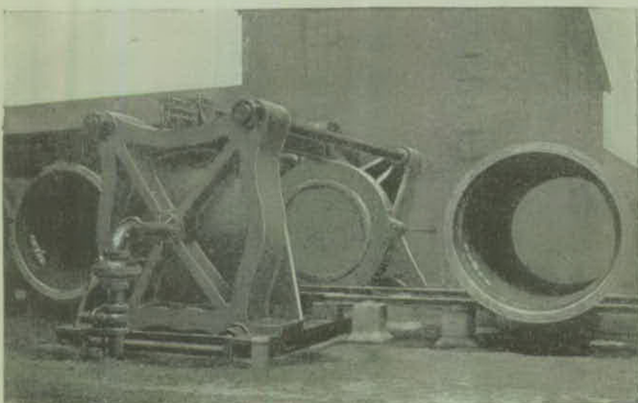
the same time the heat penetrates the sand coating on the core and destroys the paper or excelsior wrapping. This permits the core bar to be withdrawn so that the cooling pipe can contract without developing strains. After cooling until quite black, the flask is lifted out of the pit and is suspended horizontally with one clamped edge down, over a rail runway. The clamps are knocked off and pipes roll out, the sand falling between them into a bin. At intervals the sand is taken up, redampened, and carried to the ramming station to be used again. The runway leads out under the long cleaning shed. The sand from the bell is rapped out and the sand remaining from the barrel core and on the outside of the pipe is removed. Scrapers and polishers are worked over the inner and outer surfaces, and the pipe may then be washed to remove any dust that might affect the coating. Each workman examines the pipe for defects as he per-

Dipping Pipe

forms his portion of the cleaning, and such pipe as they pass are then given a careful examination by the plant inspector. After being cleaned, the pipes are rolled into an oven where they are heated to about 300° F. At this temperature they are dipped in a vat of tar and oil coating and are then placed in an inclined position to drain.

The next step is the hydrostatic test in which the pipes are brought, one at a time, into a testing press and sealed with flat gaskets forced against each end. They are then filled with water and the pressure is brought up above the test point, which is usually three hundred pounds. While at this pressure the pipe is rapped sharply with a hammer to give a shock test under the static load. From the testing press they are rolled onto the scales, the weight is stencilled on the bell and recorded and the pipe is ready for shipment.

The fittings or special castings used with cast iron pipe are made in a different department from the pipe, and



Hydrostatic Press for Testing Large Cast Iron Pipe

by methods more nearly resembling those usually encountered in grey iron foundries. In fact, in the past, a number of general foundries in various parts of the country have supplied fittings in their localities to be used with pipe furnished by standard pipe manufacturers. This practice seems to be losing favor with the engineers, however, because of the delays due to an incomplete line of patterns, and the poor workmanship from lack of skill on such castings. The heavy expense of replacing castings, once installed, is also seldom realized by foundrymen inexperienced in the water-works field, and fittings have often been shipped out and put into

Molding Machine for Making Fittings

service that would have been rejected by the pipe shop inspector.

Most of the smaller size fittings are made with solid patterns and core boxes in damp or "green" sand molds. The manner of molding is determined by the shape of the casting, as the mold must be parted so that the pattern can be removed without disturbing the sand surfaces. The flasks are conveniently shaped frames with cross bars to support the sand. Hand ramming still plays a very important part, though molding machines of various kinds are used extensively. The picture shows one type of these machines, mounted with a six-inch tee pattern. One of the flasks piled in the background is placed over the pattern shown on the left-hand side of the machine, and is filled with sand. An air cylinder underneath the pattern plate raises and drops the pattern and flask with sharp blows until the sand has packed tightly in place. Another cylinder, through arms underneath the pattern plate, swings the flask and pattern vertically to the right side of the machine, where the mold is shown in the cut. The pattern is then withdrawn from the mold and swung back to its former position, leaving the mold ready to be carried to the pouring floor. Just back of the machine is shown the core box. A special reinforcing rod or arbor is placed in one half of the box, and both halves are packed with sand. The box is then closed and one half is lifted off, leaving a firm sand core shaped as the inside of the tee. It is lifted out by the exposed tips of the arbor and placed on the supporting shoulders or "prints" formed at each bell or spigot opening in the mold. The prints fit the core snugly so that when the upper half of the mold is placed over it, it is held firmly in position and no joints are left between it and the mold through which the iron may run out. Two openings are made into the mold from the upper surface of the flask, the gate into which the iron is poured, and another which serves as an index when the mold is full and permits the air in the mold cavity to escape as it is replaced by the iron. Before closing the mold, both the mold and the core are covered with graphite or some other refractory material so that the sand will not fuse to the iron.

Tees, crosses, and bends up to the twelve-inch sizes are all made very much as described for the six-inch tee. Above this size it is usually more economical to use less expensive pattern equipment even though the molding cost is greater. Then, too, as the sections increase with the size of the fittings, dry sand molds must be used, and numerous variations of molding practice may be utilized.

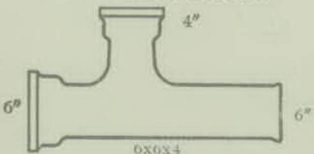
After the fittings have been poured and allowed to cool in the mold, the sand is shaken out in the foundry, and the casting is carried out to be cleaned. Most of the smaller castings are placed in a steel drum where, with slow revolving, they tumble against each other until all adhering sand has been rubbed off. Those castings not suited for cleaning in this way are brushed or sand blasted. All fins and gates are chipped and ground off and the fittings are heated and dipped in the same coating as is used for the pipe.

After the pipe and fittings are coated and weighed, they are given a final inspection, quite often with a representative of the purchaser collaborating with the plant inspector. They are then loaded on cars for shipment, and it is worthy of note that the precautions against rough handling in the field, which are suggested elsewhere in this book, are scrupulously observed by the manufacturer. The pipe are tiered on the cars, usually by means of a locomotive crane, so that shifting and damage in transit are reduced to a minimum.

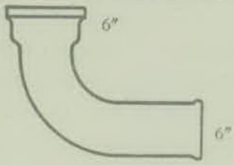
With the loading and shipping of the pipe, the activities of the manufacturer end except for the cooperation known by the somewhat undefinable term of "service." In the pipe industry this takes the form of assistance in securing favorable freight tariffs and expediting shipments, and technical advice to the less experienced users of cast iron pipe, and in the solution of unusual problems. Considerable saving of time and money for the engineer is often possible through minor changes in the design of intricate castings, required to meet local conditions, or the same results may be obtained through the use of patterns which the foundry has made at some previous time. The service of engineers in the field is also available, both from the cast iron pipe companies and from the Cast Iron Pipe Publicity Bureau. These engineers are constantly engaged in the study of corrosion, electrolysis and unusual installation conditions and acting in liaison between the distribution engineer and the foundry, endeavoring to simplify the problems of both, through their observations and research. It has been largely through the generous cooperation and thoughtful criticism of the users of cast iron pipe that the manufacturers have been able to make improvements in their products, and in return the pipe makers offer their experience in the field with the dual hope that it may be of immediate assistance, and also uncover new lines of improvement in composition, design, durability or finish of cast iron pipe.

METHOD OF READING SIZE OF FITTINGS

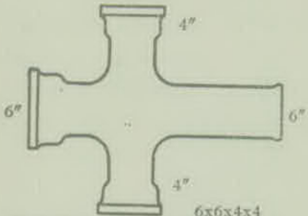
STANDARD FITTINGS



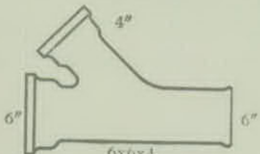
6x6x4
Bell, Spigot and Bell Tee (B-S-B)



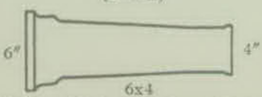
6"
Bell and Spigot ¼ Bend (B. & S.)



6x6x4x4
Bell, Spigot, Bell and Bell Cross
(B-S-B-B)

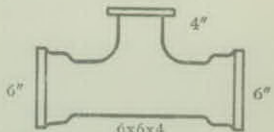


6x6x4
Bell, Spigot and Bell Y-Branch
(B-S-B)

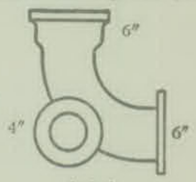


6x4
Bell and Spigot Reducer (B-S)
(Large End Bell)

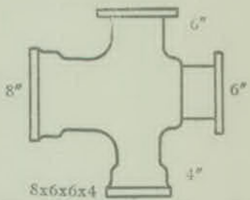
SPECIAL FITTINGS



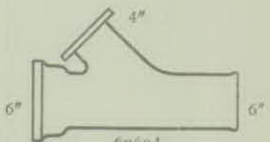
6x6x4
Bell, Bell and Flange Tee (B-B-F)



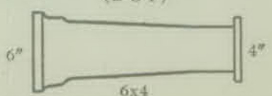
6x6x4
Bell, Flange and Flange Side
Outlet Ell (B-F-F)



8x6x6x4
Bell, Flange, Flange and Bell Cross
(B-F-F-B)



6x6x4
Bell, Spigot and Flange Y-Branch
(B-S-F)



6x4
Bell and Flange Reducer (B-F)
(Large End Bell)

INFORMATION REQUIRED ON REQUESTS FOR QUOTATIONS

IN order to enable the foundries to submit prompt and correct quotations on required piping material it is suggested that inquiries include as complete information as possible. In addition to the usual details regarding destination, method of shipment and routing or delivery road, below are listed the more important items of information that are necessary for the intelligent consideration of your inquiry or order. When part of the material is urgently needed state desired time of shipment.

BELL AND SPIGOT PIPE

Size; class or pressure; kind of service; Standard, A. W. W. A. or A. G. A.; Type 1 or 2; coated or uncoated; length of each pipe, whether 12 feet, 16 feet or 5 meter; number of lengths required or total length in feet.

FLANGED PIPE

Size; class or pressure; kind of service; coated or uncoated; number of 12 foot lengths (shop will furnish all lengths as ordered, no allowance made for gaskets unless specified); state exact length when under 12 foot; state whether Standard or Special drilling.

BELL AND SPIGOT FITTINGS

Size; class; coated or uncoated; type, whether Bell and Spigot, All Bell or Spigot and Spigot; Standard, whether A. W. W. A., A. G. A. or Special; if Special, sketch should be sent.

FLANGED FITTINGS

Size; pressure; coated or uncoated; Standard, whether American, water, gas or special; if special, sketch should be sent; state whether Standard or Special drilling.

NOTE: For special pipe and materials send blue prints.

For standard names of fittings see page 165.
For method of reading fittings see page 47.
For standard of drilling see pages 147 and 149.

SECTION 4

PRINCIPLES OF BUSINESS CONDUCT ADOPTED BY THE CAST IRON PIPE PUBLICITY BUREAU

I.

THE FOUNDATION of business is confidence which springs from integrity, fair dealing, efficient service, and mutual benefit.

II.

THE REWARD of business for service rendered is a fair profit plus a safe reserve, as commensurate with risks involved and foresight exercised.

III.

EQUITABLE CONSIDERATION is due in business alike to capital, management, employees, and the public.

IV.

KNOWLEDGE—thorough and specific—and unceasing study of the facts and forces affecting a business enterprise are essential to a lasting individual success and to efficient service to the public.

V.

PERMANENCY and continuity of service are basic aims of the business, that knowledge gained may be fully utilized, confidence established and efficiency increased.

VI.

OBLIGATIONS to itself and society prompt business unceasingly to strive toward continuity of operation, bettering conditions of employment and increasing the efficiency and opportunities of individual employees.

VII.

CONTRACTS and undertakings, written or oral, are to be performed in letter and in spirit. Changed conditions do not justify their cancellation without mutual consent.

VIII.

REPRESENTATION of goods and services should be truthfully made and scrupulously fulfilled.

IX.

WASTE in any form—of capital, labor, services, materials, or natural resources—is intolerable and constant effort will be made toward its elimination.

X.

EXCESS of every nature—inflation of credit, over-expansion, over-buying, over-stimulation of sales—which create artificial conditions and produce crises and depressions are condemned.

XI.

UNFAIR COMPETITION, embracing all acts characterized by bad faith, deception, fraud, or oppression, including commercial bribery, is wasteful, despicable and a public wrong. Business will rely for its success on the excellence of its own service.

XII.

CONTROVERSIES will, where possible, be adjusted by voluntary agreement or impartial arbitration.

XIII.

CORPORATE FORMS do not absolve from or alter the moral obligations of individuals. Responsibilities will be as courageously and conscientiously discharged by those acting in representative capacities as when acting for themselves.

XIV.

LAWFUL COOPERATION among business men and in useful business organizations in support of these principles of business conduct is commended.

XV.

BUSINESS should render restrictive legislation unnecessary through so conducting itself as to deserve and inspire public confidence.

Published through the courtesy of the Hydraulic Society.

SECTION 5

AMERICAN WATER WORKS ASSOCIATION STANDARD

Bell and Spigot Cast Iron Pipe and Fittings

American Water Works Association Standard Specifications for Cast Iron Water Pipe and Fittings

STANDARD SPECIFICATIONS FOR WATER PIPE. On May 12, 1908, the American Waterworks Association adopted a set of specifications for Cast Iron Water Pipe and Fittings. These specifications in turn were adopted as the manufacturers' standard by the Bell and Spigot Cast Iron Pipe makers throughout the country. Another specification in use, less widely, however, than the American Waterworks Association Specifications, is that adopted by the New England Waterworks Association in 1902. The latter specifications use outside diameters similar to the American Waterworks Association, but include a wider range of wall thickness for the many classes provided for. These latter specifications have been largely replaced by the American Waterworks Association Specifications.

The adoption of a standard specification for water pipe has resulted in economy not only in manufacture but also in maintenance work. When it becomes necessary to install special castings in existing lines laid with standard pipe, it is not necessary to dig up the pipe to ascertain its thickness as it is definitely known before hand. Furthermore, standard pipe and fittings can usually be obtained from stock, whereas pipe and fittings made to special specifications must be made upon order and consequently there is liable to be some delay in delivery.

The specifications as they now stand provide for pipe for working heads of from 100 ft. to 800 ft., with a different wall thickness for each 100 ft. The classes are designated by letters: Class "A" being for pressures not to exceed 100 ft., Class "B," 200 ft., and so on to Class "H" for pressures not to exceed 800 ft.

The type of joint specified is the Bell and Spigot Joint and no other joint has been approved by either Association. The reason for this is the fact that experience has shown that the Bell and Spigot joint is best fitted for underground use. Pipe with joints other than Bell and Spigot now on the market is made with a wall thickness materially less than that recommended by the American Waterworks Association. This pipe, besides having a joint that lacks the advantages of the Bell and Spigot joints, weighs less per foot and will withstand less water pressure. These pipe are cast "on the flat," and the advantages that come from making pipe by pouring the metal into vertical moulds (as required by the American Waterworks Association Specifications) is lost.

For pipe work inside of pumping stations, filter plants and for any place where the class of work does not necessitate placing the pipe underground, flanged pipe is made with wall thickness similar to that specified by the American Waterworks Association. Tables giving the dimensions of flanged pipe and fittings are included with the tables of dimensions that are part of the American Waterworks Association Specifications.

American Water Works Association Standard Specifications for Cast Iron Water Pipe and Fittings

Adopted May 12, 1908

Description of Pipes

SECTION 1. The pipes shall be made with hub and spigot joints and shall accurately conform to the dimensions given in Table No. 1. They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least 12 ft. in length, exclusive of socket.

Pipes with thickness and weight intermediate between the classes in Tables Nos. 1 and 3 shall be made of the same outside diameter as the next heavier class. Pipes with thickness and weight less than shown by Tables Nos. 1 and 3 shall be made of the same outside diameter as the Class A pipe.

All pipes having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of about 6 inches from each end of the pipe so as to obtain the required standard thickness and weight for each size and class of pipe.

For pipes of each size, from 4-inch to 24-inch, inclusive, there shall be two standards of outside diameter, and for pipes from 30-inch to 60-inch, inclusive, there shall be four standards of outside diameter, as shown by Table No. 1.

For pipes 4-inch to 12-inch, inclusive, one class of fittings shall be furnished, made from Class D pattern. Those having spigot ends shall have outside diameters of spigot ends midway between the two standards of outside diameter, as shown by Table No. 1, and shall be tapered back for a distance of 6 inches.

For pipes from 14-inch to 24-inch, inclusive, two classes of fittings shall be furnished; Class B fittings with Classes A and B pipes, and Class D fittings with Classes C and D pipes; the former shall have cast on them the letters "AB" and the latter "CD." For pipes 30-inch to 60-inch, inclusive, four classes of fittings shall be furnished, one for each class of pipe, and shall have cast on them the letter of the class to which they belong.

Allowable Variation in Diameter of Pipes and Sockets

SECTION 2. Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gauges, and no pipe will be received which is defective in joint room from any cause. The diameters of the sockets and the outside diameters of the spigot ends of the pipes shall not vary from the standard dimensions by more than .06 of an inch for pipes 16 inches or less in diameter; .08 of an inch for 18-inch, 20-inch and 24-inch pipes; .10 of an inch for 30-inch, 36-inch and 42-inch pipes; .12 of an inch for 48-inch, and .15 of an inch for 54-inch and 60-inch pipes.

Allowable Variation in Thickness

SECTION 3. For pipes whose standard thickness is less than 1 inch, the thickness of metal in the body of the pipe shall not be more than .08 of an inch less than the standard thickness, and for pipes whose standard thickness is 1 inch or more, the variation shall not exceed .10 of an inch, except that for spaces not exceeding 8 inches in length in any direction, variations from the standard thickness of .02 of an inch in excess of the allowance above given shall be permitted.

For fittings of standard patterns a variation of 50 per cent greater than allowed for straight pipes shall be permitted.

Defective Spigots May Be Cut

SECTION 4. Defective spigot ends on pipes 12 inches or more in diameter may be cut off in a lathe and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than 11 feet in length, exclusive of the socket.

In case the length of a pipe differs from 12 feet, the standard weight of the pipe given in Table No. 3 shall be modified in accordance therewith.

Fittings

SECTION 5. All fittings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The diameters of the sockets and the external diameters of the spigot ends of the fittings shall not vary from the standard dimensions by more than .12 of an inch for castings 16 inches or less in diameter; .15 of an inch for 18-inch, 20-inch and 24-inch; .20 of an inch for 30-inch, 36-inch and 42-inch, and .24 of an inch for 48-inch, 54-inch and 60-inch. These variations apply only to fittings made from standard patterns.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The manufacturer shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on plans and made of the best quality of mild steel, with hexagonal heads and nuts and sound, well-fitting threads.

Marking

SECTION 6. Every pipe and fitting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4 inches may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

1908	1908	1908
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall not be less than 2 inches in length and ⅛ of an inch in relief for pipes 8 inches in diameter and larger. For smaller sizes of pipes the letters may be 1 inch in length. The weight and the class letter shall be conspicuously painted in white in the inside of each pipe and fitting after the coating has become hard.

Allowable Percentage of Variation in Weight

SECTION 7. No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipes 16 inches or less in diameter, and 4 per cent for pipes more than 16 inches in diameter, and no excess above the standard weight of more than the given percentage for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent.

No fitting shall be accepted the weight of which shall be less than the standard weight by more than 10 per cent for pipes 12 inches or less in diameter, and 8 per cent for larger sizes, except that curves, Y pieces and breeches pipe may be 12 per cent below the standard weight, and no excess above the standard weight of more than the above percentages for the several sizes will be paid for. These variations apply only to castings made from the standard patterns.

Quality of Iron

SECTION 8. All pipes and fittings shall be made of cast-iron of good quality, and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars.

Should the dimensions of the three bars differ from those given below, a proper allowance therefor shall be made in the results of the tests.

Tests of Material

SECTION 9. Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions, the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 inches apart, and loaded in the center, shall support a load of 2,000 pounds, and show a deflection of not less than .30 of an inch before breaking; or if preferred, tensile bars shall be made which will show a breaking point of not less than 20,000 pounds per square inch.

Casting of Pipe

SECTION 10. The straight pipes shall be cast in dry sand moulds in a vertical position. Pipes 16 inches or less in diameter shall be cast with the hub end up or down, as specified in the proposals. Pipes 18 inches or more in diameter shall be cast with the hub end down.

The pipes shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Quality of Castings

SECTION 11. The pipes and fittings shall be smooth, free from scale, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging or filling will be allowed.

Cleaning and Inspection

SECTION 12. All pipes and fittings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

Coating

SECTION 13. Every pipe and fitting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 degrees Fahrenheit immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300 degrees Fahrenheit (or less if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated the pipe shall be carefully drained of the surplus varnish. Any pipe or fitting that is to be recoated shall first be thoroughly scraped and cleaned.

Hydrostatic Test

SECTION 14. When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressure to which the different sizes and classes of pipes shall be subjected are as follows:

	20-Inch Diameter and Larger, Lbs. Per Square Inch	Less Than 20-Inch Diameter, Lbs. Per Square Inch
Class A Pipe............	150	300
Class B Pipe............	200	300
Class C Pipe............	250	300
Class D Pipe............	300	300

Weighing

SECTION 15. The pipes and fittings shall be weighed for payment under the supervision of the engineer after the application of the coal-tar pitch varnish. If desired by the engineer, the pipes and fittings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 pounds.

Contractor to Furnish Men and Material

SECTION 16. The contractor shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry of the pipe and fittings; and should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the tests upon the test bars.

Power of Engineer to Inspect

SECTION 17. The engineer shall be at liberty at all times to inspect the material at the foundry, and the moldings, castings and coating of the pipes and fittings. The forms, sizes, uniformity and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings.

Inspector to Report

SECTION 18. The inspector at the foundry shall report daily to the foundry office all pipes and fittings rejected, with the causes for rejection.

Castings to be Delivered Sound and Perfect

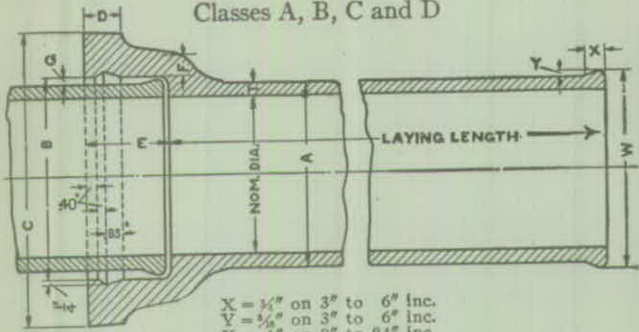
SECTION 19. All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipes or other castings which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the contractor shall not be held liable for pipes or fittings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they have received the coating.

Definition of the Word "Engineer"

SECTION 20. Wherever the word "engineer" is used herein it shall be understood to refer to the engineer or inspector acting for the purchaser and to his properly authorized agents, limited by the particular duties intrusted to them.

Dimensions of A. W. W. A. Standard Bell and Spigot Pipe

Classes A, B, C and D



X = 1/2" on 3" to 6" inc.
Y = 5/16" on 3" to 6" inc.
X = 1" on 8" to 84" inc.
Y = 1/4" on 8" to 84" inc.

Table No. 1

Nominal Diameter Inches	Class	Dimensions, Inches								
		A	B	C	D	E	F	G	T	W
3	A	3.80	4.60	7.20	1.25	3.50	.65	.40	.39	4.18
	B	3.96	4.76	7.36	1.25	3.50	.65	.40	.42	4.34
	C	3.96	4.76	7.36	1.25	3.50	.65	.40	.45	4.34
	D	3.96	4.76	7.36	1.25	3.50	.65	.40	.48	4.34
4	A	4.80	5.60	8.20	1.50	3.50	.65	.40	.42	5.18
	B	5.00	5.80	8.40	1.50	3.50	.65	.40	.45	5.38
	C	5.00	5.80	8.40	1.50	3.50	.65	.40	.48	5.38
	D	5.00	5.80	8.40	1.50	3.50	.65	.40	.52	5.38
6	A	6.90	7.70	10.50	1.50	3.50	.70	.40	.44	7.28
	B	7.10	7.90	10.70	1.50	3.50	.70	.40	.48	7.48
	C	7.10	7.90	10.70	1.50	3.50	.70	.40	.51	7.48
	D	7.10	7.90	10.70	1.50	3.50	.70	.40	.55	7.48
8	A	9.05	9.85	12.85	1.50	4.00	.75	.40	.46	9.55
	B	9.05	9.85	12.85	1.50	4.00	.75	.40	.51	9.55
	C	9.30	10.10	13.10	1.50	4.00	.75	.40	.56	9.80
	D	9.30	10.10	13.10	1.50	4.00	.75	.40	.60	9.80

Dimensions continued on next page.

For weights see pages 70 and 71.

For Classes E, F, G and H see page 72.

Pipe listed in this Table can be furnished with plain ends for use with special couplings. For weights on plain end pipe see pages 145 and 146 under heading "weight per foot without flanges."

Dimensions of A. W. W. A. Standard Bell and Spigot Pipe

Classes A, B, C and D

Table No. 1 (continued)

Nominal Diameter Inches	Class	A	B	C	D	E	F	G	T	W
10	A	11.10	11.90	14.90	1.50	4.00	.75	.40	.50	11.60
	B	11.10	11.90	14.90	1.50	4.00	.75	.40	.57	11.60
	C	11.40	12.20	15.40	1.50	4.00	.80	.40	.62	11.90
	D	11.40	12.20	15.40	1.50	4.00	.80	.40	.68	11.90
12	A	13.20	14.00	17.20	1.50	4.00	.80	.40	.54	13.70
	B	13.20	14.00	17.20	1.50	4.00	.80	.40	.62	13.70
	C	13.50	14.30	17.70	1.50	4.00	.85	.40	.68	14.00
	D	13.50	14.30	17.70	1.50	4.00	.85	.40	.75	14.00
14	A	15.30	16.10	19.50	1.50	4.00	.85	.40	.57	15.80
	B	15.30	16.10	19.50	1.50	4.00	.85	.40	.66	15.80
	C	15.65	16.45	20.05	1.50	4.00	.90	.40	.74	16.15
	D	15.65	16.45	20.05	1.50	4.00	.90	.40	.82	16.15
16	A	17.40	18.40	22.00	1.75	4.00	.90	.50	.60	17.90
	B	17.40	18.40	22.00	1.75	4.00	.90	.50	.70	17.90
	C	17.80	18.80	22.60	1.75	4.00	1.00	.50	.80	18.30
	D	17.80	18.80	22.60	1.75	4.00	1.00	.50	.89	18.30
18	A	19.50	20.50	24.30	1.75	4.00	.95	.50	.64	20.00
	B	19.50	20.50	24.30	1.75	4.00	.95	.50	.75	20.00
	C	19.92	20.92	25.12	1.75	4.00	1.05	.50	.87	20.42
	D	19.92	20.92	25.12	1.75	4.00	1.05	.50	.96	20.42
20	A	21.60	22.60	26.60	1.75	4.00	1.00	.50	.67	22.10
	B	21.60	22.60	26.60	1.75	4.00	1.00	.50	.80	22.10
	C	22.06	23.06	27.66	1.75	4.00	1.15	.50	.92	22.56
	D	22.06	23.06	27.66	1.75	4.00	1.15	.50	1.03	22.56
24	A	25.80	26.80	31.00	2.00	4.00	1.05	.50	.76	26.30
	B	25.80	26.80	31.00	2.00	4.00	1.05	.50	.89	26.30
	C	26.32	27.32	32.32	2.00	4.00	1.25	.50	1.04	26.82
	D	26.32	27.32	32.32	2.00	4.00	1.25	.50	1.16	26.82
30	A	31.74	32.74	37.34	2.00	4.50	1.15	.50	.88	32.24
	B	32.00	33.00	37.60	2.00	4.50	1.15	.50	1.03	32.50
	C	32.40	33.40	38.60	2.00	4.50	1.32	.50	1.20	32.90
	D	32.74	33.74	39.74	2.00	4.50	1.50	.50	1.37	33.24
36	A	37.96	38.96	43.96	2.00	4.50	1.25	.50	.99	38.46
	B	38.30	39.30	44.90	2.00	4.50	1.40	.50	1.15	38.80
	C	38.70	39.70	45.90	2.00	4.50	1.60	.50	1.36	39.20
	D	39.16	40.16	46.96	2.00	4.50	1.80	.50	1.58	39.66

Dimensions continued on next page.
See notes on preceding page.

Dimensions of A. W. W. A. Standard Bell and Spigot Pipe

Classes A, B, C and D

Table No. 1 (continued)

Nominal Diameter Inches	Class	Dimensions, Inches								
		A	B	C	D	E	F	G	T	W
42	A	44.20	45.20	50.80	2.00	5.00	1.40	.50	1.10	44.70
	B	44.50	45.50	51.50	2.00	5.00	1.50	.50	1.28	45.00
	C	45.10	46.10	52.90	2.00	5.00	1.75	.50	1.54	45.60
	D	45.58	46.58	54.18	2.00	5.00	1.95	.50	1.78	46.08
48	A	50.50	51.50	57.50	2.00	5.00	1.50	.50	1.26	51.00
	B	50.80	51.80	58.40	2.00	5.00	1.65	.50	1.42	51.30
	C	51.40	52.40	60.00	2.00	5.00	1.95	.50	1.71	51.90
	D	51.98	52.98	61.38	2.00	5.00	2.20	.50	1.96	52.48
54	A	56.66	57.66	64.06	2.25	5.50	1.60	.50	1.35	57.16
	B	57.10	58.10	65.30	2.25	5.50	1.80	.50	1.55	57.60
	C	57.80	58.80	66.80	2.25	5.50	2.15	.50	1.90	58.30
	D	58.40	59.40	68.20	2.25	5.50	2.45	.50	2.23	58.90
60	A	62.80	63.80	70.60	2.25	5.50	1.70	.50	1.39	63.30
	B	63.40	64.40	71.80	2.25	5.50	1.90	.50	1.67	63.90
	C	64.20	65.20	73.60	2.25	5.50	2.25	.50	2.00	64.70
	D	64.82	65.82	75.22	2.25	5.50	2.60	.50	2.38	65.32
72	A	75.34	76.59	84.19	2.25	5.50	1.87	.63	1.62	75.84
	B	76.00	77.25	85.65	2.25	5.50	2.20	.63	1.95	76.50
	C	76.88	78.13	87.33	2.25	5.50	2.64	.63	2.39	77.38
84	A	87.54	88.79	96.99	2.50	5.50	2.10	.63	1.72	88.04
	B	88.54	89.79	98.79	2.50	5.50	2.60	.63	2.22	89.04

See notes on page 66.

Standard Lugs for A. W. W. A. Bell and Spigot Pipe and Fittings
(All Classes)

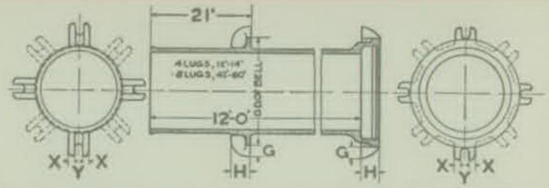


Table No. 2

Nominal Diameter Pipe, Inches	Class	Number of Lugs on Each End	Dimensions, Inches G	Dimensions, Inches X	Dimensions, Inches Y	Size of Bolts, Inches	Length of Bolts, Inches	Weight of Lugs on One Bell	Weight of Lugs on One Spigot
6	E to H	4	2.25	1.50	1.25	1	26	34	68
8	E to H	4	2.25	1.50	1.25	1	26	34	70
10	E to H	4	2.50	1.50	1.50	1¼	26	36	83
12	A to D	4	2.50	1.25	1.63	1⅜	25	32	45
12	E to H	4	2.50	1.50	1.63	1¼	26	38	88
14	A to D	4	2.50	1.25	1.63	1⅜	25	56	46
14	E to H	6	2.50	1.50	1.63	1¼	26	55	135
16	A to D	6	2.50	1.25	1.63	1⅜	25	56	73
16	E to H	6	2.50	1.50	1.63	1¼	26	56	141
18	A to D	6	2.50	1.25	1.63	1⅜	25	56	76
18	E to H	6	3.00	1.62	1.75	1½	27	72	198
20	A to D	6	2.50	1.25	1.63	1⅜	25	56	80
20	E to H	6	3.00	1.62	1.75	1½	27	73	200
24	A to D	6	2.50	1.25	1.63	1⅜	25	56	83
24	E to H	6	3.25	1.75	2.00	1¾	27	89	240
30	A to D	6	3.00	1.50	2.00	1¾	26	80	133
30	E to F	8	3.25	1.75	2.00	1¾	27	121	371
36	A to D	6	3.00	1.50	2.00	1¾	26	80	142
36	E to F	12	3.25	1.75	2.00	1¾	27	191	613

Dimension 21 inches in above cut is for pipe; this dimension varies for fittings.
Two lugs are placed on the vertical axis of each bell, the others at equal distances around circumference.
Dimensions in inches.
Weights given in pounds. All weights approximate.
Pipe furnished with lugs only when specifically ordered.
H = Depth of Bell.

Weights of A. W. W. A. Standard Bell and Spigot Cast Iron Pipe Classes A and B—Table No. 3

Nominal Inside Diameter, Inches	Class A—100-Foot Head 43 Pounds Pressure							Class B—200-Foot Head 86 Pounds Pressure							Approximate Pounds Lead per Joint 2 Inches Thick	Approximate Pounds Hemp per Joint	Nominal Inside Diameter, Inches
	Thickness, Inches	Weight of 12-Foot Length Pounds Per		Weight of 16-Foot Length Pounds Per		Weight of 5-Meter Length Pounds Per		Thickness, Inches	Weight of 12-Foot Length Pounds Per		Weight of 16-Foot Length Pounds Per		Weight of 5-Meter Length Pounds Per				
		Foot	Length	Foot	L'gth	Foot	L'gth		Foot	Length	Foot	L'gth	Foot	L'gth			
3	.39	14.5	175	....	....	....	....	.42	16.2	194	....	....	....	....	6.00	.18	3
4	.42	20.0	240	19.7	315	....	....	.45	21.7	260	21.2	340	....	....	7.50	.21	4
6	.44	30.8	370	30.3	485	30.0	493	.48	33.3	400	32.5	520	32.5	533	10.25	.31	6
8	.46	42.9	515	42.2	675	41.8	686	.51	47.5	570	46.6	745	46.2	758	13.25	.44	8
10	.50	57.1	685	55.9	895	55.7	914	.57	63.8	765	62.5	1000	62.4	1024	16.00	.53	10
12	.54	72.5	870	71.2	1140	71.0	1165	.62	82.1	985	80.6	1290	80.5	1321	19.00	.61	12
14	.57	89.6	1075	....	....	....	....	.66	102.5	1230	....	....	....	....	22.00	.81	14
16	.60	108.3	1300	....	....	....	....	.70	125.0	1500	....	....	....	....	30.00	.94	16
18	.64	129.2	1550	....	....	....	....	.75	150.0	1800	....	....	....	....	33.80	1.00	18
20	.67	150.0	1800	....	....	....	....	.80	175.0	2100	....	....	....	....	37.00	1.25	20
24	.76	204.2	2450	....	....	....	....	.89	233.3	2800	....	....	....	....	44.00	1.50	24
30	.88	291.7	3500	....	....	....	....	1.03	333.3	4000	....	....	....	....	54.25	2.06	30
36	.99	391.7	4700	....	....	....	....	1.15	454.2	5450	....	....	....	....	64.75	3.00	36
42	1.10	512.5	6150	....	....	....	....	1.28	591.7	7100	....	....	....	....	75.25	3.62	42
48	1.26	666.7	8000	....	....	....	....	1.42	750.0	9000	....	....	....	....	85.50	4.37	48
54	1.35	800.0	9600	....	....	....	....	1.55	933.3	11200	....	....	....	....	97.60	6.25	54
60	1.39	916.7	11000	....	....	....	....	1.67	1104.2	13250	....	....	....	....	108.30	8.25	60
72	1.62	1281.9	15380	....	....	....	....	1.95	1547.3	18570	....	....	....	....	146.00	12.50	72
84	1.72	1635.8	19630	....	....	....	....	2.22	2104.1	25250	....	....	....	....	170.00	15.00	84

All weights are approximate; those per foot include allowance for bell; those per length include standard bells; proportionate allowance to be made for any variation from the standard length.

All pipe are tested by water pressure, as per Section 14 of Standard Specifications.

The difference in weight per foot of 12-foot and 16-foot or 5-meter lengths is due to the weight of the bell being spread over longer lengths. For dimensions see Table No. 1. 5 meter pipe is 16 feet 4 7/8 inches long.

Weights of A. W. W. A. Standard Bell and Spigot Cast Iron Pipe Classes C and D Table No. 3 (continued)

Nominal Inside Diameter, Inches	Class C—300-Foot Head 130 Pounds Pressure: Thickness, Inches	Weight of 12-Foot Length Pounds Per Foot	Weight of 12-Foot Length Pounds Per Length	Weight of 16-Foot Length Pounds Per Foot	Weight of 16-Foot Length Pounds Per L'gth	Weight of 5-Meter Length Pounds Per Foot	Weight of 5-Meter Length Pounds Per L'gth	Class D—400-Foot Head 173 Pounds Pressure: Thickness, Inches	Weight of 12-Foot Length Pounds Per Foot	Weight of 12-Foot Length Pounds Per Length	Weight of 16-Foot Length Pounds Per Foot	Weight of 16-Foot Length Pounds Per L'gth	Weight of 5-Meter Length Pounds Per Foot	Weight of 5-Meter Length Pounds Per L'gth	Approximate Pounds Lead per Joint 2 Inches Thick	Approximate Pounds Hemp per Joint	Nominal Inside Diameter, Inches
3	.45	17.1	205	....	....	....	....	.48	18.0	216	....	....	....	....	6.00	.18	3
4	.48	23.3	280	22.8	365	....	....	.52	25.0	300	24.4	390	....	....	7.50	.21	4
6	.51	35.8	430	35.0	560	34.9	573	.55	38.3	460	37.5	600	37.4	614	10.25	.31	6
8	.56	52.1	625	50.9	815	50.9	835	.60	55.8	670	54.7	875	54.6	896	13.25	.44	8
10	.62	70.8	850	69.4	1110	69.3	1137	.68	76.7	920	75.3	1205	75.2	1234	16.00	.53	10
12	.68	91.7	1100	90.0	1440	89.9	1475	.75	100.0	1200	98.4	1575	98.3	1613	19.00	.61	12
14	.74	116.7	1400	....	....	....	....	.82	129.2	1550	....	....	....	....	22.00	.81	14
16	.80	143.8	1725	....	....	....	....	.89	158.3	1900	....	....	....	....	30.00	.94	16
18	.87	175.0	2100	....	....	....	....	.96	191.7	2300	....	....	....	....	33.80	1.00	18
20	.92	208.3	2500	....	....	....	....	1.03	229.2	2750	....	....	....	....	37.00	1.25	20
24	1.04	279.2	3350	....	....	....	....	1.16	306.7	3680	....	....	....	....	44.00	1.50	24
30	1.20	400.0	4800	....	....	....	....	1.37	450.0	5400	....	....	....	....	54.25	2.06	30
36	1.36	545.8	6550	....	....	....	....	1.58	625.0	7500	....	....	....	....	64.75	3.00	36
42	1.54	716.7	8600	....	....	....	....	1.78	825.0	9900	....	....	....	....	75.25	3.62	42
48	1.71	908.3	10900	....	....	....	....	1.96	1050.0	12600	....	....	....	....	85.50	4.37	48
54	1.90	1141.7	13700	....	....	....	....	2.23	1341.7	16100	....	....	....	....	97.60	6.25	54
60	2.00	1341.7	16100	....	....	....	....	2.38	1583.3	19000	....	....	....	....	108.30	8.25	60
72	2.39	1904.3	22850	....	....	....	....	....	.....	....	....	....	....	....	146.00	12.50	72
84	....	......	......	....	....	....	....	....	.....	....	....	....	....	....	170.00	15.00	84

For notes see preceding page.

Dimensions of A. W. W. A. Standard Bell and Spigot Pipe
Classes E, F, G and H

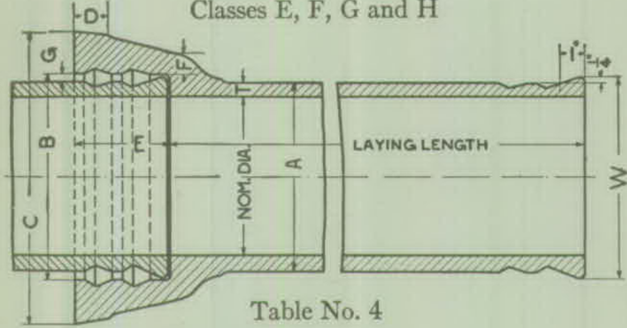


Table No. 4

Nominal Diameter Inches	Class	Dimensions, Inches								
		A	B	C	D	E	F	G	T	W
6	E	7.22	8.02	11.52	1.50	4.00	.75	.40	.58	7.72
	F	7.22	8.02	11.52	1.50	4.00	.75	.40	.61	7.72
	G	7.38	8.18	11.88	1.50	4.00	.85	.40	.65	7.88
	H	7.38	8.18	11.88	1.50	4.00	.85	.40	.69	7.88
8	E	9.42	10.22	13.92	1.50	4.00	.85	.40	.66	9.92
	F	9.42	10.22	13.92	1.50	4.00	.85	.40	.71	9.92
	G	9.60	10.40	14.30	1.50	4.00	.95	.40	.75	10.10
	H	9.60	10.40	14.30	1.50	4.00	.95	.40	.80	10.10
10	E	11.60	12.40	16.30	1.75	4.50	.95	.40	.74	12.10
	F	11.60	12.40	16.30	1.75	4.50	.95	.40	.80	12.10
	G	11.84	12.64	16.74	1.75	4.50	1.05	.40	.86	12.34
	H	11.84	12.64	16.74	1.75	4.50	1.05	.40	.92	12.34
12	E	13.78	14.58	18.68	1.75	4.50	1.05	.40	.82	14.28
	F	13.78	14.58	18.68	1.75	4.50	1.05	.40	.89	14.28
	G	14.08	14.88	19.28	1.75	4.50	1.20	.40	.97	14.58
	H	14.08	14.88	19.28	1.75	4.50	1.20	.40	1.04	14.58
14	E	15.98	16.78	21.08	2.00	4.50	1.15	.40	.90	16.48
	F	15.98	16.78	21.08	2.00	4.50	1.15	.40	.99	16.48
	G	16.32	17.12	21.82	2.00	4.50	1.35	.40	1.07	16.82
	H	16.32	17.12	21.82	2.00	4.50	1.35	.40	1.16	16.82

For weights, see page 74.

Can be furnished with single lead groove if desired. For dimensions, see Table No. 1.

Dimensions of A. W. W. A. Standard Bell and Spigot Pipe Classes E, F, G and H

Table No. 4 (continued)

Nominal Diameter Inches	Class	Dimensions, Inches								
		A	B	C	D	E	F	G	T	W
16	E	18.16	18.96	23.56	2.00	4.50	1.25	.40	.98	18.66
	F	18.16	18.96	23.56	2.00	4.50	1.25	.40	1.08	18.66
	G	18.54	19.34	24.44	2.00	4.50	1.45	.40	1.18	19.04
	H	18.54	19.34	24.44	2.00	4.50	1.45	.40	1.27	19.04
18	E	20.34	21.14	26.04	2.25	4.50	1.40	.40	1.07	20.84
	F	20.34	21.14	26.04	2.25	4.50	1.40	.40	1.17	20.84
	G	20.78	21.58	27.08	2.25	4.50	1.65	.40	1.28	21.28
	H	20.78	21.58	27.08	2.25	4.50	1.65	.40	1.39	21.28
20	E	22.54	23.34	28.44	2.25	4.50	1.50	.40	1.15	23.04
	F	22.54	23.34	28.44	2.25	4.50	1.50	.40	1.27	23.04
	G	23.02	23.82	29.52	2.25	4.50	1.75	.40	1.39	23.52
	H	23.02	23.82	29.52	2.25	4.50	1.75	.40	1.51	23.52
24	E	26.90	27.90	33.40	2.25	5.00	1.70	.50	1.31	27.40
	F	26.90	27.90	33.40	2.25	5.00	1.70	.50	1.45	27.40
	G	27.76	28.56	34.86	2.25	5.00	1.95	.50	1.75	28.26
	H	27.76	28.56	34.86	2.25	5.00	1.95	.50	1.88	28.26
30	E	33.10	34.10	40.60	2.25	5.00	1.80	.50	1.55	33.60
	F	33.46	34.46	41.46	2.25	5.00	2.00	.50	1.73	33.96
36	E	39.60	40.60	48.00	2.25	5.00	2.05	.50	1.80	40.10
	F	40.04	41.04	49.04	2.25	5.00	2.30	.50	2.02	40.54

For weights, see page 74.

Can be furnished with single lead groove if desired. For dimensions, see Table No. 1.

Weights of A. W. W. A. Standard Bell and Spigot Cast Iron Pipe Classes E, F, G and H

Table No. 5

Nominal Inside Diameter, Inches	Class E 500-Foot Head 217 Pounds Pressure			Class F 600-Foot Head 260 Pounds Pressure			Class G 700-Foot Head 304 Pounds Pressure			Class H 800-Foot Head 347 Pounds Pressure			Approximate Pounds of Lead per Joint	Approximate Pounds of Hemp per Joint	Nominal Inside Diameter, Inches
	Thickness, Inches	Weight, Pounds per Foot	Weight, Pounds per 12-Foot Length	Thickness, Inches	Weight, Pounds per Foot	Weight, Pounds per 12-Foot Length	Thickness, Inches	Weight, Pounds per Foot	Weight, Pounds per 12-Foot Length	Thickness, Inches	Weight, Pounds per Foot	Weight, Pounds per 12-Foot Length			
6	.58	42.5	510	.61	44.3	531	.65	48.1	577	.69	50.5	606	21.9	.22	6
8	.66	60.9	731	.71	66.8	802	.75	72.3	868	.80	76.1	913	28.2	.28	8
10	.74	86.9	1043	.80	92.8	1114	.86	101.4	1217	.92	107.3	1288	34.5	.34	10
12	.82	114.6	1375	.89	122.8	1474	.97	136.2	1634	1.04	144.4	1733	40.8	.40	12
14	.90	145.6	1747	.99	158.8	1905	1.07	175.1	2101	1.16	187.5	2250	47.1	.46	14
16	.98	180.7	2168	1.08	196.5	2358	1.18	218.0	2616	1.27	233.8	2805	53.4	.52	16
18	1.07	221.8	2662	1.17	239.3	2872	1.28	268.2	3218	1.39	287.8	3453	59.7	.57	18
20	1.15	265.8	3190	1.27	287.3	3448	1.39	321.8	3862	1.51	345.8	4149	66.0	.65	20
24	1.31	359.1	4309	1.45	392.3	4707	1.75	479.8	5758	1.88	510.6	6127	79.4	.78	24
30	1.55	530.9	6371	1.73	588.8	7065	....	.....	....	.....	.....	....	122.9	.93	30
36	1.80	738.1	8857	2.02	821.0	9852	....	.....	....	.....	.....	....	146.7	1.11	36

All weights are approximate; those per foot include allowance for bell; those per length include standard sockets; proportionate allowance to be made for any variation from the standard length. The above classes of pipe are tested by water pressure to 500 pounds per square inch.

For dimensions, see Table No. 4.

Dimensions of Bells for A. W. W. A. Standard Fittings

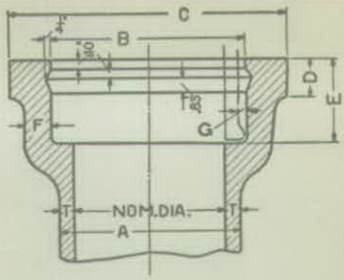


Table No. 6

Nominal Diameter Inches	Classes	Dimensions, Inches A	B	C	D	E	F	G	T
3	D	3.96	4.66	7.26	1.25	3.50	.65	.35	.48
4	D	5.00	5.70	8.30	1.50	4.00	.65	.35	.52
6	D	7.10	7.80	10.60	1.50	4.00	.70	.35	.55
8	D	9.30	10.00	13.00	1.50	4.00	.75	.35	.60
10	D	11.40	12.10	15.30	1.50	4.00	.80	.35	.68
12	D	13.50	14.20	17.60	1.50	4.00	.85	.35	.75
14	B	15.30	16.10	19.50	1.50	4.00	.85	.40	.66
14	D	15.65	16.45	20.05	1.50	4.00	.90	.40	.82
16	B	17.40	18.40	22.00	1.75	4.00	.90	.50	.70
16	D	17.80	18.80	22.60	1.75	4.00	1.00	.50	.89
18	B	19.50	20.50	24.30	1.75	4.00	.95	.50	.75
18	D	19.92	20.92	25.12	1.75	4.00	1.05	.50	.96
20	B	21.60	22.60	26.60	1.75	4.00	1.00	.50	.80
20	D	22.06	23.06	27.66	1.75	4.00	1.15	.50	1.03
24	B	25.80	26.80	31.00	2.00	4.00	1.05	.50	.89
24	D	26.32	27.32	32.32	2.00	4.00	1.25	.50	1.16
30	A	31.74	32.74	37.34	2.00	4.50	1.15	.50	.88
30	B	32.00	33.00	37.60	2.00	4.50	1.15	.50	1.03
30	C	32.40	33.40	38.60	2.00	4.50	1.32	.50	1.20
30	D	32.74	33.74	39.74	2.00	4.50	1.50	.50	1.37
36	A	37.96	38.96	43.96	2.00	4.50	1.25	.50	.99
36	B	38.30	39.30	44.90	2.00	4.50	1.40	.50	1.15
36	C	38.70	39.70	45.90	2.00	4.50	1.60	.50	1.36
36	D	39.16	40.16	46.96	2.00	4.50	1.80	.50	1.58
42	A	44.20	45.20	50.80	2.00	5.00	1.40	.50	1.10
42	B	44.50	45.50	51.50	2.00	5.00	1.50	.50	1.28
42	C	45.10	46.10	52.90	2.00	5.00	1.75	.50	1.54
42	D	45.58	46.58	54.18	2.00	5.00	1.95	.50	1.78
48	A	50.50	51.50	57.50	2.00	5.00	1.50	.50	1.26
48	B	50.80	51.80	58.40	2.00	5.00	1.65	.50	1.42
48	C	51.40	52.40	60.00	2.00	5.00	1.95	.50	1.71
48	D	51.98	52.98	61.38	2.00	5.00	2.20	.50	1.96
54	A	56.66	57.66	64.06	2.25	5.50	1.60	.50	1.35
54	B	57.10	58.10	65.30	2.25	5.50	1.80	.50	1.55
54	C	57.80	58.80	66.80	2.25	5.50	2.15	.50	1.90
54	D	58.40	59.40	68.20	2.25	5.50	2.45	.50	2.23
60	A	62.80	63.80	70.60	2.25	5.50	1.70	.50	1.39
60	B	63.40	64.40	71.80	2.25	5.50	1.90	.50	1.67
60	C	64.20	65.20	73.60	2.25	5.50	2.25	.50	2.00
60	D	64.82	65.82	75.22	2.25	5.50	2.60	.50	2.38

For dimensions of spigot, see page 66.

Laying Dimensions of A. W. W. A. Standard Bell and Spigot Bends

(All Classes)

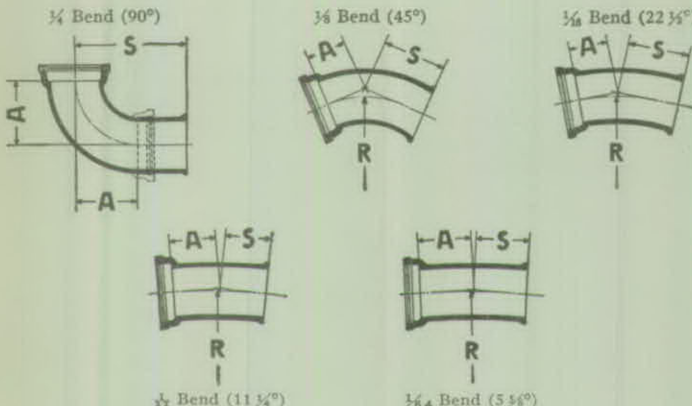


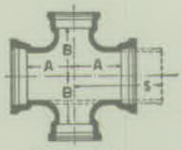
Table No. 7

Size	90° Bend (1/4)		45° Bend (1/8)			22 1/2° Bend (1/16)			11 1/4° Bend (1/32)			5 5/8° Bend (1/64)		
	A	S	A	S	R	A	S	R	A	S	R	A	S	R
3	16	24	9.94	15.94	24	9.55	15.55	48	11.82	11.82	120	.....	.....	...
4	16	24	9.94	15.94	24	9.55	15.55	48	11.82	11.82	120	.....	.....	...
6	16	24	9.94	15.94	24	9.55	15.55	48	11.82	11.82	120	.....	.....	...
8	16	26	9.94	15.94	24	9.55	15.55	48	11.82	11.82	120	.....	.....	...
10	16	28	9.94	15.94	24	9.55	15.55	48	11.82	11.82	120	.....	.....	...
12	16	28	9.94	15.94	24	9.55	15.55	48	11.82	11.82	120	.....	.....	...
14	18	30	14.91	20.91	36	14.32	14.32	72	17.73	17.73	180	.....	.....	...
16	24	36	14.91	20.91	36	14.32	14.32	72	17.73	17.73	180	.....	.....	...
18	24	36	14.91	20.91	36	14.32	14.32	72	17.73	17.73	180	.....	.....	...
20	24	36	19.88	25.88	48	19.10	19.10	96	23.64	23.64	240	23.58	23.58	480
24	30	42	24.85	30.85	60	23.87	23.87	120	23.64	23.64	240	23.58	23.58	480
30	36	48	24.85	30.85	60	23.87	23.87	120	23.64	23.64	240	23.58	23.58	480
36	48	60	37.28	37.28	90	35.80	35.80	180	23.64	23.64	240	23.58	23.58	480
42	48	60	37.28	37.28	90	35.80	35.80	180	23.64	23.64	240	23.58	23.58	480
48	54	66	37.28	37.28	90	35.80	35.80	180	23.64	23.64	240	23.58	23.58	480
54	..	..	37.28	37.28	90	35.80	35.80	180	23.64	23.64	240	23.58	23.58	480
60	..	..	37.28	37.28	90	35.80	35.80	180	23.64	23.64	240	23.58	23.58	480

Dimensions in inches.
For Bell Dimensions see page 75.
For weights see page 83.

Laying Dimensions of A. W. W. A. Standard Bell and Spigot Tees and Crosses

(All Classes)



Tee and Cross

Table No. 8

Size	A	B	S	Size	A	B	S	Size	A	B	S
3	10	10	22	36x 8	14	27	26	48x16	19	35	31
4	11	11	23	36x10	15	27	27	48x18	20	35	34
6	12	12	24	36x12	16	27	28	48x20	21	35	36
8	13	13	25	36x14	18	29	30	48x24	23	35	38
10	14	14	26	36x16	19	29	31	48x30	26	35	43
12	15	15	27	36x18	20	29	34	48x36	29	35	46
14	16	16	28	36x20	21	29	36	48x42	32	35	49
16	17	17	29	36x24	23	29	38	48x48	35	35	52
18	18	18	30	36x30	26	29	43	54x20	28	38.5	46
20	19	19	31	36x36	29	29	46	54x24	30	40	48
24	21	21	33	42x12	16	30	28	54x30	33	40	51
30x 6	13	24	25	42x14	18	32	30	54x36	36	42	54
30x 8	14	24	26	42x16	19	32	31	54x42	39	42	57
30x10	15	24	27	42x18	20	32	34	54x48	42	45	60
30x12	15	24	27	42x20	21	32	36	54x54	45	45	63
30x14	18	26	30	42x24	23	32	38	60x20	28	42	46
30x16	19	26	31	42x30	26	32	43	60x24	30	44	48
30x18	20	26	34	42x36	29	32	46	60x30	33	44	51
30x20	21	26	36	42x42	32	32	49	60x36	36	44	54
30x24	23	26	38	48x12	17	33	29	60x42	39	48	57
30x30	26	26	43	48x14	18	35	30	60x48	42	48	60
								60x54	45	48	63
								60x60	48	48	66

Dimensions in inches.

Reducing tees and crosses in sizes up to and including 24″ have same laying dimensions as straight sizes.

Large diameter tees and crosses furnished with ribs as required.

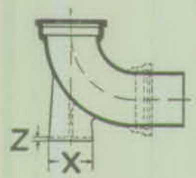
For bell dimensions, see page 75.

Tees and crosses reduce on branches only.

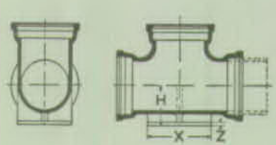
For base tees, see page 78.

For weights, see page 89.

Base Dimensions of
A. W. W. A. Standard Bell and Spigot
Base Ells and Tees
(All Classes)



Base Ell



Base Tee

Table No. 9

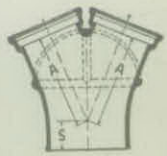
Base Ells					Base Tees				
Size of Fitting	H	X	Width of Base	Z	Size of Fitting	H	X	Width of Base	Z
3	5	5	5	5/8	3	4 1/2	7 1/2	4	5/8
4	5 1/2	6	6	5/8	4	5 1/2	9	5	5/8
6	6 1/2	7	7	11/16	6	6 1/2	11	7 1/2	3/4
8	7 1/2	9	9	13/16	8	7 1/2	13 1/2	9 1/2	3/4
10	9	10	10	15/16	10	9	16	11 1/2	7/8
12	10	11	11	1	12	10	19	13 1/2	1
14	12	12	12	1	14	12	21	16	1
16	13	12	12	1	16	13	23 1/2	18	1
18	14	13 1/2	13 1/2	1 1/8	18	14	25	20	1 1/8
20	15	13 1/2	13 1/2	1 1/8	20	15	27 1/2	22	1 1/8
24	17 1/2	14	14	1 1/8	24	17 1/2	27 1/2	26 1/2	1 1/4
..	..	..	..	..	30	21	27 1/2	32	1 3/8
..	..	..	..	..	36	24 1/2	27 1/2	34	1 1/2
..	..	..	..	..	42	28	27 1/2	36	1 3/4
..	..	..	..	..	48	31 1/2	32	36	1 7/8
..	..	..	..	..	54	36	42	42	2
..	..	..	..	..	60	39	48	48	2 1/4

Dimensions in inches.
For other dimensions see pages 76 and 77.
For bell dimensions see page 75.
For weights see pages 88 and 98.
Bases drilled if required.

Laying Dimensions of A. W. W. A. Standard Bell and Spigot Y Branches

(All Classes)

Y-Branch
Type 2



Y-Branch
(Breeches Y)
Type 1

Table No. 10

Y Branches Type 2 (45°)						Y Branches Type 1 (45°)		
Size	A	S	Size	A	S	Size	A	S
3	9.50	10.50	36x24	54.00	19.75	12	21.5	16
4	10.50	11.50	36x30	56.00	19.75	14	24.0	16
6	13.00	13.00	36x36	60.00	24.00	16	27.5	17
8	16.00	14.00	42x24	60.00	16.75	18	30.0	18
10	18.50	15.50	42x30	63.00	16.75	20	34.0	18
12	21.50	15.50	42x36	66.00	21.00	24x20	34.0	12
14	24.00	16.00	42x42	69.00	25.25	24x24	38.0	18
16	31.00	17.50	48x30	68.00	14.00	30x24	38.0	12
18	34.00	18.00	48x36	71.00	18.00	30x30	48.0	18
20	37.00	18.75	48x42	74.00	22.25	36x30	48.0	10
24x16	40.00	12.75	48x48	77.00	26.50	36x36	56.0	18
24x18	40.00	18.75				42x30	48.0	6
24x20	40.00	18.75				42x36	56.0	10
24x24	42.00	19.75				42x42	66.0	18
30x20	49.50	17.00				48x36	56.0	2
30x24	49.50	17.00				48x42	66.0	10
30x30	52.50	22.75				48x48	76.0	18

Dimensions in inches.

For weights see page 92.

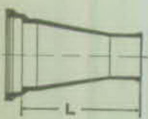
Reducing Y-Branches in sizes up to and including 20" have same laying dimensions as straight sizes.

Large diameter Y-Branches are furnished with ribs as required.

For bell dimensions see page 75.

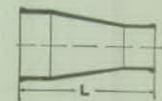
Laying Dimensions of A. W. W. A. Standard Bell and Spigot Reducers

(All Classes)



Bell Large End

Bell Small End



Spigot Ends

Table No. 11

Size	Laying Length (L)			Size	Laying Length (L)		
	Large End Bell	Small End Bell	Spigot Ends		Large End Bell	Small End Bell	Spigot Ends
3	20.5	21.0	24	42x24	77.0	78.0	82
4	20.0	20.5*	24	42x30	43.0	43.5	48
6	30.0	30.0*	34	42x30	77.0	77.5	82
8	30.0	30.0	34	42x36	43.0	43.5	48
10	30.0	30.0	34	42x36	77.0	77.5	82
12	30.0	30.0	34	48x30	77.0	77.5	82
14	32.0	32.0	36	48x30	143.0	143.5	148
16	32.0	32.0	36	48x36	77.0	77.5	82
18	32.0	32.0	36	48x36	143.0	143.5	148
20	38.0	38.0	42	48x42	77.0	77.0	82
24	38.0	38.0	42	48x42	143.0	143.0	148
30x18	37.5	38.0	42	54x36	76.5	77.5	82
30x20	37.5	38.0	42	54x36	142.5	143.5	148
30x20	77.5	78.0	82	54x42	76.5	77.0	82
30x24	37.5	38.0	42	54x42	142.5	143.0	148
30x24	77.5	78.0	82	54x48	76.5	77.0	82
36x20	43.5	44.0	48	54x48	142.5	143.0	148
36x20	77.5	78.0	82	60x36	76.5	77.5	82
36x24	43.5	44.0	48	60x36	142.5	143.5	148
36x24	77.5	78.0	82	60x42	76.5	77.0	82
36x30	43.5	43.5	48	60x42	142.5	143.0	148
36x30	77.5	77.5	82	60x48	76.5	77.0	82
42x20	43.0	44.0	48	60x48	142.5	143.0	148
42x20	77.0	78.0	82	60x54	76.5	76.5	82
42x24	43.0	44.0	48	60x54	142.5	142.5	148

Dimensions in inches.

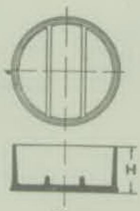
In sizes under 24 inches dimension represents larger end, laying length remains the same for all reductions.

*6x3 Reducers Small End Bell have a laying length of 30.5 inches and 4x2 Reducers Small End Bell have a laying length of 21 inches.

For bell dimensions see page 75.
For weights see page 94.

Dimensions of A. W. W. A. Standard Bell and Spigot Plugs and Caps

(All Classes)



Plug

Cap

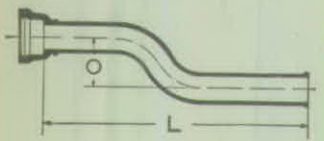
Table No. 12

Plugs				Caps					
Size	H	Size	H	Size	H	No. of Lugs	Size	H	No. of Lugs
3	5.5	18	6.5	3	4.60		18	5.00	6
4	5.5	20	6.5	4	4.60		20	5.00	6
6	5.5	24	8.0	6	4.65		24	5.25	6
8	5.5	30	8.0	8	4.75		30	5.75	6
10	6.0	36	8.0	10	4.75		36	6.00	6
12	6.0	42	9.0	12	4.75	4	42	7.00	8
14	6.0	48	9.0	14	4.90	4	48	7.00	8
16	6.5	54	9.0	16	5.00	6	54	7.50	8
		60	9.0				60	7.50	8

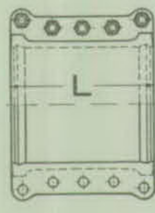
Dimensions in inches.
For bell dimensions see page 75.
Caps 12″ and larger can be furnished with lugs.
For weights see page 97.

Laying Dimensions of A. W. W. A. Standard Bell and Spigot Offsets and Sleeves

(All Classes)



Offset



Split Sleeve

Solid Sleeve

Table No. 13

Bell & Spigot Offsets						Split Sleeves		Solid Sleeves		
Size	O	L	Size	O	L	Size of Pipe	L	Size of Pipe	Length (L) Short	Length (L) Long
4	6	27	14	6	35	3	15	3	10	15
	12	30		12	46	4	15	4	10	15
	18	38		18	57	6	15	6	10	15
						8	15	8	12	15
6	6	28	16	6	35	10	18	10	12	18
	12	34		12	48	12	18	12	14	18
	18	41		18	58	14	18	14	15	18
						16	24	16	15	24
8	6	29	18	6	36	18	24	18	15	24
	12	36		12	48	20	24	20	15	24
	18	43		18	59	24	24	24	15	24
								30	15	24
10	6	30	20	6	36			36	15	24
	12	38		12	48			42	15	24
	18	46		18	60			48	15	24
								54	15	24
12	6	34						60	15	24
	12	45								
	18	56								

Dimensions in inches.
Split Sleeves furnished complete with bolts.
For bell dimensions see page 75.
For weights see page 98.

Dimensions of A. W. W. A. Standard Bell and Spigot Blow-Off Branches and Manhole Pipe

(All Classes)

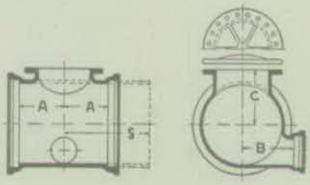


Table No. 14

Size		Blow-Off Branches					Manhole Pipe Without Blow-Off Branch		
		Without Manhole		With Manhole					
Run	Std. Outlets	A	B	A	B	C	A	C	S
8	3 & 4	12	7	..	..	....	..	....	..
10	3, 4 & 6	12	8	..	..	....	..	....	..
12	3, 4 & 6	12	10	..	..	....	..	....	..
14	4 & 6	12	11	..	..	....	..	....	..
16	4 & 6	12	12	..	..	....	..	....	..
18	4 & 6	12	13	..	..	....	..	....	..
20	4 & 6	12	14	..	..	....	..	....	..
24	6 & 8	12	16	..	..	....	..	....	..
30	6, 8 & 12	13	20	17	20	26.0	17	26.0	31
36	8 & 12	13	23	17	23	29.0	17	29.0	31
42	12 & 16	15	26	17	26	32.0	17	32.0	31
48	12 & 16	17	30	17	30	35.0	17	35.0	31
54	12 & 16	19	33	19	33	38.5	19	38.5	31
60	12 & 16	21	36	21	36	42.0	21	42.0	31

Dimensions in inches.
For dimensions and drilling of flanges, see page 145.
For bell dimensions, see page 75.
For weights, see page 92.
Manholes are regularly furnished with blind flanges and necessary bolts.

Dimensions and Weights of Cutting In Tees and Crosses for Use with Standard A. W. W. A. Pipe

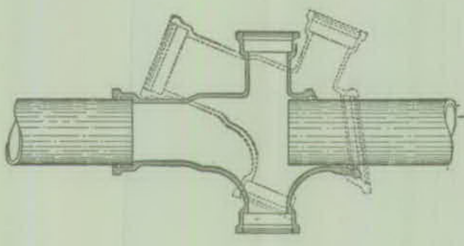


Table No. 15

Nominal Diameter, Inches	Will Take Pipe of		Laying Length On Run*	Weights	
	Inside Diameter, Inches	Maximum Thickness, Inches		3-Way	4-Way
3	3	.48	16	107	141
4	4	.52	19	140	184
6	6	.55	21	215	281
8	8	.60	23	335	434
10	10	.68	24	458	589
12	12	.75	24	616	787
14	14	.82	36	800	900
16	16	.89	36	1200	1460

Dimensions in inches.

For bell dimensions, see page 75.

Weights given in pounds. All weights approximate.

*Length to be cut from pipe to receive Cutting-in-Fitting.

All Class D. Branches with side outlets of diameters differing from main run are made to order only.

Cutting-in Branches are enlarged back of bell, as shown above, and can be slipped over the cut pipe and then drawn back into position for calking. The necessity for sleeves and extra joints is thus avoided. The lead space, however, is somewhat greater than with the usual bell; hence, the spigot tee with sleeve is generally preferred.

Dimensions and Weights of Double Bell Pipe With Boss (Tapped Tee)

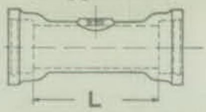


Table No. 16

Size	Class	L	Approximate Weight, Pounds
3	D	12	55
4	D	12	69
6	D	12	101
8	D	12	154
10	D	13	202
12	D	13	264

Pipe can be tapped for any regular size outlet.

Dimensions and Weights of Split Bell End Sleeves (All Classes)

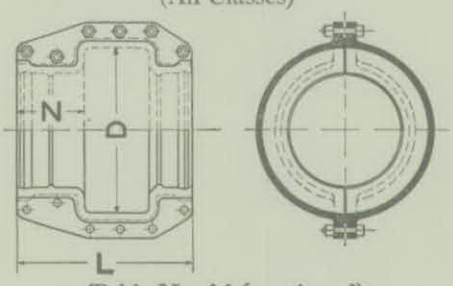
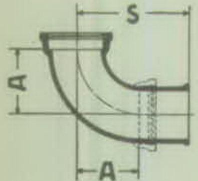


Table No. 16 (continued)

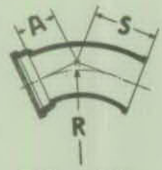
Size of Pipe	L	D	S	Approximate Weight, Pounds
3	22	8¼	8	135
4	22	9½	8	159
6	22	11¾	8	210
8	22	14¼	8	281
10	22	16½	8	367
12	22	18¾	8	435
14	22	21	8	482
16	22	23⅝	9	608
18	22	26⅛	8	724
20	23	28⅝	10	973
24	23	33¼	10	1201

All dimensions in inches. All weights approximate.
For Bell dimensions see page 75.
Split Sleeves furnished complete with bolts.
These sleeves will cover any standard bell and spigot joint.

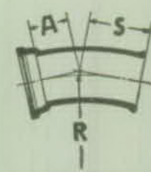
Dimensions of High Pressure Bell and Spigot Bends, Tees and Crosses
(All Classes)



¼ Bend (90°)

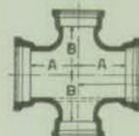


⅛ Bend (45°)



1/16 Bend (22½°)

1/32 Bend (11¼°)



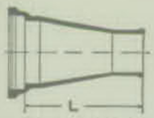
Tee and Cross

Table No. 17

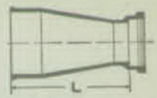
Size	90° Bend		45° Bend		22½° Bend		11¼° Bend		Tees and Crosses					
	A	S	A	S	A	S	A	S	Size	A	B	Size	A	B
6	12.25	31	12.19	30.94	7.02	25.77	6.98	25.73	6	12	12	30x30	26	26
8	14.25	33	12.19	30.94	7.02	25.77	6.98	25.73	8	13	13			
10	16.50	35	12.44	30.94	9.66	28.16	9.59	28.09	10	14	14	36x6	13	27
12	19.00	37	12.94	30.94	12.55	30.55	12.46	30.46	12	15	15	36x8	14	27
												36x10	15	27
14	21.00	39	15.43	33.43	14.93	32.93	14.82	32.82	14	16	16	36x12	16	27
16	27.25	45	18.16	35.91	17.57	35.32	17.43	35.18	16	17	17	36x14	18	29
18	27.50	45	20.90	38.40	20.20	37.70	20.04	37.54	18	18	18	36x16	19	29
									20	19	19	36x18	20	29
20	27.75	45	23.63	40.88	22.84	40.09	22.66	39.91	24	21	21	36x20	21	29
24	34.25	51	29.10	45.85	28.12	44.87	27.89	44.64				36x24	23	29
30	40.75	57	29.60	45.85	28.62	44.87	28.39	44.64	30x6	13	24	36x30	26	29
36	53.00	69	42.28	58.28	40.80	56.80	28.64	44.64	30x8	14	24	36x36	29	29
									30x10	15	24			
									30x12	15	24			
									30x14	18	26			
									30x16	19	26			
									30x18	20	26			
									30x20	21	26			
									30x24	23	26			

Dimensions in inches.
Bell dimensions same as pipe.
For bell dimensions, see page 72.
Fittings furnished without lugs unless otherwise specified.
For lugs see page 69.
Reducing Ells, Tees and Crosses in sizes up to and including 24" have same laying dimensions as straight sizes.
For weights see pages 99 and 100.

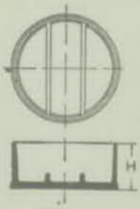
Dimensions of High Pressure Bell and Spigot Reducers, Sleeves, Plugs and Caps
(All Classes)



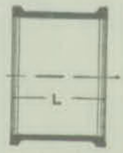
Large End Bell Reducers



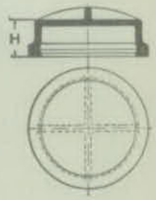
Small End Bell



Plug



Sleeve



Cap

Table No. 18

Size	Laying Lengths (L) of Reducers					Solid Sleeves		Caps
	Large End Bell	Small End Bell	Size	Large End Bell	Small End Bell	Size	L	H
8x6	38.25	38.25	20x12	39.75	39.00	6	18	6.00
10x6	38.50	38.25	20x14	39.75	39.00	8	18	6.00
10x8	38.50	38.25	20x16	39.75	39.25	10	18	6.00
			20x18	39.75	39.50	12	18	6.00
12x6	39.00	38.25						
12x8	39.00	38.25	24x12	40.25	39.00	14	18	6.25
12x10	39.00	38.50	24x14	40.25	39.00	16	18	6.25
			24x16	40.25	39.25	18	18	6.50
14x6	39.00	38.25	24x18	40.25	39.50	20	18	6.63
14x8	39.00	38.25	24x20	40.25	39.75			
14x10	39.00	38.50				24	18	7.00
14x12	39.00	39.00	30x20	40.75	39.75	30	18	7.63
			30x24	40.75	40.25	36	18	7.75
16x6	39.25	38.25	36x24	41.00	40.25			
16x8	39.25	38.25	36x30	41.00	40.75			
16x10	39.25	38.50						
16x12	39.25	39.00						
16x14	39.25	39.00						
18x10	39.50	38.50						
18x12	39.50	39.00						
18x14	39.50	39.00						
18x16	39.50	39.25						

Dimensions in inches.
For bell dimensions, see page 72.
Fittings furnished without lugs unless otherwise specified.
For lugs see page 69.
For weights see pages 99 and 101.
For Plugs H = 10 inches on all sizes.

Weights of A. W. W. A. Standard Bell and Spigot Bends

Table No. 19

Size	Class	90° Bend		45° Bend		22 1/2° Bend		11 1/4° Bend		5 5/8° Bend		Base Bends	
		With One Bell	With Two Bells	With One Bell	With Two Bells	With One Bell	With Two Bells	With One Bell	With Two Bells	With One Bell	With Two Bells	With One Bell	With Two Bells
3	D	65	73	53	65	53	62	53	70	.....	.....	83	91
4	D	82	94	66	80	66	80	66	91	.....	.....	107	119
6	D	130	140	105	121	105	121	104	138	.....	.....	170	180
8	D	200	211	150	178	150	178	150	204	.....	.....	265	276
10	D	278	280	202	234	202	234	192	260	.....	.....	352	354
12	D	366	366	265	307	265	307	250	338	.....	.....	457	457
14	B	406	406	359	403	312	400	364	452	.....	.....	518	.....
14	D	504	504	442	490	382	478	450	546	.....	.....	616	.....
16	B	594	592	445	503	388	502	453	567	.....	.....	725	.....
16	D	750	730	558	612	484	612	570	698	.....	.....	882	.....
18	B	710	706	533	599	464	599	542	677	.....	.....	883	.....
18	D	888	862	663	736	574	727	674	827	.....	.....	1061	.....
20	B	840	836	758	835	676	834	808	966	808	.....	1009	.....
20	D	1070	1064	964	1046	858	1047	1028	1217	1028	.....	1234	.....
24	B	1290	1276	1181	1275	1072	1274	1080	1282	1080	.....	1481	.....
24	D	1656	1623	1515	1625	1372	1625	1380	1633	1380	.....	1848	.....
30	A	1814	.....	1475	.....	1342	.....	1350	.....	1350	.....	.....	.....
30	B	2082	.....	1684	.....	1528	.....	1540	.....	1540	.....	.....	.....
30	C	2454	.....	1983	.....	1800	.....	1810	.....	1810	.....	.....	.....
30	D	2836	.....	2291	.....	2080	.....	2090	.....	2090	.....	.....	.....
36	A	2964	.....	2472	.....	2472	.....	1790	.....	1790	.....	.....	.....
36	B	3500	.....	2916	.....	2916	.....	2100	.....	2100	.....	.....	.....
36	C	4120	.....	3430	.....	3430	.....	2470	.....	2470	.....	.....	.....
36	D	4820	.....	4012	.....	4012	.....	2880	.....	2880	.....	.....	.....
42	A	3919	.....	3286	.....	3286	.....	2380	.....	2380	.....	.....	.....
42	B	4535	.....	3778	.....	3778	.....	2720	.....	2720	.....	.....	.....
42	C	5485	.....	4600	.....	4600	.....	3310	.....	3310	.....	.....	.....
42	D	6364	.....	5360	.....	5360	.....	3850	.....	3850	.....	.....	.....
48	A	5572	.....	4230	.....	4230	.....	3150	.....	3150	.....	.....	.....
48	B	6295	.....	4820	.....	4820	.....	3480	.....	3480	.....	.....	.....
48	C	7619	.....	5796	.....	5796	.....	4170	.....	4170	.....	.....	.....
48	D	8789	.....	6750	.....	6750	.....	4860	.....	4860	.....	.....	.....
54	A	.....	.....	5180	.....	5180	.....	3750	.....	3750	.....	.....	.....
54	B	.....	.....	5990	.....	5990	.....	4330	.....	4330	.....	.....	.....
54	C	.....	.....	7330	.....	7330	.....	5290	.....	5290	.....	.....	.....
54	D	.....	.....	8620	.....	8620	.....	6220	.....	6220	.....	.....	.....
60	A	.....	.....	5990	.....	5990	.....	4340	.....	4340	.....	.....	.....
60	B	.....	.....	7130	.....	7130	.....	5140	.....	5140	.....	.....	.....
60	C	.....	.....	8590	.....	8590	.....	6200	.....	6200	.....	.....	.....
60	D	.....	.....	10240	.....	10240	.....	7400	.....	7400	.....	.....	.....

Weights given in pounds. All weights approximate.
For dimensions, see page 76.

Weights of A. W. W. A. Standard Bell and Spigot Tees and Crosses—Table No. 20

Size	Class	Tees		Crosses	
		Two Bells	Three Bells	Three Bells	Four Bells
3	D	92	94	124	125
4x3	D	121	120	153	153
4	D	125	128	164	166
6x3	D	173	170	207	204
6x4	D	185	183	223	221
6	D	203	200	259	257
8x4	D	262	255	301	294
8x6	D	278	270	333	325
8	D	301	294	378	372
10x4	D	356	338	395	377
10x6	D	371	351	424	406
10x8	D	389	371	461	443
10	D	414	395	511	493
12x4	D	473	445	514	486
12x6	D	486	458	540	512
12x8	D	502	474	573	545
12x10	D	519	491	605	577
12	D	540	512	651	623
14x4	B	485	480	535	530
14x4	D	614	588	666	641
14x6	B	500	495	560	555
14x6	D	634	608	730	700
14x8	B	515	510	600	595
14x8	D	662	636	787	761
14x10	B	535	525	635	625
14x10	D	679	653	822	796
14x12	B	560	550	680	670
14x12	D	698	672	860	834
14	B	575	569	723	715
14	D	750	724	938	963
16x4	B	615	610	675	670
16x4	D	783	760	864	841
16x6	B	630	625	695	690
16x6	D	802	779	902	879
16x8	B	645	640	730	725
16x8	D	831	808	961	938
16x10	B	660	655	760	755
16x10	D	872	849	1042	1019
16x12	B	685	680	805	800
16x12	D	884	861	1066	1043
16x14	B	695	690	825	820
16x14	D	903	880	1104	1082
16	B	729	727	904	901
16	D	991	969	1282	1259
18x4	B	755	750	820	815
18x4	D	953	927	1046	1020
18x6	B	765	760	840	835
18x6	D	968	942	1075	1049
18x8	B	780	775	890	865
18x8	D	1000	974	1140	1114

Size	Class	Tees		Crosses	
		Two Bells	Three Bells	Three Bells	Four Bells
18x10	B	795	790	900	895
18x10	D	1038	1012	1216	1190
18x12	B	815	810	940	935
18x12	D	1075	1049	1290	1264
18x14	B	825	820	955	950
18x14	D	1083	1057	1306	1280
18x16	B	855	850	1020	1015
18x16	D	1108	1082	1356	1330
18	B	895	889	1101	1096
18	D	1170	1144	1480	1454
20x4	B	923	916	1006	999
20x4	D	1172	1148	1273	1248
20x6	B	930	920	1010	1000
20x6	D	1188	1164	1304	1280
20x8	B	945	935	1035	1025
20x8	D	1212	1188	1352	1328
20x10	B	955	945	1060	1050
20x10	D	1252	1227	1431	1407
20x12	B	975	965	1100	1090
20x12	D	1288	1263	1502	1479
20x14	B	980	970	1110	1100
20x14	D	1342	1318	1613	1588
20x16	B	1010	1000	1170	1160
20x16	D	1347	1323	1622	1597
20x18	B	1035	1025	1225	1215
20x18	D	1365	1341	1658	1634
20	B	1077	1070	1314	1307
20	D	1462	1438	1852	1828
24x6	B	1309	1289	1425	1405
24x6	D	1670	1637	1809	1775
24x8	B	1323	1303	1453	1433
24x8	D	1699	1664	1863	1830
24x10	B	1341	1321	1489	1469
24x10	D	1732	1699	1933	1900
24x12	B	1362	1342	1532	1511
24x12	D	1768	1735	2005	1972
24x14	B	1402	1381	1609	1589
24x14	D	1810	1777	2088	2055
24x16	B	1443	1423	1694	1673
24x16	D	1858	1825	2185	2151
24x18	B	1460	1440	1727	1706
24x18	D	1998	1965	2430	2397
24x20	B	1474	1454	1756	1736
24x20	D	2150	2116	2731	2697
24	B	1523	1503	1854	1834
24	D	2295	2262	2980	2947
30x6	A	1272	1300	1407	1434
30x6	B	1433	1417	1580	1563
30x6	C	1693	1673	1870	1850
30x6	D	1934	1920	2113	2099
30x8	A	1318	1346	1453	1481
30x8	B	1482	1466	1624	1609
30x8	C	1765	1745	1953	1934
30x8	D	2004	1990	2182	2168

Weights given in pounds. All weights approximate.
For dimensions, see page 77.

Weights of A. W. W. A. Standard Bell and Spigot Tees and Crosses—Table No. 20 (Continued)

Size	Class	Tees		Crosses		Size	Class	Tees		Crosses	
		Two Bells	Three Bells	Three Bells	Four Bells			Two Bells	Three Bells	Three Bells	Four Bells
30x10	A	1369	1396	1512	1540	36x18	A	2279	2246	2581	2548
30x10	B	1538	1521	1685	1668	36x18	B	2701	2650	3073	3022
30x10	C	1857	1837	2075	2056	36x18	C	3206	3136	3673	3604
30x10	D	2108	2094	2319	2306	36x18	D	4088	3991	4907	4810
30x12	A	1395	1420	1555	1580	36x20	A	2409	2346	2752	2689
30x12	B	1555	1540	1715	1700	36x20	B	2885	2800	3336	3251
30x12	C	1911	1891	2184	2164	36x20	C	3721	3610	4525	4414
30x12	D	2154	2140	2411	2398	36x20	D	4298	4153	5179	5034
30x14	A	1547	1575	1737	1764	36x24	A	2451	2513	2844	2907
30x14	B	1805	1789	2085	2069	36x24	B	3099	3014	3624	3539
30x14	C	2159	2140	2497	2477	36x24	C	4020	3909	4949	4843
30x14	D	2715	2701	3278	3265	36x24	D	4872	4727	5920	5774
30x16	A	1648	1675	1805	1832	36x30	A	2830	2708	3242	3120
30x16	B	1899	1883	2200	2184	36x30	B	3785	3629	4660	4504
30x16	C	2272	2253	2662	2642	36x30	C	4501	4308	5570	5377
30x16	D	2854	2840	3481	3467	36x30	D	5601	5359	6941	6699
30x18	A	1757	1741	2024	2007	36	A	3067	2946	3539	3418
30x18	B	2044	1976	2387	2318	36	B	4251	4096	5305	5149
30x18	C	2434	2353	2862	2781	36	C	5089	4896	6379	6185
30x18	D	2980	2966	3649	3636	36	D	6371	6128	8053	7811
30x20	A	1857	1818	2157	2118	42x12	A	2507	2577	2942	3010
30x20	B	2182	2088	2584	2490	42x12	B	2870	2889	3400	3440
30x20	C	2812	2700	3483	3372	42x12	C	3478	3507	3830	3860
30x20	D	3231	3111	3980	3861	42x12	D	3971	3989	4307	4325
30x24	A	1979	1940	2312	2274	42x14	A	2671	2739	3080	3148
30x24	B	2313	2219	2742	2648	42x14	B	3075	3114	3467	3537
30x24	C	3010	2899	3751	3639	42x14	C	3747	3776	4147	4177
30x24	D	3498	3378	4368	4249	42x14	D	4877	4896	5776	5794
30	A	2212	2129	2602	2520	42x16	A	2778	2846	3131	3170
30	B	2599	2453	3106	2960	42x16	B	3196	3225	3552	3592
30	C	3500	3327	4433	4260	42x16	C	3891	3920	4325	4354
30	D	4116	3926	5251	5061	42x16	D	5067	5085	6019	6038
36x8	A	1751	1777	1938	1963	42x18	A	2950	2941	3268	3258
36x8	B	2055	2073	2268	2287	42x18	B	3407	3357	3794	3744
36x8	C	2421	2433	2679	2691	42x18	C	4630	4549	5511	5431
36x8	D	2780	2780	3038	3039	42x18	D	5375	5265	6375	6263
36x10	A	1810	1835	1996	2021	42x20	A	3104	3056	3459	3411
36x10	B	2128	2147	2345	2364	42x20	B	3582	3486	4009	3913
36x10	C	2534	2546	2822	2834	42x20	C	4833	4697	5757	5621
36x10	D	2903	2902	3188	3188	42x20	D	5644	5470	6712	6538
36x12	A	1884	1909	2084	2109	42x24	A	3314	3266	3724	3676
36x12	B	2219	2238	2458	2477	42x24	B	3852	3756	4370	4274
36x12	C	2644	2656	2962	2973	42x24	C	5246	5110	6344	6208
36x12	D	3032	3033	3349	3350	42x24	D	6163	5989	7351	7177
36x14	A	2039	2065	2279	2304	42x30	A	3679	3553	4144	4018
36x14	B	2415	2433	2709	2728	42x30	B	4774	4590	5790	5604
36x14	C	2872	2883	3251	3263	42x30	C	6071	5824	7392	7145
36x14	D	3674	3674	4380	4380	42x30	D	7128	6825	8693	8390
36x16	A	2135	2160	2410	2436	42x36	A	4076	3950	4705	4579
36x16	B	2521	2540	2853	2872	42x36	B	5151	4966	6267	6081
36x16	C	3003	3014	3431	3442	42x36	C	6674	6428	8152	7906
36x16	D	3842	3841	4613	4612	42x36	D	7862	7559	9660	9357

Weights given in pounds. All weights approximate. For dimensions, see page 77.

Weights of A. W. W. A. Standard Bell and Spigot Tees and Crosses—Table No. 20 (Continued)

Size	Class	Tees		Crosses		Size	Class	Tees		Crosses	
		Two Bells	Three Bells	Three Bells	Four Bells			Two Bells	Three Bells	Three Bells	Four Bells
42	A	4393	4267	5109	4983	54x30	A	7497	7220	8425	8149
42	B	5836	5651	7156	6970	54x30	B	8600	8295	9252	9309
42	C	7677	7431	9541	9295	54x30	C	10480	10062	11645	11227
42	D	8983	8680	11205	10902	54x30	D	12246	11762	13540	13056
48x12	A	3266	3319	3653	3707	54x36	A	8210	7935	9451	9175
48x12	B	3752	3804	4107	4160	54x36	B	9466	9161	10881	10577
48x12	C	4510	4576	4940	5007	54x36	C	11904	11391	13639	13220
48x12	D	5902	5962	6951	7011	54x36	D	13730	13246	15742	15259
48x14	A	3422	3476	3762	3815	54x42	A	9060	8754	10746	10470
48x14	B	4173	4226	4836	4889	54x42	B	10716	10411	12819	12514
48x14	C	5240	5305	6180	6246	54x42	C	12924	12505	15289	14870
48x14	D	6122	6183	7222	7282	54x42	D	16638	14611	17812	17306
48x16	A	3565	3619	3947	4001	54x48	A	10411	10136	12910	12634
48x16	B	4046	4098	4466	4519	54x48	B	11825	11520	14534	14229
48x16	C	5342	5408	6243	6309	54x48	C	14354	13936	17540	17119
48x16	D	6359	6420	7526	7587	54x48	D	16677	16171	20217	19712
48x18	A	3775	3729	4166	4120	54	A	11567	11290	14773	14497
48x18	B	4287	4225	4718	4655	54	B	13153	12848	16683	16377
48x18	C	5782	5710	6843	6771	54	C	15947	15528	18277	19687
48x18	D	6744	6643	7966	7865	54	D	18508	18003	23166	22660
48x20	A	3956	3860	4378	4282	60x20	A	7301	6895	7552	7279
48x20	B	4500	4380	4973	4853	60x20	B	8531	8311	9336	8923
48x20	C	6080	5939	7222	7081	60x20	C	10485	1002	11170	10687
48x20	D	7052	6870	8329	8147	60x20	D	12470	11878	13247	12655
48x24	A	4221	4125	4706	4609	60x24	A	7604	7330	8118	7844
48x24	B	5262	5142	6196	6076	60x24	B	9268	8854	10052	9639
48x24	C	6560	6419	7899	7758	60x24	C	11187	10594	12128	11645
48x24	D	7655	7473	8999	8817	60x24	D	13289	12697	14351	13760
48x30	A	4748	4553	5361	5166	60x30	A	8547	8274	10544	9271
48x30	B	5951	5717	7105	6870	60x30	B	10148	9735	11259	10846
48x30	C	7566	7286	9155	8875	60x30	C	12200	11717	13483	13000
48x30	D	8769	8426	10523	10180	60x30	D	14696	14557	16158	15566
48x36	A	5150	4953	5859	5662	60x36	A	9272	8999	10568	10262
48x36	B	6732	6498	8079	7845	60x36	B	11471	11059	12997	12584
48x36	C	8205	7925	9938	9658	60x36	C	13635	13152	15325	14842
48x36	D	9619	9276	11677	11334	60x36	D	16164	15572	18220	17629
48x42	A	5503	5307	6266	6069	60x42	A	10732	9752	12829	12557
48x42	B	7377	7143	8918	8684	60x42	B	12583	12172	14857	14445
48x42	C	8938	8659	10872	10592	60x42	C	15083	14600	17721	17238
48x42	D	10590	10247	12975	12632	60x42	D	17728	18288	20640	20049
48	A	6043	5846	7043	6846	60x48	A	10681	11310	13888	13615
48	B	8385	8150	10310	10075	60x48	B	13570	13157	16089	15676
48	C	10063	9784	12424	12144	60x48	C	16327	15844	18450	19067
48	D	11913	11596	14840	14512	60x48	D	19367	18775	23105	22514
54x20	A	6267	5991	6635	6359	60x54	A	12849	12576	16055	15782
54x20	B	7238	6933	7613	7307	60x54	B	15251	14839	19012	18600
54x20	C	9061	8415	9760	9342	60x54	C	18036	17553	22227	21744
54x20	D	10578	10073	11308	10802	60x54	D	21244	20653	26011	25419
54x24	A	6654	6379	7143	6867	60	A	13584	13311	17058	16785
54x24	B	7884	7578	8645	8340	60	B	16036	15624	20007	19595
54x24	C	9625	7908	10509	10090	60	C	19217	18734	23918	23436
54x24	D	11220	10714	12141	11633	60	D	22775	22130	28171	27579

Weights given in pounds. All weights approximate. For dimensions, see page77.

Weights of A. W. W. A. Standard Bell and Spigot Y-Branches, Type 1, and Blow-Off Branches—Table No. 21

Size	Class	Y-Branches Type 1
12	D	687
14	B	738
14	D	894
16	B	942
16	D	1275
18	B	1266
18	D	1607
20	B	1635
20	D	2296
24x20	B	1663
24x20	D	2393
24	B	2300
24	D	2957
30x24	A	2171
30x24	B	2217
30x24	C	2717
30x24	D	2811
30	A	3153
30	B	3687
30	C	4285
30	D	4941
36x30	A	3343
36x30	B	3874
36x30	C	4486
36x30	D	5189
36	A	4949
36	B	5858
36	C	6804
36	D	8082
42x30	A	3368
42x30	B	3890
42x30	C	4543
42x30	D	5241
42x36	A	4904
42x36	B	5789
42x36	C	6761
42x36	D	8025
42	A	7394
42	B	8417
42	C	10377
42	D	12072
48x36	A	4727
48x36	B	5584
48x36	C	6494
48x36	D	7731
48x42	A	7345
48x42	B	8338
48x42	C	10249
48x42	D	11924
48	A	10200
48	B	12132
48	C	14716
48	D	16965

Size	Class	Blow Off Branches
8x3	D	223
8x4	D	227
10x3	D	285
10x4	D	286
10x6	D	300
12x3	D	364
12x4	D	365
12x6	D	379
14x4	B	400
14x4	D	471
14x6	B	415
14x6	D	486
16x4	B	497
16x4	D	597
16x6	C	513
16x6	D	613
18x4	B	586
18x4	D	704
18x6	B	603
18x6	D	720
20x4	B	687
20x4	D	850
20x6	B	705
20x6	D	867
24x6	B	916
24x6	D	1149
24x8	B	935
24x8	D	1170
30x6	A	1206
30x6	B	1312
30x6	C	1528
30x6	D	1776

Size	Class	Blow Off Branches	Blow Off Branches with Manhole
30x8	A	1269	1717
30x8	B	1382	1847
30x8	C	1616	2104
30x8	D	1867	2379
30x12	A	1315	1761
30x12	B	1426	1892
30x12	C	1658	2146
30x12	D	1913	2424
36x8	A	1653	2134
36x8	B	1922	2440
36x8	C	2234	2779
36x8	D	2576	3160
36x12	A	1702	2183
36x12	B	1972	2484
36x12	C	2285	2830
36x12	D	2627	3211
42x12	A	2432	2815
42x12	B	2728	3122
42x12	C	3271	3684
42x12	D	3768	4198
42x16	A	2489	2872
42x16	B	2786	3179
42x16	C	3365	3778
42x16	D	3862	4292
48x12	A	3274	3480
48x12	B	3699	3892
48x12	C	4417	4586
48x12	D	5107	5256
48x16	A	3337	3543
48x16	B	3762	3955
48x16	C	4523	4693
48x16	D	5214	5363
54x12	A	4287	4488
54x12	B	4945	5130
54x12	C	5981	6137
54x12	D	7002	7131
54x16	A	4355	4556
54x16	B	5013	5198
54x16	C	6096	6252
54x16	D	7126	7255
60x12	A	5263	5464
60x12	B	6159	6337
60x12	C	7418	7569
60x12	D	8798	8917
60x16	A	5336	5536
60x16	B	6233	6411
60x16	C	7542	7694
60x16	D	8927	9046

Weights given in pounds. All weights approximate.

For dimensions see pages 79 and 83.

Weights do not include manhole covers.

Manhole Pipe are from 5% to 10% lighter than the corresponding size and class Blow-off Branch with manhole.

Weights of A. W. W. A. Standard Bell and Spigot Y-Branches Type 2.

Table No. 22

Size	Class	Y-Branch Type 2
3	D	78
4	D	103
6x4	D	167
6	D	181
8x4	D	234
8x6	D	268
8	D	291
10x6	D	366
10x8	D	398
10	D	434
12x6	D	520
12x8	D	553
12x10	D	588
12	D	632
14x6	B	566
14x6	D	825
14x8	B	614
14x8	D	860
14x10	B	634
14x10	D	900
14x12	B	690
14x12	D	946
14	B	690
14	D	985
16x8	B	802
16x8	D	1167
16x10	B	850
16x10	D	1214
16x12	B	905
16x12	D	1270
16x14	B	915
16x14	D	1322
16	B	965
16	D	1415
18x10	B	1170
18x10	D	1460
18x12	B	1180
18x12	D	1512
18x14	B	1235
18x14	D	1575

Size	Class	Y-Branch Type 2
18x16	B	1295
18x16	D	1657
18	B	1360
18	D	1740
20x12	B	1520
20x12	D	1868
20x14	B	1525
20x14	D	1928
20x16	B	1589
20x16	D	2014
20x18	B	1654
20x18	D	2080
20	B	1725
20	D	2200
24x16	B	1835
24x16	D	2570
24x18	B	1980
24x18	D	2680
24x20	B	2200
24x20	D	3085
24	B	2600
24	D	3600
30x20	A	2743
30x20	B	3142
30x20	C	3758
30x20	D	4123
30x24	A	3178
30x24	B	3874
30x24	C	4334
30x24	D	4852
30	A	3519
30	B	4360
30	C	4950
30	D	5760
36x24	A	3572
36x24	B	4262
36x24	C	5330
36x24	D	5875
36x30	A	4340
36x30	B	4890
36x30	C	5740
36x30	D	6625

Size	Class	Y-Branch Type 2
36	A	4950
36	B	6510
36	C	7910
36	D	9180
42x24	A	5100
42x24	B	5840
42x24	C	7310
42x24	D	8120
42x30	A	5545
42x30	B	6780
42x30	C	7765
42x30	D	9025
42x36	A	6445
42x36	B	7895
42x36	C	9400
42x36	D	10890
42	A	7590
42	B	9165
42	C	11565
42	D	13370
48x30	A	6680
48x30	B	7975
48x30	C	9515
48x30	D	10900
48x36	A	7850
48x36	B	9500
48x36	C	11310
48x36	D	12955
48x42	A	9115
48x42	B	10890
48x42	C	13100
48x42	D	15115
48	A	10600
48	B	12555
48	C	15130
48	D	17385

Weights given in pounds. All weights approximate.
For dimensions, see page 79.

Weights of A. W. W. A. Standard Bell and Spigot Reducers

Table No. 23

Size	Class	Large End Bell	Small End Bell	Spigot Ends
3x2	D	39	35	31
4x2	D	44	40	36
4x3	D	50	45	40
6x4	D	104	97	82
8x4	D	132	119	104
8x6	D	150	143	121
10x4	D	162	146	131
10x6	D	180	169	150
10x8	D	201	198	170
12x4	D	201	179	163
12x6	D	218	202	181
12x8	D	240	231	202
12x10	D	267	261	229
14x6	B	249	216	194
14x6	D	288	256	234
14x8	B	275	248	220
14x8	D	314	288	260
14x10	B	305	279	250
14x10	D	344	320	290
14x12	B	339	321	284
14x12	D	378	360	324
16x6	B	300	248	226
16x6	D	355	300	278
16x8	B	326	280	252
16x8	D	381	332	304
16x10	B	356	312	282
16x10	D	410	364	334
16x12	B	391	353	317
16x12	D	445	405	368
16x14	B	389	370	315
16x14	D	484	461	407
18x8	B	374	315	287
18x8	D	438	373	345
18x10	B	404	347	317
18x10	D	468	405	375
18x12	B	438	388	352
18x12	D	502	446	410
18x14	B	437	406	350
18x14	D	541	502	448
18x16	B	469	457	383
18x16	D	585	569	492

Size	Class	Large End Bell	Small End Bell	Spigot Ends
20x10	B	516	445	414
20x10	D	615	529	499
20x12	B	556	491	455
20x12	D	656	576	539
20x14	B	554	508	453
20x14	D	700	638	583
20x16	B	592	564	490
20x16	D	751	711	635
20x18	B	633	617	531
20x18	D	800	776	683
24x14	B	680	607	552
24x14	D	866	764	710
24x16	B	717	663	589
24x16	D	917	838	762
24x18	B	758	717	630
24x18	D	965	901	810
24x20	B	803	776	675
24x20	D	1027	987	871
30x18	A	903	796	710
30x18	B	969	878	791
30x18	C	1166	1048	956
30x18	D	1305	1146	1054
30x20 Short	A	947	856	754
	B	1014	937	836
	C	1227	1134	1018
	D	1366	1232	1115
30x20 Long	A	1661	1569	1468
	B	1804	1728	1626
	C	2190	2098	1981
	D	2423	2289	2172
30x24 Short	A	1049	981	854
	B	1113	1063	935
	C	1354	1300	1144
	D	1493	1398	1242
30x24 Long	A	1921	1869	1661
	B	1998	1946	1820
	C	2438	2384	2228
	D	2670	2575	2419

Weights given in pounds. All weights approximate.

For dimensions, see page 80.

Weights of A. W. W. A. Standard Bell and Spigot Reducers

Table No. 23 (continued)

Size	Class	Large End Bells	Small End Bells	Spigot Ends	Size	Class	Large End Bells	Small End Bells	Spigot Ends
36x20 Short	A	1286	1141	1039	42x30 Short	A	1806	1660	1467
	B	1450	1272	1170		B	2065	1889	1711
	C	1739	1534	1417		C	2480	2275	2065
	D	1951	1705	1589		D	2869	2650	2399
36x20 Long	A	2018	1872	1771	42x30 Long	A	2839	2683	2500
	B	2274	2095	1994		B	3271	3095	2917
	C	2738	2533	2416		C	3938	3732	3523
	D	3072	2827	2710		D	4563	4344	4093
36x24 Short	A	1339	1280	1153	42x36 Short	A	1984	1891	1645
	B	1564	1411	1283		B	2281	2207	1926
	C	1884	1718	1562		C	2735	2642	2320
	D	2096	1890	1734		D	3184	3076	2714
36x24 Long	A	2211	2091	1964	42x36 Long	A	3143	3050	2803
	B	2468	2314	2188		B	3639	3565	3285
	C	2985	2820	2664		C	4373	4279	3958
	D	3319	3113	2957		D	5101	4993	4631
36x30 Short	A	1490	1436	1243	48x30 Short	A	3381	3168	2975
	B	1747	1645	1467		B	3883	3606	3428
	C	2051	1939	1730		C	4641	4801	4092
	D	2375	2264	2013		D	5388	5013	4762
36x30 Long	A	2366	2312	2119	48x30 Long	A	5769	5556	5362
	B	2783	2680	2502		B	6635	6359	6180
	C	3271	3159	2950		C	7928	7588	7379
	D	3796	3684	3434		D	9214	8839	8588
42x20 Short	A	1602	1364	1262	48x36 Short	A	3684	3525	3278
	B	1768	1515	1413		B	4252	4077	3796
	C	2168	1869	1753		C	5076	4849	4527
	D	2445	2092	1975		D	5925	5662	5300
42x20 Long	A	2491	2254	2152	48x36 Long	A	6316	6156	5909
	B	2764	2511	2410		B	7299	7125	6844
	C	3405	3106	2989		C	8713	8485	8164
	D	3839	3486	3369		D	10184	9920	9558
42x24 Short	A	1715	1504	1376	48x42 Short	A	4066	3998	3659
	B	1881	1654	1527		B	4667	4564	4212
	C	2313	2053	1898		C	5649	5516	5100
	D	2590	2276	2120		D	6585	6429	5959
42x24 Long	A	2685	2472	2346	48x42 Long	A	7003	6936	6597
	B	2958	2730	2603		B	8049	7948	7594
	C	3652	3392	3237		C	9746	9612	9197
	D	4086	3772	3616		D	11373	11217	10747

Weights given in pounds. All weights approximate.
For dimensions, see page 80.

Weights of A. W. W. A. Standard Bell and Spigot Reducers

Table No. 23 (continued)

Size	Class	Large End Bells	Small End Bells	Spigot Ends	Size	Class	Large End Bells	Small End Bells	Spigot Ends
54x36 Short	A	4228	3969	3722	60x36 Long	A	7999	7631	7384
	B	4925	4610	4330		B	9516	9126	8846
	C	5953	5580	5259		C	11405	10902	10581
	D	6995	6543	6181		D	13527	12916	12554
54x36 Long	A	7216	6957	6710	60x42 Short	A	5092	4816	4477
	B	8401	8087	7806		B	5991	5676	5321
	C	10178	9805	9484		C	7264	6855	6440
	D	11962	11510	11148		D	8593	8089	7619
54x42 Short	A	4609	4442	4103	60x42 Long	A	8687	8411	8072
	B	5340	5100	4745		B	10265	9950	9595
	C	6526	6247	5832		C	12439	12030	11614
	D	7655	7310	6841		D	14716	14213	13743
54x42 Long	A	7903	7737	7398	60x48 Short	A	5572	5363	4957
	B	9151	8910	8556		B	6502	6287	5832
	C	11211	10932	10517		C	7830	7555	7006
	D	13152	12807	12338		D	9259	8910	8285
54x48 Short	A	5083	4984	4578	60x48 Long	A	9552	9344	8938
	B	5851	5711	5256		B	11187	10972	10517
	C	7095	6950	6401		C	13458	13183	12634
	D	8326	8137	7512		D	15917	15568	14943
54x48 Long	A	8757	8660	8253	60x54 Short	A	6019	5910	5404
	B	10073	9933	9478		B	7018	6961	6348
	C	12239	12093	11544		C	8574	8444	7750
	D	14364	14175	13550		D	10152	9992	9178
60x36 Short	A	4711	4342	4096	60x54 Long	A	10360	10251	9745
	B	5576	5186	4906		B	12132	12075	11462
	C	6692	6189	5867		C	14803	14673	13979
	D	7934	7322	6960		D	17530	17371	16557

Weights given in pounds. All weights approximate.
For dimensions, see page 80.

Weights of A. W. W. A. Standard Bell and Spigot Sleeves Caps and Plugs

Table No. 24

Size	Class	Sleeves, Short Pattern	Sleeves, Long Pattern	Split Sleeves	Caps Without Lugs	Caps With Lugs	Plugs
3	D	36	50	...	20	....	7
4	D	47	61	72	27	....	8
6	D	68	87	86	40	....	14
8	D	104	119	133	59	....	24
10	D	123	176	158	84	....	38
12	D	174	223	222	108	142	50
14	B	220	249	264	137	170	63
14	D	240	280	286	149	183	65
16	B	274	391	323	186	237	90
16	D	305	443	359	201	251	96
18	B	321	462	373	228	282	111
18	D	360	518	469	248	305	121
20	B	374	532	428	280	338	151
20	D	440	625	502	310	370	156
24	B	477	680	535	388	440	375
24	D	583	821	652	438	493	472
30	A	648	943	...	590	682	481
30	B	652	949	...	596	688	556
30	C	760	1088	...	644	738	641
30	D	876	1262	...	702	802	723
36	A	833	1202	...	844	948	682
36	B	943	1362	...	917	1073	786
36	C	1077	1563	...	998	1108	914
36	D	1217	1772	...	1083	1196	1050
42	A	1097	1577	...	1277	1429	991
42	B	1184	1702	...	1397	1573	1138
42	C	1381	1997	...	1543	1726	1353
42	D	1561	2262	...	1684	1876	1551
48	A	1337	1922	...	1789	1965	1340
48	B	1481	2129	...	1943	2125	1506
48	C	1752	2532	...	2138	2330	1800
48	D	1986	2879	...	2337	2535	2047
54	A	1612	2316	...	2373	2555	1697
54	B	1835	2634	...	2557	2751	1945
54	C	2156	3126	...	2799	2902	2356
54	D	2450	3571	...	3043	3251	2733
60	A	1906	2731	...	2902	3089	2045
60	B	2127	3058	...	3104	3296	2434
60	C	2491	3601	...	3395	3594	2904
60	D	2895	4231	...	3678	3884	3397

Weights given in pounds. All weights approximate.
For dimensions, see pages 81 and 82.

Weights of A. W. W. A. Standard Bases and Standard Bell and Spigot Offsets

Table No. 25

Size	Class	Bases for Tees	Size	Class	Degree of Offset Inches	Weight of Offsets	Size	Class	Degree of Offset Inches	Weight of Offsets
3	All Classes	8	4	D	6	78	12	D	6	363
4		13	4	D	12	91	12	D	12	461
6		21	4	D	18	111	12	D	18	561
8		32								
10		50	6	D	6	121	14	D	6	456
12		73	6	D	12	144	14	D	12	582
14		113	6	D	18	176	14	D	18	711
16		142								
18		177	8	D	5	182	16	D	6	573
20		225	8	D	12	220	16	D	12	742
24		300	8	D	18	265	16	D	18	901
30		418								
36		548	10	D	6	253	18	D	6	705
42		676	10	D	12	315	18	D	12	909
48		889	10	D	18	378	18	D	18	1101
54		2130								
60		2510					20	D	6	846
							20	D	12	1088
							20	D	18	1334

Weights given in pounds. All weights approximate.

To find weight of base tee add the weight of base given above to the weight of standard tee found on page 89 or page 189.

For dimensions, see page 82.

Weights of High Pressure Bell and Spigot Bends, Sleeves, Plugs and Caps

Table No. 26

Size	Class	90° Bends	45° Bends	22½° Bends	11¼° Bends	Sleeves	Plugs	Caps
6	F	185	196	165	165	126	45	91
6	H	210	222	186	186	143	49	99
8	F	287	288	240	240	174	76	117
8	H	328	329	274	274	195	85	128
10	F	419	397	364	364	235	108	160
10	H	479	454	415	415	261	114	178
12	F	584	526	526	526	297	141	203
12	H	682	612	612	612	341	155	228
14	F	788	729	729	729	375	175	284
14	H	931	862	862	862	439	184	328
16	F	1121	980	980	980	456	249	357
16	H	1335	1167	1167	1167	536	265	378
18	F	1365	1287	1287	1287	615	308	460
18	H	1653	1548	1548	1548	679	326	538
20	F	1663	1663	1663	1663	662	381	551
20	H	1970	1970	1970	1970	783	440	640
24	F	2547	2548	2548	2548	891	562	828
24	H	3280	3280	3280	3280	1038	685	934
30	E	3879	3498	3498	3498	1184	984	1215
30	F	4300	3877	3877	3877	1320	1073	1338
36	E	6552	6199	6199	4108	1609	1417	1865
36	F	7292	6901	6901	4562	1812	1537	2035

Weights given in pounds. All weights approximate.
For dimensions, see pages 86 and 87.
Weights do not include lugs. For lugs, see page 69.

Weights of High Pressure Bell and Spigot Tees and Crosses

Table No. 27

Size	Class	Tees	Crosses	Size	Class	Tees	Crosses	Size	Class	Tees	Crosses
6	F	278	363	18x12	F	1325	1528	30x12	E	2523	2728
6	H	311	405	18x12	H	1587	1813	30x12	F	2774	2884
8x6	F	366	450	18x14	F	1377	1624	30x14	E	2834	3168
8x6	H	418	512	18x14	H	1654	1948	30x14	F	3118	3470
8	F	400	516	18x16	F	1438	1747	30x16	E	3204	3663
8	H	458	592	18x16	H	1722	2083	30x16	F	3505	3978
10x6	F	477	560	18	F	1509	1889	30x18	E	3381	3922
10x6	H	535	628	18	H	1849	2278	30x18	F	3692	4250
10x8	F	509	624	20x6	F	1512	1596	30x20	E	3580	4242
10x8	H	574	708	20x6	H	1761	1854	30x20	F	3912	4996
10	F	548	702	20x8	F	1545	1660	30x24	E	3919	4749
10	H	614	786	20x8	H	1801	1933	30x24	F	4273	5133
12x6	F	615	699	20x10	F	1584	1738	30	E	4562	5770
12x6	H	702	783	20x10	H	1839	2011	30	F	5019	6333
12x8	F	647	763	20x12	F	1627	1823	36x6	E	3080	3166
12x8	H	742	874	20x12	H	1891	2115	36x6	F	3447	3537
12x10	F	686	841	20x14	F	1673	1916	36x8	E	3223	3339
12x10	H	781	952	20x14	H	1958	2248	36x8	F	3602	3722
12	F	731	931	20x16	F	1733	2037	36x10	E	3377	3534
12	H	835	1062	20x16	H	2032	2396	36x10	F	3768	2929
14x6	F	774	858	20x18	F	1804	2179	36x12	E	3535	3738
14x6	H	913	1006	20x18	H	2181	2693	36x12	F	3940	4150
14x8	F	806	922	20	F	1896	2363	36x14	E	4113	4537
14x8	H	952	1085	20	H	2202	2775	36x14	F	4558	4993
14x10	F	845	1000	24x6	F	2087	2170	36x16	E	4317	4824
14x10	H	1040	1261	24x6	H	2574	2668	36x16	F	4776	5298
14x12	F	891	1091	24x8	F	2118	2235	36x18	E	4526	5122
14x12	H	1045	1272	24x8	H	2614	2748	36x18	F	4999	5612
14	F	946	1186	24x10	F	2158	2314	36x20	E	4754	5461
14	H	1114	1407	24x10	H	2654	2827	36x20	F	5244	5971
16x6	F	972	1054	24x12	F	2204	2406	36x24	E	5250	6189
16x6	H	1154	1248	24x12	H	2710	2938	36x24	F	5777	6746
16x8	F	1003	1119	24x14	F	2237	2475	36x30	E	6013	7345
16x8	H	1194	1327	24x14	H	2760	3042	36x30	F	6603	7993
16x10	F	1042	1197	24x16	F	2296	2593	36	E	6873	8687
16x10	H	1233	1404	24x16	H	2832	3186	36	F	7616	9602
16x12	F	1088	1289	24x18	F	2479	2924				
16x12	H	1288	1514	24x18	H	3032	3552				
16x14	F	1136	1384	24x20	F	2581	3125				
16x14	H	1356	1650	24x20	H	3122	3730				
16	F	1198	1507	24	F	2733	3421				
16	H	1423	1785	24	H	3316	4110				
18x6	F	1212	1294	30x6	E	2244	2329				
18x6	H	1453	1545	30x6	F	2472	2559				
18x8	F	1243	1359	30x8	E	2355	2471				
18x8	H	1493	1625	30x8	F	2596	2716				
18x10	F	1282	1438	30x10	E	2477	2634				
18x10	H	1530	1703	30x10	F	2727	2888				

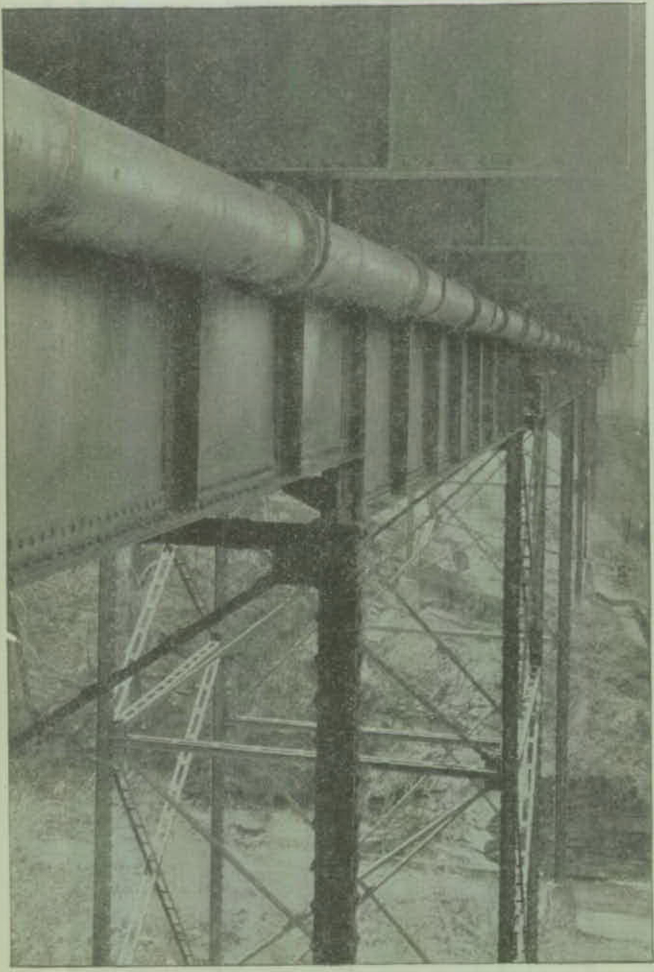
Weights given in pounds. All weights approximate.
For dimensions, see page 86.
Weights do not include lugs. For lugs, see page 69.

Weights of High Pressure Bell and Spigot Reducers

Table No. 28

Size	Class	Large End Bell	Small End Bell	Spigot Ends	Size	Class	Large End Bell	Small End Bell	Spigot Ends
8x6	F	231	220	175	18x16	F	889	848	701
8x6	H	265	248	200	18x16	H	1059	1015	838
10x6	F	291	262	205	20x12	F	905	762	656
10x6	H	329	300	237	20x12	H	1059	894	790
10x8	F	328	310	254	20x14	F	964	829	715
10x8	H	370	358	293	20x14	H	1128	995	859
12x6	F	363	311	266	20x16	F	1017	923	776
12x6	H	417	360	312	20x16	H	1202	1110	933
12x8	F	400	359	303	20x18	F	1086	1032	844
12x8	H	474	418	369	20x18	H	1289	1247	1019
12x10	F	442	415	345	24x12	F	1144	926	830
12x10	H	510	482	405	24x12	H	1402	1172	1067
14x6	F	438	370	325	24x14	F	1203	1002	889
14x6	H	517	430	381	24x14	H	1471	1272	1137
14x8	F	473	418	362	24x16	F	1264	1096	949
14x8	H	558	488	422	24x16	H	1545	1379	1211
14x10	F	518	478	404	24x18	F	1332	1205	1018
14x10	H	610	552	474	24x18	H	1631	1525	1297
14x12	F	566	549	453	24x20	F	1407	1341	1092
14x12	H	664	639	535	24x20	H	1726	1661	1392
16x6	F	532	430	386	30x20	E	1774	1528	1270
16x6	H	632	504	452	30x20	F	2005	1650	1401
16x8	F	569	478	422	30x24	E	1927	1742	1423
16x8	H	673	562	497	30x24	F	2128	1889	1574
16x10	F	611	538	465	36x24	E	2466	2074	1755
16x10	H	725	626	548	36x24	F	2748	2257	1943
16x12	F	660	610	513	36x30	E	2739	2532	2028
16x12	H	785	713	609	36x30	F	3056	2817	2252
16x14	F	719	686	572					
16x14	H	855	814	678					
18x10	F	721	607	533					
18x10	H	863	712	635					
18x12	F	770	678	581					
18x12	H	923	800	604					
18x14	F	829	754	641					
18x14	H	992	900	764					

Weights given in pounds. All weights approximate.
For dimensions, see page 87.
Weights do not include lugs. For lugs, see page 69.



Bridge Line of Bell and Spigot Cast Iron Pipe

SECTION 6

AMERICAN GAS ASSOCIATION STANDARD

Cast Iron Bell and Spigot Pipe and Fittings

American Gas Association Standard Specifications for Cast Iron Gas Pipe and Fittings

SPECIFICATIONS FOR CAST IRON PIPE FOR GAS USES. Standard specifications covering gas pipe and fittings were adopted by the American Gas Institute in 1913 and later revised and adopted by the American Gas Association. These specifications cover both Bell and Spigot and Flanged pipe, as well as the fittings in ordinary use in gas line construction.

Two types of bell are covered by these specifications. The standard bell, known as Bell No. 1, for ordinary construction and an alternate called Bell No. 2, for construction involving the use of cement or combination cement and lead joints. These specifications prepared by gas engineers to fit their particular problem, have been adopted bodily by the Bell and Spigot Pipe makers of the country. Departure from the dimensions of standard pipe and fittings usually makes it necessary to use additional equipment and patterns, with the result that the cost of production is increased. For this reason, adherence to the specifications will result in economy for the pipe user. In the past, there has been some differences of opinion as to Bell dimensions, and while this matter has been almost entirely ironed out, there seems to be a difference of opinion as to the proper depth of Bell. While, as mentioned above, it is advisable to use standard material, the manufacturers are prepared to make Bell dimensions to suit any individual customer at a cost slightly larger than is the case if standard Bells were used.

American Gas Association Standard Specifications for Cast Iron Pipe and Fittings

Description of Pipe and Fittings

SECTION 1. All pipe shall be made with bell and spigot joints. The pipe and fittings shall accurately conform to the dimensions given in the tables accompanying and forming a part of these specifications. The pipe shall be straight and of true circles in section, with their inner and outer surfaces concentric; and cast at least 12 feet in length, exclusive of socket or bell. In the case of pipe of different weight from those specified in the tables, the outside diameter of the body and bell dimensions shall conform to the tables.

Allowable Variation in Diameter

SECTION 2. All sockets and spigots shall be tested by circular gauges. All pipe and fittings shall be rejected which are defective in joint room, or which vary from standard dimensions in the diameters of the sockets and the outside diameters of spigots more than is given in the table below:

Size	Pipe	Fittings
16 in. or less	0.06 in.	0.12 in.
20 in. and 24 in.	0.08 in.	0.15 in.
30 in., 36 in. and 42 in.	0.10 in.	0.20 in.
48 in.	0.12 in.	0.24 in.

Allowable Variation in Thickness

SECTION 3. The variations allowed below the standard thickness shall not be greater than that shown in the table below:

Size	Pipe	Fittings
8 in. or less	0.08 in.	0.10 in.
10 in. to 36 in.	0.08 in.	0.12 in.
42 in. and 48 in.	0.10 in.	0.15 in.

For all sizes of pipe and for fittings 10 inches or larger, variations from the standard thickness of 0.02 inch in excess of the allowances above given shall be permitted for spaces not exceeding 8 inches in length in any direction.

Treatment of Defective Spigots

SECTION 4. Defective spigot ends on pipe 12 inches or more in diameter may be cut off in a lathe, and a half-round wrought iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent of the total number of accepted pipe of each size shall be cut and banded, and no pipe shall be banded which is less than 11 feet in length, exclusive of the socket. In case the length of a pipe differs from 12 feet, the standard weight of the pipe given shall be modified in accordance therewith.

Marking

SECTION 5. Every pipe and fitting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4 inches may also have cast upon it figures showing the year in which it was cast and a number signifying the order, in point of time, in which it was cast, the figures denoting the year being above and the number below, thus:

1913	1913	1913
1	2	3

also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside, and shall not be less than 2 inches in length and ⅛-inch in relief, for pipe 8 inches in diameter and larger. For smaller sizes of pipe, the letters may be 1 inch in length. The weight shall be conspicuously painted in white on the inside of each pipe and fitting.

Allowable Percentage of Variation in Weight

SECTION 6. No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipe 16 inches or less in diameter, and 4 per cent for pipe more than 16 inches in diameter; and no excess above the standard weight of more than the given percentage for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received, the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent. No fitting shall be accepted, the weight of which shall be less than the standard weight, by more than 10 per cent for sizes 12 inches or less in diameter, and 8 per cent for larger sizes, except that curves and "Y" pieces 16 inches in diameter and larger may be 12 per cent below the standard weight; and no excess above the standard weight of more than the above percentages for the several sizes will be paid for.

Quality of Iron

SECTION 7. All pipe and fittings shall be made of cast iron of good quality and of such character as shall make the metal of the fittings strong, tough and of even grain; and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

Tests of Material

SECTION 8. Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions, the foundry shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall support a load of 1,800 pounds and show a deflection of not less than 0.30 inch before breaking; or, if preferred, tensile bars shall be made, which will show a breaking point of not less than 18,000 pounds per square inch. The foundry shall have the right to make and break three bars from each heat or run of metal, and the test shall be based on the average results of the three bars. Should the dimensions of the bars differ from those given above, a proper allowance therefor shall be made in the results of the tests.

Tests of Pipe

SECTION 9. All pipe, after having a general inspection, shall be subject to a water pressure test of at least 300 pounds per square inch for 16 inches and smaller, and at least 150 pounds per square inch for 20 inches and larger. If required by the engineer, they shall also be subjected to a hammer test under this pressure. Any pipe showing defects by leaking, sweating or otherwise, shall be rejected.

Casting of Pipe

SECTION 10. The pipe shall be cast vertically in dry sand molds and shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction due to subsequent exposure.

Quality of Castings

SECTION 11. The pipe and fittings shall be smooth, free from scales, lumps, blisters, and sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging, filling or burning in will be allowed without special permission.

Cleaning and Inspection

SECTION 12. All pipe and fittings shall be thoroughly cleaned and subjected to a careful hammer inspection.

Weighing

SECTION 13. The pipe and fittings shall be weighed for payment, under the supervision of the engineer. If desired by the engineer, the pipe and fittings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, providing such weighing is done by a legalized weigh master. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 pounds.

Contractor to Furnish Men and Materials

SECTION 14. The contractor shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry of the pipe and fittings; and should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the tests upon the test bars.

Power of Engineer to Inspect

SECTION 15. The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding and the casting of the pipe and fittings. The forms, sizes, uniformity and condition of all pipe and fittings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings.

Inspector to Report

SECTION 16. The inspector at the foundry shall report daily to the foundry office, all pipe and fittings rejected, with the causes of rejection.

Castings to be Delivered Sound and Perfect

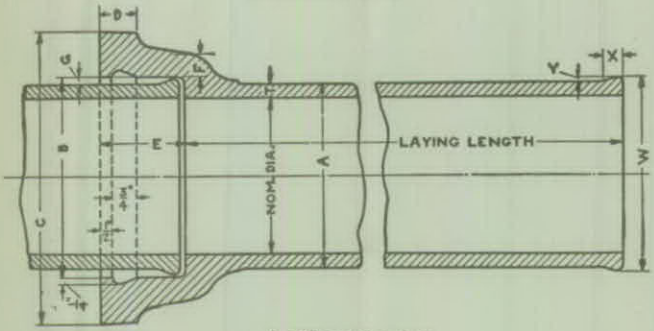
SECTION 17. All the pipe and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other castings which may have passed the engineer, shall at all times be subject to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the contractor shall not be held liable for pipe or fittings found to be cracked after they have been accepted at the agreed point of delivery.

Definition of the Word "Engineer"

SECTION 18. Wherever the word "Engineer" is used herein it shall be understood to refer to the engineer or inspector acting for the purchaser, and to his properly authorized agents, limited by the particular duties intrusted to them.

Dimensions and Weights
of
A. G. A. Standard Bell and Spigot Pipe

Standard Bell



$X = \begin{cases} .75'' \text{ for } 4'' \text{ and } 6'' \\ 1.00'' \text{ for } 8'' \text{ to } 48'' \end{cases}$

$Y = \begin{cases} .19'' \text{ for } 4'' \text{ and } 6'' \\ .25'' \text{ for } 8'' \text{ to } 48'' \end{cases}$

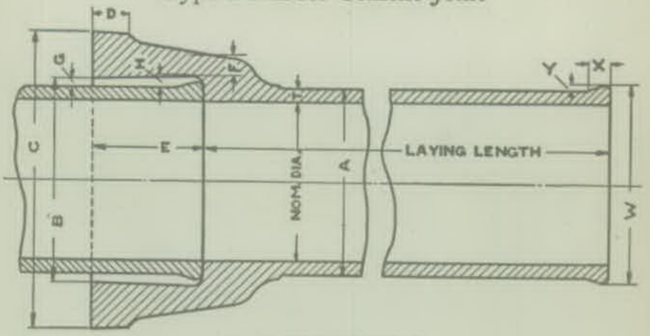
Table No. 29

Nominal Diameter Inches	Dimensions, Inches									Approx. Wts. in Lbs.		
	A	B	C	D	E	F	G	T	W	Bell	Per Foot	12-Ft. Lgth.
3	3.78	4.80	7.40	1.25	4.00	.53	.51	.39	4.06			
4	4.80	5.80	8.40	1.50	4.00	.59	.50	.40	5.18	27.00	19.33	234
6	6.90	7.90	10.70	1.50	4.00	.62	.50	.43	7.28	39.50	30.25	367
8	9.05	10.05	13.05	1.50	4.00	.69	.50	.45	9.55	52.80	42.08	509
10	11.10	12.10	15.10	1.50	4.00	.69	.50	.49	11.60	57.93	55.91	671
12	13.20	14.20	17.40	1.50	4.50	.75	.50	.54	13.70	79.47	73.83	886
16	17.40	18.40	22.00	1.75	4.50	.90	.50	.62	17.90	125.18	112.58	1351
20	21.60	22.85	26.85	1.75	4.50	.97	.63	.68	22.10	169.10	153.83	1846
24	25.80	27.05	31.25	2.00	5.00	1.05	.63	.76	26.30	235.10	206.41	2477
30	31.74	32.99	37.59	2.00	5.00	1.15	.63	.85	32.24	315.20	284.00	3408
36	37.96	39.21	44.21	2.00	5.00	1.25	.63	.95	38.46	410.20	379.25	4551
42	44.20	45.45	51.05	2.00	5.00	1.40	.63	1.07	44.70	537.50	497.66	5972
48	50.50	51.75	57.75	2.00	5.00	1.50	.63	1.26	51.00	657.00	663.50	7962

For cement joints see page 113.
The above Bell dimensions are standard for both gas pipe and fittings.

Dimensions and Weights
of
A. G. A. Standard Bell and Spigot Pipe

Type 2 Bell for Cement Joint



$X = \begin{cases} .75'' \text{ for } 4'' \text{ and } 6'' \\ 1.00'' \text{ for } 8'' \text{ to } 48'' \end{cases}$

$Y = \begin{cases} .19'' \text{ for } 4'' \text{ and } 6'' \\ .25'' \text{ for } 8'' \text{ to } 48'' \end{cases}$

Table No. 30

Nominal Diam. Inches	Dimensions, Inches										Approx. Wts. in Pounds		
	A	B	C	D	E	F	G	H	T	W	Bell	Per Foot	12-Ft. Lgth
4	4.80	5.80	8.40	1.50	4.00	.59	.50	.63	.40	5.18	27.0	19.3	234
6	6.90	7.90	10.70	1.50	4.00	.62	.50	.63	.43	7.28	39.5	30.3	367
8	9.05	10.05	13.05	1.50	4.50	.69	.50	.63	.45	9.55	56.0	42.3	512
10	11.10	12.10	15.10	1.50	5.00	.69	.50	.63	.49	11.60	64.7	56.5	678
12	13.20	14.20	17.40	1.50	5.00	.75	.50	.63	.54	13.70	84.2	74.3	891
16	17.40	18.40	22.00	1.75	6.00	.90	.50	.63	.62	17.90	146.8	115.3	1373
20	21.60	22.85	26.85	1.75	6.00	.97	.63	.75	.68	22.10	198.3	156.3	1875
24	25.80	27.05	31.25	2.00	6.00	1.05	.63	.75	.76	26.30	259.5	208.4	2501
30	31.74	32.99	37.59	2.00	6.50	1.15	.63	.75	.85	32.24	363.7	286.3	3456
36	37.96	39.21	44.21	2.00	6.50	1.25	.63	.75	.95	38.46	472.7	384.4	4613
42	44.20	45.45	51.05	2.00	6.75	1.40	.63	.75	1.07	44.70	631.8	505.5	6066
48	50.50	51.75	57.75	2.00	7.00	1.50	.63	.75	1.26	51.00	788.3	674.6	8093

For standard bell, see page 112.

Plain End Pipe
for use
With Dresser Type Couplings

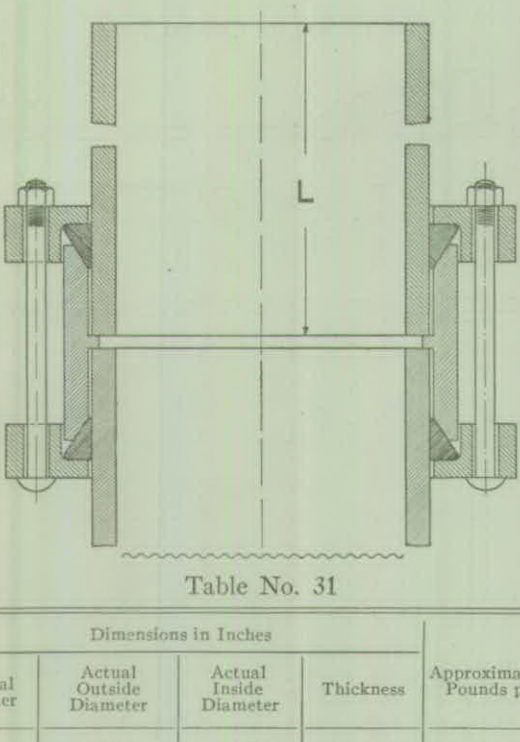
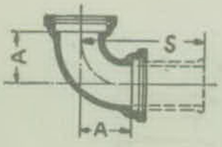


Table No. 31

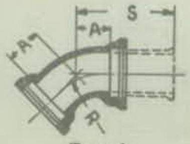
Dimensions in Inches				Approximate Weight Pounds per Foot
Nominal Diameter	Actual Outside Diameter	Actual Inside Diameter	Thickness	
4	4.80	4.00	.40	17.25
6	6.90	6.04	.43	27.13
8	9.05	8.15	.45	38.06
10	11.10	10.12	.49	51.09
12	13.20	12.12	.54	67.21
16	17.40	16.16	.62	102.15
20	21.60	20.24	.68	139.70

Couplings not furnished unless specifically ordered.
Pipe furnished in random lengths (L) from 11′-0″ to 12′-4″ overall.
Longer lengths to a maximum of 16′-4″ can be furnished.

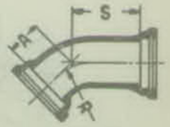
Laying Dimensions of A. G. A. Standard Bell and Spigot ¼ and ⅛ Bends



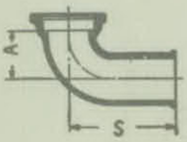
Standard
¼ Bend (90°)



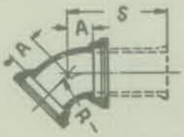
Type 1
⅛ Bend (45°)



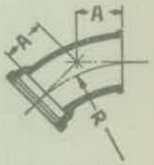
Type 2
⅛ Bend (45°)



Long Radius
¼ Bend (90°)



Standard
⅛ Bend (45°)



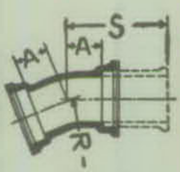
Long Radius
⅛ Bend (45°)

Table No. 32

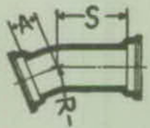
Size	¼ Bends				⅛ Bends										
	Standard		Long Radius		Type 1			Type 2			Standard			Long Radius	
	A	S	A	S	A	S	R	A	S	R	A	S	R	A	R
4	4.50	26			3.16	23.00	3.04	3.16	13.65	3.04					
6	6.25	26			4.23	23.00	5.38	4.23	14.48	5.38					
8	8.00	26			5.31	23.00	7.75	5.31	15.31	7.75					
10	9.75	26			6.39	23.00	10.36	6.39	16.14	10.36					
12	11.25	27			7.22	24.00	12.12	7.22	16.97	12.12					
16	17.00	32			9.12	25.00	16.00				7.73	23	12.62	19.88	48
20	19.00	34			11.03	27.25	19.87				9.30	23	15.69	19.88	48
24	21.00	36	30	42	12.94	29.00	24.48				10.15	23	17.75	24.85	60
30	24.00	39	36	48	15.67	31.50	30.54				11.65	23	20.87	24.85	60
36	28.00	42	48	60							13.34	23	24.50	37.28	90
42	32.00	45	60	72							14.84	23	27.62	37.28	90
48	35.00	48	66	78							16.35	23	30.75	37.28	90

Dimensions in inches.
For dimensions of Bells, see page 112.
For weights, see page 126.

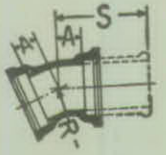
Laying Dimensions
of
A. G. A. Standard Bell and Spigot $\frac{1}{16}$ Bends



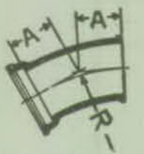
Type 1
1/16 Bend (22½°)



Type 2
1/16 Bend (22½°)



Standard
1/16 Bend (22½°)



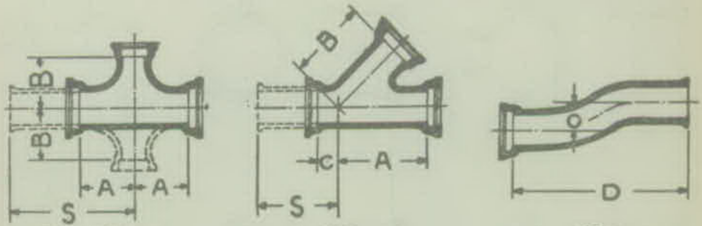
Long Radius
1/16 Bend (22½°)

Table No. 33

Size	1/16 Bends										
	Type 1			Type 2			Standard			Long Radius	
	A	S	R	A	S	R	A	S	R	A	R
4	2.69	20.25	4.00	2.69	14.70	4.00					
6	3.53	20.75	7.70	3.53	15.53	7.70					
8	4.38	21.25	11.50	4.38	16.38	11.50					
10	5.22	22.00	15.70	5.22	17.25	15.70					
12	5.81	22.50	18.15	5.81	17.81	18.15					
16	7.27	23.75	24.00				5.00	23	12.62	19.10	96
20	8.71	24.75	29.75				5.92	23	15.69	19.10	96
24	10.16	26.00	37.00				6.33	23	17.75	23.87	120
30	12.20	27.75	46.25				7.15	23	20.87	23.87	120
36							8.07	23	24.50	35.80	180
42							8.89	23	27.62	35.80	180
48							9.72	23	30.75	35.80	180

Dimensions in inches.
For weights, see page 126.
For dimensions of Bells, see page 112.

Laying Dimensions
of
A. G. A. Standard Tees, Crosses, Y-Branches and Offsets



Tee and Cross Y-Branch Offset

Table No. 34

Tees and Crosses					Y-Branches					Offsets		
Size Run	Size Branches	A	B	S	Size	A	B	C	S	Size	O	D
4	4	8	8	26	4x4	11.15	11.15	3.16	23		6	30.67
6	4–6	8	8	26	6x4	15.50	15.25	4.25	23	4	12	34.14
8	4–6–8	10	10	26	6x6	15.50	15.50	4.25	23		18	37.60
10	4	12	11	26	8x4	19.30	18.80	5.31	23		6	31.92
10	6–8–10	12	12	26	8x6	19.30	19.05	5.31	23	6	12	35.39
12	4–6–8	14	13	27	8x8	19.30	19.30	5.31	23		18	38.85
12	10–12	14	14	27	10x4	22.75	22.00	6.75	23		6	33.74
16	6–8–10	14	14	29	10x6	22.75	22.25	6.75	23	8	12	36.65
16	12–16	17	17	32	10x8	22.75	22.50	6.75	23		18	40.11
20	6–8–10	15	15	29	10x10	22.75	22.75	6.75	23		6	35.18
20	12–16–20	19	19	34	12x4	26.75	26.00	7.25	23	10	12	37.80
24	8–10–12	17	17	30	12x6	26.75	26.25	7.25	23		18	41.26
24	16–20–24	21	21	36	12x8	26.75	26.50	7.25	23		6	36.54
30	8–10–12	20	20	32	12x10	26.75	26.75	7.25	23	12	12	39.06
30	16–20–24–30	24	24	39	12x12	26.75	26.75	7.25	23		18	42.52
36	12–16–20	25	25	34	16x16	33.13	33.13	9.12	23		6	39.01
36	24–30–36	28	28	42	20x20	38.53	38.53	11.03	23	16	12	42.80
42	16–20–24	29	29	36	24x24	43.00	43.00	13.00	23		18	45.13
42	30–36–42	32	32	45	30x30	52.50	52.50	13.75	23		6	41.17
48	16–20–24–30	32	32	39	36x36	60.38	60.38	18.37	23	20	12	45.96
48	36–42–48	35	35	48	42x42	70.00	70.00	22.00	23		18	48.43
					48x48	80.00	80.00	25.00	23			

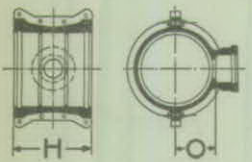
Dimensions in inches.

For weights, see page 124.

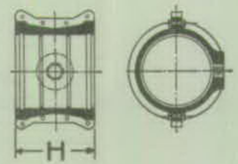
For dimensions of Bells, see page 112.

Tees and Crosses reduce on branch only.

Dimensions of A. G. A.
Standard Sleeves, Plugs and Caps

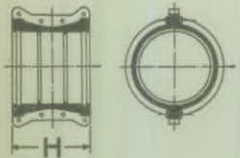


Hub Sleeve

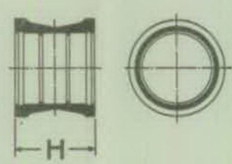


Service Sleeve

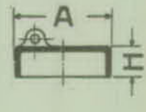
Cap



Split Sleeve



Solid Sleeve



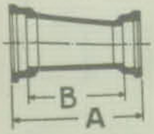
Plug

Table No. 35

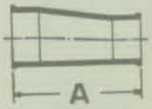
Hub Sleeves			Service Sleeves			Split Sleeves		Solid Sleeves	Caps			Plugs	
Size	H	O	Size	H	Size Tap	Size	H	H	Size	C	D	A	H
10x4	15	6.54	2	8	1¼ or 1½	2	8	8	4	5.80	4.0	4.90	4.75
10x6	15	6.54	3	12	1¼ or 3	3	12	12	6	7.90	4.0	7.00	4.75
12x4	15	7.64	4	12	2 or 3	4	12	12	8	10.05	4.0	9.15	4.75
12x6	15	7.64	6	12	3	6	12	12	10	12.10	4.0	11.20	4.75
						8	15	15					
16x6	18	9.82	8	15	3				12	14.20	4.5	13.30	5.25
16x8	18	9.82	10	15	3	10	15	15	14			15.30	5.25
20x6	18	12.10	12	15	3 or 4	12	15	15	16	18.40	4.5	17.50	5.25
20x8	18	12.10	16	18	3 or 4	16	18	18	20	22.85	4.5	21.70	5.25
20x10	18	12.10				20	18	18	24	27.05	5.0	25.90	5.75
						24	18	18					
									30	32.99	5.0	31.84	5.75
						30	18	18	36	39.21	5.0	38.06	5.75
						36	18	18	42	45.45	5.0	44.30	5.75
						42	18	18	48	51.75	5.0	50.60	5.75
						48	18	18					

Dimensions in inches.
For weights, see page 124.
For dimensions of Bells, see page 112.

Laying Dimensions and Weights of A. G. A. Standard Bell and Spigot Reducers

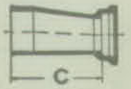


Bell and Bell

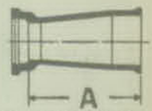


Spigot and Spigot

Eccentric Reducers



Small End Bell



Small End Bell Concentric Reducer

Table No. 36

Eccentric Reducers

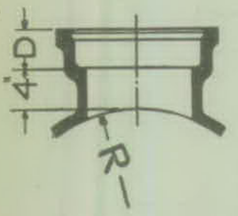
Size	A	B	C	Weight in Pounds: Two Bells	Large Bell	Small Bell	Two Spigots
4x3	20.0	12.0	16.0	57	44	39	26
6x3	25.0	17.0	21.0	80	66	55	41
6x4	20.0	12.0	16.0	81	63	56	38
8x4	28.0	20.0	24.0	117	99	84	66
8x6	20.0	12.0	16.0	114	89	81	56
10x4	36.0	28.0	32.0	160	142	122	104
10x6	28.0	20.0	24.0	156	131	118	93
10x8	20.0	12.0	16.0	148	115	110	77
12x6	37.0	28.5	33.0*	222	198	171	148
12x8	29.0	20.5	25.0*	212	181	162	130
12x10	21.0	12.5	17.0*	193	158	142	107
16x8	46.0	37.5	42.0*	388	356	304	272
16x10	38.0	29.5	34.0*	366	331	282	247
16x12	29.0	20.0	50.0*	344	293	259	209
20x10	54.0	45.5	41.5	586	551	469	434
20x12	46.0	37.0	25.5	569	518	441	401
20x16	30.0	21.0	42.0*	509	425	392	308
24x16	46.5	37.0	26.0*	792	716	641	565
24x20	30.5	21.0	50.5*	677	572	527	421
30x20	55.0	45.5	59.0	1226	1121	1023	917
30x24	40.0	30.0	35.0	1102	952	899	748
36x24	64.0	54.0	59.0	1843	1692	1576	1426
36x30	40.0	30.0	35.0	1484	1281	1217	1014
42x30	64.0	54.0	59.0	2465	2262	2108	1904
42x36	40.0	30.0	35.0	1965	1698	1607	1341
48x36	64.0	54.0		3247	2980	2821	2554
48x42	40.0	30.0		2566	2208	2139	1782

Concentric Reducers

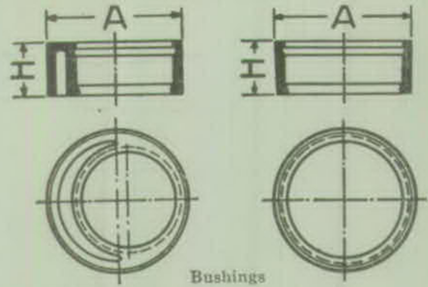
Size	A	Weight in Pounds
14x4	32.0	178
14x6	32.0	198
18x8	32.0	280
18x10	32.0	303
24x12	37.5	508
30x16	37.5	727
30x20	37.5	820
30x24	37.0	940
36x30	43.0	1418
42x36	43.0	1866
48x42	43.0	2475
54x48	43.0	3089

Dimensions in inches. Weights in pounds. All weights approximate.
For dimensions of Bells see page 112.
*Laying length of reducers with large end bell in sizes indicated is one-half inch greater than for reducers with small end bell.

Dimensions and Weights of A. G. A. Standard Bell Hat Flanges and Bushings



Hat Flanges



Bushings

Table No. 37

Hat Flanges

Nominal Diameter	Dimensions in Inches D	Dimensions in Inches R	Approximate Weight in Pounds
20x6	4.00	11.00	73
20x8	4.00	11.00	97
20x10	4.00	11.00	120
20x12	4.50	11.00	158
24x6	4.00	13.00	72
24x8	4.00	13.00	96
24x10	4.00	13.00	117
24x12	4.50	13.00	156
30x6	4.00	16.00	72
30x8	4.00	16.00	94
30x10	4.00	16.00	116
30x12	4.50	16.00	153
36x6	4.00	19.25	71
36x8	4.00	19.25	93
36x10	4.00	19.25	116
36x12	4.50	19.25	150
42x6	4.00	22.37	71
42x8	4.00	22.37	93
42x10	4.00	22.37	114
42x12	4.50	22.37	150
48x6	4.00	25.50	71
48x8	4.00	25.50	93
48x10	4.00	25.50	113
48x12	4.50	25.50	150

Bushings

Size Inches	Dimensions in Inches A	Dimensions in Inches H	Approximate Weight in Pounds
6x3	7.00	4.50	21
6x4	7.00	4.50	13
8x4	9.15	4.50	33
8x6	9.15	4.50	18
10x6	11.20	4.50	57
10x8	11.20	4.50	20
12x6	13.30	5.00	72
12x8	13.30	5.00	61
12x10	13.30	5.00	28
16x12	17.50	5.00	95

Dimensions in inches.
Weights given in pounds. All weights approximate.
For dimensions of Bells see page 112.

Standard Screw Plugs for Gas and Water Mains*

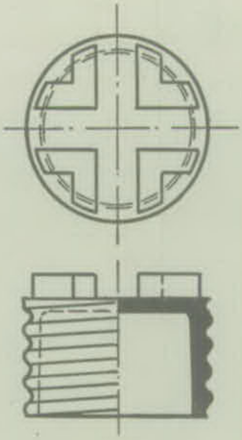


Table No. 38

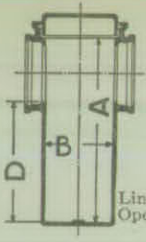
Size	Weight, Pounds
3	7
4	10
6	18
8	26
10	43
12	56

All weights are approximate.

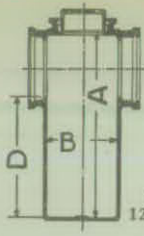
*Useful for temporary "dead ends," lessening liability of damage to pipe when withdrawn.

Dimensions and Weights of A. G. A. Standard Line Drips and Side Pots

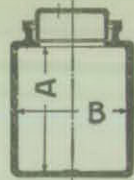
Table No. 39



Line Drip Open Top



Line Drip 12 in. Top Plug



Side Pot

Line Drips—Open Tops

Diameter Branch Inches	Dimensions—Inches A	Dimensions—Inches B	Dimensions—Inches D	Size Plug Inches	Capacity Quarts	Approximate Weight Pounds
4	42.49	14.16	37.0	14	96	467
4	30.09	14.16	24.6	14	64	382
4	17.79	14.16	12.3	14	32	298
6	44.59	14.16	37.0	14	96	497
6	32.19	14.16	24.6	14	64	412
6	19.89	14.16	12.3	14	32	327
8	46.79	14.16	37.0	14	96	538
8	34.39	14.16	24.6	14	64	453
8	22.09	14.16	12.3	14	32	369
10	48.80	14.16	37.0	14	96	589
10	36.40	14.16	24.6	14	64	504
10	24.10	14.16	12.3	14	32	420
12	48.91	16.16	35.0	16	126	766
12	37.31	16.16	23.4	16	84	667
12	25.61	16.16	11.7	16	42	568

Line Drips—12 In. Top Plug

Diameter Branch Inches	Dimensions—Inches A	Dimensions—Inches B	Dimensions—Inches D	Capacity Quarts	Approximate Weight Pounds
16	55.18	20.24	37.0	208	1079
16	42.78	20.24	24.6	138	935
16	30.48	20.24	12.3	69	792
20	60.52	24.28	38.0	304	1568
20	47.92	24.28	24.4	203	1372
20	35.22	24.28	12.7	100	1174
24	60.72	30.04	34.0	420	2215
24	49.32	30.04	22.6	280	1970
24	38.02	30.04	11.3	140	1728
30	66.67	36.06	34.0	600	3275
30	55.27	36.06	22.6	399	2948
30	43.97	36.06	11.3	198	2623
36	74.89	42.06	36.0	864	4719
36	62.89	42.06	24.0	576	4267
36	50.89	42.06	12.0	288	3815
42	81.16	47.98	36.0	1127	7016
42	69.16	47.98	24.0	752	6408
42	57.16	47.98	12.0	376	5800
48	88.37	53.96	37.0	1465	9010
48	75.97	53.96	24.6	974	8284
48	63.67	53.96	12.3	487	7504

Line Drips—Open Tops (Continued)

Diameter Branch Inches	Dimensions—Inches A	Dimensions—Inches B	Dimensions—Inches D	Size Plug Inches	Capacity Quarts	Approximate Weight Pounds
16	55.18	20.24	37.0	20	208	1051
16	42.78	20.24	24.6	20	138	907
16	30.48	20.24	12.3	20	69	764
20	60.52	24.28	38.0	24	304	1500
20	47.92	24.28	25.4	24	203	1304
20	35.22	24.28	12.7	24	100	1107
24	60.72	30.04	34.0	30	420	2070
24	49.32	30.04	22.6	30	280	1826
24	38.02	30.04	11.3	30	140	1583
30	66.67	36.06	34.0	36	600	2944
30	55.27	36.06	22.6	36	399	2617
30	43.97	36.06	11.3	36	198	2292
36	74.89	42.06	36.0	42	864	4104
36	62.89	42.06	24.0	42	576	3652
36	50.89	42.06	12.0	42	288	3200
42	81.16	47.98	36.0	48	1127	5869
42	69.16	47.98	24.0	48	752	5261
42	57.16	47.98	12.0	48	376	4652
48	88.37	53.96	37.0	54	1465	7262
48	75.97	53.96	24.6	54	974	6506
48	63.67	53.96	12.3	54	487	5756

Side Pots

Nominal Diameter Inches	A	B	Capacity Quarts	Approximate Weight Pounds
4	18	16.16	63	278
6	18	16.16	63	278
8	18	16.16	63	278
10	24	20.24	130	455
12	24	20.24	130	455
16	24	20.24	130	455
20	24	20.24	130	455
24	36	24.28	282	810
30	36	24.28	282	810
36	36	24.28	282	810

Dimensions in inches.
Weights given in pounds. All weights approximate.
For dimensions of Bells see page 112.
Weights of Drips figured without plugs.

Weights of A. G. A. Standard Bell and Spigot Tees, Crosses, Y Branches, Offsets, Caps, Plugs and Sleeves—Table No. 40

Size	Tees: Two Bells	Tees: Three Bells	Crosses: Three Bells	Crosses: Four Bells
4x4	106	105	138	137
6x4	144	138	174	169
6x6	156	151	200	194
8x4	194	192	226	224
8x6	208	206	254	251
8x8	223	221	284	282
10x4	253	251	287	285
10x6	267	266	315	314
10x8	283	282	348	346
10x10	296	295	373	372
12x4	343	350	379	385
12x6	359	366	409	416
12x8	376	383	443	450
12x10	390	397	471	478
12x12	410	417	512	519
16x6	536	534	582	580
16x8	552	549	612	610
16x10	563	561	636	634
16x12	655	652	768	765
16x16	709	707	877	875
20x6	724	730	767	774
20x8	738	745	796	802
20x10	749	755	817	824
20x12	898	893	1011	1006
20x16	953	947	1120	1115
20x20	1001	995	1216	1211
24x8	1023	1056	1081	1114
24x10	1034	1067	1103	1136
24x12	1056	1089	1147	1180
24x16	1289	1291	1456	1458
24x20	1336	1338	1552	1554
24x24	1403	1405	1684	1686

Y-Branches: Size	Three Bells	Two Bells
4x4	105	109
6x4	154	161
6x6	171	178
8x4	215	224
8x6	234	243
8x8	254	263
10x4	285	297
10x6	305	317
10x8	327	339
10x10	347	360
12x4	396	406
12x6	418	428
12x8	442	453
12x10	466	476
12x12	502	512
16x16	864	859
20x20	1271	1245
24x24	1828	1753
30x30	2784	2672
36x36	4090	3818
42x42	5981	5489
48x48	8677	7926

Offsets: Size	Weight
4x6	73
4x12	83
4x18	93
6x6	113
6x12	129
6x18	145
8x6	162
8x12	182
8x18	204
10x6	216
10x12	234
10x18	270
12x6	294
12x12	323
12x18	362
16x6	470
16x12	510
16x18	570
20x6	616
20x12	623
20x18	705

Caps: Size	Weight
4	25
6	37
8	52
10	65
12	95
16	151
20	220
24	330
30	476
36	668
42	916
48	1266

Plugs: Size	Weight
4	9
6	16
8	24
10	34
12	50
14	66
16	83
20	127
24	193
30	294
36	433
42	620
48	901

Weights of A. G. A. Standard Bell and Spigot Tees, Crosses, Y Branches, Offsets, Caps, Plugs and Sleeves—Table No. 40 (continued)

Size	Tees		Crosses	
	Two Bells	Three Bells	Three Bells	Four Bells
30x8	1488	1546	1546	1604
30x10	1499	1557	1568	1626
30x12	1521	1579	1612	1670
30x16	1834	1828	2002	1995
30x20	1882	1876	2098	2091
30x24	1948	1942	2230	2223
30x30	2035	2029	2404	2398
36x12	2206	2358	2308	2460
36x16	2255	2407	2406	2558
36x20	2297	2449	2489	2641
36x24	2718	2726	3015	3023
36x30	2789	2798	3158	3166
36x36	2859	2867	3296	3305
42x16	3109	3421	3269	3580
42x20	3154	3466	3358	3670
42x24	3216	3528	3483	3794
42x30	3831	3878	4221	4268
42x36	3908	3955	4376	4423
42x42	3997	4144	4553	4701
48x16	4414	4717	4574	4876
48x20	4459	4761	4663	4965
48x24	4521	4824	4788	5090
48x30	4581	4883	4907	5209
48x36	5331	5329	5799	5797
48x42	5415	5413	5966	5964
48x48	5470	5468	6076	6074

Sleeves							
Hub		Service		Split		Solid	
Size	Weight	Size	Weight	Size	Weight	Size	Weight
10x4	170	2	38	2	37	2	20
10x6	196	3	57	3	56	3	38
12x4	208	4	69	4	67	4	47
12x6	238	6	94	6	87	6	65
16x6	343	8	133	8	127	8	100
16x8	352	10	158	10	151	10	122
20x6	441	12	201	12	191	12	160
20x8	448	16	323	16	314	16	269
20x10	451			20	420	20	372
				24	552	24	500
				30	729	30	676
				36	939	36	871
				42	1204	42	1133
				48	1507	48	1421

Weights given in pounds. All weights approximate.
For dimensions, see pages 117 and 118.

Weights of A. G. A. Standard Bell and Spigot 1/4—1/8 and $\frac{1}{16}$ Bends

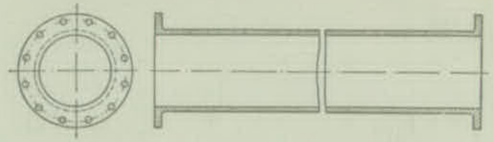
Table No. 41

Size	1/4 Bends			1/8 Bends						1/16 Bends					
	Standard		Long Radius	Type 1		Type 2	Standard		Long Radius	Type 1		Type 2	Standard		Long Radius
	B. & S.	Two Bells	B. & S.	Two Bells	B. & S.	Two Bells	B. & S.	Two Bells	B. & S.	B. & S.	Two Bells	Two Bells	B. & S.	Two Bells	B. & S.
4	68	61	....	59	63	74	....	....	....	58	58	75	....	....	....
6	100	95	....	90	97	113	....	....	....	91	87	114	....	....	....
8	149	139	....	129	138	161	....	....	....	130	124	162	....	....	....
10	198	185	....	168	183	210	....	....	....	175	160	211	....	....	....
12	278	267	....	237	253	291	....	....	....	239	223	290	....	....	....
16	491	486	....	397	410	....	387	377	448	390	373	....	366	335	449
20	707	699	....	585	607	....	544	546	610	559	538	....	508	475	611
24	1003	1002	1158	856	874	....	748	774	971	798	783	....	694	666	971
30	1478	1467	1791	1274	1303	....	1053	1111	1332	1176	1153	....	966	935	1331
36	2121	2122	2926	....	....	....	1445	1557	2446	....	....	....	1306	1280	2446
42	2984	3025	4550	....	....	....	1948	2149	3208	....	....	....	1744	1740	3209
48	4193	4184	6527	....	....	....	2625	2903	4247	....	....	....	2319	2291	4247

Weights given in pounds. All weights approximate.
For dimensions, see pages 115 and 116.

Dimensions and Weights of A. G. A. Standard Flanged Pipe and A. G. A. Standard Drilling of Pipe Flanges

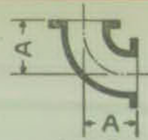
Table No. 42



Nominal Diameter Inches	Actual Outside Diameter	Thickness of Body	Actual Inside Diameter	Dimensions and Drilling of Flanges						Approximate Weights		
				Diameter of Flange	Thickness of Flange	Diameter of Bolt Circles	Number of Bolts	Diameter of Bolts	Diameter Bolt Holes	One Flange	Foot Without Flanges	12 Ft. Length With 2 Flanges
4	4.80	.40	4.00	9	.720	7 ½	4	⅝	¾	8.19	17.22	223
6	6.90	.43	6.04	11	.720	9 ½	4	⅝	¾	10.46	27.26	348
8	9.05	.45	8.15	13	.750	11 ¾	8	⅝	¾	12.65	37.98	481
10	11.10	.49	10.12	16	.860	13 ¾	8	⅝	¾	22.53	50.91	656
12	13.20	.54	12.12	18	.875	15 ¾	8	⅝	¾	25.96	67.01	856
16	17.40	.62	16.16	22 ½	1.000	20	12	¾	⅞	39.68	101.97	1303
20	21.60	.68	20.24	27	1.000	24 ½	16	¾	⅞	51.10	139.40	1775
24	25.80	.76	24.28	31	1.125	28 ¾	16	¾	⅞	65.00	186.58	2369
30	31.74	.85	30.04	37 ½	1.250	35	20	⅞	1	96.70	257.30	3281
36	37.96	.95	36.06	44	1.375	41 ¼	24	⅞	1	132.26	344.62	4400
42	44.20	1.07	42.06	50 ¾	1.560	47 ¾	28	1	1 ⅛	186.83	452.36	5802
48	50.50	1.26	47.98	57	1.750	54	32	1	1 ⅛	235.23	608.13	7768

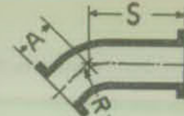
All **Flanged Pipe** faced to the exact dimension specified. Standard length of Flanged Pipe is 12 feet.
Dimensions in inches.
Weights given in pounds.

Laying Dimensions of A. G. A. Standard Flanged 1/4—1/8 and 1/16 Bends



1/4 Bend (90°)

Type 1 1/8 Bend (45°)

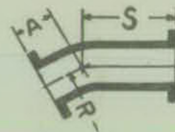


Type 2 1/8 Bend (45°)

Large 1/8 Bend (45°)

Table No. 43

Type 1 1/16 Bend (22 1/2°)



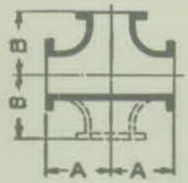
Type 2 1/16 Bend (22 1/2°)

Large 1/16 Bend (22 1/2°)

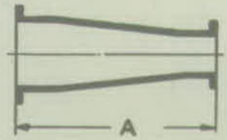
Size	1/4 Bends	1/8 Bends							1/16 Bends						
		Type 1		Type 2			Large		Type 1		Type 2			Large	
	A	A	R	A	R	S	A	R	A	R	A	R	S	A	R
4	8	3.16	3.04	3.16	3.04	13.65	....	....	2.69	4.00	2.69	4.00	14.70	....	....
6	8	4.23	5.38	4.23	5.38	14.48	....	....	3.53	7.70	3.53	7.70	15.53	....	....
8	10	5.31	7.75	5.31	7.75	15.31	....	....	4.38	11.50	4.38	11.50	16.38	....	....
10	12	6.39	10.36	6.39	10.36	16.14	....	....	5.22	15.70	5.22	15.70	17.25	....	....
12	14	7.22	12.12	7.22	12.12	16.97	....	....	5.81	18.15	5.81	18.15	17.81	....	....
16	17	9.12	16.00	....	....	....	7.73	12.62	7.27	24.00	....	....	....	5.00	12.62
20	19	11.03	19.87	....	....	....	9.30	15.69	8.71	29.75	....	....	....	5.92	15.69
24	21	12.94	24.48	....	....	....	10.15	17.75	10.16	37.00	....	....	....	6.33	17.75
30	24	15.67	30.54	....	....	....	11.65	20.87	12.20	46.25	....	....	....	7.15	20.87
36	28	....	....	....	....	....	13.34	24.50	....	....	....	....	....	8.07	24.50
42	32	....	....	....	....	....	14.84	27.62	....	....	....	....	....	8.89	27.62
48	35	....	....	....	....	....	16.35	30.75	....	....	....	....	....	9.72	30.75

Dimensions in inches. For weights see page 130. For drilling of flanges see page 127.

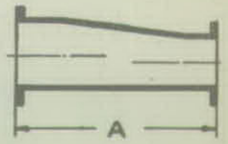
Laying Dimensions of A. G. A. Standard Flanged Tees, Crosses, Reducers and Hat Flanges



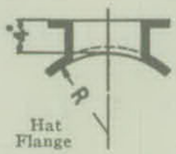
Tee and Cross



Concentric Reducer



Eccentric Reducer



Hat Flange

Table No. 44

Tees and Crosses

Size Run	Size Branches	A	B
4	4	8	8
6	4-6	8	8
8	4-6-8	10	10
10	4	12	11
10	6-8-10	12	12
12	4-6-8	14	13
12	10-12	14	14
16	6-8-10	14	14
16	12-16	17	17
20	6-8-10	15	15
20	12-16-20	19	19
24	8-10-12	17	17
24	16-20-24	21	21
30	8-10-12	20	20
30	16-20-24-30	24	24
36	12-16-20	25	25
36	24-30-36	28	28
42	16-20-24	29	29
42	30-36-42	32	32
48	16-20-24-30	32	32
48	36-42-48	35	35

Reducers

Size	A	Size	A
4x3	10.80	30x20	44.80
6x3	15.90	30x24	29.80
6x4	10.90	36x24	54.00
8x4	19.00	36x30	30.20
8x6	11.10	42x30	54.40
10x4	27.00	42x36	30.60
10x6	19.10	48x36	54.80
10x8	11.20	48x42	31.00
12x6	27.20		
12x8	19.30		
12x10	11.30		
16x8	36.60		
16x10	28.60		
16x12	19.70		
20x10	44.90		
20x12	37.00		
20x16	21.30		
24x16	35.80		
24x20	20.10		

Hat Flanges

Size	Size Outlet	R
20	6-8-10-12	11.00
24	6-8-10-12	13.00
30	6-8-10-12	16.00
36	6-8-10-12	19.25
42	6-8-10-12	22.37
48	6-8-10-12	25.50

Dimensions in inches.
For weights, see page 130.
For drilling of flanges, see page 127.

Weights of A. G. A. Standard Flanged Bends, Tees, Crosses, Reducers and Hat Flanges
Table No. 45

Size	1/4 Bends	1/8 Bends Type 1	1/8 Bends Type 2	1/8 Bends Large	1/16 Bends Type 1	1/16 Bends Type 2	1/16 Bends Large
4	36	25	40	....	24	41	....
6	51	40	63	....	37	64	....
8	78	58	90	....	53	91	....
10	129	97	139	....	89	140	....
12	180	130	184	....	116	183	....
16	315	226	...	206	202	...	164
20	463	349	...	310	302	...	239
24	662	516	...	434	443	...	326
30	1030	837	...	674	716	...	498
36	1566	...	...	1001	...	...	724
42	2324	...	...	1448	...	...	1039
48	3340	...	...	2059	...	...	1447

Hat Flanges

Size	Weight	Size	Weight
20x6	43	36x6	41
20x8	55	36x8	52
20x10	78	36x10	75
20x12	97	36x12	90
24x6	42	42x6	41
24x8	54	42x8	52
24x10	76	42x10	74
24x12	95	42x12	90
30x6	42	48x6	41
30x8	53	48x8	52
30x10	75	48x10	73
30x12	92	48x12	90

Tees and Crosses

Size	Tees	Crosses
4x4	55	70
6x4	71	85
6x6	76	94
8x4	104	119
8x6	110	130
8x8	114	139
10x4	163	181
10x6	170	193
10x8	176	204
10x10	189	230
12x4	226	244
12x6	234	259
12x8	240	272
12x10	255	300
12x12	256	305
16x6	338	359
16x8	342	368
16x10	355	392
16x12	427	487
16x16	451	533
20x6	469	488
20x8	473	495
20x10	484	517
20x12	603	663
20x16	626	708
20x20	641	739
24x8	680	703
24x10	691	725
24x12	695	733
24x16	865	947
24x20	880	978
24x24	895	1006

Size	Tees	Crosses
30x8	1073	1096
30x10	1085	1118
30x12	1088	1126
30x16	1306	1387
30x20	1321	1418
30x24	1335	1446
30x30	1374	1524
36x12	1749	1797
36x16	1766	1831
36x20	1775	1849
36x24	2000	2127
36x30	2024	2173
36x36	2033	2193
42x16	2634	2708
42x20	2647	2733
42x24	2657	2752
42x30	2958	3139
42x36	2976	3166
42x42	3092	3298
48x16	3788	3861
48x20	3799	3885
48x24	3810	3906
48x30	3830	3928
48x36	4208	4398
48x42	4219	4419
48x48	4203	4387

Reducers

Size	Wgt.
4x3	26
6x3	41
6x4	39
8x4	65
8x6	53
10x4	108
10x6	95
10x8	77
12x6	144
12x8	123
12x10	104
16x8	267
16x10	246
16x12	205
20x10	433
20x12	397
20x16	306
24x16	536
24x20	389
30x20	890
30x24	714
36x24	1395
36x30	987
42x30	1896
42x36	1336
48x36	2547
48x42	1793

Weights given in pounds. All weights approximate.
For dimensions, see pages 128 and 129. For drilling of flanges, see page 127.

SECTION 7

JOINTS FOR CAST IRON PIPE

SECTIONS THROUGH TYPICAL CAST IRON PIPE JOINTS

A. W. W. A. STANDARD

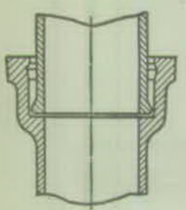


FIG. 1

A. W. W. A. STANDARD (HIGH PRESSURE)

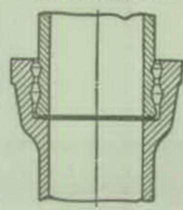


FIG. 2

A. G. A. STANDARD

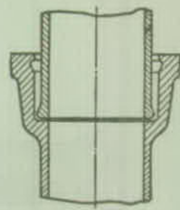


FIG. 3

A. G. A. STANDARD (FOR CEMENT)

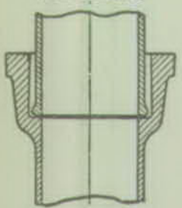


FIG. 4

TURNED & BORED JOINT

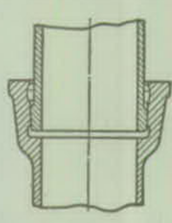


FIG. 5

BELL AND PLAIN END JOINT (METROPOLITAN TYPE)

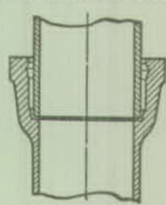


FIG. 6

FLEXIBLE JOINT (METROPOLITAN TYPE)

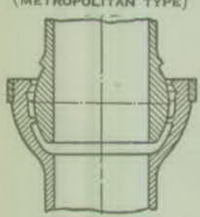


FIG. 7

FLEXIBLE JOINT (NARROWS SIPHON TYPE)

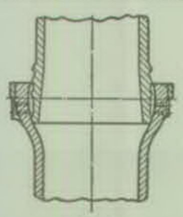


FIG. 8

FLEXIBLE JOINT (WARD TYPE)

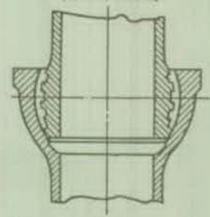


FIG. 9

PLAIN END PIPE WITH DRESSER TYPE COUPLING

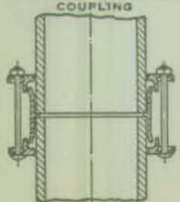


FIG. 10

FLANGED PIPE STANDARD

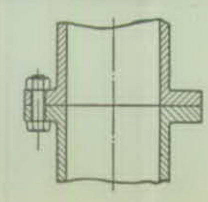


FIG. 11

FLANGED PIPE (HIGH PRESSURE)

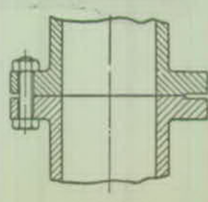


FIG. 12

TYPES OF JOINTS FOR CAST IRON PIPE

(For Sectional views see page 132)

American Water Works Association Standard Bell and Spigot Pipe

CLASS A-B-C-D

FIG. 1

For ordinary water-works systems the pipe in common use is the A. W. W. A. Bell and Spigot Standard adopted May 12, 1908. This standard is divided into classes designated by letters A-B-C-D-E-F-G and H, each class denoting strength for an additional working pressure of 100 foot head, or 43 pounds per square inch pressure. Thus a Class C pipe is good for a working pressure of 129 pounds per square inch, or a head of 300 feet. For heads up to 400 feet the pipes are made in sizes from 4 inches to 84 inches. For specifications, dimensions and weights of this pipe see pages 53 to 98.

American Water Works Association Standard Bell and Spigot Pipe

CLASS E-F-G-H (high pressure)

FIG. 2

For working pressures over 173 pounds per square inch the A. W. W. A. Standard pipe is made in sizes from 6 inches to 36 inches, and generally known as high-pressure pipe. A typical section through the joint of this pipe is shown in Fig. 2, which in design is similar to Fig. 1, except that double lead grooves are provided for additional strength and tightness. When this additional protection is not necessary this pipe may be obtained with a single lead groove similar to pipe in Classes A to D. For specifications, dimensions and weight, see pages 53 to 101.

American Gas Association Standard
Bell and Spigot Pipe
FIG. 3 (for lead)
Type 1

The recognized standard of bell and spigot cast iron pipe for gas is the A. G. A. Standard, adopted October 1913, by the American Gas Institute and revised by the American Gas Association in 1925. This Standard is made in sizes from 4 inches to 48 inches and follows the size scale of the A. W. W. A. Standard, except the 14-inch and 18-inch sizes are excluded. Only one class for each size is made, the outside diameter of the pipe corresponding with the Class A pipe in the A. W. W. A. Standard. For specifications, dimensions and weights, see pages 103 to 130.

American Gas Association Standard
Bell and Spigot Pipe
FIG. 4 (for cement)
Type 2

To distinguish this pipe from the ordinary A. G. A. Standard pipe for use with lead, it is generally called Type 2. The principal difference between the two types lies in the design of the bell. In the No. 2 the bell is somewhat deeper, the usual lead groove eliminated, and in order to properly secure the cement the inside diameter of the bell is made somewhat larger at the bottom than at the top. This bell is also used with medium pressure gas by making it up with alternate layers of lead and cement. For specifications, dimensions and weights, see pages 103 to 113.

Bored Bell and Turned Spigot Pipe

Fig. 5

This type of joint has been used quite extensively in Europe and principally for water lines. The spigot end as well as the inside of the bell are machined on a slight taper, a feature which increases the cost of the pipe. The principal merits in this type lies in the rapidity with which the pipe can be laid and the negligible leakage in the joint. Since this type of pipe is not a recognized standard in this country, pipe foundries only make this pipe to fill special orders.

Bell and Plain End Joint (Metropolitan Type)

Fig. 6

This type of joint is coming into prominence in this country through its use on deLavaud Centrifugal Pipe. It is a modification of the joint used by the Metropolitan Water Board of London, where the first bell and spigot joint originated. In ordinary bell and spigot pipe the spigot serves two purposes, namely, to center the end of the pipe in the bell and to prevent the hemp from being driven into the pipe between the spigot and the back of the bell. In the new type of joint the taper in the bell fulfills these functions. In laying it is customary to place the end of one pipe in the bell of the next and slide it forward until it rides upon the taper and automatically centers itself.

Standard Flexible Joint Pipe
(Metropolitan Type)

FIG. 7

The flexible joint on cast iron pipe is used mostly for submarine lines where the ordinary bell and spigot or flanged joints are not suitable on account of rigidity. As the name implies the joint is flexible, which facilitates the laying of the pipe and permits adjustment of the pipe on river bottoms, where settlements occur after the pipe has been laid. Various types and designs have been brought out, but to James Watt, the inventor of the steam engine, belongs the honor of being the original inventor. Most of the types in general use today are modifications of his original pipe. The Metropolitan joint, which is the most commonly used on account of its simplicity, is shown in Fig. 7. The spigot end of this pipe is carefully machined to a spherical surface, and the integrally cast-on ring on the inside of the bell also machined to a radius corresponding to the diameter of the spigot. This ring serves a threefold purpose: first, it centers the spigot of one pipe with the bell of the other, thus assuring a uniform lead space; second, it provides a stop for the lead and, third, it limits to an exact dimension the distance the spigot extends into the bell, thus providing a solid bearing in the deflection. In this type of joint the lead is stationary and can therefore be readily and effectively caulked, a feature which cannot be accomplished in types where the lead moves with the spigot. In the larger sizes of this type of pipe it is customary to shrink a steel band on the outside of the bell to prevent injury of the pipe in handling and transportation. For dimensions and weights, see page 140.

Standard Flexible Joint Pipe
(Narrows Siphon Type)

FIG. 8

This type of flexible joint pipe derives its name from the fact that the first line was installed across the entrance to the New York Harbor, between Brooklyn and Staten Island. Careful and authentic tests have proven this joint to be practically 100 per cent tight. The inside of the bell is carefully machined and ground to gauge on a radius, and the lower end of the spigot is likewise finished to correspond with the diameter of the spherical inside of the bell. Inasmuch as the lead in this joint moves with the spigot in deflecting the pipe the caulking of the lead is not possible, and to compensate for the shrinkage of the lead in cooling, small lead pellets are forced into the lead space by means of gib screws. For dimensions and weights, see page 141.

Standard Flexible Joint
(Ward Type)

FIG. 9

This is the oldest type of flexible joint. It is not generally recommended as the lead is retained as a ball on the spigot end, and may be shaved off by the edge of the ball as the pipe is bent. For dimensions and weights, see page 140.

Plain End Cast Ircn Pipe with Dresser Type Couplings

FIG. 10

For high-pressure gas lines and some water lines, an efficient joint can be made by the use of plain-end cast iron pipe and Dresser Couplings. The important part of this joint is a middle steel ring having in the center a projection against which the two ends of the pipe rest. The middle ring is flared out at each end to receive a rubber ring gasket which later is forced into place by means of two flanges drawn up by bolts. The rubber ring is thus tightly pressed against the outside diameter of the pipe and against the inside of the two flanges, and in this manner a tight joint is secured.

Cast Iron Standard Flanged Pipe

FIG. 11

This type of joint is used when combined rigidity, strength and tightness are required. The flanges are cast integrally with the pipe and accurately machined to dimensions. The body thicknesses and diameters are made in classes following the A. W. W. A. Standard, and the flanges in accordance with the American Standard for 125 pounds pressure. For dimensions and weights of this pipe, see page 145. For drilling, see page 147.

Cast Iron Flanged Pipe
Extra Heavy

FIG. 12

This pipe is similar to the standard except that the faces of the flanges are raised one-sixteenth of an inch to the inside of the bolt holes and body thickness, dimension of flanges and drilling good for a working pressure up to 250 pounds per square inch. This pipe is also made in various classes, although in only one standard for the flanges, namely the American Extra Heavy. For dimensions and weights of this pipe, see page 148. For drilling, see page 149.

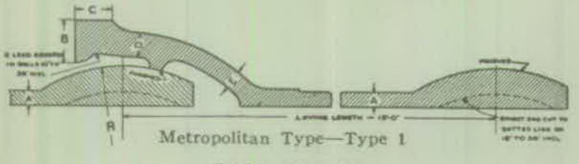
Maximum Bends in Cast Iron Pipe Joints, Curves Laid with Full Length Bell and Spigot Pipe 12′ 0″ Length

Table No. 46

Size of Pipe	Bend in One Joint	Deflection in Inches	Approximate Rad. in Feet of Curve produced by Succession of Joints
4″	4°–00′	10.00″	170′
6″	3°–30′	8.80″	196′
8″	3°–14′	8.12″	212′
10″	3°–07′	7.83″	226′
12″	3°–00′	7.50″	230′
16″	2°–41′	6.80″	260′
18″	2°–26′	6.10″	283′
20″	2°–09′	5.40″	320′
24″	1°–47′	4.50″	390′
30″	1°–26′	3.60″	480′
36″	1°–12′	3.00″	570′
42″	1°–02′	2.60″	660′
48″	0°–55′	2.30″	750′

Joint opening not to exceed .8″.
Caulking space not less than .25″.

General Dimensions, Thicknesses and Weights of Standard Flexible Joint Pipe

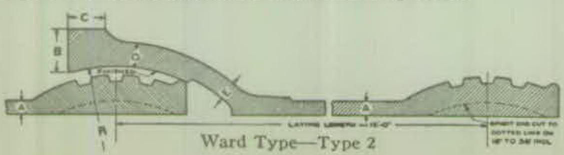


Metropolitan Type—Type 1

Table No. 47

Size Inches	Class	Dimensions—Inches A	B	C	D	E	R	Weight per Length Pounds	Lead per Solid Joint—Pounds Type 1	Type 2
6	B	.48	1.56	1.37	1.00	.87	4.68	503	9	12
6	D	.55	1.56	1.37	1.00	.87	4.68	555	9	12
8	B	.51	1.81	1.56	1.12	.94	5.92	673	14	19
8	D	.60	1.81	1.56	1.12	.94	5.92	780	14	19
10	B	.57	2.06	1.75	1.18	1.00	7.20	947	22	28
10	D	.68	2.06	1.75	1.18	1.00	7.20	1080	22	28
12	B	.62	2.25	1.87	1.25	1.06	8.50	1210	39	49
12	D	.75	2.25	1.87	1.25	1.06	8.50	1400	39	49
14	B	.66	2.50	2.00	1.31	1.12	9.75	1450	51	64
14	D	.82	2.50	2.00	1.31	1.12	9.75	1750	51	64
16	B	.70	2.75	2.12	1.43	1.25	10.88	1862	60	76
16	D	.89	2.75	2.12	1.43	1.25	10.88	2250	60	76
18	B	.75	2.87	2.25	1.56	1.31	12.06	2300	73	91
18	D	.96	2.87	2.25	1.56	1.31	12.06	2760	73	91
20	B	.80	3.12	2.37	1.62	1.37	13.44	2625	92	112
20	D	1.03	3.12	2.37	1.62	1.37	13.44	3200	92	112
24	B	.89	3.37	2.68	1.75	1.50	15.56	3534	112	136
24	D	1.16	3.37	2.68	1.75	1.50	15.56	4290	112	136
30	B	1.03	3.87	3.18	2.12	1.72	18.38	5067	146	181
30	D	1.37	3.87	3.18	2.12	1.72	18.38	6360	146	181
36	B	1.15	4.12	3.50	2.50	1.94	21.88	6063	177	225
36	D	1.58	4.12	3.50	2.50	1.94	21.88	7900	177	225

All weights approximate.
Deflection about 13 degrees.
For heavy service, see types shown in the following tables.



Ward Type—Type 2

General Dimensions, Thickness and Weights of Standard Narrows Siphon Type Flexible Joint Pipe

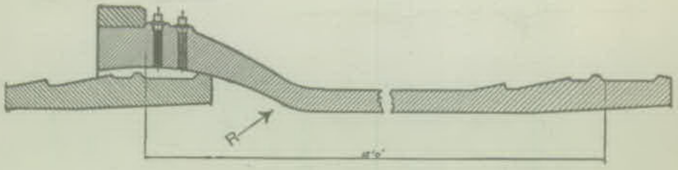


Table No. 48

Size Inches	Thickness Inches	Radius R Inches	Gib Screws		Weight Pounds
			Diameter Inches	Number	
16	.89	10.88	13/16	16	2488
18	.96	11.94	13/16	18	3018
20	1.03	13.00	13/16	20	3502
24	1.16	15.13	13/16	24	4676
30	1.37	18.03	13/16	28	6629
36	1.58	21.56	13/16	36	9212
42	1.78	24.75	13/16	40	12370
48	1.96	28.00	13/16	44	15652

All weights approximate.

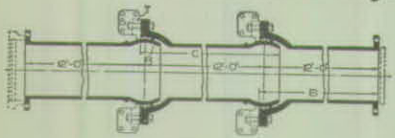
Based on Class D Pipe.

Maximum angle of deflection 10° 30′.

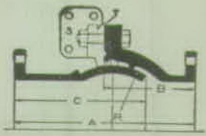
For work in deep water a new type of joint known as the Narrows Siphon Flexible Joint has been developed. This combines absolute tightness with ease of laying and is ideal for deep water installations. Designed primarily for the first Narrows Siphon it proved so satisfactory that it was used for the parallel line of larger capacity.

For work in deep water it is advisable to use a laying cradle and lay the pipe in a continuous line rather than make up several lengths on the surface and join the sections under water. The use of this cradle and resulting deflection of the joint would loosen lead calked in the usual way. In this Type Flexible Joint Pipe the lead is calked throughout the bell instead of only on the surface. This is accomplished by forcing additional lead through the holes in the bell. As a result of this process the joint is absolutely tight even after deflection.

General Dimensions, Thicknesses and Weights of Standard Flexible Joint Pipe



Type No. 3



Type No. 4

Table No. 49

Dimensions Common to Nos. 3 and 4

Size Inches	Class D Thickness Inches	Radius R Inches	Gun-Metal Bolts in	
			Joint S	Flange T
12	.75	7.80	6	16
14	.82	8.95	6	18
16	.89	10.10	6	20
18	.96	11.35	6	22
20	1.03	12.90	6	24
24	1.16	15.05	6	28
30	1.37	18.75	6	28
36	1.58	22.20	6	32

Full Lengths, Type No. 3

Size Inches	Lengths—Inches		Approximate Pounds Section C
	B	C	
12	145.13	148.93	1514
14	145.75	150.65	1937
16	145.81	151.13	2402
18	146.00	152.00	2834
20	146.20	152.83	3491
24	146.20	153.60	4693
30	146.75	155.75	6914
36	147.00	157.40	9941

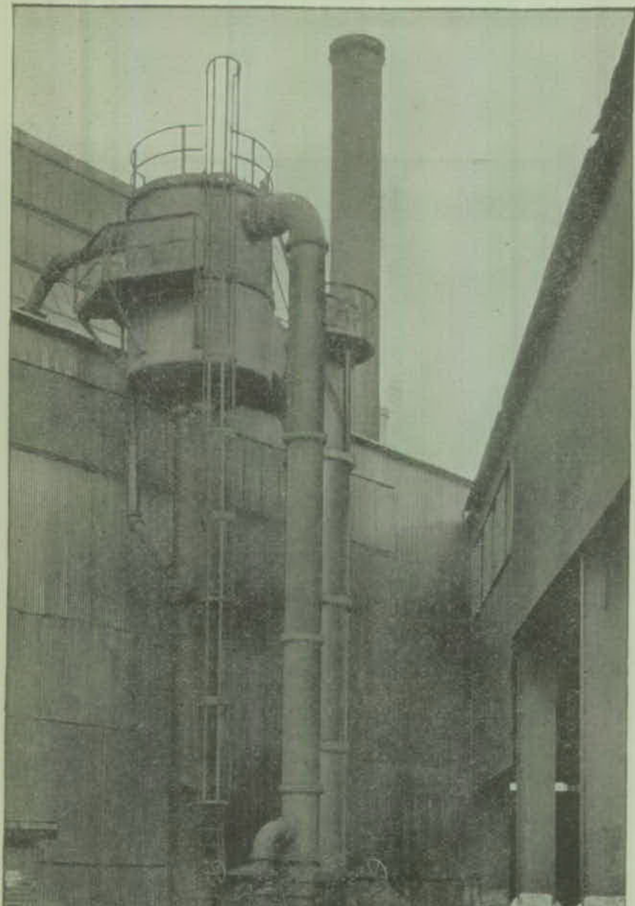
Short Lengths, Type No. 4

Size Inches	Lengths—Inches			Approximate Pounds per Joint
	A	B	C	
12	22.00	11.13	15.80	638
14	22.50	11.75	17.40	816
16	25.50	13.31	19.32	1056
18	26.00	14.00	20.00	1212
20	28.00	15.20	21.63	1601
24	31.00	16.70	23.90	2219
30	35.25	19.00	28.00	3180
36	38.00	21.00	30.40	5252

Made to order only. Maximum deflection about 18 degrees. Weights approximate only. Type No. 3 end sections may be ordered bell or spigot instead of flange if desired. Flange dimensions Class D. Bolts furnished to order only—not included with the castings. Type No. 4 joints are furnished complete with lead calked bell and bolted collar, ready for use. Details modified to meet special requirements.

SECTION 8

STANDARD FLANGED PIPE



Cast Iron Flanged Pipe for Exhaust Steam

Dimensions and Weights of Standard Flanged Pipe Classes A and B

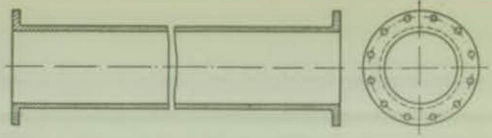
Table No. 50

Dimensions and Drilling of Flanges						Class A—100-Foot Head 43 Pounds Pressure				Class B—200-Foot Head 86 Pounds Pressure				
Nominal Diameter Inches	Diameter of Flange, Inches	Thickness of Flange, Inches	Diameter of Bolt Circle, Inches	Number of Bolts	Diameter of Bolts Inches	Thickness Inches	Weight, Pounds per Foot without Flanges	Weight, Pounds per 12-Foot Length 2 Flanges	Weight, Pounds per Single Flange	Thickness Inches	Weight, Pounds per Foot without Flanges	Weight, Pounds per 12-Foot Length 2 Flanges	Weight, Pounds per Single Flange	Nominal Diameter Inches
3	7.50	.75	6.00	4	⅝	.39	13.0	169	6.4	.42	14.6	188	6.2	3
4	9.00	.94	7.50	8	⅝	.42	18.0	238	11.1	.45	20.1	263	10.7	4
6	11.00	1.00	9.50	8	¾	.44	27.9	365	15.0	.48	31.1	402	14.4	6
8	13.50	1.13	11.75	8	¾	.46	38.7	511	23.1	.51	42.7	559	23.1	8
10	16.00	1.19	14.25	12	⅞	.50	51.9	687	32.2	.57	58.8	770	32.2	10
12	19.00	1.25	17.00	12	⅞	.54	67.0	899	47.7	.62	76.4	1012	47.7	12
14	21.00	1.38	18.75	12	1	.57	82.3	1104	58.1	.66	94.7	1253	58.1	14
16	23.50	1.44	21.25	16	1	.60	98.8	1332	73.2	.70	114.6	1522	73.2	16
18	25.00	1.56	22.75	16	1 ⅛	.64	118.3	1576	78.1	.75	137.8	1810	78.1	18
20	27.50	1.69	25.00	20	1 ⅛	.67	137.4	1848	99.8	.80	163.1	2157	99.8	20
24	32.00	1.88	29.50	20	1 ¼	.76	186.5	2512	137.2	.89	217.3	2882	137.2	24
30	38.75	2.13	36.00	28	1 ¼	.88	266.1	3622	214.4	1.03	312.6	4166	207.2	30
36	46.00	2.38	42.75	32	1 ½	.99	358.7	4959	327.4	1.15	418.7	5654	314.8	36
40	50.75	2.50	47.25	36	1 ⅜	1.06	427.2	5940	406.6	1.23	497.0	6753	394.5	40
42	53.00	2.63	49.50	36	1 ½	1.10	464.6	6492	458.5	1.28	542.2	7395	444.2	42
48	59.50	2.75	56.00	44	1 ½	1.26	608.0	8408	555.9	1.42	687.2	9324	538.9	48

See notes on next page.

Dimensions and Weights of Standard Flanged Pipe Classes C and D

Table No. 50 (continued)



Dimensions and Drilling of Flanges						Class C—300-Foot Head 130 Pounds Pressure				Class D—400-Foot Head 173 Pounds Pressure				
							Weight, Pounds per				Weight, Pounds per			
Nominal Diameter Inches	Diameter of Flange, Inches	Thickness of Flange, Inches	Diameter of Bolt Circle, Inches	Number of Bolts	Diameter of Bolts Inches	Thickness Inches	Foot without Flanges	12-Foot Length 2 Fl'nges	Single Flange	Thickness Inches	Foot without Flanges	12-Foot Length 2 Fl'nges	Single Flange	Nominal Diameter Inches
3	7.50	.75	6.00	4	5/8	.45	15.5	198	6.2	.48	16.4	209	6.2	3
4	9.00	.94	7.50	8	5/8	.48	21.3	277	10.7	.52	22.8	295	10.7	4
6	11.00	1.00	9.50	8	3/4	.51	32.9	424	14.4	.55	35.3	452	14.4	6
8	13.50	1.13	11.75	8	3/4	.56	48.0	620	22.0	.60	51.2	658	22.0	8
10	16.00	1.19	14.25	12	7/8	.62	65.5	847	30.6	.68	71.4	918	30.6	10
12	19.00	1.25	17.00	12	7/8	.68	85.4	1116	45.6	.75	93.7	1216	45.6	12
14	21.00	1.38	18.75	12	1	.74	108.1	1407	55.1	.82	119.2	1541	55.1	14
16	23.50	1.44	21.25	16	1	.80	133.3	1738	69.1	.89	147.5	1908	69.1	16
18	25.00	1.56	22.75	16	1 1/8	.87	162.4	2094	72.8	.96	178.4	2286	72.8	18
20	27.50	1.69	25.00	20	1 1/8	.92	190.6	2473	92.9	1.03	212.3	2733	92.9	20
24	32.00	1.88	29.50	20	1 1/4	1.04	257.6	3345	126.8	1.16	286.0	3686	126.8	24
30	38.75	2.13	36.00	28	1 1/4	1.20	366.9	4795	196.0	1.37	421.2	5427	186.4	30
36	46.00	2.38	42.75	32	1 1/2	1.36	497.7	6572	299.9	1.58	581.9	7548	282.5	36
40	50.75	2.50	47.25	36	1 3/8	1.48	601.6	7965	372.7	1.72	703.4	9143	351.1	40
42	53.00	2.63	49.50	36	1 1/2	1.54	657.4	8720	415.4	1.78	764.1	9953	392.1	42
48	59.50	2.75	56.00	44	1 1/2	1.71	832.7	11001	504.4	1.96	960.8	12471	470.8	48

Flanges in accordance with American Standard for 125 pounds steam pressure. For dimensions of flanges see page 147.
All flanged pipe faced to exact dimension specified. All weights approximate. Standard length of flanged pipe is 12 feet.

American Standard *Dimensions and Drilling Templates of Flanges for Cast Iron Pipe and Fittings for Maximum Working Saturated Steam Pressure of 125 Pounds per Square Inch

Table No. 51

Nominal Size Inches	Diameter of Flange Inches	Thickness of Flange Inches	Diameter of Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Size of Bolt Holes Inches	Length of Bolts Inches
1	4 ¼	7/16	3 ⅛	4	½	⅝	1 ½
1 ¼	4 ⅝	½	3 ½	4	½	⅝	1 ¾
1 ½	5	9/16	3 ⅞	4	½	⅝	2
2	6	⅝	4 ¾	4	⅝	¾	2
2 ½	7	11/16	5 ½	4	⅝	¾	2 ¼
3	7 ½	¾	6	4	⅝	¾	2 ¼
3 ½	8 ½	13/16	7	8	⅝	¾	2 ½
4	9	15/16	7 ½	8	⅝	¾	2 ¾
5	10	15/16	8 ½	8	¾	⅞	2 ¾
6	11	1	9 ½	8	¾	⅞	3
8	13 ½	1 ⅛	11 ¾	8	¾	⅞	3 ¼
10	16	1 3/16	14 ¼	12	⅞	1	3 ½
12	19	1 ¼	17	12	⅞	1	3 ½
14	21	1 ⅜	18 ¾	12	1	1 ⅛	4
16	23 ½	1 7/16	21 ¼	16	1	1 ⅛	4
18	25	1 9/16	22 ¾	16	1 ⅛	1 ¼	4 ½
20	27 ½	1 11/16	25	20	1 ⅛	1 ¼	4 ¾
24	32	1 ⅞	29 ½	20	1 ¼	1 ⅜	5 ¼
30	38 ¾	2 ⅛	36	28	1 ¼	1 ⅜	5 ¾
36	46	2 ⅜	42 ¾	32	1 ½	1 ⅝	6 ½
42	53	2 ⅝	49 ½	36	1 ½	1 ⅝	7 ¼
48	59 ½	2 ¾	56	44	1 ½	1 ⅝	7 ½
54	66 ¼	3	62 ¾	44	1 ¾	2	8 ¼
60	73	3 ⅛	69 ¼	52	1 ¾	2	8 ½
72	86 ½	3 ½	82 ½	60	1 ¾	2	9 ½
84	99 ¾	3 ⅞	95 ½	64	2	2 ¼	10 ½
96	113 ¼	4 ¼	108 ½	68	2 ¼	2 ½	11 ½

All dimensions in inches.

Drilling templates are in multiples of four, so that fittings may be made to face in any quarter, and bolt holes straddle the center line.

For bolts smaller than 1 ¾ inches the bolt holes are drilled ⅛ inch and for bolts 1 ¾ inches and larger the bolt holes are drilled ¼ inch larger than the nominal diameter of bolts.

The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 inches and larger can be spot faced or back faced, so that standard length bolts can be used.

Flanges to be plain faced.

*See note page 164.

Dimensions and Weights of High Pressure Flanged Pipe—Classes E, F, G and H.

Table No. 52

Dimensions and Drilling of Flanges						Class E—500-Foot Head 217 Pounds Pressure				Class F—600-Foot Head 260 Pounds Pressure				
							Weight, Pounds per				Weight, Pounds per			
Nominal Diameter Inches	Diameter of Flange, Inches	Thickness of Flange, Inches	Diameter of Bolt Circle, Inches	Number of Bolts	Diameter of Bolts Inches	Thickness Inches	Foot without Flanges	12-Foot Length 2 Flange	Single Flange	Thickness Inches	Foot without Flanges	12-Foot Length 2 Flange	Single Flange	Nominal Diameter Inches
6	12.50	1.44	10.63	12	¾	.58	37.7	515	31.1	.61	39.5	536	31.1	6
8	15.00	1.62	13.00	12	⅞	.66	54.7	748	45.9	.71	60.6	819	45.9	8
10	17.50	1.87	15.25	16	1	.74	78.8	1079	66.5	.80	84.7	1149	66.5	10
12	20.50	2.00	17.75	16	1⅛	.82	104.2	1441	95.1	.89	112.4	1539	95.1	12
14	23.00	2.13	20.25	20	1⅛	.90	133.1	1837	120.1	.99	146.2	1995	120.1	14
16	25.50	2.25	22.50	20	1¼	.98	165.0	2277	148.7	1.08	180.8	2467	148.7	16
18	28.00	2.37	24.75	24	1¼	1.07	202.3	2790	181.2	1.17	219.8	3000	181.2	18
20	30.50	2.50	27.00	24	1¼	1.15	241.1	3328	217.3	1.27	262.5	3585	217.3	20
24	36.00	2.75	32.00	24	1½	1.31	328.5	4590	323.8	1.45	361.6	4987	323.8	24
30	43.00	3.00	39.25	28	1¾	1.55	484.7	6747	465.3	1.73	538.0	7357	450.3	30
36	50.00	3.37	46.00	32	2	1.80	674.2	9384	646.8	2.02	748.7	10229	622.2	36
Class G—700-Foot Head. 304 Pounds Presssure										Class H—800-Foot Head. 347 Pounds Pressure				
6	12.50	1.44	10.63	12	¾	.65	42.9	576	30.4	.69	45.2	603	30.4	6
8	15.00	1.62	13.00	12	⅞	.75	65.1	871	44.7	.80	68.8	915	44.7	8
10	17.50	1.87	15.25	16	1	.86	92.5	1239	64.3	.92	98.5	1311	64.3	10
12	20.50	2 00	17.75	16	1⅛	.97	124.6	1678	91.6	1.04	132.9	1778	91.6	12
14	23.00	2.12	20.25	20	1⅛	1.07	160.2	2153	115.2	1.16	172.6	2302	115.2	14
16	25.50	2.25	22.50	20	1¼	1.18	199.2	2675	142.1	1.27	215.0	2864	142.1	16
18	28.00	2.37	24.75	24	1¼	1.28	244.6	3280	172.2	1.39	264.1	3514	172.2	18
20	30.50	2.50	27.00	24	1¼	1.39	[illegible]	3945	205.9	1.51	318.3	4231	205.9	20
24	36.00	2.75	32.00	24	1½	1.75	446.2	5948	296.8	1.88	476.9	6316	296.8	24

Flanges in accordance with American Standard for 250 pounds steam pressure. For dimensions see page 149. All flanged pipe faced to the exact dimensions specified. The standard length of flanged pipe is 12 feet. All weights approximate. Flanges furnished with raised faces unless otherwise specified. For special flanges see page 151.

American Standard *Dimensions and Drilling Templates of Flanges for Cast Iron Pipe and Fittings for Maximum Working Saturated Steam Pressure of 250 Pounds per Square Inch

Table No. 53

Nominal Size Inches	Diameter of Flange Inches	Thickness of Flange Inches	Diameter of Raised Face Inches	Diameter of Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Size of Bolt Holes Inches	Length of Bolts Inches
1	4 7/8	11/16	2	3 1/2	4	5/8	3/4	2
1 1/4	5 1/4	3/4	2 1/2	3 7/8	4	5/8	3/4	2 1/4
1 1/2	6 1/8	13/16	2 7/8	4 1/2	4	3/4	7/8	2 1/2
2	6 1/2	7/8	3 5/8	5	8	5/8	3/4	3
2 1/2	7 1/2	1	4 1/8	5 7/8	8	3/4	7/8	3
3	8 1/4	1 1/8	5	6 5/8	8	3/4	7/8	3 1/4
3 1/2	9	1 3/16	5 1/2	7 1/4	8	3/4	7/8	3 1/4
4	10	1 1/4	6 3/16	7 7/8	8	3/4	7/8	3 1/2
5	11	1 3/8	7 5/16	9 1/4	8	3/4	7/8	3 3/4
6	12 1/2	1 7/16	8 1/2	10 5/8	12	3/4	7/8	3 3/4
8	15	1 5/8	10 5/8	13	12	7/8	1	4 1/4
10	17 1/2	1 7/8	12 3/4	15 1/4	16	1	1 1/8	5
12	20 1/2	2	15	17 3/4	16	1 1/8	1 1/4	5 1/4
14 O. D.	23	2 1/8	16 1/4	20 1/4	20	1 1/8	1 1/4	5 1/2
16 O. D.	25 1/2	2 1/4	18 1/2	22 1/2	20	1 1/4	1 3/8	6
18 O. D.	28	2 3/8	21	24 3/4	24	1 1/4	1 3/8	6 1/4
20 O. D.	30 1/2	2 1/2	23	27	24	1 1/4	1 3/8	6 1/2
24 O. D.	36	2 3/4	27 1/4	32	24	1 1/2	1 5/8	7 1/2
30 O. D.	43	3	37 5/16	39 1/4	28	1 3/4	2	8 3/4
36 O. D.	50	3 3/8	43 11/16	46	32	2	2 1/4	9 1/4
42 O. D.	57	3 11/16	50 11/16	52 3/4	36	2	2 1/4	9 3/4
48 O. D.	65	4	58 5/16	60 3/4	40	2	2 1/4	10 1/2

All dimensions in inches.

Drilling templates are in multiples of four, so that fittings may be made to face in any quarter, and bolt holes straddle the center line.

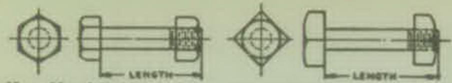
For bolt holes smaller than 1 3/4 inches the bolt holes are drilled 1/8 inch and for bolts 1 3/4 inches and larger the bolt holes are drilled 1/4 inch larger than the nominal diameter of bolts.

The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 inches and larger can be spot faced or back faced, so that standard length bolts can be used.

Flanges shall have a raised face 1/16 inch high included in the minimum flange thickness dimensions.

In sizes 14 inches and larger "Nominal Size" refers to outside diameter of fittings; for flange pipe as shown on page 148, however, this figure represents the inside diameter of the pipe.

*See note page 164.



Hex. Head Bolt and Nut Square Head Bolt and Nut

Dimensions of Standard Bolts and Nuts for American Standard Flanges

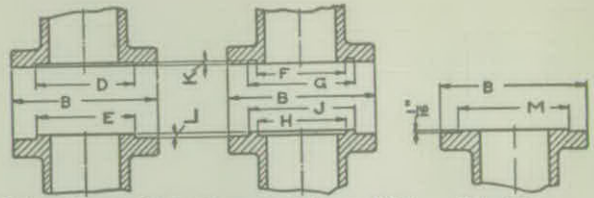
Table No. 54

Diameter of Bolt	Threads per Inch	Area at Root of Threads	Hexagon Head			Hexagon Nut			Square Head			Square Nut			Total Load at 10,000 Lbs. per Square Inch
1/4	20	0.026	3/8	29/64	3/16	1/2	37/64	1/4	3/8	17/32	3/16	1/2	45/64	1/4	260
5/16	18	0.045	15/32	35/64	15/64	19/32	11/16	5/16	15/32	21/32	15/64	19/32	27/32	5/16	450
3/8	16	0.067	9/16	41/64	9/32	11/16	51/64	3/8	9/16	51/64	9/32	11/16	63/64	3/8	670
7/16	14	0.092	21/32	3/4	21/64	25/32	29/32	7/16	21/32	59/64	21/64	25/32	1 7/64	7/16	920
1/2	13	0.125	3/4	7/8	3/8	7/8	1	1/2	3/4	1 1/16	3/8	7/8	1 15/64	1/2	1250
9/16	12	0.161	27/32	63/64	27/64	31/32	1 1/8	9/16	27/32	1 3/16	27/64	31/32	1 3/8	9/16	1610
5/8	11	0.201	15/16	1 3/32	15/32	1 1/16	1 7/32	5/8	15/16	1 21/64	15/32	1 1/16	1 1/2	5/8	2010
3/4	10	0.301	1 1/8	1 19/64	9/16	1 1/4	1 7/16	3/4	1 1/8	1 29/32	9/16	1 1/4	1 49/64	3/4	3010
7/8	9	0.419	1 5/16	1 33/64	21/32	1 7/16	1 21/32	7/8	1 5/16	1 55/64	21/32	1 7/16	2 1/32	7/8	4190
1	8	0.550	1 1/2	1 47/64	3/4	1 5/8	1 7/8	1	1 1/2	2 1/8	3/4	1 5/8	2 19/64	1	5500
1 1/8	7	0.693	1 11/16	1 61/64	27/32	1 13/16	2 3/32	1 1/8	1 11/16	2 25/64	27/32	1 13/16	2 9/16	1 1/8	6930
1 1/4	7	0.890	1 7/8	2 11/64	15/16	2	2 5/16	1 1/4	1 7/8	2 21/32	15/16	2	2 53/64	1 1/4	8900
1 3/8	6	1.056	2 1/16	2 25/64	1 1/32	2 3/16	2 17/32	1 3/8	2 1/16	2 59/64	1 1/32	2 3/16	3 3/32	1 3/8	10560
1 1/2	6	1.294	2 1/4	2 39/64	1 1/8	2 3/8	2 3/4	1 1/2	2 1/4	3 3/16	1 1/8	2 3/8	3 23/64	1 1/2	12940
1 5/8	5 1/2	1.515	2 7/16	2 13/16	1 7/32	2 9/16	2 31/32	1 5/8	2 7/16	3 29/64	1 7/32	2 9/16	3 5/8	1 5/8	15150
1 3/4	5	1.746	2 5/8	3 1/32	1 5/16	2 3/4	3 3/16	1 3/4	2 5/8	3 23/32	1 5/16	2 3/4	3 57/64	1 3/4	17460
1 7/8	5	2.051	2 13/16	3 1/4	1 13/32	2 15/16	3 13/32	1 7/8	2 13/16	3 63/64	1 13/32	2 15/16	4 5/32	1 7/8	20510
2	4 1/2	2.301	3	3 15/32	1 1/2	3 1/8	3 5/8	2	3	4 1/4	1 1/2	3 1/8	4 27/64	2	23010
2 1/8	4 1/2	2.646	3 3/16	3 11/16	1 19/32	3 5/16	3 53/64	2 1/8	3 3/16	4 1/2	1 19/32	3 5/16	4 11/16	2 1/8	26460
2 1/4	4 1/2	3.021	3 3/8	3 29/32	1 11/16	3 1/2	4 3/64	2 1/4	3 3/8	4 25/32	1 11/16	3 1/2	4 61/64	2 1/4	30210

All dimensions in inches.

General Dimensions of Various Facings of Pipe and Fitting Flanges For Extra Heavy (250 lbs.) Pressures

Table No. 55



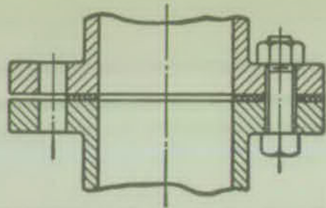
Male and Female Joint   Tongue and Groove Joint   Raised Face

Size	Diameter of Flange B	Male and Female Joint: Diameter of Recess D	Male and Female Joint: Diameter of Male E	Tongue and Grooved Joint: Inside Diameter Groove F	Tongue and Grooved Joint: Outside Diameter Groove G	Tongue and Grooved Joint: Inside Diameter Tongue H	Tongue and Grooved Joint: Outside Diameter Tongue J	Tongue and Grooved Joint: Depth of Recess K	Tongue and Grooved Joint: Height of Face L	Diameter of Raised Face M
1	4 7/8	2 3/8	2 5/16	1 3/16	2 9/16	1 1/4	2 1/2	1/8	3/16	2
1 1/4	5 1/4	2 13/16	2 3/4	2 1/16	3 1/16	2 1/8	3	1/8	3/16	2 1/2
1 1/2	6 1/8	3 3/16	3 1/8	2 11/16	3 11/16	2 3/4	3 5/8	1/8	3/16	2 7/8
2	6 1/2	3 11/16	3 5/8	3 1/16	4 3/16	3 1/8	4 1/8	1/8	3/16	3 5/8
2 1/2	7 1/2	4 3/16	4 1/8	3 9/16	4 11/16	3 5/8	4 5/8	1/8	3/16	4 1/8
3	8 1/4	5 1/16	5	4 3/16	5 5/16	4 1/4	5 1/4	1/8	3/16	5
3 1/2	9	5 9/16	5 1/2	4 11/16	5 13/16	4 3/4	5 3/4	1/8	3/16	5 1/2
4	10	6 1/16	6	5 3/16	6 5/16	5 1/4	6 1/4	1/8	3/16	6 3/16
5	11	7 5/16	7 1/4	6 3/16	7 5/16	6 1/4	7 1/4	1/8	3/16	7 5/16
6	12 1/2	8 3/16	8 1/8	7 7/16	8 9/16	7 1/2	8 1/2	1/8	3/16	8 1/2
8	15	10 11/16	10 5/8	9 9/16	10 7/16	9 5/8	10 3/8	3/16	1/4	10 5/8
10	17 1/2	12 13/16	12 3/4	11 9/16	13 3/16	11 5/8	13 1/8	3/16	1/4	12 3/4
12	20 1/2	15 5/16	15 1/4	13 9/16	15 3/16	13 5/8	15 1/8	3/16	1/4	15
14	23	16 9/16	16 1/2	15 13/16	17 7/16	15 7/8	17 3/8	3/16	1/4	16 1/4
16	25 1/2	18 9/16	18 1/2	18 5/16	20 3/16	18 3/8	20 1/8	3/16	1/4	18 1/2
18	28	21 1/16	21	20 5/16	22 7/16	20 3/8	22 3/8	3/16	1/4	21
20	30 1/2	23 1/16	23	22 1/4	24 3/8	22 5/16	24 5/16	3/16	1/4	23
24	36	27 9/16	27 1/2	26 7/16	28 9/16	26 1/2	28 1/2	3/16	1/4	27 1/4

All Dimensions are in inches.

For drilling see page 149.

Dimensions and Weights of Bolts, Nuts and Gaskets for Standard Flanged Pipe and Fittings



Section through Ring Gasket   Section through Full Gasket

Table No. 56

Standard (125 Lbs. Pressure)								Extra Heavy (250 Lbs. Pressure)							
Nominal Diameter of Pipe	Bolts and Nuts			Ring Gasket		Full Gasket		Nominal Diameter of Pipe	Bolts and Nuts			Ring Gasket		Full Gasket	
	Number	Size and Length	Wght. per 100	Inside Diameter	Outs. Diameter	Inside Diameter	Outs. Diameter		Number	Size and Length	Wght. per 100	Inside Diameter	Outs. Diameter	Inside Diameter	Outs. Diameter
2 ½	4	⅝x2 ¼	47.5	2 ½	4 ⅜	2 ½	7	2 ½	4	¾x3	82.9	2 ½	5 ⅜	2 ½	7 ½
3	4	⅝x2 ¼	47.5	3	5 ⅜	3	7 ½	3	8	¾x3 ¼	86.0	3	5 ⅞	3	8 ¼
3 ½	4	⅝x2 ½	49.6	3 ½	6 ⅜	3 ½	8 ½	3 ½	8	¾x3 ¼	86.0	3 ½	6 ½	3 ½	9
4	8	⅝x2 ¾	51.7	4	6 ⅞	4	9	4	8	¾x3 ½	89.1	4	7 ⅛	4	10
5	8	¾x2 ¾	79.8	5	7 ¾	5	10	5	8	¾x3 ¾	92.1	5	8 ½	5	11
6	8	¾x3	82.9	6	8 ¾	6	11	6	12	¾x3 ¾	92.1	6	9 ⅞	6	12 ½
8	8	¾x3 ¼	86.0	8	11	8	13 ½	8	12	⅞x4 ¼	140.0	8	12 ⅛	8	15
10	12	⅞x3 ½	128.6	10	13 ⅜	10	16	10	16	1 x5	210.0	10	14 ¼	10	17 ½
12	12	⅞x3 ½	128.6	12	16 ⅛	12	19	12	16	1 ⅛x5 ¼	285.0	12	16 ⅝	12	20 ½
14	12	1 x4	189.0	14	17 ¾	14	21	14	20	1 ⅛x5 ½	292.0	14	19 ⅛	14	23
16	16	1 x4	189.0	16	20 ¼	16	23 ½	16	20	1 ¼x6	393.0	16	21 ¼	16	25 ½
18	16	1 ⅛x4 ½	265.0	18	21 ⅝	18	25	18	24	1 ¼x6 ¼	402.0	18	23 ½	18	28
20	20	1 ⅛x4 ¾	272.0	20	23 ⅞	20	27 ½	20	24	1 ¼x6 ½	515.0	20	25 ⅝	20	30 ½
24	20	1 ¼x5 ¼	365.0	24	28 ¼	24	32	24	24	1 ⅝x7 ½	....	24	30 ⅜	24	36

Dimensions in inches. For standard flanges see pages 147 and 149.

Dimensions and Weights of American Standard *Blind Flanges

Table No. 57

Size of Pipe	Standard for 125 Lbs. Steam Working Pressure: Diameter of Flange	Thickness of Flange	Thickness of Dished Section	Approx. Weight Pounds	Extra Heavy for 250 Lbs. Steam Working Pressure: Diameter of Flange	Thickness of Flange	Thickness of Dished Section	Approx. Weight Pounds
1 1/2	5	9/16	....	3	6 1/8	13/16	....	6
2	6	5/8	....	5	6 1/2	7/8	....	8
2 1/2	7	11/16	....	7	7 1/2	1	....	12
3	7 1/2	3/4	....	9	8 1/4	1 1/8	....	16
3 1/2	8 1/2	13/16	....	12	9	1 3/16	....	20
4	9	15/16	....	16	10	1 1/4	....	26
5	10	15/16	....	20	11	1 3/8	....	34
6	11	1	....	25	12 1/2	1 7/16	....	46
8	13 1/2	1 1/8	....	42	15	1 5/8	....	75
10	16	1 3/16	....	63	17 1/2	1 7/8	15/16	120
12	19	1 1/4	15/16	88	20 1/2	2	1	155
14	21	1 3/8	7/8	115	23	2 1/8	1 1/8	210
16	23 1/2	1 7/16	1	160	25 1/2	2 1/4	1 1/4	270
18	25	1 9/16	1 1/16	190	28	2 3/8	1 3/8	350
20	27 1/2	1 11/16	1 1/8	250	30 1/2	2 1/2	1 1/2	440
24	32	1 7/8	1 1/4	370	36	2 3/4	1 5/8	670
30	38 3/4	2 1/8	1 7/16	620	....	....	....	....
36	46	2 3/8	1 5/8	990	....	....	....	....
42	53	2 5/8	1 13/16	1470	....	....	....	....
48	59 1/2	2 3/4	2	2000	....	....	....	....

All dimensions in inches. Standard flanges have plain faces. Extra heavy flanges have raised faces.

All blind flanges for sizes 12 inches (19 inches O. D.) and larger are dished, with inside radius equal to the port diameter.

*See note page 164.

Dimensions and Weights of American Standard *Cast Iron Companion Flanges for Steel or Wrought Iron Pipe

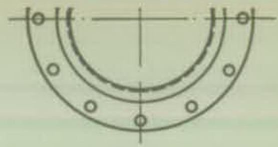
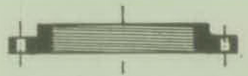


Table No. 58



Size of Pipe	Standard for 125 Lbs. Steam Working Pressure: Diameter of Flange	Thickness of Flange	Diameter of Hub	Thickness of Hub	Approx. Weight Pounds	Extra Heavy for 250 Lbs. Steam Working Pressure: Diameter of Flange	Thickness of Flange	Diameter of Hub	Thickness of Hub	Approx. Weight Pounds
1 1/2	5	9/16	2 5/16	.87	3	6 1/8	13/16	2 3/4	1 1/8	6
2	6	5/8	3 1/16	1.00	5	6 1/2	7/8	3 5/16	1 1/4	7
2 1/2	7	11/16	3 9/16	1.14	7	7 1/2	1	3 15/16	1 7/16	11
3	7 1/2	3/4	4 1/4	1.20	8	8 1/4	1 1/8	4 5/8	1 9/16	14
3 1/2	8 1/2	13/16	4 13/16	1.25	11	9	1 3/16	5 1/4	1 5/8	18
4	9	15/16	5 5/16	1.30	14	10	1 1/4	5 3/4	1 3/4	23
5	10	15/16	6 7/16	1.41	17	11	1 3/8	7	1 7/8	29
6	11	1	7 9/16	1.51	22	12 1/2	1 7/16	8 1/8	1 15/16	37
8	13 1/2	1 1/8	9 11/16	1.71	31	15	1 5/8	10 1/4	2 3/16	56
10	16	1 3/16	11 15/16	1.93	45	17 1/2	1 7/8	12 5/8	2 3/8	81
12	19	1 1/4	14 1/16	2.13	63	20 1/2	2	14 3/4	2 9/16	115
14	21	1 3/8	15 3/8	2.25	82	23	2 1/8	16 1/4	2 11/16	155
16	23 1/2	1 7/16	17 1/2	2.45	105	25 1/2	2 1/4	18 3/8	2 7/8	195
18	25	1 9/16	19 5/8	2.65	120	28	2 3/8	20 5/8	3 1/8	240
20	27 1/2	1 11/16	21 3/4	2.85	150	30 1/2	2 1/2	22 3/4	3 5/16	300
24	32	1 7/8	26	3.25	220	36	2 3/4	27 3/8	3 11/16	450

All dimensions in inches. Standard flanges have plain faces. Extra heavy flanges have raised faces.
For standard threads see page 158.
All regular sizes of steel or wrought iron pipe in sizes 14 inches and larger are designated by the outside diameter.
*See note page 164.

American Standard *Dimensions and Drilling Templates of Flanges for Cast Iron Pipe and Fittings for Maximum Working Saturated Steam Pressure of 25 Pounds per Square Inch

Table No. 59

Nominal Size Inches	Diameter of Flange Inches	Thickness of Flange Inches	Diameter of Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Size of Bolt Holes Inches	Length of Bolts Inches
14	21	1 1/4	18 3/4	12	3/4	7/8	3 1/2
16	23 1/2	1 1/4	21 1/4	16	3/4	7/8	3 1/2
18	25	1 3/8	22 3/4	16	7/8	1	4
20	27 1/2	1 3/8	25	20	7/8	1	4
24	32	1 1/2	29 1/2	20	7/8	1	4
30	38 3/4	1 3/4	36	28	1	1 1/8	5
36	46	1 7/8	42 3/4	32	1	1 1/8	5
42	53	2	49 1/2	36	1 1/8	1 1/4	5 1/2
48	59 1/2	2 1/4	56	44	1 1/8	1 1/4	6
54	66 1/4	2 3/8	62 3/4	44	1 1/8	1 1/4	6
60	73	2 1/2	69 1/4	52	1 1/4	1 3/8	6 1/2
72	86 1/2	2 7/8	82 1/2	60	1 1/4	1 3/8	7 1/2
84	99 3/4	3 1/8	95 1/2	64	1 3/8	1 1/2	8
96	113 1/4	3 3/8	108 1/2	68	1 3/8	1 1/2	8 1/2

All dimensions in inches.

Drilling templates are in multiples of four, so that fittings may be made to face in any quarter, and bolt holes straddle the center line.

Bolt holes are drilled 1/8 inch larger than the nominal diameter of bolts.

The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 inches and larger can be spot faced or back faced, so that standard length bolts can be used.

Flanges to be plain faced.

*See note page 164.

Dimensions of American Standard Pipe Threads for Steel or Wrought Iron Pipe

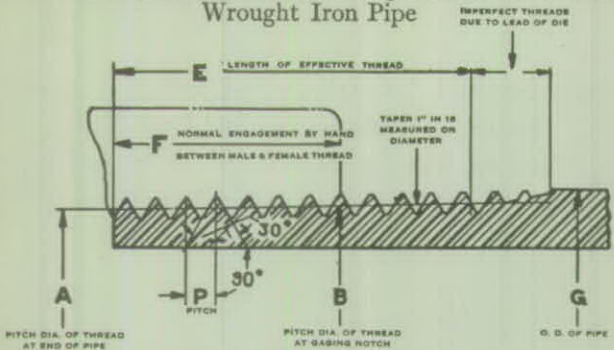
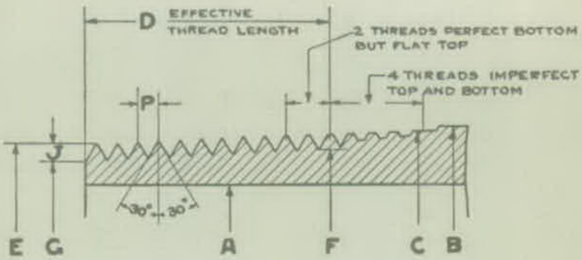


Table No. 60

Size	A	B	E	F	G	Depth of Thread	Pitch of Thread	Threads per Inch
1/8	.36351	.37476	.2638	.180	.405	.02963	.03704	27
1/4	.47739	.48989	.4018	.200	.540	.04444	.05556	18
3/8	.61201	.62701	.4078	.240	.675	.04444	.05556	18
1/2	.75843	.77843	.5337	.320	.840	.03714	.07143	14
3/4	.96768	.98886	.5457	.339	1.050	.05714	.07143	14
1	1.21363	1.23863	.6828	.400	1.315	.06956	.08696	11 1/2
1 1/4	1.55713	1.58338	.7068	.420	1.660	.06956	.08696	11 1/2
1 1/2	1.79609	1.82234	.7235	.420	1.900	.06956	.08696	11 1/2
2	2.26902	2.29627	.7565	.436	2.375	.06956	.08696	11 1/2
2 1/2	2.71953	2.76216	1.1375	.682	2.875	.100	.12500	8
3	3.34063	3.38850	1.2000	.766	3.500	.100	.12500	8
3 1/2	3.83750	3.88881	1.2500	.821	4.000	.100	.12500	8
4	4.33438	4.38713	1.3000	.844	4.500	.100	.12500	8
4 1/2	4.83125	4.88594	1.3500	.875	5.000	.100	.12500	8
5	5.39073	5.44929	1.4063	.937	5.563	.100	.12500	8
6	6.44609	6.50597	1.5125	.958	6.625	.100	.12500	8
7	7.43984	7.50234	1.6125	1.000	7.625	.100	.12500	8
8	8.43359	8.50003	1.7125	1.063	8.625	.100	.12500	8
9	9.42734	9.49797	1.8125	1.130	9.625	.100	.12500	8
10	10.54531	10.62094	1.9250	1.210	10.750	.100	.12500	8
11	11.53906	11.61938	2.0250	1.285	11.750	.100	.12500	8
12	12.53281	12.61781	2.1250	1.360	12.750	.100	.12500	8
14 O.D.	13.77500	13.87262	2.2500	1.562	14.000	.100	.12500	8
15 O.D.	14.76875	14.87419	2.3500	1.687	15.000	.100	.12500	8
16 O.D.	15.76250	15.87575	2.4500	1.812	16.000	.100	.12500	8
17 O.D.	16.75625	16.87500	2.5500	1.900	17.000	.100	.12500	8
18 O.D.	17.75000	17.87500	2.6500	2.000	18.000	.100	.12500	8
20 O.D.	19.73750	19.87031	2.8500	2.125	20.000	.100	.12500	8
22 O.D.	21.72500	21.86562	3.0500	2.250	22.000	.100	.12500	8
24 O.D.	23.71250	23.86094	3.2500	2.375	24.000	.100	.12500	8

Dimensions in inches.
For standard dimensions of pipe, see page 158.

Dimensions for Cast Iron Pipe Threads



A = Nominal I. D.
B = O. D. of Pipe
C = B − .10
D = P (.80 C − 6.8)
E = (C + .8P) − P (.05 C + 1.1)

F = C − 2 J + .125 P
G = E − 2 J
H = No. Threads Per Inch
J = .8 P
P = Pitch

Total Taper ¾" Per Foot

Table No. 60 (continued)

Size	A	B	C	D	E	F	G	H	J
*1¼	1.375	2.000	1.900	.7235	1.865	1.772	1.726	11½	.0696
*1½	1.600	2.475	2.375	.7565	2.338	2.247	2.199	11½	.0696
*2	2.100	2.975	2.875	1.1375	2.819	2.690	2.619	8	.1000
*2½	2.600	3.600	3.500	1.2000	3.440	3.315	3.241	8	.1000
3	3.120	3.960	3.860	1.2360	3.798	3.676	3.598	8	.1000
4	4.100	5.000	4.900	1.3400	4.831	4.716	4.632	8	.1000
6	6.140	7.100	7.000	1.5500	6.918	6.816	6.719	8	.1000
8	8.030	9.050	8.950	1.7450	8.856	8.766	8.657	8	.1000
10	9.960	11.100	11.000	1.9500	10.894	10.816	10.694	8	.1000
12	12.000	13.200	13.100	2.1600	12.981	12.916	12.781	8	.1000
14	14.000	15.300	15.200	2.3700	15.067	15.016	14.867	8	.1000
16	16.000	17.400	17.300	2.5800	17.154	17.116	16.954	8	.1000

*Same as one size larger American Std. Tapered Pipe Thread.
All dimensions in inches.

Dimensions of Standard, Extra Strong and Double Extra Strong Wrought Iron Pipe

Table No. 61

Size Pipe	External Dia.	Standard			Extra Strong			Double Extra Strong		
		Thickness	Internal Dia.	Weight Pr. Ft.	Thickness	Internal Dia.	Weight Pr. Ft.	Thickness	Internal Dia.	Weight Pr. Ft.
1/8	.405	.068	.269	.244	.095	.215	.314	......	......	......
1/4	.540	.088	.364	.424	.119	.302	.535	......	......	......
3/8	.675	.091	.493	.567	.126	.423	.738	......	......	......
1/2	.840	.109	.622	.850	.147	.546	1.087	.294	.252	1.714
3/4	1.050	.113	.824	1.130	.154	.742	1.473	.308	.434	2.440
1	1.315	.133	1.049	1.678	.179	.957	2.171	.358	.599	3.659
1 1/4	1.660	.140	1.380	2.272	.191	1.278	2.996	.382	.896	5.214
1 1/2	1.900	.145	1.610	2.717	.200	1.500	3.631	.400	1.100	6.408
2	2.375	.154	2.067	3.652	.218	1.939	5.022	.436	1.503	9.029
2 1/2	2.875	.203	2.469	5.793	.276	2.323	7.661	.552	1.771	13.695
3	3.500	.216	3.068	7.575	.300	2.900	10.252	.600	2.300	18.583
3 1/2	4.000	.226	3.548	9.109	.318	3.364	12.505	.636	2.728	22.850
4	4.500	.237	4.026	10.790	.337	3.826	14.983	.674	3.152	27.541
4 1/2	5.000	.247	4.506	12.538	.355	4.290	17.611	.710	3.580	32.530
5	5.363	.258	5.047	14.617	.375	4.813	20.778	.750	4.063	38.552
6	6.625	.280	6.065	18.974	.432	5.761	28.573	.864	4.897	53.160
7	7.625	.301	7.023	23.544	.500	6.625	38.048	.875	5.875	63.079
8	8.625	.277	8.071	24.696	.500	7.625	43.388	.875	6.875	72.424
8	8.625	.322	7.981	28.554	......	......	......	......	......	......
9	9.625	.342	8.941	33.907	.500	8.625	48.728	......	......	......
10	10.750	.279	10.192	31.201	.500	9.750	54.735	......	......	......
10	10.750	.307	10.136	34.240	......	......	......	......	......	......
10	10.750	.365	10.020	40.483	......	......	......	......	......	......
11	11.750	.375	11.000	45.557	.500	10.750	60.075	......	......	......
12	12.750	.330	12.090	43.773	.500	11.750	65.415	......	......	......
12	12.750	.375	12.000	49.562	......	......	......	......	......	......

Dimensions in inches.

For standard flanges see page 154.
For standard threads see page 156.

SECTION 9

STANDARD FLANGED FITTINGS

STANDARDIZATION OF FLANGES AND FLANGED FITTINGS

RECOGNIZING the importance of the adoption of a standard for cast iron flanges which would cover, in so far as possible, all types of flanges including those on cast iron pipe, flange connections on steam engines, steam pumps, cast iron valves for steam, water, etc., The American Society of Mechanical Engineers appointed a committee in 1892, for the purpose of investigating the subject and reporting thereon to the Society. The A. S. M. E. Council hoped that it might be possible to devise some standard which would be sufficiently broad to induce the various manufacturers to adopt it in place of the dimensions which were then in use by them individually.

The same year the National Association of Master Steam and Hot Water Fitters appointed a committee for a like purpose which recognized the importance of the subject and held numerous meetings, individually and jointly, with the American Society of Mechanical Engineers' Committee.

At the annual convention of the National Association of Master Steam and Hot Water Fitters held in New York, June, 1894, their committee on Flange Standardization recommended the holding of a joint conference with The American Society of Mechanical Engineers' Committee. This recommendation was favorably received and a joint conference was held on July 18, 1894, in the rooms of The American Society of Mechanical Engineers. It was attended by the members of both committees and also by many representatives of the leading manufacturers.

After discussion of the various dimensions of flanges, the conference reached a unanimous agreement that all manufacturers, engineers, and users should adopt standard dimensions for flange diameters designed for pipe sizes from 2 to 12 inches inclusive and pressures up to 200 lbs. per sq. in. It was further agreed that all manufacturers would send to their customers information compiled by the committees covering diameters of flanges, bolt circles, etc., so that full knowledge could be extended.

In 1901, the "Manufacturers' Standard" for pressures up to 250 pounds was developed. Later, about 1910, a group of manufacturers formed an organization known as The Committee of Manufacturers on Standardization of Fittings and Valves (Manufacturers' Standardization of the Valve and Fittings Industry), and began the work of designing a completely standardized line of flanged fittings, including flange dimensions, center to face and face to face dimensions and shell thicknesses. This work was completed and published in 1912.

During the years 1912 to 1914 a Joint Conference Committee composed of representatives of the Committee of Manufacturers on the Standardization of Fittings and Valves and The American Society of Mechanical Engineers, formulated a group of compromise standard dimensions of pipe flanges and flanged fittings for use under working steam pressures of 125 and 250 lb. per sq. in. These standards were based on the 1912 U. S. Standard and the Manufacturers' Standard adopted the same year. The Joint Committee's report was completed in January, 1914, and revised in March, 1914. This revision was accepted at conference in Washington which was attended by representatives of the United States Government, The Master Steam and Hot Water Fitters, the Manufacturers' Committee and The American Society of Mechanical Engineers. The A. S. M. E. adopted the report of its committee in December, 1914.

In 1918 the A. S. M. E. Committee on Standardization of Flanges and Pipe Fittings completed in cooperation with the Committee of the Manufacturers a new standard to be known as the "American Low-Pressure Standard" for 50 lbs. per sq. in. working pressure.

In the Spring of 1921 when the unification and extension of the flanged and screwed fittings standards in use in this country seemed desirable, the American Engineering Standards Committee authorized the organization of a Sectional Committee on the Standardization of Pipe Flanges and Fittings under the joint sponsorship of the Heating and Piping Contractors' National Association, which prior to 1918 was known as the National Association of Master Steam and Hot Water Fitters, the Manufacturers' Standardization Society of the Valve and Fittings Industry, and The American Society of Mechanical Engineers. This Sectional Committee numbered sixty-two representatives appointed by twenty-nine national organizations.

After several years of work, the Sectional Committee has completed the revision of the standards known as "Cast Iron Pipe Flanges and Flanged Fittings for working steam pressures of 125 and 250 lbs. per sq. in." These supersede the so called "1914 American Standards." The Committee has also formulated a standard for 25 lbs. per sq. in. working pressure which will supersede the 50 lbs. standard approved and published by the A. S. M. E. in December, 1918.

All three of these standards contain tables of templates for drilling flange thicknesses, center to face and face to face dimensions of fittings and body thicknesses for all types of fittings that are commonly used and stocked by manufacturers.

By making the flange diameters, bolt circle diameters, number of bolts, center to face, and face to face dimensions of Cast Iron Fittings for 25 and 125 lbs. per sq. in. working pressures, the same, it is possible to interchange fittings in pipe lines designed for these pressures. It should be noted however that the thickness of flange, and thickness of body dimensions differ due to the difference in working pressures.

In working up an "American Standard" for Steel Pipe Flanges and Fittings for 250 lbs. per sq. in., the Sectional Committee on Pipe Flanges and Fittings thought it advisable to make the essential dimensions the same as for Cast Iron Fittings of the same working pressure. This was accomplished and we now have interchangeability between fittings manufactured to these two standards.

Cast Iron Flange Pipe is regularly equipped with flanges which conform to these Standards. Pipe of Classes A, B, C and D being provided with flanges in accordance with the American Standard for 125 lbs. per sq. in. steam working pressure and Classes E, F, G and H being provided with flanges in accordance with the 250 lbs. standard.

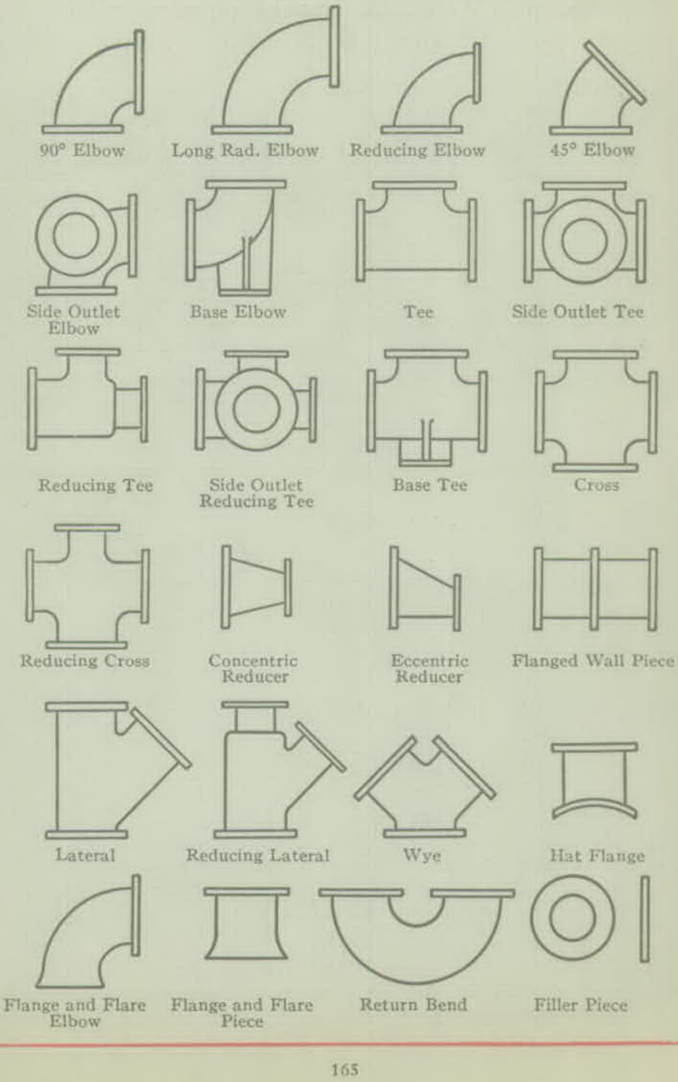
In the pages that immediately follow will be found the dimensions of flanged fittings made in accordance with the standard for 125 and 250 lbs. per sq. in. steam working pressure. In designing these fittings no allowance was made for water hammer.

For use in the design of water plants fittings which conform to the A. W. W. A. Specifications as to radii, laying dimensions and thickness can be furnished. On pages 186 to 192 will be found tables of these fittings equipped with the standard Flanges mentioned above.

Unless otherwise specified the term "size" in the following tables refer to the nominal inside diameter of the fittings.

NOTE: The Tables of American Standard Cast Iron Pipe Flanges and Flanged Fittings herewith are based on the tentative specifications and have not been approved by the sponsor organizations. They are, therefore, subject to revision.

Names of Flanged Fittings



Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 125 Pounds per Square Inch

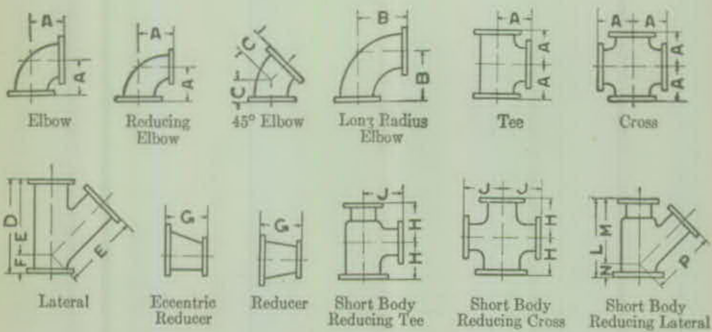
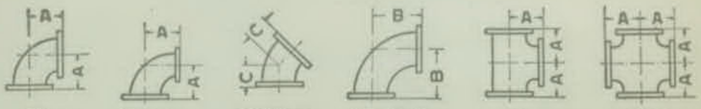


Table No. 62

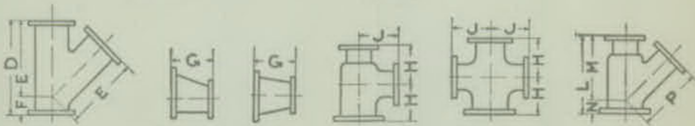
Size	A	B	C	D	E	F	G	Short Body Red. Tees and Crosses: Size of Outlets	H	J	Short Body Red. Laterals: Size of Br'ch's	L	M	N	P
1	3½	5	1¾	7½	5¾	1¾	....	......	..	....	......	..	....	...	....
1¼	3¾	5½	2	8	6¼	1¾	....	......	..	....	......	..	....	...	....
1½	4	6	2¼	9	7	2	....	......	..	....	......	..	....	...	....
2	4½	6½	2½	10½	8	2½	....	......	..	....	......	..	....	...	....
2½	5	7	3	12	9½	2½	....	......	..	....	......	..	....	...	....
3	5½	7¾	3	13	10	3	6	......	..	....	......	..	....	...	....
3½	6	8½	3½	14½	11½	3	6½	......	..	....	......	..	....	...	....
4	6½	9	4	15	12	3	7	......	..	....	......	..	....	...	....
5	7½	10¼	4½	17	13½	3½	8	......	..	....	......	..	....	...	....
6	8	11½	5	18	14½	3½	9	......	..	....	......	..	....	...	....
8	9	14	5½	22	17½	4½	11	......	..	....	......	..	....	...	....
10	11	16½	6½	25½	20½	5	12	......	..	....	......	..	....	...	....
12	12	19	7½	30	24½	5½	14	......	..	....	......	..	....	...	....
14	14	21½	7½	33	27	6	16	......	..	....	......	..	....	...	....
16	15	24	8	36½	30	6½	18	......	..	....	......	..	....	...	....
18	16½	26½	8½	39	32	7	19	12 and smaller	13	15½	8 and smaller	26	25	1	27½
20	18	29	9½	43	35	8	20	14 "	14	17	10 "	28	27	1	29½
24	22	34	11	49½	40½	9	24	16 "	15	19	12 "	32	31½	½	34½
30	25	41½	15	59	49	10	30	20 "	18	23	14 "	39	39	0	42
36	28	49	18	....	....	....	36	24 "	20	26	......	..	....	...	....
42	31	56½	21	....	....	....	42	24 "	23	30	......	..	....	...	....
48	34	64	24	....	....	....	48	32 "	26	34	......	..	....	...	....

See notes on pages 164, 171 and 172.

Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 250 Pounds per Square Inch



Elbow — Reducing Elbow — 45° Elbow — Long Radius Elbow — Tee — Cross



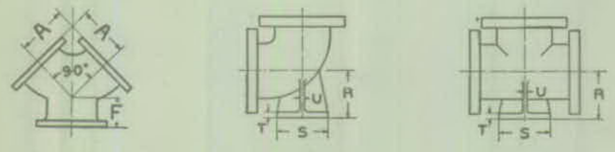
Lateral — Eccentric Reducer — Reducer — Short Body Reducing Tee — Short Body Reducing Cross — Short Body Reducing Lateral

Table No. 62 (continued)

Size	A	B	C	D	E	F	G	Short Body Reducing Tees and Crosses			Short Body Red. Laterals				
								Size of Outlets	H	J	Size of Br'ch's	L	M	N	P
1	4	5	2	8½	6½	2	....	......	....	....	......	..	..	..	....
1¼	4¼	5½	2½	9½	7¼	2¼	....	......	....	....	......	..	..	..	....
1½	4½	6	2¾	11	8½	2½	....	......	....	....	......	..	..	..	....
2	5	6½	3	11½	9	2½	....	......	....	....	......	..	..	..	....
2½	5½	7	3½	13	10½	2½	....	......	....	....	......	..	..	..	....
3	6	7¾	3½	14	11	3	6	......	....	....	......	..	..	..	....
3½	6½	8½	4	15½	12½	3	6½	......	....	....	......	..	..	..	....
4	7	9	4½	16½	13½	3	7	......	....	....	......	..	..	..	....
5	8	10¼	5	18½	15	3½	8	......	....	....	......	..	..	..	....
6	8½	11½	5½	21½	17½	4	9	......	....	....	......	..	..	..	....
8	10	14	6	25½	20½	5	11	......	....	....	......	..	..	..	....
10	11½	16½	7	29½	24	5½	12	......	....	....	......	..	..	..	....
12	13	19	8	33½	27½	6	14	......	....	....	......	..	..	..	....
14O.D.	15	21½	8½	37½	31	6½	16	......	....	....	......	..	..	..	....
16 "	16½	24	9½	42	34½	7½	18	......	....	....	......	..	..	..	....
18 "	18	26½	10	45½	37½	8	19	12 and smaller	14	17	8 and smaller	34	31	3	32½
20 "	19½	29	10½	49	40½	8½	20	14 "	15¼	18½	10 "	37	34	3	36
24 "	22½	34	12	57½	47½	10	24	16 "	17	21½	12 "	44	41	3	43
30 "	27½	41½	15	....	....	....	30	20 "	20½	25½	......	..	..	..	....

See notes on pages 164, 171 and 172.
All dimensions in inches.

Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 125 and 250 Pounds per Square Inch



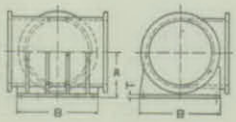
True Wye Base Elbow Base Tee

Table No. 62 (continued)

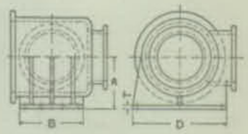
Size	Standard 125 Lbs. Steam Working Pressure						Extra Heavy 250 Lbs. Steam Working Pressure					
	A	F	S	T	U	R	A	F	S	T	U	R
1	3½	1¾	3½	7/16	3/8	3½	4	2	4	5/8	½	3¾
1¼	3¾	1¾	3½	7/16	3/8	3⅝	4¼	2¼	4	5/8	½	4
1½	4	2	4¼	7/16	½	3¾	4½	2½	4⅞	11/16	½	4⅜
2	4½	2½	4⅝	½	½	4⅛	5	2½	5¼	¾	½	4½
2½	5	2½	4⅝	½	½	4½	5½	2½	5¼	¾	½	4¾
3	5½	3	5	9/16	½	4⅞	6	3	6⅛	13/16	⅝	5¼
3½	6	3	5	9/16	½	5¼	6½	3	6⅛	13/16	⅝	5⅜
4	6½	3	6	5/8	½	5½	7	3	6½	⅞	⅝	6
5	7½	3½	7	11/16	⅝	6¼	8	3½	7½	1	¾	6½
6	8	3½	7	11/16	⅝	7	8½	4	7½	1	¾	7½
8	9	4½	9	15/16	⅞	8⅛	10	5	10	1¼	⅞	9
10	11	5	9	15/16	⅞	9¾	11½	5½	10	1¼	⅞	10½
12	12	5½	11	1	1	11¼	13	6	12½	1 7/16	1	12
14	14	6	11	1	1	12½	15	6½	12½	1 7/16	1	13½
16	15	6½	11	1	1	13¾	16½	7½	12½	1 7/16	1⅛	14¾
18	16½	7	13½	1⅛	1⅛	15	18	8	15	1⅝	1⅛	16¼
20	18	8	13½	1⅛	1⅛	16	19½	8½	15	1⅝	1¼	17⅞
24	22	9	13½	1⅛	1⅛	18½	22½	10	17½	1⅞	1¼	20¾
30	25	10										

See notes on pages 164, 171 and 172.
All dimensions in inches.

Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 125 and 250 Pounds per Square Inch



Anchorage Tees



Reducing Anchorage Tees

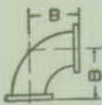
Table No. 62 (continued)

Size	Size Outlet and Smaller	Standard 125 Lbs. Steam Working Pressure				Extra Heavy 250 Lbs. Steam Working Pressure			
		A	B	D	T	A	B	D	T
2½	2½	4½	7		11/16	4¼	7½		¾
3	3	4⅜	7½		¾	5¼	8¼		13/16
3½	3½	5¼	8½		13/16	5⅝	9		15/16
4	5½	5½	9		15/16	6	10		15/16
5	5	6¼	10		15/16	6¼	11		1
6	6	7	11		1	7½	12½		1 1/16
8	8	8⅜	13½		1⅛	9	15		1⅛
10	10	9¾	16		1 5/16	10½	17½		1¼
12	12	11¼	19		1¼	12	20½		1¼
14	14	12½	21		1⅜	13½	23		1⅜
16	16	13¾	23½		1 7/16	14¼	25½		1 9/16
18	18 to 14	15	25		1 9/16	16¼	28		1 11/16
18	12	15½	19	25	1 9/16	16¼	20½	28	1 11/16
20	20 to 16	16	27½		1 11/16	17⅜	30½		1⅞
20	14	16	21	27½	1 11/16	17⅜	23	30½	1⅞
24	24 to 18	18½	32		1⅞	20¾	36		2 1/16
24	16	18½	23½	32	1⅞	20¾	25½	36	2 1/16
30	30 to 24	22	38¾		2⅛	24¾	43		2 5/16
30	20	22	27½	38¾	2⅛	24¾	30½	43	2 5/16
36	36 to 30	25½	46		2⅜				
36	24	25½	32	46	2⅜				
42	42 to 30	29¼	53		2⅝				
42	24	29¼	36½	53	2⅝				
48	48 to 42	32¾	59½		2¾				
48	30	32¾	41¾	59½	2¾				

See notes on pages 164, 171 and 172.
All dimensions in inches.
On extra heavy anchorage tees the "Size" refers to the outside diameter of the fitting.

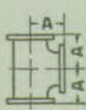
Laying Dimensions of American Standard Flanged Fittings for 25 Pounds Steam Working Pressure

90 Deg. Elbow

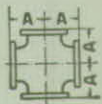


90 Deg. Long Radius Elbow

45 Deg. Elbow



Straight Tee



Straight Cross

Table No. 63

Size	Center to Face Elbow Tee and Cross (A)	Center to Face Long Radius Elbow (B)	Center to Face 45 Deg. Elbow (C)	Diameter of Flange	Minimum Thickness of Flange	Minimum Metal Thickness of Body
14	14	21 ½	7 ½	21	1 ¼	⅝
16	15	24	8	23 ½	1 ¼	11/16
18	16 ½	26 ½	8 ½	25	1 ⅜	¾
20	18	29	9 ½	27 ½	1 ⅜	13/16
24	22	34	11	32	1 ½	⅞
30	25	41 ½	15	38 ¾	1 ¾	1 1/16
36	28	49	18	46	1 ⅞	1 3/16
42	31	56 ½	21	53	2	1 ¼
48	34	64	24	59 ½	2 ¼	1 7/16
54	39	71 ½	27	66 ¼	2 ⅜	1 9/16
60	44	79	30	73	2 ½	1 11/16
72	53	94	36	86 ½	2 ⅞	1 15/16

See notes on pages 164, 171 and 172.

No dimensions are given in this Standard for sizes below 14". For sizes 12" and smaller the regular American 125 Lb. Standard cast iron flanged fittings are used; for sizes 14" and larger, the flanged diameters, bolt circles and number of bolts are the same as the American 125 Lb. Standard with a reduction in the thickness of flanges and bolt diameters as shown in Table 57, thereby maintaining interchangeability between the two Standards.

The center to face dimensions for fittings for sizes from 14" to 48", inclusive, are the same as the American 125 Lb. Standard cast iron flanged fittings.

American Standard Flanged Fittings for 25, 125 and 250 Pounds Steam Working Pressure

Marking. All fittings must have marks cast on them, indicating the manufacturer and figures indicating the maximum working steam pressure for which the fittings are intended.

Elbows. There are two types of elbow, known as "Elbows" and "Long Radius Elbows"; unless long radius elbows are specifically ordered the former will be furnished.

Reducing Fittings. Reducing elbows and side outlet elbows carry same dimensions center to face as straight sized elbows corresponding with the size of the larger opening.

Tees, side outlet tees, crosses and laterals, sizes 16 inches and smaller, reducing on the outlet or branch have the same dimensions center to face and face to face as straight sized fittings corresponding to the size of the larger opening. Sizes 18 inches and larger, reducing on the outlet or branch, are made in two lengths depending on the size of the outlet as given in the tables of dimensions.

Tees, crosses and laterals, reducing on the run only, have the same dimensions center to face and face to face as straight sized fittings corresponding to the size of the larger opening.

Reducers and eccentric reducers for all reductions have the same face to face dimensions as given in the table for the larger opening.

Side outlet elbows and side outlet tees have all openings on intersecting center lines.

Laterals. Laterals, both straight and reducing, in sizes 8 inches and larger shall be reinforced for the inherent weakness in the casting design.

See notes page 164.

AMERICAN 25 POUNDS STANDARD

Size. The term "size" is used to indicate the nominal inside diameter of port.

Dimensions. No dimensions are given in this Standard for sizes below 14 inches. For sizes 12 inches and smaller the regular American 125 Pound Standard Cast Iron Flanged Fittings are used; for sizes 14 inches and larger the flanged diameters, bolt circles and number of bolts are the same as the American 125 Pound Standard with a reduction in the thickness of flanges and bolt diameters as shown in Table 57, thereby maintaining interchangeability between the two Standards.

The center to face dimensions for fittings for sizes 14 inches to 48 inches inclusive are the same as the American 125 Pound Standard Cast Iron Flanged Fittings.

For standard flanges see page 155.

For standard dimensions of fittings see page 170.

For theoretical weights of fittings see page 185.

AMERICAN 125 POUND STANDARD

Size. The term "size" is used to indicate the nominal inside diameter of port.

For standard flanges see page 147.

For standard dimensions of fittings see pages 166 to 169.

For theoretical weights of fittings see pages 173 to 178.

AMERICAN 250 POUNDS STANDARD

Size. In sizes 14 inches and larger "Nominal size" refers to the outside diameter of fittings.

For standard flanges see page 149.

For standard dimensions of fittings see pages 167 to 169.

For theoretical weights of fittings see pages 179 to 184.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

Table No. 64

Sizes	90 Degree Elbow	45 Degree Elbow	90 Deg. Long Radius Elbow	Side Outlet Elbow	Tees	Cross and Side Outlet Tees	Laterals
1	5	4	7	8	9	11	10
1 ¼	7	6	9	10	11	15	13
1 ½	9	8	11	13	15	19	17
2	14	12	16	20	21	28	25
2 ½	19	17	23	28	30	39	36
3	24	20	28	34	37	48	44
3 ½	31	27	37	46	49	63	59
4	41	36	48	59	64	82	75
5	52	45	62	74	81	105	96
6	68	60	85	96	105	135	125
8	110	94	145	150	165	210	210
10	175	145	230	240	270	330	340
12	250	220	350	340	380	470	520
14	350	270	470	470	530	650	680
16	470	360	670	620	700	850	950
18	580	420	840	760	860	1040	1150
20	740	540	1080	970	1100	1330	1480
24	1160	800	1640	1510	1730	2080	2080
30	1850	1430	2800	2350	2710	3210	3680
36	2800	2280	4450	3500	4050	4750	
42	4010	3380	6610	4930	5790	6710	
48	5400	4680	9250	6520	7620	8740	

For dimensions, see page 166.

All weights listed are for fittings faced and drilled, based upon minimum thicknesses and dimensions given in preceding table without allowances for variation. Cast iron is considered to weigh 0.26 pound per cubic inch.

Weights of laterals do not include reinforcing ribs.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

Table No. 65

Sizes	Reducing Elbows	Reducers and Eccentric Reducers	Sizes	Reducing Elbows	Reducers and Eccentric Reducers
3 x 1½	17		14x 8	240	200
3 x 2	19	16	14x10	280	220
3 x 2½	22	19	14x12	320	250
3½x 2	24	20	16x 8	300	250
3½x 3	28	24	16x10	340	280
4 x 2	29	24	16x12	380	310
4 x 2½	31	26	16x14	420	340
4 x 3	33	28	18x10	390	320
4 x 3½	37	31	18x12	440	350
5 x 2½	37	31	18x14	480	380
5 x 3	40	32	18x16	540	430
5 x 4	48	39	20x12	520	410
6 x 3	47	39	20x14	570	450
6 x 3½	51	43	20x16	640	490
6 x 4	56	47	20x18	680	520
6 x 5	60	50	24x12	740	580
8 x 4	77	66	24x16	880	670
8 x 5	82	71	24x18	930	700
8 x 6	90	77	24x20	1010	760
10 x 5	115	95	24x22	1080	800
10 x 6	125	100			
10 x 8	150	120			
12 x 6	165	140			
12 x 8	190	155			
12 x10	220	180			

For dimensions, see page 166.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

Table No. 66

Sizes	Lateral Reducing Outlet (Not Ribbed)	Sizes	Lateral Reducing Outlet (Not Ribbed)
3 x 3 x1½	36	12x12x 8	430
3 x 3 x2	39	12x12x10	470
3 x 3 x2½	42	14x14x 8	550
3½x 3½x2	49	14x14x10	590
3½x 3½x2½	52	14x14x12	640
3½x 3½x3	55	16x16x 8	740
4 x 4 x2	60	16x16x10	790
4 x 4 x2½	63	16x16x12	830
4 x 4 x3	66	16x16x14	880
4 x 4 x3½	70	18x18x10	*930
5 x 5 x2½	79	18x18x12	*980
5 x 5 x3	82	18x18x14	1030
5 x 5 x3½	86	18x18x16	1100
5 x 5 x4	93	20x20x10	*840
6 x 6 x3	105	20x20x12	*1220
6 x 6 x3½	105	20x20x14	*1270
6 x 6 x4	115	20x20x16	1350
6 x 6 x5	120	20x20x18	1400
8 x 8 x4	175	24x24x12	*1250
8 x 8 x5	180	24x24x14	*1810
8 x 8 x6	195	24x24x16	*1890
10 x10 x5	270	24x24x18	1950
10 x10 x6	280	24x24x20	2040
10 x10 x8	310	24x24x22	2120
12 x12 x6	400		

For dimensions, see page 166.

Weights of laterals do not include reinforcing ribs.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

*These sizes made in the short body pattern only.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

Table No. 67

Reducing Tees

Sizes	Weight	Sizes	Weight	Sizes	Weight
3 x3 x2½	36	4x3 x2	46	6x6x3	89
3 x3 x2	33	4x2½x4	56	6x5x6	100
3 x3 x1½	31	4x2½x3	49	6x5x5	95
3 x2½x3	35	4x2½x2½	47	6x5x4	92
3 x2½x2½	34	4x2½x2	45	6x5x3	84
3 x2½x2	31	4x2 x4	54	6x4x6	98
3 x2½x1½	29	4x2 x3	47	6x4x5	93
3 x2 x3	33	4x2 x2½	45	6x4x4	89
3 x2 x2½	32	4x2 x2	43	6x4x3	82
3 x2 x2	29	5x5 x4	78	6x3x6	92
3 x2 x1½	27	5x6 x3½	74	6x3x5	86
3 x1½x3	32	5x5 x3	70	6x3x4	83
3 x1½x2½	30	5x5 x2½	68	6x3x3	76
3 x1½x2	27	5x4 x5	78	8x8x6	150
3 x1½x1½	25	5x4 x4	75	8x8x5	145
3½x3½x3	46	5x4 x3	68	8x8x4	145
3½x3½x2½	44	5x4 x2½	66	8x6x8	155
3½x3½x2	42	5x3 x5	72	8x6x6	140
4 x4 x3½	60	5x3 x4	68	8x6x5	135
4 x4 x3	57	5x3 x3	61	8x6x4	130
4 x4 x2½	55	5x3 x2½	59	8x5x8	150
4 x4 x2	53	5x2½x5	70	8x5x6	135
4 x3 x4	57	5x2½x4	67	8x5x5	130
4 x3 x3	50	5x2½x3	60	8x5x4	125
4 x3 x2½	49	5x2½x2½	58	8x4x8	150
		6x6 x5	99		
		6x6 x4	96		
		6x6 x3½	92		

For dimensions, see page 166.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

Table No. 67 (continued)

Reducing Tees

Sizes	Weight	Sizes	Weight	Sizes	Weight
8x 4x 6	135	14x14x10	480	16x12x12	620
8x 4x 5	130	14x14x 8	460	16x12x10	590
8x 4x 4	125	14x12x14	510	16x12x 8	570
10x10x 8	250	14x12x12	490	16x10x16	650
10x10x 6	240	14x12x10	460	16x10x14	620
10x10x 5	230	14x12x 8	440	16x10x12	600
10x 8x10	260	14x10x14	490	16x10x10	570
10x 8x 8	240	14x10x12	470	16x10x 8	550
10x 8x 6	220	14x10x10	450	16x 8x16	640
10x 6x10	250	14x10x 8	420	16x 8x14	610
10x 6x 8	230	14x 8x14	480	16x 8x12	580
10x 6x 6	210	14x 8x12	460	16x 8x10	560
12x12x10	360	14x 8x10	430	16x 8x 8	540
12x12x 8	340	14x 8x 8	410	18x18x16	860
12x12x 6	320	16x16x14	670	18x18x14	820
12x10x12	370	16x16x12	650	18x18x12	*660
12x10x10	340	16x16x10	620	18x18x10	*640
12x10x 8	320	16x16x 8	610	20x20x18	1060
12x10x 6	310	16x14x16	680	20x20x16	1040
12x 8x12	350	16x14x14	650	20x20x14	*840
12x 8x10	330	16x14x12	630	20x20x12	*820
12x 8x 8	310	16x14x10	600	20x20x10	*790
12x 8x 6	300	16x14x 8	580	24x24x20	1640
12x 6x12	340	16x12x16	670	24x24x18	1600
12x 6x10	320	16x12x14	640	24x24x16	*1170
12x 6x 8	300			24x24x14	*1140
12x 6x 6	280			24x24x12	*1110
14x14x12	500				

For dimensions, see page 166.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

*These sizes made in short body pattern only.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

Table No. 68

Reducing Crosses

Sizes	Weight	Sizes	Weight
3 x 3 x1½x1½	36	12x12x 8x 8	380
3 x 3 x2 x2	40	12x12x10x10	420
3 x 3 x2½x2½	44	14x14x 8x 8	500
3½x 3½x2 x2	47	14x14x10x10	550
3½x 3½x2½x2½	53	14x14x12x12	600
3½x 3½x3 x3	57	16x16x 8x 8	650
4 x 4 x2 x2	59	16x16x10x10	690
4 x 4 x2½x2½	64	16x16x12x12	740
4 x 4 x3 x3	68	16x16x14x14	790
4 x 4 x3½x3½	74	*18x18x10x10	700
5 x 5 x2½x2½	78	*18x18x12x12	750
5 x 5 x3 x3	82	18x18x14x14	930
5 x 5 x3½x3½	89	18x18x16x16	1000
5 x 5 x4 x4	96	*20x20x10x10	860
6 x 6 x3 x3	100	*20x20x12x12	910
6 x 6 x3½x3½	105	*20x20x14x14	960
6 x 6 x4 x4	115	20x20x16x16	1200
6 x 6 x5 x5	120	20x20x18x18	1250
8 x 8 x4 x4	165	*24x24x12x12	1210
8 x 8 x5 x5	175	*24x24x14x14	1250
8 x 8 x6 x6	190	*24x24x16x16	1310
10 x10 x5 x5	250	24x24x18x18	1810
10 x10 x6 x6	270	24x24x20x20	1900
10 x10 x8 x8	300	24x24x22x22	1980
12 x12 x6 x6	350		

For dimensions, see page 166.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

*These sizes made in short body pattern only.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

Table No. 69

Nominal Pipe Sizes	90 Degree Elbow	45 Degree Elbow	90 Deg. Long Radius Elbow	Side Outlet Elbow	Regular and Single and Double Sweep Tees	Cross and Side Outlet Tees	Laterals (Not Ribbed)
1	9	7	10	13	14	18	15
1 ¼	11	10	13	17	18	23	20
1 ½	16	15	18	24	25	32	30
2	20	18	23	30	32	41	37
2 ½	30	28	34	43	46	58	57
3	40	35	44	55	58	74	73
3 ½	49	44	55	71	76	94	91
4	65	58	72	94	99	130	120
5	87	76	98	125	135	170	165
6	115	105	135	170	180	230	230
8	185	155	220	260	280	350	360
10	290	240	350	400	430	540	570
12	410	340	510	560	620	770	820
14 O.D.	560	440	710	790	870	1090	1180
16 O.D.	750	620	960	1040	1150	1430	1610
18 O.D.	970	780	1260	1330	1490	1840	2100
20 O.D.	1220	960	1630	1670	1880	2320	2670
24 O.D.	1840	1430	2470	2490	2800	3450	4020
30 O.D.	3120	2230	4290	4150	4740	5760	

For dimensions, see page 167.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

Weights of laterals do not include reinforcing ribs.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

Table No. 70

Nominal Pipe Sizes	Reducing Elbow	Reducers and Eccentric Reducers	Nominal Pipe Sizes	Reducing Elbow	Reducers and Eccentric Reducers
3 x1½	28	24	12x 8	300	250
3 x2	30	25	12x10	360	290
3 x2½	35	29	14x 8	390	320
3½x2	35	29	14x10	440	360
3½x3	44	36	14x12	490	410
4 x2	43	36	16x 8	470	390
4 x2½	48	40	16x10	530	440
4 x3	52	44	16x12	600	490
4 x3½	56	48	16x14	670	550
5 x2½	60	50	18x10	650	520
5 x3	65	54	18x12	710	580
5 x4	78	63	18x14	790	640
6 x3	82	67	18x16	870	670
6 x3½	89	71	20x12	840	660
6 x4	93	77	20x14	930	730
6 x5	100	85	20x16	1020	800
8 x4	130	105	20x18	1120	880
8 x5	140	115	24x12	1150	920
8 x6	155	130	24x16	1350	1070
10 x5	190	155	24x18	1460	1170
10 x6	210	170	24x20	1590	1260
10 x8	240	190			
12 x6	280	220			

For dimensions, see page 167.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

Table No. 71

Nominal Pipe Sizes	Lateral Reducing Outlet (Not Ribbed)	Nominal Pipe Sizes	Lateral Reducing Outlet (Not Ribbed)
3 x 3 x1½	58	12x12x 6	640
3 x 3 x2	60	12x12x 8	690
3 x 3 x2½	68	12x12x10	750
3½x 3½x2	73	14x14x 8	910
3½x 3½x2½	80	14x14x10	980
3½x 3½x3	85	14x14x12	1050
4 x 4 x2	92	16x16x 8	1190
4 x 4 x2½	98	16x16x10	1270
4 x 4 x3	105	16x16x12	1350
4 x 4 x3½	110	16x16x14	1440
5 x 5 x2½	130	18x18x10	1580
5 x 5 x3	135	18x18x12	1660
5 x 5 x3½	140	18x18x14	1760
5 x 5 x4	145	18x18x16	1870
6 x 6 x3	180	20x20x10	*1620
6 x 6 x3½	185	20x20x12	2040
6 x 6 x4	195	20x20x14	2140
6 x 6 x5	210	20x20x16	2260
8 x 8 x4	290	20x20x18	2390
8 x 8 x5	300	24x24x12	*2470
8 x 8 x6	320	24x24x14	3100
10 x10 x5	450	24x24x16	3200
10 x10 x6	470	24x24x18	3350
10 x10 x8	510	24x24x20	3520

For dimensions, see page 167.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

Weights of laterals do not include reinforcing ribs.

*These sizes made in the short body pattern only.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

Table No. 72

Reducing Tees

Nominal Pipe Sizes	Weight	Nominal Pipe Sizes	Weight	Nominal Pipe Sizes	Weight
3 x3 x2½	58	4x3 x2	71	6x6x3	150
3 x3 x2	53	4x2½x4	86	6x5x6	175
3 x3 x1½	51	4x2½x3	76	6x5x5	160
3 x2½x3	58	4x2½x2½	72	6x5x4	155
3 x2½x2½	54	4x2½x2	68	6x5x3	145
3 x2½x2	50	4x2 x4	82	6x4x6	165
3 x2½x1½	48	4x2 x3	72	6x4x5	155
3 x2 x3	54	4x2 x2½	68	6x4x4	145
3 x2 x2½	50	4x2 x2	64	6x4x3	135
3 x2 x2	46	5x5 x4	125	6x3x6	155
3 x2 x1½	44	5x5 x3½	120	6x3x5	145
3 x1½x3	52	5x5 x3	115	6x3x4	140
3 x1½x2½	48	5x5 x2½	110	6x3x3	125
3 x1½x2	44	5x4 x5	125	8x8x6	260
3 x1½x1½	42	5x4 x4	120	8x8x5	240
3½x3½x3	72	5x4 x3	110	8x8x4	240
3½x3½x2½	68	5x4 x2½	105	8x6x8	260
3½x3½x2	63	5x3 x5	120	8x6x6	240
4 x4 x3½	93	5x3 x4	110	8x6x5	230
4 x4 x3	89	5x3 x3	100	8x6x4	220
4 x4 x2½	85	5x3 x2½	95	8x5x8	250
4 x4 x2	80	5x2½x5	115	8x5x6	230
4 x3 x4	90	5x2½x4	105	8x5x5	215
4 x3 x3	80	5x2½x3	96	8x5x4	210
4 x3 x2½	76	5x2½x2½	92	8x4x8	240
		6x6 x5	170		
		6x6 x4	160		
		6x6 x3½	150		

For dimensions, see page 167.

All weights are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

Table No. 72 (continued)

Reducing Tees

Nominal Pipe Sizes	Weight	Nominal Pipe Sizes	Weight	Nominal Pipe Sizes	Weight
8x 4x 6	220	14x14x10	770	16x12x12	950
8x 4x 5	210	14x14x 8	730	16x12x10	900
8x 4x 4	200	14x12x14	820	16x12x 8	860
10x10x 8	400	14x12x12	770	16x10x16	1030
10x10x 6	370	14x12x10	730	16x10x14	970
10x10x 5	360	14x12x 8	690	16x10x12	900
10x 8x10	400	14x10x14	790	16x10x10	870
10x 8x 8	360	14x10x12	730	16x10x 8	830
10x 8x 6	340	14x10x10	690	16x 8x16	1000
10x 6x10	380	14x10x 8	650	16x 8x14	940
10x 6x 8	350	14x 8x14	760	16x 8x12	890
10x 6x 6	320	14x 8x12	710	16x 8x10	850
12x12x10	570	14x 8x10	660	16x 8x 8	800
12x12x 8	540	14x 8x 8	630	18x18x16	1420
12x12x 6	510	16x16x14	1090	18x18x14	1360
12x10x12	570	16x16x12	1040	18x18x12	*1130
12x10x10	530	16x16x10	990	18x18x10	*1080
12x10x 8	500	16x16x 8	950	20x20x18	1800
12x10x 6	470	16x14x16	1100	20x20x16	1730
12x 8x12	560	16x14x14	1040	20x20x14	*1460
12x 8x10	510	16x14x12	990	20x20x12	*1410
12x 8x 8	480	16x14x10	950	20x20x10	*1360
12x 8x 6	450	16x14x 8	910	24x24x20	2620
12x 6x12	540	16x12x16	1050	24x24x18	2540
12x 6x10	500	16x12x14	1000	24x24x16	*2090
12x 6x 8	460			24x24x14	*2030
12x 6x 6	440			24x24x12	*1970
14x14x12	820				

For dimensions, see page 167.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

*These sizes made in short body pattern only.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

Table No. 73

Reducing Crosses

Nominal Pipe Sizes	Weight	Nominal Pipe Sizes	Weight
3 x 3 x1 ½x1 ½	59	12x12x 8x 8	620
3 x 3 x2 x2	63	12x12x10x10	690
3 x 3 x2 ½x2 ½	72	14x14x 8x 8	820
3 ½x 3 ½x2 x2	74	14x14x10x10	900
3 ½x 3 ½x2 ½x2 ½	82	14x14x12x12	990
3 ½x 3 ½x3 x3	89	16x16x 8x 8	1040
4 x 4 x2 x2	91	16x16x10x10	1120
4 x 4 x2 ½x2 ½	100	16x16x12x12	1210
4 x 4 x3 x3	110	16x16x14x14	1320
4 x 4 x3 ½x3 ½	115	18x18x10x10	*1210
5 x 5 x2 ½x2 ½	125	18x18x12x12	*1320
5 x 5 x3 x3	135	18x18x14x14	1590
5 x 5 x3 ½x3 ½	145	18x18x16x16	1710
5 x 5 x4 x4	155	20x20x10x10	*1490
6 x 6 x3 x3	170	20x20x12x12	*1580
6 x 6 x3 ½x3 ½	175	20x20x14x14	*1680
6 x 6 x4 x4	190	20x20x16x16	2030
6 x 6 x5 x5	200	20x20x18x18	2170
8 x 8 x4 x4	270	24x24x12x12	*2150
8 x 8 x5 x5	280	24x24x14x14	*2270
8 x 8 x6 x6	310	24x24x16x16	*2380
10 x10 x5 x5	400	24x24x18x18	2920
10 x10 x6 x6	420	24x24x20x20	3080
10 x10 x8 x8	470	24x24x22x22	3240
12 x12 x6 x6	570		

For dimensions, see page 167.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

*These sizes made in the short body pattern only.

Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 25 Pounds per Square Inch

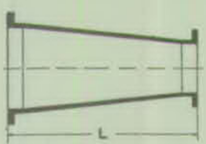
Table No. 74

Size	90 Degree Elbow	45 Degree Elbow	90 Degree Long Radius Elbow	Tee	Cross
14	270	210	360	420	520
16	350	270	480	530	660
18	440	320	620	660	810
20	550	410	790	840	1020
24	840	590	1170	1280	1550
30	1400	1100	2090	2090	2500
36	2320	1900	3250	3040	3600
42	2830	2430	4400	4140	4860
48	3970	3520	6710	5750	6690
54	5560	4850	9180	8100	9450
60	7220	6130	11890	10540	12260
72	11770	10010	19300	17200	19980

For dimensions, see page 170.

All weights listed are for fittings faced and drilled, based upon minimum thicknesses and dimensions given in preceding table without allowances for variation. Cast iron is considered to weigh 0.26 pound per cubic inch.

Dimensions of Flanged Fittings for Water



Reducer

¼ Bend (90°) ⅛ Bend (45°) 1/16 Bend (22½°) 1/32 Bend (11¼°) 1/64 Bend (5⅝°)

Table No. 75

Size	A 90° Bends	A 45° Bends	A 22½° Bends	A 11¼° Bends	A 5⅝° Bends	A Long Radius 90° Bends	L Short Pattern	L Long Pattern
4	16	9.94	9.55	.....	.....	11	..	..
6	16	9.94	9.55	.....	.....	12	16	26
8	16	9.94	9.55	.....	.....	13	16	26
10	16	9.94	9.55	.....	.....	14	16	26
12	16	9.94	9.55	.....	.....	15	16	26
14	18	14.91	14.32	.....	.....	16	24	34
16	24	14.91	14.32	.....	.....	17	24	34
18	24	14.91	14.32	.....	.....	18	24	34
20	24	19.88	19.10	23.64	23.57	19	30	40
24	30	24.85	23.87	23.64	23.57	21	30	40
30	36	24.85	23.87	23.64	23.57	..	34	74
36	48	37.28	35.80	23.64	23.57	..	40	74
42	48	37.28	35.80	23.64	23.57	..	40	74
48	48	37.28	35.80	23.64	23.57	..	40	74
54	..	37.28	35.80	23.64	23.57	..	..	..
60	..	37.28	35.80	23.64	23.57	..	..	..

All dimensions in inches.

For standard flanges see page 147.

Fittings furnished with flanges faced plain unless otherwise specified.

Tees and crosses ribbed and bolted as necessary.

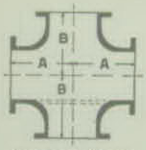
For bases see page 78.

For radii of bends see page 76.

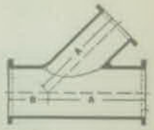
Size of reducers, as well as tees and crosses 24 inches and under, given above represents opening at large end, laying length remains the same for all reductions.

Radii and laying lengths in accordance with A. W. W. A. Specifications.

Dimensions of Flanged Fittings for Water



Tee and Cross



Y Branch

Table No. 76

Tees and Crosses			Y Branches Type 2					
Size	A	B	Size	A	B	Size	A	B
4	11.0	11.0	4	14.5	9.50	30x20	54.0	15.50
6	12.0	12.0	6x4	16.0	10.00	30x24	54.0	15.50
8	13.0	13.0	6	17.0	11.00	30	57.0	21.25
10	14.0	14.0	8x4	18.0	12.00			
12	15.0	15.0	8x6	19.0	12.00	36x24	58.5	18.25
			8	20.0	12.00	36x30	60.5	18.25
14	16.0	16.0				36	64.5	22.50
16	17.0	17.0	10x6	21.0	13.50			
18	18.0	18.0	10x8	22.0	13.50	42x24	65.0	15.25
20	19.0	19.0	10	22.5	13.50	42x30	68.0	15.25
24	21.0	21.0				42x36	71.0	19.50
			12x6	23.0	13.50	42	74.0	23.75
30x12	19.5	24.0	12x8	25.5	13.50			
30x14	22.5	26.0	12x10	25.5	13.50	48x30	73.0	12.50
30x16	23.5	26.0	12	25.5	13.50	48x36	76.0	16.50
30x18	24.5	26.0				48x42	79.0	20.75
30x20	25.5	26.0	14x6	26.0	11.00	48	82.0	25.00
30x24	27.5	26.0	14x8	26.5	11.75			
30	30.5	30.5	14x10	27.0	12.50			
			14x12	27.5	13.25			
36x12	19.5	27.0	14	28.0	14.00			
36x14	22.5	29.0						
36x16	23.5	29.0	16x8	27.0	15.50			
36x18	24.5	29.0	16x10	29.0	15.50			
36x20	25.5	29.0	16x12	31.0	15.50			
36x24	27.5	29.0	16x14	33.0	15.50			
36x30	30.5	33.5	16	35.0	15.50			
36	33.5	33.5						
			18x10	36.0	16.00			
42x12	20.0	30.0	18x12	36.0	16.00			
42x14	23.0	32.0	18x14	36.0	16.00			
42x16	24.0	32.0	18x16	38.0	16.00			
42x18	25.0	32.0	18	38.0	16.00			
42x20	26.0	32.0						
42x24	28.0	32.0	20x12	41.0	16.75			
42x30	31.0	36.5	20x14	41.0	16.75			
42x36	34.0	36.5	20x16	41.0	16.75			
42	37.0	37.0	20x18	41.0	16.75			
			20	41.0	16.75			
48x16	24.0	35.0						
48x18	25.0	35.0	24x16	44.0	10.75			
48x20	26.0	35.0	24x18	44.0	16.75			
48x24	28.0	35.0	24x20	44.0	16.75			
48x30	31.0	39.5	24	46.0	17.75			
48x36	34.0	39.5						
48x42	37.0	40.0						
48	40.0	40.0						

See notes on previous page.

Weights of Flanged Bends for Water

Table No. 77

Size	Class	90° Bends	45° Bends	22½° Bends	11¼° Bends	5⅝° Bends	Long Radius 90° Bends
4	D	70	58	58	....	....	61
6	D	102	84	84	....	....	90
8	D	151	125	125	....	....	140
10	D	211	172	172	....	....	202
12	D	287	238	238	....	....	285
14	B	337	363	363	....	....	319
14	D	388	420	420	....	....	377
16	B	496	444	444	....	....	416
16	D	602	526	526	....	....	490
18	B	589	515	515	....	....	505
18	D	706	611	611	....	....	601
20	B	712	712	712	841	841	631
20	D	853	853	853	1021	1021	749
24	B	1128	1127	1127	1131	1131	912
24	D	1377	1377	1377	1376	1376	1090
30	A	1682	1473	1473	1450	1450	....
30	B	1887	1641	1641	1641	1641	....
30	C	2121	1833	1833	1830	1830	....
30	D	2357	2026	2026	2019	2019	....
36	A	2892	2752	2752	2044	2044	....
36	B	3243	3179	3179	2258	2258	....
36	C	3706	3512	3512	2538	2538	....
36	D	4198	3971	3971	2824	2824	....
42	A	....	3640	3640	2724	2724	....
42	B	....	4067	4067	3017	3017	....
42	C	....	4675	4675	3375	3375	....
42	D	....	5263	5263	3753	3753	....
48	A	....	4692	4692	3497	3497	....
48	B	....	5127	5127	3757	3757	....
48	C	....	5918	5918	4268	4268	....
48	D	....	6612	6612	4702	4702	....
54	A	....	5802	5802	4362	4362	....
54	B	....	6334	6334	4694	4694	....
54	C	....	7561	7561	5514	5514	....
54	D	....	8563	8563	6146	6146	....
60	A	....	7006	7006	5372	5372	....
60	B	....	7937	7937	5956	5956	....
60	C	....	8965	8965	6691	6691	....
60	D	....	10382	10382	7514	7514	....

Weights given in pounds. All weights approximate.
For dimensions, see page 186.
For standard flanges, see page 147.
For standard bases, see page 78.

Weights of Flanged Tees, Crosses and Y-Branches for Water
Table No. 78

Size	Class	Tees	Crosses	Y-Branches
3	..	....	....	68
4	D	89	115	117
6x4	D	126	152	164
6	D	139	179	185
8x4	D	183	210	228
8x6	D	196	237	259
8	D	215	276	293
10x4	D	253	280	.....
10x6	D	272	306	367
10x8	D	284	341	406
10	D	303	396	453
12x4	D	351	378	.....
12x6	D	365	404	530
12x8	D	382	439	590
12x10	D	398	494	628
12	D	426	557	677
14x4	B	396	422	.....
14x4	D	456	483	.....
14x6	B	409	449	584
14x6	D	470	510	837
14x8	B	426	483	634
14x8	D	487	544	882
14x10	B	454	538	685
14x10	D	512	596	937
14x12	B	485	601	741
14x12	D	544	659	1003
14	B	498	627	773
14	D	573	717	1069
16x4	B	508	535	.....
16x4	D	580	606	.....
16x6	B	522	562	.....
16x6	D	597	637	.....
16x8	B	539	596	772
16x8	D	616	678	1110
16x10	B	555	628	840
16x10	D	640	726	1186
16x12	B	583	685	933
16x12	D	672	788	1277
16x14	B	596	730	980
16x14	D	700	845	1378
16	B	628	789	1065
16	D	737	916	1512

Size	Class	Tees	Crosses	Y-Branches
18x4	B	593	620	.....
18x4	D	707	733	.....
18x6	B	607	647	.....
18x6	D	725	770	.....
18x8	B	624	681	.....
18x8	D	743	805	.....
18x10	B	640	713	1234
18x10	D	767	853	1502
18x12	B	668	770	1248
18x12	D	782	884	1563
18x14	B	685	804	1303
18x14	D	816	952	1624
18x16	B	730	893	1404
18x16	D	850	1019	1754
18	B	741	913	1464
18	D	871	1061	1830
20x6	B	756	796	.....
20x6	D	902	947	.....
20x8	B	773	830	.....
20x8	D	919	981	.....
20x10	B	789	862	.....
20x10	D	944	1030	.....
20x12	B	821	927	1671
20x12	D	993	1129	1987
20x14	B	842	963	1676
20x14	D	1028	1199	2057
20x16	B	879	1042	1738
20x16	D	1056	1255	2138
20x18	B	896	1068	1774
20x18	D	1081	1303	2197
20	B	936	1156	1880
20	D	1110	1363	2317
24x6	B	1074	1114	.....
24x6	D	1301	1346	.....
24x8	B	1092	1149	.....
24x8	D	1318	1380	.....
24x10	B	1108	1181	.....
24x10	D	1342	1428	.....
24x12	B	1140	1246	.....
24x12	D	1391	1527	.....
24x14	B	1163	1291	.....
24x14	D	1427	1597	.....
24x16	B	1198	1361	2038
24x16	D	1453	1652	2740
24x18	B	1211	1387	2182
24x18	D	1574	1859	2845
24x20	B	1257	1479	2419
24x20	D	1631	1971	3263
24	B	1335	1635	2852
24	D	1744	2189	3905

Weights given in pounds. All weights approximate.
For dimensions see page 187.
For standard flanges see page 147. For standard bases see page 78.

Weights of Flanged Tees, Crosses and Y-Branches for Water

Table No. 78 (continued)

Size	Class	Tees	Crosses	Y-Branches	Size	Class	Tees	Crosses	Y-Branches
30x12	A	1410	1526	.....	36x18	A	2309	2513	.....
30x12	B	1546	1661	.....	36x18	B	2483	2688	.....
30x12	C	1701	1817	.....	36x18	C	2851	3088	.....
30x12	D	1857	1973	.....	36x18	D	3395	3795	.....
30x14	A	1572	1717	.....	36x20	A	2413	2663	.....
30x14	B	1731	1876	.....	36x20	B	2642	2892	.....
30x14	C	1933	2098	.....	36x20	C	3169	3585	.....
30x14	D	2264	2532	.....	36x20	D	3553	4015	.....
30x16	A	1650	1828	.....	36x24	A	2621	2957	4136
30x16	B	1816	1994	.....	36x24	B	2869	3205	4801
30x16	C	2035	2239	.....	36x24	C	3466	4006	5790
30x16	D	2388	2710	.....	36x24	D	3961	4603	6283
30x18	A	1720	1924	.....	36x30	A	3021	3580	4956
30x18	B	1895	2098	.....	36x30	B	3544	4288	5469
30x18	C	2127	2363	.....	36x30	C	4036	4883	6255
30x18	D	2502	2852	.....	36x30	D	4674	5712	7018
30x20	A	1809	2059	3083	36	A	3426	4209	5660
30x20	B	1992	2241	3506	36	B	4003	4995	7176
30x20	C	2386	2773	4059	36	C	4596	5741	8504
30x20	D	2640	3061	4381	36	D	5379	6796	9686
30x24	A	1985	2322	3552	42x12	A	2564	2680	.....
30x24	B	2183	2519	4289	42x12	B	2792	2907	.....
30x24	C	2627	3130	4660	42x12	C	3113	3229	.....
30x24	D	2899	3434	5144	42x12	D	3417	3533	.....
30	A	2341	2899	3924	42x14	A	2826	2971	.....
30	B	2614	3223	4810	42x14	B	3092	3236	.....
30	C	3119	3923	4319	42x14	C	3491	3655	.....
30	D	3509	4424	6045	42x14	D	4135	4500	.....
36x12	A	1921	2037	.....	42x16	A	2936	3115	.....
36x12	B	2090	2206	.....	42x16	B	3216	3394	.....
36x12	C	2315	2431	.....	42x16	C	3640	3844	.....
36x12	D	2551	2667	.....	42x16	D	4328	4752	.....
36x14	A	2130	2275	.....	42x18	A	3041	3245	.....
36x14	B	2328	2473	.....	42x18	B	3332	3537	.....
36x14	C	2613	2778	.....	42x18	C	4000	4389	.....
36x14	D	3095	3403	.....	42x18	D	4500	4966	.....
36x16	A	2223	2401	.....	42x20	A	3162	3412	.....
36x16	B	2432	2610	.....	42x20	B	3468	3717	.....
36x16	C	2736	2940	.....	42x20	C	4179	4633	.....
36x16	D	3252	3615	.....	42x20	D	4700	5231	.....

See notes on previous page.

Weights of Flanged Tees, Crosses and Y-Branches for Water

Table No. 78 (continued)

Size	Class	Tees	Crosses	Y-Branches	Size	Class	Tees	Crosses	Y-Branches
42x24	A	3404	3741	5909	48x20	A	3998	4247	.....
42x24	B	3735	4072	5645	48x20	B	4307	4556	.....
42x24	C	4544	5130	8004	48x20	C	5239	5762	.....
42x24	D	5163	5870	8735	48x20	D	5840	6437	.....
42x30	A	3858	4416	6395	48x24	A	4287	4624	.....
42x30	B	4501	5266	7646	48x24	B	4858	5357	.....
42x30	C	5295	6260	8501	48x24	C	5650	6299	.....
42x30	D	5999	7127	9638	48x24	D	6407	7211	.....
42x36	A	4315	5098	8687	48x30	A	4814	5372	7703
42x36	B	5037	6058	8825	48x30	B	5507	6304	8972
42x36	C	5989	7291	10216	48x30	C	6505	7541	10359
42x36	D	6783	8280	11587	48x30	D	7356	8588	11552
42	A	4834	5903	8631	48x36	A	5343	6126	8999
42	B	5673	7042	10199	48x36	B	6232	7366	10583
42	C	6816	8569	12967	48x36	C	7263	8618	12242
42	D	7687	9664	15512	48x36	D	8202	9778	13738
48x16	A	3724	3903	.....	48x42	A	5934	7003	10349
48x16	B	4006	4185	.....	48x42	B	7031	8577	12082
48x16	C	4831	5236	.....	48x42	C	8083	9825	14127
48x16	D	5383	5861	.....	48x42	D	9211	11268	15969
48x18	A	3851	4056	.....	48	A	6536	7903	11942
48x18	B	4148	4352	.....	48	B	7844	9807	13822
48x18	C	5018	5466	.....	48	C	9009	11206	16684
48x18	D	5600	6127	.....	48	D	10223	12759	18954

See notes on page 189.

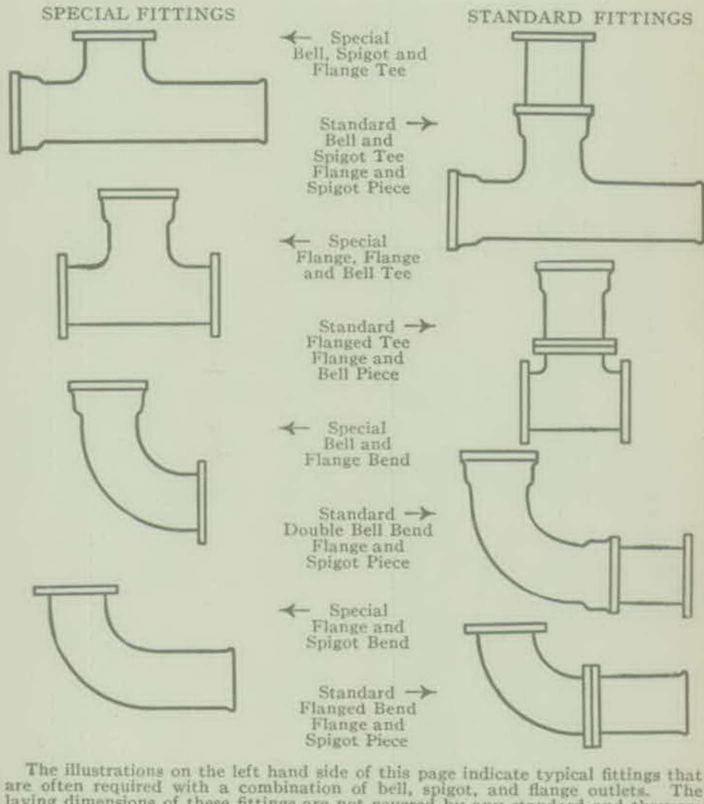
Weights of Flanged Reducers for Water—Table No. 79

Size	Class	Reducers Long Pattern	Reducers Short Pattern
6x4	D	89	68
8x4	D	113	81
8x6	D	127	94
10x4	D	143	104
10x6	D	162	117
10x8	D	186	135
12x4	D	183	123
12x6	D	201	148
12x8	D	225	165
12x10	D	257	188
14x6	B	254	201
14x6	D	289	218
14x8	B	285	225
14x8	D	319	243
14x10	B	325	256
14x10	D	360	276
14x12	B	371	293
14x12	D	408	314
16x6	B	300	234
16x6	D	320	257
16x8	B	330	259
16x8	D	376	284
16x10	B	370	290
16x10	D	415	317
16x12	B	418	328
16x12	D	464	354
16x14	B	426	340
16x14	D	505	390
18x8	B	365	285
18x8	D	417	315
18x10	B	409	318
18x10	D	457	348
18x12	B	455	356
18x12	D	505	387
18x14	B	461	367
18x14	D	548	424
18x16	B	510	404
18x16	D	603	467
20x10	B	525	422
20x10	D	599	481
20x12	B	579	467
20x12	D	652	524
20x14	B	585	485
20x14	D	700	559
20x16	B	636	521
20x16	D	764	614
20x18	B	721	588
20x18	D	812	657
24x14	B	717	582
24x14	D	842	676
24x16	B	768	623
24x16	D	909	730
24x18	B	810	655
24x18	D	968	775
24x20	B	875	710
24x20	D	1049	841

Size	Class	Reducers Long Pattern	Reducers Short Pattern
30x18	A	1545	863
30x18	B	1672	923
30x18	C	1942	1036
30x18	D	2107	1105
30x20	A	1637	923
30x20	B	1755	973
30x20	C	2072	1109
30x20	D	2233	1175
30x24	A	1844	1034
30x24	B	1980	1095
30x24	C	2340	1250
30x24	D	2498	1305
36x20	A	2023	1288
36x20	B	2190	1374
36x20	C	2573	1567
36x20	D	2814	1690
36x24	A	2231	1416
36x24	B	2405	1503
36x24	C	2834	1726
36x24	D	3088	1853
36x30	A	2459	1574
36x30	B	2765	1731
36x30	C	3157	1930
36x30	D	3557	1997
42x20	A	2489	1597
42x20	B	2704	1709
42x20	C	3180	1945
42x20	D	3480	2095
42x24	A	2694	1726
42x24	B	2964	1862
42x24	C	3444	2104
42x24	D	3754	2254
42x30	A	3018	1883
42x30	B	3276	2134
42x30	C	3760	2305
42x30	D	4219	2537
42x36	A	3506	2139
42x36	B	3701	2341
42x36	C	4258	2618
42x36	D	4798	2893
48x30	A	3462	2230
48x30	B	3829	2414
48x30	C	4399	2703
48x30	D	4918	2924
48x36	A	3858	2488
48x36	B	4256	2589
48x36	C	4898	3013
48x36	D	5507	3342
48x42	A	4305	2794
48x42	B	4756	2923
48x42	C	5492	3388
48x42	D	6157	3722

Weights given in pounds. All weights approximate. For dimensions see page 186. For standard flanges see page 147.

Comparison Between Special Bell and Spigot and Flanged Fittings and Combination of Standard Fittings



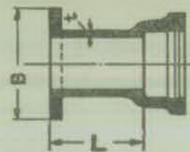
The illustrations on the left hand side of this page indicate typical fittings that are often required with a combination of bell, spigot, and flange outlets. The laying dimensions of these fittings are not covered by any standard and they are therefore usually named "Special" inasmuch as they are made to order to suit certain conditions in piping installations.

On the right hand side and opposite each "Special" fitting is shown a combination of Standard fittings that can be used to obtain the same outlet effects as the specials. The laying dimensions may not be interchangeable since the dimensions of the Standard fittings are fixed whereas the Specials can be made to any desired lengths.

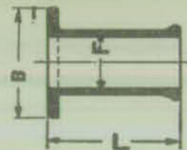
The use of standard fittings wherever possible is always recommended as the most economical and such fittings can usually be shipped out of stock. In sending inquiries for fittings of dimensions deviating from the standard, state specifically the type of outlets wanted, reading, size, etc., as shown on page 47, and give exact dimension from center line to outlet.

Dimensions and Weights of Standard Flange and Bell, Flange and Spigot and Flange and Flare Fittings

Table No. 80



Flange and Bell



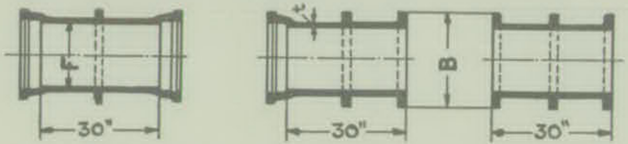
Flange and Spigot

Flange and Flare

Size	American Standard Flanges and Drilling					Class	Thickness of Body 't'	Outside Diam. Body F	Flange and Bell		Flange and Spigot		Flange and Flare		
	Diameter of Flange 'B'	Thickness of Flange	Diam. Bolt Circle	Number of Bolts	Size of Bolts				L	Approx. Weight	L	Approx. Weight	R	L	Approx. Weight
3	7 ½	¾	6	4	⅝	D	.48	3.96	10	42	16	30	6	8	25
4	9	15/16	7 ½	8	⅝	D	.52	5.00	10	65	16	46	6	8	42
6	11	1	9 ½	8	¾	D	.55	7.10	10	90	16	68	6	8	57
8	13 ½	1 ⅛	11 ¾	8	¾	D	.60	9.30	10	110	16	98	8	10	94
10	16	1 3/16	14 ¼	12	⅞	D	.68	11.40	10	172	18	150	10	10	126
12	19	1 ¼	17	12	⅞	D	.75	13.50	10	230	18	205	12	12	196
14	21	1 ⅜	18 ¾	12	1	B	.66	15.30	10	254	18	228	14	12	204
14	21	1 ⅜	18 ¾	12	1	D	.82	15.65	10	290	18	268	..	..	...
16	23 ½	1 7/16	21 ¼	16	1	B	.70	17.40	10	330	20	305	16	16	280
16	23 ½	1 7/16	21 ¼	16	1	D	.89	17.80	10	375	20	348	..	..	...
18	25	1 9/16	22 ¾	16	1 ⅛	B	.75	19.50	10	384	20	352	18	16	345
18	25	1 9/16	22 ¾	16	1 ⅛	D	.96	19.92	10	438	20	406	..	..	...
20	27 ½	1 11/16	25	20	1 ⅛	B	.80	21.60	10	462	24	458	20	18	440
20	27 ½	1 11/16	25	20	1 ⅛	D	1.03	22.06	10	535	24	532	..	..	...
24	32	1 ⅞	29 ½	20	1 ¼	B	.89	25.80	10	630	24	628	24	18	600
24	32	1 ⅞	29 ½	20	1 ¼	D	1.16	26.32	10	740	24	738	..	..	...

For dimensions of Bells, see page 66.
Dimensions in inches.
Weights given in pounds. All weights approximate.
The above are standard lengths; other lengths can be furnished.

Dimensions and Weights of Standard Wall Castings

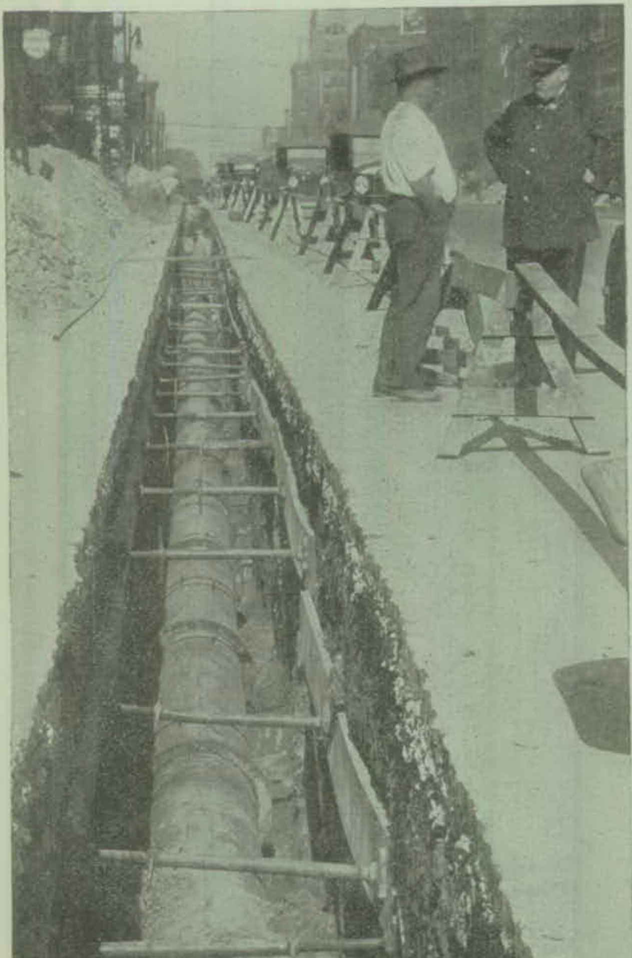


Bell and Bell — Bell and Flange — Flange and Flange

Table No. 81

Size	American Standard Flanges and Drilling: Diameter of Flange 'B'	Thickness of Flange	Diameter Bolt Circles	Number of Bolts	Size of Bolts	Class	Thickness of Body 't'	Outside Diam. Body F	Approximate Weights: Bell and Bell	Bell and Flange	Flange and Flange	One Bell	One Flange
3	7 1/2	3/4	6	4	5/8	D	.48	3.96	85	72	59	19.3	6.2
4	9	15/16	7 1/2	8	5/8	D	.52	5.00	113	101	89	22.9	10.7
6	11	1	9 1/2	8	3/4	D	.55	7.10	168	149	131	32.9	14.4
8	13 1/2	1 1/8	11 3/4	8	3/4	D	.60	9.30	253	223	195	51.6	22.0
10	16	1 3/16	14 1/4	12	7/8	D	.68	11.40	339	305	270	65.4	30.6
12	19	1 1/4	17	12	7/8	D	.75	13.50	450	410	371	85.1	45.6
14	21	1 3/8	18 3/4	12	1	B	.66	15.30	470	440	411	87.8	58.1
14	21	1 3/8	18 3/4	12	1	D	.82	15.65	544	504	463	95.8	55.1
16	23 1/2	1 7/16	21 1/4	16	1	B	.70	17.40	587	547	506	114.1	73.2
16	23 1/2	1 7/16	21 1/4	16	1	D	.89	17.80	694	635	576	128.1	69.1
18	25	1 9/16	22 3/4	16	1 1/8	B	.75	19.50	691	635	578	134.5	78.1
18	25	1 9/16	22 3/4	16	1 1/8	D	.96	19.92	823	744	664	152.5	72.8
20	27 1/2	1 11/16	25	20	1 1/8	B	.80	21.60	823	765	707	158.2	99.8
20	27 1/2	1 11/16	25	20	1 1/8	D	1.03	22.06	1002	905	809	189.2	92.9
24	32	1 7/8	29 1/2	20	1 1/4	B	.89	25.80	1084	1019	954	202.0	137.0
24	32	1 7/8	29 1/2	20	1 1/4	D	1.16	26.32	1348	1222	1096	253.0	127.0

For dimensions of Bells, see page 66.
Dimensions in inches.
Weights given in pounds. All weights approximate.
The above are standard lengths; other lengths can be furnished.



Laying Cast Iron Pipe under City Streets

SECTION 10

PIPE LAYING

THERE seems to have been a tendency in the past to use less care in the laying of underground pipe lines than is ordinarily exercised in the construction of any other engineering structure. The reason probably was the fact that even though haphazard methods were used the failures were either not blamed on these methods or were so rare as not to be considered of great importance. Modern practice is along different lines and the tendency is to put more care into installing mains and in this way insure continuity of service and lower maintenance cost and to reduce the danger of damage from breaks. This step is consistent with the care taken by the pipe manufacturers in the making of pipe. There have been innumerable cases where the blame for a break was laid on the pipe, only upon investigation to find that the fault lay either with the way the pipe was handled after delivery or with some fault in the laying. In order to promote better pipe construction, an effort will be made to outline here the principal points of pipe laying with the hope that their adoption will eliminate some of the faults that have been relatively common heretofore.

Unloading Pipe. From the time the pipe is shaken out of the molds until it is loaded on the cars, the manufacturer exercises care to avoid injury to his product and each carload of pipe is inspected before leaving the foundry to determine whether or not any damage has been caused by rough handling during the loading process. Effort is also made to load cars so that damage in transit will be reduced to a minimum. Damage due to rough handling of trains will occasionally occur and the buyer of pipe should inspect each length of pipe for cracks upon removing it from the cars and damaged pipe should be noted on the bill-of-lading and immediately called to the attention of the railroad agent to insure proper adjustment with the railroad company. In unloading the cars and in all subsequent handling of pipe, care should be exercised so that at no time will the pipe be dropped great distances or on

Unloading Pipe from Truck with Skids

hard ground. It is preferable to so arrange handling equipment that pipe is either unloaded by derrick or rolled off on skids.

Dropping pipe from trucks or cars to pavements is foolhardy, saves little time and is liable to cause damage that may not appear until after the pipe is installed in the line.

Delivering Pipe on Ground. In delivering pipe, economy requires that pipe of large diameters, particularly, be strung along the line with Bells facing the direction in which work is to proceed. Furthermore, the pipe should be so strung that each piece lies opposite its place in the ditch in order to avoid unnecessary handling.

When feasible, the pipe should be placed as close to the ditch as possible and on the side away from the dirt pile. Traffic conditions, digging machine operations and other

Pipe Improperly Unloaded

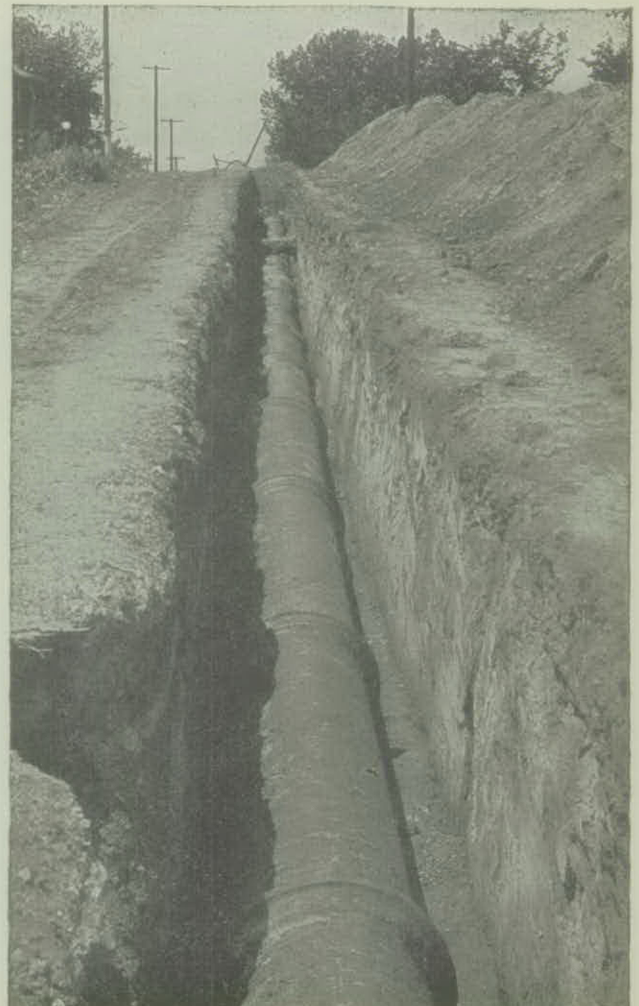
considerations will affect this procedure, but the general rule is to string the pipe in such a way as to cut down handling to a minimum and at the same time cause the least interference with traffic and reduce the danger of damage to the pipe from passing vehicles. Where Traveling Cranes are used for installing the pipe, it is sometimes possible to string the pipe on the same side of the ditch as the dirt pile or occasionally on the opposite side of the street when the boom is long enough to pick the pipe up from these locations.

Excavation. The width of ditch for various sizes of pipe is determined more by the ability to properly back-fill than by any other consideration. It is conceivable to lay a 36-inch pipe, for instance, in a trench 48 inches wide

Pipe Strung Along Street Ready for Laying

dug in clay, but it would be a physical impossibility to properly back-fill under the pipe with the small clearance that would be available. On the other hand, a ditch dug in sand where flooding can be adopted in back-filling, can be much narrower than where tamping of fill is necessary. A fair average width of trench for various sizes of pipe is shown in the following table:

Pipe Sizes Inches	Trench Widths Inches	Pipe Sizes Inches	Trench Widths Inches
6	19	30	45
8	22	36	51
10	24	42	58
12	26	48	64
14	28	54	70
16	30	60	76
18	33	72	89
20	35	84	101
24	40	..	...



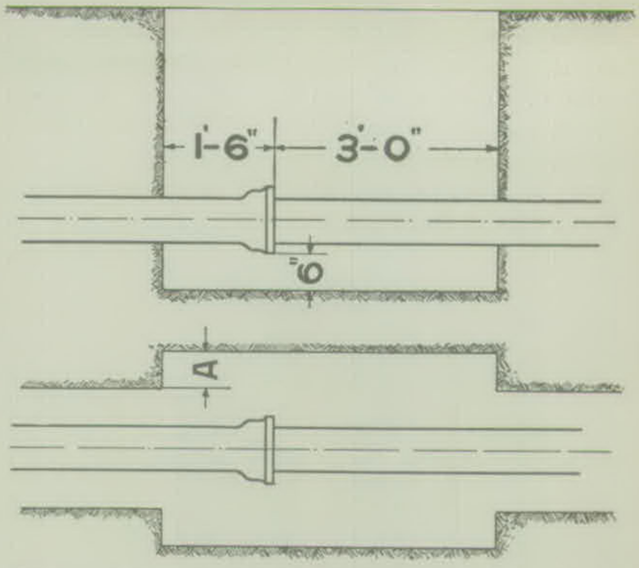
Pipe in the Trench Ready for Backfilling

The depth of trench in the case of water pipe of small diameter must be at least sufficient to bring the pipe below the maximum depth of frost. In the case of larger pipes, the minimum depth may be such that the bottom half of the pipe is always below frost. Large mains laid in heavy traffic streets, under railroad crossings, or in any place where shock might be transmitted to the pipe, should be laid deeper than the minimum requirements mentioned above. In some cases a minimum cover of 5 feet is required on mains of even the largest diameter in order to provide a cushion over the pipe to absorb shocks due to traffic.

At each joint a bell hole should be dug so as to make proper calking as easy as possible. The digging of bell-holes of such a size that the calker is unable to properly swing his calking hammer is poor economy. Proper care in bell-hole digging is a great help toward tight joints. The diagram opposite shows the proper dimensions for bell-holes.

In the case of rock excavation the only extra precaution necessary is to see that the rock is removed in such a way that at no place does it come closer than 6 inches to the finished pipe line. Failure to do this may result in pipe resting on a point of rock, a condition which is very liable to cause a break. In rock excavation the ditch should not be back-filled with the broken rock, but sand, clay or loam should be used, sand being preferable. In case sand is difficult to procure, at least that part of the ditch up to 6 inches above the pipe should be filled with loose material properly tamped, and the remainder of the trench may be filled with the broken rock.

Pipe lines should be carried around underground



Dimension "A" varies from 6 inches to 10 inches, depending on kind of soil, calking material used and method of calking (hand or air). In smaller sizes of pipe bell holes may not extend to the surface of the ground in stiff material but may be dished out for about a foot and a half above the top of the pipe.

obstructions, such as sewers, conduits, other pipe lines, subways and such like, using special castings if necessary. Care should be taken here as in the case of rock excavation to see to it that the pipe line does not rest on any unyielding structure and also that it is not called upon to support another structure by having it rest on the pipe.

The bottom of the trench should be made to conform to the grade to which the pipe is to be laid. Blocks should be placed immediately behind the bell and about two feet from the spigot. These blocks should be laid on undisturbed earth and set in slots in the bottom of the trench so that they project about ¾ of an inch above the trench bottom. Where blocks are set in slots, care should be taken that the slot is not concave as in this case the middle portion of the block will be unsupported and the benefit to be derived by blocking is lost. They should be set so that they have bearing over the entire surface.

The primary purpose of blocking is to support and level the pipe during construction and while the earth in the

An Intricate Installation of Gas and Water Lines

ditch is settling. Its length and thickness depends on the nature of the soil and size of the pipe. In general, the following sizes of blocking will be found satisfactory:

BLOCKING		
Pipe Sizes Inches	Length Inches	Thickness Inches
16 to 24	24	2
30 to 36	30	2
48 to 60	48	3
60 to 84	60	3

Cast Iron Pipe should be lowered into the trench with ropes and not dropped in from the bank. Small sizes up to 12-inch may be lowered by taking a turn of rope around each end of the pipe, standing on one end of each rope and paying out the other until the pipe rests on the bottom of the trench.

Lowering Small Pipe Into Trench by Hand

Larger sizes are best handled by means of derricks. These may be of the three-legged ditch type, Gantry type or Traveling Cranes. The use of a Traveling Crane simplifies construction in that it makes it possible to pick pipe directly from the trucks, from opposite sides of the roadway or to lift them over the dirt pile. It also makes it unnecessary to string the pipe with Bells all in one direction as they can easily be turned when being lifted by the derrick.

Before entering the Spigot into the Bell of the pipe already laid, the first strands of yarn are held in place on the Spigot end of the pipe by the yarner or yarners. This yarn enters with the Spigot end and centers it in the Bell. This is important, and if by chance when the derrick

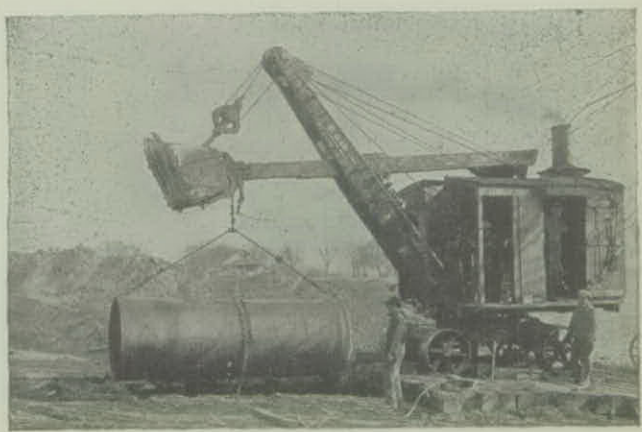
Tripod for Lowering Large Pipe into Trench

"slacks off" on the pipe the joint space on the bottom is smaller than on the top, the pipe should again be raised either by the derrick or by means of wedges and additional yarn driven into the lower part of the Bell.

Yarning. Each strand of yarn should be cut somewhat longer than the circumference of the pipe so that the ends will overlap and the overlapped ends of successive strands

Special Gantry Crane for Laying Large Pipe

should be staggered. The separate strands should be driven home with the yarning iron and hammers and when the last one is in place, all strands should be thoroughly compacted. This is essential to a good joint as the yarn forms the compressible gasket that insures tight joints.



Handling Cast Iron Pipe with a Steam Shovel

Sufficient yarn should be used to fill a joint up to within 2 inches of the face of the Bell.

Making the Joint. The most common type of joint is made with Cast Lead, but joints using lead wool, cement and patent jointing compounds are used to a considerable extent. Plain end pipe with bronze welded joints or couplings is occasionally used, especially for the distribution of high pressure gas.

LEAD JOINTS

Size of Pipe	Approximate Pounds of Lead per Joint 2 in. Thick		Approximate Pounds of Hemp per Joint	
	Water	Gas	Water	Gas
3	6.00	......	.18	....
4	7.50	8.14	.21	.23
6	10.25	11.31	.31	.34
8	13.25	14.56	.44	.49
10	16.00	17.67	.53	.59
12	19.00	20.85	.61	.67
14	22.00	......	.81	....
16	30.00	27.20	.94	1.03
18	33.80	......	1.00	....
20	37.00	41.28	1.25	1.39
24	44.00	49.07	1.50	1.67
30	54.25	60.06	2.06	2.28
36	64.75	71.57	3.00	3.32
42	75.25	83.13	3.62	4.00
48	85.50	102.63	4.37	5.20
54	97.60	......	6.25	....
60	108.30	......	8.25	....
72	146.00	......	12.50	....
84	170.00	......	15.00	....

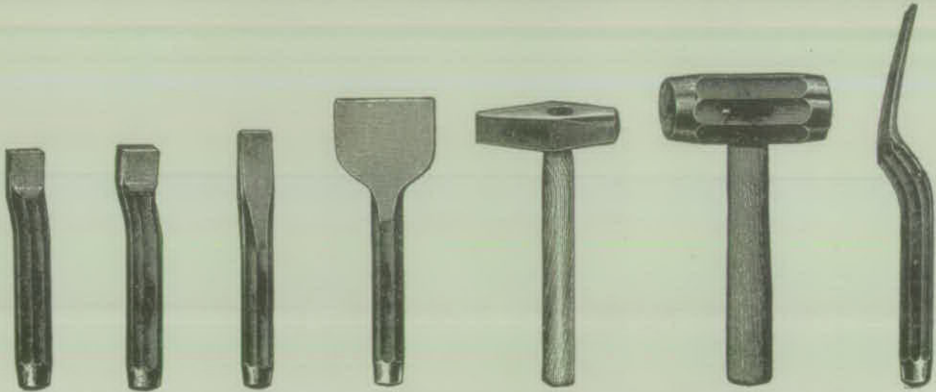
Lead Joints. After the joint is yarned, the lead runner is put in place on the joint so that it fits tightly against the face of the Bell and the outside of the pipe. Clay should be used whenever necessary to make a tight joint between runner and pipe. The pouring gate should be built up with clay to a point at least 1 inch above the top of the joint space. All joints should be poured from one ladle full of lead, or when more than one is used, no time should be allowed to elapse between pouring successive ladles. In the case of joints on pipe above 48 inches in diameter it is sometimes necessary to pour the joint in halves. When this is done, the runner is placed around the bottom half of the joint with a pouring gate on each side a little more than half way up on the pipe. Lead is then poured into both gates until it has reached a point just below the midpoint of the pipe. The bottom of the runner remains

Pouring a Lead Joint, Showing Runner in Place

in place and the upper ends are then placed over the top half of the pipe and a pouring gate built up at the extreme top as in pouring ordinary joints. The remainder of the joint is then poured in the usual manner. In extreme cold weather it sometimes becomes necessary to heat the joints of large size pipe to avoid "misses." As soon as the joint has cooled, the runner is removed and the joint is ready for calking.

The best practice in calking joints requires that each calking tool be used from the smallest to the largest that

Calking Tools



1 2 3 4 5 6 7

1. Regular pattern hand calking iron, 3/8-inch thick at point
2. Regular pattern hand calking iron, 5/8-inch thick at point
3. 3/4-inch cold chisel
4. Lead cutting chisel, 3 inches wide at point
5. Pipe cutting chisel, with handle
6. 3 1/2-pound calking hammer, with handle
7. Regular pattern yarning iron, 3/8-inch thick at point

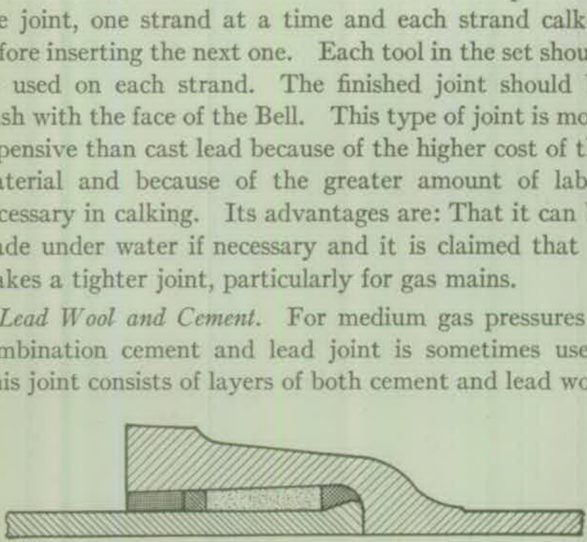
will fit in the joint space and that the joint be calked completely around with each tool. This requires more work than would be necessary if only the larger tools were used but the joint that results is worth the additional effort. On large jobs the use of pneumatic calking hammers is recommended. They result in better calking and cut down the

Pneumatic Calking with Lead Wool

cost of the work. Excessive calking should be avoided to prevent splitting bells of pipe.

Lead Wool. Lead wool is ordinary lead made into a shredded form and is furnished in the shape of loosely made rope. In making lead wool joints, the yarning is handled in the same manner as in cast lead joints, except that the joint is yarned to within 1⅛ inches to 1⅜ inches of the face of the Bell. The lead wool is then placed in the joint, one strand at a time and each strand calked before inserting the next one. Each tool in the set should be used on each strand. The finished joint should be flush with the face of the Bell. This type of joint is more expensive than cast lead because of the higher cost of the material and because of the greater amount of labor necessary in calking. Its advantages are: That it can be made under water if necessary and it is claimed that it makes a tighter joint, particularly for gas mains.

Lead Wool and Cement. For medium gas pressures a combination cement and lead joint is sometimes used. This joint consists of layers of both cement and lead wool



Combination Lead and Cement Joint

as shown in the above sketch. This forms a remarkably tight joint which offers considerable resistance to any tendency to blow out.

Lead Alloys. In some cases, where extremely high pressures are to be used, lead alloys have been used in place of commercial lead. The purpose in using an alloy is to get a material that is harder and consequently less liable to "flow" or flatten out if the pressure tends to blow the lead out of the joint. The City of Boston, after experimenting with different alloys for use in its high pressure fire fighting system, adopted one consisting of 96% lead, 2% tin and 2% antimony. It was found that this combination of metals gave a joint that calked relatively easily, was hard enough to resist blowing out and yet did not interfere with the flexibility of the joint. The manner of making this joint is similar to that of making the ordinary cast lead joint.

Lead Substitutes. Several kinds of self-calking substitutes for lead have been developed, some of which have been in service long enough to demonstrate that this type of material is well adapted for jointing purposes. The best known and oldest in common use is called "Leadite."

Pouring a Bell and Spigot Joint with Leadite

This material is a mixture of iron, sulphur, slag and other substances which, when melted and cooled, forms a hard slag-like mass. It is furnished in powdered form and is delivered in bags weighing 100 pounds. Less heat is required for melting it than in the case of lead and the best possible results are obtained when a gasoline fired furnace is used although the ordinary coal burning lead kettle can be used by taking care to avoid overheating.

In yarning the joint, it is important that a dry yarn be used and that the inside of the Bell and outside of the Spigot be thoroughly cleaned. The use of tarred or oiled yarn causes the inside of the joint to become oily and is very apt to result in a poor joint. Braided hemp is even better than ordinary yarn as a uniform thickness of joint is insured. The runner is placed in the usual manner and the pouring gate built up with clay to a height of from 6 inches to 8 inches above the top of the Bell. The manufacturers furnish cone-shaped metallic runner heads that can be used in place of clay for this high pouring gate. It is important that a high gate be used. The joint is now ready for pouring. The Leadite is at a proper temperature when it flows freely, reflects one's image as in a mirror and is free from foam or bubbles. If it is too hot or too cold it will be somewhat thicker than the required consistency and it should be either heated or cooled as the case may require before pouring. The joint should be poured from one ladle full until the joint and pouring gate are completely full. As soon as jointing material has cooled, the runner should be removed, the joint inspected and the runner head cut off. In case of a missed joint the material should be cut out for several inches and all loose material removed. The missed part is then re-run. The joint requires no calking and is ready for use as soon as it has cooled. It is characteristic of this joint to sweat or seep a little at first. This should not be a cause for worry as it takes up and is tight in a short time. The principal advantage of this type of joint is a saving in labor that results from the fact that no calking is necessary. There is also a saving due to the lower cost of material and to the fact that the bell holes may be considerably smaller as no room is necessary for swinging calking hammers.

Cement Joints. The use of cement for making joints in Cast Iron Pipe is fairly common practice in the gas industry and to a smaller extent for water distribution. A number of different schemes have been developed for making this type of joint, but the system described below seems to be the most common.

First of all the pipe should be properly supported before the joint is started so as to eliminate any possibility of movement of the pipe before the cement has set. The next step is to insert the yarn which has previously been dipped in a thin mixture of neat cement and water and to drive it home with hammers in the usual manner. Extreme care should be taken to be sure that the yarn is absolutely free from all oil and grease. Cement for the joint itself should be about ¾ cement to ¼ water and thoroughly mixed and kneaded by hand by workmen wearing rubber gloves while mixing the cement as well as while making up the joint. Experience shows that neat cement mixed with sufficient quantity of water and thoroughly kneaded in the hand to a consistency so that no moisture will show when squeezed tightly in the hand will give proper results. Cement mortar should be made up in small batches so that no mortar shall stand more than three minutes before using. A wooden or iron tool similar in shape to a yarning iron but with a broader face is used for ramming the mortar into the joint. The joint is then finished off with cement and a filet formed at the face of the bell.

In extremely hot weather it is necessary to protect the joint from the direct rays of the sun and the joint kept moist until set (about 48 hours). In cold weather care must be taken to prevent freezing of mortar both before and after the joint is made.

Rubber Rings for Bell and Spigot Gas Joints. In Germany, France and England, where experiences with vulcanized rubber in bell and spigot joints range over periods of fifty years or more, the reports dealing with their durability draw the interesting conclusion that gas will not destroy vulcanized rubber in such joints.

Mr. Walter Hole has proved in England by rather complete and scientifically conducted tests (*) that when a rubber ring is put into a bell and spigot gas joint and sealed up, its life is rendered indefinitely long because the ingredients in the gas, consisting of such materials as benzol, toluol, solvent naphtha, petroleum, etc., can do no more than cause the rubber ring to swell or "get fat" and thereby more completely shut off any leakage of gas through the joint.

Several special shapes or designs for these rubber rings have been devised to be used in bell and spigot joints in combination with lead and jute, with cement and jute, and with such special materials as leadite.

One of the biggest problems that the gas industry is facing is the problem of preventing leakage or unaccounted for gas in the distribution systems. The development of a suitable vulcanized rubber ring to be used in bell and spigot joints promises to solve this problem in the most

(*) See article by Mr. Walter Hole on "The Utility and Durability of Rubber as a Jointing Material for Gas Mains" in Gas Journal (London), November 21, 1923, pages 504 to 509.

economical way and without altering present pipe standards or methods of field construction. Moreover, tests have revealed that this method of making gas joints is equally efficient for high pressure distribution as well as for medium and low pressure distribution. This factor makes it possible to throw into service at any later date an existing low pressure distribution system converted to

Dresser Type Couplings on Small Pipe

an intermediate system or high pressure system without any material increase in leakage from the joints that have been constructed to serve for low pressures.

Coupled Joints. For connecting plain end pipe several types of couplings have been developed, the best known of which is the Dresser Coupling.

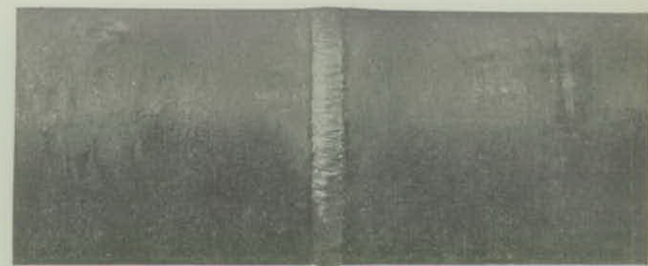
This coupling consists of two flanges, two gaskets, a middle ring and the necessary bolts. The gaskets are made of plain rubber for water and natural gas lines and of lead or duck tipped rubber for manufactured gas lines. The use of lead or duck is necessary to avoid deterioration of the rubber due to contact with drip oils.

In making the joint, a flange and a gasket are slipped over the ends of the pipe to be connected, the middle ring is then placed on the pipe already installed. The end of the length being laid is then inserted in the middle ring and the flanges with their gaskets are drawn up evenly. To insure uniform compression of the gasket, bolts diametrically opposite each other are drawn up a little at a time until all are drawn up to the limit. The best joint is obtained when two men work on opposite bolts, each drawing his up an equal amount. On small size pipe several lengths may be joined together on the bank before lowering into the trench. For large size pipe, the joint must be made in the ditch.

The advantages of this joint are flexibility, tightness, especially in the case of high pressure gas lines, and ability to withstand extremely high pressures in case of either gas or water. There is a saving in cost of pipe because the use of plain end pipe eliminates the extra metal in the bell.

Bronze Welded Joints. For high pressure gas distribution plain end pipe joined by a collar of tobin bronze may be used. With this type of joint expansion is usually taken care of by means of special couplings inserted at regular intervals.

The pipe ends are first thoroughly cleaned of all foreign matter and then butted together. The pipe is heated to a dull red and tack welded in two or three places. The permanent weld is put on proceeding in one direction around the pipe until the joint is completed. Care should be taken to avoid excessive heat as too much heat will burn out the zinc, leaving gas bubbles in the bronze, causing a spongy and leaky joint. Too much oxygen should also be avoided, a neutral flame being necessary in order to avoid oxidizing the zinc and weakening the joint. A small amount of bronze welding flux is required. This is



Bronze Welded Joint on Cast Iron Pipe

applied by dipping the heated bronze rod in the flux from time to time during the welding operation. The general appearance of the joint is rippled, as can be seen in the accompanying photograph.

Joints in Wet Ditches. In wet excavations, the different kinds of joints require that certain precautions be taken to insure first class work. In the case of cast lead and lead alloys, it is important that the water be kept pumped out until the joint is finished. If the yarn has become wet due to flooding of the trench or from water standing in the pipe, a small amount of kerosene poured into the joint prior to pouring the lead will do away with missed joints.

Lead wool joints can be made under water if necessary but even with this material it is advisable, wherever possible, to remove the water before making the joint. When it is impossible to pump out the water, as in the case of submarine lines, additional care is necessary because first it is more difficult to get the material itself to take a compact form when wet, and second, the unfavorable working conditions make first class work more difficult.

When making Leadite joints in wet trenches, the only precaution that should be taken is to leave a small opening at the bottom of the runner so that while the Leadite is being poured in it can force the water out. When Leadite starts to come through the opening in the bottom it should be stopped up with clay and the joint finished in the usual manner. Leadite can be poured into water without causing any explosion or disturbances.

In making up screwed joints or coupled joints in wet trenches, the only additional precaution necessary is to keep dirt out of the joint and to see to it that the workmen do not become careless in order to get through with the job.

Calking. The subject of calking has already been dealt with under lead and lead wool joints, but a little repetition may not be out of place. The best lead joint can only be obtained by carefully calking. In the case of cast lead, the shrinkage due to cooling causes the joint to open up around the circumference of the pipe, hence the necessity for calking. The depth to which calking is effective has been found to be about ¾ of an inch when calking is properly done. By proper calking is meant using each tool, beginning with the cold chisel and using each successive size until the one occupying the entire joint space is used. Slip-shod work consists in using only the large tools. This method finishes off the face of the joint so it looks smooth, but has little effect below the surface. Although a reasonably heavy blow is necessary to properly calk a joint, too great force is to be avoided as it is liable to result in split bells.

In the case of lead wool joints it is equally essential that each tool be used, and on each strand of the material. Failure to follow this method will result in small voids in the joint that will eventually develop into leaks. The use of air hammers is almost a necessity in the case of lead wool joints if first class work is to be expected. Their use on cast lead joints, particularly on large diameter pipe, is also recommended. On page 194 are shown typical calking tools for hand work.

Submarine Pipe Laying. In laying cast iron pipe lines under water, the type of joints to be used and the method of laying depend on the depth of the water, whether it is still or flowing, whether used for navigation or not, the nature of the bottom and other local conditions. It would be impossible in the short space allotted to this class of work to cover the method in detail, but a general outline will be given.

In shallow water it is often economy to construct coffer dams and, after pumping them out, to lay the pipe in the open just as on dry land. If the water is navigable the coffer dam should be constructed in sections, in order to provide a channel for boats. In still water the line may be laid on shore along the bank and floated by means of large barrels attached to the pipe. When the entire length of pipe has been put together and calked one end is towed out until the pipe occupies the line proposed. It is then lowered by releasing the barrels, care being taken during the sinking process so that the joints do not become distorted. This requires that barrels throughout the entire length be released at the same time. Coffer dams are then constructed at the shore ends and pipe connected up in the usual manner.

A somewhat similar method is to lay the pipe on the shore along a continuation of the proposed line and as each length is connected up to push it down skids into the water where barrels are attached to it. As each successive length is laid, the line extends further into the water. The finished line is sunk in the manner described above.

Another method is to drive piling in pairs along the proposed line and to lay the pipe on timbers supported between piles. When the entire line is connected up sills are laid across the top of the piles and pipe supported from the sills by means of chain hoists. The pipe is raised enough to release the platform upon which it was laid and then lowered gradually to the bottom of the water. It is not necessary that the entire line be lowered at once, but it should be lowered beginning at one end and proceeding to the other in such a way that the total deflection of the joints is kept down to about 2½ degrees.

Still another method is to join several lengths together on a barge, lower them into place by means of a derrick and make the joints between sections with lead wool, using a diver for the under water joints. In case it is not desirable to use lead wool, the end pipe in each section can be equipped with flanges and bell flange spigot pieces, the under water joint then becomes a matter of making up a flanged joint.

For large lines in deep water an excellent method is to provide a laying cradle having a curved shape so that its lower part is in contact with and parallel to the bottom and its upper part at an angle of about 60° to the surface of the water. After each length of pipe is installed, the barge carrying the cradle is moved forward and the next length connected up until the entire line is laid. The use of this method requires a special joint. This joint, known as the Narrows Syphon Type, has a general appearance of a ball and socket and permits of a considerable deflection without causing joint leaks. The surface of the spigot is machined accurately on a spherical surface and in the case of large pipe polished to a high degree. The joint is run in the usual manner and, after cooling, slugs of lead are introduced into the joint through holes in the bell and forced into it by means of screw plugs. Grease is forced into the joint at the same time that the lead pellets are.

In laying submarine lines the necessity for the use of flexible joints should be considered, and while many lines may be laid with ordinary joints, when there is likely to be considerable change in direction either during the laying of pipe or after it is laid, it is advisable to provide some flexible joints. This can be done by providing at intervals a length of pipe with a standard bell on one end and the flexible spigot on the other, the next pipe having a flexible bell and a standard spigot or, if preferable, flanged joints can be provided where the flexible joint is to be used and a flexible joint provided with flanges inserted at these points. Submarine lines should be covered over particularly where there is navigation.

Testing. The best modern practice requires that all pipe lines be tested before back-filling. This applies to both water and gas mains. In the case of water mains the test pressure should be equal to the pressure under which the line will be called upon to operate or, preferably, twice this amount. Care should be taken to see that all caps and plugs are properly braced before the test pressure is applied and that all piers and masonry supports at bends are in place.

In the case of water lines, before attempting to raise the pressure in the line under test, all air must be expelled. This is best done by opening a fire hydrant near the high point of the line and by opening a corporation cock that has previously been inserted at the high point in order to expel air in that portion of the pipe above the hydrant branch. When all of the air has been expelled, the valve or valves between the old part of the system and the line under test are closed. Pressure is then applied to the portion under test either by means of a hand pump in the case of small lines, or small sections of large lines, or by use of a gasoline pump or fire engine in the case of larger lines. In any event a displacement meter should be so located in the discharge from the pump that when the pressure is up to the stated point, all the water may be caused to pass through this meter. In this way the actual amount of water lost can be measured. While the pipe is under pressure it should be thoroughly inspected from one end to the other. This inspection should cover the pipe itself and all of the joints. Leaking joints can be made tight in the case of lead and lead wool by additional calking. In the case of lead substitutes the pipe is usually not tested for several days after pressure has been applied as it is known before hand that the joints will leak for a few days before taking up. After all leaks have been repaired the ditch should be back-filled.

In testing gas pipe air pressure is used and leaks are detected by applying soapsuds to each joint. In the case of leaks, bubbles will appear and the joint can be made tight by calking. As a rule in gas lines the actual leakage is not measured by a displacement meter, but the

Lugged Bends Reinforced with Masonry Piers

tightness of the pipe is determined by the fact that the pressure, when once built up remains stationary for a period of time.

Piers. Masonry piers should be constructed behind all bends, and in the case of large pipe behind caps and plugs. These piers should be designed to carry the load that will be imposed upon them with the pipe working under its maximum head and with a reasonable allowance for water hammer. They should bear, if at all possible, against undisturbed earth and, in case this is not possible, they should be made correspondingly larger due to poor bearing capacity of newly filled ground. The use of piers behind bends refers to bends in the vertical plane as well as those used in changing direction. These piers should be so designed that they will not interfere with recalking joints if such work should become necessary.

Back-Filling. One part of pipe line construction work that is given too little attention is that of back-filling. The old-fashioned idea of tossing the dirt into the trench and leaving nature take its course, is a prolific source of trouble. The ideal system is one that replaces the excavated earth in such a way that future settlement is reduced to a minimum. When a ditch is poorly back-filled the pipe is very often called upon to act as a beam in supporting material directly over it. This introduces stresses in the pipe itself and at the joints that may cause breakage of the pipe or undue deflection of the joint. As mentioned under the subject of excavation, the width of the trench should be such that back-filling can be done properly, that is, there should be enough room between the pipe and the sides of the ditch so that the material can be placed under the lower quarters of the pipe, and if the material is such that tamping is necessary, there should be sufficient room for this work. In the case of excavation in sand, back-filling can be done efficiently by the proper use of flooding, although even in this case some care is necessary to see that no voids are left beneath the pipe. After the material has been tamped up to about the center of the pipe, as far as the pipe itself is concerned, there is little trouble to be experienced as the remainder of the back-filling consists in merely filling the ditch. If the pipe, however, is in a city street or a travelled highway, the same care should be applied to the remainder of the trench as to the lower part. Some engineers require that the material shall be heaped over the trench to take care of a reasonable amount of settlement, while others claim that if back-filling is properly handled this is not necessary. All excess material should be removed in the case of pipe

Concrete Piers to Support Pipe Through Filled Ground

in city streets as soon as possible, as the mere laying of pipe is often an annoyance to the people on the street and any effort on the part of those installing the pipe to minimize this annoyance is effort well spent.

The suggestions for back-filling mentioned heretofore apply to the average pipe job, but there are special cases where special precautions must be taken. In filled ground and in swampy locations the best possible foundation is often so poor that it becomes advisable to use piers under each length of pipe, and this method should be followed rather than dependence placed on a material that obviously will not properly support the pipe.

In the case of rock excavation, the ditch should not be filled with the excavated material, as all subsequent work is made considerably harder and more expensive, and the possibility of danger to the pipe due to back-filling with

Valve Vault Under Construction

broken rock is so great that it becomes advisable to use other material. Sand, if available, forms the best material for back-filling trenches in rock. In case it becomes necessary to lay a cast iron pipe through cinders, slag piles, garbage dumps or other material that is highly corrosive, the best results can be obtained if the trench is back-filled with clay. Back-filling with the excavated material is bound to cause trouble eventually and while hauling clay for the work may be expensive, it adds to the life of the pipe and results in a better job.

Valve Basins, Vaults, Valve Boxes, Etc. There is a difference of opinion among waterworks men as to whether valve boxes or valve vaults should be used. The argument in favor of building a vault over each valve is that it makes it possible to repack the valve, to replace broken stems, and to do any other work that may be necessary on the valve without the necessity of making an opening in the street. In the case of valves located in parkways, these arguments do not hold, and there are some who claim that it is cheaper to use a valve box and, when repairs

Cutter for Cast Iron Pipe

become necessary, to make the necessary excavation. In any event, either a valve vault or a valve box should be so constructed as to insure speedy closing of the valve in the event of emergencies. The exact location should be noted on the distribution atlas.

Cutting Pipe. There are two general methods used for cutting cast iron pipe. One by the use of a pipe cutting machine of some kind and the other by the use of hammers, diamond points, chisels, etc. The ordinary wheel type of cutter is used for pipe up to about 16 inches in diameter. The operation of this type of cutter requires no particular explanation, nor is a great amount of skill necessary. For pipes above this size there are machines on the market that use a cutting tool (for making the cut) similar to the tools used in the ordinary machine shop. This machine is mounted on pipe concentrically and operated by means of crank handle, the feed being automatic. Cuts made with this machine are similar in nature to a cut made in a lathe and in addition to eliminating the possibility of a ragged cut or of cracking the pipe, this device makes it possible to salvage the cut piece. When pipe is cut by hand, a certain degree of skill and care is necessary. Small pipe can easily be cut by use of Cold Chisels and Hardys. The process consists in going around the pipe several times with the chisel and hammer until finally the piece breaks off. When cutting pipe in the trench or when cutting larger pipe on the bank, it becomes advisable to use a chisel with a diamond shaped point. This tool is used after the manner of a chisel, except that, due to its shape, it actually removes the iron in small chips instead of merely deforming it. After a groove has been completely cut around the pipe a hammer and chisels are used in much the same manner as when cutting pipe on the bank. It is possible, by striking hard blows with heavy hammers, to cause small cracks in the pipe that is being cut, which often do not show up for some time. Proper supervision should be exercised so that the pipe is not injured in the cutting process.

SECTION 11

SUBSTITUTES FOR CAST IRON PIPE

AT different times in the past there have appeared on the market various substitutes for bell and spigot cast iron pipe. Almost without exception manufacturers of these pipes have made no claim as to the superiority of their product over cast iron—their only claim has been that their product costs less. In speaking of cost, the figure that was stressed was the cost of the pipe—no attention was paid to the annual cost such as interest, sinking fund and maintenance. When annual costs have come in for consideration, the only salvation of the substitute pipe was to claim a long life for the material. This long life claim was enough in many instances to sell the first order of pipe, but in very few places was it considered when the second lot of pipe was bought. Some makers after experience had shown their product to be short-lived, attempted to hold their market by claiming that new methods of manufacture or new coatings had been developed that corrected the faults in the pipe that they had marketed previously. These claims worked in some cases, especially where the pipe was used in the installation of a new waterworks, where no local official had any experience with pipe of any kind. It is interesting to note that in very few if any cases where the substitute pipe has been replaced, anything but bell and spigot cast iron pipe has been considered for the replacement work.

The principal substitutes are wood pipe, steel pipe of various kinds, concrete pipe and cast iron pipe made by processes not conformable to the requirements of the standard specifications adopted by water works and gas associations.

Wood pipe for low heads is cheaper in the first cost than is cast iron. It fails, either by decay of the staves or by rusting out of the steel windings or bands that hold the staves together. After wood pipe had been in service long enough for these faults to develop, more rigid specifications concerning the stave material, steel banding and coatings were drawn up and enforced as far as possible. In spite of these rigid specifications failures have occurred repeatedly, and for water distribution purposes wood pipe is acknowledged to be only temporary and is not found where permanency is required.

Steel pipe, using various coatings, and manufactured by different processes, has been used somewhat spasmodically during the past forty years, and the consensus of opinion seems to be that the steel line is as good as its coatings, and that perfect coatings are still to be found. A small bubble or pin hole in the coating on the steel line will have the effect of concentrating corrosion at that point and will cause a pit to go through a pipe more quickly than if no coating had been used. Even where the greatest care is used in applying the coating the fact that the surface is certain to be marred in laying makes for the short life for steel pipe for underground use. Steel is readily attacked by soil corrosion and its thin shell is soon pierced by pits. Its life may be as much as thirty years under the most favorable conditions, and under unfavorable conditions may be as little as five years. Even if it were possible to lay a steel main so cheaply that it could be replaced at the end of a reasonable life (basing cost on present prices of labor and material) it would be doubtful economy. There comes a time in the life of a steel pipe when maintenance costs become so great as to make it economy to replace the line. Unfortunately experience has shown that the line is often kept in service after this point is reached, and that considerable money is spent in repairing leaks and in damage to pavements that would have been avoided had cast iron pipe been used in the initial installation. Furthermore, the loss of water represents a loss of money and possibly lack of pressure to the consumer. Oftentimes the line is such that the waterworks operators would hesitate to raise the pressure in order to make up for the losses in the line, with the result that there is a period during which poor water service is rendered, during times of ordinary draft and during times of fire the supply is totally deficient. As said before, even if the saving in the first cost of steel over cast iron pipe would replace the line at the end of a reasonable life, using present day costs, if the price of labor and material during the next thirty years should advance in any where near the same proportion that they did in the past thirty years, this would be far from holding true.

Concrete pipe lends itself to a limited use in waterworks construction work. For local distribution it is entirely unfitted and has been used to only a small extent for larger gravity flow lines, particularly lines that work under relatively low heads. Its particular disadvantages are difficulty of making repairs in the event of break, lack of uniformity in product due to the manufacturing methods and the human element, difficulty in getting tight joints, porousness, inability to make alterations readily and uncertain life.

As far as cast iron pipe manufactured by processes that have long since been abandoned by most of the waterworks pipe manufacturers, there is this much to be said: Prior to the time that the present day specifications were drawn up it was customary among all manufacturers of cast iron pipe to cast it on the flat or in an inclined position. It became evident to both the manufacturers and the users that these methods of casting were liable to cause the metal to be thick on one side of the pipe and thin on the other. This method of casting made it possible for the slag and impurities in the iron to collect in the wall of the pipe along top of the mold. For these reasons the present day specifications requiring that pipe shall be cast vertically in dry sand molds were drawn up. This method is now in common use and there are only a few makers of special type of pipe who cast their pipe in the old fashioned way.

Since the above was written, equipment has been developed for casting pipe horizontally which makes it possible to cast it in this way sufficiently uniform in thickness. New methods of gating, also, practically avoid the danger of slag and other impurities in the iron collecting in the wall of the pipe along top of the mold.

SECTION 12

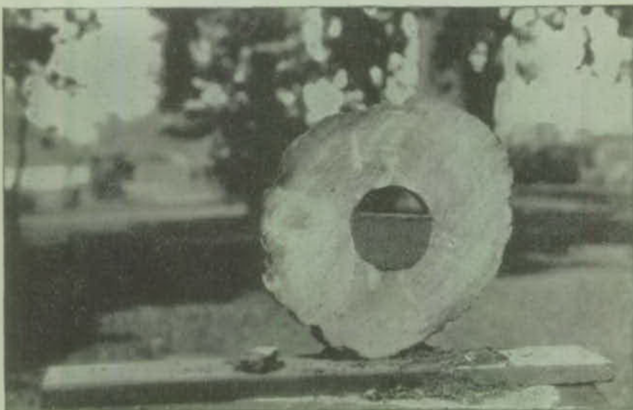
PREVENTION OF LOSS OF CARRYING CAPACITY IN WATER MAINS

THE almost universal adoption of cast iron pipe for water mains makes the loss in carrying capacity which occurs in metal pipes in some sections of the country an important problem to all water works men. It is well known that in some localities water mains have lost an appreciable part of their capacity in the course of time and, for this reason, consideration of the causes of this trouble and the remedies that may be applied is of great interest. Obviously, this loss in carrying capacity results in increased operating expense, either because it necessitates greater pumping pressures or because of the necessity for installing additional mains. There are in all, four causes for the loss in carrying capacity in water mains.

1. Sedimentation.
2. Animal or vegetable growth.
3. Mineral deposit.
4. Tuberculation.

These various deposits may occur at the same time in a line; in fact it has been stated that the presence of animal or vegetable organisms in a main hastens tuberculation. On the other hand, a mineral deposit in the line may actually act as a protection and effectively prevent any other form of incrustation.

Sedimentation. There are two distinct types of sedimentation. The first type is commonly known as "red mud" and it is the result of a considerable percentage of clay or iron in the water. This mud is distributed evenly all around the inside surface of the pipe and cuts down the carrying capacity both by the reduction in effective area and by the increased friction which results therefrom. The ordinary form of sedimentation is the result of turbid water and consists of a deposit of mud on the bottom of



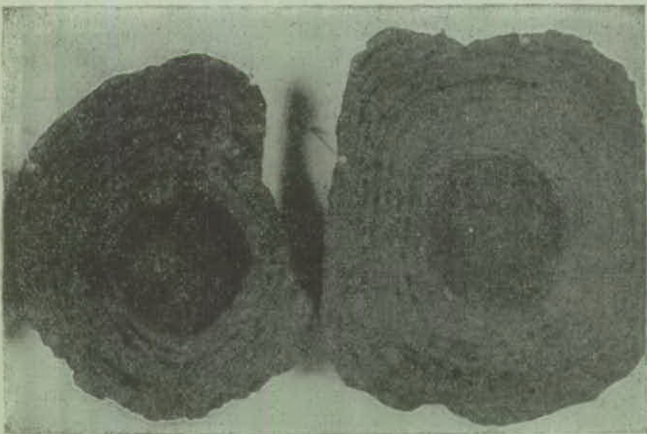
Sediment Almost Closing Old Wooden Mains

the pipe. This may cause serious trouble in cases where the deposit is heavy and may result in actually closing the pipe in low points along the line.

Animal or Vegetable Growth. The use of surface waters soft enough to make a satisfactory water supply often results in animal or vegetable growth on the inside of the pipe, although this trouble may also occur where ground water containing bacteria is used. One type of growth, pipe sponge, may be identified by a tendency for large masses to break away from the surface of the pipe and float in the supply, resulting in the stoppage of service pipes. Unfortunately, pipe coating does not prevent this trouble and some other remedy must be found. Investigations show that iron in solution in the water is necessary for the growth of the sponge and mechanical filtration as well as the use of lime water as a coagulant are valuable remedies. Pipe moss, although somewhat similar in form, is not as serious in that it adheres closely to the surface of the pipe and is not liable to result in the stoppage of services. Unfortunately, pipe moss cannot be removed by flushing the mains, a valuable remedy for the sponge, and cleaning is necessary to remove the moss.

Mineral Deposit. Wherever a water supply flows over lime stone or shale, the water is liable to take up some of the minerals, which are later deposited on the inside of the pipe. This trouble occurs to a noticeable extent in the Middle West where ground water is used without filtration. A similar deposit may be obtained where excess lime is used in the preparation of the water This trouble also occurs where the water supply contains a very high percentage of other mineral salts. However, on pipe of large diameters it has been found that this type of deposit is very smooth and does not increase the friction loss to any appreciable extent.

Tuberculation By far the most serious cause of loss of carrying capacity in water mains is tuberculation. This trouble results from the formation on the inside of the pipe of small knobs or buttons of rust known as tubercules. These may occur at widely separated points on the inside of the pipe or, in some cases, successive layers of tubercules may build up, resulting in the actual stoppage of small sized pipe. It would appear that tuberculation only forms at a point where there is some defect in the coating so that the water actually reaches the iron. Tuberculation is due principally to iron corrosion resulting from the presence of carbonic or some other acid in the water. Unfortunately, the waters which cause tuberculation are the desirable ones for household use, in that they are soft



Tubercules from a Steel Main Showing the Successive Layers of Growth

and low in total solids and alkalinity. Naturally a water of this kind contains more of the acids mentioned above.

It is interesting to note that this trouble is not limited to recent installations. In a book, "The Brooklyn Water Works," published in 1867, considerable attention is devoted to this question. However, even at that time it was known that tuberculation would not affect the purity of the water nor would it materially reduce the life of the pipe. Investigations show that the actual pitting on cast iron under the tubercules is almost negligible.

Prevalence. It is well to note that the troubles above are not by any means universal. For instance, tuberculation is not found to any noticeable degree on the Pacific Coast, except in the case of some snow waters. The water of the Great Lakes does not affect cast iron pipe, and many of the Great Lake cities have had no trouble of this nature in the many years that their lines have been in service. Another example is the Mississippi River, which shows very little action throughout its length although some of its tributaries are so turbulent that they cause a great deal of sedimentation The surface waters of the New England States, in all probability, cause most of the trouble which occurs in this country. In a discussion of this question at the American Water Works Association Convention in 1908 it was brought out that no surface water in that section is entirely free from some form of incrustation.

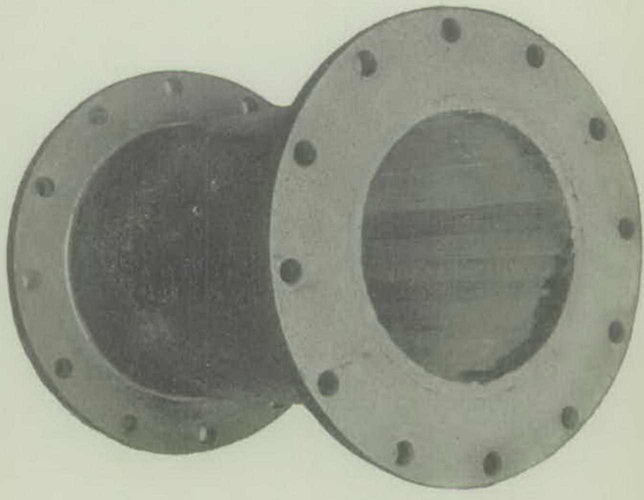
The trouble resulting from tuberculation is most serious on small pipe and several reasons have been advanced to account for this. It has been suggested that small pipe is used in general for distribution systems and, for this reason, the flow of water in the pipe is less uniform. Other writers suggest that the eddy currents in small pipe bring proportionately more water in contact with the iron. The logical suggestion seems to be, however, that tubercules of the same height as are found in large pipe may practically cut off the flow in a pipe of small diameter. It has been found that on large pipe tubercules grow to an inch or an inch and a half in height before their growth is arrested.

Remedies. Flushing mains is effective in improving the carrying capacity with some forms of incrustations. It is uniformly effective in the case of sedimentation, and with some types of animal or vegetable growth. In flushing mains it is customary to open several hydrants at a time, starting near the pumping plant and working out into the distribution system. The most satisfactory method is to start with the three hydrants next to the pumping plant open and as the first hydrant is closed opening the fourth hydrant on the line, continuing to work away from the pumping plant. In this way the sediment is blown out of the line and away from the pumping plant.

For tuberculation and the harder forms of incrustation the only remedy is cleaning the mains. Cleaning cast iron mains consists of inserting the scraper into the pipe, this machine is carried through the line and cuts the tubercules from the surface. The section to be cleaned is cut off from the main pipe system and a cut is made in the pipe at each end to receive the cleaner. One end of the line is sleeved after the cleaner is inserted and the pressure is turned on behind the machine. Once started the cleaner moves from three to four feet per second, coming out in the open end of the section and bringing with it all sediment and tubercules. Where the pressure is very low it may be necessary to pull the cleaner through the line with a cable. Cleaning not only removes the incrustation but any tools or foreign matter which may have been left in the pipe during construction. The method of cleaning mains discussed above has been in use for twenty-five years, and in many instances has been very successful, resulting in from fifteen per cent. to eighty per cent. improvement in the carrying capacity of the line.

Unfortunately the passage of the cleaner may injure the coating to some extent and in a few localities it has been found that tuberculation occurs very rapidly following cleaning.

Prevention. Tuberculation in cast iron water pipe may be prevented by improvement in coating, and where



Wood Lined Cast Iron Flanged Pipe

trouble is expected it will probably pay to cover the pipe with some of the patented coatings now on the market. Unfortunately, most of the processes used for purification will not help in preventing the troubles we have mentioned although excess liming may eliminate tuberculation to a marked degree. The only definite prevention which has been offered is the use of cement lined cast iron pipe.* This material combines maximum carrying capacity with the great durability found in cast iron pipe.

For conveying very corrosive liquids cast iron pipe may be lined with wood. This type of installation has found favor with the coal companies where the water may have a high percentage of sulphur, forming a corrosive acid. For the average installation cement lined cast iron pipe is not only cheaper but more satisfactory than the wood lined pipe.

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*See page 243.

SECTION 13

CEMENT LINED PIPE

WHEN very soft waters are conveyed through iron pipes that are either uncoated or have a defective coating, nodules of rust will form on the walls of the pipe. Waters sufficiently soft to cause severe tuberculation are comparatively rare and are found principally in the East. In severe cases these rust nodules may finally reduce the carrying capacity of the pipe to such an extent that pressures are seriously affected. For their growth it is essential that the organisms causing the nodules or tubercules come in direct contact with the iron, and coatings, to be effective against tuberculation, must be free from even the smallest pin-holes. Tar coatings as now applied to cast iron pipe will prevent formation of tubercules except under the most severe conditions. Where these conditions exist a coating of Portland cement mortar has been found to be the most effective preventative.

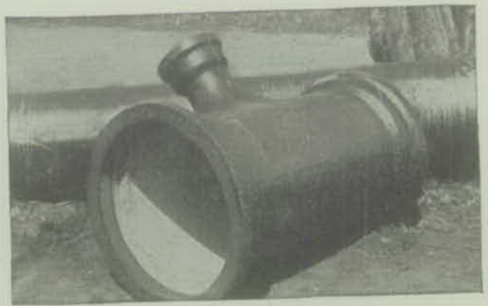
Cement coatings have been in use for a number of years. The earliest were made of natural cement mortar and were applied to sheet metal pipes. These pipes fulfilled the expectation of their makers in that tuberculation was prevented, but, due to the rusting out of the steel and wrought sheets, the pipe failed in a relatively short time. In 1921 cement lining was first applied to cast iron pipe. The method of application was rather crude and consisted in standing the pipe on end, inserting a "bullet" to which a rope was attached, pouring in sufficient mortar for the coating, and withdrawing the "bullet." As the "bullet" was withdrawn it spread the cement mortar fairly evenly over the walls of the pipe. The lining as applied by this process was usually from 3/16" to 1/4" in thickness. The pipe so manufactured were installed and the carrying capacity measured immediately after installation and again after the pipe had been in service one year. These tests were carried out at Charleston, South Carolina, where tuberculation conditions are unusually severe. The co-

Cement Lined Pipe Cut in the Field, Showing the Adherence of Cement

efficient for the pipe when first laid was 135 and one year afterward was 128, under conditions where the ordinary pipe would have a co-efficient in the neighborhood of 100.

After these first lines were laid and proved successful, the method of lining the pipe was studied and improved upon. The method now used (and required by standard specifications) is to apply the lining centrifugally. In general, the process consists in supporting the pipe horizontally on rollers, inserting a trough full of cement mortar, overturning the trough, revolving the pipe at a peripheral speed of 300′ per minute until the mortar is evenly spread, increasing the speed to 600′ per minute, and finally curing the coating.

The lining applied by the centrifugal method is very dense and has a porcelain-like surface. It adheres to the iron so tenaciously that the pipe can be cut or tapped



Cement Lined Tee

without danger of breaking off the coating adjacent to the cut or to the tap hole. The smooth surface makes for a high co-efficient, and due to the complete elimination of tuberculation, this high co-efficient is maintained throughout the life of the pipe.

The standard specifications for cement lined cast iron pipe are as follows:

Standard Specifications for Cement Lining Cast Iron Pipe and Fittings

Adopted August, 1925.

Cement

The cement used for making the mortar shall be standard Portland cement, complying in all respects with the requirements of the specifications of the American Society for Testing Materials.

Sand

Sand used for the mortar shall be clean, free from organic matter, loam and other foreign material. It shall be screened before mixing with the cement through a screen having a mesh of not coarser than 12 to 1 inch.

Proportions

The mortar used for lining the pipe shall be mixed in approximately the proportions of one part of screened sand to three parts Portland cement by volume. Cement mortar shall be thoroughly mixed, preferably in a power mixer, only sufficient water being added to it to permit of deposition and properly distributing it in the pipes to be coated. The mortar, after mixing, shall be used promptly for lining the pipe, and no mortar that has attained its initial set shall be used.

Preparation of Pipe for Lining

The pipe shall not be coated on the inside with tar or any asphaltic product, but the interior surface shall be thoroughly cleaned of core sand, mud, grease or other foreign matter, leaving a clean iron surface on which the cement lining is to be applied. Before lining, the pipe shall be hydrostatically tested.

Method of Applying Lining

The lining shall be applied to the interior surface of the cast iron pipe centrifugally. The mortar shall be spread evenly over the inner surface of the pipe by mechanical means while the pipe is being revolved at a peripheral speed of about 300 feet per minute. The pipe shall then be allowed to come to rest and a careful examination made for uniformity of lining. Any bare spots may be covered with mortar. The pipe shall then be immediately revolved at a peripheral speed of 600 feet per minute for a sufficient length of time to obtain a smooth interior surface, due care being taken to avoid the separation of the ingredients. The bottom of the bell and the end of the spigot may be covered with mortar by applying with a brush. All mortar shall be removed from the interior surface of the bell, except as above noted.

Outside Coating

If desired, the pipe may be coated outside with tar or asphaltic coating, brushed or sprayed on.

Lining Fittings

The interior surface of the fittings shall be lined by applying the cement mortar with a brush, uniformly and evenly, after which the fitting is to be jarred by rapping it with a hammer until a smooth surface of the lining is secured.

Thickness of Lining

The standard average thickness of lining for various sizes shall be as follows:

Nominal Size of Pipe.	Thickness of Cement Lining.
4-inch and smaller	$\frac{1}{16}$ of an inch
6-inch	$\frac{1}{16}$ of an inch
8-inch	$\frac{1}{8}$ of an inch
10-inch	$\frac{1}{8}$ of an inch
12-inch	$\frac{1}{8}$ of an inch
16-inch	$\frac{1}{8}$ of an inch
18-inch	$\frac{3}{16}$ of an inch
20-inch	$\frac{3}{16}$ of an inch
24-inch	$\frac{3}{16}$ of an inch

A tolerance of $\frac{1}{32}$ of an inch in thickness shall be permitted on 4-inch and 6-inch pipe, and a tolerance of $\frac{1}{16}$ of an inch permitted on pipe from 8 inches to 24 inches in diameter.

Curing Cement Lining

The cement lined pipe shall be immediately protected in a suitable manner from the direct rays of the sun. To prevent too rapid drying, suitable means shall be provided to keep lining damp for a period of at least 24 hours. During this period, when lining is sufficiently set, it shall be thoroughly wet down. In cold weather proper precaution shall be taken to prevent freezing.

No pipe shall be shipped until the lining is thoroughly hard and in no case shall shipment be made in less than 48 hours.

SECTION 14

TABLES OF FLOW OF WATER THROUGH CAST IRON PIPE

SECTION 14

FLOW TABLES

In attempting to compute the capacity of a pipe line or to figure the probable loss in head, after the pipe has reached a certain age, it is absolutely essential to know something about the water to be conveyed. In most cases the quality of the water is such that the carrying capacity is affected very little by the age of the pipe. In other cases, the water may be so soft as to cause tuberculation and consequent loss in carrying capacity or so turbid as to cause deposits of sand or mud with the same effect. Waters that cause tuberculation are the rare exception and outside of a few raw water conduits, muddy water is also unusual.

In spite of this fact, many of the books and articles on hydraulics and water supply, make the bold statement that a definite correction factor must be applied to flow formulae as the pipe increases in age. It is evident that this is incorrect, since first of all a large number of experiments have been made that show quite definitely that in many places, there is no change whatever in carrying capacity with age. Secondly, assume that a layer of tubercles 2 inches thick are produced as a result of many years use of a pipe, it is evident that the carrying capacity of a 12 inch pipe would be considerably more reduced than would a 48 inch pipe with the same thickness of tubercles, a fact that is not taken into consideration in the formulae in common use.

In presenting the flow tables, that follow, we are giving the values for new pipe. In most cases, it can be told beforehand whether or not the water to be conveyed will cause tuberculation. If tuberculation is not to be expected, ordinary Cast Iron Pipe should be used and the carrying capacity figured as shown in the tables. If it is known beforehand, the water is of such a nature as to cause tuberculation, cement lined Cast Iron Pipe should be used and, as in previous case, the tables used without any correction factor.

The following tables represent the Flow of Water through Clean Cast Iron Pipe computed by the Formula derived after careful investigation by Edward Wegmann, C. E.[1] and Albert N. Aeryns, C. E.[2] The Wegmann-Aeryns Formula, which appeared in the Engineering News-Record for July 16, 1925, is as follows:

$$V = 182.5 \quad R^{0.723} \quad S^{0.539}$$

in which

V = Velocity in feet per second
R = Hydraulic radius in feet
S = Slope of the hydraulic gradient, or loss of head in feet per foot of pipe.

It should be remembered that the "loss of head," or friction head, given in feet per thousand feet of length, is also the fall in feet per thousand (the slope) required to produce the given velocity in pipe of the diameter given. The following examples illustrate the various uses of the table:

EXAMPLE 1. MAXIMUM DELIVERY

To find the maximum delivery of an 8-inch pipe, 7,500 feet long under 150 foot head. The available head per thousand feet is 150+7.5=20 feet per thousand. The table for 8-inch pipe, under "loss of head," shows that for a loss of head of 15.7 feet per thousand the corresponding delivery at velocity of 5.32 feet per second is 1,200,000 gallons per day; the approximate value for a loss of 20 feet may then be calculated by interpolation.

EXAMPLE 2. DETERMINATION OF DIAMETER

To find diameter of pipe necessary to deliver 3,000,000 gallons per day through a line 25,000 feet long under 150 foot head. The available head per thousand feet is 150÷25=6 feet per thousand. Reading across table from discharge of 3,000,000 gallons, at the left, the first

[1] Consulting Engineer, New York City.
[2] Associate in Sanitary Engineering, Polytechnic Institute, Brooklyn, N. Y.

"loss of head" of 6 feet or less per thousand is 5.1 under 14-inch pipe. Hence the least diameter which will answer in regular commercial sizes is 14 inches.

EXAMPLE 3. FRICTION LOSS

To find loss of head through a 10-inch line, 4,000 feet long delivering 1,000 gallons per minute. The table shows "loss of head" in a 10-inch pipe delivering 972 gallons per minute to be 6.8 feet per 1,000 feet of length; hence in 4,000 feet the loss will be 27.2 feet. If the water is delivered at a point 100 feet above pump, the total head pumped against is 100 feet (static) plus 27.2 feet (friction), or 127.2 feet total.

EXAMPLE 4. DELIVERY DETERMINED FROM PRESSURE REDUCTION

Two accurate pressure gauges should be placed at a known distance apart, and measurement made of the difference in elevation of the points where readings are taken; thus, if in a 12-inch pipe the gauges are 500 feet apart and show a difference in pressure of 2 pounds (4.6 feet) while one gauge is 1.8 feet above the other, the actual loss of head will be 4.6 plus or minus 1.8=6.4 or 2.8 feet per 500 feet, or 12.8 or 5.6 teet per thousand feet. In the table for 12-inch pipe we find that a loss of head of 5.2 feet per thousand is due to velocity of 3.94 corresponding to discharge of 2,000,000 gallons per day.

EXAMPLE 5

To find the pressure at any point in a water main when diameter, rate of delivery and static head are known. Assume that 1,200,000 gallons per day are to be pumped through 5,000 feet of 12-inch pipe laid on an incline to a total vertical height of 100 feet and that it is desired to learn the pressure in the pipe at each 1,000 feet from the pump. At the given delivery the loss of head in a 12-inch pipe is 2.0 per 1,000 feet or 10.0 for 5,000 feet; to this is added the static head, making total of 110. feet. The drop in pressure for each 1,000 feet will then be one-fifth of this quantity or 22 feet.

FLOW OF WATER IN CAST IRON PIPE

Frictional Heads, per Thousand Feet, at Given Rates of Discharge

Discharge Gals. per Minute	Discharge Gals. per 24 Hours	4" Pipe		6" Pipe		8" Pipe	
		Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe
35	50,000	0.89	1.4				
69	100,000	1.78	5.2	.79	0.7		
104	150,000	2.68	11.0	1.18	1.4		
139	200,000	3.56	18.7	1.58	2.4	.89	.6
153	220,000	3.91	22.3	1.73	2.9	.98	.7
167	240,000	4.27	26.2	1.89	3.4	1.06	.8
181	260,000	4.63	30.4	2.05	3.9	1.15	.9
194	280,000	4.99	34.9	2.21	4.5	1.24	1.1
208	300,000	5.34	39.7	2.36	5.1	1.33	1.2
243	350,000	6.23	52.9	2.76	6.8	1.55	1.6
278	400,000	7.12	67.7	3.15	8.7	1.77	2.0
312	450,000	8.00	84.2	3.55	10.9	1.99	2.5
347	500,000	8.90	102.0	3.94	13.2	2.22	3.1
417	600,000	10.68	144.0	4.73	18.5	2.66	4.3
486	700,000			5.52	24.7	3.10	5.8
556	800,000			6.30	31.6	3.55	7.4
625	900,000			7.09	39.3	3.99	9.2
694	1,000,000			7.89	47.8	4.43	11.2
833	1,200,000			9.46	67.0	5.32	15.7
972	1,400,000					6.20	20.8
1111	1,600,000					7.09	26.7
1250	1,800,000					7.98	33.2
1389	2,000,000					8.86	40.4
1528	2,200,000					9.75	48.2

Tables of Flow of Water through Clean Cast Iron Pipe Computed by the Wegmann-Aeryns Formula published in the Engineering News-Record, July 16, 1925.

FLOW OF WATER IN CAST IRON PIPE (continued)

Frictional Heads, per Thousand Feet, at Given Rates of Discharge

Discharge Gals. per Minute	Discharge Gals. per 24 Hours	10″ Pipe		12″ Pipe		14″ Pipe	
		Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe
174	250,000	0.71	0.3	0.49	0.1		
208	300,000	0.85	0.4	0.59	0.2		
243	350,000	0.99	0.5	0.69	0.2	0.51	0.1
278	400,000	1.13	0.7	0.79	0.3	0.58	0.1
312	450,000	1.28	0.8	0.89	0.3	0.65	0.2
347	500,000	1.42	1.0	0.99	0.4	0.72	0.2
417	600,000	1.70	1.4	1.18	0.6	0.87	0.3
486	700,000	1.99	1.9	1.38	0.8	1.01	0.3
556	800,000	2.27	2.4	1.58	1.0	1.16	0.4
625	900,000	2.55	3.0	1.77	1.2	1.30	0.5
694	1,000,000	2.84	3.6	1.97	1.4	1.45	0.7
833	1,200,000	3.40	5.1	2.36	2.0	1.74	0.9
972	1,400,000	3.97	6.8	2.76	2.7	2.02	1.2
1111	1,600,000	4.54	8.7	3.15	3.4	2.32	1.6
1250	1,800,000	5.11	10.7	3.55	4.3	2.60	2.0
1389	2,000,000	5.67	13.1	3.94	5.2	2.90	2.4
1528	2,200,000	6.24	15.6	4.33	6.2	3.18	2.9
1667	2,400,000	6.81	18.4	4.73	7.3	3.48	3.4
1806	2,600,000	7.38	21.3	5.12	8.5	3.76	3.9
1944	2,800,000	7.94	24.4	5.52	9.7	4.05	4.5
2083	3,000,000	8.51	27.8	5.91	11.0	4.35	5.1
2222	3,200,000	9.08	31.3	6.30	12.5	4.63	5.7
2361	3,400,000	9.65	35.0	6.70	14.0	4.92	6.4
2500	3,600,000			7.09	15.5	5.21	7.1
2639	3,800,000			7.48	17.2	5.50	7.9
2778	4,000,000			7.88	18.8	5.79	8.7
2917	4,200,000			8.28	20.6	6.08	9.5
3056	4,400,000			8.67	22.5	6.37	10.3
3194	4,600,000			9.06	24.4	6.66	11.2
3333	4,800,000			9.45	26.4	6.95	12.1
3472	5,000,000			9.85	28.5	7.24	13.1

FLOW OF WATER IN CAST IRON PIPE (continued)

Frictional Heads, per Thousand Feet, at Given Rates of Discharge

Discharge Gals. per Minute	Discharge Gals. per 24 Hours	16″ Pipe		18″ Pipe		20″ Pipe	
		Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft of pipe
347	500,000	0.55	0.09	0.44	0.05		
417	600,000	0.66	0.13	0.52	0.07		
486	700,000	0.77	0.17	0.61	0.10		
556	800,000	0.89	0.22	0.70	0.12		
625	900,000	1.00	0.28	0.79	0.15		
694	1,000,000	1.11	0.34	0.88	0.19	0.71	0.11
833	1,200,000	1.33	0.47	1.05	0.26	0.85	0.15
972	1,400,000	1.55	0.63	1.23	0.35	0.99	0.20
1111	1,600,000	1.77	0.80	1.40	0.44	1.13	0.26
1250	1,800,000	1.99	1.00	1.57	0.55	1.28	0.32
1389	2,000,000	2.22	1.22	1.75	0.67	1.42	0.39
1528	2,200,000	2.44	1.45	1.93	0.80	1.56	0.47
1667	2,400,000	2.66	1.71	2.10	0.94	1.70	0.55
1806	2,600,000	2.88	1.98	2.28	1.09	1.84	0.64
1944	2,800,000	3.10	2.28	2.45	1.26	1.99	0.74
2083	3,000,000	3.32	2.59	2.63	1.42	2.13	0.84
2222	3,200,000	3.55	2.91	2.80	1.61	2.27	0.94
2361	3,400,000	3.77	3.26	2.98	1.80	2.41	1.05
2500	3,600,000	3.99	3.63	3.15	2.00	2.55	1.17
2639	3,800,000	4.21	4.01	3.33	2.21	2.70	1.30
2778	4,000,000	4.43	4.41	3.50	2.43	2.84	1.43
3472	5,000,000	5.54	6.67	4.38	3.68	3.55	2.16
4167	6,000,000	6.65	9.35	5.25	5.16	4.26	3.03
4861	7,000,000	7.76	12.50	6.13	6.87	4.96	4.03
5556	8,000,000	8.86	16.00	7.01	8.80	5.67	5.17
6250	9,000,000	9.97	19.80	7.88	10.90	6.38	6.43
6944	10,000,000	11.08	24.10	8.76	13.30	7.09	7.82
7639	11,000,000	12.19	28.80	9.63	15.80	7.80	9.33
8333	12,000,000	13.30	33.80	10.51	18.70	8.51	11.00
9028	13,000,000					9.22	12.70
9722	14,000,000					9.93	14.60

FLOW OF WATER IN CAST IRON PIPE (continued)

Frictional Heads, per Thousand Feet, at Given Rates of Discharge

Discharge Gals. per Minute	Discharge Gals. per 24 Hours	24" Pipe		30" Pipe		36" Pipe	
		Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe
1389	2,000,000	0.98	0.16				
2083	3,000,000	1.48	0.33	0.94	0.11		
2778	4,000,000	1.97	0.57	1.26	0.18	0.88	0.07
3472	5,000,000	2.46	0.86	1.57	0.28	1.09	0.11
4167	6,000,000	2.96	1.21	1.89	0.39	1.31	0.16
4861	7,000,000	3.45	1.60	2.20	0.52	1.53	0.21
5556	8,000,000	3.94	2.06	2.52	0.66	1.75	0.27
6250	9,000,000	4.43	2.56	2.84	0.83	1.97	0.33
6944	10,000,000	4.92	3.11	3.15	1.01	2.19	0.40
7639	11,000,000	5.42	3.71	3.47	1.20	2.41	0.48
8333	12,000,000	5.91	4.36	3.78	1.41	2.63	0.56
9028	13,000,000	6.40	5.06	4.10	1.64	2.85	0.65
9722	14,000,000	6.89	5.81	4.41	1.88	3.06	0.75
10420	15,000,000	7.39	6.60	4.73	2.14	3.28	0.85
11110	16,000,000	7.88	7.44	5.04	2.41	3.50	0.96
11810	17,000,000	8.37	8.32	5.36	2.69	3.72	1.07
12500	18,000,000	8.86	9.26	5.67	3.00	3.94	1.20
13190	19,000,000	9.36	10.20	5.99	3.32	4.16	1.32
13890	20,000,000	9.85	11.30	6.30	3.65	4.38	1.45
15280	22,000,000	10.80	13.40	6.93	4.35	4.82	1.73
16670	24,000,000	11.80	15.80	7.56	5.12	5.25	2.04
18060	26,000,000	12.80	18.30	8.20	5.93	5.69	2.36
19440	28,000,000	13.80	21.00	8.83	6.81	6.13	2.71
20830	30,000,000					6.57	3.08
24310	35,000,000					7.66	4.10
27780	40,000,000					8.76	5.25

FLOW OF WATER IN CAST IRON PIPE (continued)

Frictional Heads, per Thousand Feet, at Given Rates of Discharge

Discharge Gals. per Minute	Discharge Gals. per 24 Hours	42" Pipe		48" Pipe		54" Pipe	
		Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe
2431	3,500,000	0.56	0.03				
2778	4,000,000	0.64	0.03				
3125	4,500,000	0.72	0.04				
3472	5,000,000	0.80	0.05	0.62	0.03	0.48	0.01
4167	6,000,000	0.96	0.07	0.74	0.04	0.58	0.02
4861	7,000,000	1.13	0.09	0.86	0.05	0.68	0.03
5556	8,000,000	1.29	0.12	0.98	0.06	0.78	0.03
6250	9,000,000	1.45	0.15	1.10	0.08	0.88	0.04
6944	10,000,000	1.61	0.18	1.23	0.09	0.97	0.05
7639	11,000,000	1.77	0.22	1.35	0.11	1.07	0.06
8333	12,000,000	1.93	0.26	1.48	0.13	1.17	0.07
9028	13,000,000	2.09	0.30	1.60	0.15	1.27	0.08
9722	14,000,000	2.25	0.34	1.72	0.18	1.36	0.10
10420	15,000,000	2.41	0.38	1.84	0.20	1.46	0.11
11110	16,000,000	2.57	0.44	1.97	0.22	1.56	0.12
11810	17,000,000	2.73	0.49	2.09	0.25	1.66	0.14
12500	18,000,000	2.89	0.55	2.22	0.28	1.75	0.15
13190	19,000,000	3.05	0.61	2.34	0.31	1.85	0.17
13890	20,000,000	3.22	0.67	2.46	0.34	1.95	0.19
15280	22,000,000	3.54	0.79	2.71	0.40	2.14	0.22
16670	24,000,000	3.86	0.93	2.96	0.48	2.33	0.26
18060	26,000,000	4.18	1.08	3.20	0.55	2.53	0.30
19440	28,000,000	4.50	1.24	3.45	0.63	2.72	0.35
20830	30,000,000	4.82	1.41	3.69	0.72	2.92	0.40
24310	35,000,000	5.63	1.88	4.31	0.96	3.40	0.53
27780	40,000,000	6.44	2.41	4.92	1.23	3.89	0.68
34720	50,000,000	8.04	3.65	6.16	1.86	4.86	1.02
41670	60,000,000	9.65	5.11	7.39	2.61	5.84	1.44
48610	70,000,000			8.62	3.47	6.81	1.91

FLOW OF WATER IN CAST IRON PIPE (continued)
Frictional Heads, per Thousand Feet, at Given Rates of Discharge

Discharge Gals. per Minute	Discharge Gals. per 24 Hours	60″ Pipe		72″ Pipe		84″ Pipe	
		Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe	Velocity ft. per Second	Loss of Head ft. per 1000 ft. of pipe
5556	8,000,000	0.63	0.02				
6250	9,000,000	0.71	0.02				
6944	10,000,000	0.79	0.03				
7639	11,000,000	0.87	0.04				
8333	12,000,000	0.95	0.04				
9028	13,000,000	1.03	0.05				
9722	14,000,000	1.10	0.06	0.77	0.02		
10420	15,000,000	1.18	0.06	0.82	0.02		
11110	16,000,000	1.26	0.07	0.88	0.03		
11810	17,000,000	1.34	0.08	0.93	0.03		
12500	18,000,000	1.42	0.09	0.98	0.04		
13190	19,000,000	1.50	0.10	1.04	0.04		
13890	20,000,000	1.58	0.11	1.09	0.04		
15280	22,000,000	1.73	0.13	1.20	0.05		
16670	24,000,000	1.89	0.15	1.31	0.06		
18060	26,000,000	2.05	0.18	1.42	0.07		
19440	28,000,000	2.21	0.20	1.53	0.08		
20830	30,000,000	2.36	0.23	1.64	0.09	0.78	0.04
24310	35,000,000	2.76	0.31	1.92	0.13	0.91	0.06
27780	40,000,000	3.15	0.40	2.19	0.16	1.04	0.07
31250	45,000,000	3.55	0.49	2.46	0.20	1.17	0.09
34720	50,000,000	3.94	0.60	2.74	0.24	1.30	0.11
41670	60,000,000	4.73	0.84	3.28	0.34	1.56	0.15
48610	70,000,000	5.52	1.12	3.83	0.45	1.82	0.20
55560	80,000,000	6.30	1.44	4.38	0.57	2.08	0.26
62500	90,000,000	7.09	1.79	4.92	0.71	2.34	0.33
69440	100,000,000	7.88	2.18	5.47	0.87	2.60	0.40
83330	120,000,000	9.46	3.05	6.57	1.22	3.12	0.56
97220	140,000,000			7.66	1.62	3.64	0.74
111100	160,000,000			8.76	2.07	4.16	0.95
125000	180,000,000					4.68	1.18
138900	200,000,000					5.20	1.44
152800	220,000,000					5.72	1.72
166700	240,000,000					6.24	2.02
180600	260,000,000					6.76	2.34

SECTION 15

THE ELECTROLYSIS OF UNDERGROUND PIPE LINES AND ITS MITIGATION

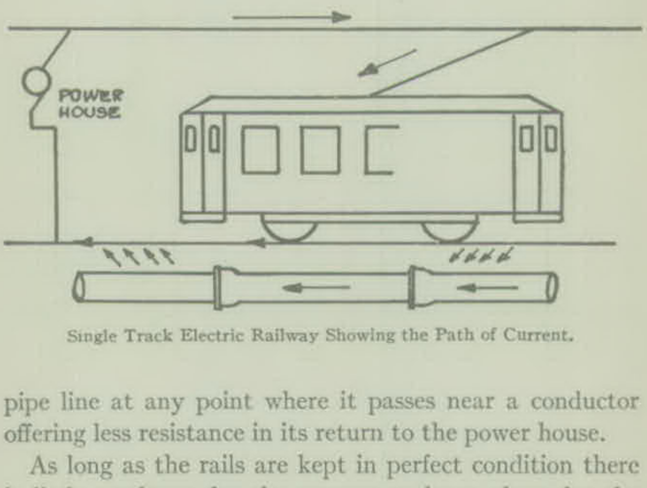
ONE problem which may confront the engineer in charge of a pipe line is the prevention or mitigation of damage to the pipe due to stray electric currents in the ground. This trouble may occur where the pipe line at some point in its length passes near the rails of an electric railroad, and the prevalence of electrolytic corrosion has naturally increased with the growth of the street railway systems in this country. These roads use their tracks to carry the current which runs their cars back to the power house, and where these tracks are not kept in perfect condition a portion of this return current finds its way into the ground. If the various networks of pipe, which are so important to the life of the people of our cities, offer a path for this current it is natural that some of this stray current is carried by the pipe. At points where this current leaves the pipe there is serious danger from electrolysis, and as each ampere of current may remove from the pipe twenty pounds of iron in one year, should even a small amount of current be discharged from a limited area, the pipe will be badly damaged.

Unfortunately it is not always possible to tell from the condition of the pipe whether the trouble is electrolysis or due to some other form of corrosion. In some instances elaborate electrolysis surveys are necessary to determine whether the cause of the trouble to the whole pipe system is electrolytic. Damage to pipe at any particular point may be shown by means of the Earth Current Meter, which measures the direction and approximate magnitude of a current entering upon or leaving a pipe line. Generally speaking, if the trouble is concentrated near the power stations of the street railway or occurs directly under a track leading to the power house, readings should be made with this instrument. Although most sections of the country are practically free from electrolysis troubles, in view of its importance in certain places it is worthy of some consideration here.

Many of the electric companies recognize their responsibility in this matter and we find that in some cities agreements have been signed between interested parties in which the electric railway company assumes the responsibility for damage by electrolysis where proven. Even where such agreements do not exist the courts have in certain instances ruled that it is the duty of the railway companies to keep their tracks in good condition so as to minimize the trouble.

Methods of entirely eliminating electrolysis generally necessitate elaborate changes in the railway system that are either expensive to install or costly to operate. There are, however, certain steps that the railroad company can take at a minimum of expense which are valuable in reducing electrolysis in underground mains to a minimum, and if co-operation between the two utilities has been established these steps are usually available.

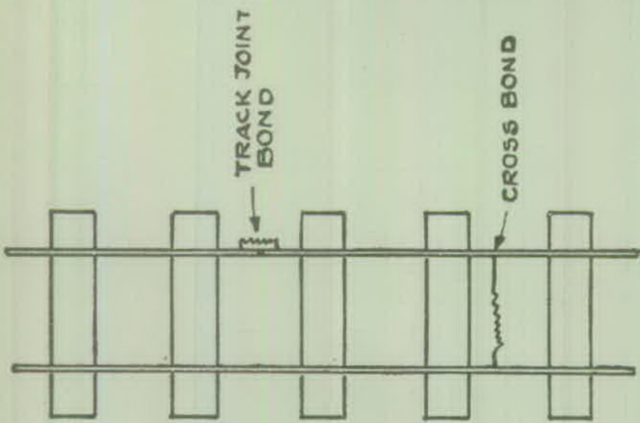
In the figure following, the path of current in the usual type of electric railway is shown diagrammatically. The current leaves the power house on the overhead wire, passes through the motors on the car and returns through the tracks to the power house. If the tracks offer much resistance to the flow of current an excessive amount of it leaks off the line and travels through the ground. If there is in the ground some good conductor of electricity, such as a pipe line, part of the current takes this easier path, leaving the pipe for the rails as it nears the power house. It is at this point that the greatest amount of trouble occurs, although part of the current will leave the



Single Track Electric Railway Showing the Path of Current.

pipe line at any point where it passes near a conductor offering less resistance in its return to the power house.

As long as the rails are kept in perfect condition there is little tendency for the current to leave them for the earth, and this is the most effective step that can be taken towards the prevention of electrolysis. The better the conductivity of the track the less the danger from stray currents, and for this reason it is important that the joints between two adjoining rails be kept in good condition. In fact the resistance of a rail joint should not be greater than the resistance of ten feet of rail. In a properly constructed track either the rails are welded together, forming a continuous line, or a heavy copper band is securely fastened to the ends of adjacent rails bridging the joints. As insurance against the temporary failure of one of these joints it is important to have at regular intervals cross bonds between the two lines of rails in a track. These bonds permit the interchange of current between the rails in case a high resistance joint occurs in one of them. In



Proper Bonding for a Street Railway.

a well maintained track these cross bonds are usually placed from 200 to 500 feet apart.

It is very important that heavy cables be laid around all track intersections or switches, which from their nature introduce resistance into the track. These cables should be large enough to carry all the current and should be carefully inspected at regular intervals to insure their being in perfect condition.

A properly constructed and drained road bed is very useful in preventing electrolysis. Dry rock ballast is a very poor conductor of electricity and the use of this kind of material in track construction cuts down the amount of current leaking into the soil.

Whether it is possible to obtain the co-operation of the electric company or not there are certain steps in the prevention of electrolysis which may be applied to the pipe line itself. Much has been written as to the efficiency of insulating coatings applied to the line. It is true that if a perfectly water tight coating could be applied to the pipe electrolytic damage would be avoided. However, the difficulty in obtaining an absolutely continuous coating makes this method of mitigation unsatisfactory. In fact an effort to protect the line by means of special coatings may even be dangerous as it may serve to concentrate the corrosive action where the current leaves the pipe on small areas where the coating has failed, and this results in deep pitting. It has been suggested that the use of protective coatings in the areas where the pipe is picking up current might be of value as protective coatings on pipe at these points would increase the resistance of the path between the soil and the pipe and cuts down the amount of current picked up. However, the difficulty of definitely determining the right areas in which to use this protection makes it inadvisable to use any coating other than the regular tar coating furnished on pipe.

A method often suggested for eliminating electrolysis is pipe drainage. This consists of connecting the pipe line near the power house to the negative busbar or to the rails by means of a cable. At first glance this would seem to be a good method, but careful study shows that by making the path of the current along the pipe easy to follow the amount of current flowing on the line is increased and trouble may result. This type of electrolysis mitigation should never be used except after a careful study of the situation by an expert and then only in conjunction with other mitigative measures.

For a new pipe line probably the best method of preventing electrolysis troubles is to use insulating joints for the pipe. To be satisfactory the joints must be insulating to such an extent that they prevent the line from being a good conductor. All joints should offer high resistance to the flow of current, as the introduction of one or two high resistance joints in a line may cause additional damage where the current leaves the pipe for the earth to pass around the joint. For this reason insulating jointing compounds should not be used for repairs in existing lines where the original joints were of lead. The use of insulating joints in making up lines which tie into existing networks usually will not of itself change the electrolytic condition of the system, as no current will flow over the new line.

Insulating joints may be made of cement or leadite. The first mentioned material is widely used for gas lines and gives very satisfactory results. It may, however, be necessary to use wooden rings in the base of the bell to prevent contact between the bell of one pipe and the spigot of the adjoining pipe. The gas company in one of the largest cities of the East uses this type of joint with marked success although the water company of the same city reports considerable trouble from electrolysis. Leadite is a useful insulating material and due to the ease with which it is handled as well as the satisfaction it affords for use with medium water pressures it deserves careful consideration in the installation of new lines.

In laying a pipe line it is very important to place the pipe as far away as possible from the street car tracks and other conductors. This has a very marked effect in preventing electrolysis and the reason is obvious when we consider that the resistance of the soil may be high and increases with the distance that the current has to flow through it. Care in locating pipe lines in regard to the tracks will invariably reduce electrolysis trouble.

The importance of electrolysis in certain sections is obvious when we consider that stray electric currents attack all the various types of pipe used for water and gas distribution. With metal pipe of the various kinds the resistance which they offer to this damage depends to a great extent on their thickness. At first glance it might appear that concrete pipe would be free from this trouble, but such is not the case, as the current working through the cement may attack the reinforcement, causing the cement to crack off and resulting in the early failure of the pipe.

From the above it will be seen that where there is a possibility of electrolytic trouble it is important that the railway company keep the track bonds in good condition and their road bed clean and dry. The man in charge of the pipe line can do his part in preventing electrolysis by the use of insulating joints with his pipe as well as by care in the location of new lines, good results being obtained by carefully locating pipe lines with regard to the various other conductors.

SECTION 16

FAILURES OF WATER CONDUITS IN SERVICE AND THEIR PREVENTION

NOTHING is more necessary to the comfort and health of any community than an ample supply of pure water. For this reason the failure of pipe lines carrying water is of vital importance to every person in a community and any step that will make this service more dependable is worth consideration. The results of an investigation of all breaks reported as having occurred in cast iron pipe lines carrying water are given in the following pages and we believe that a consideration of the causes of pipe failures described will enable those in charge of pipe lines to avoid breaks which might otherwise occur.

The importance of the water supply of a community lends to any break in this service a news value which far exceeds the actual importance of the failure. For this reason, newspaper clippings supply an accurate record of most of the breaks in water pipe lines occurring in this country. With these clippings as a basis, form letters have been sent out addressed to the Superintendent of Water Works in the cities where the breaks occurred asking for general information regarding these failures. The letter explains that the information requested will be of value in avoiding similar breaks in the future, and it speaks well for the spirit of co-operation of this group of men that replies have been received to over 60% of these letters.

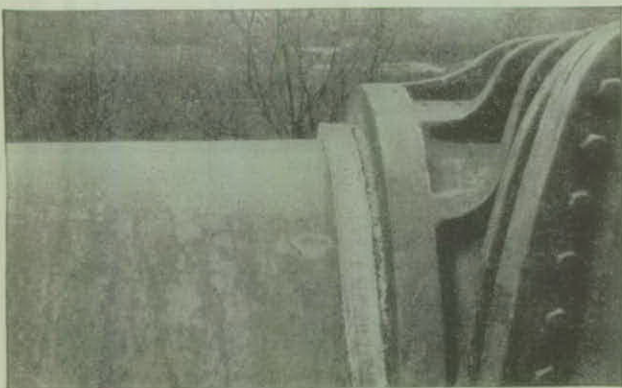
SUMMARY OF FAILURES IN CAST IRON WATER MAINS	Sept. 1, 1916 to Sept. 1, 1925		
CAST IRON PIPE			
Breaks in modern cast iron pipe	285		
Breaks in pipe made by old method, *i. e.*, cast on the side	34		
Breaks in pipe cast in local foundries without proper equipment	16		
Total Failures in Cast Iron Lines		335	
Failure Due to Blowing out of Lead Calking Material		89	
Failures Reported as Cast Iron, Actually Other Material		62	
Breaks Reported in Error; No Failure in Pipe		44	
Total Breaks Investigated			530

SUMMARY OF BREAKS IN MODERN CAST IRON PIPE

Causes of Failures in Cast Iron Pipe Exclusive of Joint Failures	Distribution	Supply	Total
Settlement of earth under pipe	58	19	77
Settlement of walls, etc., on pipe	4	1	5
External blow	32	30	62
Longitudinal expansion of pipe	..	2	2
Electrolysis	10	..	10
Freezing	25	2	27
Pressure increase	16	5	21
Vibration	11	4	15
Poor construction	1	4	5
Water hammer	7	3	10
Resting on rock	4	5	9
Miscellaneous	2	..	2
Defective pipe	11	4	15
Cause unknown	22	3	25
	203	82	285

There is some difficulty in definitely classifying the cause of the various breaks. For instance, an old pipe may carry water for years in spite of a minor defect that only discloses itself when a nearby excavation causes the line to settle. In such a case it is reasonable to assume that the pipe would have continued to give perfect service if the undue strain had not occurred. Therefore, wherever possible, the break is classified by the immediate cause of the failure.

Joint Failures. Undoubtedly the majority of leaks in water mains are due to the blowing out of the lead used for calking. Carelessness in laying pipe invariably results in a great deal of joint trouble, and even a line perfectly



Lead Forced from the Bell of a Valve by Pulsation.

installed may develop some leaks if the ground through which the line runs is not solid. One typical city of 150,000 inhabitants in the middle west reports an average of twenty leaks a year, and of this number 85% are joint failures.

On old lines it was sometimes customary to tie plugs or sharp bends into pipe lines by means of steel straps or to place wooden stakes back of the fittings to prevent shifting. Blow outs usually occur after these wooden stakes have rotted or the steel straps corroded and failed. Probably the safest method of holding a fitting in place is by means of a block of concrete.

We must expect to find occasional joints which fail due to poor calking, although these are usually discovered in the test of the line in the trench. If such poorly calked joints exist in an untested line they are almost certain to fail eventually under a sudden increase of pressure or even under the steady pulsation of the water. For this reason a service test after the pipe is in the trench and before back-filling is desirable on any pipe line.

Cast Iron Pipe Breaks. History has shown that cast iron pipe is literally "GOOD FOR CENTURIES," however, even cast iron pipe must be laid with a reasonable amount of care. Pipe are cast in twelve foot or longer lengths and are intended to carry water. They are not designed to act as beams, and most failures are the result of subjecting pipe to bending stresses.

Settlement of Supports. The number of conduits running under the streets of a modern city is really astonishing and it is not surprising that it is difficult to dig up one line without affecting several others. Careful excavation and sheeting will prevent trouble. However, as several utilities have conduits under the streets it is sometimes difficult to obtain the necessary co-operation. When excavations are being made near water lines it is important that a careful check on the work be made by the water department to see that proper precautions are taken to protect their lines.

Here again the tendency of unprotected wood to rot causes trouble. Many installations are laid temporarily on wood piles; later in the rush of work permanent supports are forgotten until at last the wooden supports give way resulting in a serious break. Whenever it is necessary to place pipe on supports it is a real economy to make these supports of concrete or masonry and be sure that they are permanent.

Pipe lines must often be laid across shifting ground, and these lines are always subject to breaks. In fact, the tendency in modern pipe line construction is to support each length of pipe on concrete piers in passing through such ground and extending to solid earth.

There are a few cities in this country that are built over extensive coal mining operations and in these cities the

Pipe Supported on Concrete Piers

lines are subjected to continuous strains. Breaks become a part of the regular routine and no precautions will prevent their occurrence. One superintendent stated that they experienced several hundred breaks in distribution lines and services in one year and it is only by continuous effort that the lines in these localities are kept in repair.

Occasionally washouts, due to heavy rains, cause breaks by undermining the pipe. This can be avoided by careful construction. However the constantly changing channel in rivers and streams take a regular toll in breaks of the submerged supply lines. Better engineering practice in anchoring lines and in trenching for submerged pipe is gradually eliminating such breaks.

One of the most widely discussed breaks which has occurred in some years, that of the 42-inch line in Copley

Pipe Line Completely Exposed by Washout of the Supporting Fill

Square, Boston, was due primarily to settlement. Some time previous to the break, which occurred in 1916, a concrete sewer had been built under the pipe and the lower portion of the pipe embedded in the concrete. This held the pipe rigidly at one point so that a very slight settlement at the other end of the pipe resulted in severe strain and ultimately in the breaking of the pipe.

External Blow. Almost one-eighth of the breaks investigated were caused by subjecting the pipe to a heavy blow. The danger of such a blow is greatest before the pipe is covered. In back-filling it is important to avoid rolling heavy rocks into the trench so that they will strike the pipe. It is sometimes necessary to lay pipe without cover in crossing bridges. These lines are in constant danger from automobiles and trucks, and in several instances falling trees have broken such lines. Submerged

Cast Iron Pipe Exposed by Blasting

lines, unless laid in a trench, are often broken by anchors or dredge buckets.

Even with several feet of earth over the pipe they are not absolutely secure and pile drivers often pierce pipe lines when a careful record of their location is not kept. Blasting is sometimes carelessly done without sufficient protection being provided for nearby pipe lines, and in at least two instances pipe lines were maliciously dynamited to injure the companies supplied.

The most remarkable instance that has come to our attention happened in New York. A heavy machine was being lifted up the side of an office building. The machine slipped from the ropes eleven stories in the air. It crashed through the sidewalk and struck a six-inch cast iron pipe. It is probable that this pipe prevented the machine from plunging into the subway, which would undoubtedly have resulted in heavy loss of life.

Settlement of Structure Crushing Pipe. Another way in which settlement will result in broken pipe may be cited. If any heavy structure, such as a bridge or foundation wall, is placed so that it rests on the pipe a very slight settlement will be sufficient to crush the pipe no matter how carefully made.

Here again co-operation with other departments of the city is essential. It is not only necessary for the water superintendent to use care in the layout of his lines but also the sewer and even the highway department must be informed of the location of important lines so that they can be avoided when other work is being laid out.

Longitudinal Expansion. In laying cast iron pipe in cold weather it is better not to place the spigot end in contact with the bottom of the bell of the next pipe, as a small allowance is necessary to take care of the natural expansion of the pipe as the temperature rises. Few people realize that a pipe line expands over a foot in every mile during the change from winter to summer temperature. Under the conditions mentioned above a break may occur although ordinarily this change in length is easily taken care of in the regular bell and spigot joint.

Freezing. Except at points where water lines are carried across bridges or otherwise exposed there is little danger of breaks due to freezing. It is customary in the north to place pipe lines from five to six feet under the surface, and as frost seldom penetrates to this depth this affords ample protection from freezing. Investigations recently completed show that larger lines carried across bridges are immune from freezing if a constant flow through them is kept up. However, for smaller lines or

Wooden Protection Over a Pipe Line at Bridge Crossing

lines where the flow is intermittent it is better to enclose the pipe in a wooden box or with a sheet metal cover over a coating of felt.

Vibration. Unusual care should be taken where a pipe line passes under railroad tracks or highways subjected to heavy traffic. In some soils vibrations are transmitted many feet and these vibrations subject the pipe and joints to severe strains. By placing the lines at considerable depth under such crossings and by using care that the earth supporting the pipe is firm and level trouble can often be avoided. However, it has been recommended that important lines under railroad tracks be placed in a tunnel or conduit of a larger size than the pipe, thus effectively eliminating the vibration.

Contact With Rock. In laying pipe it is very important to have the bottom of the trench level and free from rocks. Some of the worst breaks that have ever occurred have

Pipe Broken Directly Under a Rail Joint

been the result of allowing the pipe to rest on a stone. This may not cause an immediate failure, but during years of service the natural pulsation of the water in the line results in strains in the metal at the point of contact which finally causes a break.

Water Hammer. Careful engineering has reduced to a great extent the number of failures due to water hammer. The necessity for installing air valves at the high points of any long line is now recognized as well as the advantages of an air chamber of sufficient size to control the surges. It is well to remember that air in any line is dangerous and wherever possible it should be removed in filling the pipe, care on this point reduces water hammer to a minimum.

There are several other minor causes of main failures which can be avoided by care in construction. Electrolysis

Large Rock Directly Under Break in Pipe

which is sometimes considered unavoidable may be minimized by the careful design and installation of a main. Electrolysis mitigation is discussed more in detail elsewhere.

Injury to the Pipe Before Laying. Occasionally the investigation of a break discloses the fact that the pipe was injured before laying. This trouble can be avoided by exercising a reasonable amount of care in handling the pipe. All cast iron pipe is subjected to a hydraulic test at the foundry to at least twice the working pressure, and up to the time of shipment the pipe must be free from incipient cracks. However, if for any reason the pipe is transferred while en route it may be injured. For this reason it is important to inspect the pipe carefully when

Careless Unloading Resulting in Serious Damage to Pipe

accepting it from the railroad. By order of the Interstate Commerce Commission carriers cannot pay claims for damage or loss unless the consignee immediately notifies the railroad agent at destination in writing in order to enable the railroad to check the final claim when presented. For this reason if damage in transit is found a notation of breakage on the freight bill should be obtained from the agent. In unloading from the cars and trucking to the line a reasonable amount of care should be exercised to prevent injury and as a precaution each length should be "rung" before laying.

Old Cast Iron Pipe. The first cast iron pipe used in this country has been in service over one hundred years and there are many miles of this early pipe still in use. In view of the difficulties under which this pipe was made

Effect of Santa Barbara Earthquake on Surface Structures

at that time it is not remarkable that it should sometimes fail under the increased strains of modern service. The remarkable record that this pipe has made amply justifies the judgment of those early city fathers that authorized its installation. Not so easy to understand, however, is the installation at this time, when standard pipe is available, of inferior pipe made in local foundries without adequate equipment for either the manufacture or the testing of the pipe. Yet the record of breaks shows that this is sometimes done. This record would be much worse except for the omission from the summary of breaks occurring in one well known pipe line. In two and a half miles of thirty-inch pipe over one hundred breaks are reported as occurring in twenty years' service. This pipe was purchased from a foundry which has since discontinued the manufacture of pipe, and this trouble was due to the high phosphorus content of the iron. Analysis shows that the pipe contains 1.33% of phosphorus, which is a far higher percentage than allowed by American Manufacturers today.

That cast iron pipe properly installed is permanent has been clearly shown by the way this pipe has withstood the strains set up by earthquakes. In the disastrous quake at Santa Barbara only three breaks, one of which was caused by a falling wall, occurred in the one hundred twenty-four miles of cast iron mains in use in the city.

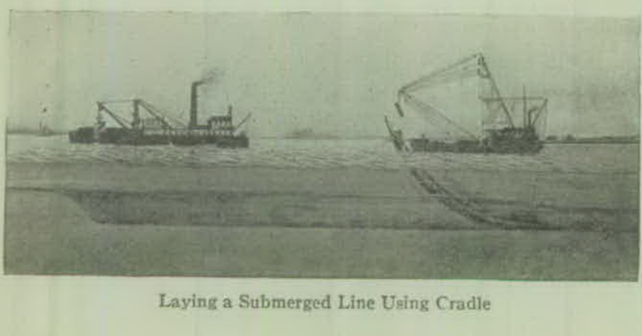
Cast iron pipe with bell and spigot joints is amply durable to withstand the ordinary strains of service and, properly installed, it is good for centuries.

Long Water Supply Line Laid Through Rolling Country

SECTION 17

TYPICAL INSTALLATIONS

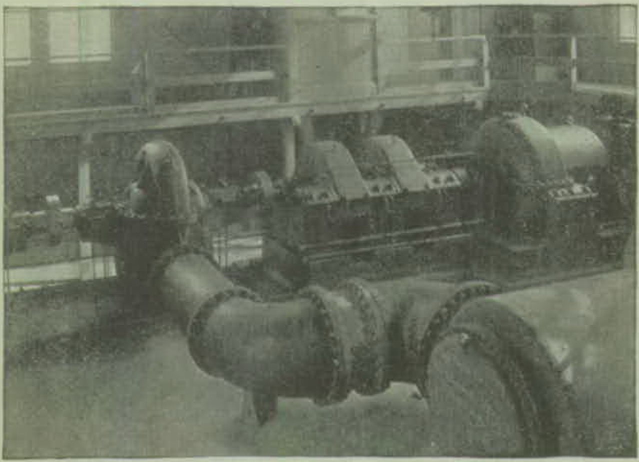
Curve Laid With Full Length Bell and Spigot Pipe



Laying a Submerged Line Using Cradle

Raising a Bell and Spigot Water Line Under 120 Pounds Pressure

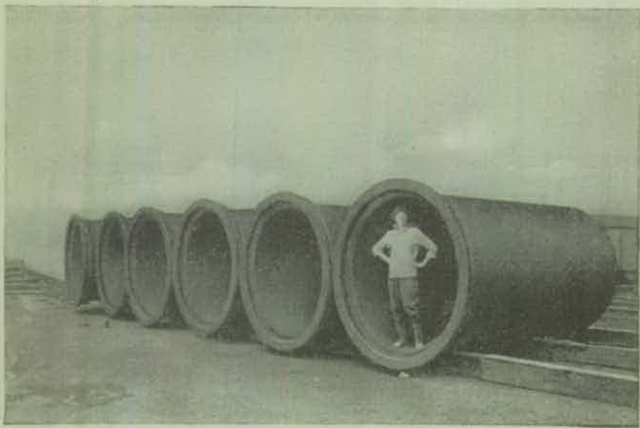
Two 36-inch Submerged Water Lines with Valve Connections



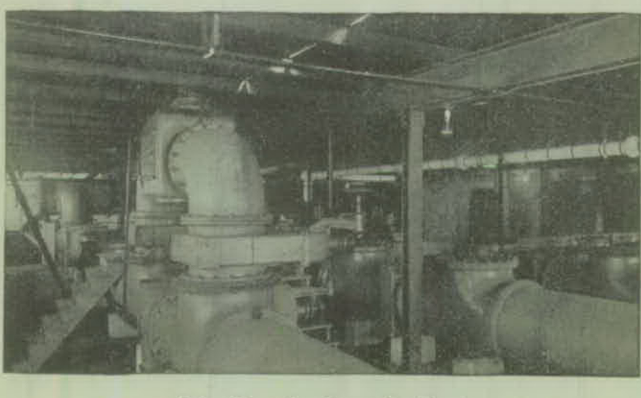
Cast Iron Pipe in the Pump Room

Cast Iron Pipe in the Filter Gallery

A 36-inch and a 20-inch Bell and Spigot Gas Line in the Same Trench



72-inch Gas Pipe for the Astoria Tunnel



Valve House in a Large Gas Plant

48-inch Plain End Gas Pipe with Dresser Couplings

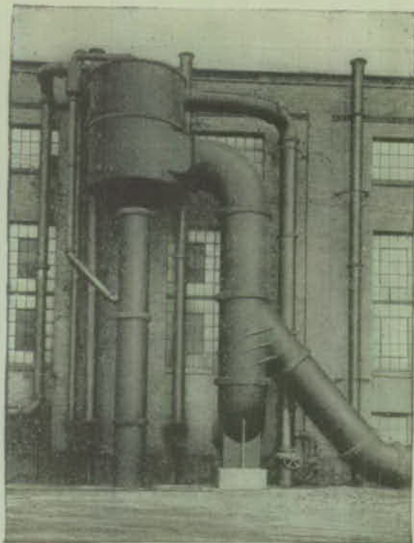
High Pressure
Fire Line

Cast Iron Pipe for Highway Culverts

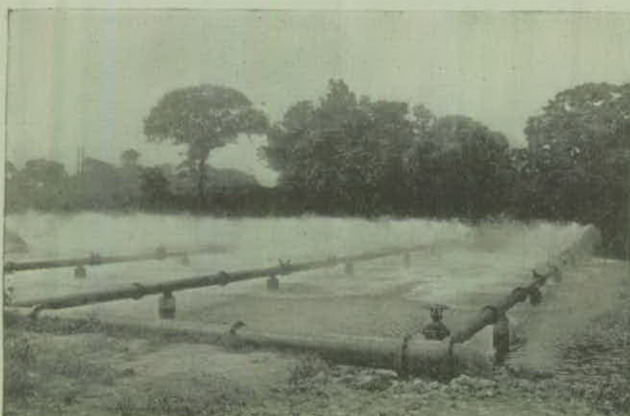
Railway Culvert
Under Deep Fill

Large Sewer Siphon Line

In a Sewage Disposal Plant

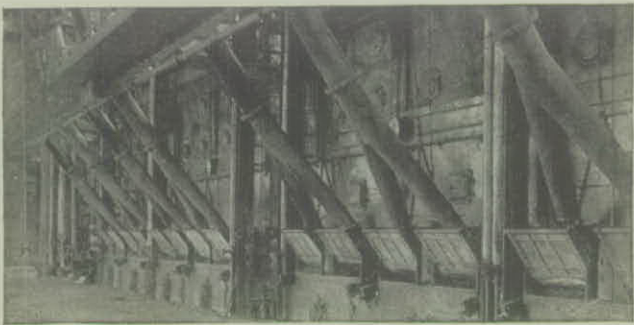


Cast Iron Line to Condenser

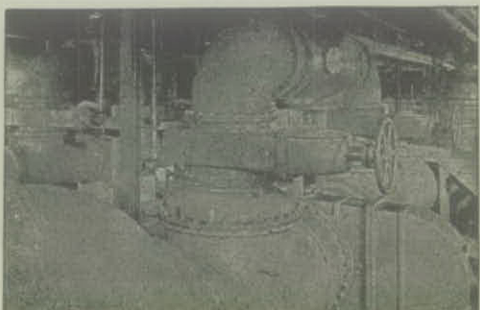


Spray Cooling Pond Piping

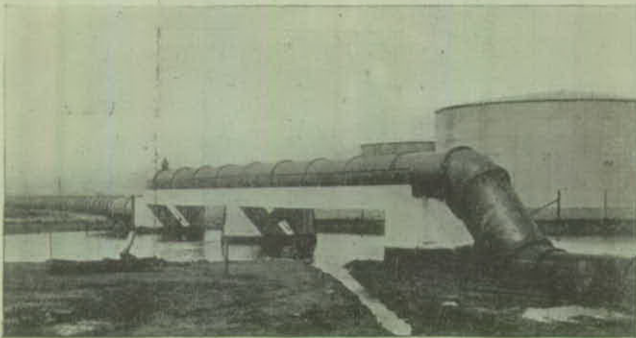
Water



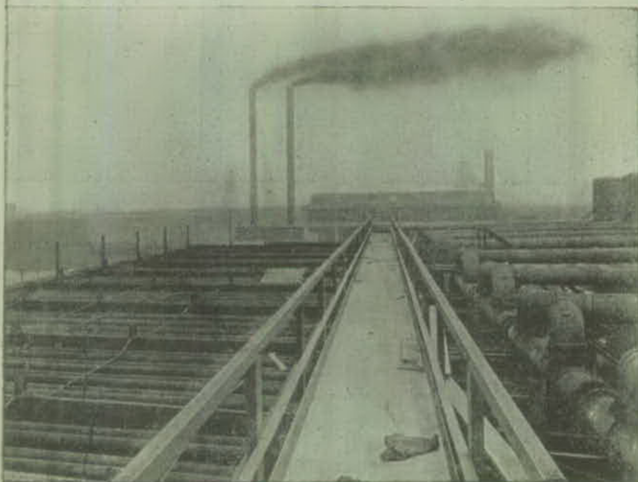
Coal



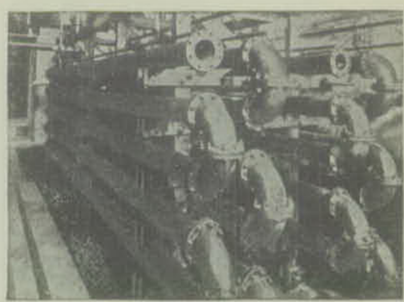
Steam



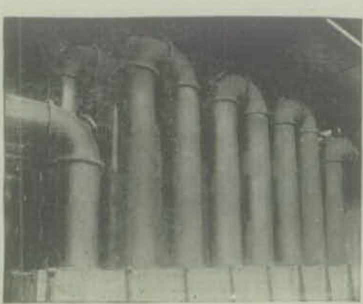
Water Supply Line for a large oil refinery



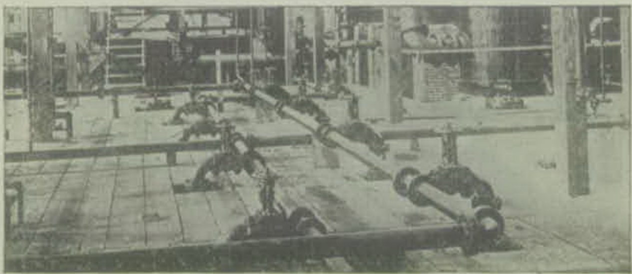
Condenser Boxes Showing Piping



SO_2 Gas Cooler

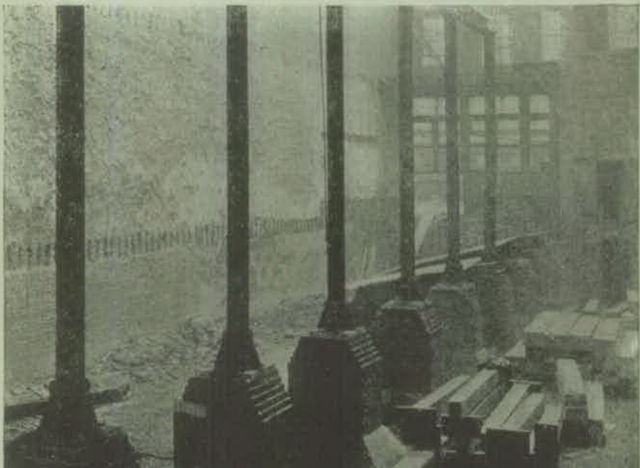


Sulphuric Acid Coils



Acid Distributing Piping

Cast Iron Pipe Columns in Warehouse Construction



Cast Iron Pipe Columns Are Fire Resisting

SECTION 18

USEFUL ENGINEERING TABLES

Equivalents of Fractions of an Inch

Fractions			Decimals	Millimeters	Fractions			Decimals	Millimeters
		1/64	.015625	.3969			33/64	.515625	13.0966
	1/32		.03125	.7937		17/32		.53125	13.4935
		3/64	.046875	1.1906			35/64	.546875	13.8904
1/16			.0625	1.5875	9/16			.5625	14.2872
		5/64	.078125	1.9843			37/64	.578125	14.6841
	3/32		.09375	2.3812		19/32		.59375	15.0810
		7/64	.109375	2.7781			39/64	.609375	15.4778
1/8			.125	3.1749	5/8			.625	15.8747
		9/64	.140625	3.5718			41/64	.640625	16.2716
	5/32		.15625	3.9687		21/32		.65625	16.6684
		11/64	.171875	4.3655			43/64	.671875	17.0653
3/16			.1875	4.7624	11/16			.6875	17.4622
		13/64	.203125	5.1593			45/64	.703125	17.8591
	7/32		.21875	5.5561		23/32		.71875	18.2559
		15/64	.234375	5.9530			47/64	.734375	18.6528
1/4			.25	6.3499	3/4			.75	19.0497
		17/64	.265625	6.7468			49/64	.765625	19.4465
	9/32		.28125	7.1436		25/32		.78125	19.8434
		19/64	.296875	7.5405			51/64	.796875	20.2403
5/16			.3125	7.9374	13/16			.8125	20.6371
		21/64	.328125	8.3342			53/64	.828125	21.0340
	11/32		.34375	8.7311		27/32		.84375	21.4309
		23/64	.359375	9.1280			55/64	.859375	21.8277
3/8			.375	9.5248	7/8			.875	22.2246
		25/64	.390625	9.9217			57/64	.890625	22.6215
	13/32		.40625	10.3186		29/32		.90625	23.0183
		27/64	.421875	10.7154			59/64	.921875	23.4152
7/16			.4375	11.1123	15/16			.9375	23.8121
		29/64	.453125	11.5092			61/64	.953125	24.2089
	15/32		.46875	11.9060		31/32		.96875	24.6058
		31/64	.484375	12.3029			63/64	.984375	25.0027
1/2			.50	12.6998	1			1.00	25.3995

Millimeters and Equivalent Decimals and Nearest Fractions of Inches

One Millimeter = .03937"　　　　One Inch = 25.40 Mill.

Milli-meter	Inches		Milli-meter	Inches	
	Decimal	Nearest Fraction		Decimal	Nearest Fraction
1	.03937	3/64	51	2.00787	2 1/64
2	.07874	5/64	52	2.04724	2 3/64
3	.11811	1/8	53	2.08661	2 5/64
4	.15748	5/32	54	2.12598	2 1/8
5	.19685	13/64	55	2.16535	2 5/32
6	.23622	15/64	56	2.20472	2 13/64
7	.27559	9/32	57	2.24409	2 1/4
8	.31496	5/16	58	2.28346	2 9/32
9	.35433	23/64	59	2.32283	2 21/64
10	.39370	25/64	60	2.36220	2 23/64
11	.43307	7/16	61	2.40157	2 13/32
12	.47244	15/32	62	2.44094	2 7/16
13	.51181	1/2	63	2.48031	2 31/64
14	.55118	35/64	64	2.51968	2 33/64
15	.59055	19/32	65	2.55905	2 9/16
16	.62992	5/8	66	2.59842	2 19/32
17	.66929	43/64	67	2.63779	2 41/64
18	.70886	45/64	68	2.67716	2 43/64
19	.74803	3/4	69	2.71653	2 23/32
20	.78740	25/32	70	2.75590	2 3/4
21	.82677	53/64	71	2.79527	2 51/64
22	.86614	55/64	72	2.83464	2 53/64
23	.90051	29/32	73	2.87401	2 7/8
24	.94488	15/16	74	2.91338	2 29/32
25	.98425	63/64	75	2.95275	2 61/64
26	1.02362	1 1/64	76	2.99212	2 63/64
27	1.06299	1 1/16	77	3.03149	3 1/32
28	1.10236	1 7/64	78	3.07086	3 5/64
29	1.14173	1 9/64	79	3.11023	3 7/64
30	1.18110	1 3/16	80	3.14960	3 5/32
31	1.22047	1 7/32	81	3.18897	3 3/16
32	1.25984	1 1/4	82	3.22834	3 15/64
33	1.29921	1 19/64	83	3.26771	3 17/64
34	1.33858	1 11/32	84	3.30708	3 5/16
35	1.37795	1 3/8	85	3.34645	3 11/32
36	1.41732	1 27/64	86	3.38582	3 25/64
37	1.45669	1 29/64	87	3.42519	3 27/64
38	1.49606	1 1/2	88	3.46456	3 15/32
39	1.53543	1 17/32	89	3.50393	3 1/2
40	1.57480	1 37/64	90	3.54330	3 35/64
41	1.61417	1 39/64	91	3.58267	3 37/64
42	1.65354	1 21/32	92	3.62204	3 5/8
43	1.69291	1 11/16	93	3.66141	3 21/32
44	1.73228	1 47/64	94	3.70078	3 45/64
45	1.77165	1 49/64	95	3.74015	3 47/64
46	1.81102	1 13/16	96	3.77952	3 25/32
47	1.85039	1 27/32	97	3.81889	3 13/16
48	1.88976	1 57/64	98	3.85826	3 55/64
49	1.92913	1 59/64	99	3.89763	3 57/64
50	1.96850	1 31/32	100	3.93700	3 15/16

Equivalents of Measure

LENGTHS

1 meter, m = 10 decimeters, dm = 100 centimeters, cm = 1000 millimeters, mm.
1 meter, m = 0.1 decameter, dkm = 0.01 hectometer, hm = 0.001 kilometer, km.
1 meter, m = 39.37 inches, U. S. Standard = 39.370113 inches, British Standard.
1 millimeter, mm = 1000 microns, μ = 0.03937 inch = 39.37 mils.

Meters, m	Inches, in.	Feet, ft.	Yard, yd.	Rods, r.	Chains, ch.	Miles, U. S.		Kilo-meters, km.
						Statute	Nautical	
1	39.37	3.28083	1.09361	0.19884	0.04971	0.$\overset{3}{0}$6214	0.$\overset{3}{0}$5396	0.001
0.02540	1	0.08333	0.02778	0.$\overset{2}{0}$5051	0.$\overset{2}{0}$1263	0.$\overset{4}{0}$1578	0.$\overset{4}{0}$1371	0.$\overset{4}{0}$2540
0.30480	12	1	0.33333	0.06061	0.01515	0.$\overset{3}{0}$1894	0.$\overset{3}{0}$1645	0.$\overset{3}{0}$3048
0.91440	36	3	1	0.18182	0.04545	0.$\overset{3}{0}$5682	0.$\overset{3}{0}$4934	0.$\overset{3}{0}$9144
5.02921	198	16.5	5.5	1	0.25	0.$\overset{2}{0}$3125	0.$\overset{2}{0}$2714	0.$\overset{2}{0}$5029
20.1168	792	66	22	4	1	0.01250	0.01085	0.02012
1609.35	63360	5280	1760	320	80	1	0.86839	1.60935
1853.25	72962.5	6080.20	2026.73	368.497	92.1243	1.15155	1	1.85325
1000	39370	3280.83	1093.61	198.838	49.7096	0.62137	0.53959	1

1 yard, U. S. = 1.0000029 yards British. 1 yard British = 0.9999971 yard U. S.
1 chain, Gunter's = 100 links. 1 link = 7.92 inches.
1 cable length, U. S. = 120 fathoms = 960 spans = 720 feet = 219.457 meters.
1 league, U. S. = 3 statute miles = 24 furlongs.
1 international geographical mile = $\frac{1}{15}°$ at equator = 7422 m = 4.611808 U. S. statute miles.
1 international nautical mile = $\frac{1}{60}°$ at meridian = 1852 m = 0.999326 U. S. nautical miles.
1 U. S. nautical mile = $\frac{1}{60}°$ of circumference of sphere whose surface equals that of the earth = 6080.27 feet = 1.15155 statute miles = 1853.27 meters.
1 British nautical mile = 6080.00 feet = 1.15152 statute miles = 1853.19 meters.

SURFACES AND AREAS

1 sq. meter, m^2 = 100 sq. decimeters, dm^2 = 10000 sq. centimeters, cm^2.
1 sq. meter, m^2 = 0.01 are, a = 0.0001 hectare, ha.
1 sq. millimeter, mm^2 = 0.01 cm^2 = 0.00155 sq. inch = 1973.5 circular mils.
1 are, a = 1 sq. decameter, dkm = 0.0247104 acre.

Sq. Meters, m^2	Sq. Inches, sq. in.	Sq. Feet, sq. ft.	Sq. Yards, sq. yd.	Sq. Rods, sq. r.	Acres, A	Hec-tares, ha.	Sq. Miles, Statute	Sq. Kilo-meters, km^2
1	1550.00	10.7639	1.19599	0.03954	0.$\overset{3}{0}$2471	0.0001	0.$\overset{6}{0}$3861	0.$\overset{5}{0}$1
0.$\overset{3}{0}$6452	1	0.$\overset{2}{0}$6944	0.$\overset{3}{0}$7716	0.$\overset{4}{0}$2551	0.$\overset{6}{0}$1594	0.$\overset{7}{0}$6452	0.$\overset{9}{0}$2491	0.$\overset{9}{0}$6452
0.09290	144	1	0.11111	0.$\overset{2}{0}$3673	0.$\overset{4}{0}$2296	0.$\overset{5}{0}$9290	0.$\overset{7}{0}$3587	0.$\overset{7}{0}$9290
0.83613	1296	9	1	0.03306	0.$\overset{3}{0}$2066	0.$\overset{4}{0}$8361	0.$\overset{6}{0}$3228	0.$\overset{6}{0}$8361
25.2930	39204	272.25	30.25	1	0.00625	0.$\overset{2}{0}$2529	0.$\overset{5}{0}$9766	0.$\overset{4}{0}$2529
4046.87	6272640	43560	4840	160	1	0.40469	0.$\overset{2}{0}$1563	0.$\overset{2}{0}$4047
10000	15499969	107639	11959.9	395.366	2.47104	1	0.$\overset{2}{0}$3861	0.01
2589999		27878400	3097600	102400	640	259.000	1	2.59000
1000000		10763867	1195985	39536.6	247.104	100	0.38610	1

1 sq. rod, sq. pole, or sq. perch = 625 sq. links = $\frac{1}{160}$ acre.
1 sq. chain, Gunter's = 16 sq. rods = $\frac{1}{10}$ acre.
1 acre = 4 sq. roods = 160 sq. rods. Square of 1 acre = 208.7103 feet square.

Notations $\overset{2}{0}$, $\overset{3}{0}$, $\overset{4}{0}$, etc., indicate that the $\overset{2}{0}$, $\overset{3}{0}$, $\overset{4}{0}$, etc., are to be replaced by 2, 3, 4, etc., ciphers.

EXAMPLE—1 sq. rod = 0.$\overset{5}{0}$9766 = 0.000009766 sq. miles.

Printed through the courtesy of the Carnegie Steel Company.

Equivalents of Measure

VOLUME AND CAPACITY

1 cu. meter, m^3 = 1000 cu. decimeter, dm^3 = 1000000 cu. centimeters, cm^3.
1 liter, 1 = 10 deciliters, dl = 100 centiliters, cl = 1000 milliliters, ml = 1000 cu. centimeters, cm^3, or cc.
1 liter, 1 = 0.1 decaliter, dkl = 0.01 hectoliter, hl = 1 cu. decimeter, dm^3.

Cubic Decimeter, dm^3, l	Cubic Inches, cu. in.	Cubic Feet, cu. ft.	Cubic Yards, cu. yd.	U. S. Quarts		U. S. Gallons		U. S. Bushels, bu.
				Liquid, l. qt.	Dry, d. qt.	Liquid, l. gal.	Dry, d. gal.	
1	61.0234	0.03531	$0.\overset{2}{0}1308$	1.05668	0.90808	0.26417	0.22702	0.02838
0.01639	1	$0.\overset{3}{0}5787$	$0.\overset{4}{0}2143$	0.01732	0.01488	$0.\overset{2}{0}4329$	$0.\overset{2}{0}3720$	$0.\overset{3}{0}4650$
28.3170	1728	1	0.03704	29.9221	25.7140	7.48055	6.42851	0.80356
764.559	46656	27	1	807.896	694.279	201.974	173.570	21.6962
0.94636	57.75	0.03342	$0.\overset{2}{0}1238$	1	0.85937	0.25	0.21484	0.02686
1.10123	67.2006	0.03889	$0.\overset{2}{0}1440$	1.16365	1	0.29091	0.25	0.03125
3.78543	231	0.13368	$0.\overset{2}{0}4951$	4	3.43747	1	0.85937	0.10742
4.40492	268.803	0.15556	$0.\overset{2}{0}5761$	4.65460	4	1.16365	1	0.125
35.2393	2150.42	1.24446	0.04609	37.2368	32	9.30920	8	1

U. S. Dry Measure: 1 bushel = 4 pecks = 8 gallons = 32 quarts = 64 pints.
U. S. Liquid Measure: 1 gallon = 4 quarts = 8 pints = 32 gills = 128 fluid ounces.
U. S. Apoth. Measure: 1 fl. ounce, f℥ = 8 fl. drams, f℥ = 480 minims, m = 29.574 cu. centimeter, cm^3.
British Imperial gallon dry and liquid measure = 1.03202 U. S. dry gal. = 1.20091 U. S. liquid gal.
British Imperial gallon = 277.410 cu. in. = 4545.9631 cm^3.

Weight of water at maximum density, 4°C, 45° Lat., and sea level.

1 cu. ft. = 62.4283 lbs. av. = 28.3170 kg. 1 cu. in. = 0.57804 oz. av. = 16.3872 g.
1 gal., U. S. liquid = 8.34545 lbs. = 3.78543 kg.
1 gal., British Imperial = 10.0221 lbs. = 4.5459631 kg.

MASSES AND WEIGHTS

1 gram, g = 10 decigrams, dg = 100 centigrams, cg = 1000 milligrams, mg.
1 gram, g = 0.1 decagram, dkg = 0.01 hectogram, hg = 0.001 kilogram, kg.
1 kilogram, kg = 1 cu. decimeter of water or liter, 4°C, 45° Lat. and sea level = 15432.35639 grains, U. S. and British Standard.

Kilograms, kg.	Grains, gr.	Ounces		Pounds		Tons		
		Troy, oz. t.	Avoir, oz. av.	Troy, lb. t.	Avoir, lb. av.	Net, Short, 2000lbs.	Gross, Long, 2240lbs.	Metric, 1000 kg.
1	15432.4	32.1507	35.2740	2.67923	2.20462	$0.\overset{2}{0}1102$	$0.\overset{3}{0}9842$	0.001
$0.\overset{4}{0}6480$	1	$0.\overset{2}{0}2083$	$0.\overset{2}{0}2286$	$0.\overset{3}{0}1736$	$0.\overset{3}{0}1429$	$0.\overset{7}{0}7143$	$0.\overset{7}{0}6378$	$0.\overset{7}{0}6480$
0.03110	480	1	1.09714	0.08333	0.06857	$0.\overset{4}{0}3429$	$0.\overset{4}{0}3061$	$0.\overset{4}{0}3110$
0.02835	437.5	0.91146	1	0.07595	0.06250	$0.\overset{4}{0}3125$	$0.\overset{4}{0}2790$	$0.\overset{4}{0}2835$
0.37324	5760	12	13.1657	1	0.82286	$0.\overset{3}{0}4114$	$0.\overset{3}{0}3674$	$0.\overset{3}{0}3732$
0.45359	7000	14.5833	16	1.21528	1	0.00050	$0.\overset{3}{0}4464$	$0.\overset{3}{0}4536$
907.185	14000000	29166.7	32000	2430.56	2000	1	0.89286	0.90719
1016.05	15680000	32666.7	35840	2722.22	2240	1.12	1	1.01605
1000	15432356	32150.7	35274.0	2679.23	2204.62	1.10231	0.98421	1

1 ounce avoir. = 16 drams, avoir. 1 ounce troy = 20 pennyweight, dwt.
1 ounce apoth., ℥ = 8 drams, ʒ = 24 scruples, ℈ = 480 grains, gr = 31.1035 g.
1 hundredweight = 1/20 long ton = 4 quarters = 8 stone = 112 lbs. = 50.8024 kg.

Notations $\overset{2}{0}$, $\overset{3}{0}$, $\overset{4}{0}$, etc., indicate that the $\overset{2}{0}$, $\overset{3}{0}$, $\overset{4}{0}$, etc., are to be replaced by 2, 3, 4, etc., ciphers.

EXAMPLE—1 grain = $0.\overset{2}{0}2083$ = 0.002083 oz. t. 1 grain = $0.\overset{4}{0}6480$ = 0.00006480 kg.

Printed through the courtesy of the Carnegie Steel Company.

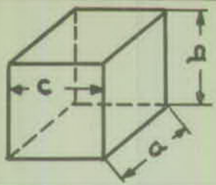
Circumferences and Areas of Circles

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
1/64	.04909	.00019	2 11/16	8.4430	5.6727	7	21.991	38.485
1/32	.09818	.00077	3/4	8.6394	5.9396	1/8	22.384	39.871
3/64	.14726	.00173	13/16	8.8357	6.2126	1/4	22.776	41.282
1/16	.19635	.00307	7/8	9.0321	6.4918	3/8	23.169	42.718
3/32	.29452	.00690	15/16	9.2284	6.7771	1/2	23.562	44.179
1/8	.39270	.01227	3	9.4248	7.0686	5/8	23.955	45.664
5/32	.49087	.01917	1/16	9.6211	7.3662	3/4	24.347	47.173
3/16	.58905	.02761	1/8	9.8175	7.6699	7/8	24.740	48.707
7/32	.68722	.03758	3/16	10.014	7.9798	8	25.133	50.265
1/4	.78540	.04909	1/4	10.210	8.2958	1/8	25.525	51.849
9/32	.88357	.06213	5/16	10.407	8.6179	1/4	25.918	53.456
5/16	.98175	.07670	3/8	10.603	8.9462	3/8	26.311	55.088
11/32	1.0799	.09281	7/16	10.799	9.2806	1/2	26.704	56.745
3/8	1.1781	.11045	1/2	10.996	9.6211	5/8	27.096	58.426
13/32	1.2763	.12962	9/16	11.192	9.9678	3/4	27.489	60.132
7/16	1.3744	.15033	5/8	11.388	10.321	7/8	27.882	61.862
15/32	1.4726	.17257	11/16	11.585	10.680	9	28.274	63.617
1/2	1.5708	.19635	3/4	11.781	11.045	1/8	28.667	65.397
17/32	1.6690	.22166	13/16	11.977	11.416	1/4	29.060	67.201
9/16	1.7671	.24850	7/8	12.174	11.793	3/8	29.452	69.029
19/32	1.8653	.27688	15/16	12.370	12.177	1/2	29.845	70.882
5/8	1.9635	.30680	4	12.566	12.566	5/8	30.238	72.760
21/32	2.0617	.33824	1/16	12.763	12.962	3/4	30.631	74.662
11/16	2.1598	.37122	1/8	12.959	13.364	7/8	31.023	76.589
23/32	2.2580	.40574	3/16	13.155	13.772	10	31.416	78.540
3/4	2.3562	.44179	1/4	13.352	14.186	1/4	32.201	82.516
25/32	2.4544	.47937	5/16	13.548	14.607	1/2	32.987	86.590
13/16	2.5525	.51849	3/8	13.744	15.033	3/4	33.772	90.763
27/32	2.6507	.55914	7/16	13.941	15.466	11	34.558	95.033
7/8	2.7489	.60132	1/2	14.137	15.904	1/4	35.343	99.402
29/32	2.8471	.64504	9/16	14.334	16.349	1/2	36.128	103.87
15/16	2.9452	.69029	5/8	14.530	16.800	3/4	36.914	108.43
31/32	3.0434	.73708	11/16	14.726	17.257	12	37.699	113.10
1	3.1416	.7854	3/4	14.923	17.721	1/4	38.485	117.86
1/16	3.3379	.8866	13/16	15.119	18.190	1/2	39.270	122.72
1/8	3.5343	.9940	7/8	15.315	18.665	3/4	40.055	127.68
3/16	3.7306	1.1075	15/16	15.512	19.147	13	40.841	132.73
1/4	3.9270	1.2272	5	15.708	19.635	1/4	41.626	137.89
5/16	4.1233	1.3530	1/16	15.904	20.129	1/2	42.412	143.14
3/8	4.3197	1.4849	1/8	16.101	20.629	3/4	43.197	148.49
7/16	4.5160	1.6230	3/16	16.297	21.135	14	43.982	153.94
1/2	4.7124	1.7671	1/4	16.493	21.648	1/4	44.768	159.48
9/16	4.9087	1.9175	5/16	16.690	22.166	1/2	45.553	165.13
5/8	5.1051	2.0739	3/8	16.886	22.691	3/4	46.338	170.87
11/16	5.3014	2.2365	7/16	17.082	23.221	15	47.124	176.71
3/4	5.4978	2.4053	1/2	17.279	23.758	1/4	47.909	182.65
13/16	5.6941	2.5802	9/16	17.475	24.301	1/2	48.695	188.69
7/8	5.8905	2.7612	5/8	17.671	24.850	3/4	49.480	194.83
15/16	6.0868	2.9483	11/16	17.868	25.406	16	50.265	201.06
2	6.2832	3.1416	3/4	18.064	25.967	1/4	51.051	207.39
1/16	6.4795	3.3410	13/16	18.261	26.535	1/2	51.836	213.82
1/8	6.6759	3.5466	7/8	18.457	27.109	3/4	52.622	220.35
3/16	6.8722	3.7583	15/16	18.653	27.688	17	53.407	226.98
1/4	7.0686	3.9761	6	18.850	28.274	1/4	54.192	233.71
5/16	7.2649	4.2000	1/8	19.242	29.465	1/2	54.978	240.53
3/8	7.4613	4.4301	1/4	19.635	30.680	3/4	55.763	247.45
7/16	7.6576	4.6664	3/8	20.028	31.919	18	56.549	254.47
1/2	7.8540	4.9087	1/2	20.420	33.183	1/4	57.334	261.59
9/16	8.0503	5.1572	5/8	20.813	34.472	1/2	58.119	268.80
5/8	8.2467	5.4119	3/4	21.206	35.785	3/4	58.905	276.12
			7/8	21.598	37.122			

Circumferences and Areas of Circles

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
19	59.690	283.53	34½	108.385	934.82	50	157.080	1963.5
¼	60.476	291.04	¾	109.170	948.42	51	160.221	2042.8
½	61.261	298.65	35	109.956	962.11	52	163.363	2123.7
¾	62.046	306.35	¼	110.741	975.91	53	166.504	2206.2
20	62.832	314.16	½	111.527	989.80	54	169.646	2290.2
¼	63.617	322.06	¾	112.312	1003.8	55	172.788	2375.8
½	64.403	330.06	36	113.097	1017.9	56	175.929	2463.0
¾	65.188	338.16	¼	113.883	1032.1	57	179.071	2551.8
21	65.973	346.36	½	114.668	1046.3	58	182.212	2642.1
¼	66.759	354.66	¾	115.454	1060.7	59	185.354	2734.0
½	67.544	363.05	37	116.239	1075.2	60	188.496	2827.4
¾	68.330	371.54	¼	117.024	1089.8	61	191.637	2922.5
22	69.115	380.13	½	117.810	1104.5	62	194.779	3019.1
¼	69.900	388.82	¾	118.596	1119.2	63	197.920	3117.2
½	70.686	397.61	38	119.381	1134.1	64	201.062	3217.0
¾	71.471	406.49	¼	120.166	1149.1	65	204.204	3318.3
23	72.257	415.48	½	120.951	1164.2	66	207.345	3421.2
¼	73.042	424.56	¾	121.737	1179.3	67	210.487	3525.7
½	73.827	433.74	39	122.522	1194.6	68	213.628	3631.7
¾	74.613	443.01	¼	123.308	1210.0	69	216.770	3739.3
24	75.398	452.39	½	124.093	1225.4	70	219.911	3848.5
¼	76.184	461.86	¾	124.878	1241.0	71	223.053	3959.2
½	76.969	471.44	40	125.664	1256.6	72	226.195	4071.5
¾	77.754	481.11	¼	126.449	1272.4	73	229.336	4185.4
25	78.540	490.87	½	127.235	1288.2	74	232.478	4300.8
¼	79.325	500.74	¾	128.020	1304.2	75	235.619	4417.9
½	80.111	510.71	41	128.805	1320.3	76	238.761	4536.5
¾	80.896	520.77	¼	129.591	1336.4	77	241.903	4656.6
26	81.681	530.93	½	130.376	1352.7	78	245.044	4778.4
¼	82.467	541.19	¾	131.161	1369.0	79	248.186	4901.7
½	83.252	551.55	42	131.947	1385.4	80	251.327	5026.5
¾	84.038	562.00	¼	132.732	1402.0	81	254.469	5153.0
27	84.823	572.56	½	133.518	1418.6	82	257.611	5281.0
¼	85.608	583.21	¾	134.303	1435.4	83	260.752	5410.6
½	86.394	593.96	43	135.088	1452.2	84	263.894	5541.8
¾	87.179	604.81	¼	135.874	1469.1	85	267.035	5674.5
28	87.965	615.75	½	136.659	1486.2	86	270.177	5808.8
¼	88.750	626.80	¾	137.445	1503.3	87	273.319	5944.7
½	89.535	637.94	44	138.230	1520.5	88	276.460	6082.1
¾	90.321	649.18	¼	139.015	1537.9	89	279.602	6221.1
29	91.106	660.52	½	139.801	1555.3	90	282.743	6361.7
¼	91.892	671.96	¾	140.586	1572.8	91	285.885	6503.9
½	92.677	683.49	45	141.372	1590.4	92	289.027	6647.6
¾	93.462	695.13	¼	142.157	1608.2	93	292.168	6792.9
30	94.248	706.86	½	142.942	1626.0	94	295.310	6939.8
¼	95.033	718.69	¾	143.728	1643.9	95	298.451	7088.2
½	95.819	730.62	46	144.513	1661.9	96	301.593	7238.2
¾	96.604	742.64	¼	145.299	1680.0	97	304.734	7389.8
31	97.389	754.77	½	146.084	1698.2	98	307.876	7543.0
¼	98.175	766.99	¾	146.869	1716.5	99	311.018	7697.7
½	98.960	779.31	47	147.655	1734.9	100	314.159	7854.0
¾	99.746	791.73	¼	148.440	1753.5	101	317.30	8011.85
32	100.531	804.25	½	149.226	1772.1	102	320.44	8171.28
¼	101.316	816.86	¾	150.011	1790.8	103	323.58	8332.29
½	102.102	829.58	48	150.796	1809.6	104	326.73	8494.87
¾	102.887	842.39	¼	151.582	1828.5	105	329.87	8659.01
33	103.673	855.30	½	152.367	1847.5	106	333.01	8824.73
¼	104.458	868.31	¾	153.153	1866.5	107	336.15	8992.02
½	105.243	881.41	49	153.938	1885.7	108	339.29	9160.88
¾	106.029	894.62	¼	154.723	1905.0	109	342.43	9331.32
34	106.814	907.92	½	155.509	1924.4	110	345.58	9503.32
¼	107.600	921.32	¾	156.294	1943.9			

USEFUL FORMULAE FOR ESTIMATING WEIGHTS OF CAST IRON PIPE AND PIPE FITTINGS



PARALLELEPIPEDS

VOLUME IN CUB. INCHES $= a \times b \times c$

WEIGHT IN POUNDS = VOLUME X .26

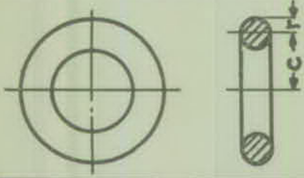
CIRCLE

r = RADIUS; D = DIAMETER
CIRCUMFERENCE = 3.14 X D
AREA = $3.14 \times r^2$

SPHERE

AREA = $3.14 \times D^2$ VOLUME = $\frac{3.14 \times D^3}{6}$

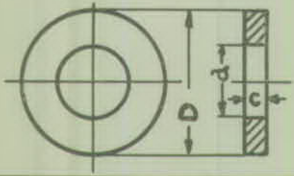
WEIGHT IN POUNDS = VOLUME X .26



TORUS

VOLUME IN CUB. INCHES = $2 \times 3.14^2 \times C \times r^2 = 19.72 \times C \times r^2$

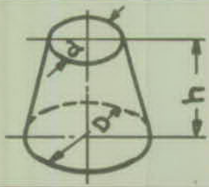
WEIGHT IN POUNDS = VOLUME X .26



CIRCULAR RING

VOLUME IN CUB. INCHES = (AREA D − AREA d) X C

WEIGHT IN POUNDS = VOLUME X .26



FRUSTUM OF CONE

$$\text{VOLUME} = \frac{H}{3} \times \left(\text{AREA [d]} + \text{AREA [D]} + \sqrt{\text{AREA[d]} \times \text{AREA [D]}} \right)$$

WEIGHT IN POUNDS = VOLUME X .26

SPECIFIC GRAVITY OF IRON = 7.1

ONE CUB. INCH OF IRON WEIGHS 0.26 POUNDS

ONE CUB. FOOT OF IRON WEIGHS 450 POUNDS

Specific Gravities and Weights

Substance	Specific Gravity	Weight, Pounds per Cu. Ft.
Ashlar Masonry		
Granite, syenite, gneiss	2.3–3.0	165
Limestone, marble	2.3–2.8	160
Sandstone, bluestone	2.1–2.4	140
Mortar Rubble Masonry		
Granite, syenite, gneiss	2.2–2.8	155
Limestone, marble	2.2–2.6	150
Sandstone, bluestone	2.0–2.2	130
Dry Rubble Masonry		
Granite, syenite, gneiss	1.9–2.3	130
Limestone, marble	1.9–2.1	125
Sandstone, bluestone	1.8–1.9	110
Brick Masonry		
Pressed brick	2.2–2.3	140
Common brick	1.8–2.0	120
Soft brick	1.5–1.7	100
Concrete Masonry		
Cement, stone, sand	2.2–2.4	144
Cement, slag, etc	1.9–2.3	130
Cement, cinder, etc	1.5–1.7	100
Various Building Mat'l		
Ashes, cinders		40–45
Cement, portland, loose		90
Cement, portland, set	2.7–3.2	183
Lime, gypsum, loose		53–64
Mortar, set	1.4–1.9	103
Slags, bank slag		67–72
Slags, bank screenings		98–117
Slags, machine slag		96
Slags, slag sand		49–55
Earth, etc., Excavated		
Clay, dry		63
Clay, damp, plastic		110
Clay and gravel, dry		100
Earth, dry, loose		76
Earth, dry, packed		95
Earth, moist, loose		78
Earth, moist, packed		96
Earth, mud, flowing		108
Earth, mud, packed		115
Riprap, limestone		80–85
Riprap, sandstone		90
Riprap, shale		105
Sand, gravel, dry, loose		90–105
Sand, gravel, dry, packed		100–120
Sand, gravel, dry, wet		118–120
Excavations In Water		
Sand or gravel		60
Sand or gravel and clay		65
Clay		80
River mud		90
Soil		70
Stone riprap		65

Substance	Specific Gravity	Weight, Pounds per Cu. Ft.
Minerals		
Asbestos	2.1–2.8	153
Barytes	4.50	281
Basalt	2.7–3.2	184
Bauxite	2.55	159
Borax	1.7–1.8	109
Chalk	1.8–2.6	137
Clay, marl	1.8–2.6	137
Dolomite	2.9	181
Feldspar, orthoclase	2.5–2.6	159
Gneiss, serpentine	2.4–2.7	159
Granite, syenite	2.5–3.1	175
Greenstone, trap	2.8–3.2	187
Gypsum, alabaster	2.3–2.8	159
Hornblende	3.0	187
Limestone, marble	2.5–2.8	165
Magnesite	3.0	187
Phosphate rock, apatite	3.2	200
Porphyry	2.6–2.9	172
Pumice, natural	0.37–0.90	40
Quartz, flint	2.5–2.8	165
Sandstone, bluestone	2.2–2.5	147
Shale, slate	2.7–2.9	175
Soapstone, talc	2.6–2.8	169
Stone, Quarried, Piled		
Basalt, granite, gneiss		96
Limestone, marble, quartz		95
Sandstone		82
Shale		92
Greenstone, hornblende		107
Bituminous Substances		
Asphaltum	1.1–1.5	81
Coal, anthracite	1.4–1.7	97
Coal, bituminous	1.2–1.5	84
Coal, lignite	1.1–1.4	78
Coal, peat, turf, dry	0.65–0.85	47
Coal, charcoal, pine	0.28–0.44	23
Coal, charcoal, oak	0.47–0.57	33
Coal, coke	1.0–1.4	75
Graphite	1.9–2.3	131
Paraffine	0.87–0.91	56
Petroleum	0.87	54
Petroleum, refined	0.79–0.82	50
Petroleum, benzine	0.73–0.75	46
Petroleum, gasoline	0.66–0.69	42
Pitch	1.07–1.15	69
Tar, bituminous	1.20	75
Coal and Coke, Piled		
Coal, anthracite		47–58
Coal, bituminous, lignite		40–54
Coal, peat, turf		20–26
Coal, charcoal		10–14
Coal, coke		23–32

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

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Specific Gravities and Weights

Substance	Specific Gravity	Weight, Pounds per Cu. Ft.
Metals, Alloys, Ores		
Aluminum, cast-hammered	2.55–2.75	165
Aluminum, bronze	7.7	481
Brass, cast-rolled	8.4–8.7	534
Bronze, 7.9 to 14% Sn	7.4–8.9	509
Copper, cast-rolled	8.8–9.0	556
Copper, ore, pyrites	4.1–4.3	262
Gold, cast-hammered	19.25–19.3	1205
Iron, cast, pig	7.2	450
Iron, wrought	7.6–7.9	485
Iron, steel	7.8–7.9	490
Iron, spiegel-eisen	7.5	468
Iron, ferro-silicon	6.7–7.3	437
Iron ore, hematite	5.2	325
Iron ore, hematite in bank		160–180
Iron ore, hematite, loose		130–160
Iron ore, limonite	3.6–4.0	237
Iron ore, magnetite	4.9–5.2	315
Iron, slag	2.5–3.0	172
Lead	11.37	710
Lead ore, galena	7.3–7.6	475
Manganese	7.2–8.0	500
Manganese ore, pyrolusite	3.7–4.6	259
Mercury	13.6	849
Nickel	8.9–9.2	565
Nickel, monel metal	8.8–9.0	556
Platinum, cast-hammered	21.1–21.5	1330
Silver, cast-hammered	10.4–10.6	656
Tin, cast-hammered	7.2–7.5	459
Tin, ore, cassiterite	6.4–7.0	418
Zinc, cast-rolled	6.9–7.2	440
Zinc, ore, blende	3.9–4.2	253
Various Solids		
Cereals, oats, bulk		32
Cereals, barley, bulk		39
Cereals, corn, rye, bulk		48
Cereals, wheat, bulk		48
Hay and Straw, bales		20
Cotton, Flax, Hemp	1.47–1.50	93
Fats	0.90–0.97	58
Flour, loose	0.40–0.50	28
Flour, pressed	0.70–0.80	47
Glass, common	2.40–2.60	156
Glass, plate or crown	2.45–2.72	161
Glass, crystal	2.90–3.00	184
Leather	0.86–1.02	59
Paper	0.70–1.15	58
Potatoes, piled		42
Rubber, caoutchouc	.092–0.96	59
Rubber goods	1.0–2.0	94
Salt, granulated, piled		48
Saltpeter		67
Starch	1.53	96
Sulphur	1.93–2.07	125
Wool	1.32	82

Substance	Specific Gravity	Weight, Pounds per Cu. Ft.
Timber, U. S. Seasoned		
Ash, white-red	0.62–0.65	40
Cedar, white-red	0.32–0.38	22
Chestnut	0.66	41
Cypress	0.48	30
Fir, Douglas spruce	0.51	32
Fir, eastern	0.40	25
Elm, white	0.72	45
Hemlock	0.42–0.52	29
Hickory	0.74–0.84	49
Locust	0.73	46
Maple, hard	0.68	43
Maple, white	0.53	33
Oak, chestnut	0.86	54
Oak, live	0.95	59
Oak, red, black	0.65	41
Oak, white	0.74	46
Pine, Oregon	0.51	32
Pine, red	0.48	30
Pine, white	0.41	26
Pine, yellow, long-leaf	0.70	44
Pine, yellow, short-leaf	0.61	38
Poplar	0.48	30
Redwood, California	0.42	26
Spruce, white, black	0.40–0.46	27
Walnut, black	0.61	38
Walnut, white	0.41	26
Moisture Contents:		
Seasoned timber 15 to 20%		
Green timber up to 50%		
Various Liquids		
Alcohol, 100%	0.79	49
Acids, muriatic, 40%	1.20	75
Acids, nitric, 91%	1.50	94
Acids, sulphuric, 87%	1.80	112
Lye, soda, 66%	1.70	106
Oils, vegetable	0.91–0.94	58
Oils, mineral, lubricants	0.90–0.93	57
Water, 4°C, max. denisty	1.0	62.428
Water, 100°C	0.9584	59.830
Water, ice	0.88–0.92	56
Water, snow, fresh fallen	.125	8
Water, sea water	1.02–1.03	64
Gases, Air = 1		
Air, 0°C, 760 mm	1.0	.08071
Ammonia	0.5920	.0478
Carbon dioxide	1.5291	.1234
Carbon monoxide	0.9673	.0781
Gas, illuminating	0.35–0.45	.028–.036
Gas, natural	0.47–0.48	.038–.039
Hydrogen	0.0693	.00559
Nitrogen	0.9714	.0784
Oxygen	1.1056	.0892

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

Reproduced from Marks Mechanical Engineers' Handbook

Quantities of Material for Concrete
Based on 3.8 Cubic Feet per Barrel of Cement (4 Sacks per Barrel), Sand and Stone Measured Loose

Proportions by Parts			Quantities per Bbl. of Cement			Quantities of Material for 1 Yd. of Rammed Concrete					
						45% Voids Average Broken Stone			40% Voids Average Gravel		
Cement	Sand	Stone	Cement Bbl.	Loose Sand Cu. Ft.	Loose Stone Cu. Ft.	Cement Bbl.	Sand Cu. Yd.	Stone Cu. Yd.	Cement Bbl.	Sand Cu. Yd.	Gravel Cu. Yd.
1	1	1½	1	3.8	5.7	3.08	0.43	0.65	2.97	0.42	0.63
..	...	2	..	...	7.6	2.73	0.38	0.77	2.62	0.37	0.74
..	...	2½	..	...	9.5	2.45	0.34	0.86	2.34	0.33	0.82
..	...	3	..	...	11.4	2.22	0.31	0.94	2.12	0.30	0.90
1	1½	2	1	5.7	7.6	2.40	0.51	0.68	2.31	0.49	0.65
..	...	2½	..	...	9.5	2.18	0.46	0.77	2.09	0.44	0.74
..	...	3	..	...	11.4	2.00	0.42	0.84	1.91	0.40	0.81
..	...	3½	..	...	13.3	1.84	0.39	0.91	1.76	0.37	0.87
..	...	4	..	...	15.2	1.71	0.36	0.96	1.63	0.34	0.92
1	2	3	1	7.6	11.4	1.81	0.51	0.76	1.74	0.49	0.74
..	...	3½	..	...	13.3	1.68	0.47	0.83	1.61	0.45	0.79
..	...	4	..	...	15.2	1.57	0.44	0.88	1.50	0.42	0.84
..	...	4½	..	...	17.1	1.48	0.42	0.94	1.41	0.40	0.89
..	...	5	..	...	19.0	1.39	0.39	0.98	1.32	0.37	0.93
1	2½	3½	1	9.5	13.3	1.55	0.55	0.76	1.49	0.52	0.73
..	...	4	..	...	15.2	1.46	0.51	0.82	1.40	0.49	0.79
..	...	4½	..	...	17.1	1.37	0.48	0.87	1.31	0.46	0.83
..	...	5	..	...	19.0	1.30	0.46	0.92	1.24	0.44	0.87
..	...	5½	..	...	20.9	1.23	0.43	0.95	1.17	0.41	0.91
..	...	6	..	...	22.8	1.17	0.41	0.99	1.11	0.39	0.94

Quantities of Material for Concrete

Based on 3.8 Cubic Feet per Barrel of Cement (4 Sacks per Barrel), Sand and Stone Measured Loose (continued)

Proportions by Parts			Quantities per Bbl. of Cement			Quantities of Material for 1 Yd. of Rammed Concrete					
						45% Voids Average Broken Stone			40% Voids Average Gravel		
Cement	Sand	Stone	Cement Bbl.	Loose Sand Cu. Ft.	Loose Stone Cu. Ft.	Cement Bbl.	Sand Cu. Yd.	Stone Cu. Yd.	Cement Bbl.	Sand Cu. Yd.	Gravel Cu. Yd.
1	3	4	1	11.4	15.2	1.36	0.57	0.77	1.30	0.55	0.73
..	...	4½	..	...	17.1	1.28	0.54	0.81	1.23	0.52	0.78
..	...	5	..	...	19.0	1.22	0.52	0.86	1.17	0.49	0.82
..	...	5½	..	...	20.9	1.16	0.49	0.90	1.11	0.47	0.86
..	...	6	..	...	22.8	1.11	0.47	0.94	1.05	0.44	0.89
..	...	6½	..	...	24.7	1.06	0.45	0.97	1.01	0.43	0.92
..	...	7	..	...	26.6	1.01	0.43	0.99	0.96	0.40	0.95
1	4	5	1	15.2	19.0	1.08	0.61	0.76	1.04	0.59	0.73
..	...	6	..	...	22.8	0.99	0.56	0.84	0.95	0.54	0.80
..	...	7	..	...	26.6	0.92	0.52	0.91	0.88	0.50	0.87
..	...	8	..	...	30.4	0.85	0.48	0.96	0.81	0.46	0.91
..	...	9	..	...	34.2	0.80	0.45	1.01	0.76	0.43	0.96

1 Bag of Cement .... =94 Lbs.
1 Bag of Cement .... = 1 Cu. Ft.
4 Bags of Cement .... =1 Bbl.
1 Bbl. of Cement .... =400 lb. Gross, 376 lb. Net

Printed through the courtesy of the Lehigh Portland Cement Company.

Proportioning Concrete

Proportions of Mixtures			Material for One Cubic Yard Concrete								
			Gravel ¼-inch and Under			Stone 1-inch and Under Dust Screened Out			Stone 2½-inch and Under Dust Screened Out		
Cement	Sand	Stone	Cement Bbls.	Sand Yards	Stone Yards	Cement Bbls.	Sand Yards	Stone Yards	Cement Bbls.	Sand Yards	Stone Yards
1	2	3	1.54	.47	.73	1.70	.52	.77	1.73	.53	.79
1	2	4	1.34	.41	.81	1.46	.44	.89	1.48	.45	.90
1	2	5	1.17	.36	.89	1.27	.39	.97	1.29	.39	.98
1	2½	4	1.24	.47	.75	1.35	.52	.82	1.38	.53	.84
1	2½	5	1.10	.42	.83	1.19	.46	.91	1.21	.46	.92
1	2½	6	.98	.37	.89	1.07	.41	.97	1.07	.41	.98
1	3	5	1.03	.47	.78	1.11	.51	.85	1.14	.52	.87
1	3	6	.92	.42	.84	1.01	.46	.92	1.02	.47	.93
1	3	7	.84	.38	.89	.91	.42	.97	.92	.42	.98
1	4	6	.83	.51	.77	.90	.55	.82	.92	.56	.84
1	4	7	.77	.47	.81	.83	.51	.89	.84	.51	.90
1	4	8	.71	.43	.86	.77	.47	.93	.78	.48	.95
1	4	9	.65	.40	.89	.71	.43	.97	.73	.46	1.01

1 Bag of Cement.......................... =94 Lbs.
1 Bag of Cement.......................... = 1 Cu. Ft.
4 Bags of Cement.......................... = 1 Bbl.
1 Bbl. of Cement.......... =400 lb. Gross, 376 lb. Net

Printed through the courtesy of the Lehigh Portland Cement Company.

Nominal Weight in Pounds per Foot of Cast Iron Cylinders or Pipe Without Flanges

(Based on cast iron weighing 450 lbs. per cu. ft.)

Inside Dia. Inches	WEIGHT PER FOOT IN POUNDS — Thickness of Metal in Inches														
	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
2	5.5	8.7	12.3	16.1	20.3	24.7	29.5	34.5	40.0						
2 1/2	6.8	10.6	14.7	19.2	24.0	29.0	34.4	40.0	46.0						
3	7.9	12.4	17.2	22.2	27.6	32.3	39.3	45.6	52.2						
3 1/2	9.2	14.3	19.6	25.3	31.3	37.6	44.2	51.1	58.3						
4	10.4	16.1	22.1	28.4	35.0	41.9	49.1	56.6	64.4	72.4					
4 1/2	11.7	18.0	24.5	31.5	38.7	46.2	54.0	62.1	70.6	79.2					
5	12.9	19.8	27.0	34.5	42.3	50.5	58.9	67.7	76.7	85.9	95.6				
5 1/2	14.1	21.6	29.5	37.6	46.0	54.8	63.8	73.2	82.8	92.7	102.9				
6	15.3	23.5	31.9	40.7	49.7	59.1	68.7	78.7	89.0	99.4	110.3	121.5			
7	17.8	27.2	36.8	46.8	57.1	67.7	78.5	89.7	101.0	112.9	125.0	137.4			
8	20.3	30.8	41.7	52.9	64.4	76.2	88.4	101.0	114.0	126.4	139.7	153.3	167.2		
9	22.7	34.5	46.6	59.1	71.8	84.8	98.2	112.0	126.0	139.8	154.4	169.2	184.4		
10	25.2	38.2	51.5	65.2	79.2	93.4	108.0	123.0	138.0	153.3	169.1	185.2	201.5	218.2	
11	27.6	41.9	56.5	71.3	86.5	102.0	118.0	134.0	150.0	166.8	183.8	201.1	218.7	236.6	
12	30.1	46.6	61.4	77.5	93.9	111.0	128.0	145.0	163.0	180.3	198.5	216.7	235.9	255.0	274.4
13	32.5	49.2	66.3	83.6	101.0	119.0	137.0	156.0	175.0	193.7	213.2	232.9	253.0	273.4	294.1
14	35.0	52.9	71.2	89.7	109.0	128.0	147.0	167.0	187.0	207.2	227.9	248.9	270.2	291.8	313.7
15		56.6	76.1	95.9	116.0	136.0	157.0	178.0	199.0	220.7	242.6	264.8	287.3	310.1	333.3
16		60.3	81.0	102.0	123.0	145.0	167.0	189.0	212.0	234.2	257.3	280.7	304.5	328.5	352.9
18		67.7	90.8	114.0	138.0	162.0	187.0	211.0	236.0	261.1	286.7	312.6	338.8	365.3	392.1
20			101.0	127.0	153.0	179.0	206.0	233.0	261.0	288.1	316.1	344.4	373.1	402.0	431.3
22			110.0	139.0	168.0	197.0	226.0	255.0	285.0	315.0	345.5	376.3	407.4	438.8	470.9
24			120.0	151.0	182.0	214.0	245.0	278.0	310.0	342.0	374.9	408.2	441.7	475.5	509.7
26			130.0	163.0	197.0	231.0	265.0	299.0	334.0	368.9	404.3	440.0	476.0	512.3	548.9
28			140.0	175.0	211.0	248.0	284.0	321.0	358.0	395.9	433.7	471.9	510.3	549.1	588.1
30			149.0	188.0	226.0	265.0	304.0	343.0	383.0	422.9	463.1	503.7	544.6	585.8	627.3
32				199.9	240.4	282.0	323.5	365.3	407.4	449.8	492.5	535.6	578.9	622.6	666.5
34				212.1	255.5	299.1	343.1	387.3	431.9	476.8	521.9	567.4	613.2	659.3	705.7
36				224.4	270.2	316.3	362.7	409.4	456.4	503.7	551.4	599.3	647.5	695.7	744.9
38					284.9	333.4	382.3	431.4	480.9	530.7	580.8	631.2	681.9	732.8	784.2
40					299.6	350.6	401.9	453.5	505.4	557.6	610.1	663.0	716.1	769.6	823.3
42						367.7	421.5	475.5	530.0	584.6	639.4	694.9	750.4	806.3	862.6
44						384.9	441.1	497.6	554.4	611.6	669.0	726.7	784.8	843.1	902.0
46							460.7	519.6	578.9	638.5	698.4	758.6	819.1	879.8	941.0
48							480.3	541.7	603.4	665.5	727.8	790.4	853.4	916.6	980.2

Nominal Weight in Pounds per Foot of Cast Iron Cylinders or Pipe without Flanges

Based on cast iron weighing 450 lbs. per cu. ft.

Inside Dia. Inches	WEIGHT PER FOOT IN POUNDS — Thickness of Metal in Inches														
	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2⅛	2¼	2⅜	2½	2⅝	2¾	2⅞	3
50	627.9	692.4	757.2	822.3	887.7	953.4	1019.4	1085.7	1152.3	1219.3	1286.5	1354.0	1421.9	1490.0	1558.5
52	652.4	719.4	786.6	854.1	921.9	990.1	1058.6	1127.4	1196.4	1265.8	1335.5	1405.5	1475.8	1546.4	1617.3
54	676.9	746.3	816.0	886.0	956.3	1026.8	1097.8	1169.0	1240.5	1312.6	1384.7	1457.0	1529.4	1602.7	1666.7
56	701.5	773.4	845.4	917.9	990.6	1063.7	1137.0	1210.7	1284.7	1359.0	1433.6	1508.5	1583.7	1659.2	1735.0
58	725.9	800.2	874.8	949.7	1024.9	1100.4	1177.2	1252.3	1328.7	1405.5	1482.3	1559.7	1639.4	1715.4	1793.7
60	750.5	827.2	904.2	981.6	1059.2	1137.1	1215.4	1294.0	1372.9	1452.0	1531.5	1611.5	1691.7	1771.8	1852.7
62	774.9	854.1	933.6	1013.4	1093.5	1173.9	1254.6	1335.6	1417.0	1498.6	1580.5	1662.6	1745.3	1828.0	1911.3
64	799.5	881.1	961.5	1045.3	1127.8	1210.7	1293.8	1377.3	1461.1	1545.2	1629.5	1714.2	1799.3	1884.5	1970.3
66	824.0	908.0	992.4	1077.1	1162.1	1247.4	1333.1	1419.0	1505.2	1591.7	1678.6	1765.7	1853.3	1941.0	2028.9
68	848.5	935.0	1021.8	1108.9	1196.4	1284.2	1372.2	1460.6	1549.3	1638.3	1727.6	1817.2	1907.1	1997.1	2087.6
70	873.0	962.0	1051.3	1140.8	1230.7	1321.0	1411.5	1502.3	1592.4	1684.8	1776.6	1868.6	1959.0	2053.6	2146.6
72	897.6	989.0	1080.6	1175.8	1265.1	1357.7	1450.4	1543.9	1637.5	1731.4	1825.6	1920.1	2014.9	2110.0	2205.5
74	921.9	1015.9	1110.1	1204.5	1299.4	1394.5	1489.9	1585.6	1681.6	1778.0	1874.6	1971.5	2068.8	2166.3	2264.2
76	946.2	1042.7	1139.5	1236.4	1333.6	1431.2	1529.1	1627.3	1725.7	1824.5	1923.6	2023.0	2122.7	2222.7	2323.0
78	948.9	1069.5	1168.9	1268.3	1368.0	1468.0	1568.3	1668.9	1769.9	1871.1	1972.6	2074.5	2176.6	2279.1	2381.8
80	995.5	1096.9	1198.3	1300.1	1402.3	1504.7	1607.5	1710.6	1813.9	1917.6	2021.6	2125.9	2230.5	2335.4	2440.7
82	1019.9	1123.8	1227.7	1332.0	1436.6	1541.5	1646.7	1752.2	1858.1	1964.2	2070.6	2177.4	2284.4	2391.8	2499.5
84	1044.2	1150.6	1257.0	1363.7	1470.9	1578.3	1685.9	1793.9	1902.2	2010.8	2119.6	2228.8	2338.3	2448.2	2558.3
86	1068.9	1177.4	1286.3	1395.5	1505.2	1615.0	1725.1	1835.5	1946.3	2057.3	2168.7	2280.3	2392.2	2504.5	2617.1
88	1093.5	1204.6	1316.0	1427.7	1539.5	1651.8	1764.3	1877.2	1990.4	2105.8	2217.6	2328.6	2446.1	2560.9	2675.9
90	1118.2	1231.4	1345.3	1459.5	1573.7	1688.5	1803.4	1918.9	2034.5	2150.4	2266.7	2383.2	2500.1	2617.2	2734.7
92	1142.5	1258.6	1374.6	1491.3	1608.0	1724.2	1842.7	1960.5	2075.2	2197.0	2315.7	2433.6	2554.0	2673.6	2793.5
94	1166.8	1285.4	1404.0	1523.1	1642.3	1761.8	1882.0	2002.2	2122.7	2243.6	2364.7	2486.1	2607.9	2730.0	2852.3
96	1191.5	1312.5	1433.6	1555.0	1676.6	1798.9	1921.1	2043.5	2165.8	2290.1	2400.9	2529.8	2661.4	2790.8	2898.2
98	1213.8	1319.7	1449.6	1568.9	1697.9	1822.4	1946.4	2077.5	2197.8	2329.0	2449.5	2580.8	2702.4	2830.9	2956.4
100	1273.1	1347.8	1478.8	1600.2	1731.3	1868.7	1995.5	2118.7	2241.4	2374.7	2498.0	2631.8	2755.7	2890.2	3014.0

Friction Heads for Elbows

Heads Required to Overcome the Resistance of Ninety-Degree Circular Bends

Velocity in Feet per Second	Radius of Bend in Diameters of Pipe							
	0.5	0.75	1.00	1.25	1.5	2.0	3.0	5.0
	Head, in Feet							
1	.016	.005	.002	.002	.001	.001	.001	.001
2	.062	.018	.009	.007	.005	.005	.004	.004
3	.140	.041	.020	.015	.012	.011	.010	.009
4	.245	.072	.036	.026	.021	.019	.017	.016
5	.388	.113	.056	.041	.033	.029	.027	.025
6	.559	.162	.081	.059	.048	.042	.038	.036
7	.761	.221	.110	.080	.066	.057	.052	.050
8	.994	.288	.144	.104	.086	.074	.069	.065
9	1.260	.365	.182	.132	.108	.094	.086	.082
10	1.550	.450	.225	.163	.134	.116	.106	.101
12	2.340	.649	.324	.236	.192	.167	.153	.145

The above table has been calculated by the well-known Weisbach formula for pipe or bends of circular cross section; i. e., round water-pipe specials.

Let R =radius of curve or bend in inches.
r =radius of section of pipe in inches.
K =coefficient of resistance.
v =velocity of flow in feet per second.
a° =angle embraced by curve or bend (a right-angle bend =90°).
h =friction head in feet or decimal of foot.
g =acceleration due to gravity =32.2.

Then $K = 0.131 + 1.847 \left\{ \frac{r}{R} \right\}^{\frac{7}{2}}$

And $h = K\frac{v^2}{2g} \times \frac{a^\circ}{180}$

Suppose a 90° bend of circular cross section, 20 inches diameter (r =10) and 25 inches radius of curvature (=R). What friction head is developed by a velocity of flow of 2.7896 feet per second?

$$K = 0.131 + 1.847 \left\{ \frac{10}{25} \right\}^{\frac{7}{2}} = 0.206$$

And $h = .206 \frac{2.7896^2}{64.4} \times \frac{90}{180} = 0.01245$ feet

Commercial Pipe Sizes for Fire Streams*

Number of 1¼-Inch Hose Nozzles	Ordinary Fire Streams											
	40 Pounds Pressure		50 Pounds Pressure		60 Pounds Pressure		70 Pounds Pressure		80 Pounds Pressure		90 Pounds Pressure	
	Required Size Pipe Ins.	Flow Cu. Ft. per Min.	Required Size Pipe Ins.	Flow Cu. Ft. per Min.	Required Size Pipe Ins.	Flow Cu. Ft. per Min.	Required Size Pipe Ins.	Flow Cu. Ft. per Min.	Required Size Pipe Ins.	Flow Cu. Ft. per Min.	Required Size Pipe Ins.	Flow Cu. Ft. per Min.
1	4	20	6	23	6	25	6	27	6	29	6	30
2	6	40	8	45	8	50	8	53	8	57	8	61
3	8	61	8	68	10	74	10	80	10	86	10	91
4	10	81	10	90	10	99	10	107	12	114	12	121
5	10	101	12	113	12	124	12	134	12	143	12	152
6	12	121	12	135	12	149	14	160	14	172	14	182
7	12	141	14	158	14	174	14	187	14	200	16	212
8	12	162	14	181	14	199	16	214	16	229	16	242
9	14	182	14	203	16	223	16	241	16	257	18	273
10	14	202	16	226	16	248	16	267	18	286	18	303
11	16	222	16	248	18	273	18	294	18	314	18	333
12	16	243	18	271	18	298	18	321	20	343	20	364
13	16	263	18	293	18	323	20	348	20	372	20	394
14	18	283	18	316	20	348	20	374	20	400	20	424
15	18	303	20	339	20	372	20	401	20	429	24	455
	High-Pressure Fire Streams											
	100 Pounds Pressure		110 Pounds Pressure		120 Pounds Pressure		130 Pounds Pressure		140 Pounds Pressure		150 Pounds Pressure	
1	6	32	6	33	6	35	6	36	6	38	6	39
2	8	64	8	67	10	70	10	73	10	75	10	78
3	10	96	10	100	10	105	10	109	12	113	12	117
4	12	128	12	134	12	140	12	145	12	151	14	156
5	14	160	14	167	14	174	14	181	14	188	14	195
6	14	191	14	200	14	209	16	218	16	226	16	234
7	16	223	16	234	16	244	16	254	16	264	18	273
8	16	255	16	267	18	279	18	290	18	301	18	313
9	18	287	18	301	18	314	18	326	18	339	20	352
10	18	319	18	334	20	349	20	363	20	377	20	391
11	20	351	20	367	20	384	20	399	20	414	20	430
12	20	383	20	401	20	419	20	435	24	452	24	469
13	20	415	20	424	24	454	24	472	24	490	24	508
14	24	447	24	467	24	488	24	508	24	528	24	547
15	24	479	24	501	24	523	24	544	24	565	24	586

To convert cubic feet to gallons, multiply by 7.4805.

In calculating above table, the following assumptions were made: Nozzles, 1¼-inch smooth bore, playing simultaneously, and attached to 200 feet of best quality rubber-lined hose; pressures measured at hose connections; velocity of water in pipe approximately 3 feet per second.

*Reproduced by courtesy of N. S. Hill, Jr.

Contents of Pipe

Capacities in Cubic Feet and in United States Gallons (231 Cubic Inches) per Foot of Length

Diameter, Inches	Diameter, Feet	For 1 Foot Length		Diameter, Inches	Diameter, Feet	For 1 Foot Length		Diameter, Inches	Diameter, Feet	For 1 Foot Length	
		Cubic Feet, Also Area in Sq. Ft.	U. S. Gals. (231 Cu. Ins.)			Cubic Feet, Also Area in Sq. Ft.	U. S. Gals. (231 Cu. Ins.)			Cubic Feet, Also Area in Sq. Ft.	U. S. Gals. (231 Cu. Ins.)
1/4	.0208	.0003	.0026	6.75	.5625	.2485	1.859	19.0	1.583	1.969	14.73
5/16	.0260	.0005	.0040	7.00	.5833	.2673	1.999	19.5	1.625	2.074	15.52
3/8	.0313	.0008	.0057	7.25	.6042	.2868	2.144	20.0	1.666	2.182	16.32
7/16	.0365	.0010	.0078	7.50	.6250	.3068	2.295	20.5	1.708	2.292	17.15
1/2	.0417	.0014	.0102	7.75	.6458	.3275	2.450	21.0	1.750	2.405	17.99
9/16	.0469	.0017	.0129	8.00	.6667	.3490	2.611	21.5	1.792	2.521	18.86
5/8	.0521	.0021	.0159	8.25	.6875	.3713	2.777	22.0	1.833	2.640	19.75
11/16	.0573	.0026	.0193	8.50	.7083	.3940	2.948	22.5	1.875	2.761	20.65
3/4	.0625	.0031	.0230	8.75	.7292	.4175	3.125	23.0	1.917	2.885	21.58
13/16	.0677	.0036	.0270	9.00	.7500	.4418	3.305	23.5	1.958	3.012	22.53
7/8	.0729	.0042	.0312	9.25	.7708	.4668	3.492	24.0	2.000	3.142	23.50
15/16	.0781	.0048	.0359	9.50	.7917	.4923	3.682	25.0	2.083	3.409	25.50
1.00	.0833	.0055	.0408	9.75	.8125	.5185	3.879	26.0	2.166	3.687	27.58
1.25	.1042	.0085	.0638	10.00	.8333	.5455	4.081	27.0	2.250	3.976	29.74
1.50	.1250	.0123	.0918	10.25	.8542	.5730	4.286	28.0	2.333	4.276	31.99
1.75	.1458	.0168	.1250	10.50	.8750	.6013	4.498	29.0	2.416	4.587	34.31
2.00	.1667	.0218	.1632	10.75	.8958	.6303	4.714	30.0	2.500	4.909	36.72
2.25	.1875	.0276	.2066	11.00	.9167	.6600	4.937	31.0	2.583	5.241	39.21
2.50	.2083	.0341	.2550	11.25	.9375	.6903	5.163	32.0	2.666	5.585	41.78
2.75	.2292	.0413	.3085	11.50	.9583	.7213	5.395	33.0	2.750	5.940	44.43
3.00	.2500	.0491	.3673	11.75	.9792	.7530	5.633	34.0	2.833	6.305	47.17
3.25	.2708	.0576	.4310	12.00	1.000	.7854	5.876	35.0	2.916	6.681	49.98
3.50	.2917	.0668	.4998	12.50	1.042	.8523	6.375	36.0	3.000	7.069	52.88
3.75	.3125	.0767	.5738	13.00	1.083	.9218	6.895	37.0	3.083	7.468	55.86
4.00	.3333	.0873	.6528	13.50	1.125	.9940	7.435	38.0	3.166	7.876	58.92
4.25	.3542	.0985	.7370	14.00	1.167	1.069	7.997	39.0	3.250	8.296	62.06
4.50	.3750	.1105	.8263	14.50	1.208	1.147	8.578	40.0	3.333	8.728	65.29
4.75	.3958	.1231	.9205	15.00	1.250	1.227	9.180	41.0	3.416	9.168	68.58
5.00	.4167	.1364	1.020	15.50	1.292	1.310	9.801	42.0	3.500	9.620	71.96
5.25	.4375	.1503	1.124	16.00	1.333	1.396	10.44	43.0	3.583	10.084	75.43
5.50	.4583	.1650	1.234	16.50	1.375	1.485	11.11	44.0	3.666	10.560	79.00
5.75	.4792	.1803	1.349	17.00	1.417	1.576	11.79	45.0	3.750	11.044	82.62
6.00	.5000	.1963	1.469	17.50	1.458	1.670	12.50	46.0	3.833	11.540	86.32
6.25	.5208	.2130	1.594	18.00	1.500	1.767	13.22	47.0	3.916	12.048	90.12
6.50	.5417	.2305	1.724	18.50	1.542	1.867	13.97	48.0	4.000	12.566	94.02

1 Cubic foot of water weighs 62.35 pounds; 1 gallon (U. S.) weighs 8.335 pounds.

Contents of Tanks and Cisterns per Foot of Depth

1 Gallon = 231 cubic inches = 1 cubic foot ÷ 7.4805 = 0.13368 cubic feet.

Diam. Ft. In.	Area Sq. Ft.	Gals. 1 Foot Depth	Diam. Ft. In.	Area Sq. Ft.	Gals. 1 Foot Depth	Diam. Ft. In.	Area Sq. Ft.	Gals. 1 Foot Depth
4— 0	12.57	94.00	10—3	82.52	617.26	20—3	322.06	2409.2
4— 1	13.10	97.96	10—6	86.59	647.74	20—6	330.06	2469.1
4— 2	13.64	102.00	10—9	90.76	678.95	20—9	338.16	2529.6
4— 3	14.19	106.12	11—0	95.03	710.90	21—0	346.36	2591.0
4— 4	14.75	110.32	11—3	99.40	743.58	21—3	354.66	2653.0
4— 5	15.32	114.61	11—6	103.87	776.99	21—6	363.05	2715.8
4— 6	15.90	118.97	11—9	108.43	811.14	21—9	371.54	2779.3
4— 7	16.50	123.42	12—0	113.10	846.03	22—0	380.13	2843.6
4— 8	17.10	127.95	12—3	117.86	881.65	22—3	388.82	2908.6
4— 9	17.72	132.56	12—6	122.72	918.00	22—6	397.61	2974.3
4—10	18.35	137.25	12—9	127.68	955.09	22—9	406.49	3040.8
4—11	18.99	142.02	13—0	132.73	992.91	23—0	415.48	3108.0
5— 0	19.63	146.88	13—3	137.89	1031.5	23—3	424.56	3175.9
5— 1	20.29	151.82	13—6	143.14	1070.8	23—6	433.74	3244.6
5— 2	20.97	156.83	13—9	148.49	1110.8	23—9	443.01	3314.0
5— 3	21.65	161.93	14—0	153.94	1151.5	24—0	452.39	3384.1
5— 4	22.34	167.12	14—3	159.48	1193.0	24—3	461.86	3455.0
5— 5	23.04	172.38	14—6	165.13	1235.3	24—6	471.44	3526.6
5— 6	23.76	177.72	14—9	170.87	1278.2	24—9	481.11	3598.9
5— 7	24.48	183.15	15—0	176.71	1321.9	25—0	490.87	3672.0
5— 8	25.22	188.66	15—3	182.65	1366.4	25—3	500.74	3745.8
5— 9	25.97	194.25	15—6	188.69	1411.5	25—6	510.71	3820.3
5—10	26.73	199.92	15—9	194.83	1457.4	25—9	520.77	3895.6
5—11	27.49	205.67	16—0	201.06	1504.1	26—0	530.93	3971.6
6— 0	28.27	211.51	16—3	207.39	1551.4	26—3	541.19	4048.4
6— 3	30.68	229.50	16—6	213.82	1599.5	26—6	551.55	4125.9
6— 6	33.18	248.23	16—9	220.35	1648.4	26—9	562.00	4204.1
6— 9	35.78	267.69	17—0	226.98	1697.9	27—0	572.56	4283.0
7— 0	38.48	287.88	17—3	233.71	1748.2	27—3	583.21	4362.7
7— 3	41.28	308.81	17—6	240.53	1799.3	27—6	593.96	4443.1
7— 6	44.18	330.48	17—9	247.45	1851.1	27—9	604.81	4524.3
7— 9	47.17	352.88	18—0	254.47	1903.6	28—0	615.75	4606.2
8— 0	50.27	376.01	18—3	261.59	1956.8	28—3	626.80	4688.8
8— 3	53.46	399.88	18—6	268.80	2010.8	28—6	637.94	4772.1
8— 6	56.75	424.48	18—9	276.12	2065.5	28—9	649.18	4856.2
8— 9	60.13	449.82	19—0	283.53	2120.9	29—0	660.52	4941.0
9— 0	63.62	475.89	19—3	291.04	2177.1	29—3	671.96	5026.6
9— 3	67.20	502.70	19—6	298.65	2234.0	29—6	683.49	5112.9
9— 6	70.88	530.24	19—9	306.35	2291.7	29—9	695.13	5199.9
9— 9	74.66	558.51	20—0	314.16	2350.1	30—0	706.86	5287.7
10— 0	78.54	587.52	.....	.....	......	.....	.....	......

Relative Delivery of Water

Nominal Diameter, Inches	Relative Flow Capacities of Full Smooth Pipe — Diameters in Inches: 4	6	8	10	12	14	16	18	20	24	30	36	42	48	54	60	72	84	Diameter Feet	Relative Flow Capacity
84										23.0	13.1	8.3	5.65	4.05	3.0	2.3	1.47	1.0	7.0	130.0
72									24.5	15.6	8.9	5.67	3.83	2.75	2.05	1.6	1.0		6.0	88.0
60								20.3	15.6	9.9	5.7	3.6	2.43	1.75	1.3	1.0			5.0	56.0
54							20.7	15.6	12.0	7.6	4.85	2.76	1.87	1.44	1.0				4.5	43.0
48						21.7	15.6	11.6	8.92	5.66	3.24	2.05	1.39	1.0					4.0	32.0
42					23.0	15.6	11.05	8.33	6.4	4.05	2.32	1.47	1.0						3.5	22.9
36				24.6	15.6	10.6	7.6	5.66	4.35	2.76	1.58	1.0							3.0	15.59
30			27.2	15.6	10.0	6.7	4.8	3.6	2.76	1.75	1.0								2.5	9.88
24		32.0	15.6	8.9	5.66	3.85	2.76	2.05	1.58	1.0									2.0	5.657
20	56.0	20.28	9.9	5.66	3.6	2.44	1.75	1.3	1.0										1.67	3.586
18	43.0	15.6	7.6	4.35	2.76	1.87	1.34	1.0											1.50	2.756
16	32.0	11.6	5.7	3.24	2.05	1.40	1.0												1.33	2.053
14	23.0	8.3	4.05	2.32	1.47	1.0													1.18	1.47
12	15.6	5.66	2.76	1.58	1.0														1.0	1.0
10	9.9	3.6	1.75	1.0															0.83	0.634
8	5.66	2.05	1.0																0.67	0.363
6	2.76	1.0																	0.5	0.177
4	1.0																		0.33	0.064

Right-hand column, Relative Flow Capacity, is based on arbitrary of 1.0 for 12-inch pipe.

Calculations for above table based on assumption that relative deliveries at same loss of head are to each other as $\frac{5}{2}$ power of the respective diameters.

Illustrative Example: How many 10-inch pipe will equal in total flow one 36-inch pipe?

Reading horizontally from 36 to intersection, table shows 24.6 10-inch pipe required—or, in practice, 25. Similarly 10 12-inch pipe = 1 30-inch pipe.

Pressures in Pounds per Square Inch, Corresponding to Heads of Water in Feet

Head Ft.	0	1	2	3	4	5	6	7	8	9
0	......	0.433	0.866	1.299	1.732	2.165	2.598	3.031	3.464	3.897
10	4.330	4.763	5.196	5.629	6.062	6.495	6.928	7.361	7.794	8.227
20	8.660	9.093	9.526	9.959	10.392	10.825	11.258	11.691	12.124	12.557
30	12.990	13.423	13.856	14.289	14.722	15.155	15.588	16.021	16.454	16.887
40	17.320	17.753	18.186	18.619	19.052	19.485	19.918	20.351	20.784	21.217
50	21.650	22.083	22.516	22.949	23.382	23.815	24.248	24.681	25.114	25.547
60	25.980	26.413	26.846	27.279	27.712	28.145	28.578	29.011	29.444	29.877
70	30.310	30.743	31.176	31.609	32.042	32.475	32.908	33.341	33.774	34.207
80	34.640	35.073	35.506	35.939	36.372	36.805	37.238	37.671	38.104	38.537
90	38.970	39.403	39.836	40.269	40.702	41.135	41.568	42.001	42.436	42.867

Heads of Water in Feet, Corresponding to Pressures in Pounds per Square Inch

Pressure Lbs. per Sq. In.	0	1	2	3	4
0	....	2.309	4.619	6.928	9.238
10	23.095	25.404	27.714	30.023	32.333
20	46.189	48.499	50.808	53.118	55.427
30	69.284	71.594	73.903	76.213	78.522
40	92.379	94.688	96.998	99.307	101.62
50	115.47	117.78	120.09	122.40	124.71
60	138.57	140.88	143.19	145.50	147.81
70	161.66	163.97	166.28	168.59	170.90
80	184.76	187.07	189.38	191.69	194.00
90	207.85	210.16	212.47	214.78	217.09

	5	6	7	8	9
0	11.547	13.857	16.166	18.476	20.785
10	34.642	36.952	39.261	41.570	43.880
20	57.737	60.046	62.356	64.665	66.975
30	80.831	83.141	85.450	87.760	90.069
40	103.93	106.24	108.55	110.85	113.16
50	127.02	129.33	131.64	133.95	136.26
60	150.12	152.42	154.73	157.04	159.35
70	173.21	175.52	177.83	180.14	182.45
80	196.31	198.61	200.92	203.23	205.54
90	219.40	221.71	224.02	226.33	228.64

At 62° F., 1 foot head = 0.433 lb. per square inch; 0.433 × 144 = 62.355 lbs. per cubic foot. 1 lb. per square inch = 2.30947 feet head. 1 atmosphere = 14.7 lbs. per square inch = 33.94 feet head.

Discharge of Gas in Cubic Feet per Hour, Through Pipe of Different Diameters and Various Lengths, in Linear Yards

Pressure of Water in Inches, 1, 1.5, 2, 2.5. Specific Gravity, .400

Length in Yards	4-Inch Pipe				6-Inch Pipe				8-Inch Pipe			
	1	1.5	2	2.5	1	1.5	2	2.5	1	1.5	2	2.5
100	6,831	8,370	9,658	10,800	18,820	23,050	26,600	29,770	38,650	47,350	54,640	61,100
150	5,580	6,831	7,888	8,817	15,370	18,820	21,700	24,300	31,550	38,650	44,600	49,940
200	4,829	5,920	6,831	7,674	13,310	16,400	18,820	21,000	27,340	33,460	38,650	43,200
300	3,944	4,829	5,580	6,233	10,870	13,310	15,370	17,180	22,310	27,340	31,550	35,270
500	3,055	3,740	4,320	4,829	8,418	10,310	11,940	13,310	17,280	21,170	24,400	27,340
750	2,490	3,055	3,522	3,944	6,872	8,418	9,720	10,870	14,100	17,280	19,800	22,310
1,000	2,160	2,646	3,055	3,413	5,950	7,290	8,418	9,410	12,220	14,960	17,280	19,320
1,250	1,932	2,366	2,732	3,055	5,340	6,320	7,540	8,418	10,940	13,650	15,520	17,280
1,500	1,761	2,160	2,490	2,789	4,860	5,950	6,872	7,672	9,900	12,200	14,100	15,800
1,750	1,634	2,000	2,310	2,582	4,500	5,500	6,366	7,115	9,237	11,300	13,040	14,600
2,000	1,530	1,870	2,160	2,415	4,209	5,155	5,950	6,655	8,640	10,585	12,200	13,670
	10-Inch Pipe				12-Inch Pipe				16-Inch Pipe			
500	30,100	37,100	42,600	47,700	47,600	58,320	67,200	75,240	98,000	120,200	138,240	154,560
750	24,650	30,190	34,800	39,000	38,800	47,600	55,000	61,470	79,770	97,740	113,200	128,020
1,000	21,640	26,150	30,100	33,750	33,660	41,200	47,600	53,240	69,120	84,670	98,000	109,260
1,500	17,400	21,300	24,760	27,560	27,500	33,600	38,880	43,515	56,600	69,120	79,800	89,230
2,000	15,050	18,500	21,300	23,850	23,800	29,250	33,600	37,620	49,000	60,100	69,120	77,280
2,500	13,175	16,136	18,632	20,880	21,190	26,100	30,116	33,631	43,680	53,540	61,824	69,120
3,000	12,027	14,561	17,008	19,016	19,440	23,800	27,500	30,740	39,885	48,870	56,600	64,000
4,000	10,413	12,756	14,729	16,468	16,830	20,600	23,800	26,620	34,560	42,340	49,000	54,630

Discharge of Gas in Cubic Feet per Hour, Through Pipe of Different Diameters and Various Lengths in Linear Yards (continued)

Pressure of Water in Inches, 1, 1.5, 2, 2.5. Specific Gravity, .400

Length in Yards	20-Inch Pipe 1	20-Inch Pipe 1.5	20-Inch Pipe 2	20-Inch Pipe 2.5	24-Inch Pipe 1	24-Inch Pipe 1.5	24-Inch Pipe 2	24-Inch Pipe 2.5	30-Inch Pipe 1	30-Inch Pipe 1.5	30-Inch Pipe 2	30-Inch Pipe 2.5
500	170,600	204,600	241,000	270,000	271,200	326,000	375,000	425,800	468,000	574,000	664,000	744,200
750	139,600	170,600	197,600	222,400	217,200	271,200	310,000	344,000	384,000	468,000	558,900	607,600
1,000	120,744	147,900	170,600	191,000	189,200	233,280	271,200	301,160	332,000	406,000	468,000	526,000
1,500	98,800	120,700	139,600	155,800	155,000	190,500	217,200	245,800	272,070	332,760	384,140	457,600
2,000	85,300	102,300	124,500	135,000	134,600	163,000	187,600	212,900	234,000	287,000	332,000	372,100
2,500	76,500	93,500	108,000	120,744	119,000	145,500	168,000	194,400	210,000	257,000	298,000	332,000
3,000	69,800	85,300	98,800	110,200	108,600	135,600	155,000	172,000	192,000	234,000	270,000	303,800
4,000	60,370	73,950	85,300	95,500	95,350	116,640	135,600	150,580	166,000	203,000	234,000	263,000

Length in Yards	36-Inch Pipe 1	36-Inch Pipe 1.5	36-Inch Pipe 2	36-Inch Pipe 2.5
500	744,000	912,000	1,121,200	1,256,400
750	606,000	744,000	856,000	1,032,000
1,000	530,000	644,000	744,000	832,000
1,500	428,500	524,860	606,000	677,630
2,000	372,000	456,000	524,880	628,200
2,500	332,000	408,000	468,000	530,000
3,000	303,000	372,000	428,000	516,000
4,000	265,000	322,000	372,000	416,000

Above tables computed by Dr. Pole's formula:

$$Q = 1350\ D^2 \sqrt{\frac{H\ D}{G\ L}} \qquad D = .056 \sqrt[5]{\frac{Q^2\ G\ L}{H}}$$

in which

Q = quantity of gas, cubic feet per hour
D = diameter of pipe, inches
H = pressure by head of water in inches
L = length of pipe, linear yards
G = specific gravity of gas (taken as .400)

For other values of G, multiply quantities given in table by square root of .4 and divide by square root of new value. For lengths one-fourth those in table, discharge of gas is doubled; for lengths four times greater than table, the discharge equals one-half of quantities in table.

Four times the pressure doubles the discharge.

Weight of Air at Different Temperatures and Pressures, in Pounds per Cubic Foot

Based on Atmospheric Pressure of 14.7 Lbs. per Square Inch

Temp. of Air, in Degs. F.	Gauge Pressure, in Pounds										
	0	5	10	20	30	40	50	60	70	80	90
-20	.0900	.1205	.1515	.2125	.2744	.3360	.3970	.4580	.5190	.5800	.6410
-10	.0882	.1184	.1485	.2090	.2685	.3283	.3880	.4478	.5076	.5674	.6272
0	.0864	.1160	.1455	.2040	.2630	.3215	.3800	.4385	.4970	.5555	.6140
10	.0846	.1136	.1425	.1995	.2568	.3145	.3720	.4292	.4863	.5433	.6006
20	.0828	.1112	.1395	.1955	.2516	.3071	.3645	.4205	.4770	.5330	.5890
30	.0811	.1088	.1366	.1916	.2465	.3015	.3570	.4121	.4672	.5221	.5771
40	.0795	.1067	.1338	.1876	.2415	.2954	.3503	.4038	.4576	.5114	.5652
50	.0780	.1045	.1310	.1839	.2367	.2905	.3432	.3960	.4487	.5014	.5541
60	.0764	.1025	.1283	.1803	.2323	.2840	.3362	.3882	.4402	.4927	.5447
70	.0750	.1005	.1260	.1770	.2280	.2791	.3302	.3808	.4316	.4824	.5332
80	.0736	.0988	.1239	.1738	.2237	.2739	.3242	.3738	.4234	.4729	.5224
90	.0723	.0970	.1218	.1707	.2195	.2688	.3182	.3670	.4154	.4639	.5122
100	.0710	.0954	.1197	.1676	.2155	.2638	.3122	.3602	.4079	.4555	.5033
110	.0698	.0937	.1176	.1645	.2115	.2593	.3070	.3542	.4011	.4481	.4950
120	.0686	.0921	.1155	.1618	.2080	.2549	.3018	.3481	.3944	.4403	.4866
130	.0674	.0905	.1135	.1590	.2045	.2505	.2966	.3446	.3924	.4296	.4770
140	.0663	.0889	.1115	.1565	.2015	.2465	.2915	.3364	.3813	.4262	.4711
150	.0652	.0874	.1096	.1541	.1985	.2425	.2865	.3308	.3751	.4193	.4636
175	.0626	.0840	.1054	.1482	.1910	.2335	.2755	.3181	.3607	.4033	.4450
200	.0603	.0809	.1014	.1427	.1840	.2248	.2655	.3054	.3473	.3882	.4291
225	.0581	.0779	.0976	.1373	.1770	.2163	.2555	.2949	.3344	.3738	.4129
250	.0560	.0751	.0941	.1323	.1705	.2085	.2466	.2845	.3223	.3602	.3981
275	.0541	.0726	.0910	.1278	.1645	.2011	.2378	.2745	.3111	.3478	.3844
300	.0523	.0707	.0881	.1237	.1592	.1945	.2300	.2654	.3008	.3362	.3716
350	.0491	.0658	.0825	.1160	.1495	.1828	.2160	.2492	.2824	.3156	.3488
400	.0463	.0621	.0779	.1090	.1405	.1720	.2035	.2348	.2661	.2974	.3287
450	.0437	.0586	.0735	.1033	.1330	.1628	.1925	.2220	.2515	.2810	.3105
500	.0414	.0555	.0696	.0978	.1260	.1540	.1820	.2100	.2380	.2660	.2940
550	.0394	.0528	.0661	.0930	.1198	.1464	.1730	.1996	.2262	.2528	.2794
600	.0376	.0504	.0631	.0885	.1140	.1395	.1650	.1904	.2158	.2412	.2668

Properties of Aqueous Vapors

Temperature in Degrees Fahrenheit	Weight of 1 Cubic Foot of Pure Dry Air, Pounds	Saturated Mixtures of Air and Water Vapor					
		Elastic Force of Vapor, Inches of Mercury	Elastic Force of Air Alone, Saturated Inches of Mercury	Weight of Vapor in 1 Cubic Foot of Mixture, Pounds	Weight of Air in 1 Cubic Foot of Mixture, Pounds	Total Weight 1 Cubic Foot of Mixture, Pounds	Weight of Water Vapor Mixed with 1 Lb. of Air, Lbs.
0	.0864	0.044	29.877	.00008	.0862	.0863	.0009
12	.0842	0.075	29.846	.00013	.0839	.0841	.0015
22	.0824	0.117	29.804	.00020	.0821	.0823	.0024
32	.0807	0.181	29.740	.00030	.0802	.0805	.0037
42	.0791	0.267	29.654	.00044	.0784	.0788	.0056
52	.0776	0.388	29.533	.00062	.0766	.0772	.0081
62	.0761	0.556	29.365	.00087	.0747	.0756	.0117
72	.0746	0.785	29.136	.00121	.0727	.0740	.0167
82	.0733	1.092	28.829	.00166	.0706	.0723	.0235
92	.0719	1.501	28.420	.00225	.0683	.0706	.0329
102	.0707	2.036	27.885	.00300	.0659	.0689	.0456
112	.0694	2.731	27.190	.00396	.0631	.0670	.0628
122	.0682	3.621	26.300	.00518	.0600	.0651	.0863
132	.0671	4.750	25.171	.00669	.0564	.0631	.1185
142	.0660	6.167	23.754	.00856	.0524	.0609	.1635
152	.0649	7.929	21.992	.01085	.0477	.0585	.2276
162	.0638	10.097	19.824	.01364	.0423	.0559	.3224
172	.0628	12.749	17.172	.01699	.0361	.0530	.4711
182	.0618	15.965	13.956	.02100	.0288	.0498	.7280
192	.0609	19.826	10.095	.02575	.0205	.0463	1.2532
202	.0600	24.442	5.479	.03135	.0110	.0423	2.8851
212	.0591	29.921	.000	.03792	.0000	.0379	Infinite

At atmospheric pressure, 29.921 inches of mercury or 14.6963 lbs. per sq. inch.

(From Kent's Mechanical Engineers' Pocket Book, Eighth Edition)

Factors for Correction of Volume of Gas at Different Temperatures and Under Different Atmospheric Pressures

Volume, at 60° F. and 30.0 Inches Hg. =1.000.

Temperature in Degrees Fahrenheit	Barometric Pressure, Inches of Mercury							
	28.6	28.7	28.8	28.9	29.0	29.1	29.2	29.3
-30	1.173	1.177	1.181	1.186	1.190	1.194	1.198	1.202
-25	1.160	1.164	1.168	1.172	1.176	1.180	1.184	1.188
-20	1.147	1.151	1.155	1.159	1.163	1.166	1.170	1.175
-15	1.134	1.138	1.142	1.146	1.150	1.154	1.158	1.161
-10	1.121	1.125	1.129	1.133	1.137	1.141	1.145	1.149
-5	1.109	1.113	1.117	1.120	1.124	1.128	1.132	1.136
0	1.095	1.099	1.103	1.107	1.111	1.114	1.117	1.122
5	1.083	1.087	1.090	1.093	1.098	1.102	1.105	1.109
10	1.071	1.075	1.078	1.082	1.086	1.090	1.093	1.097
15	1.059	1.063	1.066	1.069	1.074	1.077	1.081	1.085
20	1.047	1.051	1.055	1.058	1.062	1.065	1.069	1.073
25	1.035	1.039	1.043	1.046	1.050	1.054	1.057	1.061
30	1.023	1.027	1.031	1.034	1.038	1.042	1.045	1.049
35	1.012	1.015	1.018	1.022	1.026	1.030	1.033	1.037
40	1.001	1.004	1.007	1.011	1.014	1.018	1.021	1.025
42	.995	.999	1.003	1.006	1.010	1.013	1.017	1.020
44	.991	.994	.998	1.001	1.004	1.008	1.012	1.015
46	.986	.990	.993	.997	1.000	1.004	1.007	1.011
48	.981	.985	.988	.992	.995	.999	1.002	1.006
50	.977	.980	.984	.987	.990	.994	.997	1.001
52	.972	.975	.979	.982	.986	.989	.992	.996
54	.967	.970	.974	.977	.981	.984	.988	.991
56	.962	.966	.969	.973	.976	.979	.982	.986
58	.958	.961	.964	.968	.971	.975	.978	.981
60	.953	.956	.959	.963	.966	.969	.973	.976
62	.947	.951	.954	.958	.961	.964	.968	.971
64	.943	.946	.949	.953	.956	.959	.963	.966
66	.938	.941	.944	.948	.951	.954	.958	.961
68	.932	.936	.939	.942	.946	.949	.952	.956
70	.927	.931	.934	.937	.941	.944	.947	.950
72	.922	.925	.929	.932	.935	.939	.942	.945
74	.917	.920	.924	.927	.930	.933	.937	.940
76	.912	.915	.918	.921	.925	.928	.931	.935
78	.906	.909	.913	.916	.919	.923	.926	.929
80	.901	.904	.907	.910	.914	.917	.920	.923
82	.895	.898	.901	.905	.908	.911	.914	.918
84	.889	.893	.896	.899	.903	.906	.909	.912
85	.887	.890	.893	.896	.900	.903	.906	.909
90	.872	.875	.878	.881	.885	.888	.892	.895
95	.857	.860	.863	.866	.870	.873	.876	.879
100	.840	.843	.846	.850	.853	.856	.859	.862
105	.823	.827	.830	.833	.836	.839	.842	.845

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Factors for Correction of Volume of Gas at Different Temperatures and Under Different Atmospheric Pressures (cont.)

Volume, at 60° F. and 30.0 Inches Hg. = 1.000.

Temperature in Degrees Fahrenheit	Barometric Pressure, Inches of Mercury.						
	29.4	29.5	29.6	29.7	29.8	29.9	30.0
-30	1.206	1.210	1.214	1.218	1.222	1.227	1.231
-25	1.192	1.196	1.200	1.204	1.208	1.212	1.217
-20	1.179	1.183	1.187	1.191	1.195	1.199	1.203
-15	1.165	1.169	1.173	1.177	1.181	1.185	1.189
-10	1.152	1.156	1.160	1.164	1.166	1.172	1.176
-5	1.140	1.144	1.148	1.151	1.155	1.159	1.163
0	1.126	1.130	1.133	1.137	1.141	1.145	1.149
5	1.113	1.117	1.120	1.124	1.128	1.132	1.136
10	1.101	1.105	1.108	1.112	1.116	1.120	1.123
15	1.088	1.092	1.096	1.100	1.103	1.107	1.111
20	1.076	1.080	1.084	1.087	1.091	1.095	1.099
25	1.065	1.068	1.072	1.075	1.079	1.083	1.086
30	1.053	1.056	1.060	1.063	1.067	1.071	1.074
35	1.041	1.044	1.048	1.051	1.055	1.058	1.062
40	1.028	1.032	1.036	1.039	1.043	1.046	1.050
42	1.024	1.027	1.031	1.034	1.038	1.041	1.045
44	1.019	1.022	1.026	1.029	1.033	1.036	1.040
46	1.014	1.018	1.021	1.025	1.028	1.031	1.035
48	1.009	1.013	1.016	1.019	1.023	1.026	1.030
50	1.004	1.008	1.011	1.015	1.018	1.022	1.025
52	.999	1.003	1.006	1.010	1.013	1.017	1.020
54	.995	.998	1.001	1.005	1.008	1.012	1.015
56	.990	.993	.996	1.000	1.003	1.007	1.010
58	.985	.988	.992	.995	.998	1.002	1.005
60	.980	.983	.986	.990	.993	.997	1.000
62	.975	.978	.981	.985	.988	.991	.995
64	.969	.973	.976	.980	.983	.986	.990
66	.964	.968	.971	.974	.978	.981	.985
68	.959	.962	.966	.969	.972	.976	.979
70	.954	.957	.960	.964	.967	.970	.974
72	.949	.952	.955	.959	.962	.965	.968
74	.943	.947	.950	.953	.957	.960	.963
76	.938	.941	.944	.948	.951	.954	.958
78	.932	.936	.939	.942	.946	.949	.952
80	.927	.930	.933	.937	.940	.943	.946
82	.921	.924	.927	.931	.934	.937	.941
84	.915	.919	.922	.925	.928	.932	.935
85	.913	.916	.919	.922	.926	.929	.932
90	.898	.901	.905	.908	.911	.914	.917
95	.882	.885	.889	.892	.895	.898	.901
100	.865	.868	.872	.875	.878	.881	.885
105	.848	.851	.855	.858	.861	.864	.867

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Compound Interest Table

Giving Value of $1 at End of Any Year, From 1 to 100

Years	½%	1%	1½%	2%	2½%	3%	3½%
1	1.0050	1.0100	1.0150	1.0200	1.0250	1.0300	1.0350
2	1.0100	1.0201	1.0302	1.0404	1.0506	1.0609	1.0712
3	1.0151	1.0303	1.0457	1.0612	1.0769	1.0927	1.1087
4	1.0202	1.0406	1.0614	1.0824	1.1038	1.1255	1.1475
5	1.0253	1.0510	1.0773	1.1041	1.1314	1.1593	1.1877
6	1.0304	1.0615	1.0934	1.1262	1.1597	1.1941	1.2293
7	1.0355	1.0721	1.1098	1.1487	1.1887	1.2299	1.2723
8	1.0407	1.0829	1.1265	1.1717	1.2184	1.2668	1.3168
9	1.0459	1.0937	1.1434	1.1951	1.2489	1.3048	1.3629
10	1.0511	1.1046	1.1605	1.2190	1.2801	1.3439	1.4106
11	1.0564	1.1157	1.1779	1.2434	1.3121	1.3842	1.4600
12	1.0617	1.1268	1.1956	1.2682	1.3449	1.4258	1.5111
13	1.0670	1.1381	1.2136	1.2936	1.3785	1.4685	1.5640
14	1.0723	1.1495	1.2318	1.3195	1.4130	1.5126	1.6187
15	1.0777	1.1610	1.2502	1.3459	1.4483	1.5580	1.6753
16	1.0831	1.1726	1.2690	1.3728	1.4845	1.6047	1.7340
17	1.0885	1.1843	1.2880	1.4002	1.5216	1.6528	1.7947
18	1.0939	1.1961	1.3073	1.4282	1.5597	1.7024	1.8575
19	1.0994	1.2081	1.3270	1.4568	1.5987	1.7535	1.9225
20	1.1049	1.2202	1.3469	1.4859	1.6386	1.8061	1.9898
21	1.1104	1.2324	1.3671	1.5157	1.6796	1.8603	2.0594
22	1.1160	1.2447	1.3876	1.5460	1.7216	1.9161	2.1315
23	1.1216	1.2572	1.4084	1.5769	1.7646	1.9736	2.2061
24	1.1272	1.2697	1.4295	1.6084	1.8087	2.0328	2.2833
25	1.1328	1.2824	1.4509	1.6406	1.8539	2.0938	2.3632
26	1.1385	1.2953	1.4727	1.6734	1.9003	2.1566	2.4460
27	1.1442	1.3082	1.4948	1.7069	1.9478	2.2213	2.5316
28	1.1499	1.3213	1.5172	1.7410	1.9965	2.2879	2.6202
29	1.1556	1.3345	1.5400	1.7758	2.0464	2.3566	2.7119
30	1.1614	1.3478	1.5631	1.8114	2.0976	2.4273	2.8068
31	1.1672	1.3613	1.5865	1.8476	2.1500	2.5001	2.9050
32	1.1730	1.3749	1.6103	1.8845	2.2038	2.5751	3.0067
33	1.1789	1.3887	1.6345	1.9222	2.2589	2.6523	3.1119
34	1.1848	1.4026	1.6590	1.9607	2.3153	2.7319	3.2209
35	1.1907	1.4166	1.6839	1.9999	2.3732	2.8139	3.3336
36	1.1967	1.4308	1.7091	2.0399	2.4325	2.8983	3.4503
37	1.2027	1.4451	1.7348	2.0807	2.4933	2.9852	3.5710
38	1.2087	1.4595	1.7608	2.1223	2.5557	3.0748	3.6960
39	1.2147	1.4741	1.7872	2.1647	2.6196	3.1670	3.8254
40	1.2208	1.4889	1.8140	2.2080	2.6851	3.2620	3.9593
41	1.2269	1.5038	1.8412	2.2522	2.7522	3.3599	4.0978
42	1.2330	1.5188	1.8688	2.2972	2.8210	3.4607	4.2413
43	1.2392	1.5340	1.8969	2.3432	2.8915	3.5645	4.3897
44	1.2454	1.5493	1.9253	2.3901	2.9638	3.6715	4.5433
45	1.2516	1.5648	1.9542	2.4379	3.0379	3.7816	4.7024
46	1.2579	1.5805	1.9835	2.4866	3.1139	3.8950	4.8669
47	1.2642	1.5963	2.0133	2.5363	3.1917	4.0119	5.0373
48	1.2705	1.6122	2.0435	2.5871	3.2715	4.1323	5.2136
49	1.2768	1.6283	2.0741	2.6388	3.3533	4.2562	5.3961
50	1.2832	1.6446	2.1052	2.6916	3.4371	4.3839	5.5849

Compound Interest Table

Giving Value of $1 at End of Any Year, From 1 to 100

Years	½%	1%	1½%	2%	2½%	3%	3½%
51	1.2896	1.6611	2.1368	2.7454	3.5230	4.5154	5.7804
52	1.2961	1.6777	2.1689	2.8003	3.6111	4.6509	5.9827
53	1.3026	1.6945	2.2014	2.8563	3.7014	4.7904	6.1921
54	1.3091	1.7114	2.2344	2.9135	3.7939	4.9341	6.4088
55	1.3156	1.7285	2.2679	2.9717	3.8888	5.0821	6.6331
56	1.3222	1.7458	2.3020	3.0312	3.9860	5.2346	6.8653
57	1.3288	1.7633	2.3365	3.0918	4.0856	5.3917	7.1056
58	1.3355	1.7809	2.3715	3.1536	4.1878	5.5534	7.3543
59	1.3421	1.7987	2.4071	3.2167	4.2925	5.7200	7.6017
60	1.3489	1.8167	2.4432	3.2810	4.3998	5.8916	7.8781
61	1.3556	1.8349	2.4799	3.3467	4.5098	6.0684	8.1538
62	1.3624	1.8532	2.5171	3.4136	4.6225	6.2504	8.4392
63	1.3692	1.8717	2.5548	3.4819	4.7381	6.4379	8.7346
64	1.3760	1.8905	2.5931	3.5515	4.8565	6.6311	9.0403
65	1.3829	1.9094	2.6320	3.6225	4.9780	6.8300	9.3567
66	1.3898	1.9285	2.6715	3.6950	5.1024	7.0349	9.6842
67	1.3968	1.9477	2.7116	3.7689	5.2300	7.2459	10.0231
68	1.4038	1.9672	2.7523	3.8443	5.3607	7.4633	10.3739
69	1.4108	1.9869	2.7936	3.9211	5.4947	7.6872	10.7370
70	1.4178	2.0068	2.8355	3.9996	5.6321	7.9178	11.1128
71	1.4249	2.0268	2.8780	4.0795	5.7729	8.1554	11.5018
72	1.4320	2.0471	2.9212	4.1611	5.9172	8.4000	11.9043
73	1.4392	2.0676	2.9650	4.2444	6.0652	8.6520	12.3210
74	1.4464	2.0882	3.0094	4.3293	6.2168	8.9116	12.7522
75	1.4536	2.1091	3.0546	4.4158	6.3722	9.1789	13.1986
76	1.4609	2.1302	3.1004	4.5042	6.5315	9.4543	13.6605
77	1.4682	2.1515	3.1469	4.5942	6.6948	9.7379	14.1386
78	1.4755	2.1730	3.1941	4.6861	6.8622	10.0301	14.6335
79	1.4829	2.1948	3.2420	4.7798	7.0337	10.3310	15.1456
80	1.4903	2.2167	3.2907	4.8754	7.2096	10.6409	15.6757
81	1.4978	2.2389	3.3400	4.9729	7.3898	10.9601	16.2244
82	1.5053	2.2613	3.3901	5.0724	7.5746	11.2889	16.7922
83	1.5128	2.2839	3.4410	5.1739	7.7639	11.6276	17.3800
84	1.5204	2.3067	3.4926	5.2773	7.9580	11.9764	17.9883
85	1.5280	2.3298	3.5450	5.3829	8.1570	12.3357	18.6179
86	1.5356	2.3531	3.5982	5.4905	8.3609	12.7058	19.2695
87	1.5433	2.3766	3.6521	5.6003	8.5699	13.0870	19.9439
88	1.5510	2.4004	3.7069	5.7124	8.7842	13.4796	20.6420
89	1.5588	2.4244	3.7625	5.8266	9.0038	13.8839	21.3644
90	1.5666	2.4486	3.8189	5.9431	9.2289	14.3005	22.1122
91	1.5744	2.4731	3.8762	6.0620	9.4596	14.7295	22.8861
92	1.5823	2.4979	3.9344	6.1832	9.6961	15.1714	23.6871
93	1.5902	2.5228	3.9934	6.3069	9.9385	15.6265	24.5162
94	1.5981	2.5481	4.0533	6.4330	10.1869	16.0953	25.3742
95	1.6061	2.5735	4.1141	6.5617	10.4416	16.5782	26.2623
96	1.6141	2.5993	4.1758	6.6929	10.7026	17.0755	27.1815
97	1.6222	2.6253	4.2384	6.8268	10.9702	17.5878	28.1329
98	1.6303	2.6515	4.3020	6.9633	11.2445	18.1154	29.1175
99	1.6385	2.6780	4.3665	7.1026	11.5256	18.6589	30.1366
100	1.6467	2.7048	4.4320	7.2446	11.8137	19.2186	31.1914

Compound Interest Table

Giving Value of $1 at End of Any Year, From 1 to 100

Years	4%	4½%	5%	5½%	6%	6½%	7%
1	1.0400	1.0450	1.0500	1.0550	1.0600	1.0650	1.0700
2	1.0816	1.0920	1.1025	1.1130	1.1236	1.1342	1.1449
3	1.1249	1.1412	1.1576	1.1742	1.1910	1.2079	1.2250
4	1.1699	1.1925	1.2155	1.2388	1.2625	1.2865	1.3108
5	1.2167	1.2462	1.2763	1.3070	1.3382	1.3701	1.4026
6	1.2653	1.3023	1.3401	1.3788	1.4185	1.4591	1.5007
7	1.3159	1.3609	1.4071	1.4547	1.5036	1.5540	1.6058
8	1.3686	1.4221	1.4775	1.5347	1.5938	1.6550	1.7182
9	1.4233	1.4861	1.5513	1.6191	1.6895	1.7626	1.8385
10	1.4802	1.5530	1.6289	1.7081	1.7908	1.8771	1.9672
11	1.5395	1.6229	1.7103	1.8021	1.8983	1.9992	2.1049
12	1.6010	1.6959	1.7959	1.9012	2.0122	2.1291	2.2522
13	1.6651	1.7722	1.8856	2.0058	2.1329	2.2675	2.4098
14	1.7317	1.8519	1.9799	2.1161	2.2609	2.4149	2.5785
15	1.8009	1.9353	2.0789	2.2325	2.3966	2.5718	2.7590
16	1.8730	2.0224	2.1829	2.3553	2.5404	2.7390	2.9522
17	1.9479	2.1134	2.2920	2.4848	2.6928	2.9170	3.1588
18	2.0258	2.2085	2.4066	2.6215	2.8543	3.1067	3.3799
19	2.1068	2.3079	2.5270	2.7656	3.0256	3.3086	3.6165
20	2.1911	2.4117	2.6533	2.9178	3.2071	3.5236	3.8697
21	2.2788	2.5202	2.7860	3.0782	3.3996	3.7527	4.1406
22	2.3699	2.6337	2.9253	3.2475	3.6035	3.9966	4.4304
23	2.4647	2.7522	3.0715	3.4262	3.8197	4.2564	4.7405
24	2.5633	2.8760	3.2251	3.6146	4.0489	4.5331	5.0724
25	2.6658	3.0054	3.3864	3.8134	4.2919	4.8277	5.4274
26	2.7725	3.1407	3.5557	4.0231	4.5494	5.1415	5.8074
27	2.8834	3.2820	3.7335	4.2444	4.8223	5.4757	6.2139
28	2.9987	3.4297	3.9201	4.4778	5.1117	5.8316	6.6488
29	3.1187	3.5840	4.1161	4.7241	5.4184	6.2107	7.1143
30	3.2434	3.7453	4.3219	4.9840	5.7435	6.6144	7.6123
31	3.3731	3.9139	4.5380	5.2581	6.0881	7.0443	8.1451
32	3.5081	4.0900	4.7649	5.5473	6.4534	7.5022	8.7153
33	3.6484	4.2740	5.0032	5.8524	6.8406	7.9898	9.3253
34	3.7943	4.4664	5.2533	6.1742	7.2510	8.5092	9.9781
35	3.9461	4.6673	5.5160	6.5138	7.6861	9.0623	10.6766
36	4.1039	4.8774	5.7918	6.8721	8.1473	9.6513	11.4239
37	4.2681	5.0969	6.0814	7.2501	8.6361	10.2786	12.2236
38	4.4388	5.3262	6.3855	7.6488	9.1543	10.9467	13.0793
39	4.6164	5.5659	6.7048	8.0695	9.7035	11.6583	13.9948
40	4.8010	5.8164	7.0400	8.5133	10.2857	12.4161	14.9745
41	4.9931	6.0781	7.3920	8.9815	10.9029	13.2231	16.0227
42	5.1928	6.3516	7.7616	9.4755	11.5570	14.0826	17.1443
43	5.4005	6.6374	8.1497	9.9967	12.2505	14.9980	18.3444
44	5.6165	6.9361	8.5572	10.5465	12.9855	15.9729	19.6285
45	5.8412	7.2482	8.9850	11.1266	13.7646	17.0111	21.0025
46	6.0748	7.5744	9.4343	11.7385	14.5905	18.1168	22.4726
47	6.3178	7.9153	9.9060	12.3841	15.4659	19.2944	24.0457
48	6.5705	8.2715	10.4013	13.0653	16.3939	20.5485	25.7289
49	6.8333	8.6437	10.9213	13.7838	17.3775	21.8842	27.5299
50	7.1067	9.0326	11.4674	14.5420	18.4202	23.3067	29.4570

Compound Interest Table

Giving Value of $1 at End of Any Year, From 1 to 100

Years	4%	4½%	5%	5½%	6%	6½%	7%
51	7.3910	9.4391	12.0408	15.3418	19.5254	24.8216	31.5190
52	7.6866	9.8639	12.6428	16.1856	20.6969	26.4350	33.7253
53	7.9941	10.3077	13.2749	17.0758	21.9387	28.1533	36.0861
54	8.3138	10.7716	13.9387	18.0149	23.2550	29.9833	38.6122
55	8.6464	11.2563	14.6356	19.0058	24.6503	31.9322	41.3150
56	8.9922	11.7628	15.3674	20.0511	26.1293	34.0078	44.2071
57	9.3519	12.2922	16.1358	21.1539	27.6971	36.2183	47.3015
58	9.7260	12.8455	16.9426	22.3174	29.3589	38.5725	50.6127
59	10.1150	13.4234	17.7897	23.5448	31.1205	41.0797	54.1555
60	10.5196	14.0274	18.6792	24.8398	32.9877	43.7498	57.9464
61	10.9404	14.6586	19.6131	26.2060	34.9670	46.5936	62.0027
62	11.3780	15.3183	20.5938	27.6473	37.0650	49.6222	66.3429
63	11.8332	16.0076	21.6235	29.1679	39.2889	52.8476	70.9869
64	12.3065	16.7279	22.7047	30.7721	41.6462	56.2827	75.9559
65	12.7987	17.4807	23.8399	32.4646	44.1450	59.9411	81.2729
66	13.3107	18.2673	25.0319	34.2501	46.7937	63.8372	86.9620
67	13.8431	19.0894	26.2835	36.1339	49.6013	67.9867	93.0493
68	14.3968	19.9484	27.5977	38.1213	52.5774	72.4058	99.5627
69	14.9727	20.8461	28.9775	40.2179	55.7320	77.1122	106.5321
70	15.5716	21.7841	30.4264	42.4299	59.0759	82.1245	113.9894
71	16.1945	22.7644	31.9477	44.7636	62.6205	87.4626	121.9686
72	16.8423	23.7888	33.5451	47.2256	66.3777	93.1476	130.5065
73	17.5160	24.8593	35.2224	49.8230	70.3604	99.2022	139.6419
74	18.2166	25.9780	36.9835	52.5632	74.5820	105.6504	149.4168
75	18.9453	27.1470	38.8327	55.4542	79.0569	112.5176	159.8760
76	19.7031	28.3686	40.7743	58.5042	83.8003	119.8313	171.0673
77	20.4912	29.6452	42.8130	61.7219	88.8284	127.6203	183.0421
78	21.3108	30.9792	44.9537	65.1166	94.1581	135.9156	195.8550
79	22.1633	32.3733	47.2014	68.6980	99.8075	144.7501	209.5648
80	23.0498	33.8301	49.5614	72.4764	105.7960	154.1589	224.2344
81	23.9718	35.3525	52.0395	76.4626	112.1438	164.1792	239.9308
82	24.9307	36.9433	54.6415	80.6681	118.8724	174.8509	256.7260
83	25.9279	38.6058	57.3736	85.1048	126.0047	186.2162	274.6968
84	26.9650	40.3430	60.2422	89.7856	133.5650	198.3202	293.9255
85	28.0436	42.1585	63.2544	94.7238	141.5789	211.2111	314.5003
86	29.1653	44.0556	66.4171	99.9336	150.0736	224.9398	336.5154
87	30.3320	46.0381	69.7379	105.4299	159.0781	239.5609	360.0714
88	31.5452	48.1098	73.2248	111.2286	168.6227	255.1323	385.2764
89	32.8071	50.2747	76.8861	117.3462	178.7401	271.7159	412.2458
90	34.1193	52.5371	80.7304	123.8002	189.4645	289.3775	441.1030
91	35.4841	54.9013	84.7669	130.6092	200.8324	308.1870	471.9802
92	36.9035	57.3718	89.0052	137.7927	212.8823	328.2191	505.0188
93	38.3796	59.9536	93.4555	145.3713	225.6553	349.5534	540.3701
94	39.9148	62.6515	98.1283	153.3667	239.1946	372.2744	578.1960
95	41.5114	65.4708	103.0347	161.8019	253.5463	396.4722	618.6697
96	43.1718	68.4170	108.1864	170.7010	268.7590	422.2429	661.9766
97	44.8987	71.4957	113.5957	180.0896	284.8846	449.6887	708.3150
98	46.6947	74.7130	119.2755	189.9945	301.9776	478.9184	757.8970
99	48.5625	78.0751	125.2393	200.4442	320.0963	510.0481	810.9498
100	50.5049	81.5885	131.5013	211.4686	339.3021	543.2013	867.7163

Annuity Table
Giving Yearly Payments Required to Redeem $100 at End of Any Year, From 1 to 100

Years	2½%	3%	3½%	4%	4½%	5%	6%
1	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2	49.38	49.26	49.14	49.02	48.90	48.78	48.54
3	32.51	32.36	32.19	32.03	31.88	31.72	31.41
4	24.08	23.90	23.73	23.55	23.37	23.20	22.86
5	19.02	18.84	18.65	18.46	18.28	18.10	17.74
6	15.65	15.46	15.27	15.08	14.89	14.70	14.34
7	13.25	13.05	12.85	12.66	12.47	12.28	11.91
8	11.45	11.25	11.05	10.85	10.66	10.47	10.10
9	10.05	9.84	9.64	9.45	9.26	9.07	8.70
10	8.93	8.72	8.52	8.33	8.14	7.95	7.59
11	8.01	7.81	7.61	7.42	7.23	7.04	6.68
12	7.25	7.05	6.85	6.66	6.47	6.28	5.93
13	6.60	6.40	6.21	6.01	5.83	5.65	5.30
14	6.05	5.85	5.66	5.47	5.28	5.10	4.76
15	5.58	5.38	5.18	4.99	4.81	4.63	4.30
16	5.16	4.96	4.77	4.58	4.40	4.23	3.90
17	4.79	4.60	4.40	4.22	4.04	3.87	3.54
18	4.47	4.27	4.08	3.90	3.72	3.55	3.24
19	4.18	3.98	3.79	3.61	3.44	3.27	2.96
20	3.91	3.72	3.54	3.36	3.19	3.02	2.72
21	3.68	3.49	3.30	3.13	2.96	2.80	2.50
22	3.46	3.27	3.09	2.92	2.75	2.60	2.30
23	3.27	3.08	2.90	2.73	2.57	2.41	2.13
24	3.09	2.90	2.73	2.56	2.40	2.25	1.97
25	2.93	2.74	2.57	2.40	2.24	2.10	1.82
26	2.78	2.59	2.42	2.26	2.10	1.96	1.69
27	2.64	2.46	2.29	2.12	1.97	1.83	1.57
28	2.51	2.33	2.16	2.00	1.85	1.71	1.46
29	2.39	2.21	2.04	1.89	1.74	1.60	1.36
30	2.28	2.10	1.94	1.78	1.64	1.51	1.26
31	2.17	2.00	1.84	1.69	1.54	1.41	1.18
32	2.08	1.90	1.74	1.60	1.46	1.33	1.10
33	1.99	1.82	1.66	1.51	1.37	1.25	1.03
34	1.90	1.73	1.58	1.43	1.30	1.18	.96
35	1.82	1.65	1.50	1.36	1.23	1.11	.90
36	1.75	1.58	1.43	1.29	1.16	1.04	.84
37	1.67	1.51	1.36	1.22	1.10	.98	.79
38	1.61	1.45	1.30	1.16	1.04	.93	.74
39	1.54	1.38	1.24	1.11	.99	.88	.69
40	1.48	1.33	1.18	1.05	.93	.83	.65
41	1.43	1.27	1.13	1.00	.89	.78	.61
42	1.37	1.22	1.08	.95	.84	.74	.57
43	1.32	1.17	1.03	.91	.80	.70	.53
44	1.27	1.12	.99	.87	.76	.66	.50
45	1.23	1.08	.95	.83	.72	.63	.47
46	1.18	1.04	.91	.79	.68	.59	.44
47	1.14	1.00	.87	.75	.65	.56	.41
48	1.10	.96	.83	.72	.62	.53	.39
49	1.06	.92	.80	.69	.59	.50	.37
50	1.03	.89	.76	.66	.56	.48	.34

Annuity Table

Giving Yearly Payments Required to Redeem $100 at End of Any Year, From 1 to 100 (continued)

Years	2½%	3%	3½%	4%	4½%	5%	6%
51	.99	.85	.73	.63	.53	.45	.32
52	.96	.82	.70	.60	.51	.43	.30
53	.93	.79	.67	.57	.48	.41	.29
54	.89	.76	.65	.55	.46	.39	.27
55	.87	.73	.62	.52	.44	.37	.25
56	.84	.71	.60	.50	.42	.35	.24
57	.81	.68	.57	.48	.40	.33	.22
58	.78	.66	.55	.46	.38	.31	.21
59	.76	.64	.53	.44	.36	.30	.20
60	.74	.61	.51	.42	.35	.28	.19
61	.71	.59	.49	.40	.33	.27	.18
62	.69	.57	.47	.39	.31	.26	.17
63	.67	.55	.45	.37	.30	.24	.16
64	.65	.53	.44	.35	.29	.23	.15
65	.63	.51	.42	.34	.27	.22	.14
66	.61	.50	.40	.32	.26	.21	.13
67	.59	.48	.39	.31	.25	.20	.12
68	.57	.46	.37	.30	.24	.19	.12
69	.56	.45	.36	.29	.23	.18	.11
70	.54	.43	.35	.27	.22	.17	.10
71	.52	.42	.33	.26	.21	.16	.10
72	.51	.41	.32	.25	.20	.15	.09
73	.49	.39	.31	.24	.19	.15	.09
74	.48	.38	.30	.23	.18	.14	.08
75	.47	.37	.29	.22	.17	.13	.08
76	.45	.35	.28	.21	.16	.13	.07
77	.44	.34	.27	.21	.16	.12	.07
78	.43	.33	.26	.20	.15	.11	.06
79	.41	.32	.25	.19	.14	.11	.06
80	.40	.31	.24	.18	.14	.10	.06
81	.39	.30	.23	.17	.13	.10	.05
82	.38	.29	.22	.17	.13	.09	.05
83	.37	.28	.21	.16	.12	.09	.05
84	.36	.27	.21	.15	.11	.08	.05
85	.35	.26	.20	.15	.11	.08	.04
86	.34	.26	.19	.14	.10	.08	.04
87	.33	.25	.18	.14	.10	.07	.04
88	.32	.24	.18	.13	.10	.07	.04
89	.31	.23	.17	.13	.09	.07	.03
90	.30	.23	.17	.12	.09	.06	.03
91	.30	.22	.16	.12	.08	.06	.03
92	.29	.21	.15	.11	.08	.06	.03
93	.28	.21	.15	.11	.08	.05	.03
94	.27	.20	.14	.10	.07	.05	.03
95	.26	.19	.14	.10	.07	.05	.02
96	.26	.19	.13	.09	.07	.05	.02
97	.25	.18	.13	.09	.06	.04	.02
98	.24	.18	.12	.09	.06	.04	.02
99	.24	.17	.12	.08	.06	.04	.02
100	.23	.16	.12	.08	.06	.04	.02

Annuity Table

Capitalization of Annuity of $1,000 for From 5 to 100 Years

Years	2½%	3%	3½%	4%
5	4,645.88	4,579.60	4,514.92	4,451.68
10	8,752.17	8,530.13	8,316.45	8,110.74
15	12,381.41	11,937.80	11,517.23	11,118.06
20	15,589.215	14,877.27	14,212.12	13,590.21
25	18,424.67	17,413.01	16,481.28	15,621.93
30	20,930.59	19,600.21	18,391.85	17,291.86
35	23,145.31	21,487.04	20,000.43	18,664.37
40	25,103.53	23,114.36	21,354.83	19,792.65
45	26,833.15	24,518.49	22,495.23	20,719.89
50	28,362.48	25,729.58	23,455.21	21,482.08
70	32,897.85	29,123.36	26,000.65	23,394.57
100	36,614.21	31,598.81	27,655.36	24,504.96

Years	4½%	5%	5½%	6%
5	4,389.91	4,329.45	4,268.09	4,212.40
10	7,912.67	7,721.73	7,537.54	7,360.19
15	10,739.42	10,379.53	10,037.48	9,712.30
20	13,007.88	12,462.13	11,950.26	11,469.96
25	14,828.12	14,093.86	13,413.82	12,783.38
30	16,288.77	15,372.36	14,533.63	13,764.85
35	17,460.89	16,374.36	15,390.48	14,488.65
40	18,401.49	17,159.01	16,044.92	15,046.31
45	19,156.24	17,773.99	16,547.65	15,455.85
50	19,761.93	18,255.86	16,931.97	15,761.87
70	21,202.16	19,342.74	17,752.90	16,384.51
100	21,949.21	19,847.90	18,095.83	16,612.64

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