TO MARK PROGRESS

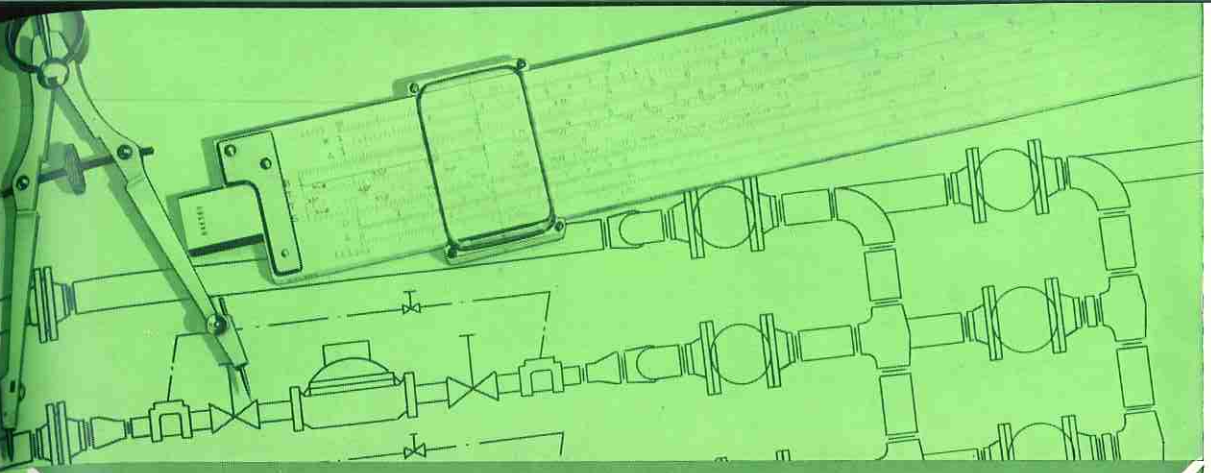
LADISH

Controlled Quality

FITTINGS

CATALOG NO. 55

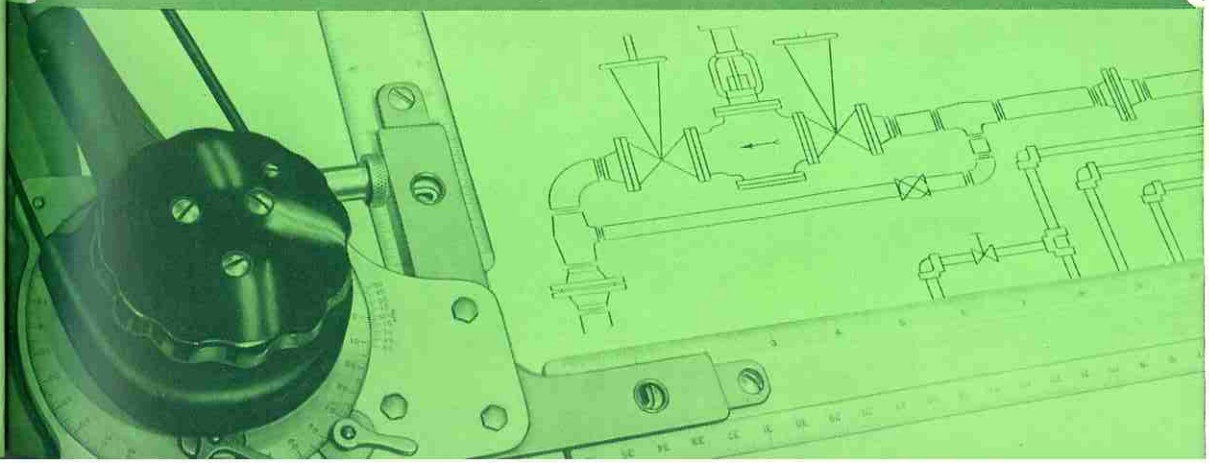
SEAMLESS WELDING FITTINGS	FORGED STEEL FLANGES	LARGE DIAMETER FLANGES	LONG WELDING NECKS	FORGED STEEL FITTINGS



LADISH

Engineering and TECHNICAL DATA SECTION

TO MARK PROGRESS



1 SEAMLESS WELDING FITTINGS

2 FORGED STEEL FLANGES

3 LARGE O. D. & TEMA FLANGES, LONG NECKS, ROLLED RINGS

4 FORGED STEEL FITTINGS

5 STAINLESS AND ALLOY FITTINGS

6 ENGINEERING AND TECHNICAL DATA

7 GENERAL INDEX AND PART NUMBERS

LADISH

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TO MARK PROGRESS

DIMENSIONAL TOLERANCES

For Ladish Seamless Steel Butt-Welding Fittings

Ladish welding fittings are manufactured in accordance with the dimensional tolerances and material specifications of the American Standard ASA B16.9-1951, for Steel Butt-Welding Fittings. The dimensional tolerances listed below are the maximum permitted. Rigid standards for inspection procedure guarantee accuracy in production and result in Ladish Fittings which normally run much closer to nominal dimensions than to the permitted extremes.

WALL THICKNESS

The wall thickness of the fitting at any point shall not be less than 87½% of the nominal thickness.

OUTSIDE DIAMETER

The outside diameter of fittings at beginning of bevel:

For sizes up to and including 2½"	+ 1/16" − 1/32"
For sizes 3" through 4"	+ 1/16" − 1/16"
For sizes 5" through 8"	+ 3/32" − 1/16"
For sizes 10" through 18"	+ 5/32" − 1/8"
For sizes 20" through 24"	+ 1/4" − 3/16"

INSIDE DIAMETER

The inside diameter of fittings at welding ends:

For sizes up to and including 2½"	± 1/32"
For sizes 3" through 8"	± 1/16"
For sizes 10" through 18"	± 1/8"
For sizes 20" through 24"	± 3/16"

CENTER TO END OF 90° & 45° ELBOWS & TEES, END TO END OF REDUCERS

For sizes up to and including 8"	± 1/16"
For sizes 10" through 24"	± 3/32"

OVERALL LENGTH OF WELDING CAPS

Overall length dimension:

For sizes up to and including 4"	± 1/8"
For sizes 5" through 24"	± 1/4"

BACK TO FACE, ALIGNMENT OF ENDS, CENTER TO CENTER OF 180° RETURNS

Back-to-face dimension:

For all sizes	± 1/4"

Alignment of ends:

For sizes up through 8"	± 1/32"
For sizes 10" through 24"	± 1/16"

Center-to-center dimension:

For sizes up to and including 8"	± 1/4"
For sizes 10" through 24"	± 3/8"

END TO END, FILLET RADIUS, LAP THICKNESS & OUTSIDE DIAMETER OF LAP JOINT STUB ENDS

End-to-end dimension:

For sizes up to and including 8"	± 1/16"
For sizes 10" through 24"	± 3/32"

Fillet radius:

For sizes up to and including 3½"	+ 0" − 1/32"
For sizes 4" through 24"	+ 0" − 1/16"

Thickness of lap:

For all sizes	+ 1/16" − 0"

Outside diameter of lap:

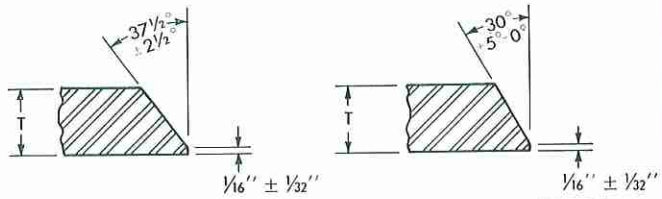
For all sizes	± 1/64"

Outside diameter of barrel:

For sizes 1" through 1½"	+ 1/64" − 1/32"
For sizes 2" through 4"	+ 1/32" − 1/32"
For sizes 5" through 8"	+ 1/16" − 1/32"
For sizes 10" through 18"	+ 3/32" − 1/32"
For sizes 20" through 24"	+ 1/8" − 1/32"

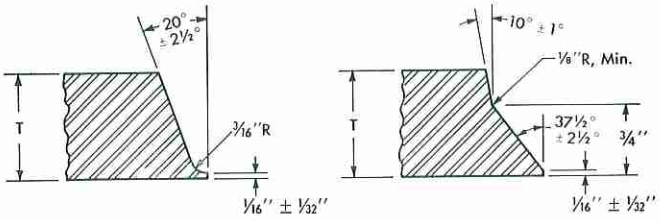
WELDING BEVEL STANDARDS

For wall thickness "T," ¾" or less



The 37½° bevel is recommended in ASA B16.5 and B16.9. The 30° bevel is commonly used in pipe line and large diameter systems.

For wall thickness "T," greater than ¾"



The U-Bevel has been replaced by the combination 37½°—10° bevel in ASA B16.5. It is expected that ASA B16.9 will make the same change.

DIMENSIONAL TOLERANCES

Ladish Flanges including Long Welding Necks and Large Diameter Flanges

Exacting control over manufacture and inspection assures accurate forging and machining of Ladish Flanges... resulting in generally closer tolerances than required by ASA. The dimensional tolerances listed below include those of the American Standard B16.5, and additional manufacturing tolerances not covered by this standard.

OUTSIDE DIAMETER

When O.D. is 24" or less ..... ± 1/16"
When O.D. is over 24" ..... ± 1/8"

INSIDE DIAMETER

Threaded
To Standard Gauge Limits

Slip-On, Lap Joint
10" and smaller ..... + 1/32" − 0"
12" to 24" ..... + 1/16" − 0"
26" and larger ..... + 3/32" − 0"

Welding Neck, Long Welding Neck
10" and smaller ..... ± 1/32"
12" to 18" ..... ± 1/16"
20" and larger ..... + 1/8" − 1/16"

DIAMETER OF CONTACT FACE

1/16" Raised Face ..... ± 1/32"
1/4" Raised Face, Tongue and Groove, Male or Female ..... ± 1/64"

DIAMETER OF COUNTERBORE

Threaded
10" and smaller ..... + 1/32" − 0"
12" and larger ..... + 1/16" − 0"

FLANGE THICKNESS

18" and smaller ..... + 1/8" − 0"
Over 18" ..... + 3/16" − 0"

HUB

Welding Neck
Outside Diameter of Hub at Point of Weld
5" and smaller ..... + 3/32" − 1/32"
6" and larger ..... + 5/32" − 1/32"
Thickness of Hub at Point of Weld
Not less than 87½% of the nominal thickness of the pipe to which the flange is to be attached.

Long Welding Neck
Outside Diameter of Neck
10" and smaller ..... + 3/32" − 1/32"
12" and larger ..... + 3/32" − 1/16"

DRILLING

Bolt Circle
Special ..... ± 1/16"
Regular ..... ± 1/32"
Bolt Hole Spacing
Special ..... ± 1/32"
Regular ..... ± 1/64"
Eccentricity of Bolt Circle and Facing
With respect to bore ..... 1/32" Max.

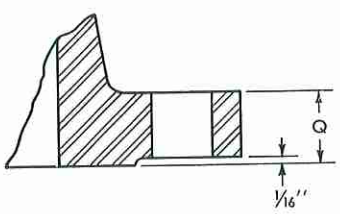
OVERALL HEIGHT

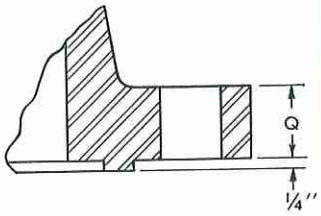
Threaded, Slip-On, Lap Joint, Blind
All sizes ..... ± 1/16"

Welding Neck, Long Welding Neck
10" and smaller ..... ± 1/16"
12" and larger ..... ± 1/8"

FACINGS

150 and 300 lb. Standard



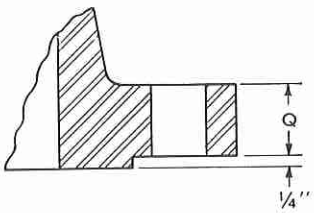


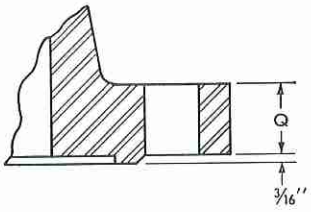
1/16" raised face is standard and is included in the flange thickness "Q."

All other facings (see page 161) are added to the flange thickness "Q."

See pages 160-161 for diametral dimensions.

400, 600, 900, 1500, and 2500 lb. Standard





1/4" raised face is standard and is added to the flange thickness "Q."

All other facings (see page 161) are added to the flange thickness "Q."

See pages 160-161 for diametral dimensions.

DIMENSIONAL TOLERANCES

For Ladish Forged Steel Socket Welding Fittings

Ladish Socket Welding Fittings are manufactured in accordance with the dimensional tolerances and material specifications of the American Standard ASA (B16.11-1946), for Steel Socket Welding Fittings. The dimensional tolerances listed below are the maximum permitted. The dimension from center of fitting to base of socket is standard. Outstanding controls over manufacturing processes augmented by rigid inspection standards have been instituted by Ladish to assure that fittings are produced to closer tolerances than the maximums set by the Standard.

CENTER TO BOTTOM OF SOCKET

For Sizes 1/8" and 1/4"	± 0.03"
For Sizes 3/8", 1/2" and 3/4"	± 0.06"
For Sizes 1", 1 1/4", 1 1/2" and 2"	± 0.08"
For Sizes 2 1/2" and larger	± 0.10"

BOTTOM TO BOTTOM OF SOCKETS—COUPLINGS

For Sizes 1/8" and 1/4"	± 0.06"
For Sizes 3/8", 1/2" and 3/4"	± 0.12"
For Sizes 1", 1 1/4", 1 1/2" and 2"	± 0.16"
For Sizes 2 1/2" and larger	± 0.20"

BOTTOM OF SOCKET TO OPPOSITE FACE—HALF COUPLINGS

For Sizes 1/8" and 1/4"	± 0.03"
For Sizes 3/8", 1/2" and 3/4"	± 0.06"
For Sizes 1", 1 1/4", 1 1/2" and 2"	± 0.08"
For Sizes 2 1/2" and larger	± 0.10"

AMERICAN STANDARD (B16.11-1946)

This standard covers the following range of sizes for use with Schedules 40 and 80 pipe as of the publication date of this catalog . . .

90° and 45° Elbows	1/8" through 3"
Tees	1/8" through 3"
Crosses	1/8" through 3"
Couplings	1/8" through 3"

Sizes 1/2" through 3" are included for use with Schedule 160 pipe. Fittings for use with Double Extra Strong pipe are not included in this standard.

BORE DIAMETER OF SOCKET

For Sizes 2" and smaller	− 0" + 0.010"
For Sizes 2 1/2" and larger	− 0" + 0.015"

BORE DIAMETER OF FITTING

For Sizes 2" and smaller	± 0.015"
For Sizes 2 1/2" and larger	± 0.030"

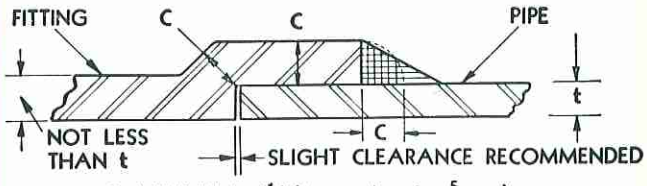
CONCENTRICITY OF BORES

The socket and fitting bores shall be concentric within a tolerance of ± 0.030" for all sizes.

COINCIDENCE OF AXES

The maximum allowable variation in the alignment of the socket and fitting bore axes shall be 1/16" in 12".

FILLET WELD DIMENSIONS



C—MINIMUM=$1\frac{1}{4}$t (*but not less than* $\frac{5}{32}$ *in.*)
t=NOMINAL PIPE WALL THICKNESS

Minimum requirements for socket and fillet weld dimensions as prescribed in the American Standard Code for Pressure Piping, ASA B31.1.

MANUFACTURING STANDARDS AND MATERIAL SPECIFICATIONS

for Ladish Seamless Welding Fittings

Ladish Seamless Welding Fittings are manufactured to the dimensional standards of The American Standards Association and from material included in the ASTM, ASME, and API Specifications and to the special requirements of the purchaser.

American Standard ASA B16.9-1951 covers the range of sizes listed below and the dimensional tolerances shown on page 239. It establishes the pressure ratings such as may be calculated in accordance with the rules established in the various sections of the Code for Pressure Piping, ASA B31.1-1951, as described and tabulated on pages 247 through 262 of this catalog.

Some of the material specifications are tabulated below, and an abbreviated but more comprehensive listing of piping material specifications is given on pages 229 through 236.

RANGE OF SIZES COVERED BY AMERICAN STANDARD ASA B16.9-1951

This standard covers the following range of sizes as of the publication date of this catalog.

90° Long Radius Elbows	1" through 24"
45° Elbows	1" through 24"
180° Long Radius Returns	1" through 24"
Tees	1" through 12"
(Center to end of run only)	14" through 24"
Welding Reducers (Reductions to one size less than half the nominal pipe size)	1" through 24"
Welding Caps	1" through 24"
Lap Joint Stub Ends	1" through 24"

MATERIAL SPECIFICATIONS FOR SEAMLESS WELDING FITTINGS

MATERIAL	MARKING SYMBOL*	ASTM SPECIFICATION AND GRADE OF PERMISSIBLE RAW MATERIALS		
		PIPE	PLATE	FORGINGS
Carbon steel	WPA	A106—A	A285—B and C	A105—I
Carbon steel	WPB	A106—B	A212—A and B	A105—II
Carbon-Molybdenum steel	WP1	A335—P1	A204—B	A182—F1
½% Cr-½% Mo steel	WP2	A335—P2	**	**
1% Cr-½% Mo steel	WP12	A335—P12	A301—B	A182—F12
1¼% Cr-½% Mo steel	WP11	A335—P11	**	A182—F11
1¾% Cr-¾% Mo steel	WP3	A335—P3	**	**
2% Cr-½% Mo steel	WP3b	A335—P3b	**	**
2¼% Cr-1% Mo steel	WP22	A335—P22	**	A182—F22
3% Cr-1% Mo steel	WP21	A335—P21	**	**
5% Cr-½% Mo steel	WP5	A335—P5	**	A182—F5
7% Cr-½% Mo steel	WP7	A335—P7	**	**
9% Cr-1% Mo steel	WP9	A335—P9	**	A182—F9
18% Cr-8% Ni steel	WP304	A312—TP304	**	A182—F304
25% Cr-20% Ni steel	WP310	A312—TP310	**	A182—F310
18% Cr-8% Ni-Ti steel	WP321	A312—TP321	**	A182—F321
18% Cr-10% Ni-Cb steel	WP347	A312—TP347	**	A182—F347
18%Cr-12% Ni-Mo steel	WP316	A312—TP316	**	A182—F316

*When fittings are of welded construction, the symbols shown above shall be supplemented by the letter "W".

**No ASTM Specification has as yet been written for plate and/or forging materials of this general analysis. However, fittings may be manufactured from plate or forgings, the chemical composition and physical properties of which are equivalent to those of the comparable grade of pipe.

MANUFACTURING STANDARDS AND MATERIAL SPECIFICATIONS

for Forged Flanges and Screwed and Socket Welding Fittings

Ladish Forged Steel American Standard Flanges are manufactured to the dimensional standards of ASA B16.5-1953. This standard covers the range of sizes listed below and the dimensional tolerances shown on page 240. It establishes pressure-temperature ratings which are constant throughout all sizes of any one material, one pressure, and one gasket-facing class. As can be seen in the tabulation on pages 263-268, this results in a considerable condensation of ratings, as compared to the ratings for pipe and Seamless Welding Fittings, where ratings vary with size of fitting and the type of service as covered by the various sections of the Code for Pressure Piping.

Ladish Forged Steel Socket Welding Fittings comply with the dimensional requirements of American Standard B16.11-1946. This standard covers the range of sizes and the dimensional tolerances shown on page 241. It permits pressure ratings equal to those of pipe of the same schedule number and strength of material. However, this basis of rating has not been commonly used because of the magnitude of such a listing and because of the establishment (prior to the adoption of the standard) of a nominal set of ratings representing an average value of the manufacturer's recommended working pressure for the entire range of sizes. These ratings for Carbon Steel and 1% Chromium-½% Molybdenum Steel are tabulated on page 269.

There is not as yet an American Standard for Forged Steel Screwed Fittings for high pressure applications. The true, clean threads of Ladish fittings comply with the American Standard B2.1-1945 for Taper Pipe Threads, as summarized on page 246.

Ladish Forged Steel Flanges and Fittings are manufactured from material included in the ASTM and ASME Specifications and to the special requirements of the purchaser. Some of the material specifications are tabulated below, and an abbreviated but more comprehensive listing of piping material specifications is given on pages 229 through 236.

For welding bevel standards, see page 239. The standard recommends the straight 37½° bevel for ¾″ and lesser wall thicknesses and the combination 37½°—10° bevel for wall thicknesses greater than ¾″.

RANGE OF SIZES COVERED BY AMERICAN STANDARD ASA B16.5-1953

This standard covers the following types and range of pressures and sizes as of the publication date of this catalog.

Welding Neck, Threaded, Blind, Lap Joint
- 150 lb., 300 lb., 400 lb., 600 lb., 900 lb., 1500 lb. ..... ½″ through 24″
- 2500 lb. ..... ½″ through 12″

Slip-On Flanges
- 150 lb., 300 lb., 400 lb., 600 lb., 900 lb. ..... ½″ through 24″
- 1500 lb. ..... ½″ through 2½″

Socket Welding Flanges
- 150 lb., 300 lb., 600 lb. ..... ½″ through 3″
- 1500 lb. ..... ½″ through 2½″

MATERIAL SPECIFICATIONS FOR FORGED STEEL FLANGES, AND SCREWED AND SOCKET WELDING FITTINGS

ASTM SPECIFICATION	GRADE	SYMBOL
A181*	I	.....
A181*	II	.....
A105	I	.....
A105	II	.....
A182	Carbon-Moly	F1
A335	½% Cr-½% Mo	P2**
A182	1% Cr-½% Mo	F12
A182	1¼% Cr-½% Mo	F11
A335	2% Cr-½% Mo	P3b**
A182	2¼% Cr- 1% Mo	F22

ASTM SPECIFICATION	GRADE	SYMBOL
A335	3% Cr-1% Mo	P21**
A182	5% Cr-½% Mo	F5
A335	5% Cr-½% Mo-Si	P5b**
A182	9% Cr-1% Mo	F9
A182	18% Cr-8% Ni	F304
A182	18% Cr-8% Ni-Mo	F316
A182	18% Cr-8% Ni-Ti	F321
A182	18% Cr-8% Ni-Cb	F347
A182	25% Cr-20% Ni	F310

** ASTM specifications directly covering forged flanges and fittings for these general material specifications do not presently exist. Flanges and fittings shall be specified to conform to the nearest grade in A182, except chemistry to conform to the ASTM Specification listed above.

* To be used for 150 lb. and 300 lb. classes only.

DIMENSIONS OF WELDED AND SEAMLESS PIPE

CARBON AND ALLOY STEEL PIPE

ASA B36.10-1950

NOMINAL PIPE SIZE	OUTSIDE DIAMETER	NOMINAL WALL THICKNESS													NOMINAL PIPE SIZE
		SCHED. 10	SCHED. 20	SCHED. 30	STD. WEIGHT	SCHED. 40	SCHED. 60	EXTRA STRONG	SCHED. 80	SCHED. 100	SCHED. 120	SCHED. 140	SCHED. 160	XX STRONG	
⅛	0.405	.....	.....	.....	0.068	0.068	.....	0.095	0.095	.....	.....	.....	.....	.....	⅛
¼	0.540	.....	.....	.....	0.088	0.088	.....	0.119	0.119	.....	.....	.....	.....	.....	¼
⅜	0.675	.....	.....	.....	0.091	0.091	.....	0.126	0.126	.....	.....	.....	.....	.....	⅜
½	0.840	.....	.....	.....	0.109	0.109	.....	0.147	0.147	.....	.....	.....	0.187	0.294	½
¾	1.050	.....	.....	.....	0.113	0.113	.....	0.154	0.154	.....	.....	.....	0.218	0.308	¾
1	1.315	.....	.....	.....	0.133	0.133	.....	0.179	0.179	.....	.....	.....	0.250	0.358	1
1¼	1.660	.....	.....	.....	0.140	0.140	.....	0.191	0.191	.....	.....	.....	0.250	0.382	1¼
1½	1.900	.....	.....	.....	0.145	0.145	.....	0.200	0.200	.....	.....	.....	0.281	0.400	1½
2	2.375	.....	.....	.....	0.154	0.154	.....	0.218	0.218	.....	.....	.....	0.343	0.436	2
2½	2.875	.....	.....	.....	0.203	0.203	.....	0.276	0.276	.....	.....	.....	0.375	0.552	2½
3	3.500	.....	.....	.....	0.216	0.216	.....	0.300	0.300	.....	.....	.....	0.438	0.600	3
3½	4.000	.....	.....	.....	0.226	0.226	.....	0.318	0.318	.....	.....	.....	.....	0.636†	3½
4	4.500	.....	.....	.....	0.237	0.237	.....	0.337	0.337	.....	0.438	.....	0.531	0.674	4
5	5.563	.....	.....	.....	0.258	0.258	.....	0.375	0.375	.....	0.500	.....	0.625	0.750	5
6	6.625	.....	.....	.....	0.280	0.280	.....	0.432	0.432	.....	0.562	.....	0.718	0.864	6
8	8.625	.....	0.250	0.277	0.322	0.322	0.406	0.500	0.500	0.593	0.718	0.812	0.906	0.875	8
10	10.750	.....	0.250	0.307	0.365	0.365	0.500	0.500	0.593	0.718	0.843	1.000	1.125	.....	10
12	12.750	.....	0.250	0.330	0.375	0.406	0.562	0.500	0.687	0.843	1.000	1.125	1.312	.....	12
14	14.000	0.250	0.312	0.375	0.375	0.438	0.593	0.500	0.750	0.937	1.093	1.250	1.406	.....	14
16	16.000	0.250	0.312	0.375	0.375	0.500	0.656	0.500	0.843	1.031	1.218	1.438	1.593	.....	16
18	18.000	0.250	0.312	0.438	0.375	0.562	0.750	0.500	0.937	1.156	1.375	1.562	1.781	.....	18
20	20.000	0.250	0.375	0.500	0.375	0.593	0.812	0.500	1.031	1.281	1.500	1.750	1.968	.....	20
24	24.000	0.250	0.375	0.562	0.375	0.687	0.968	0.500	1.218	1.531	1.812	2.062	2.343	.....	24
30	30.000	0.312	0.500	0.625	0.375†	.....	.....	0.500†	.....	.....	.....	.....	.....	.....	30

STAINLESS STEEL PIPE

ASA B36.19-1952

NOMINAL PIPE SIZE	OUTSIDE DIAMETER	NOMINAL WALL THICKNESS				NOMINAL PIPE SIZE
		SCHEDULE 5S*	SCHEDULE 10S*	SCHEDULE 40S	SCHEDULE 80S	
⅛	0.405	.....	0.049	0.068	0.095	⅛
¼	0.540	.....	0.065	0.088	0.119	¼
⅜	0.675	.....	0.065	0.091	0.126	⅜
½	0.840	0.065	0.083	0.109	0.147	½
¾	1.050	0.065	0.083	0.113	0.154	¾
1	1.315	0.065	0.109	0.133	0.179	1
1¼	1.660	0.065	0.109	0.140	0.191	1¼
1½	1.900	0.065	0.109	0.145	0.200	1½
2	2.375	0.065	0.109	0.154	0.218	2
2½	2.875	0.083	0.120	0.203	0.276	2½
3	3.500	0.083	0.120	0.216	0.300	3
3½	4.000	0.083	0.120	0.226	0.318	3½
4	4.500	0.083	0.120	0.237	0.337	4
5	5.563	0.109	0.134	0.258	0.375	5
6	6.625	0.109	0.134	0.280	0.432	6
8	8.625	0.109	0.148	0.322	0.500	8
10	10.750	0.134	0.165	0.365	0.500**	10
12	12.750	0.165	0.180	0.375**	0.500**	12

All dimensions given in inches.
The wall thicknesses shown represent nominal or average wall dimensions which are subject to a — 12½% mill tolerance.
† Not included in B36.10-1950.

*Schedule 5S and 10S wall thicknesses do not permit threading in accordance with ASA B2.1.
**Note that Schedule 40S and Schedule 80S in these sizes do not agree with Schedule 40 and Schedule 80 of ASA B36.10.

MATERIAL SPECIFICATIONS FOR BOLTS, BOLT-STUDS AND NUTS

The material specifications for the bolting material, on which the flange pressure-temperature ratings listed on pages 263 through 268 are based, are listed in the table below.

For service pressures below 300 lb. or temperatures below 500° F., carbon steel bolting equal to or better than Grade B of ASTM Specification A307-52T may be used.

For high-temperature service, ASA B16.5-1953 recommends the use of alloy steel bolt-studs with semi-finished, heavy hexagonal, (ASA B18.2) nuts at each end. Alloy steel bolts with semi-finished, heavy hexagonal heads (ASA B18.2) may be used for other services. All alloy steel bolts, bolt-studs, and their nuts should be threaded to conform with ASA B1.4.

Carbon steel bolts may have standard, regular square heads or standard heavy hexagonal heads and should have standard (ASA B18.2) heavy, hexagonal nuts. All carbon steel bolts and bolt-studs should have ASA B1.1 coarse threads—Class 2A, and their nuts—Class 2B threads.

MATERIAL SPECIFICATIONS FOR BOLTS AND BOLT-STUDS

ASTM SPECIFICATION	GRADE	TYPE OF STEEL	MAXIMUM SERVICE TEMPERATURE	PHYSICAL PROPERTIES*			
				TENSILE STRENGTH MIN. PSI	YIELD POINT MIN. PSI	ELONGATION IN 2" MIN. %	REDUCTION OF AREA MIN. %
A307	B	Carbon	450° F.	55000 to 90000	.....	.....	.....
A325	...	Carbon	750° F.	90000 to 120000	55000 to 81000	14%	35%
A261	BO	Carbon	850° F.	100000	75000	16%	45%
A354	BB	Alloy	750° F.	100000 to 105000	75000 to 80000	20%	50%
A354	BC	Alloy	750° F.	115000 to 125000	95000 to 105000	16%	45%-50%
A354	BD	Alloy	750° F.	150000	120000	14%	35%
A193	B7	Alloy	900° F.	105000 to 135000	85000 to 115000	15%-17%	50%
A193	B6	Alloy	900° F.	100000 to 150000	80000 to 125000	13%-17%	45%-55%
A193	B5	Alloy	1100° F.	95000 to 120000	75000 to 95000	15%-17%	45%-55%
A193	B7a	Alloy	1100° F.	115000 to 140000	95000 to 120000	15%-16%	45%-55%
A193	B14	Alloy	1100° F.	125000 to 145000	105000 to 120000	14%-16%	45%-50%
A193	B16	Alloy	1100° F.	100000 to 125000	85000 to 105000	16%-18%	45%-50%
A193	B8, B8c, B8t	Austenitic	1500° F.	75000	30000	35%	50%
A320	L7	Alloy	−150° F.†	105000 to 125000	80000 to 105000	16%-20%	50%
A320	L10	Alloy	−150° F.†	70000	40000	25%	40%
A320	L9	Alloy	−225° F.†	105000 to 125000	80000 to 105000	16%-20%	50%
A320	L8F	Austenitic	−300° F.†	75000	30000	35%	50%

* See specification for detailed physical and chemical requirements. The maximum temperatures are in accordance with the ASME Unfired Pressure Vessel Code for all materials listed except those materials covered by specification A320.

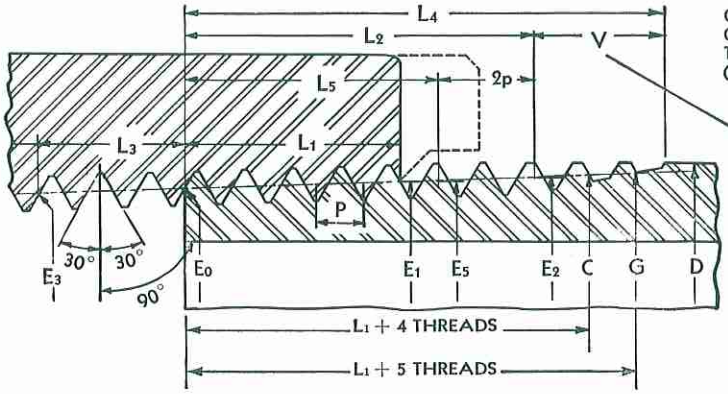
† The maximum service temperature for the materials covered by A320 represent the highest acceptance test temperature for impact requirement.

MATERIAL SPECIFICATIONS FOR NUTS

ASTM SPECIFICATION	GRADE	TYPE OF STEEL	BRINELL HARDNESS NUMBER	MANDREL DIAMETER FOR DRIFT TEST	STRIPPING TEST STRESS— PSI
A307	.....	Carbon	.....	.....	90000
A325	.....	Carbon	.....	.....	105000 to 125000
A194	0	Carbon	120 Min.	Equals pitch diameter of thread	130000
A194	1	Carbon	120 Min.	Equals nominal bolt size	150000
A194	2	Carbon	160 Min.	Equals nominal bolt size	150000
A194	2H	Carbon	248 to 352	Equals nominal bolt size	150000
A194	3	Alloy	248 to 352	Equals nominal bolt size	150000
A194	4	Alloy	248 to 352	Equals nominal bolt size	150000
A194	8	Austenitic	149 Min.	.....	.....
A194	8c	Austenitic	149 Min.	.....	.....
A194	8t	Austenitic	149 Min.	.....	.....
A194	8F	Austenitic	149 Min.	.....	.....

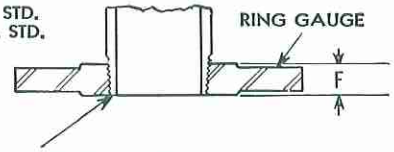
NOTE: Refer to ASTM Specifications for details of physical and chemical requirements.

THREAD STANDARDS



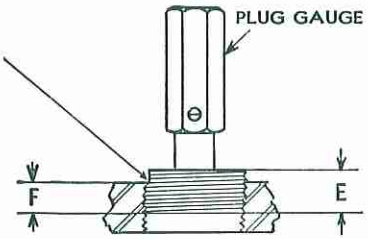
0.8P = THREAD DEPTH—AMER. STD.
0.760P = THREAD DEPTH—A.P.I. STD.
TOTAL TAPER ¾" PER FOOT
(MEASURED ON DIAMETER)

IMPERFECT THREADS
DUE TO LEAD OR DIE



GAUGE TO GO ON FLUSH BY HAND
F = THICKNESS OF WORKING RING GAUGE

PLUG GAUGE TO ENTER UNTIL NOTCH IS FLUSH WITH FIRST THREAD STANDARD TOLERANCE IS ± ONE THREAD



C = STRAIGHT PIPE THREAD PITCH DIA. FOR LOCKNUT CONNECTIONS

G = MINIMUM PITCH DIA. STRAIGHT FEMALE LOCKNUT THREAD

NOMINAL PIPE SIZE	OUTSIDE DIAMETER OF PIPE	THREADS PER INCH	PITCH OF THREAD	PITCH DIAMETER AT BEGINNING OF EXTERNAL THREADS	HANDTIGHT ENGAGEMENT		EFFECTIVE THREAD EXTERNAL		WRENCH MAKE-UP LENGTH FOR INTERNAL THREAD		OVERALL LENGTH EXTERNAL THREAD
					LENGTH	PITCH DIAMETER	LENGTH	PITCH DIAMETER	LENGTH	PITCH DIAMETER	
	D	N	P	E_o	L_1 ‡	E_1	L_2 †	E_2	L_3	E_3	L_4
⅛	.405	27	.0370	.3635	.180	.3748	.2639	.3800	.1111	.3566	.3924
¼	.540	18	.0556	.4774	.200	.4899	.4018	.5025	.1667	.4670	.5946
⅜	.675	18	.0556	.6120	.240	.6270	.4078	.6375	.1667	.6016	.6006
½	.840	14	.0714	.7584	.320	.7784	.5337	.7918	.2143	.7450	.7815
¾	1.050	14	.0714	.9677	.339	.9889	.5457	1.0018	.2143	.9543	.7935
1	1.315	11½	.0870	1.2136	.400	1.2386	.6828	1.2563	.2609	1.1973	.9845
1¼	1.660	11½	.0870	1.5571	.420	1.5834	.7068	1.6013	.2609	1.5408	1.0085
1½	1.900	11½	.0870	1.7961	.420	1.8223	.7235	1.8413	.2609	1.7798	1.0252
2	2.375	11½	.0870	2.2690	.436	2.2963	.7565	2.3163	.2609	2.2527	1.0582
2½	2.875	8	.1250	2.7195	.682	2.7622	1.1375	2.7906	.2500	2.7039	1.5712
3	3.500	8	.1250	3.3406	.766	3.3885	1.2000	3.4156	.2500	3.3250	1.6337
3½	4.000	8	.1250	3.8375	.821	3.8888	1.2500	3.9156	.2500	3.8219	1.6837
4	4.500	8	.1250	4.3344	.844	4.3871	1.3000	4.4156	.2500	4.3188	1.7337
* 4½	5.000	8	.1250	4.8313	.875	4.8859	1.3500	4.8418	.....	.....	.....
5	5.563	8	.1250	5.3907	.937	5.4493	1.4063	5.4786	.2500	5.3751	1.8400
6	6.625	8	.1250	6.4461	.958	6.5060	1.5125	6.5406	.2500	6.4305	1.9462
* 7	7.625	8	.1250	7.4398	1.000	7.5023	1.6125	7.4524	.....	.....	.....
8	8.625	8	.1250	8.4336	1.063	8.5000	1.7125	8.5406	.2500	8.4180	2.1462
* 9	9.625	8	.1250	9.4273	1.130	9.4980	1.8125	9.4415	.....	.....	.....
10	10.750	8	.1250	10.5453	1.210	10.6209	1.9250	10.6656	.2500	10.5297	2.3587
*11	11.750	8	.1250	11.5391	1.285	11.6194	2.0250	11.5549	.....	.....	.....
12	12.750	8	.1250	12.5328	1.360	12.6178	2.1250	12.6656	.2500	12.5172	2.5587
14	14.000	8	.1250	13.7750	1.562	13.8726	2.2500	13.9156	.2500	13.7594	2.6837
*15	15.000	8	.1250	14.7688	1.687	14.8742	2.3500	14.7872	.....	.....	.....
16	16.000	8	.1250	15.7625	1.812	15.8758	2.4500	15.9156	.2500	15.7469	2.8837
*17	17.000	8	.1250	16.7563	1.900	16.8750	2.5500	16.7762	.....	.....	.....
18	18.000	8	.1250	17.7500	2.000	17.8750	2.6500	17.9156	.2500	17.7344	3.0837
20	20.000	8	.1250	19.7375	2.125	19.8703	2.8500	19.9156	.2500	19.7219	3.2837
*22	22.000	8	.1250	21.7250	2.250	21.8656	3.0500	21.7488	.....	.....	.....
24	24.000	8	.1250	23.7125	2.375	23.8609	3.2500	23.9156	.2500	23.6969	3.6837

Data per American Standard B2.1-1945 (For Taper Pipe Threads) and API Standard 6-A (for line pipe threads).

* Sizes discontinued in American Standards listed for reference only.

† Also length of plug gauge.

‡ Length of ring gauge and length from gauging notch to small end of plug gauge.

The American Standard Pipe Thread and the API Standard Line Pipe Thread are interchangeable.

CALCULATING WALL THICKNESS AND WORKING PRESSURE

WELDED AND SEAMLESS STEEL PIPE

Of the various codes generally used by engineers designing various pressure piping systems and by authorities drafting state and municipal regulations, the American Standard B31.1-1951 as revised by Supplement No. 1, ASA B31.1a-1953 and addended by ASA B31.1.8-1952, Code for Pressure Piping, affords the basis for the minimum safety requirements for the design, manufacture and installation of pressure piping for the widest range of applications.

Six basic types of service are covered by individual sections of the Code as follows:

SECTION 1 covers the requirements for steam generating plants, central heating plants and industrial plants.

SECTION 2 is currently being revised to cover the requirements of gas and air piping systems in industrial installations only.

SECTION 3 covers the requirements for oil piping systems . . . Division A covering inside refinery limits, or within city or village limits; and Division B covering oil transmission lines outside refinery, city, or village limits.

SECTION 4 covers the requirements of piping in district heating and central heating generating plants for pressures 600 psi and less and temperatures 750° F. and less.

SECTION 5 covers refrigeration piping systems.

SECTION 8 covers the requirements for gas transmission and distribution piping systems. Such piping within the legal boundaries of cities or villages was formerly known as part of Division 1 of Section 2; and such piping in cross country gas transportation systems and their compressing stations was formerly known as part of Division 2 of Section 2.

Each of the sections provides the basis for the determination of pipe wall thickness required for the internal working pressure. Piping systems are, of course, subjected to stresses from loads other than internal pressure. The effect of stresses imposed by thermal expansion, vibration, line weight, pulsating pressure and other external loads upon wall thickness must also be considered by the designer.

Only the internal pressure loading is considered herein, because it is most generally the primary consideration of the designer and lends itself most readily to a specific approach. By means of specified formulas and allowable working fibre stresses under graduated temperature conditions, required wall thicknesses can be calculated for piping under the jurisdiction of each section of the code. These formulas are:

FOR SECTIONS 1, 3, AND 4

$$t = \frac{P \times D}{2S + 2yP} + C$$

FOR SECTION 5 AND SECTION 8*

$$t = \frac{P \times D}{2S + .8P} + C$$

where,

t = Minimum pipe wall thickness in inches. (Customary trade practice is to order pipe by its nominal wall thickness which is subject to a mill tolerance of —12½%. The nominal wall thickness, T, is therefore obtained by multiplying t by 8/7.)

P = Maximum internal working pressure in lbs. per sq. in. gauge.

D = Outside diameter of pipe in inches.

S = Allowable stress in material due to internal pressure at the operating temperature in lbs. per sq. in. The "S" values in Tables 1, 3 and 5 are based on the following joint efficiencies:

Seamless pipe	1.00
Electric-fusion-welded pipe	
Stress-relieved and radiographically examined (ASTM A155)	1.00
Double-submerged-arc-welded (API 5LX)	.85
Electric-reistance-welded pipe	.85
Lap-welded pipe	.80
Butt-welded pipe	.60

y = a coefficient having values as follows:

Temperature Deg. F.	900° and below	950°	1000°	1050°	1100°	1150° and above
Ferritic Steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic Steels	0.4	0.4	0.4	0.4	0.5	0.7

C = Allowance for mechanical strength and/or corrosion in inches. The minimum "C" allowances for plain end steel pipe are:

FOR SECTIONS 1, 4 AND 5

0.05" for pipe 1" and smaller.
0.065" for pipe larger than 1".

FOR SECTION 3

Not specified in code.

FOR SECTION 8*

$$\frac{600}{Y} + a$$

Where **a** equals .025" minimum for indeterminate conditions and where "Y" is the minimum specified yield point for material in psi.

Since **y** = .4 for all temperatures applicable to Sections 5 and 8, the two formulas are actually the same, except for "C."

*Gas transmission and distribution piping systems within city or village limits only.

CALCULATING WALL THICKNESS AND WORKING PRESSURE

WELDED AND SEAMLESS STEEL PIPE (Continued)

The formulas can be readily transposed to solve for the maximum allowable working pressure, the least required stress value, or the least commercial wall thickness required for various operating temperatures under various sections of the code. To the extent that space permits in this catalog, Ladish Engineers have tabulated a number of pre-calculated values based on such transposition.

Maximum allowable working pressures under various sections of the Code, for standardized and/or more commonly used wall thicknesses of ½" through 30" sizes of pipe of common materials are tabulated for various operating temperatures on pages 252 through 262.

For a more complete coverage of materials and wall thicknesses, pages 249 through 253 provide tables with which simple calculations can be made for working pressures, stress values, or wall thicknesses.

Transposition of the pipe formula in terms of **P/S** permits calculation of values that are independent of internal pressure and strength of material, and dependent only upon the cross-sectional dimensions of pipe, the corrosion allowances (for which minimum values are established), and the coefficient, "**y**." Thus,

$$P/S = \frac{1}{\frac{1}{2}\left(\frac{D}{t-c}\right) - y}$$

Since the minimum corrosion allowance varies with the various sections of the code, **P/S** values have been calculated and tabulated for the various sections. Also, since the coefficient **y**, varies with temperature and material, three sets of **P/S** values for each section of code have been calculated to accommodate these variations. To alert the user and to assist in the selection of the proper values, the **y** values, Stress Tables, and **P/S** Tables are cross-referenced by a color system. For example, the **P/S** values in green are used with those allowable stresses (in green) for ferritic steels at temperatures of 1000° and above, and for Austenitic steels at temperatures of 1150° and above.

Since Ladish Seamless Welding Fittings are designed so that their pressure-temperature ratings are at least equal to those of straight pipe of the same size, thickness, and material, the pipe formulas and following tables are directly applicable to Ladish Seamless Welding Fittings.

Included in these tables are materials which are sometimes used in pipe but not necessarily used in the manufacture of Ladish Fittings.

Use of the tables in various solutions of the pipe formula are illustrated in the following examples.

I. *To determine the maximum allowable working pressure* for 4" Schedule 80-A106, Grade B piping complying with Section 1 of the Code, under operating temperature of 650° F., multiply the 15000 PSI allowable stress read from Table 3 by the .1066 **P/S** value read from Table 4 as follows:

$$P = S \times (P/S) = 15000 \times .1066 = 1599 \text{ PSI}$$
Working Pressure

II. *To determine the stress* in 4" Schedule 80 pipe subjected to 1650 PSI internal working pressure at 600° F., for usage in compliance with Section 3, divide the 1650 PSI pressure by the .1138 **P/S** value read from Table 6 as follows:

$$S = \frac{P}{P/S} = \frac{1650}{.1138} = 14499 \text{ PSI Stress}$$

Then refer to the 600° F. temperature column in Table 5, and locate the allowable stress value nearest to, but not less than, the 14499 calculated value. The 15500 value indicates that Grade B is the permissible grade for the Seamless Carbon Steel group of materials. The 16400 value indicates that Grade C is the permissible grade for Welded Carbon Steel group of materials.

Had the operating temperature in this case been 1000° F., the working pressure equal to 800 PSI, and the material known to be ferritic steel, the .1179 **P/S** value in green would have been used as follows:

$$S = \frac{P}{P/S} = \frac{800}{.1179} = 6785 \text{ PSI Stress}$$

Again from Table 5 it can be seen that this 6785 PSI exceeds the 6250 PSI allowable stress of A335, Grade P2 material but would be satisfactory for the A335, Grade P5a material, whose allowable stress of 7300 PSI exceeds the working stress of 6785 PSI.

III. *To determine the least commercial nominal wall thickness* of 4" A335 Grade P2 pipe for use at 1000 PSI working pressure at 950° F. in compliance with Section 1 of the Code, divide the 1000 PSI known working pressure by the 10000 PSI allowable stress listed for A335 Grade P2 in Table 3 to obtain the corresponding **P/S** value as follows:

$$P/S = \frac{P}{S} = \frac{1000}{10000} = .1000$$

Then refer to the red column of Table 4 for 4" pipe size and locate the **P/S** value nearest to, but not less than, the .1000 calculated value. The .1077 value indicates that Schedule 80 is the least commercial nominal thickness required. Note that since the allowable stress value of 10000 PSI was coded in red, the red column of Table 4 was used for the comparison of calculated **P/S** value and tabulated **P/S** value.

GAS PIPING SYSTEMS WITHIN CITY OR VILLAGE LIMITS

ASA Code for Pressure Piping B31.1.8-1952 — Section 8

TABLE 1 — ALLOWABLE STRESS VALUES

MATERIAL	ASTM OR API SPECIFICATION	GRADE OR SYMBOL	MINIMUM TENSILE STRENGTH	MINIMUM YIELD POINT	ALLOWABLE STRESS PSI FOR TEMPERATURES IN DEG. F. NOT TO EXCEED Ⓐ			
					100°	150°	200°	450°
SEAMLESS STEEL	A106, A53, 5L	A	48000	30000	18000	17650	17300	15600
		B	60000	35000	21000	20600	20200	18200
	5L	C	75000	45000	27000	26500	25950	23400
	5LX Ⓓ				0.6 Y.P.Ⓔ			
	A120				15000	14700	14450	13000
ELECTRIC RESISTANCE WELDED®	A53, A135, 5L	A	48000	30000	15300	15000	14700	13250
		B	60000	35000	17850	17500	17150	15450
	5L	C	75000	45000	22950	22500	20100	19900
	5LX Ⓓ				0.51 Y.P.Ⓔ			
ELECTRIC FUSION WELDED®		A	45000	24000	14400	14150	13850	12500
	A155	B	50000	27000	16200	15900	15600	14050
		C	55000	30000	16500	16200	15850	14300
	5LX Ⓓ				0.51 Y.P.Ⓔ			
LAP WELDED®	A53, 5L	O. H. or E. F. (Class I)	45000	25000	12000	11750	11550	10400
BUTT WELDED®			45000	25000	9000	8830	8660	7800

Ⓐ Allowable "S" values for intermediate temperatures may be obtained by interpolation.

Ⓑ The "S" values in this table are based on the joint efficiencies listed on page 247.

If tests of weld-test specimens and/or cylindrical samples of the electric-resistance-welded pipe demonstrate the strength of the weld to be at least equal to the stipulated minimum tensile strength of the pipe, the "S" values may be taken as equal to the corresponding grades of seamless pipe.

Likewise, the double-submerged-arc-welded pipe warrants "S" values equal to the corresponding grades of seamless pipe if tested as above or if stress relieved and radiographically examined.

Ⓓ Pipe covered by this specification is not intended for high-temperature service.

Ⓔ Y.P. = stipulated minimum yield strength of the material (but not to be taken as over 80 per cent of the stipulated minimum tensile strength).

NOTES FOR P/S VALUE TABLE

Since the minimum corrosion allowance varies with the yield point according to Section 8 of the code, P/S values are tabulated for two common grades of material wherein C = 0.042" for 35000 PSI Y.P. and C = 0.039" for 42000 PSI Y.P.

TABLE 2 — P/S VALUES FOR PLAIN END PIPE

NOM. PIPE SIZE	DESIGNATION OF PIPE WALL THICKNESS	NOM. WALL THICK.	P/S VALUES FOR 35000 PSI MIN. Y. P. MATERIAL	P/S VALUES FOR 42000 PSI MIN. Y. P. MATERIAL
¾	Std. (Sch. 40)	.113	.1135	.1198
	XH (Sch. 80)	.154	.1907	.1973
	Sch. 160	.218	.3202	.3274
	XXH	.308	.5256	.5340
1	Std. (Sch. 40)	.133	.1195	.1245
	XH (Sch. 80)	.179	.1881	.1933
	Sch. 160	.250	.3017	.3074
	XXH	.358	.4936	.5001
1¼	Std. (Sch. 40)	.140	.1016	.1055
	XH (Sch. 80)	.191	.1603	.1644
	Sch. 160	.250	.2331	.2375
	XXH	.382	.4094	.4143
1½	Std. (Sch. 40)	.145	.0928	.0962
	XH (Sch. 80)	.200	.1483	.1518
	Sch. 160	.281	.2349	.2387
	XXH	.400	.3725	.3767
2	Std. (Sch. 40)	.154	.0808	.0835
	XH (Sch. 80)	.218	.1321	.1349
	Sch. 160	.343	.2380	.2410
	XXH	.436	.3234	.3266
2½	Std. (Sch. 40)	.203	.0983	.1006
	XH (Sch. 80)	.276	.1473	.1497
	Sch. 160	.375	.2162	.2186
	XXH	.552	.3497	.3524
3	Std. (Sch. 40)	.216	.0869	.0888
	XH (Sch. 80)	.300	.1330	.1349
	Sch. 160	.438	.2113	.2134
	XXH	.600	.3103	.3124
3½	Std. (Sch. 40)	.226	.0805	.0821
	XH (Sch. 80)	.318	.1244	.1260
		.636	.2871	.2889
4	Std. (Sch. 40)	.237	.0755	.0770
	XH (Sch. 80)	.337	.1177	.1192
	Sch. 120	.438	.1613	.1629
	Sch. 160	.531	.2033	.2049
	XXH	.674	.2698	.2715
5	Std. (Sch. 40)	.258	.0679	.0691
	XH (Sch. 80)	.375	.1072	.1084
	Sch. 120	.500	.1510	.1522
	Sch. 160	.625	.1958	.1970
	XXH	.750	.2421	.2434
6	Std. (Sch. 40)	.280	.0628	.0638
	XH (Sch. 80)	.432	.1057	.1067
	Sch. 120	.562	.1437	.1447
	Sch. 160	.718	.1904	.1914
	XXH	.864	.2359	.2370
8	Sch. 20	.250	.0417	.0424
	Sch. 30	.277	.0473	.0480
	Std. (Sch. 40)	.322	.0569	.0576
	Sch. 60	.406	.0747	.0755
	XH (Sch. 80)	.500	.0953	.0961
	Sch. 100	.593	.1157	.1165
	Sch. 120	.718	.1437	.1445
	Sch. 140	.812	.1654	.1662
	XXH	.875	.1800	.1808
	Sch. 160	.906	.1872	.1880
10	Sch. 20	.250	.0334	.0339
	Sch. 30	.307	.0430	.0435
	Std. (Sch. 40)	.365	.0528	.0534
	XH (Sch. 60)	.500	.0759	.0765
	Sch. 80	.593	.0920	.0926
	Sch. 100	.718	.1140	.1146
	Sch. 120	.843	.1366	.1372
	Sch. 140	1.000	.1652	.1659
	Sch. 160	1.125	.1885	.1891
12	Sch. 20	.250	.0281	.0286
	Sch. 30	.330	.0394	.0398
	Std.	.375	.0457	.0462
	Sch. 40	.406	.0501	.0506
	XH	.500	.0637	.0642
	Sch. 60	.562	.0726	.0731
	Sch. 80	.687	.0909	.0914
	Sch. 100	.843	.1142	.1147
	Sch. 120	1.000	.1379	.1384
	Sch. 140	1.125	.1570	.1576
	Sch. 160	1.312	.1864	.1870
14	Sch. 10	.250	.0255	.0260
	Sch. 20	.312	.0334	.0339
	Std. (Sch. 30)	.375	.0415	.0420
	Sch. 40	.438	.0497	.0501
	XH	.500	.0579	.0583
	Sch. 60	.593	.0701	.0705
	Sch. 80	.750	.0909	.0914
	Sch. 100	.937	.1163	.1168
	Sch. 120	1.093	.1378	.1382
	Sch. 140	1.250	.1599	.1604
	Sch. 160	1.406	.1821	.1826
16	Sch. 10	.250	.0223	.0227
	Sch. 20	.312	.0292	.0296
	Std. (Sch. 30)	.375	.0363	.0367
	XH (Sch. 40)	.500	.0505	.0509
	Sch. 60	.656	.0683	.0687
	Sch. 80	.843	.0901	.0905
	Sch. 100	1.031	.1123	.1127
	Sch. 120	1.218	.1349	.1353
	Sch. 140	1.438	.1618	.1623
	Sch. 160	1.593	.1813	.1817
18	Sch. 10	.250	.0198	.0202
	Sch. 20	.312	.0259	.0263
	Std.	.375	.0322	.0325
	Sch. 30	.438	.0385	.0388
	XH	.500	.0448	.0451
	Sch. 40	.562	.0510	.0514
	Sch. 60	.750	.0701	.0705
	Sch. 80	.937	.0895	.0899
	Sch. 100	1.156	.1126	.1130
	Sch. 120	1.375	.1360	.1364
	Sch. 140	1.562	.1564	.1568
	Sch. 160	1.781	.1806	.1810
20	Sch. 10	.250	.0178	.0181
	Std. (Sch. 20)	.375	.0289	.0292
	XH (Sch. 30)	.500	.0402	.0405
	Sch. 40	.593	.0486	.0489
	Sch. 60	.812	.0687	.0691
	Sch. 80	1.031	.0891	.0894
	Sch. 100	1.281	.1128	.1131
	Sch. 120	1.500	.1339	.1342
	Sch. 140	1.750	.1583	.1587
	Sch. 160	1.968	.1801	.1804
22		.375	.0263	.0266
		.500	.0365	.0368
		.687	.0519	.0522
		.812	.0623	.0626
		1.031	.0807	.0810
		1.281	.1021	.1024
		1.500	.1211	.1214
24	Sch. 10	.250	.0148	.0151
	Std. (Sch. 20)	.375	.0241	.0243
	XH	.500	.0334	.0337
	Sch. 30	.562	.0381	.0383
	Sch. 40	.687	.0475	.0477
	Sch. 60	.968	.0689	.0692
	Sch. 80	1.218	.0883	.0886
	Sch. 100	1.531	.1131	.1133
	Sch. 120	1.812	.1356	.1359
	Sch. 140	2.062	.1560	.1563
	Sch. 160	2.343	.1793	.1796
26		.375	.0222	.0224
		.500	.0308	.0311
		.562	.0351	.0353
		.687	.0438	.0440
		.812	.0525	.0528
		.937	.0613	.0616
		1.281	.0859	.0861
		1.531	.1040	.1042
30	Sch. 20	.375	.0192	.0194
	Sch. 30	.500	.0267	.0269
		.625	.0341	.0343
		.750	.0416	.0418
		1.000	.0568	.0570

POWER PIPING, DISTRICT HEATING AND REFRIGERATION SYSTEMS

Sections 1, 4® and 5® of ASA Code for Pressure Piping — ASA B31.1-1951 and B31.1a-1953
ASME 1952 Power Boiler Code and 1952 Unfired Pressure Vessel Code

TABLE 3 — ALLOWABLE STRESS VALUES

MATERIAL			ASTM SPECIFICATION®	GRADE OR SYMBOL	MINIMUM TENSILE STRENGTH	FOOT NOTES	VALUES OF ALLOWABLE STRESS IN PSI FOR TEMPERATURES IN DEGREES F. NOT TO EXCEED®					
							-20° to 650°	700°	750°	800°	850°	900°
CODE FOR PRESSURE PIPING POWER BOILER CODE	CARBON STEELS	SEAMLESS	A53, A106	A	48000	Ⓐ Ⓑ Ⓔ	12000	11650	10700	9000	7100	5000
			A53, A106	B	60000	Ⓐ Ⓑ Ⓔ	15000	14350	12950	10800	7800	5000
		ELECTRIC RESISTANCE WELDED	A53, A135	A	48000	Ⓐ Ⓑ Ⓔ Ⓕ	10200	9900	9100	7650①	6050①	4250①
			A53, A135	B	60000	Ⓐ Ⓑ Ⓔ Ⓕ	12750	12200	11000	9200①	6650①	4250①
		LAP WELDED	A53		45000	Ⓐ Ⓑ Ⓔ	9000	8700①	7800①			
		BUTT WELDED	A53		45000	Ⓐ Ⓑ Ⓔ	6750	6500①	5800①			
UNFIRED PRESSURE VESSEL CODE		SEAMLESS	SA53, SA106	A	48000		12000	11650	10700	9300	7900	6500
			SA53, SA106	B	60000		15000	14350	12950	10800	8650	6500
		ELECTRIC RESISTANCE WELDED	SA53, SA135	A	48000	Ⓓ	10200	9900	9100	7900	6700	5500
			SA53, SA135	B	60000	Ⓓ	12750	12200	11000	9200	7350	5500
		LAP-WELDED	SA53		45000	Ⓓ	9000	8800	8200			
CODE FOR PRESSURE PIPING POWER BOILER CODE UNFIRED PRESSURE VESSEL CODE	SEAMLESS ALLOY STEELS	CARBON-MOLY	A335	P1	55000		13750	13750	13750	13450	13150	12500
		½% Cr-½% Mo	A335	P2	55000		13750	13750	13750	13450	13150	12500
		1% Cr-½% Mo	A335	P12	60000		15000	15000	15000	14750	14200	13100
		1¼% Cr-½% Mo	A335	P11	60000		15000	15000	15000	15000	14400	13100
		2¼% Cr-1% Mo	A335	P22	60000		15000	15000	15000	15000	14400	13100
		3% Cr-1% Mo	A335	P21	60000		15000	14800	14500	13900	13200	12000
		5% Cr-½% Mo	A335	P5a	60000		13700®	13400	13100	12800	12400	11500
		5% Cr-½% Mo-Si	A335	P5b	60000		13700®	13400	13100	12800	12480	10900
		CHROME-NICKEL	A312	TP321-TP347	75000		14850®	14800	14700	14550	14300	14100
		VALUES OF ALLOWABLE STRESS IN PSI FOR TEMPERATURES IN DEGREES F.					-20° to 100°	200°	300°	400°	500°	600°
		5% Cr-½% Mo	A335	P5a & P5b	60000		15000	15000	15000	15000	14500	14000
		CHROME-NICKEL	A312	TP321-TP347	75000		18750	18750	17000	15800	15200	14900

TABLE 4 — P/S VALUES FOR PLAIN END PIPE

NOM. PIPE SIZE	DESIGNATION OF PIPE WALL THICKNESS	NOM. WALL THICK.	P/S VALUES WHEN y = .4	WHEN y = .5	WHEN y = .7
¾	Std. (Sch. 40)	.113	.0970	.0979	.0999
	XH (Sch. 80)	.154	.1731	.1762	.1826
	Sch. 160	.218	.3009	.3102	.3307
	XXH	.308	.5034	.5301	.5929
1	Std. (Sch. 40)	.133	.1062	.1074	.1097
	XH (Sch. 80)	.179	.1741	.1771	.1837
	Sch. 160	.250	.2865	.2949	.3134
	XXH	.358	.4762	.5000	.5556
1¼	Std. (Sch. 40)	.140	.0719	.0724	.0735
	XH (Sch. 80)	.191	.1292	.1309	.1345
	Sch. 160	.250	.2004	.2045	.2132
	XXH	.382	.3724	.3868	.4192
1½	Std. (Sch. 40)	.145	.0670	.0675	.0684
	XH (Sch. 80)	.200	.1214	.1229	.1260
	Sch. 160	.281	.2062	.2106	.2199
	XXH	.400	.3409	.3529	.3797
2	Std. (Sch. 40)	.154	.0604	.0607	.0615
	XH (Sch. 80)	.218	.1108	.1121	.1146
	Sch. 160	.343	.2149	.2196	.2297
	XXH	.436	.2989	.3081	.3283
2½	Std. (Sch. 40)	.203	.0812	.0818	.0832
	XH (Sch. 80)	.276	.1295	.1312	.1347
	Sch. 160	.375	.1974	.2014	.2098
	XXH	.552	.3291	.3403	.3651
3	Std. (Sch. 40)	.216	.0729	.0735	.0746
	XH (Sch. 80)	.300	.1185	.1199	.1229
	Sch. 160	.438	.1960	.1999	.2082
	XXH	.600	.2937	.3026	.3221
3½	Std. (Sch. 40)	.226	.0683	.0688	.0697
	XH (Sch. 80)	.318	.1118	.1130	.1157
		.636	.2729	.2805	.2972
4	Std. (Sch. 40)	.237	.0647	.0652	.0660
	XH (Sch. 80)	.337	.1066	.1077	.1101
	Sch. 120	.438	.1498	.1521	.1569
	Sch. 160	.531	.1914	.1951	.2030
	XXH	.674	.2574	.2642	.2789
5	Std. (Sch. 40)	.258	.0593	.0596	.0603
	XH (Sch. 80)	.375	.0983	.0992	.1013
	Sch. 120	.500	.1417	.1437	.1480
	Sch. 160	.625	.1862	.1897	.1972
	XXH	.750	.2322	.2377	.2496
6	Std. (Sch. 40)	.280	.0555	.0559	.0565
	XH (Sch. 80)	.432	.0982	.0992	.1012
	Sch. 120	.562	.1359	.1378	.1417
	Sch. 160	.718	.1824	.1858	.1929
	XXH	.864	.2276	.2329	.2443
8	Sch. 20	.250	.0362	.0364	.0366
	Sch. 30	.277	.0417	.0419	.0423
	Std. (Sch. 40)	.322	.0514	.0516	.0522
8	Sch. 60	.406	.0691	.0696	.0706
	XH (Sch. 80)	.500	.0896	.0904	.0921
	Sch. 100	.593	.1099	.1111	.1136
	Sch. 120	.718	.1377	.1397	.1437
	Sch. 140	.812	.1593	.1619	.1674
	XXH	.875	.1739	.1769	.1834
	Sch. 160	.906	.1810	.1844	.1914
10	Sch. 20	.250	.0290	.0291	.0292
	Sch. 30	.307	.0385	.0387	.0390
	Std. (Sch. 40)	.365	.0484	.0486	.0491
	XH (Sch. 60)	.500	.0714	.0719	.0729
	Sch. 80	.593	.0874	.0882	.0898
	Sch. 100	.718	.1093	.1105	.1130
	Sch. 120	.843	.1318	.1336	.1372
	Sch. 140	1.000	.1604	.1630	.1685
	Sch. 160	1.125	.1835	.1870	.1942
12	Sch. 20	.250	.0244	.0245	.0246
	Sch. 30	.330	.0356	.0358	.0360
	Std.	.375	.0419	.0421	.0425
	Sch. 40	.406	.0463	.0465	.0470
	XH	.500	.0599	.0603	.0610
	Sch. 60	.562	.0688	.0693	.0703
	Sch. 80	.687	.0870	.0878	.0893
	Sch. 100	.843	.1102	.1115	.1140
	Sch. 120	1.000	.1339	.1357	.1395
	Sch. 140	1.125	.1530	.1554	.1603
	Sch. 160	1.312	.1823	.1856	.1928

POWER PIPING, DISTRICT HEATING AND REFRIGERATION SYSTEMS

Sections 1, 4Ⓐ and 5Ⓑ of ASA Code for Pressure Piping — ASA B31.1-1951 and B31.1a-1953
ASME 1952 Power Boiler Code and 1952 Unfired Pressure Vessel Code

TABLE 3—ALLOWABLE STRESS VALUES (Continued)

VALUES OF ALLOWABLE STRESS IN PSI FOR TEMPERATURES IN DEGREES F. NOT TO EXCEEDⓄ						GRADE OR SYMBOL	ASTM OR API SPECIFICATION
950°	1000°	1050°	1100°	1150°	1200°		
3000Ⓘ	1500Ⓘ					A	A53, A106
3000Ⓘ	1500Ⓘ					B	A53, A106
						A	A53, A135
						B	A53, A135
							A53
							A53
4500	2500					A	SA53, SA106
4500	2500					B	SA53, SA106
						A	SA53, SA135
						B	SA53, SA135
							SA53
8500Ⓚ	5500Ⓚ					P1	A335
10000	6250					P2	A335
11000	7500	5000	2800	1550Ⓜ	1000Ⓜ	P12	A335
11000	7800	5500	4000	2500Ⓜ	1200Ⓜ	P11	A335
11000	7800	5800	4200	3000	2000Ⓜ	P22	A335
9000	7000	5500	4000	2700	1500Ⓜ	P21	A335
10000	7300	5200	3300	2200	1500	P5a	A335
9000	5500	3500	2500	1800	1200	P5b	A335
13850	13500	13100	10300Ⓜ	7600Ⓜ	5000	TP321-TP347	A312

NOTE: Where welded construction is used, consideration should be given to the possibility of graphite formation in the following steels: Carbon steel above 775° F.; carbon-molybdenum steel above 875° F.; chrome-molybdenum steel (with chromium under 0.60) above 975° F.

NOTE: "S" values for temperatures above 900° F. are colored as a cross reference to the applicable column of the P/S value of Table 4.

Ⓐ Allowable Stress Values for these materials apply to District Heating Piping Systems—Section 4—for temperatures up to 750° F. inclusive.

Ⓑ Allowable Stress Values tabulated at −20° to 650° F. also apply to Refrigeration Piping Systems—Section 5 of the Code.

Ⓓ Allowable "S" values for intermediate temperatures may be obtained by interpolation.

Ⓔ Pipe in accordance with API Specification 5L may be used.

Ⓕ For electric-resistance-welded pipe for applications where the temperature is below 650° F., and where pipe furnished under this classification is subjected to supplemental tests and/or heat treatments, (as agreed to by the supplier and the purchaser) demonstrate the strength characteristics of the weld to be equal to the minimum tensile strength specified for the pipe, the "S" values equal to the corresponding seamless grades may be used.

Ⓖ ASME Specification numbers are prefaced by letter S.

Ⓘ Not listed in Code for Pressure Piping.

Ⓙ These values permitted for Open-Hearth and Electric-Furnace steels only.

Ⓚ These values listed only in Table P-7 of Power Boiler Code. Table UCS-23 of Unfired Pressure Vessel Code lists values of 10000 and 6250 respectively.

Ⓜ The values listed in Table UHA-23 of Unfired Pressure Vessel Code are 12500 and 8000 respectively.

Ⓝ These values listed only in Table P-7 and Table UCS-23.

Ⓟ Applicable at 650°. For values from −20° to 600° see lower part of Table 3.

TABLE 4—P/S VALUES FOR PLAIN END PIPE (Continued)

NOM. PIPE SIZE	DESIGNATION OF PIPE WALL THICKNESS	NOM. WALL THICK.	P/S VALUES WHEN y=.4	WHEN y=.5	WHEN y=.7
14	Sch. 10	.250	.0222	.0222	.0223
	Sch. 20	.312	.0301	.0302	.0303
	Std. (Sch. 30)	.375	.0381	.0383	.0386
	Sch. 40	.438	.0463	.0465	.0469
	XH	.500	.0544	.0547	.0553
	Sch. 60	.593	.0666	.0670	.0679
	Sch. 80	.750	.0874	.0881	.0897
	Sch. 100	.937	.1127	.1140	.1167
	Sch. 120	1.093	.1341	.1359	.1397
	Sch. 140	1.250	.1562	.1587	.1639
	Sch. 160	1.406	.1783	.1815	.1884
16	Sch. 10	.250	.0194	.0194	.0195
	Sch. 20	.312	.0263	.0263	.0265
	Std. (Sch. 30)	.375	.0333	.0334	.0336
	XH (Sch. 40)	.500	.0475	.0477	.0482
	Sch. 60	.656	.0653	.0657	.0666
	Sch. 80	.843	.0871	.0878	.0894
	Sch. 100	1.031	.1092	.1104	.1129
	Sch. 120	1.218	.1317	.1335	.1371
	Sch. 140	1.438	.1586	.1611	.1665
	Sch. 160	1.593	.1780	.1812	.1880
18	Sch. 10	.250	.0172	.0173	.0173
	Sch. 20	.312	.0233	.0234	.0235
	Std.	.375	.0296	.0297	.0298
	Sch. 30	.438	.0358	.0360	.0362
	XH	.500	.0421	.0423	.0427
	Sch. 40	.562	.0484	.0486	.0491
	Sch. 60	.750	.0674	.0679	.0688
	Sch. 80	.937	.0868	.0876	.0891
18	Sch. 100	1.156	.1098	.1111	.1136
	Sch. 120	1.375	.1332	.1350	.1387
	Sch. 140	1.562	.1536	.1559	.1610
	Sch. 160	1.781	.1777	.1809	.1877
20	Sch. 10	.250	.0155	.0155	.0156
	Std. (Sch. 20)	.375	.0266	.0267	.0268
	XH (Sch. 30)	.500	.0379	.0380	.0383
	Sch. 40	.593	.0462	.0465	.0469
	Sch. 60	.812	.0663	.0668	.0677
	Sch. 80	1.031	.0866	.0874	.0889
	Sch. 100	1.281	.1103	.1115	.1140
	Sch. 120	1.500	.1314	.1331	.1367
	Sch. 140	1.750	.1557	.1582	.1634
	Sch. 160	1.968	.1775	.1807	.1874
24	Sch. 10	.250	.0129	.0129	.0129
	Std. (Sch. 20)	.375	.0221	.0222	.0223
	XH	.500	.0315	.0316	.0318
	Sch. 30	.562	.0361	.0362	.0365
	Sch. 40	.687	.0455	.0457	.0461
	Sch. 60	.968	.0669	.0674	.0683
	Sch. 80	1.218	.0863	.0870	.0886
	Sch. 100	1.531	.1110	.1122	.1148
	Sch. 120	1.812	.1335	.1353	.1391
	Sch. 140	2.062	.1538	.1562	.1613
	Sch. 160	2.343	.1771	.1803	.1871
30	Sch. 20	.375	.0177	.0177	.0178
		.500	.0251	.0252	.0253

NOTES FOR P/S VALUE TABLE

At temperatures above 900° F., P/S values vary with temperature and/or material as tabulated on Page 247, and are cross-referenced by color to assist in the selection of the proper values.

These values are calculated with an assumed corrosion allowance of 0.05" for 1" I.P.S. and smaller, and 0.065" for sizes above 1" I.P.S.

Since "y", and therefore the P/S values, vary with temperature and/or material, as shown in the table at left, the allowable stress tables and P/S tables are cross-referenced by colors to assist in the selection of the proper values.

COEFFICIENT "y"

Temperature Deg. F.	900° and below	950°	1000°	1050°	1100°	1150° and above
Ferritic Steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic Steels	0.4	0.4	0.4	0.4	0.5	0.7

OIL TRANSMISSION LINES OUTSIDE CITY OR VILLAGE LIMITS
OIL PIPING SYSTEMS WITHIN REFINERY LIMITS

Section 3 Divisions A and B of ASA B31.1-1951 and B31.1a-1953

TABLE 5 — ALLOWABLE STRESS VALUES

	MATERIAL	ASTM OR API SPECIFICATION	GRADE OR SYMBOL	MINIMUM TENSILE STRENGTH	FOOT NOTES	VALUES OF ALLOWABLE STRESS IN PSI FOR TEMPERATURES IN DEGREES F. NOT TO EXCEED									
						Ⓐ100°	-20° to 100°	200°	300°	400°	500°	600°	650°	700°	750°
CARBON STEEL Ⓑ	SEAMLESS	A53, A106, 5L	A	48000	Ⓓ	25500	16000	15300	14500	13800	13100	12350	12000	11650	10700
		A53, A106, 5L	B	60000	Ⓓ	29750	20000	19100	18150	17250	16350	15500	15000	14350	12950
		5L	C	75000	Ⓓ Ⓔ	38250	25000	23850	22700	21550	20400	19300	18750	17750	15650
		5LX	X-42	60000	Ⓙ	35700									
	ELECTRIC RESISTANCE WELDED	A53, A135, 5L	A	48000	Ⓓ Ⓔ Ⓕ	21700	13600	13000	12300	11750	11100	10500	10200	9900	9100
		A53, A135, 5L	B	60000	Ⓓ Ⓔ Ⓕ	25300	17000	16200	15400	14650	13900	13150	12750	12200	11000
		5L	C	75000	Ⓓ Ⓔ Ⓕ	32500	21250	20300	19300	18300	17350	16400	15950	15100	13300
		5LX	X-42	60000	Ⓙ Ⓚ	.85 Y.P.									
	ELECTRIC FUSION WELDED	A155	C45	45000	Ⓓ Ⓔ Ⓗ Ⓘ	18350	15000	14350	13650	13000	12350	11650	11300	11000	10250
		A155	C50	50000	Ⓓ Ⓔ Ⓗ Ⓘ	20650	16650	15900	15200	14450	13650	12900	12500	12100	11150
		A155	C55	55000	Ⓓ Ⓔ Ⓗ Ⓘ	21200	18350	17500	16700	15850	15000	14200	13750	13250	12050
		5LX	All Grades		Ⓙ	.85 Y.P.									
	LAP WELDED	A53, 5L	Class I	45000		15950	12000	11500	10900	10400	9900	9300	9050	8800	8200
		5L	Class II	48000			12800	12250	11600	11050	10500	9900	9600	9300	8850
	BUTT WELDED	A53, 5L	Class I	45000		15300	9000	8600	8200	7800					
		5L	Class II	48000			9600	9200	8700	8300					
SEAMLESS ALLOY STEEL	CARBON-MOLY	A335	P1	55000	Ⓓ		18350	17650	16950	16300	15600	14900	14550	14200	13850
	½% Cr-½% Mo	A335	P2	55000			18350	17650	16950	16300	15600	14900	14550	14200	13850
	1% Cr-½% Mo	A335	P12	60000			18750	18250	17600	17050	16450	15900	15650	15350	15050
	1¼% Cr-½% Mo	A335	P11	60000			18750	18250	17650	17150	16600	16050	15800	15550	15300
	2¼% Cr-1% Mo	A335	P22	60000			18750	18250	17650	17150	16600	16050	15800	15500	15300
	3% Cr-1% Mo	A335	P21	60000			18750	18100	17400	16750	16100	15450	15150	14800	14500
	5% Cr-½% Mo	A335	P5a	60000			18750	17900	17050	16200	15350	14500	14100	13650	13250
	5% Cr-½% Mo-Si	A335	P5b	60000			18750	17900	17050	16200	15350	14500	14100	13650	13250
	18 Cr-8 Ni	A312	TP304	75000			18750	16650	15000	13650	12500	11600	11200	10800	10400
	18 Cr-8 Ni-2½ Mo	A312	TP316	75000			18750	18750	17900	17500	17200	17100	17050	17000	16900
	18 Cr-8 Ni-Ti	A312	TP321	75000			18750	18750	17000	15800	15200	14900	14850	14800	14700
	18 Cr-8 Ni-Cb	A312	TP347	75000			18750	18750	17000	15800	15200	14900	14850	14800	14700

NOTE: "S" Values above 900° F. are color coded to the applicable columns of the P/S table.

Ⓐ Stress Values in this column only are applicable to Oil Transmission Lines outside city, village, or refinery limits.

Ⓑ Carbon Steel to be from Open-Hearth or Electric-Furnace Process.

Ⓓ Carbon and carbon-molybdenum steels may be subject to graphitization above 900° F.

Ⓔ Non-silicon killed carbon steel is not recommended above 900° F.

Ⓕ "S" values include a joint efficiency of 85%.

Ⓗ Flange quality plate (A-285) is not recommended over 850° F.

Ⓘ "S" values shown for Class 1 piping (heat treated and radiographed) are based on a joint efficiency factor of 1.00. Where such operations are not done, "S" values shown shall be multiplied by the proper joint efficiency factor and reduced accordingly.

FOOTNOTES CONTINUED ON PAGE 253

TABLE 6 — P/S VALUES FOR PLAIN END PIPE

NOM. PIPE SIZE	DESIGNATION OF PIPE WALL THICKNESS	NOM. WALL THICK.	P/S VALUES WHEN y = .4	WHEN y = .5	WHEN y = .7
1	Std. (Sch. 40)	.133	.1062	.1074	.1097
	XH (Sch. 80)	.179	.1741	.1771	.1837
	Sch 160	.250	.2865	.2949	.3134
	XXH	.358	.4762	.5000	.5556
1¼	Std. (Sch. 40)	.140	.0912	.0920	.0937
	XH (Sch. 80)	.191	.1494	.1517	.1564
	Sch. 160	.250	.2217	.2267	.2375
	XXH	.382	.3964	.4128	.4499
1½	Std. (Sch. 40)	.145	.0838	.0845	.0859
	XH (Sch. 80)	.200	.1389	.1408	.1449
	Sch. 160	.281	.2249	.2300	.2411
	XXH	.400	.3615	.3750	.4054
2	Std. (Sch. 40)	.154	.0737	.0742	.0754
	XH (Sch. 80)	.218	.1247	.1262	.1295
	Sch. 160	.343	.2299	.2353	.2469
	XXH	.436	.3148	.3250	.3476
2½	Std. (Sch. 40)	.203	.0923	.0932	.0950
	XH (Sch. 80)	.276	.1411	.1431	.1473
	Sch. 160	.375	.2096	.2141	.2237
	XXH	.552	.3425	.3546	.3817
3	Std. (Sch. 40)	.216	.0820	.0827	.0841
	XH (Sch. 80)	.300	.1279	.1296	.1330
	Sch. 160	.438	.2060	.2103	.2195
	XXH	.600	.3045	.3141	.3351
3½	Std. (Sch. 40)	.226	.0763	.0768	.0780
	XH (Sch. 80)	.318	.1200	.1215	.1245
		.636	.2821	.2903	.3082
4	Std (Sch. 40)	.237	.0718	.0723	.0734
	XH (Sch. 80)	.337	.1138	.1152	.1179
	Sch. 120	.438	.1573	.1598	.1651
	Sch. 160	.531	.1991	.2032	.2118
	XXH	.674	.2655	.2727	.2885
5	Std. (Sch. 40)	.258	.0649	.0653	.0662
	XH (Sch. 80)	.375	.1041	.1052	.1075
	Sch. 120	.500	.1477	.1499	.1546
	Sch. 160	.625	.1924	.1962	.2042
	XXH	.750	.2387	.2445	.2571
6	Std. (Sch. 40)	.280	.0603	.0607	.0614
	XH (Sch. 80)	.432	.1031	.1042	.1064
	Sch. 120	.562	.1410	.1430	.1472
	Sch. 160	.718	.1876	.1912	.1988
	XXH	.864	.2330	.2385	.2505
8	Sch. 20	.250	.0398	.0400	.0403
	Sch. 30	.277	.0453	.0455	.0460
	Std. (Sch. 40)	.322	.0550	.0553	.0559
	Sch. 60	.406	.0728	.0733	.0744
	XH (Sch. 80)	.500	.0933	.0942	.0960
	Sch. 100	.593	.1137	.1150	.1177
8	Sch. 120	.718	.1416	.1437	.1479
	Sch. 140	.812	.1633	.1660	.1717
	XXH	.875	.1778	.1811	.1879
	Sch. 160	.906	.1850	.1885	.1959
10	Sch. 20	.250	.0318	.0319	.0321
	Sch. 30	.307	.0414	.0416	.0419
	Std. (Sch. 40)	.365	.0513	.0515	.0521
	XH (Sch. 60)	.500	.0743	.0749	.0760
	Sch. 80	.593	.0904	.0912	.0929
	Sch. 100	.718	.1124	.1136	.1163
	Sch. 120	.843	.1349	.1368	.1406
	Sch. 140	1.000	.1635	.1663	.1720
	Sch. 160	1.125	.1867	.1903	.1978
12	Sch. 20	.250	.0268	.0269	.0270
	Sch. 30	.330	.0381	.0382	.0385
	Std.	.375	.0444	.0446	.0450
	Sch. 40	.406	.0488	.0490	.0495
	XH	.500	.0624	.0628	.0636
	Sch. 60	.562	.0713	.0718	.0729
	Sch. 80	.687	.0895	.0903	.0920
	Sch. 100	.843	.1128	.1141	.1167
	Sch. 120	1.000	.1365	.1384	.1423
	Sch. 140	1.125	.1556	.1581	.1633
	Sch. 160	1.312	.1850	.1885	.1958

OIL TRANSMISSION LINES OUTSIDE CITY OR VILLAGE LIMITS
OIL PIPING SYSTEMS WITHIN REFINERY LIMITS

Section 3 Divisions A and B of ASA B31.1-1951 and B31.1a-1953

TABLE 5—ALLOWABLE STRESS VALUES (Continued)

VALUES OF ALLOWABLE STRESS IN PSI FOR TEMPERATURES IN DEGREES F. NOT TO EXCEED															GRADE OR SYMBOL	ASTM OR API SPECIFICATION
800°	850°	900°	950°	1000°	1050°	1100°	1150°	1200°	1250°	1300°	1350°	1400°	1450°	1500°		
9300	7900	6500	4500	2500	1600	1000									A	A53, A106, 5L
10800	8650	6500	4500	2500	1600	1000									B	A53, A106, 5L
12500	9550	6500	4500	2500	1600	1000									C	5L
															X-42	5LX
7900	6700	5500	3800	2150	1350	850									A	A53, A135, 5L
9200	7350	5500	3800	2150	1350	850									B	A53, A135, 5L
10700	8100	5500	3800	2150	1350	850									C	5L
															X-42	5LX
9000	7750	6500	4500	2500	1600	1000									C45	A155
9600	8050	6500	4500	2500	1600	1000									C50	A155
10200	8350	6500	4500	2500	1600	1000									C55	A155
															All Grades	5LX
															Class I	A53, 5L
															Class II	5L
															Class I	A53, 5L
															Class II	5L
13500	13150	12500	10000	6250	4000	2400									P1	A335
13500	13150	12500	10000	6250	4000	2400									P2	A335
14750	14200	13100	11000	7500	5000	2800									P12	A335
15000	14400	13100	11000	7800	5500	4000	2500	1200							P11	A335
15000	14400	13100	11000	7800	5800	4200	3000	2000							P22	A335
13900	13200	12000	9000	7000	5500	4000	2700	1500							P21	A335
12800	12400	11500	10000	7300	5200	3300	2200	1500							P5a	A335
12800	12400	10900	9000	5500	3500	2500	1800	1200							P5b	A335
10000	9700	9400	9100	8800	8500	7500	5750	4500	3250	2450	1800	1400	1000	750	TP304	A312
16750	16500	16000	15100	14000	12200	10400	8500	6800	5300	4000	3000	2350	1850	1500	TP316	A312
14550	14300	14100	13850	13500	13100	12500	8000	5000	3600	2700	2000	1550	1200	1000	TP321	A312
14550	14300	14100	13850	13500	13100	12500	8000	5000	3600	2700	2000	1550	1200	1000	TP347	A312

Ⓙ Specification API 5LX provides higher yield strength by agreement between producer and consumer. "S" values for these higher grades shall be 0.85 times the yield strength.

Ⓚ For electric-resistance-welded pipe where pipe furnished under this classification is subjected to supplemental tests and/or heat treatments as agreed to by the supplier and the purchaser, and whereby such supplemental tests and/or heat treatments demonstrate the strength characteristics of the weld to be equal to the minimum tensile strength specified for the pipe, the "S" values equal to the corresponding seamless grades may be used.

NOTES FOR P/S VALUE TABLE

At temperatures above 900° F., P/S values vary with temperature and/or material as tabulated on Page 247, and are cross-referenced by color to assist in the selection of the proper values.

These values are calculated with an assumed minimum corrosion allowance of 0.05", which has been retained from the earlier code.

TABLE 6—P/S VALUES FOR PLAIN END PIPE (Continued)

NOM. PIPE SIZE	DESIGNATION OF PIPE WALL THICKNESS	NOM. WALL THICK.	P/S VALUES WHEN y = .4	WHEN y = .5	WHEN y = .7
14	Sch. 10	.250	.0244	.0244	.0246
	Sch. 20	.312	.0323	.0324	.0326
	Std. (Sch. 30)	.375	.0404	.0405	.0408
	Sch. 40	.438	.0485	.0487	.0492
	XH	.500	.0567	.0570	.0577
	Sch. 60	.593	.0688	.0693	.0703
	Sch. 80	.750	.0897	.0905	.0922
	Sch. 100	.937	.1151	.1164	.1192
	Sch. 120	1.093	.1365	.1384	.1423
	Sch. 140	1.250	.1586	.1612	.1665
	Sch. 160	1.406	.1808	.1841	.1911
16	Sch. 10	.250	.0213	.0214	.0214
	Sch. 20	.312	.0282	.0283	.0284
	Std. (Sch. 30)	.375	.0352	.0354	.0356
	XH (Sch. 40)	.500	.0495	.0497	.0502
	Sch. 60	.656	.0673	.0677	.0686
	Sch. 80	.843	.0891	.0899	.0915
	Sch. 100	1.031	.1112	.1125	.1151
	Sch. 120	1.218	.1338	.1356	.1394
	Sch. 140	1.438	.1607	.1633	.1688
	Sch. 160	1.593	.1801	.1834	.1904
18	Sch. 10	.250	.0189	.0190	.0190
	Sch. 20	.312	.0250	.0251	.0252
	Std.	.375	.0313	.0314	.0316
	Sch. 30	.438	.0376	.0377	.0380

NOM PIPE SIZE	DESIGNATION OF PIPE WALL THICKNESS	NOM. WALL THICK.	P/S VALUES WHEN y = .4	WHEN y = .5	WHEN y = .7
18	XH	.500	.0439	.0441	.0445
	Sch. 40	.562	.0501	.0503	.0509
	Sch. 60	.750	.0692	.0697	.0707
	Sch. 80	.937	.0886	.0894	.0910
	Sch. 100	1.156	.1117	.1129	.1155
	Sch. 120	1.375	.1350	.1369	.1407
	Sch. 140	1.562	.1554	.1579	.1630
	Sch. 160	1.781	.1796	.1829	.1898
20	Sch. 10	.250	.0170	.0170	.0171
	Std. (Sch. 20)	.375	.0281	.0282	.0284
	XH (Sch. 30)	.500	.0394	.0396	.0399
	Sch. 40	.593	.0478	.0480	.0485
	Sch. 60	.812	.0679	.0684	.0693
	Sch. 80	1.031	.0882	.0890	.0906
	Sch. 100	1.281	.1119	.1132	.1158
	Sch. 120	1.500	.1330	.1348	.1386
	Sch. 140	1.750	.1574	.1599	.1652
	Sch. 160	1.968	.1792	.1824	.1894
22		.375	.0255	.0256	.0257
		.500	.0358	.0359	.0362
		.687	.0511	.0514	.0519
		.812	.0616	.0620	.0627
		1.031	.0799	.0806	.0819
		1.281	.1013	.1023	.1045
		1.500	.1203	.1218	.1249

NOM. PIPE SIZE	DESIGNATION OF PIPE WALL THICKNESS	NOM. WALL THICK.	P/S VALUES WHEN y = .4	WHEN y = .5	WHEN y = .7
24	Sch. 10	.250	.0142	.0142	.0142
	Std. (Sch. 20)	.375	.0234	.0234	.0235
	XH	.500	.0328	.0329	.0331
	Sch. 30	.562	.0374	.0375	.0378
	Sch. 40	.687	.0468	.0470	.0474
	Sch. 60	.968	.0682	.0687	.0697
	Sch. 80	1.218	.0876	.0884	.0900
	Sch. 100	1.531	.1123	.1136	.1162
	Sch. 120	1.812	.1349	.1368	.1406
	Sch. 140	2.062	.1552	.1577	.1628
	Sch. 160	2.343	.1786	.1818	.1887
26		.375	.0216	.0216	.0217
		.500	.0302	.0303	.0305
		.562	.0345	.0346	.0348
		.687	.0431	.0433	.0437
		.812	.0519	.0522	.0527
		.937	.0607	.0610	.0618
		1.281	.0852	.0859	.0874
		1.531	.1033	.1044	.1066
30		.375	.0187	.0187	.0188
	Sch. 20	.500	.0261	.0262	.0263
	Sch. 30	.625	.0336	.0337	.0339
		.750	.0411	.0412	.0416
		1.000	.0562	.0566	.0572

POWER PIPING, DISTRICT HEATING AND REFRIGERATION SYSTEMS MAXIMUM ALLOWABLE WORKING PRESSURES

Sections 1, 4® and 5®—ASA B31.1-1951 and ASA B31.1a-1953 ASME 1952 Power Boiler Code and 1952 Unfired Pressure Vessel Code

TABLE 7

NOMINAL PIPE SIZE	DESIGNATION OF PIPE	WALL THICKNESS	ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH														
			TEMPERATURES—DEGREES FAHRENHEIT														
			−20° To 650°		700°		750°		800°		850°		900°		950°		
			Seamless Steel Pipe Per ASTM Specification A106 Grades A and B														
			A	B	A	B	A	B	A	B	A	B	A	B	P2	P5a	P22
1/2	Standard (Sch. 40)	.109	1374	1718	1334	1643	1225	1483	1031	1237	813	893	573	573	1159	1159	1275
	Extra Stg. (Sch. 80)	.147	2441	3051	2370	2919	2176	2634	1831	2197	1444	1587	1017	1017	2076	2076	2284
	Schedule 160	.187	3654	4568	3547	4370	3258	3943	2741	3289	2162	2375	1523	1523	3141	3141	3455
	Double Extra Stg.	.294	7367	9209	7152	8809	6569	7950	5525	6630	4359	4788	3070	3070	6540	6540	7194
3/4	Standard (Sch. 40)	.113	1164	1455	1130	1392	1038	1256	873	1048	689	757	485	485	979	979	1077
	Extra Stg. (Sch. 80)	.154	2077	2597	2017	2484	1852	2242	1558	1869	1229	1350	866	866	1762	1762	1938
	Schedule 160	.218	3611	4514	3505	4318	3220	3897	2708	3250	2136	2347	1505	1505	3102	3102	3412
	Double Extra Stg.	.308	6041	7551	5865	7224	5386	6519	4531	5437	3574	3927	2517	2517	5301	5301	5831
1	Standard (Sch. 40)	.133	1274	1593	1237	1524	1136	1375	956	1147	754	828	531	531	1074	1074	1181
	Extra Stg. (Sch. 80)	.179	2089	2612	2028	2498	1863	2255	1567	1880	1236	1358	871	871	1771	1771	1948
	Schedule 160	.250	3438	4298	3338	4111	3066	3710	2579	3094	2034	2235	1433	1433	2949	2949	3244
	Double Extra Stg.	.358	5714	7143	5548	6833	5095	6167	4286	5143	3381	3714	2381	2381	5000	5000	5500
1 1/4	Standard (Sch. 40)	.140	863	1079	838	1032	769	931	647	777	510	561	360	360	724	724	796
	Extra Stg. (Sch. 80)	.191	1550	1938	1505	1854	1382	1673	1163	1395	917	1008	646	646	1309	1309	1440
	Schedule 160	.250	2405	3006	2335	2876	2144	2595	1804	2164	1423	1563	1002	1002	2045	2045	2250
	Double Extra Stg.	.382	4469	5586	4338	5344	3985	4823	3352	4022	2644	2905	1862	1862	3868	3868	4255
1 1/2	Standard (Sch. 40)	.145	804	1005	781	961	717	868	603	724	476	523	335	335	675	675	743
	Extra Stg. (Sch. 80)	.200	1457	1821	1414	1742	1299	1572	1093	1311	862	947	607	607	1229	1229	1352
	Schedule 160	.281	2474	3093	2402	2959	2206	2670	1856	2227	1464	1608	1031	1031	2106	2106	2317
	Double Extra Stg.	.400	4091	5114	3971	4892	3648	4415	3068	3682	2420	2659	1705	1705	3529	3529	3882
2	Standard (Sch. 40)	.154	725	906	704	867	646	782	544	652	429	471	302	302	607	607	668
	Extra Stg. (Sch. 80)	.218	1330	1662	1291	1590	1186	1435	997	1197	787	864	554	554	1121	1121	1233
	Schedule 160	.343	2579	3224	2504	3084	2299	2783	1934	2321	1526	1676	1075	1075	2196	2196	2416
	Double Extra Stg.	.436	3587	4484	3482	4289	3198	3871	2690	3228	2122	2331	1495	1495	3081	3081	3389
2 1/2	Standard (Sch. 40)	.203	974	1218	946	1165	869	1052	731	877	577	633	406	406	818	818	900
	Extra Stg. (Sch. 80)	.276	1554	1943	1509	1858	1386	1677	1166	1399	919	1010	648	648	1312	1312	1443
	Schedule 160	.375	2369	2961	2300	2833	2112	2556	1777	2132	1402	1540	987	987	2014	2014	2215
	Double Extra Stg.	.552	3949	4937	3834	4723	3521	4262	2962	3554	2337	2567	1646	1646	3403	3403	3743
3	Standard (Sch. 40)	.216	875	1094	849	1046	780	944	656	787	518	569	365	365	735	735	809
	Extra Stg. (Sch. 80)	.300	1422	1778	1381	1700	1268	1535	1067	1280	841	924	593	593	1199	1199	1319
	Schedule 160	.438	2352	2940	2283	2813	2097	2538	1764	2117	1392	1529	980	980	1999	1999	2199
	Double Extra Stg.	.600	3524	4406	3422	4215	3143	3803	2643	3172	2085	2291	1469	1469	3026	3026	3329
3 1/2	Standard (Sch. 40)	.226	820	1025	796	980	731	884	615	738	485	533	342	342	688	688	757
	Extra Stg. (Sch. 80)	.318	1342	1677	1302	1604	1196	1448	1006	1207	794	872	559	559	1130	1130	1243
		.636	3275	4094	3179	3916	2920	3534	2456	2947	1938	2129	1365	1365	2805	2805	3086
4	Standard (Sch. 40)	.237	776	971	754	928	692	838	582	699	459	505	324	324	652	652	717
	Extra Stg. (Sch. 80)	.337	1279	1599	1242	1530	1141	1380	959	1151	757	831	533	533	1077	1077	1185
	Schedule 160	.531	2297	2871	2230	2747	2048	2479	1723	2067	1359	1493	957	957	1951	1951	2146
	Double Extra Stg.	.674	3089	3861	2999	3694	2754	3333	2317	2780	1828	2008	1287	1287	2642	2642	2906

Refer to pages 247-253 for basis of determining these values and those for other materials.
Values are also applicable to Ladish Seamless Welding Fittings.
®Values for temperatures above 750° F. are not applicable to District Heating Piping Systems.
®Values listed under columns headed −20° to 650° F. are applicable to Refrigeration Piping System @ 0° F.

POWER PIPING AND DISTRICT HEATING SYSTEMS MAXIMUM ALLOWABLE WORKING PRESSURES

Section 1—ASA B31.1-1951 and ASA B31.1a-1953
ASME 1952 Power Boiler Code and 1952 Unfired Pressure Vessel Code

TABLE 7 (Continued)

ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH																			
TEMPERATURES—DEGREES FAHRENHEIT																			
1000°					1050°				1100°				1150°				1200°		
Seamless Alloy Steel Pipe Per ASTM Specifications A335 Grades P2, P5a and P22 and A312 Grades TP316 ® and TP347																			
P2	P5a	P22	TP316	TP347	P5a	P22	TP316	TP347	P5a	P22	TP316	TP347	P5a	P22	TP316	TP347	P5a	TP316	TP347
741	866	925	1603	1546	617	688	1397	1500	391	498	1205	1194	261	356	1008	901	178	806	593
1354	1581	1689	2848	2746	1126	1256	2481	2665	715	910	2159	2138	477	650	1841	1646	325	1473	1083
2094	2446	2614	4263	4111	1743	1944	3715	3989	1106	1407	3267	3235	737	1005	2848	2547	503	2279	1676
4703	5493	5869	8595	8288	3912	4364	7490	8042	2483	3160	6802	6736	1655	2257	6395	5718	1129	5116	3762
624	729	779	1358	1310	519	579	1183	1271	330	420	1018	1008	220	300	849	759	150	679	500
1141	1333	1424	2423	2337	950	1059	2112	2268	603	767	1832	1815	402	548	1552	1388	274	1242	913
2067	2414	2579	4213	4062	1720	1918	3671	3942	1091	1389	3226	3195	728	992	2811	2513	496	2249	1654
3706	4328	4625	7048	6796	3083	3439	6141	6595	1957	2490	5513	5460	1304	1779	5040	4506	889	4032	2965
686	801	856	1487	1434	570	636	1296	1391	362	461	1117	1106	241	329	932	834	165	746	549
1148	1341	1433	2437	2350	955	1065	2124	2281	606	772	1842	1824	404	551	1561	1396	276	1249	919
1959	2288	2445	4011	3868	1630	1818	3495	3753	1034	1316	3067	3037	689	940	2664	2382	470	2131	1567
3473	4056	4334	6667	6429	2889	3222	5810	6238	1833	2334	5200	5150	1222	1667	4723	4223	833	3778	2778
459	537	573	1007	971	382	426	877	942	243	309	753	746	162	221	625	559	110	500	368
841	982	1049	1809	1744	699	780	1576	1693	444	565	1361	1348	296	404	1143	1022	202	915	673
1333	1556	1663	2806	2705	1109	1237	2445	2625	704	895	2127	2106	469	640	1812	1620	320	1450	1066
2620	3060	3270	5214	5027	2180	2431	4543	4878	1383	1761	4023	3984	922	1258	3563	3186	629	2851	2096
428	499	534	938	905	356	397	817	878	226	287	702	695	150	205	581	520	103	465	342
788	920	983	1700	1639	655	731	1481	1590	416	529	1278	1266	277	378	1071	958	189	857	630
1374	1605	1715	2887	2784	1143	1275	2516	2701	726	924	2190	2169	484	660	1869	1671	330	1495	1100
2373	2772	2962	4773	4602	1974	2202	4159	4466	1253	1595	3670	3635	835	1139	3227	2886	570	2582	1899
384	449	480	846	815	320	357	737	791	203	258	631	625	135	185	523	467	92	418	308
716	837	894	1551	1496	596	665	1352	1451	378	481	1166	1155	252	344	974	871	172	779	573
1436	1677	1792	3009	2901	1194	1332	2622	2815	758	965	2284	2262	505	689	1952	1746	345	1562	1149
2052	2397	2561	4185	4035	1707	1904	3647	3916	1083	1379	3204	3173	722	985	2791	2495	492	2232	1642
520	607	649	1137	1096	433	483	991	1064	275	349	851	843	183	250	707	632	125	566	416
842	983	1051	1813	1748	700	781	1580	1696	445	566	1364	1351	296	404	1145	1024	202	916	674
1311	1532	1636	2764	2665	1091	1217	2408	2586	692	881	2095	2074	462	629	1783	1594	315	1427	1049
2282	2665	2848	4607	4443	1899	2118	4015	4311	1205	1533	3539	3505	803	1095	3103	2775	548	2483	1826
466	545	582	1021	984	388	433	889	955	246	313	764	757	164	224	634	567	112	507	373
768	897	959	1659	1600	639	713	1446	1552	406	516	1247	1235	270	369	1045	934	184	836	615
1301	1520	1624	2744	2646	1083	1208	2391	2568	687	874	2079	2059	458	625	1770	1582	312	1416	1041
2013	2351	2512	4112	3965	1675	1868	3583	3847	1063	1353	3147	3117	709	966	2738	2448	483	2190	1611
436	509	544	956	922	362	404	833	895	230	293	716	709	153	209	592	530	105	474	349
723	845	902	1565	1509	602	671	1364	1465	382	486	1175	1164	255	347	983	879	174	787	579
1858	2170	2318	3821	3684	1545	1724	3329	3575	981	1248	2917	2889	654	892	2526	2259	446	2021	1486
413	482	515	906	873	343	383	789	848	218	277	678	672	145	198	561	502	99	449	330
688	804	859	1492	1439	573	639	1301	1396	363	462	1120	1109	242	330	936	837	165	749	551
1269	1482	1583	2680	2584	1056	1177	2335	2507	670	853	2029	2010	447	609	1726	1543	305	1380	1015
1743	2036	2175	3604	3475	1450	1618	3140	3372	920	1171	2748	2721	614	837	2371	2120	418	1897	1395

Refer to pages 247-253 for basis of determining these values and those for other materials.
Values are also applicable to Ladish Seamless Welding Fittings.
®Type TP316 is not listed in the allowable stress tables of Sections 1 and 4, so "P" values listed herein are based upon allowable stress in Table P7 of 1952 Power Boiler Code, wherein stress levels are generally comparable to those of this section of the Code for Pressure Piping.

POWER PIPING, DISTRICT HEATING AND REFRIGERATION SYSTEMS MAXIMUM ALLOWABLE WORKING PRESSURES

Sections 1, 4® and 5®—ASA B31.1-1951 and ASA B31.1a-1953
ASME 1952 Power Boiler Code and 1952 Unfired Pressure Vessel Code

TABLE 7 (Continued)

NOMINAL PIPE SIZE	DESIGNATION OF PIPE	WALL THICKNESS	ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH														
			TEMPERATURES—DEGREES FAHRENHEIT														
			—20° To 650°		700°		750°		800°		850°		900°		950°		
			Seamless Steel Pipe Per ASTM Specification A106 Grades A and B														
			A	B	A	B	A	B	A	B	A	B	A	B	P2	P5a	P22
5	Standard (Sch. 40)	.258	712	890	691	851	635	768	534	640	421	463	297	297	596	596	656
	Extra Stg. (Sch. 80)	.375	1180	1475	1145	1411	1052	1273	885	1062	698	767	492	492	992	992	1091
	Schedule 160	.625	2234	2793	2169	2672	1992	2411	1676	2011	1322	1452	931	931	1897	1897	2087
	Double Extra Stg.	.750	2786	3483	2705	3332	2485	3007	2090	2508	1649	1811	1161	1161	2377	2377	2615
6	Standard (Sch. 40)	.280	666	833	647	796	594	719	500	599	394	433	278	278	559	559	615
	Extra Stg. (Sch. 80)	.432	1178	1473	1144	1409	1051	1272	884	1061	697	766	491	491	992	992	1091
	Schedule 160	.718	2189	2736	2125	2617	1952	2362	1642	1970	1295	1423	912	912	1858	1858	2044
	Double Extra Stg.	.864	2731	3414	2652	3266	2435	2947	2048	2458	1616	1775	1138	1138	2329	2329	2562
8	Standard (Sch. 40)	.322	617	771	599	738	550	666	463	555	365	401	257	257	516	516	568
	Extra Stg. (Sch. 80)	.500	1075	1344	1044	1286	959	1160	806	968	636	699	448	448	904	904	994
	Schedule 160	.906	2172	2715	2109	2597	1937	2344	1629	1955	1285	1412	905	905	1844	1844	2028
	Double Extra Stg.	.875	2087	2609	2026	2495	1861	2252	1565	1878	1235	1356	870	870	1769	1769	1946
10	Standard (Sch. 40)	.365	581	726	564	695	518	627	436	523	344	378	242	242	486	486	535
	Extra Stg. (Sch. 60)	.500	857	1071	832	1025	764	925	643	771	507	557	357	357	719	719	791
	Schedule 80	.593	1049	1311	1018	1254	935	1132	787	944	621	682	437	437	882	882	970
	Schedule 160	1.125	2202	2753	2138	2633	1963	2376	1652	1982	1303	1431	918	918	1870	1870	2057
12	Standard	.375	503	629	488	601	448	543	377	453	297	327	210	210	421	421	463
	Extra Strong	.500	719	899	698	860	641	776	539	647	425	467	300	300	603	603	663
	Schedule 80	.687	1044	1305	1014	1248	931	1127	783	940	618	679	435	435	878	878	966
	Schedule 160	1.312	2188	2735	2124	2616	1951	2361	1641	1969	1294	1422	912	912	1856	1856	2042
14 O. D.	Standard (Sch. 30)	.375	457	572	444	547	408	493	343	411	271	297	191	191	383	383	421
	Extra Strong	.500	653	816	634	781	582	704	490	588	386	424	272	272	547	547	602
	Schedule 80	.750	1049	1311	1018	1254	935	1132	787	944	621	682	437	437	881	881	969
	Schedule 100	.937	1352	1691	1313	1617	1206	1459	1014	1217	800	879	564	564	1140	1140	1254
16 O. D.	Standard (Sch. 30)	.375	400	500	388	478	356	431	300	360	236	260	167	167	334	334	367
	Extra Stg. (Sch. 40)	.500	570	713	553	682	508	615	428	513	337	371	238	238	477	477	525
	Schedule 80	.843	1045	1307	1015	1250	932	1128	784	941	618	679	436	436	878	878	966
	Schedule 100	1.031	1310	1638	1272	1567	1168	1414	983	1179	775	852	546	546	1104	1104	1214
18 O. D.	Standard	.375	355	444	345	425	317	383	266	320	210	231	148	148	297	297	327
	Extra Strong	.500	505	632	490	604	450	545	379	455	299	328	211	211	423	423	465
	Schedule 60	.750	809	1011	785	967	721	873	607	728	479	526	337	337	679	679	747
	Schedule 100	1.156	1318	1647	1279	1576	1175	1422	988	1186	780	856	549	549	1111	1111	1222
20 O. D.	Standard (Sch. 20)	.375	319	399	310	382	285	344	239	287	189	207	133	133	267	267	294
	Extra Stg. (Sch. 30)	.500	455	569	442	544	406	491	341	409	269	296	190	190	380	380	418
	Schedule 60	.812	796	995	772	951	709	859	597	716	471	517	332	332	668	668	735
	Schedule 80	1.031	1039	1299	1009	1243	927	1121	779	935	615	675	433	433	874	874	961
24 O. D.	Standard (Sch. 20)	.375	265	332	257	317	236	286	199	239	157	172	111	111	222	222	244
	Extra Strong	.500	378	473	367	452	337	408	284	340	224	246	158	158	316	316	348
	Schedule 40	.687	546	683	530	653	487	589	410	491	323	355	228	228	457	457	503
	Schedule 60	.968	803	1004	779	960	716	866	602	723	475	522	335	335	674	674	741
30 O. D.	Schedule 20	.375	212	266	206	254	189	229	159	191	126	138	89	89	177	177	195
		.500	301	377	292	360	269	325	226	271	178	196	126	126	252	252	277

Refer to pages 247-253 for basis of determining these values and those for other materials.
Values are also applicable to Ladish Seamless Welding Fittings.
®Values for temperatures above 750° F. are not applicable to District Heating Piping Systems.
®Values listed under columns headed –20° to 650° F are applicable to Refrigeration Piping System @ 0° F.

POWER PIPING AND DISTRICT HEATING SYSTEMS MAXIMUM ALLOWABLE WORKING PRESSURES

Section 1—ASA B31.1-1951 and ASA B31.1a-1953
ASME 1952 Power Boiler Code and 1952 Unfired Pressure Vessel Code

TABLE 7 (Continued)

ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH																			
TEMPERATURES — DEGREES FAHRENHEIT																			
1000°					1050°				1100°				1150°				1200°		
Seamless Alloy Steel Pipe Per ASTM Specifications A335 Grades P2, P5a and P22 and A312 Grades TP316 ® and TP347																			
P2	P5a	P22	TP316	TP347	P5a	P22	TP316	TP347	P5a	P22	TP316	TP347	P5a	P22	TP316	TP347	P5a	TP316	TP347
377	440	470	830	801	314	350	723	777	199	253	620	614	133	181	513	458	90	410	302
633	739	790	1376	1327	527	588	1199	1288	334	425	1032	1022	223	304	861	770	152	689	507
1233	1440	1538	2607	2514	1025	1144	2272	2439	651	828	1973	1954	434	592	1676	1499	296	1341	986
1560	1822	1947	3251	3135	1298	1448	2833	3042	824	1048	2472	2448	549	749	2122	1897	374	1697	1248
353	412	441	777	749	294	328	677	727	186	237	581	576	124	170	480	429	85	384	283
633	739	789	1375	1326	526	587	1198	1286	334	425	1032	1022	223	304	860	769	152	688	506
1206	1408	1505	2554	2462	1003	1119	2225	2389	637	810	1932	1914	424	579	1640	1466	289	1312	965
1527	1783	1906	3186	3073	1270	1417	2777	2982	806	1026	2422	2399	537	733	2077	1857	366	1661	1222
326	381	407	720	694	271	303	627	673	172	219	537	531	115	157	444	397	78	355	261
576	672	718	1254	1210	479	534	1093	1174	304	387	940	931	203	276	783	700	138	626	461
1196	1397	1493	2534	2444	995	1110	2208	2371	632	804	1918	1899	421	574	1627	1455	287	1302	957
1146	1339	1431	2435	2348	954	1064	2122	2278	605	770	1840	1822	403	550	1559	1394	275	1247	917
307	358	383	678	653	255	285	590	634	162	206	505	501	108	147	417	373	74	334	246
456	532	569	1000	964	379	423	871	935	241	306	748	741	160	219	620	554	109	496	365
561	656	700	1224	1180	467	521	1066	1145	296	377	917	908	198	269	763	682	135	611	449
1214	1418	1515	2569	2477	1010	1126	2239	2404	641	816	1945	1926	427	583	1651	1476	291	1321	971
266	310	332	587	566	221	247	511	549	140	179	438	434	94	128	361	323	64	289	213
381	445	476	839	809	317	354	731	785	201	256	627	621	134	183	519	464	92	415	305
558	652	697	1218	1175	464	518	1061	1140	295	375	913	904	196	268	759	679	134	607	447
1205	1407	1504	2552	2461	1003	1118	2224	2388	636	810	1930	1912	424	578	1639	1465	289	1311	964
241	282	301	533	514	201	224	465	499	127	162	398	394	85	116	328	293	58	262	193
346	404	431	762	734	288	321	664	713	182	232	569	563	122	166	470	420	83	376	277
561	655	700	1224	1180	466	520	1066	1145	296	377	916	907	197	269	762	682	135	610	449
729	852	910	1578	1521	607	677	1375	1476	385	490	1186	1174	257	350	992	887	175	794	584
210	245	262	466	450	175	195	406	436	111	141	347	344	74	101	286	255	50	228	168
301	352	376	665	641	251	280	580	622	159	202	496	491	106	145	410	366	72	328	241
559	653	697	1219	1176	465	519	1063	1141	295	375	913	904	197	268	760	679	134	608	447
706	824	881	1529	1474	587	655	1332	1431	373	474	1148	1137	248	339	960	858	169	768	565
186	218	232	414	400	155	173	361	388	98	125	309	306	66	89	253	226	45	203	149
267	312	333	589	568	222	248	514	552	141	179	440	436	94	128	363	325	64	290	214
430	502	537	944	910	358	399	822	883	227	289	706	699	151	206	585	523	103	468	344
710	829	886	1537	1482	591	659	1340	1438	375	477	1155	1144	250	341	966	863	170	772	568
168	196	209	372	359	139	155	325	348	88	113	278	275	59	80	228	204	40	182	134
239	280	299	531	512	199	222	462	496	126	161	395	391	84	115	326	291	57	260	192
423	494	528	928	895	352	393	809	869	223	284	695	688	149	203	575	515	102	460	339
556	649	693	1212	1169	462	516	1057	1134	293	373	909	900	196	267	756	676	133	605	445
139	163	174	309	298	116	129	270	290	74	94	231	229	49	67	190	169	33	152	112
199	232	248	441	425	165	184	384	413	105	134	329	325	70	95	270	242	48	216	159
288	337	360	637	614	240	267	555	596	152	194	475	471	101	138	392	350	69	313	231
427	499	533	937	903	355	396	816	876	225	287	701	694	150	205	581	519	102	464	342
111	130	139	248	239	93	103	216	232	59	75	184	182	39	53	151	135	27	121	89
158	185	197	351	339	132	147	306	329	83	106	262	260	56	76	215	192	38	172	127

Refer to pages 247-253 for basis of determining these values and those for other materials.
Values are also applicable to Ladish Seamless Welding Fittings.
®Type TP316 is not listed in the allowable stress tables of Sections 1 and 4, so "P" values listed herein are based upon allowable stress in Table P7 of 1952 Power Boiler Code, wherein stress levels are generally comparable to those of this section of the Code for Pressure Piping.

OIL TRANSMISSION LINES OUTSIDE CITY OR VILLAGE LIMITS® AND OIL PIPING SYSTEMS WITHIN REFINERY LIMITS—MAXIMUM ALLOWABLE WORKING PRESSURES

Section 3, Divisions A and B®—ASA B31.1-1951 and ASA B31.1a-1953

TABLE 8

NOMINAL PIPE SIZE	DESIGNATION OF PIPE	NOMINAL WALL THICKNESS	ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH														
			TEMPERATURES — DEGREES FAHRENHEIT														
			100° ®	100°	200°	300°	400°	500°	600°	650°	700°	750°	800°		850°		900°
			Seamless Steel Pipe Per ASTM Specification A106, Grades A® and B														
			B	B	B	B	B	B	B	B	B	B	A	B	A	B	A&B
1/2	Standard (Sch. 40)	.109	3406	2290	2187	2078	1975	1872	1775	1717	1643	1483	1065	1237	905	990	744
	Extra Stg. (Sch. 80)	.147	6051	4068	3885	3692	3509	3326	3153	3051	2919	2634	1892	2197	1607	1759	1322
	Schedule 160	.187	9059	6090	5816	5527	5253	4979	4720	4568	4370	3943	2832	3289	2406	2634	1979
	Double Extra Stg.	.294	18264	12278	11725	11142	10590	10037	9515	9208	8809	7950	5709	6630	4850	5310	3990
3/4	Standard (Sch. 40)	.113	2886	1940	1853	1761	1673	1586	1504	1455	1392	1256	902	1048	766	839	631
	Extra Stg. (Sch. 80)	.154	5150	3462	3306	3142	2986	2830	2683	2596	2484	2242	1610	1869	1367	1497	1125
	Schedule 160	.218	8952	6018	5747	5461	5191	4920	4664	4514	4318	3897	2798	3250	2377	2603	1956
	Double Extra Stg.	.308	14976	10068	9615	9137	8684	8231	7803	7551	7224	6519	4682	5437	3977	4354	3272
1	Standard (Sch. 40)	.133	3159	2124	2028	1928	1832	1736	1646	1593	1524	1375	988	1147	839	919	690
	Extra Stg. (Sch. 80)	.179	5179	3482	3325	3160	3003	2847	2699	2612	2498	2255	1619	1880	1375	1506	1132
	Schedule 160	.250	8523	5730	5472	5200	4942	4684	4441	4298	4111	3710	2664	3094	2263	2478	1862
	Double Extra Stg.	.358	14167	9524	9095	8643	8214	7786	7381	7143	6833	6167	4429	5143	3762	4119	3095
1 1/4	Standard (Sch. 40)	.140	2713	1824	1742	1655	1573	1491	1414	1368	1309	1181	848	985	720	789	593
	Extra Stg. (Sch. 80)	.191	4445	2988	2854	2712	2577	2443	2316	2241	2144	1935	1389	1614	1180	1292	971
	Schedule 160	.250	6596	4434	4234	4024	3824	3625	3436	3326	3181	2871	2062	2394	1751	1918	1441
	Double Extra Stg.	.382	11793	7928	7571	7195	6838	6481	6144	5946	5688	5133	3687	4281	3132	3429	2577
1 1/2	Standard (Sch. 40)	.145	2493	1676	1601	1521	1446	1370	1299	1257	1203	1085	779	905	662	725	545
	Extra Stg. (Sch. 80)	.200	4132	2778	2653	2521	2396	2271	2153	2084	1993	1799	1292	1500	1097	1201	903
	Schedule 160	.281	6691	4498	4296	4082	3880	3677	3486	3374	3227	2912	2092	2429	1777	1945	1462
	Double Extra Stg.	.400	10755	7230	6905	6561	6236	5911	5603	5423	5188	4681	3362	3904	2856	3127	2350
2	Standard (Sch. 40)	.154	2193	1474	1408	1338	1271	1205	1142	1106	1058	954	685	796	582	638	479
	Extra Stg. (Sch. 80)	.218	3710	2494	2382	2263	2151	2039	1933	1870	1789	1615	1160	1347	985	1079	811
	Schedule 160	.343	6840	4598	4391	4173	3966	3759	3563	3448	3299	2977	2138	2483	1816	1989	1494
	Double Extra Stg.	.436	9365	6296	6013	5714	5430	5147	4879	4722	4517	4077	2928	3400	2487	2723	2046
2 1/2	Standard (Sch. 40)	.203	2746	1846	1763	1675	1592	1509	1431	1384	1325	1195	858	997	729	798	600
	Extra Stg. (Sch. 80)	.276	4198	2822	2695	2561	2434	2307	2187	2116	2025	1827	1312	1524	1115	1221	917
	Schedule 160	.375	6236	4192	4003	3804	3616	3427	3249	3144	3008	2714	1949	2264	1656	1813	1362
	Double Extra Stg.	.552	10189	6850	6542	6216	5908	5600	5309	5138	4915	4435	3185	3699	2706	2963	2226
3	Standard (Sch. 40)	.216	2440	1640	1566	1488	1415	1341	1271	1230	1177	1062	763	886	648	709	533
	Extra Stg. (Sch. 80)	.300	3805	2558	2443	2321	2206	2091	1982	1918	1835	1656	1189	1381	1010	1106	831
	Schedule 160	.438	6129	4120	3935	3739	3554	3368	3193	3090	2956	2668	1916	2225	1627	1782	1339
	Double Extra Stg.	.600	9059	6090	5816	5527	5253	4979	4720	4568	4370	3943	2832	3289	2406	2634	1979
3 1/2	Standard (Sch. 40)	.226	2270	1526	1457	1385	1316	1248	1183	1144	1095	988	710	824	603	660	496
	Extra Stg. (Sch. 80)	.318	3570	2400	2292	2178	2070	1962	1860	1800	1722	1554	1116	1296	948	1038	780
		.636	8392	5642	5388	5120	4866	4612	4373	4232	4048	3653	2624	3047	2229	2440	1834
4	Standard (Sch. 40)	.237	2136	1436	1371	1303	1239	1174	1113	1077	1030	930	668	775	567	621	467
	Extra Stg. (Sch. 80)	.337	3386	2276	2174	2065	1963	1861	1764	1707	1633	1474	1058	1229	899	984	740
	Schedule 160	.531	5923	3982	3803	3614	3434	3255	3086	2986	2857	2578	1852	2150	1573	1722	1294
	Double Extra Stg.	.674	7899	5310	5071	4819	4580	4341	4115	3982	3810	3438	2469	2867	2097	2297	1726

Refer to pages 247-253 for basis of determining these values and those for other materials. A corrosion allowance of 0.050″ has been assumed. Values are also applicable to Ladish Seamless Welding Fittings.

®Allowable working pressure for Grade A material equals the following percentages of those tabulated for Grade B material: 82.5% at 750°, 81.2% at 700° and 80% at 650° and lower.

®For Division B, Oil Transmission Lines Outside City or Village Limits not exceeding 100° F.

OIL PIPING SYSTEMS WITHIN REFINERY LIMITS
MAXIMUM ALLOWABLE WORKING PRESSURES

Section 3, Division A—ASA B31.1-1951 and ASA B31.1a-1953

TABLE 8 (Continued)

ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH																					
TEMPERATURES—DEGREES FAHRENHEIT																					
950°			1000°			1050°			1100°			1150°		1200°		1250°	1300°	1350°	1400°	1450°	1500°
Seamless Alloy Steel Pipe Per ASTM Specification A335, Grades P2, P5a and P22																Seamless Stainless Steel Pipe Per ASTM Specification A312, Grade TP316					
P2	P5a	P22	P2	P5a	P22	P2	P5a	P22	P2	P5a	P22	P5a	P22	P5a	P22						
1159	1159	1275	741	866	925	474	617	688	285	391	498	261	356	178	237	629	474	356	279	219	178
2076	2076	2284	1354	1581	1689	866	1126	1256	520	715	910	477	650	325	433	1148	866	650	509	401	325
3141	3141	3455	2094	2446	2614	1340	1743	1944	804	1106	1407	737	1005	503	670	1776	1340	1005	787	620	503
6540	6540	7194	4703	5493	5869	3010	3912	4364	1806	2483	3160	1655	2257	1129	1505	3988	3010	2257	1768	1392	1129
979	979	1077	624	729	779	400	519	579	240	330	420	220	300	150	200	529	400	300	235	185	150
1762	1762	1938	1141	1333	1424	730	950	1059	438	603	767	402	548	274	365	968	730	548	429	338	274
3102	3102	3412	2067	2414	2579	1323	1720	1918	794	1091	1389	728	992	496	661	1753	1323	992	777	612	496
5301	5301	5831	3706	4328	4625	2372	3083	3439	1423	1957	2490	1304	1779	889	1186	3142	2372	1779	1393	1097	889
1074	1074	1181	686	801	856	439	570	636	263	362	461	241	329	165	219	581	439	329	258	203	165
1771	1771	1948	1148	1341	1433	735	955	1065	441	606	772	404	551	276	367	974	735	551	432	340	276
2949	2949	3244	1959	2288	2445	1254	1630	1818	752	1034	1316	689	940	470	627	1661	1254	940	736	580	470
5000	5000	5500	3473	4056	4334	2222	2889	3222	1333	1833	2334	1222	1667	833	1111	2945	2222	1667	1306	1028	833
920	920	1012	586	684	731	375	487	543	225	309	394	206	281	141	187	497	375	281	220	173	141
1517	1517	1669	978	1142	1220	626	813	907	375	516	657	344	469	235	313	829	626	469	368	289	235
2267	2267	2494	1484	1734	1853	950	1235	1378	570	784	998	523	713	356	475	1259	950	713	558	439	356
4128	4128	4541	2812	3284	3509	1800	2339	2609	1080	1485	1890	990	1350	675	900	2384	1800	1350	1057	832	675
845	845	930	537	627	670	344	447	498	206	283	361	189	258	129	172	455	344	258	202	159	129
1408	1408	1549	906	1058	1130	580	753	840	348	478	609	319	435	217	290	768	580	435	341	268	217
2300	2300	2530	1507	1760	1881	964	1254	1398	579	796	1013	530	723	362	482	1278	964	723	567	446	362
3750	3750	4125	2534	2959	3162	1622	2108	2351	973	1338	1703	892	1216	608	811	2149	1622	1216	953	750	608
742	742	816	471	550	588	302	392	437	181	249	317	166	226	113	151	400	302	226	177	139	113
1262	1262	1388	809	945	1010	518	673	751	311	427	544	285	389	194	259	686	518	389	304	240	194
2353	2353	2588	1543	1802	1926	988	1284	1432	593	815	1037	543	741	370	494	1309	988	741	580	457	370
3250	3250	3575	2173	2537	2711	1390	1808	2016	834	1147	1460	765	1043	521	695	1842	1390	1043	817	643	521
932	932	1025	594	694	741	380	494	551	228	314	399	209	285	143	190	504	380	285	223	176	143
1431	1431	1574	921	1075	1149	589	766	854	354	486	619	324	442	221	295	781	589	442	346	273	221
2141	2141	2355	1398	1633	1745	895	1163	1297	537	738	940	492	671	336	447	1186	895	671	526	414	336
3546	3546	3901	2386	2786	2977	1527	1985	2214	916	1260	1603	840	1145	573	763	2023	1527	1145	897	706	573
827	827	910	526	614	656	336	437	488	202	278	353	185	252	126	168	446	336	252	198	156	126
1296	1296	1426	831	971	1037	532	692	771	319	439	559	293	399	200	266	705	532	399	313	246	200
2103	2103	2313	1372	1602	1712	878	1141	1273	527	724	922	483	659	329	439	1163	878	659	516	406	329
3141	3141	3455	2094	2446	2614	1340	1743	1944	804	1106	1407	737	1005	503	670	1776	1340	1005	787	620	503
768	768	845	488	569	608	312	406	452	187	257	328	172	234	117	156	413	312	234	183	144	117
1215	1215	1337	778	909	971	498	647	722	299	411	523	274	374	187	249	660	498	374	293	230	187
2903	2903	3193	1926	2250	2404	1233	1603	1788	740	1017	1294	678	925	462	616	1633	1233	925	724	570	462
723	723	795	459	536	573	294	382	426	176	242	308	161	220	110	147	389	294	220	172	136	110
1152	1152	1267	737	861	920	472	613	684	283	389	495	259	354	177	236	625	472	354	277	218	177
2032	2032	2235	1324	1546	1652	847	1101	1228	508	699	890	466	635	318	424	1123	847	635	498	392	318
2727	2727	3000	1803	2106	2250	1154	1500	1673	692	952	1212	635	866	433	577	1529	1154	866	678	534	433

Refer to pages 247-253 for basis of determining these values and those for other materials. A corrosion allowance of 0.050″ has been assumed. Values are also applicable to Ladish Seamless Welding Fittings.

OIL TRANSMISSION LINES OUTSIDE CITY OR VILLAGE LIMITS® AND OIL PIPING SYSTEMS WITHIN REFINERY LIMITS—MAXIMUM ALLOWABLE WORKING PRESSURES

Section 3, Divisions A and B®—ASA B31.1-1951 and ASA B31.1a-1953

TABLE 8 (Continued)

NOMINAL PIPE SIZE	DESIGNATION OF PIPE	NOMINAL WALL THICKNESS	ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH														
			TEMPERATURES—DEGREES FAHRENHEIT														
			100° ®	100°	200°	300°	400°	500°	600°	650°	700°	750°	800°		850°		900°
			Seamless Steel Pipe Per ASTM Specification A106, Grades A® and B														
			B	B	B	B	B	B	B	B	B	B	A	B	A	B	A&B
5	Standard (Sch. 40)	.258	1931	1298	1240	1178	1120	1061	1006	974	931	840	604	701	513	561	422
	Extra Stg. (Sch. 80)	.375	3097	2082	1988	1889	1796	1702	1614	1562	1494	1348	968	1124	822	900	677
	Schedule 160	.625	5724	3848	3675	3492	3319	3146	2982	2886	2761	2492	1789	2078	1520	1664	1251
	Double Extra Stg.	.750	7101	4774	4559	4332	4118	3903	3700	3580	3425	3091	2220	2578	1886	2065	1552
6	Standard (Sch. 40)	.280	1794	1206	1152	1094	1040	986	935	904	865	781	561	651	476	522	392
	Extra Stg. (Sch. 80)	.432	3067	2062	1969	1871	1778	1686	1598	1546	1479	1335	959	1113	814	892	670
	Schedule 160	.718	5581	3752	3583	3405	3236	3067	2908	2814	2692	2429	1745	2026	1482	1623	1219
	Double Extra Stg.	.864	6932	4660	4450	4229	4019	3810	3612	3495	3344	3017	2167	2516	1841	2015	1515
8	Standard (Sch. 40)	.322	1636	1100	1051	998	949	899	853	825	789	712	512	594	435	476	358
	Extra Stg. (Sch. 80)	.500	2776	1866	1782	1693	1609	1525	1446	1400	1339	1208	868	1008	737	807	606
	Schedule 160	.906	5504	3700	3534	3358	3191	3025	2868	2775	2655	2396	1721	1998	1462	1600	1203
	Double Extra Stg.	.875	5290	3556	3396	3227	3067	2907	2756	2667	2551	2303	1654	1920	1405	1538	1156
10	Standard (Sch. 40)	.365	1526	1026	980	931	885	839	795	770	736	664	477	554	405	444	333
	Extra Stg. (Sch. 60)	.500	2210	1486	1419	1349	1282	1215	1152	1114	1066	962	691	802	587	643	483
	Schedule 80	.593	2689	1808	1727	1641	1559	1478	1401	1356	1297	1171	841	976	714	782	588
	Schedule 160	1.125	5554	3734	3566	3389	3221	3053	2894	2800	2679	2418	1736	2016	1475	1615	1214
12	Standard	.375	1321	888	848	806	766	726	688	660	637	575	413	480	351	384	289
	Extra Stg.	.500	1856	1248	1192	1133	1076	1020	967	936	895	808	580	674	493	540	406
	Schedule 80	.687	2663	1790	1709	1624	1544	1463	1387	1342	1284	1159	832	967	707	774	582
	Schedule 160	1.312	5504	3700	3534	3358	3191	3025	2868	2775	2655	2396	1721	1998	1462	1600	1203
14 O. D.	Standard (Sch. 30)	.375	1202	808	772	733	697	661	626	606	580	523	376	436	319	349	263
	Extra Stg.	.500	1687	1134	1083	1029	978	927	879	850	814	734	527	612	448	490	369
	Schedule 80	.750	2669	1794	1713	1628	1547	1467	1390	1346	1287	1162	834	969	709	776	583
	Schedule 100	.937	3424	2302	2198	2089	1985	1882	1784	1726	1652	1491	1070	1243	909	996	748
16 O. D.	Standard (Sch. 30)	.375	1047	704	672	639	607	576	546	528	505	456	327	380	278	304	229
	Extra Stg. (Sch. 40)	.500	1473	990	945	898	854	809	767	742	710	641	460	535	391	428	322
	Schedule 80	.843	2651	1782	1702	1617	1537	1457	1381	1336	1279	1154	829	962	704	771	579
	Schedule 100	1.031	3308	2224	2124	2018	1918	1818	1724	1668	1596	1440	1034	1201	878	962	723
18 O. D.	Standard	.375	931	626	598	568	540	512	485	470	449	405	291	338	247	271	203
	Extra Stg.	.500	1306	878	838	797	757	718	680	658	630	569	408	474	347	380	285
	Schedule 60	.750	2059	1384	1322	1256	1194	1131	1073	1038	993	896	644	747	547	599	450
	Schedule 100	1.156	3323	2234	2133	2027	1927	1826	1731	1676	1603	1447	1039	1206	882	966	726
20 O. D.	Standard (Sch. 20)	.375	836	562	537	510	485	459	436	422	403	364	261	303	222	243	183
	Extra Stg. (Sch. 30)	.500	1172	788	753	715	680	644	611	591	565	510	366	426	311	341	256
	Schedule 60	.812	2020	1358	1297	1232	1171	1110	1052	1018	974	879	631	733	536	587	441
	Schedule 80	1.031	2624	1764	1685	1601	1521	1442	1367	1323	1266	1142	820	953	697	763	573
24 O. D.	Standard (Sch. 20)	.375	696	468	447	425	404	383	363	351	336	303	218	253	185	202	152
	Extra Stg.	.500	976	656	626	595	566	536	508	492	471	425	305	354	259	284	213
	Schedule 40	.687	1392	936	894	849	807	765	725	702	672	606	435	505	370	405	304
	Schedule 60	.968	2029	1364	1303	1238	1176	1115	1057	1023	979	883	634	737	539	590	443
30 O. D.		.375	556	374	357	339	323	306	290	280	268	242	174	202	148	162	122
	Schedule 20	.500	776	522	499	474	450	427	405	392	375	338	243	282	206	226	170

Refer to pages 247-253 for basis of determining these values and those for other materials. A corrosion allowance of 0.050″ has been assumed. Values are also applicable to Ladish Seamless Welding Fittings.

®Allowable working pressure for Grade A material equals the following percentages of those tabulated for Grade B material: 82.5% at 750°, 81.2% at 700° and 80% at 650° and lower.

®For Division B, Oil Transmission Lines Outside City or Village Limits not exceeding 100° F.

OIL PIPING SYSTEMS WITHIN REFINERY LIMITS
MAXIMUM ALLOWABLE WORKING PRESSURES

Section 3, Division A—ASA B31.1-1951 and ASA B31.1a-1953

TABLE 8 (Continued)

ALLOWABLE WORKING PRESSURES—POUNDS PER SQUARE INCH																					
TEMPERATURES — DEGREES FAHRENHEIT																					
950°			1000°			1050°			1100°			1150°		1200°		1250°	1300°	1350°	1400°	1450°	1500°
Seamless Alloy Steel Pipe Per ASTM Specification A335, Grades P2, P5a and P22																Seamless Stainless Steel Pipe Per ASTM Specification A312, Grade TP316					
P2	P5a	P22	P2	P5a	P22	P2	P5a	P22	P2	P5a	P22	P5a	P22	P5a	P22						
653	653	718	414	483	516	265	344	384	159	218	278	146	199	99	132	351	265	199	156	122	99
1052	1052	1157	672	785	839	430	559	624	258	355	452	237	323	161	215	570	430	323	253	199	161
1962	1962	2158	1276	1491	1593	817	1062	1184	490	674	858	449	613	306	408	1082	817	613	480	378	306
2445	2445	2690	1607	1877	2005	1028	1337	1491	617	848	1080	566	771	386	514	1363	1028	771	604	476	386
607	607	668	384	448	479	246	319	356	147	203	258	135	184	92	123	325	246	184	144	114	92
1042	1042	1146	665	777	830	426	553	617	255	351	447	234	319	160	213	564	426	319	250	197	160
1912	1912	2103	1243	1451	1551	795	1034	1153	477	656	835	437	596	298	398	1054	795	596	467	368	298
2385	2385	2624	1566	1829	1954	1002	1303	1453	601	827	1052	551	752	376	501	1328	1002	752	589	463	376
553	553	608	349	408	436	224	291	324	134	184	235	123	168	84	112	296	224	168	131	103	84
942	942	1036	600	701	749	384	499	557	230	317	403	211	288	144	192	509	384	288	226	178	144
1885	1885	2074	1224	1430	1528	784	1019	1136	470	646	823	431	588	294	392	1038	784	588	460	362	294
1811	1811	1992	1174	1372	1466	752	977	1090	451	620	789	413	564	282	376	996	752	564	442	348	282
515	515	567	326	380	406	208	271	302	125	172	219	115	156	78	104	276	208	156	122	96	78
749	749	824	475	555	593	304	395	441	182	251	319	167	228	114	152	403	304	228	179	141	114
912	912	1003	581	678	725	372	483	539	223	307	390	204	279	139	186	492	372	279	218	172	139
1903	1903	2093	1236	1444	1543	791	1029	1147	475	653	831	435	593	297	396	1048	791	593	465	366	297
446	446	491	281	329	351	180	234	261	108	149	189	99	135	68	90	239	180	135	106	83	68
628	628	691	398	464	496	254	331	369	153	210	267	140	191	95	127	337	254	191	149	118	95
903	903	993	575	672	718	368	478	534	221	304	386	202	276	138	184	488	368	276	216	170	138
1885	1885	2074	1224	1429	1527	783	1018	1136	470	646	822	431	587	294	392	1038	783	587	460	362	294
405	405	446	255	298	318	163	212	237	98	135	171	90	122	61	82	216	163	122	96	75	61
570	570	627	361	421	450	231	300	335	138	190	242	127	173	87	115	306	231	173	136	107	87
905	905	996	576	673	719	369	479	535	221	304	387	203	277	138	184	489	369	277	217	171	138
1164	1164	1280	745	870	930	477	620	691	286	393	501	262	358	179	238	632	477	358	280	221	179
354	354	389	223	260	278	142	185	206	85	117	150	78	107	53	71	189	142	107	84	66	53
497	497	547	314	366	392	201	261	291	120	166	211	110	151	75	100	266	201	151	118	93	75
899	899	989	572	668	714	366	476	531	220	302	384	201	275	137	183	485	366	275	215	169	137
1125	1125	1238	719	840	898	460	599	668	276	380	483	253	345	173	230	610	460	345	270	213	173
314	314	345	198	231	246	126	164	183	76	104	133	70	95	47	63	167	126	95	74	58	47
441	441	485	278	325	347	178	231	258	107	147	187	98	134	67	89	236	178	134	105	82	67
697	697	767	442	516	551	283	368	410	170	233	297	156	212	106	141	375	283	212	166	131	106
1129	1129	1242	722	843	901	462	601	670	277	381	485	254	347	173	231	612	462	347	271	214	173
282	282	310	178	207	222	114	148	165	68	94	119	62	85	43	57	151	114	85	67	53	43
396	396	436	249	291	311	160	207	231	96	132	168	88	120	60	80	211	160	120	94	74	60
684	684	752	433	506	541	277	360	402	166	229	291	152	208	104	139	367	277	208	163	128	104
890	890	979	566	661	707	362	471	525	217	299	381	199	272	136	181	480	362	272	213	168	136
234	234	257	147	172	183	94	122	136	56	78	99	52	71	35	47	125	94	71	55	43	35
329	329	362	207	242	258	132	172	192	79	109	139	73	99	50	66	175	132	99	78	61	50
470	470	517	296	346	370	190	246	275	114	156	199	104	142	71	95	251	190	142	111	88	71
687	687	756	436	509	544	279	362	404	167	230	293	153	209	105	139	369	279	209	164	129	105
187	187	206	118	137	147	75	98	109	45	62	79	41	56	28	38	100	75	56	44	35	28
262	262	288	164	192	205	105	137	153	63	87	110	58	79	39	53	139	105	79	62	49	39

Refer to pages 247-253 for basis of determining these values and those for other materials. A corrosion allowance of 0.050″ has been assumed. Values are also applicable to Ladish Seamless Welding Fittings.

GAS PIPING SYSTEMS WITHIN CITY OR VILLAGE LIMITS

Section 8—ASA B31.1.8-1952

MAXIMUM ALLOWABLE WORKING PRESSURES

TABLE 9

NOMINAL PIPE SIZE	DESIGNATION OF PIPE	WALL THICKNESS	ALLOWABLE WORKING PRESSURES 100° F. ASTM A106 GRADE B	100° F. API 5LX GRADE X42	450° F. ASTM A106 GRADE B	450° F. API 5LX GRADE X42
1/2	Standard (Sch. 40)	.109	2846	3616	2466	3134
	Extra Stg. (Sch. 80)	.147	4744	5907	4111	5119
3/4	Standard (Sch. 40)	.113	2384	3019	2066	2616
	Extra Stg. (Sch. 80)	.154	4005	4972	3471	4309
1	Standard (Sch. 40)	.133	2510	3137	2175	2719
	Extra Stg. (Sch. 80)	.179	3950	4871	3423	4222
1 1/4	Standard (Sch. 40)	.140	2134	2659	1849	2304
	Extra Stg. (Sch. 80)	.191	3366	4143	2917	3590
1 1/2	Standard (Sch. 40)	.145	1949	2424	1689	2101
	Extra Stg. (Sch. 80)	.200	3114	3825	2699	3315
2	Standard (Sch. 40)	.154	1697	2104	1471	1824
	Extra Stg. (Sch. 80)	.218	2774	3399	2404	2946
2 1/2	Standard (Sch. 40)	.203	2064	2535	1789	2197
	Extra Stg. (Sch. 80)	.276	3093	3772	2681	3269
3	Standard (Sch. 40)	.216	1825	2238	1582	1939
	Extra Stg. (Sch. 80)	.300	2793	3399	2421	2946
3 1/2	Standard (Sch. 40)	.226	1691	2069	1465	1793
	Extra Stg. (Sch. 80)	.318	2612	3175	2264	2752
4	Standard (Sch. 40)	.237	1586	1940	1374	1682
	Extra Stg. (Sch. 80)	.337	2472	3004	2142	2603
	Schedule 160	.531	4269	5163	3700	4475
	Double Extra Stg.	.674	5666	6842	4910	5930
5	Standard (Sch. 40)	.258	1426	1741	1236	1509
	Extra Stg. (Sch. 80)	.375	2251	2732	1951	2367
	Schedule 160	.625	4112	4964	3564	4302
	Double Extra Stg.	.750	5084	6134	4406	5316
6	Standard (Sch. 40)	.280	1319	1608	1143	1393
	Extra Stg. (Sch. 80)	.432	2220	2689	1924	2330
	Schedule 160	.718	3998	4823	3465	4180
	Double Extra Stg.	.864	4954	5972	4293	5176
8	Standard (Sch. 40)	.322	1195	1452	1036	1258
	Extra Stg. (Sch. 80)	.500	2001	2422	1734	2099
	Schedule 160	.906	3931	4738	3407	4106
	Double Extra Stg.	.875	3780	4556	3276	3949

NOMINAL PIPE SIZE	DESIGNATION OF PIPE	WALL THICKNESS	ALLOWABLE WORKING PRESSURES 100° F. ASTM A106 GRADE B	100° F. API 5LX GRADE X42	450° F. ASTM A106 GRADE B	450° F. API 5LX GRADE X42
10	Standard (Sch. 40)	.365	1109	1346	961	1166
	Extra Stg. (Sch. 60)	.500	1594	1928	1381	1671
	Schedule 80	.593	1932	2334	1674	2022
	Schedule 160	1.125	3959	4765	3431	4130
12	Standard	.375	960	1164	832	1009
	Extra Strong	.500	1338	1618	1159	1402
	Schedule 80	.687	1909	2303	1654	1996
	Schedule 160	1.312	3914	4712	3392	4084
14 O. D.	Standard (Sch. 30)	.375	872	1058	755	917
	Extra Strong	.500	1216	1469	1054	1273
	Schedule 80	.750	1909	2303	1654	1996
	Schedule 100	.937	2442	2943	2117	2551
16 O. D.	Standard (Sch. 30)	.375	762	925	661	802
	Extra Stg. (Sch. 40)	.500	1061	1283	919	1112
	Schedule 80	.843	1892	2281	1640	1977
	Schedule 100	1.031	2358	2840	2044	2461
18 O. D.	Standard	.375	676	819	586	710
	Extra Strong	.500	941	1137	815	985
	Schedule 60	.750	1472	1777	1276	1540
	Schedule 100	1.156	2365	2848	2049	2468
20 O. D.	Standard (Sch. 20)	.375	607	736	526	638
	Extra Stg. (Sch. 30)	.500	844	1021	732	885
	Schedule 60	.812	1443	1741	1250	1509
	Schedule 80	1.031	1871	2253	1622	1952
22 O. D.		.375	552	670	479	581
		.500	767	927	664	804
		.812	1308	1578	1134	1367
		1.281	2144	2580	1858	2236
24 O. D.	Standard (Sch. 20)	.375	506	612	439	531
	Extra Strong	.500	701	849	608	736
	Schedule 40	.687	998	1202	865	1042
	Schedule 60	.968	1447	1744	1254	1511
26 O. D.		.375	466	564	404	489
		.500	647	784	561	679
		.812	1103	1331	956	1153
		1.281	1804	2170	1563	1880
30 O. D.	Schedule 20	.375	403	489	349	424
	Schedule 30	.500	561	678	486	587
		.625	716	864	621	749
		.750	874	1053	757	913
		1.000	1193	1436	1034	1245

Intermediate values may be obtained by interpolation.
Refer to pages 247-253 for basis of determining these values and those for other materials.
Values are also applicable to Ladish Seamless Welding Fittings.

Pressure-Temperature Ratings for Ladish Forged Steel Pipe Flanges

ASA STANDARD B16.5-1953

On pages 263 through 268 are tabulated pressure-temperature ratings for Ladish Forged Steel Flanges conforming to ASA B16.5-1953. Ratings are given for the eleven carbon and alloy steel material specifications as well as the five stainless steel specifications included in this Standard.

These ratings remain constant throughout all sizes of any one pressure class and gasket facing class. However, reference should be made to codes of regulatory agencies to determine the size, pressure and temperature limitations imposed upon the use of threaded, socket welding and slip-on flanges.

The Class A ratings in these tables apply to:

(a) Ring joint facing.
(b) Small tongue and groove facing used with any type gasket.
(c) Large tongue and groove facing used with any type gasket, except flat solid metal.
(d) Other facings with gaskets which result in no increase in bolt load or flange moment over those resulting from the facing-gasket combinations listed in (a) through (c) above.

The Class B ratings in these tables apply to all other facings and gaskets not covered in Class A.

These ratings are based on the use of bolting material in accordance with the specifications tabulated on page 245. The various flange materials listed on pages 263 through 268 are classified by their ASTM designation on page 243.

All pressures are in pounds per square inch (gage). Temperatures and pressures listed are maximum internal fluid temperatures and pressures at flange.

Hydrostatic tests shall be made with water at a temperature not to exceed 125° F. or as required by applicable codes. Test pressures are manufacturer's shell tests applicable to valves and fittings. Flanges may be tested after attachment to the pressure vessel or piping in accordance with applicable code requirements, in which cases the test pressures may be higher than those given above. In such cases consideration should be given to the gaskets for the blanking-off flanges.

Where welded construction is used, consideration should be given to the possibility of graphite formation in the following steels: Carbon steel above 775° F., Carbon-Molybdenum steel above 875° F., Chrome-Molybdenum steel (with Chromium under 0.6%) above 975° F.

Consideration should be given to the possibility of excessive oxidation (scaling) on the following steels: 1 Cr-½ Mo, 1¼ Cr-½ Mo, 2 Cr-½ Mo, 2¼ Cr-1 Mo and 3 Cr-1 Mo above 1050° F.; and 5 Cr-½ Mo above 1100° F.

In using these ratings the user is cautioned to select gasket materials adequate for the service conditions and the ability of the gasket to resist injurious crushing.

PRIMARY SERVICE PRESSURE RATING		150 lb.		300 lb.		400 lb.		600 lb.		900 lb.		1500 lb.		2500 lb.	
HYDROSTATIC SHELL TEST PRESSURES		425	350	1100	900	1450	1200	2175	1800	3250	2700	5400	4500	9000	7500
FACING AND/OR GASKET CLASS		A	B	A	B	A	B	A	B	A	B	A	B	A	B
SERVICE TEMPERATURES DEGREES F.	MATERIAL	MAXIMUM, NON-SHOCK, SERVICE PRESSURE RATINGS, POUNDS PER SQUARE INCH (GAGE)													
100°	*	275	230	720	600	960	800	1440	1200	2160	1800	3600	3000	6000	5000
150°	*	255	220	710	590	945	785	1420	1180	2130	1770	3550	2950	5915	4915
200°	*	240	210	700	580	930	770	1400	1160	2100	1740	3500	2900	5830	4830
250°	*	225	200	690	570	920	760	1380	1140	2070	1710	3450	2850	5750	4750
300°	*	210	190	680	560	910	740	1365	1120	2050	1680	3415	2800	5690	4660
350°	*	195	180	675	550	900	725	1350	1095	2025	1645	3375	2740	5625	4565
400°	*	180	170	665	540	890	710	1330	1075	2000	1615	3330	2690	5550	4475
450°	*	165	160	650	520	870	695	1305	1040	1955	1560	3255	2600	5430	4335
500°	*	150	150	625	500	835	665	1250	1000	1875	1500	3125	2500	5210	4165
550°	*	140	140	590	475	790	630	1180	950	1775	1420	2955	2370	4925	3950
600°	*	130	130	555	445	740	590	1110	890	1660	1330	2770	2220	4620	3700
650°	*	120	120	515	415	690	550	1030	830	1550	1240	2580	2070	4300	3450
700°	Carbon Steel	110	110	470	380	635	500	940	760	1410	1140	2350	1900	3920	3160
	Carbon Moly	110	110	480	390	640	520	960	775	1440	1165	2400	1945	4000	3240
	½ Cr, ½ Mo	110	110	480	390	640	520	960	775	1440	1165	2400	1945	4000	3240
	1 Cr, ½ Mo	110	110	485	390	645	520	965	775	1450	1165	2415	1945	4025	3240
	1¼ Cr, ½ Mo	110	110	485	390	645	520	965	775	1450	1165	2415	1945	4025	3240
	2 Cr, ½ Mo	110	110	480	390	640	520	960	775	1440	1165	2400	1945	4000	3240
	2¼ Cr, 1 Mo	110	110	485	390	645	520	965	775	1450	1165	2415	1945	4025	3240
	3 Cr, 1 Mo	110	110	480	390	640	520	960	775	1440	1165	2400	1945	4000	3240
	5 Cr, ½ Mo	110	110	485	390	645	520	965	775	1450	1165	2415	1945	4025	3240
	5 Cr, ½ Mo, Si	110	110	480	390	640	520	960	775	1440	1165	2400	1945	4000	3240
	9 Cr, 1 Mo	110	110	485	390	645	520	965	775	1450	1165	2415	1945	4025	3240

* Same ratings apply to all eleven materials that are listed for the 700° group.
The above ratings are all subject to the stipulations made above.

Pressure-Temperature Ratings for Ladish Forged Carbon and Alloy Steel Pipe Flanges

(Continued) ASA STANDARD B16.5-1953

PRIMARY SERVICE PRESSURE RATING		150 lb.		300 lb.		400 lb.		600 lb.		900 lb.		1500 lb.		2500 lb.	
FACING AND/OR GASKET CLASS		A	B	A	B	A	B	A	B	A	B	A	B	A	B
SERVICE TEMPERATURES DEGREES F.	MATERIAL	MAXIMUM, NON-SHOCK, SERVICE PRESSURE RATINGS, POUNDS PER SQUARE INCH (GAGE)													
750°	Carbon Steel	100	100	425	340	575	450	850	680	1275	1020	2125	1700	3550	2830
	Carbon Moly	100	100	445	365	590	485	890	725	1330	1090	2220	1815	3700	3030
	½ Cr, ½ Mo	100	100	445	365	590	485	890	725	1330	1090	2220	1815	3700	3030
	1 Cr, ½ Mo	100	100	450	365	600	485	900	725	1350	1090	2250	1815	3745	3030
	1¼ Cr, ½ Mo	100	100	450	365	600	485	900	725	1350	1090	2250	1815	3745	3030
	2 Cr, ½ Mo	100	100	445	365	590	485	890	725	1330	1090	2220	1815	3700	3030
	2¼ Cr, 1 Mo	100	100	450	365	600	485	900	725	1350	1090	2250	1815	3745	3030
	3 Cr, 1 Mo	100	100	445	365	590	485	890	725	1330	1090	2220	1815	3700	3030
	5 Cr, ½ Mo	100	100	450	365	600	485	900	725	1350	1090	2250	1815	3745	3030
	5 Cr, ½ Mo, Si	100	100	445	365	590	485	890	725	1330	1090	2220	1815	3700	3030
	9 Cr, 1 Mo	100	100	450	365	600	485	900	725	1350	1090	2250	1815	3745	3030
800°	Carbon Steel	92	92	365	300	490	400	730	600	1100	900	1830	1500	3050	2500
	Carbon Moly	92	92	410	340	545	450	815	675	1225	1015	2040	1690	3400	2815
	½ Cr, ½ Mo	92	92	410	340	545	450	815	675	1225	1015	2040	1690	3400	2815
	1 Cr, ½ Mo	92	92	415	340	555	450	835	675	1250	1015	2080	1690	3470	2815
	1¼ Cr, ½ Mo	92	92	415	340	555	450	835	675	1250	1015	2080	1690	3470	2815
	2 Cr, ½ Mo	92	92	410	340	545	450	815	675	1225	1015	2040	1690	3400	2815
	2¼ Cr, 1 Mo	92	92	415	340	555	450	835	675	1250	1015	2080	1690	3470	2815
	3 Cr, 1 Mo	92	92	410	340	545	450	815	675	1225	1015	2040	1690	3400	2815
	5 Cr, ½ Mo	92	92	415	340	555	450	835	675	1250	1015	2080	1690	3470	2815
	5 Cr, ½ Mo, Si	92	92	410	340	545	450	815	675	1225	1015	2040	1690	3400	2815
	9 Cr, 1 Mo	92	92	415	340	555	450	835	675	1250	1015	2080	1690	3470	2815
850°	Carbon Steel†	82	82	300	245	400	330	600	490	900	740	1500	1230	2500	2050
	Carbon Moly	82	82	370	315	495	415	745	625	1115	940	1860	1565	3100	2605
	½ Cr, ½ Mo	82	82	370	315	495	415	745	625	1115	940	1860	1565	3100	2605
	1 Cr, ½ Mo	82	82	385	315	510	415	765	625	1150	940	1915	1565	3190	2605
	1¼ Cr, ½ Mo	82	82	385	315	510	415	765	625	1150	940	1915	1565	3190	2605
	2 Cr, ½ Mo	82	82	370	315	495	415	745	625	1115	940	1860	1565	3100	2605
	2¼ Cr, 1 Mo	82	82	385	315	510	415	765	625	1150	940	1915	1565	3190	2605
	3 Cr, 1 Mo	82	82	370	315	495	415	745	625	1115	940	1860	1565	3100	2605
	5 Cr, ½ Mo	82	82	385	315	510	415	765	625	1150	940	1915	1565	3190	2605
	5 Cr, ½ Mo, Si	82	82	370	315	495	415	745	625	1115	940	1860	1565	3100	2605
	9 Cr, 1 Mo	82	82	385	315	510	415	765	625	1150	940	1915	1565	3190	2605
875°	Carbon Steel†	75	75	260	235	350	315	525	470	785	705	1305	1170	2180	1955
	Carbon Moly†	75	75	355	300	470	400	710	600	1060	900	1770	1500	2950	2500
	½ Cr, ½ Mo	75	75	355	300	470	400	710	600	1060	900	1770	1500	2950	2500
	1 Cr, ½ Mo	75	75	365	300	490	400	735	600	1100	900	1830	1500	3055	2500
	1¼ Cr, ½ Mo	75	75	365	300	490	400	735	600	1100	900	1830	1500	3055	2500
	2 Cr, ½ Mo	75	75	355	300	470	400	710	600	1060	900	1770	1500	2950	2500
	2¼ Cr, 1 Mo	75	75	365	300	490	400	735	600	1100	900	1830	1500	3055	2500
	3 Cr, 1 Mo	75	75	355	300	470	400	710	600	1060	900	1770	1500	2950	2500
	5 Cr, ½ Mo	75	75	365	300	490	400	735	600	1100	900	1830	1500	3055	2500
	5 Cr, ½ Mo, Si	75	75	355	300	470	400	710	600	1060	900	1770	1500	2950	2500
	9 Cr, 1 Mo	75	75	365	300	490	400	735	600	1100	900	1830	1500	3055	2500
900°	Carbon Steel†	70	70	225	225	295	295	445	445	670	670	1115	1115	1855	1855
	Carbon Moly†	70	70	335	280	450	375	670	560	1010	840	1680	1400	2800	2335
	½ Cr, ½ Mo	70	70	335	280	450	375	670	560	1010	840	1680	1400	2800	2335
	1 Cr, ½ Mo	70	70	350	290	465	390	700	585	1050	875	1750	1460	2915	2430
	1¼ Cr, ½ Mo	70	70	350	290	465	390	700	585	1050	875	1750	1460	2915	2430
	2 Cr, ½ Mo	70	70	335	280	450	375	670	560	1010	840	1680	1400	2800	2335
	2¼ Cr, 1 Mo	70	70	350	290	465	390	700	585	1050	875	1750	1460	2915	2430
	3 Cr, 1 Mo	70	70	335	280	450	375	670	560	1010	840	1680	1400	2800	2335
	5 Cr, ½ Mo	70	70	350	290	465	390	700	585	1050	875	1750	1460	2915	2430
	5 Cr, ½ Mo, Si	70	70	335	280	450	375	670	560	1010	840	1680	1400	2800	2335
	9 Cr, 1 Mo	70	70	350	290	465	390	700	585	1050	875	1750	1460	2915	2430

The above ratings are all subject to the stipulations on page 263.

† Product used within the jurisdiction of Section 1 Power Boilers of the ASME Boiler and Pressure Vessel Code is subject to the same maximum temperature limitations placed upon the material in Table P7, 1952 edition thereof.

Pressure-Temperature Ratings for Ladish Forged Carbon and Alloy Steel Pipe Flanges

(Continued)

ASA STANDARD B16.5-1953

PRIMARY SERVICE PRESSURE RATING		150 lb.		300 lb.		400 lb.		600 lb.		900 lb.		1500 lb.		2500 lb.	
FACING AND/OR GASKET CLASS		A	B	A	B	A	B	A	B	A	B	A	B	A	B
SERVICE TEMPERATURES DEGREES F.	MATERIAL	MAXIMUM, NON-SHOCK, SERVICE PRESSURE RATINGS, POUNDS PER SQUARE INCH (GAGE)													
925°	Carbon Steel†‡	60	60	190	190	250	250	375	375	565	565	945	945	1570	1570
	Carbon Moly†‡	60	60	320	265	425	355	635	530	955	795	1590	1325	2650	2210
	½ Cr, ½ Mo	60	60	320	265	425	355	635	530	955	795	1590	1325	2650	2210
	1 Cr, ½ Mo	60	60	335	280	445	370	665	555	1000	835	1665	1390	2775	2315
	1¼ Cr, ½ Mo	60	60	335	280	445	370	665	555	1000	835	1665	1390	2775	2315
	2 Cr, ½ Mo	60	60	320	265	425	355	635	530	955	795	1590	1325	2650	2210
	2¼ Cr, 1 Mo	60	60	335	280	445	370	665	555	1000	835	1665	1390	2775	2315
	3 Cr, 1 Mo	60	60	320	265	425	355	635	530	955	795	1590	1325	2650	2210
	5 Cr, ½ Mo	60	60	335	280	445	370	665	555	1000	835	1665	1390	2775	2315
	5 Cr, ½ Mo, Si	60	60	320	265	425	355	635	530	955	795	1590	1325	2650	2210
	9 Cr, 1 Mo	60	60	335	280	445	370	665	555	1000	835	1665	1390	2775	2315
950°	Carbon Steel†‡	55	55	155	155	205	205	310	310	465	465	770	770	1285	1285
	Carbon Moly†‡	55	55	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	½ Cr, ½ Mo	55	55	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	1 Cr, ½ Mo	55	55	315	265	420	350	635	530	950	790	1585	1320	2640	2200
	1¼ Cr, ½ Mo	55	55	315	265	420	350	635	530	950	790	1585	1320	2640	2200
	2 Cr, ½ Mo	55	55	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	2¼ Cr, 1 Mo	55	55	315	265	420	350	635	530	950	790	1585	1320	2640	2200
	3 Cr, 1 Mo	55	55	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	5 Cr, ½ Mo	55	55	315	265	420	350	635	530	950	790	1585	1320	2640	2200
	5 Cr, ½ Mo, Si	55	55	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	9 Cr, 1 Mo	55	55	315	265	420	350	635	530	950	790	1585	1320	2640	2200
975°	Carbon Steel†‡	50	50	120	120	160	160	240	240	360	360	600	600	1000	1000
	Carbon Moly†‡	50	50	280	230	370	310	555	465	835	695	1395	1160	2320	1935
	½ Cr, ½ Mo	50	50	280	230	370	310	555	465	835	695	1395	1160	2320	1935
	1 Cr, ½ Mo	50	50	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	1¼ Cr, ½ Mo	50	50	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	2 Cr, ½ Mo	50	50	280	230	370	310	555	465	835	695	1390	1155	2315	1930
	2¼ Cr, 1 Mo	50	50	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	3 Cr, 1 Mo	50	50	275	230	365	305	550	455	825	685	1370	1145	2285	1905
	5 Cr, ½ Mo	50	50	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	5 Cr, ½ Mo, Si	50	50	250	205	330	275	495	415	745	620	1245	1035	2070	1725
	9 Cr, 1 Mo	50	50	300	250	400	335	600	500	900	750	1500	1250	2500	2085
1000°	Carbon Steel†‡	40	40	85	85	115	115	170	170	255	255	430	430	715	715
	Carbon Moly†‡	40	40	215	180	285	240	430	355	645	535	1070	895	1785	1490
	½ Cr, ½ Mo	40	40	215	180	285	240	430	355	645	535	1070	895	1785	1490
	1 Cr, ½ Mo	40	40	255	215	345	285	515	430	770	645	1285	1070	2145	1785
	1¼ Cr, ½ Mo	40	40	265	225	355	295	535	445	800	670	1335	1115	2230	1855
	2 Cr, ½ Mo	40	40	215	175	285	235	425	355	635	530	1065	885	1770	1475
	2¼ Cr, 1 Mo	40	40	265	225	355	295	535	445	800	670	1335	1115	2230	1855
	3 Cr, 1 Mo	40	40	240	200	320	265	480	400	720	600	1200	1000	2000	1665
	5 Cr, ½ Mo	40	40	250	210	335	280	500	415	750	625	1250	1045	2085	1740
	5 Cr, ½ Mo, Si	40	40	190	155	250	210	375	315	565	470	945	785	1570	1310
	9 Cr, 1 Mo	40	40	290	245	390	325	585	485	875	730	1455	1215	2430	2025
1025°	1 Cr, ½ Mo			215	180	285	240	430	355	645	535	1070	895	1785	1490
	1¼ Cr, ½ Mo†			230	190	305	255	455	380	685	570	1140	950	1900	1585
	2 Cr, ½ Mo			180	150	240	200	355	295	535	445	890	745	1485	1240
	2¼ Cr, 1 Mo			235	195	310	260	465	390	700	585	1165	970	1945	1620
	3 Cr, 1 Mo			215	180	285	240	430	355	645	535	1070	895	1785	1490
	5 Cr, ½ Mo			215	180	285	240	430	355	645	535	1070	895	1785	1490
	5 Cr, ½ Mo, Si			155	130	205	170	310	255	465	385	770	645	1285	1070
	9 Cr, 1 Mo			240	200	320	265	480	400	720	600	1200	1000	2000	1665

The above ratings are all subject to the stipulations on page 263.

† Product used within the jurisdiction of Section 1 Power Boilers of the ASME Boiler and Pressure Vessel Code is subject to the same maximum temperature limitations placed upon the material in Table P7, 1952 edition thereof.

‡ Product used within the jurisdiction of Section 1 Power Piping of the ASA Code for Pressure Piping B31.1 is subject to the same maximum temperature limitations placed upon piping of the same general compositions in Table 3a, Supplement No. 1 to the 1951 edition of ASA B31.1.

Pressure-Temperature Ratings for Ladish Forged Carbon and Alloy Steel Pipe Flanges

(Continued) ASA STANDARD B16.5-1953

PRIMARY SERVICE PRESSURE RATING		150 lb.		300 lb.		400 lb.		600 lb.		900 lb.		1500 lb.		2500 lb.	
FACING AND/OR GASKET CLASS		A	B	A	B	A	B	A	B	A	B	A	B	A	B
SERVICE TEMPERATURES DEGREES F.	MATERIAL	MAXIMUM, NON-SHOCK, SERVICE PRESSURE RATINGS, POUNDS PER SQUARE INCH (GAGE)													
1050°	1 Cr, ½ Mo			170	145	230	190	345	285	515	430	855	715	1430	1190
	1¼ Cr, ½ Mo†			190	155	250	210	375	315	565	470	945	785	1570	1310
	2 Cr, ½ Mo			145	120	190	160	290	240	430	360	720	600	1200	1000
	2¼ Cr, 1 Mo			200	165	265	220	400	330	595	495	995	830	1655	1380
	3 Cr, 1 Mo			190	155	250	210	375	315	565	470	945	785	1570	1310
	5 Cr, ½ Mo			180	150	240	200	355	295	535	445	890	745	1485	1240
	5 Cr, ½ Mo, Si			120	100	160	135	240	200	360	300	600	500	1000	835
	9 Cr, 1 Mo			190	155	250	210	375	315	565	470	945	785	1570	1310
1075°	1 Cr, ½ Mo			135	110	160	150	265	225	400	335	670	555	1115	930
	1¼ Cr, ½ Mo†			165	135	215	180	325	270	490	405	815	680	1355	1130
	2 Cr, ½ Mo			120	100	160	130	240	200	355	300	595	495	995	825
	2¼ Cr, 1 Mo†			170	145	230	190	345	285	515	430	855	715	1430	1190
	3 Cr, 1 Mo			165	135	215	180	325	270	490	405	815	680	1355	1130
	5 Cr, ½ Mo			145	120	195	160	290	245	435	365	730	605	1215	1010
	5 Cr, ½ Mo, Si			105	85	135	115	205	170	310	257	515	430	855	715
	9 Cr, 1 Mo			150	125	200	170	300	250	455	375	755	630	1255	1050
1100°	1 Cr, ½ Mo			95	80	130	105	190	160	290	240	480	400	800	665
	1¼ Cr, ½ Mo†			135	115	185	150	275	230	410	345	685	570	1145	950
	2 Cr, ½ Mo			95	80	125	105	190	155	285	235	470	395	785	655
	2¼ Cr, 1 Mo†			145	120	190	160	290	240	430	360	720	600	1200	1000
	3 Cr, 1 Mo			135	115	185	150	275	230	410	345	685	570	1145	950
	5 Cr, ½ Mo			115	95	150	125	225	190	340	285	565	470	945	785
	5 Cr, ½ Mo, Si			85	70	115	95	170	145	255	215	430	355	715	595
	9 Cr, 1 Mo			115	95	150	125	225	190	340	285	565	470	945	785
1125°	1 Cr, ½ Mo†‡			75	60	100	85	150	125	225	185	375	310	620	520
	1¼ Cr, ½ Mo†‡			110	95	150	125	225	185	335	280	555	465	930	775
	2 Cr, ½ Mo			75	65	105	85	155	130	230	195	385	320	645	535
	2¼ Cr, 1 Mo†			125	105	165	135	245	205	370	310	615	515	1030	855
	3 Cr, 1 Mo			115	95	155	130	230	190	345	285	575	480	955	800
	5 Cr, ½ Mo			95	80	125	105	190	155	285	235	470	395	785	655
	5 Cr, ½ Mo, Si			75	60	100	80	145	125	220	185	370	305	615	510
	9 Cr, 1 Mo			95	80	125	105	190	155	285	235	470	395	785	655
1150°	1 Cr, ½ Mo†‡			55	45	70	60	105	90	160	135	265	220	445	370
	1¼ Cr, ½ Mo†‡			85	70	115	95	170	145	255	215	430	355	715	595
	2 Cr, ½ Mo			60	50	80	65	120	100	180	150	300	250	500	415
	2¼ Cr, 1 Mo†			105	85	135	115	205	170	310	255	515	430	855	715
	3 Cr, 1 Mo			95	75	125	105	185	155	280	230	465	385	770	645
	5 Cr, ½ Mo			75	65	100	85	150	125	225	190	375	315	630	525
	5 Cr, ½ Mo, Si			60	50	80	70	125	105	185	155	310	255	515	430
	9 Cr, 1 Mo			75	65	100	85	150	125	225	190	375	315	630	525
1175°	1 Cr, ½ Mo †‡			45	35	60	50	85	75	130	110	220	180	365	305
	1¼ Cr, ½ Mo†‡			65	55	85	70	125	105	190	160	315	265	530	440
	2 Cr, ½ Mo			50	40	65	55	100	85	150	125	255	210	420	350
	2¼ Cr, 1 Mo†‡			85	70	115	95	170	145	255	215	430	355	715	595
	3 Cr, 1 Mo‡			70	60	95	80	145	120	215	180	360	300	600	500
	5 Cr, ½ Mo			65	55	85	70	125	105	190	160	315	265	530	440
	5 Cr, ½ Mo, Si			50	45	70	55	105	85	155	130	255	215	430	355
	9 Cr, 1 Mo			65	55	85	70	125	105	190	160	315	265	530	440
1200°	1 Cr, ½ Mo†‡			35	30	45	40	70	55	105	85	170	145	285	240
	1¼ Cr, ½ Mo†‡			40	35	55	45	80	70	125	105	205	170	345	285
	2 Cr, ½ Mo			40	35	55	45	80	70	125	105	205	170	345	285
	2¼ Cr, 1 Mo†‡			70	55	90	75	135	115	205	170	345	285	570	475
	3 Cr, 1 Mo‡			50	45	70	55	105	85	155	130	255	215	430	355
	5 Cr, ½ Mo			50	45	70	55	105	85	155	130	255	215	430	355
	5 Cr, ½ Mo, Si			40	35	55	45	80	70	125	105	205	170	345	285
	9 Cr, 1 Mo			50	45	70	55	105	85	155	130	255	215	430	355

The above ratings are all subject to the stipulations on page 263.

† Product used within the jurisdiction of Section 1 Power Boilers of the ASME Boiler and Pressure Vessel Code is subject to the same maximum temperature limitations placed upon the material in Table P7, 1952 edition thereof.

‡ Product used within the jurisdiction of Section 1 Power Piping of the ASA Code for Pressure Piping B31.1 is subject to the same maximum temperature limitations placed upon piping of the same general compositions in Table 3a, Supplement No. 1 to the 1951 edition of ASA B31.1.

Pressure-Temperature Ratings for Ladish Forged Stainless Steel Pipe Flanges

ASA STANDARD B16.5-1953

PRIMARY SERVICE PRESSURE RATING		150 lb.		300 lb.		400 lb.		600 lb.		900 lb.		1500 lb.		2500 lb.	
HYDROSTATIC SHELL TEST PRESSURES	TYPE 304 ONLY	425	350	925	775	1250	1050	1875	1550	2775	2325	4650	3875	7725	6450
	TYPES 347, 321, 316, 310	425	350	1100	900	1450	1200	2175	1800	3250	2700	5400	4500	9000	7500
FACING AND/OR GASKET CLASS		A	B	A	B	A	B	A	B	A	B	A	B	A	B
SERVICE TEMPERATURES DEGREES F.	MATERIAL	MAXIMUM, NON-SHOCK, SERVICE PRESSURE RATINGS, POUNDS PER SQUARE INCH (GAGE)													
100°	304	275	230	615	515	825	685	1235	1030	1850	1545	3085	2570	5145	4285
	347, 321, 316, 310	275	230	720	600	960	800	1440	1200	2160	1800	3600	3000	6000	5000
200°	304	240	210	550	455	730	610	1095	915	1645	1370	2740	2285	4565	3805
	347, 321, 316, 310	240	210	700	580	930	770	1400	1160	2100	1740	3500	2900	5830	4830
300°	304	210	190	495	410	660	550	985	825	1480	1235	2470	2055	4115	3430
	347, 321, 316, 310	210	190	680	560	910	740	1365	1120	2050	1680	3415	2800	5690	4660
400°	304	180	170	450	375	600	500	900	750	1350	1125	2245	1870	3745	3120
	347, 321, 316, 310	180	170	665	540	890	710	1330	1075	2000	1615	3330	2690	5550	4475
500°	304	150	150	410	345	550	455	825	685	1235	1030	2055	1715	3430	2855
	347, 321, 316, 310	150	150	625	500	835	665	1250	1000	1875	1500	3125	2500	5210	4165
600°	304	130	130	380	320	510	425	765	635	1145	955	1910	1590	3180	2650
	347, 321, 316, 310	130	130	555	445	740	590	1110	890	1660	1330	2770	2220	4620	3700
650°	304	120	120	370	305	490	410	735	615	1105	920	1845	1535	3070	2560
	347, 321, 316, 310	120	120	515	415	690	550	1030	830	1550	1240	2580	2070	4300	3450
700°	304	110	110	355	300	475	400	710	600	1065	900	1775	1500	2960	2500
	347, 321, 316	110	110	495	400	660	530	985	795	1480	1195	2465	1990	4110	3315
	310	110	110	490	395	655	525	980	790	1470	1185	2455	1975	4090	3290
750°	304	100	100	340	285	455	380	685	570	1025	855	1710	1425	2850	2375
	347, 321, 316	100	100	470	380	625	510	940	765	1410	1145	2355	1910	3920	3185
	310	100	100	465	375	620	500	930	750	1395	1130	2325	1880	3875	3135
800°	304	92	92	330	275	440	365	660	550	985	825	1645	1370	2745	2285
	347, 321, 316	92	92	450	365	595	485	895	730	1345	1095	2240	1825	3730	3045
	310	92	92	440	355	585	475	880	715	1320	1070	2200	1785	3665	2975
850°	304	82	82	320	265	425	355	640	530	960	800	1595	1330	2660	2215
	347, 321, 316	82	82	425	350	565	465	850	700	1275	1045	2125	1745	3540	2905
	310	82	82	415	340	550	450	830	675	1245	1015	2070	1690	3455	2815
900°	304	70	70	310	260	415	345	620	515	930	775	1545	1290	2580	2150
	347, 321, 316	70	70	400	335	535	445	805	665	1205	1000	2010	1665	3350	2770
	310	70	70	390	320	520	425	780	640	1165	955	1945	1595	3240	2660
925°	304	60	60	305	255	410	345	615	510	920	770	1535	1280	2560	2130
	347, 321, 316	60	60	390	325	520	435	780	650	1175	975	1955	1620	3260	2705
	310	60	60	375	310	500	415	755	620	1130	930	1880	1550	3135	2580
950°	304	55	55	305	255	405	340	610	510	915	760	1525	1270	2540	2115
	347, 321, 316	55	55	380	315	505	420	760	635	1140	950	1900	1580	3165	2635
	310	55	55	365	300	485	400	725	600	1090	900	1820	1500	3030	2500
975°	304	50	50	300	250	405	335	605	505	905	755	1510	1260	2520	2100
	347, 321, 316	50	50	370	310	490	410	735	615	1105	925	1840	1540	3070	2565
	310	50	50	350	290	470	390	700	585	1050	875	1755	1460	2925	2435
1000°	304	40	40	300	250	400	335	600	500	900	750	1500	1250	2500	2085
	347, 321, 316	40	40	355	300	475	400	715	600	1070	900	1785	1500	2975	2500
	310	40	40	340	280	450	375	675	565	1015	845	1690	1410	2820	2350
1025°	304			295	245	395	330	595	495	890	740	1485	1235	2470	2060
	347, 321, 316			345	290	460	385	690	575	1035	865	1725	1440	2880	2400
	310			325	270	435	360	650	540	975	815	1625	1355	2710	2260
1050°	304			290	245	390	325	585	485	875	730	1455	1215	2430	2025
	347, 321, 316			335	280	445	370	670	555	1000	835	1670	1390	2785	2320
	310			315	260	415	345	625	520	940	780	1565	1305	2605	2170
1075°	304			275	230	365	305	550	455	825	685	1370	1145	2285	1905
	347, 321, 316			325	270	430	360	645	540	970	805	1615	1345	2690	2240
	310			300	250	400	335	600	500	900	750	1500	1250	2500	2085
1100°	304			255	215	345	285	515	430	770	645	1285	1070	2145	1785
	347, 321, 316			310	260	415	345	625	520	935	780	1555	1295	2595	2160
	310			290	245	390	325	585	485	875	730	1455	1215	2430	2025
1125°	304			225	190	305	250	455	380	680	570	1135	945	1895	1575
	347, 321, 316			300	250	400	335	600	500	900	750	1500	1250	2500	2085
	310			270	225	360	300	540	450	810	675	1350	1125	2250	1875

The above ratings are all subject to the stipulations on page 263.

Pressure-Temperature Ratings for Ladish Forged Stainless Steel Pipe Flanges

(Continued) ASA STANDARD B16.5-1953

PRIMARY SERVICE PRESSURE RATING		150 lb.		300 lb.		400 lb.		600 lb.		900 lb.		1500 lb.		2500 lb.	
FACING AND/OR GASKET CLASS		A	B	A	B	A	B	A	B	A	B	A	B	A	B
SERVICE TEMPERATURES DEGREES F.	MATERIAL	MAXIMUM, NON-SHOCK, SERVICE PRESSURE RATINGS, POUNDS PER SQUARE INCH (GAGE)													
1150°	304			195	165	265	220	395	330	590	495	985	820	1645	1370
	347, 321			260	215	345	290	520	435	780	650	1305	1085	2170	1810
	316			290	245	390	325	585	485	875	730	1455	1215	2430	2025
	310			250	205	330	275	495	415	745	620	1245	1035	2070	1725
1175°	304			175	145	235	195	350	295	525	440	880	730	1465	1220
	347, 321			215	180	290	240	430	360	650	540	1080	900	1800	1500
	316			260	220	350	290	525	435	785	655	1310	1095	2185	1820
	310			225	190	305	250	455	380	680	570	1135	945	1895	1575
1200°	304			155	130	205	170	310	255	465	385	770	645	1285	1070
	347, 321			170	145	230	190	345	285	515	430	855	715	1430	1190
	316			235	195	310	260	465	390	700	585	1165	970	1945	1620
	310			205	170	275	230	410	345	615	515	1030	855	1715	1430
1225°	304			135	110	175	150	265	220	400	330	665	555	1105	925
	347, 321			140	120	190	160	285	235	425	355	710	595	1185	990
	316			205	175	275	230	415	345	620	520	1035	865	1730	1440
	310			185	155	245	205	370	305	555	460	920	770	1535	1280
1250°	304			110	95	150	125	225	185	335	280	555	465	930	775
	347, 321			115	95	150	125	225	190	340	285	565	470	945	785
	316			180	150	240	200	365	305	545	455	910	755	1515	1260
	310			165	135	215	180	325	270	490	405	815	680	1355	1130
1275°	304			100	80	130	110	195	165	295	245	490	405	815	680
	347, 321			95	80	125	105	190	155	285	235	470	395	785	655
	316			160	135	215	175	320	265	480	400	795	665	1330	1105
	310			140	120	190	155	285	235	425	355	705	590	1180	980
1300°	304			85	70	110	95	170	140	250	210	420	350	700	585
	347, 321			75	65	100	85	150	125	225	190	375	315	630	525
	316			135	115	185	150	275	230	410	345	685	570	1145	950
	310			120	100	160	135	240	200	360	300	600	500	1000	835
1325°	304			75	60	95	80	145	120	220	180	365	305	605	505
	347, 321			65	55	85	70	125	105	190	160	315	265	530	440
	316			115	95	155	130	230	190	345	285	575	480	955	800
	310			100	85	135	110	200	165	300	250	500	420	835	695
1350°	304			60	50	80	70	125	105	185	155	310	255	515	430
	347, 321			50	45	70	55	105	85	155	130	255	215	430	355
	316			95	75	125	105	185	155	280	230	465	385	770	645
	310			80	65	105	90	160	135	240	200	405	335	670	560
1375°	304			55	45	75	60	110	90	165	135	275	230	455	380
	347, 321			45	40	60	50	95	75	140	115	230	195	385	320
	316			80	65	105	90	160	135	240	200	405	335	670	560
	310			70	55	90	75	135	115	205	170	340	280	565	470
1400°	304			50	40	65	55	95	80	145	120	240	200	400	335
	347, 321			40	35	55	45	80	70	125	105	205	170	345	285
	316			70	55	90	75	135	115	205	170	345	285	570	475
	310			55	45	75	60	110	90	165	135	275	230	455	380
1425°	304			40	35	55	45	80	70	125	105	205	170	345	285
	347, 321			35	30	50	40	70	60	110	90	180	150	300	250
	316			60	50	80	65	120	100	180	150	300	250	500	415
	310			45	40	60	50	95	75	140	115	230	195	385	320
1450°	304			35	30	45	40	70	55	105	85	170	145	285	240
	347, 321			30	25	40	35	60	50	95	75	155	130	255	215
	316			50	45	70	55	105	85	155	130	255	215	430	355
	310			40	30	50	40	75	65	115	95	190	155	315	260
1475°	304			30	25	40	35	60	50	90	75	150	125	250	210
	347, 321			30	25	40	30	55	45	85	70	140	120	235	195
	316			45	35	55	50	85	70	130	105	215	180	355	300
	310			30	25	40	35	65	55	95	80	160	130	265	220
1500°	304			25	20	35	30	50	45	75	65	130	105	215	180
	347, 321			25	20	35	30	50	45	75	65	130	105	215	180
	316			35	30	45	40	70	55	105	85	170	145	285	240
	310			25	20	35	30	50	45	75	65	130	105	215	180

The above ratings are all subject to the stipulations on page 263.

PRESSURE-TEMPERATURE SERVICE RATINGS

For Forged Steel Screwed and Socket Welding Fittings

For Steam, Water, Oil, Oil Vapor, Gas or Air

MATERIAL	TEMPERATURE DEGREES FAHRENHEIT	NOMINAL PRESSURE RATING P.S.I.			
		2000 LB.	3000 LB.	4000 LB.*	6000 LB.
		NON-SHOCK WORKING PRESSURE-LBS. PER SQUARE INCH.			
CARBON STEEL FITTINGS	100° F.	2000	3000	4000	6000
	150° F.	1980	2960	3960	5915
	200° F.	1950	2920	3890	5830
	250° F.	1920	2880	3840	5750
	300° F.	1900	2840	3800	5690
	350° F.	1880	2820	3760	5625
	400° F.	1850	2780	3700	5550
	450° F.	1810	2715	3620	5430
	500° F.	1740	2600	3480	5210
	550° F.	1640	2460	3290	4925
	600° F.	1550	2310	3090	4620
	650° F.	1440	2150	2880	4300
	700° F.	1320	1960	2620	3920
	750° F.	1190	1775	2370	3550
	800° F.	1020	1525	2040	3050
	850° F.	835	1250	1670	2500
	900° F.	620	925	1235	1855
	950° F.	425	640	850	1285
	1000° F.	235	355	475	715

MATERIAL	TEMPERATURE DEGREES FAHRENHEIT	NOMINAL PRESSURE RATING P.S.I.			
		2000 LB.	3000 LB.	4000 LB.*	6000 LB.
		NON-SHOCK WORKING PRESSURE-LBS. PER SQUARE INCH.			
1% CHROMIUM ½% MOLYBDENUM STEEL FITTINGS	100° F.	2000	3000	4000	6000
	150° F.	1980	2960	3960	5915
	200° F.	1950	2920	3890	5830
	250° F.	1920	2880	3840	5750
	300° F.	1900	2840	3800	5690
	350° F.	1880	2820	3760	5625
	400° F.	1850	2780	3700	5550
	450° F.	1810	2715	3620	5430
	500° F.	1740	2600	3480	5210
	550° F.	1640	2460	3290	4925
	600° F.	1550	2310	3090	4620
	650° F.	1440	2150	2880	4300
	700° F.	1340	2010	2680	4025
	750° F.	1245	1870	2490	3745
	800° F.	1155	1735	2310	3470
	850° F.	1060	1595	2125	3190
	900° F.	970	1455	1940	2915
	950° F.	880	1320	1760	2640
	1000° F.	715	1070	1430	2145

*Applies only to Socket Welding Fittings.

Carbon Steel Forgings: ASTM specification A105, Grade II.

1% Chromium, ½% Molybdenum forgings: ASTM specification A182, Grade F-12.

When so desired by the user for specific applications, the 2000, 3000 and 4000 pound Socket Welding Fittings can be rated the same as Schedules 40, 80 and 160 pipe, respectively, of the same or equivalent material in accordance with the rules established in the various sections of the Code for Pressure Piping (ASA B31.1).

Table of PROPERTIES of PIPE

$$I = 0.04909\,(D^4 - d^4) = AR^2$$
$$Z = I/y = 0.0982\,(D^4 - d^4)/D$$
$$R = 0.25\,\sqrt{D^2 + d^2}$$
$$M_r = 2.25\,I/y = 4.5\,I/D$$
$$Q = 3.125\,aV$$

In the tables on this and the following six pages are included complete listings of the physical characteristics of pipe in the most common sizes. Schedule numbers and weight designations are in agreement with ASA B36.10-1950 dimensions for carbon and alloy steel pipe and ASA B36.19-1952 for stainless steel pipe.

The information given in these tables will be found very helpful in solving problems relative to the support and anchorage of piping systems. Heat losses and insulating requirements can be readily determined from the data to be found in these tables.

The values listed in these tables of Properties of Pipe are computed by the formulas shown above where:

I = Moment of inertia of pipe section, inches fourth.
Z = Section modulus, inches cube.
R = Radius of gyration, inches.
M_r = Strength factor, representing the strength of the pipe to resist bending action. It is the resisting moment in thousands of foot pounds, the stress in the material being 27,000 pounds per square inch. For other stresses the resisting moment is directly proportional.
Q = Flow in U.S. gallons per minute at a mean velocity, V, of 10 feet per second.
D = Outside diameter of pipe, inches.
d = Inside diameter of pipe, inches.
A = Area of metal, square inches.
a = Transverse area, square inches.
y = Distance of farthest fibre from neutral axis = D/2, inches.

NOMINAL PIPE SIZE	SCHEDULE NO. CARBON & ALLOY STEELS	SCHEDULE NO. STAINLESS STEELS	WEIGHT DESIGNATION	OUTSIDE DIAM. in. D	INSIDE DIAM. in. d	WALL THICKNESS in.	WEIGHT PER FOOT lb./ft.	WT. OF WATER PER FT. PIPE lb./ft.	SQ. FT. OUTSIDE SURFACE PER FOOT	SQ. FT. INSIDE SURFACE PER FOOT	TRANSVERSE AREA in.² a	AREA OF METAL in.² A	MOMENT OF INERTIA in.⁴ I	SECTION MODULUS in.³ Z	RADIUS OF GYRATION in. R	STRENGTH FACTOR 1000 ft.-lbs. Mr	FLOW G. P. M. Q
1/8	...	10S	....	.405	.307	.049	.186	.0320	.106	.0804	.0740	.0548	.00090	.00440	.1270	.00980	2.313
	40	40S	Std.	.405	.269	.068	.244	.0246	.106	.0705	.0568	.0720	.00106	.00530	.1215	.01182	1.775
	80	80S	X-Stg.	.405	.215	.095	.314	.0157	.106	.0563	.0364	.0925	.00122	.00600	.1146	.01351	1.138
1/4	...	10S	....	.540	.410	.065	.330	.0570	.141	.1073	.1320	.0970	.00280	.01030	.1695	.02320	4.125
	40	40S	Std.	.540	.364	.088	.424	.0451	.141	.0955	.1041	.1250	.00331	.01230	.1628	.02760	3.253
	80	80S	X-Stg.	.540	.302	.119	.535	.0310	.141	.0794	.0716	.1574	.00378	.01395	.1547	.03138	2.238
3/8	...	10S	....	.675	.545	.065	.423	.1010	.177	.1427	.2333	.1245	.00590	.01740	.2160	.03910	7.290
	40	40S	Std.	.675	.493	.091	.567	.0827	.177	.1295	.1910	.1670	.00730	.02160	.2090	.04860	5.969
	80	80S	X-Stg.	.675	.423	.126	.738	.0609	.177	.1106	.1405	.2173	.00862	.02554	.1991	.05746	4.391
1/2	...	10S	....	.840	.670	.083	.671	.1550	.220	.1764	.3568	.1974	.01430	.03410	.2692	.07670	11.150
	40	40S	Std.	.840	.622	.109	.850	.1316	.220	.1637	.3040	.2503	.01710	.04070	.2613	.09156	9.500
	80	80S	X-Stg.	.840	.546	.147	1.087	.1013	.220	.1433	.2340	.3200	.02010	.04780	.2505	.10760	7.313
	160	...	....	.840	.466	.187	1.310	.0740	.220	.1220	.1706	.3836	.02213	.05269	.2402	.11860	5.331
	...	...	XX-Stg.	.840	.252	.294	1.714	.0216	.220	.0660	.0499	.5043	.02424	.05772	.2192	.12990	1.559
3/4	...	10S	....	1.050	.884	.083	.857	.2660	.275	.2314	.6138	.2522	.02970	.05660	.3430	.12720	19.180
	40	40S	Std.	1.050	.824	.113	1.130	.2301	.275	.2168	.5330	.3326	.03704	.07055	.3337	.15870	16.656
	80	80S	X-Stg.	1.050	.742	.154	1.473	.1875	.275	.1948	.4330	.4335	.04479	.08531	.3214	.19190	13.530
	...	...	....	1.050	.675	.188	1.727	.1514	.275	.1759	.3570	.5081	.04950	.09430	.3121	.21300	11.156
	160	...	....	1.050	.614	.218	1.940	.1280	.275	.1607	.2961	.5698	.05270	.10038	.3041	.22590	9.253
	...	...	XX-Stg.	1.050	.434	.308	2.440	.0633	.275	.1137	.1479	.7180	.05792	.11030	.2840	.24820	4.622

Table of PROPERTIES of PIPE (Cont.)

NOMINAL PIPE SIZE	SCHEDULE NO. CARBON & ALLOY STEELS	SCHEDULE NO. STAINLESS STEELS	WEIGHT DESIGNATION	OUTSIDE DIAM. in. D	INSIDE DIAM. in. d	WALL THICKNESS in.	WEIGHT PER FOOT lb./ft.	WT. OF WATER PER FT. PIPE lb./ft.	SQ. FT. OUTSIDE SURFACE PER FOOT	SQ. FT. INSIDE SURFACE PER FOOT	TRANSVERSE AREA in.^{2} a	AREA OF METAL in.^{2} A	MOMENT OF INERTIA in.^{4} I	SECTION MODULUS in.^{3} Z	RADIUS OF GYRATION in. R	STRENGTH FACTOR 1000 ft.-lbs. Mr	FLOW G. P. M. Q
1	...	10S	....	1.315	1.097	.109	1.404	.4090	.344	.2872	.9448	.4129	.07560	.1150	.4282	.2588	29.53
	40	40S	Std.	1.315	1.049	.133	1.678	.3740	.344	.2740	.8640	.4939	.08734	.1328	.4205	.2989	27.00
	80	80S	X-Stg.	1.315	.957	.179	2.171	.3112	.344	.2520	.7190	.6388	.10560	.1606	.4066	.3614	22.47
	...	...	....	1.315	.877	.219	2.561	.2614	.344	.2290	.6040	.7534	.11770	.1798	.3952	.4028	18.87
	160	...	....	1.315	.815	.250	2.850	.2261	.344	.2134	.5217	.8364	.12516	.1903	.3868	.4283	16.30
	...	...	XX-Stg.	1.315	.599	.358	3.659	.1221	.344	.1570	.2818	1.0760	.14050	.2136	.3613	.4807	8.81
1 1/4	...	10S	....	1.660	1.442	.109	1.806	.7080	.434	.3775	1.633	.5314	.1606	.1934	.5499	.4353	51.03
	40	40S	Std.	1.660	1.380	.140	2.272	.6471	.434	.3620	1.495	.6685	.1947	.2346	.5397	.5278	46.72
	80	80S	X-Stg.	1.660	1.278	.191	2.996	.5553	.434	.3356	1.283	.8815	.2418	.2913	.5237	.6555	40.09
	160	...	....	1.660	1.160	.250	3.764	.4575	.434	.3029	1.057	1.1070	.2833	.3421	.5063	.7696	33.03
	...	...	XX-Stg.	1.660	.896	.382	5.214	.2732	.434	.2331	.6305	1.5340	.3411	.4110	.4716	.9247	19.70
1 1/2	...	10S	....	1.900	1.682	.109	2.085	.9630	.497	.4403	2.221	.613	.2469	.2599	.6344	.5847	69.41
	40	40S	Std.	1.900	1.610	.145	2.717	.8820	.497	.4213	2.036	.800	.3099	.3262	.6226	.7340	63.62
	80	80S	X-Stg.	1.900	1.500	.200	3.631	.7648	.497	.3927	1.767	1.068	.3912	.4118	.6052	.9265	55.22
	160	...	....	1.900	1.337	.281	4.862	.6082	.497	.3519	1.405	1.430	.4826	.5080	.5809	1.143	43.91
	...	...	XX-Stg.	1.900	1.100	.400	6.408	.4117	.497	.2903	.950	1.885	.5678	.5977	.5489	1.345	29.69
2	...	10S	....	2.375	2.157	.109	2.638	1.583	.622	.5647	3.654	.775	.5003	.4213	.8034	.9479	114.19
	40	40S	Std.	2.375	2.067	.154	3.652	1.452	.622	.5401	3.355	1.075	.6657	.5606	.7871	1.261	104.84
	...	...	....	2.375	2.041	.167	3.938	1.420	.622	.5360	3.280	1.158	.7100	.5979	.7829	1.345	102.50
	...	...	....	2.375	2.000	.188	4.380	1.363	.622	.5237	3.142	1.289	.7764	.6538	.7764	1.471	98.19
	80	80S	X-Stg.	2.375	1.939	.218	5.022	1.279	.622	.5074	2.953	1.477	.8679	.7309	.7665	1.644	92.28
	...	...	....	2.375	1.875	.250	5.673	1.196	.622	.4920	2.761	1.669	.9555	.8046	.7565	1.810	86.28
	...	...	....	2.375	1.750	.312	6.883	1.041	.622	.4581	2.405	2.025	1.102	.9280	.7376	2.088	75.16
	160	...	....	2.375	1.689	.343	7.450	.767	.622	.4422	2.240	2.190	1.162	.9790	.7286	2.203	70.00
	...	...	XX-Stg.	2.375	1.503	.436	9.029	.769	.622	.3929	1.774	2.656	1.311	1.104	.7027	2.485	55.44
2 1/2	...	10S	....	2.875	2.635	.120	3.53	2.360	.753	.6900	5.453	1.038	.9878	.6872	.9755	1.546	170.41
	40	40S	Std.	2.875	2.469	.203	5.79	2.072	.753	.6462	4.788	1.704	1.530	1.064	.9474	2.394	149.63
	...	...	....	2.875	2.441	.217	6.16	2.026	.753	.6381	4.680	1.812	1.611	1.121	.9430	2.521	146.25
	80	80S	X-Stg.	2.875	2.323	.276	7.66	1.834	.753	.6095	4.238	2.254	1.924	1.339	.9241	3.012	132.44
	160	...	....	2.875	2.125	.375	10.01	1.535	.753	.5564	3.547	2.945	2.353	1.638	.8938	3.685	110.84
	...	...	XX-Stg.	2.875	1.771	.552	13.69	1.067	.753	.4627	2.464	4.028	2.871	1.997	.8442	4.493	77.00
3	...	10S	....	3.500	3.260	.120	4.33	3.62	.916	.853	8.346	1.272	1.821	1.041	1.196	2.341	260.81
	...	...	....	3.500	3.250	.125	4.52	3.60	.916	.851	8.300	1.329	1.900	1.086	1.195	2.440	259.38
	...	...	....	3.500	3.204	.148	5.30	3.52	.916	.840	8.100	1.560	2.230	1.275	1.188	2.870	253.13
	...	...	....	3.500	3.124	.188	6.65	3.34	.916	.819	7.700	1.958	2.700	1.545	1.175	3.480	240.63
	40	40S	Std.	3.500	3.068	.216	7.57	3.20	.916	.802	7.393	2.228	3.017	1.724	1.164	3.879	231.03
	...	...	....	3.500	3.018	.241	8.39	3.10	.916	.790	7.155	2.467	3.294	1.882	1.155	4.235	223.59
	...	...	....	3.500	2.992	.254	8.80	3.06	.916	.785	7.050	2.590	3.450	1.975	1.151	4.450	220.31
	...	...	....	3.500	2.922	.289	9.91	2.91	.916	.765	6.700	2.920	3.790	2.170	1.141	4.890	209.38
	80	80S	X-Stg.	3.500	2.900	.300	10.25	2.86	.916	.761	6.605	3.016	3.892	2.225	1.136	5.007	206.41
	...	...	....	3.500	2.875	.312	10.64	2.81	.916	.753	6.492	3.122	4.015	2.294	1.132	5.162	202.88
	...	...	....	3.500	2.687	.406	13.42	2.46	.916	.704	5.673	3.948	4.808	2.747	1.103	6.182	177.28
	160	...	....	3.500	2.624	.438	14.32	2.34	.916	.687	5.407	4.214	5.044	2.882	1.094	6.485	168.97
	...	...	XX-Stg.	3.500	2.300	.600	18.58	1.80	.916	.601	4.155	5.466	5.993	3.424	1.047	7.705	129.84
3 1/2	...	10S	....	4.000	3.760	.120	4.97	4.81	1.047	.984	11.10	1.46	2.754	1.377	1.372	3.098	346.88
	...	...	....	4.000	3.744	.128	5.38	4.78	1.047	.981	11.01	1.58	2.970	1.485	1.370	3.340	344.06
	...	...	....	4.000	3.732	.134	5.58	4.75	1.047	.978	10.95	1.64	3.070	1.535	1.367	3.450	342.19
	...	...	....	4.000	3.704	.148	6.26	4.66	1.047	.971	10.75	1.84	3.420	1.710	1.364	3.850	335.94
	...	...	....	4.000	3.624	.188	7.71	4.48	1.047	.950	10.32	2.27	4.130	2.065	1.350	4.650	322.50

Table of PROPERTIES of PIPE (Cont.)

NOMINAL PIPE SIZE	SCHEDULE NO. CARBON & ALLOY STEELS	SCHEDULE NO. STAINLESS STEELS	WEIGHT DESIGNATION	OUTSIDE DIAM. in. D	INSIDE DIAM. in. d	WALL THICKNESS in.	WEIGHT PER FOOT lb./ft.	WT. OF WATER PER FT. PIPE lb./ft.	SQ. FT. OUTSIDE SURFACE PER FOOT	SQ. FT. INSIDE SURFACE PER FOOT	TRANSVERSE AREA in.² a	AREA OF METAL in.² A	MOMENT OF INERTIA in.⁴ I	SECTION MODULUS in.³ Z	RADIUS OF GYRATION in. R	STRENGTH FACTOR 1000 ft.-lbs. Mr	FLOW G. P. M. Q
3½ (CONT.)	40	40S	Std.	4.000	3.548	.226	9.11	4.28	1.047	.929	9.89	2.68	4.788	2.394	1.337	5.386	309.06
	...	...	....	4.000	3.438	.281	11.17	4.02	1.047	.900	9.28	3.29	5.715	2.858	1.319	6.425	290.00
	80	80S	X-Stg.	4.000	3.364	.318	12.51	3.85	1.047	.880	8.89	3.68	6.280	3.140	1.307	7.065	277.81
	...	...	....	4.000	3.312	.344	13.42	3.73	1.047	.867	8.62	3.95	6.658	3.329	1.283	7.490	269.38
	...	...	....	4.000	3.062	.469	17.68	3.19	1.047	.802	7.37	5.20	8.250	4.125	1.259	9.281	230.31
	...	...	XX-Stg.	4.000	2.728	.636	22.85	2.53	1.047	.716	5.84	6.72	9.848	4.924	1.210	11.081	182.50
4	...	10S	....	4.500	4.260	.120	5.61	6.18	1.178	1.115	14.25	1.65	3.97	1.761	1.550	3.97	445.31
	...	...	....	4.500	4.244	.128	5.99	6.14	1.178	1.111	14.15	1.76	4.21	1.871	1.545	4.21	442.19
	...	...	....	4.500	4.232	.134	6.26	6.11	1.178	1.110	14.10	1.84	4.39	1.950	1.542	4.39	440.63
	...	...	....	4.500	4.216	.142	6.61	6.06	1.178	1.105	13.98	1.93	4.58	2.035	1.540	4.58	436.88
	...	...	....	4.500	4.170	.165	7.64	5.92	1.178	1.093	13.67	2.24	5.26	2.340	1.531	5.27	427.19
	...	...	....	4.500	4.124	.188	8.56	5.80	1.178	1.082	13.39	2.52	5.86	2.600	1.525	5.85	418.44
	...	...	....	4.500	4.090	.205	9.39	5.71	1.178	1.071	13.15	2.76	6.38	2.840	1.520	6.39	410.94
	40	40S	Std.	4.500	4.026	.237	10.79	5.51	1.178	1.055	12.73	3.17	7.23	3.214	1.510	7.23	397.81
	...	...	....	4.500	4.000	.250	11.35	5.45	1.178	1.049	12.57	3.34	7.56	3.360	1.505	7.56	392.81
	...	...	....	4.500	3.958	.271	12.24	5.35	1.178	1.038	12.31	3.60	8.09	3.600	1.498	8.10	384.69
	...	...	....	4.500	3.938	.281	12.67	5.27	1.178	1.031	12.17	3.73	8.33	3.703	1.495	8.33	380.31
	...	...	....	4.500	3.900	.300	13.42	5.19	1.178	1.023	11.96	3.95	8.75	3.890	1.487	8.75	373.75
	...	...	....	4.500	3.876	.312	14.00	5.12	1.178	1.013	11.80	4.11	9.05	4.020	1.482	9.05	368.75
	80	80S	X-Stg.	4.500	3.826	.337	14.98	4.98	1.178	1.002	11.50	4.41	9.61	4.271	1.477	9.61	359.38
	...	...	....	4.500	3.750	.375	16.52	4.78	1.178	.982	11.04	4.86	10.43	4.636	1.464	10.43	345.00
	120	...	....	4.500	3.624	.438	19.00	4.47	1.178	.949	10.32	5.59	11.65	5.177	1.444	11.65	322.50
	...	...	....	4.500	3.500	.500	21.36	4.16	1.178	.916	9.62	6.28	12.77	5.676	1.425	12.77	300.63
	160	...	....	4.500	3.438	.531	22.60	4.02	1.178	.900	9.28	6.62	13.27	5.900	1.416	13.27	290.00
	...	...	XX-Stg.	4.500	3.152	.674	27.54	3.38	1.178	.826	7.80	8.10	15.28	6.793	1.374	15.28	243.75
5	...	10S	....	5.563	5.295	.134	7.770	9.54	1.456	1.386	22.02	2.29	8.42	3.028	1.920	6.81	688.13
	40	40S	Std.	5.563	5.047	.258	14.62	8.66	1.456	1.321	20.01	4.30	15.16	5.451	1.878	12.26	625.31
	...	...	....	5.563	4.859	.352	19.59	8.06	1.456	1.272	18.60	5.76	19.65	7.064	1.847	15.89	581.25
	80	80S	X-Stg.	5.563	4.813	.375	20.78	7.87	1.456	1.260	18.19	6.11	20.67	7.431	1.839	16.72	568.44
	...	...	....	5.563	4.688	.437	23.95	7.47	1.456	1.227	17.26	7.04	23.31	8.370	1.819	18.85	539.40
	120	...	....	5.563	4.563	.500	27.10	7.08	1.456	1.195	16.35	7.95	25.74	9.253	1.799	20.82	510.94
	160	...	....	5.563	4.313	.625	32.96	6.32	1.456	1.129	14.61	9.70	30.03	10.800	1.760	24.29	456.56
	...	...	XX-Stg.	5.563	4.063	.750	38.55	5.62	1.456	1.064	12.97	11.34	33.63	12.090	1.722	27.21	405.31
6	...	10S	....	6.625	6.357	.134	9.29	13.70	1.735	1.660	31.75	2.73	14.38	4.34	2.290	9.77	992.19
	...	...	....	6.625	6.287	.169	11.56	13.45	1.735	1.650	31.00	3.43	17.90	5.41	2.281	12.15	968.75
	...	...	....	6.625	6.265	.180	12.50	13.38	1.735	1.640	30.81	3.65	19.00	5.76	2.280	12.90	962.81
	...	...	....	6.625	6.249	.188	12.93	13.31	1.735	1.639	30.70	3.80	19.71	5.95	2.279	13.40	959.38
	...	...	....	6.625	6.187	.219	15.02	13.05	1.735	1.620	30.10	4.41	22.66	6.84	2.268	15.41	940.63
	...	...	....	6.625	6.125	.250	17.02	12.80	1.735	1.606	29.50	5.01	25.55	7.71	2.26	17.40	921.88
	...	...	....	6.625	6.071	.277	18.86	12.55	1.735	1.591	28.95	5.54	28.00	8.46	2.25	19.05	904.69
	40	40S	Std.	6.625	6.065	.280	18.97	12.51	1.735	1.587	28.99	5.58	28.14	8.50	2.24	19.12	905.94
	...	...	....	6.625	5.875	.375	25.10	11.75	1.735	1.540	27.10	7.37	36.20	10.90	2.21	24.60	846.88
	80	80S	X-Stg.	6.625	5.761	.432	28.57	11.29	1.735	1.510	26.07	8.40	40.49	12.22	2.19	27.50	814.69
	...	...	....	6.625	5.625	.500	32.79	10.85	1.735	1.475	24.85	9.63	45.60	13.78	2.16	31.00	776.56
	120	...	....	6.625	5.501	.562	36.40	10.30	1.735	1.470	23.77	10.74	49.91	15.07	2.15	33.90	742.81
	160	...	....	6.625	5.189	.718	45.30	9.16	1.735	1.359	21.15	13.36	58.99	17.81	2.10	40.07	660.94
	...	...	XX-Stg.	6.625	4.897	.864	53.16	8.14	1.735	1.280	18.83	15.64	66.33	20.02	2.06	45.06	588.44

Table of PROPERTIES of PIPE (Cont.)

NOMINAL PIPE SIZE	SCHEDULE NO. CARBON & ALLOY STEELS	SCHEDULE NO. STAINLESS STEELS	WEIGHT DESIGNATION	OUTSIDE DIAM. in. D	INSIDE DIAM. in. d	WALL THICKNESS in.	WEIGHT PER FOOT lb./ft.	WT. OF WATER PER FT. PIPE lb./ft.	SQ. FT. OUTSIDE SURFACE PER FOOT	SQ. FT. INSIDE SURFACE PER FOOT	TRANSVERSE AREA in.² a	AREA OF METAL in.² A	MOMENT OF INERTIA in.⁴ I	SECTION MODULUS in.³ Z	RADIUS OF GYRATION in. R	STRENGTH FACTOR 1000 ft.-lbs. Mr	FLOW G. P. M. Q
	...	10S	....	8.625	8.329	.148	13.40	23.6	2.26	2.180	54.5	3.94	35.4	8.22	3.00	18.5	1703.1
	...	...	....	8.625	8.309	.158	14.26	23.6	2.26	2.178	54.3	4.19	37.5	8.70	2.99	19.6	1696.9
	...	...	....	8.625	8.295	.165	14.91	23.5	2.26	2.175	54.1	4.37	39.4	9.14	2.99	20.6	1690.6
	...	...	....	8.625	8.249	.188	16.90	23.2	2.26	2.161	53.5	5.00	44.5	10.30	2.98	23.2	1671.9
	...	...	....	8.625	8.219	.203	18.30	23.1	2.26	2.152	53.1	5.38	47.7	11.05	2.98	24.9	1659.4
	...	...	....	8.625	8.187	.219	19.64	22.9	2.26	2.148	52.7	5.80	51.3	11.90	2.97	26.8	1646.9
	...	...	....	8.625	8.149	.238	21.43	22.7	2.26	2.136	52.2	6.30	55.5	12.87	2.97	29.0	1631.3
	20	...	....	8.625	8.125	.250	22.40	22.5	2.26	2.127	51.8	6.58	57.7	13.39	2.96	30.1	1618.8
	30	...	....	8.625	8.071	.277	24.70	22.2	2.26	2.115	51.2	7.26	63.3	14.69	2.95	33.1	1600.0
	40	40S	Std.	8.625	7.981	.322	28.55	21.6	2.26	2.090	50.0	8.40	72.5	16.81	2.94	37.8	1562.5
8	...	...	....	8.625	7.937	.344	30.40	21.4	2.26	2.078	49.5	8.94	76.8	17.81	2.93	40.0	1546.9
	...	...	....	8.625	7.921	.352	31.00	21.3	2.26	2.072	49.3	9.12	78.2	18.10	2.93	40.7	1540.6
	...	...	....	8.625	7.875	.375	33.10	21.1	2.26	2.062	48.7	9.74	83.1	19.27	2.92	43.4	1521.9
	60	...	....	8.625	7.813	.406	35.70	20.8	2.26	2.045	47.9	10.48	88.8	20.58	2.91	46.3	1496.9
	...	...	....	8.625	7.687	.469	40.83	20.1	2.26	2.013	46.4	12.01	100.4	23.28	2.89	52.4	1450.0
	80	80S	X-Stg.	8.625	7.625	.500	43.39	19.8	2.26	2.006	45.6	12.76	105.7	24.51	2.88	55.2	1425.0
	100	...	....	8.625	7.439	.593	50.90	18.8	2.26	1.947	43.5	14.96	121.4	28.14	2.85	63.3	1359.4
	...	...	....	8.625	7.375	.625	53.40	18.5	2.26	1.931	42.7	15.71	126.5	29.33	2.84	66.0	1334.4
	120	...	....	8.625	7.189	.718	60.70	17.6	2.26	1.882	40.6	17.84	140.6	32.61	2.81	73.4	1268.8
	140	...	....	8.625	7.001	.812	67.80	16.7	2.26	1.833	38.5	19.93	153.8	35.65	2.78	80.2	1203.1
	...	...	XX-Stg.	8.625	6.875	.875	72.42	16.1	2.26	1.800	37.1	21.30	162.0	37.56	2.76	84.5	1159.4
	160	...	....	8.625	6.813	.906	74.70	15.8	2.26	1.784	36.4	21.97	165.9	38.48	2.76	86.6	1137.5
	...	10S	....	10.750	10.420	.165	18.65	36.9	2.81	2.73	85.3	5.50	76.8	14.29	3.74	32.2	2665.6
	...	...	....	10.750	10.374	.188	21.12	36.7	2.81	2.72	84.5	6.20	86.5	16.10	3.74	36.3	2640.6
	...	...	....	10.750	10.344	.203	22.86	36.5	2.81	2.71	84.0	6.71	93.3	17.35	3.73	39.1	2625.0
	...	...	....	10.750	10.310	.219	24.60	36.2	2.81	2.70	83.4	7.24	100.5	18.70	3.72	42.1	2606.3
	20	...	....	10.750	10.250	.250	28.03	35.9	2.81	2.68	82.6	8.26	113.6	21.12	3.71	47.5	2581.3
	...	...	....	10.750	10.192	.279	31.20	35.3	2.81	2.66	81.6	9.18	125.9	23.42	3.70	52.7	2550.0
	30	...	....	10.750	10.136	.307	34.24	35.0	2.81	2.65	80.7	10.07	137.4	25.57	3.69	57.5	2521.9
	...	...	....	10.750	10.054	.348	38.66	34.4	2.81	2.64	79.3	11.40	154.4	28.80	3.68	65.0	2478.1
	40	40S	Std.	10.750	10.020	.365	40.48	34.1	2.81	2.62	78.9	11.91	160.7	29.90	3.67	67.3	2465.6
10	...	...	....	10.750	9.960	.395	43.68	33.7	2.81	2.61	77.9	12.85	172.5	32.09	3.66	72.2	2434.4
	60	80S	X-Stg.	10.750	9.750	.500	54.74	32.3	2.81	2.55	74.7	16.10	212.0	39.43	3.63	88.7	2334.4
	...	...	....	10.750	9.687	.531	57.98	31.9	2.81	2.54	73.7	17.06	223.6	41.60	3.62	93.6	2303.1
	80	...	....	10.750	9.564	.593	64.40	31.1	2.81	2.50	71.8	18.91	244.9	45.56	3.60	102.5	2243.7
	100	...	....	10.750	9.314	.718	77.00	29.5	2.81	2.44	68.1	22.62	286.2	53.25	3.56	119.8	2128.1
	...	...	....	10.750	9.250	.750	80.10	29.1	2.81	2.42	67.2	23.56	296.2	55.10	3.54	124.0	2100.0
	120	...	....	10.750	9.064	.843	89.20	27.9	2.81	2.37	64.5	26.23	324.3	60.34	3.51	135.8	2015.6
	140	...	....	10.750	8.750	1.000	104.20	26.1	2.81	2.29	60.1	30.63	367.8	68.43	3.46	154.0	1878.1
	...	...	....	10.750	8.625	1.063	109.90	25.3	2.81	2.26	58.4	32.34	384.3	71.50	3.45	160.9	1825.0
	160	...	....	10.750	8.500	1.125	116.00	24.6	2.81	2.22	56.7	34.01	399.4	74.31	3.43	167.2	1771.8
	...	10S	....	12.750	12.390	.180	24.16	52.2	3.34	3.24	120.6	7.11	140.4	22.0	4.44	49.6	3768.7
	...	...	....	12.750	12.344	.203	27.2	52.0	3.34	3.23	119.9	7.99	157.2	24.7	4.43	55.6	3746.9
12	...	...	....	12.750	12.312	.219	29.3	51.7	3.34	3.22	119.1	8.52	167.6	26.3	4.43	59.2	3721.9
	...	...	....	12.750	12.274	.238	31.8	51.5	3.34	3.22	118.5	9.36	183.5	28.8	4.43	65.0	3703.1
	20	...	....	12.750	12.250	.250	33.4	51.3	3.34	3.12	118.0	9.84	192.3	30.2	4.42	68.0	3687.5

Table of PROPERTIES of PIPE (Cont.)

NOMINAL PIPE SIZE	SCHEDULE NO. CARBON & ALLOY STEELS	SCHEDULE NO. STAINLESS STEELS	WEIGHT DESIGNATION	OUTSIDE DIAM. in. D	INSIDE DIAM. in. d	WALL THICKNESS in.	WEIGHT PER FOOT lb./ft.	WT. OF WATER PER FT. PIPE lb./ft.	SQ. FT. OUTSIDE SURFACE PER FOOT	SQ. FT. INSIDE SURFACE PER FOOT	TRANSVERSE AREA in.² a	AREA OF METAL in.² A	MOMENT OF INERTIA in.⁴ I	SECTION MODULUS in.³ Z	RADIUS OF GYRATION in. R	STRENGTH FACTOR 1000 ft.-lbs. Mr	FLOW G. P. M. Q
12 (CONT.)	...	...	....	12.750	12.192	.279	37.2	50.7	3.34	3.19	116.9	10.93	212.5	33.3	4.41	75.0	3653.1
	...	...	....	12.750	12.150	.300	40.0	50.5	3.34	3.18	116.1	11.75	228.0	35.8	4.40	80.6	3628.1
	30	...	....	12.750	12.090	.330	43.8	49.7	3.34	3.16	114.8	12.88	248.5	39.0	4.39	87.7	3587.5
	...	...	....	12.750	12.062	.344	45.5	49.7	3.34	3.16	114.5	13.46	259.0	40.7	4.38	91.6	3578.1
	...	40S	Std.	12.750	12.000	.375	49.6	48.9	3.34	3.14	113.1	14.58	279.3	43.8	4.37	98.6	3534.4
	40	...	....	12.750	11.938	.406	53.6	48.5	3.34	3.13	111.9	15.74	300.3	47.1	4.37	106.0	3496.9
	...	...	....	12.750	11.874	.438	57.5	48.2	3.34	3.11	111.0	16.95	321.0	50.4	4.35	113.5	3468.8
	...	80S	X-Stg.	12.750	11.750	.500	65.4	46.9	3.34	3.08	108.4	19.24	361.5	56.7	4.33	127.6	3387.5
	60	...	....	12.750	11.626	.562	73.2	46.0	3.34	3.04	106.2	21.52	400.5	62.8	4.31	141.3	3318.8
	...	...	....	12.750	11.500	.625	80.9	44.9	3.34	3.01	103.8	23.81	438.7	68.8	4.29	154.8	3243.8
	80	...	....	12.750	11.376	.687	88.6	44.0	3.34	2.98	101.6	26.03	475.2	74.6	4.27	167.7	3175.0
	100	...	....	12.750	11.064	.843	108.0	41.6	3.34	2.90	96.1	31.53	561.8	88.1	4.22	198.3	3003.1
	...	...	....	12.750	11.000	.875	110.9	41.1	3.34	2.88	95.0	32.64	578.5	90.7	4.21	204.2	2968.8
	120	...	....	12.750	10.750	1.000	125.5	39.3	3.34	2.81	90.8	36.91	641.7	100.7	4.17	226.5	2837.5
	140	...	....	12.750	10.500	1.125	140.0	37.5	3.34	2.75	86.6	41.08	700.7	109.9	4.13	247.3	2706.3
	...	...	....	12.750	10.313	1.219	150.1	36.3	3.34	2.70	83.8	44.15	742.4	116.5	4.10	262.0	2618.8
	160	...	....	12.750	10.126	1.312	161.0	34.9	3.34	2.65	80.5	47.14	781.3	122.6	4.07	275.8	2515.6
14	...	...	....	14.000	13.624	.188	28	63.4	3.67	3.57	146.0	8.17	203.0	29.0	4.88	65.2	4562.5
	...	...	....	14.000	13.560	.220	32	63.0	3.67	3.55	145.0	9.53	237.0	33.8	4.88	76.2	4531.3
	...	...	....	14.000	13.524	.238	35	62.5	3.67	3.54	144.0	10.30	244.0	34.8	4.87	78.4	4500.0
	10	...	....	14.000	13.500	.250	37	62.1	3.67	3.54	143.0	10.82	256.0	36.6	4.86	82.4	4468.8
	20	...	....	14.000	13.375	.312	46	60.8	3.67	3.50	140.5	13.44	314.9	45.0	4.84	101.2	4390.6
	30	...	Std.	14.000	13.250	.375	55	59.7	3.67	3.47	137.9	16.05	372.8	53.2	4.82	119.8	4309.4
	...	...	....	14.000	13.188	.406	58	59.5	3.67	3.45	137.0	17.34	401.0	57.4	4.81	129.0	4281.3
	40	...	....	14.000	13.124	.438	63	58.5	3.67	3.44	135.3	18.66	429.6	61.4	4.80	138.2	4228.1
	...	...	....	14.000	13.062	.469	68	58.1	3.67	3.42	134.0	19.95	457.0	65.2	4.78	147.0	4187.5
	...	...	X-Stg.	14.000	13.000	.500	72	57.4	3.67	3.40	132.7	21.21	483.8	69.1	4.78	155.5	4146.9
	60	...	....	14.000	12.814	.593	85	55.9	3.67	3.35	129.0	24.98	562.4	80.3	4.74	180.8	4031.3
	...	...	....	14.000	12.750	.625	89	55.3	3.67	3.34	127.7	26.26	588.5	84.1	4.73	189.2	3990.6
	...	...	....	14.000	12.688	.656	94	54.7	3.67	3.32	126.4	27.51	614.2	87.7	4.72	197.4	3950.0
	80	...	....	14.000	12.500	.750	107	51.2	3.67	3.27	122.7	31.22	687.5	98.2	4.69	221.0	3834.4
	100	...	....	14.000	12.125	.937	131	50.0	3.67	3.17	115.5	38.47	820.5	117.2	4.63	263.7	3609.4
	120	...	....	14.000	11.814	1.093	151	47.5	3.67	3.09	109.6	44.32	929.8	132.8	4.58	298.8	3425.0
	140	...	....	14.000	11.500	1.250	171	45.0	3.67	3.01	103.9	50.07	1027.5	146.8	4.53	330.3	3246.9
	...	...	....	14.000	11.313	1.344	182	43.5	3.67	2.96	100.5	53.42	1082.0	154.6	4.50	347.8	3140.6
	160	...	....	14.000	11.188	1.406	190	42.6	3.67	2.93	98.3	55.63	1116.9	159.6	4.48	359.0	3071.9
16	...	...	....	16.000	15.624	.188	32	83.3	4.20	4.09	192.0	9.39	294.0	36.7	5.59	82.7	6000.0
	...	...	....	16.000	15.524	.238	40	82.5	4.20	4.06	190.0	11.80	367.0	45.9	5.58	103.2	5937.5
	10	...	....	16.000	15.500	.250	42	82.1	4.20	4.06	189.0	12.40	385.0	48.1	5.57	108.2	5906.3
	...	...	....	16.000	15.438	.281	47	81.2	4.20	4.04	187.0	13.90	430.0	53.8	5.56	121.0	5843.8
	20	...	....	16.000	15.375	.312	52	80.1	4.20	4.03	185.6	15.40	474.0	59.2	5.55	133.3	5800.0
	...	...	....	16.000	15.312	.344	57	80.0	4.20	4.01	184.1	16.94	519.0	64.9	5.54	146.0	5753.1

Table of PROPERTIES of PIPE (Cont.)

NOMINAL PIPE SIZE	SCHEDULE NO. CARBON & ALLOY STEELS	SCHEDULE NO. STAINLESS STEELS	WEIGHT DESIGNATION	OUTSIDE DIAM. in. D	INSIDE DIAM. in. d	WALL THICKNESS in.	WEIGHT PER FOOT lb./ft.	WT. OF WATER PER FT. PIPE lb./ft.	SQ. FT. OUTSIDE SURFACE PER FOOT	SQ. FT. INSIDE SURFACE PER FOOT	TRANSVERSE AREA in.^{2} a	AREA OF METAL in.^{2} A	MOMENT OF INERTIA in.^{4} I	SECTION MODULUS in.^{3} Z	RADIUS OF GYRATION in. R	STRENGTH FACTOR 1000 ft.-lbs. Mr	FLOW G. P. M. Q
16 (CONT.)	30	...	Std.	16.000	15.250	.375	63	79.1	4.20	4.00	182.6	18.41	562.1	70.3	5.53	158.1	5706.3
	...	...	....	16.000	15.188	.406	68	78.6	4.20	3.98	181.0	19.89	605.0	75.6	5.52	170.0	5656.3
	...	...	....	16.000	15.124	.438	73	78.2	4.20	3.96	180.0	21.42	650.0	81.2	5.51	183.0	5625.0
	...	...	....	16.000	15.062	.469	78	77.5	4.20	3.94	178.5	22.90	694.0	86.8	5.50	195.0	5578.1
	40	...	X-Stg.	16.000	15.000	.500	83	76.5	4.20	3.93	176.7	24.35	731.9	91.5	5.48	205.9	5521.9
	...	...	....	16.000	14.938	.531	88	75.8	4.20	3.91	175.2	25.82	774.8	96.8	5.47	217.9	5475.0
	60	...	....	16.000	14.688	.656	108	73.4	4.20	3.85	169.4	31.62	932.6	116.6	5.43	262.3	5293.8
	...	...	....	16.000	14.625	.687	112	72.7	4.20	3.83	168.0	33.07	971.3	121.4	5.42	273.2	5250.0
	...	...	....	16.000	14.500	.750	122	71.5	4.20	3.80	165.1	35.93	1047.0	130.9	5.40	294.5	5159.4
	80	...	....	16.000	14.314	.843	137	69.7	4.20	3.75	160.9	40.14	1156.6	144.6	5.37	325.3	5028.1
	100	...	....	16.000	13.938	1.031	165	66.0	4.20	3.65	152.6	48.49	1366.0	170.7	5.30	384.2	4768.8
	120	...	....	16.000	13.564	1.218	193	62.6	4.20	3.55	144.5	56.56	1555.8	194.5	5.24	437.6	4515.6
	140	...	....	16.000	13.124	1.438	224	58.6	4.20	3.44	135.3	65.79	1761.2	220.1	5.17	495.2	4228.1
	...	...	....	16.000	13.000	1.500	232	57.4	4.20	3.40	132.7	68.33	1816.0	227.0	5.15	510.8	4146.9
	160	...	....	16.000	12.814	1.593	245	55.9	4.20	3.35	129.0	72.10	1893.3	236.6	5.12	532.4	4031.3
18	10	...	....	18.000	17.500	.250	47	104.6	4.71	4.58	241.0	13.96	550.0	61.1	6.28	137.5	7531.3
	20	...	....	18.000	17.375	.312	59	102.5	4.71	4.55	237.1	17.36	679.3	75.5	6.25	169.8	7409.4
	...	...	Std.	18.000	17.250	.375	71	101.2	4.71	4.51	233.7	20.76	806.6	89.6	6.23	201.7	7303.1
	30	...	....	18.000	17.124	.438	82	99.5	4.71	4.48	229.5	24.95	963.1	107.0	6.21	240.7	7171.9
	...	...	X-Stg.	18.000	17.000	.500	93	98.2	4.71	4.45	227.0	27.49	1053.0	117.0	6.19	263.3	7093.8
	40	...	....	18.000	16.876	.562	105	97.2	4.71	4.42	224.0	30.85	1177.0	130.9	6.17	294.0	7000.0
	...	...	....	18.000	16.813	.594	110	96.1	4.71	4.40	222.0	32.47	1233.0	137.0	6.16	303.3	6937.5
	...	...	....	18.000	16.750	.625	116	95.8	4.71	4.39	220.5	34.15	1290.0	143.2	6.14	322.0	6890.6
	60	...	....	18.000	16.500	.750	138	92.5	4.71	4.32	213.8	40.64	1515.0	168.3	6.10	378.7	6681.3
	...	...	....	18.000	16.375	.812	149	91.2	4.71	4.29	210.6	43.87	1625.0	180.6	6.08	406.2	6581.3
	80	...	....	18.000	16.126	.937	171	88.5	4.71	4.22	204.2	50.23	1833.9	203.8	6.04	458.5	6381.3
	100	...	....	18.000	15.688	1.156	208	83.7	4.71	4.11	193.3	61.18	2182.0	242.3	5.97	545.5	6040.6
	120	...	....	18.000	15.250	1.375	244	79.2	4.71	3.99	182.7	71.82	2497.9	277.5	5.90	624.4	5709.4
	140	...	....	18.000	14.876	1.562	275	75.3	4.71	3.89	173.8	80.66	2749.8	305.5	5.84	687.5	5431.3
	...	...	....	18.000	14.625	1.687	294	72.7	4.71	3.83	168.0	86.48	2909.0	323.2	5.80	727.2	5250.0
	160	...	....	18.000	14.438	1.781	309	71.0	4.71	3.78	163.7	90.75	3020.2	335.5	5.77	754.9	5115.6
20	10	...	....	20.000	19.500	.250	53	130.0	5.24	5.11	299.0	15.52	759	75.9	6.98	171.0	9343.8
	...	...	....	20.000	19.374	.313	66	128.1	5.24	5.08	295.0	19.36	937	93.7	6.95	211.0	9218.8
	20	...	Std.	20.000	19.250	.375	79	126.0	5.24	5.04	291.1	23.12	1113	111.3	6.94	250.5	9096.9
	...	...	....	20.000	19.124	.438	92	125.1	5.24	5.01	288.0	26.95	1290	129.0	6.92	290.0	9000.0
	30	...	X-Stg.	20.000	19.000	.500	105	122.8	5.24	4.97	283.5	30.63	1457	145.7	6.90	327.9	8859.4
	...	...	....	20.000	18.875	.562	117	121.1	5.24	4.94	279.8	34.35	1624	162.4	6.87	365.3	8743.8
	40	...	....	20.000	18.814	.593	123	120.4	5.24	4.93	278.0	36.15	1704	170.4	6.86	383.4	8687.5
	...	...	....	20.000	18.750	.625	129	119.5	5.24	4.91	276.1	38.04	1787	178.7	6.85	402.1	8628.1
	60	...	....	20.000	18.376	.812	167	114.9	5.24	4.81	265.2	48.95	2257	225.7	6.79	507.9	8287.5
	...	...	....	20.000	18.250	.875	179	113.2	5.24	4.78	261.6	52.57	2409	240.9	6.77	542.0	8175.0
	...	...	....	20.000	18.188	.906	185	112.7	5.24	4.76	259.8	54.36	2484	248.4	6.76	558.9	8118.8
	80	...	....	20.000	17.938	1.031	209	109.4	5.24	4.80	252.7	61.44	2771	277.1	6.72	623.5	7896.9
	100	...	....	20.000	17.438	1.281	256	103.4	5.24	4.56	238.8	75.34	3317	331.7	6.63	746.3	7462.5
	120	...	....	20.000	17.000	1.500	297	98.3	5.24	4.45	227.0	87.18	3755	375.5	6.56	844.9	7093.8

Table of PROPERTIES of PIPE (Cont.)

NOMINAL PIPE SIZE	SCHEDULE NO. CARBON & ALLOY STEELS	SCHEDULE NO. STAINLESS STEELS	WEIGHT DESIGNATION	OUTSIDE DIAM. in. D	INSIDE DIAM. in. d	WALL THICKNESS in.	WEIGHT PER FOOT lb./ft.	WT. OF WATER PER FT. PIPE lb./ft.	SQ. FT. OUTSIDE SURFACE PER FOOT	SQ. FT. INSIDE SURFACE PER FOOT	TRANSVERSE AREA in.² a	AREA OF METAL in.² A	MOMENT OF INERTIA in.⁴ I	SECTION MODULUS in.³ Z	RADIUS OF GYRATION in. R	STRENGTH FACTOR 1000 ft.-lbs. Mr	FLOW G. P. M. Q
20 (CONT.)	140	....	....	20.000	16.500	1.750	342	92.6	5.24	4.32	213.8	100.33	4217	421.7	6.48	948.8	6681.3
	...	....	....	20.000	16.313	1.844	357	90.5	5.24	4.27	209.0	105.20	4489	448.9	6.54	1010.0	6531.3
	160	....	....	20.000	16.064	1.968	379	87.9	5.24	4.21	202.7	111.49	4586	458.6	6.41	1031.9	6334.4
22	...	....	....	22.000	21.500	.250	58	157.4	5.76	5.63	363.1	17.18	1010	91.8	7.69	206.6	11346.9
	...	....	....	22.000	21.376	.312	72	155.6	5.76	5.60	358.9	21.26	1250	113.6	7.67	255.6	11215.6
	...	....	....	22.000	21.250	.375	87	153.7	5.76	5.56	354.7	25.48	1490	135.4	7.65	304.6	11084.4
	...	....	....	22.000	21.126	.437	103	152.0	5.76	5.53	350.5	29.60	1721	156.4	7.63	351.9	10953.1
	...	....	....	22.000	21.000	.500	115	150.2	5.76	5.50	346.4	33.77	1953	177.5	7.61	399.4	10825.0
	...	....	....	22.000	20.876	.562	129	148.4	5.76	5.47	342.3	37.85	2175	197.7	7.58	444.8	10696.9
	...	....	....	22.000	20.750	.625	143	146.6	5.76	5.43	338.2	41.97	2400	218.2	7.56	490.9	10568.8
	...	....	....	22.000	20.624	.688	157	144.8	5.76	5.40	334.1	46.06	2618	238.0	7.54	535.5	10440.1
	...	....	....	22.000	20.500	.750	170	143.1	5.76	5.37	330.1	50.07	2829	257.2	7.52	578.7	10315.6
24	10	....	....	24.000	23.500	.250	63	189.0	6.28	6.15	435.0	18.67	1320	110.0	8.40	247.5	13593.8
	...	....	....	24.000	23.376	.312	79	186.9	6.28	6.12	430.0	23.20	1630	136.0	8.38	306.0	13437.5
	20	....	Std.	24.000	23.250	.375	95	183.8	6.28	6.09	424.6	27.83	1942	161.9	8.35	364.0	13268.8
	...	....	....	24.000	23.125	.437	110	181.8	6.28	6.05	420.0	32.39	2248	187.4	8.33	421.6	13125.0
	...	....	X-Stg.	24.000	23.000	.500	125	181.0	6.28	6.02	416.0	36.90	2550	213.0	8.31	480.0	13000.0
	30	....	....	24.000	22.876	.562	141	178.5	6.28	5.99	411.0	41.40	2840	237.0	8.28	534.0	12843.8
	...	....	....	24.000	22.750	.625	156	175.9	6.28	5.96	406.5	45.90	3137	261.4	8.27	588.0	12703.1
	40	....	....	24.000	22.626	.687	171	174.2	6.28	5.92	402.1	50.30	3422	285.2	8.25	641.7	12565.6
	...	....	....	24.000	22.500	.750	186	172.1	6.28	5.89	397.6	54.78	3705	308.8	8.22	694.8	12425.0
	60	....	....	24.000	22.064	.968	238	165.8	6.28	5.78	382.3	70.04	4652	387.7	8.15	872.3	11946.9
	...	....	....	24.000	21.938	1.031	253	163.6	6.28	5.74	378.0	74.41	4920	410.0	8.13	922.5	11812.5
	80	....	....	24.000	21.564	1.218	297	158.2	6.28	5.65	365.2	87.17	5673	472.8	8.07	1063.7	11412.5
	100	....	....	24.000	20.938	1.531	367	149.3	6.28	5.48	344.3	108.07	6847	570.6	7.96	1283.9	10759.4
	120	....	....	24.000	20.376	1.812	429	141.4	6.28	5.33	326.1	126.30	7823	651.9	7.87	1466.8	10190.6
	140	....	....	24.000	19.876	2.062	484	134.4	6.28	5.20	310.3	142.10	8627	718.9	7.79	1617.6	9696.9
	...	....	....	24.000	19.625	2.187	510	130.9	6.28	5.14	302.0	149.90	9010	750.8	7.75	1689.0	9437.5
	160	....	....	24.000	19.314	2.343	542	127.0	6.28	5.06	293.1	159.40	9457	788.1	7.70	1773.2	9156.3
26	...	....	....	26.000	25.500	.250	67	221.4	6.81	6.68	510.7	19.85	1646	126.6	9.10	284.8	15959.4
	...	....	....	26.000	25.376	.312	84	219.2	6.81	6.64	505.8	25.18	2076	159.7	9.08	359.3	15806.3
	...	....	....	26.000	25.250	.375	103	217.1	6.81	6.61	500.7	30.19	2478	190.6	9.06	428.8	15646.9
	...	....	....	26.000	25.126	.437	119	215.0	6.81	6.58	495.8	35.09	2866	220.5	9.04	496.1	15493.8
	...	....	....	26.000	25.000	.500	136	212.8	6.81	6.54	490.9	40.06	3259	250.7	9.02	564.1	15340.6
	...	....	....	26.000	24.876	.562	153	210.7	6.81	6.51	486.0	44.91	3638	279.8	9.00	629.6	15187.5
	...	....	....	26.000	24.750	.625	169	208.6	6.81	6.48	481.1	49.82	4013	308.7	8.98	694.6	15034.4
	...	....	....	26.000	24.624	.688	186	206.4	6.81	6.45	476.2	54.71	4385	337.3	8.95	758.9	14881.3
	...	....	....	26.000	24.500	.750	202	204.4	6.81	6.41	471.4	59.49	4744	364.9	8.93	821.0	14731.3
30	10	....	....	30.000	29.376	.312	99	293.7	7.85	7.69	677.8	29.19	3201	213.4	10.50	480.1	21180.0
	...	....	....	30.000	29.250	.375	119	291.2	7.85	7.66	672.0	34.90	3823	254.8	10.48	573.4	20998.8
	...	....	....	30.000	29.125	.437	138	288.7	7.85	7.62	666.2	40.63	4432	295.5	10.45	664.8	20819.7
	20	....	....	30.000	29.000	.500	158	286.2	7.85	7.59	660.5	46.34	5033	335.5	10.43	755.0	20641.3
	...	....	....	30.000	28.875	.562	177	283.7	7.85	7.56	654.8	52.02	5627	375.1	10.41	844.0	20463.8
	30	....	....	30.000	28.750	.625	196	281.3	7.85	7.53	649.2	57.68	6213	414.2	10.39	931.9	20286.9

FRICTION LOSS

In Steel Pipes Carrying Water

Among the many proposed empirical formulae for drop in pressure due to frictional resistance of the pipe, that of Williams and Hazen has been most widely used, and gives accurate values for water at about 60° F. having a kinematic viscosity of about 31.5 SSU.

In a convenient form it reads:

$$V = C R^{0.63} \left(\frac{H}{L}\right)^{0.54} \times 1.32$$

or

$$H = \left(\frac{147.85\ Q}{C D^{2.63}}\right)^{1.852}$$

Where:

V = Velocity in feet per sec.

R = Hydraulic Radius = $\frac{\text{Dia. pipe in ft.}}{4}$

H = Friction head in feet
(If desired in pounds per sq. in. multiply H × .433)

L = Length of pipe in feet

C = Constant depending upon roughness of pipe also upon R.

Where:

$\frac{H}{10}$ = Friction Head for L = 100 ft.

Q = Flow in gallons per min.

D = Inside dia. of pipe in inches (actual)

The following tables on pages 278 to 283 show the friction losses for both smooth new steel pipe under column C=120 and for ordinary 15-year-old steel pipe under column C=100.

The inside pipe diameters are identical with Standard Butt-Welding Fittings for Standard Weight, Extra Strong, and Double Extra Strong pipe.

Nearly all pipe in actual use is of iron or steel and deterioration depends upon the quality of both the metal and the water. Steel pipes turberculate and corrode over a period of years, and a gradual roughening of the interior takes place. If the carrying capacity of a pipe is of importance over a service period of years, allowance for this increased frictional resistance should be made in order to maintain the required flow. The tables should facilitate the handling of problems dealing with friction losses and allowable velocities.

Tables on following pages are determined by the Williams and Hazen Equation published by John Wiley & Sons, Inc.

Friction Losses in Pounds per Square Inch per 100 Feet Length of STANDARD Weight Pipe Carrying Water

C = 120 — SMOOTH NEW STEEL PIPE C = 100 — ORDINARY 15 YEAR OLD STEEL PIPE

Gallons Per Minute	½" PIPE .622" I. D.			¾" PIPE .824" I. D.			1" PIPE 1.049" I. D.			1¼" PIPE 1.380" I. D.			1½" PIPE 1.610" I. D.			2" PIPE 2.067" I. D.			Gallons Per Minute
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	
1	1.06	.65	.91																1
2	2.10	2.40	3.36	1.20	.59	.83	.74	.185	.259										2
3	3.17	4.90	6.86	1.81	1.27	1.77	1.10	.390	.546										3
4	4.23	8.38	11.70	2.41	2.17	3.04	1.49	.665	.931	.86	.177	.248	.63	.08	.112				4
5	5.28	12.70	17.80	3.01	3.26	4.56	1.85	1.01	1.41	1.07	.264	.370	.78	.12	.17				5
6	6.34	17.90	25.1	3.61	4.55	6.37	2.23	1.41	1.97	1.29	.372	.521	.94	.17	.24	.57	.052	.073	6
7	7.39	23.8	33.28	4.21	6.08	8.50	2.58	1.90	2.66	1.50	.492	.689	1.10	.233	.326	.67	.069	.097	7
8	8.45	30.40	42.60	4.82	7.75	10.85	2.98	2.42	3.39	1.72	.630	.882	1.26	.294	.412	.77	.088	.123	8
9	9.51	37.80	52.90	5.42	9.65	13.50	3.32	2.85	3.99	1.93	.770	1.078	1.41	.372	.521	.86	.110	.154	9
10	10.6	46.30	64.80	6.02	11.80	16.50	3.72	3.52	4.93	2.14	.950	1.425	1.57	.44	.616	.96	.134	.188	10
12				7.22	16.40	22.80	4.46	5.10	7.14	2.57	1.33	1.86	1.89	.62	.868	1.15	.187	.262	12
15				9.02	24.80	34.70	5.60	7.75	10.85	3.21	2.02	2.83	2.36	.94	1.316	1.50	.320	.448	15
18				10.84	34.70	48.60	6.69	10.60	14.84	3.86	2.83	3.96	2.83	1.31	1.834	1.72	.397	.556	18
20				12.03	42.20	59.0	7.44	13.00	18.2	4.29	3.44	4.82	3.15	1.61	2.254	1.91	.480	.672	20
25							9.30	19.60	27.44	5.36	5.15	7.21	3.80	2.30	3.22	2.50	.780	1.092	25
30							11.15	27.60	38.64	6.43	7.00	9.8	4.72	3.40	4.76	2.87	1.04	1.46	30
35							13.02	37.00	51.8	7.51	9.60	12.84	5.51	4.55	6.37	3.35	1.35	1.89	35
40							14.88	47.00	65.8	8.58	12.4	17.36	6.30	5.83	7.66	3.82	1.74	2.44	40
45							16.70	58.80	82.32	9.65	15.5	21.70	7.08	7.20	10.08	4.30	2.15	3.01	45
50										10.72	18.6	26.04	7.87	8.80	12.32	4.78	2.63	3.68	50
55										11.78	22.3	31.22	8.66	10.50	14.7	5.26	3.15	4.41	55
60										12.87	26.4	36.96	9.44	12.30	17.22	5.74	3.70	5.18	60
65										13.92	30.8	43.12	10.23	14.20	19.88	6.21	4.24	5.94	65
70										15.01	35.4	49.56	11.02	16.4	22.96	6.69	4.97	6.96	70
75										16.06	40.0	56.0	11.80	18.6	26.04	7.17	5.52	7.73	75
80										17.16	45.0	63.0	12.59	21.1	29.54	7.65	6.24	8.74	80
85										18.21	50.8	71.2	13.38	23.4	32.76	8.13	7.00	9.80	85
90										19.30	56.0	78.4	14.71	26.0	36.4	8.61	7.75	10.85	90
95													14.95	28.8	40.32	9.08	8.50	11.90	95
100													15.74	31.6	44.24	9.56	9.45	13.23	100
110													17.31	37.9	53.06	10.5	11.20	15.68	110
120													18.89	44.3	62.02	11.5	13.2	18.48	120
130													20.46	51.5	72.10	12.4	15.4	21.56	130
140													22.04	59.0	82.60	13.4	17.6	24.64	140
150													23.6	67.5	94.5	14.3	20.0	28.00	150
160													25.2	76.0	106.4	15.3	22.6	31.6	160
170													26.8	85.3	119.4	16.3	25.3	35.4	170
180													28.4	94.5	132.3	17.2	28.2	39.5	180
190																18.2	31.0	43.4	190
200																19.1	34.2	47.88	200
220																21.0	40.6	56.8	220
240																22.9	47.7	66.8	240
260																24.9	55.6	77.8	260
280																26.8	63.7	89.2	280
300																28.7	72.5	101.5	300
320																			320
340																			340
360																			360
380																			380
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8000																			8000
9000																			9000
10000																			10000
12000																			12000

8" PIPE 7.981" I. D.			
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
100			
110			
120			
130	.83	.021	.029
140	.90	.024	.034
150	.96	.028	.039
160	1.02	.032	.045
170	1.08	.035	.049
180	1.15	.039	.055
190	1.21	.044	.062
200	1.28	.048	.067
220	1.40	.057	.080
240	1.53	.067	.094
260	1.66	.078	.109
280	1.79	.089	.125
300	1.91	.101	.141
320	2.05	.111	.154
340	2.18	.127	.178
360	2.30	.141	.197
380	2.43	.155	.217
400	2.60	.172	.241
450	2.92	.213	.298
500	3.19	.260	.364
550	3.52	.310	.434
600	3.85	.363	.508
650	4.16	.422	.591
700	4.46	.485	.679
750	4.80	.550	.770
800	5.10	.617	.864
850	5.48	.693	.970
900	5.75	.770	1.078
950	6.06	.850	1.19
1000	6.38	.935	1.31
1100	7.03	1.12	1.57
1200	7.66	1.31	1.83
1300	8.30	1.52	2.13
1400	8.95	1.74	2.44
1500	9.58	1.98	2.77
1600	10.21	2.24	3.14
1800	11.50	2.78	3.89
2000	12.78	3.38	4.73
2200	14.05	4.03	5.64
2400	15.32	4.72	6.61
2600	16.70	5.50	7.70
2800	18.00	6.30	8.82
3000	19.20	7.14	10.00
3200	20.50	8.15	11.4
3500	22.40	9.48	13.3
3800	24.40	10.51	14.71
4200	26.90	12.90	18.06
4500	28.80	15.10	21.14
5000	32.00	18.4	25.8
5500	35.30	21.9	30.7

10" PIPE 10.02" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.73	.0129	.018
.77	.014	.0196
.81	.016	.022
.90	.019	.027
.98	.022	.031
1.06	.026	.036
1.15	.029	.041
1.22	.035	.049
1.31	.038	.053
1.39	.042	.059
1.47	.046	.064
1.55	.051	.071
1.63	.057	.080
1.84	.071	.099
2.04	.086	.120
2.24	.102	.143
2.45	.120	.168
2.65	.140	.196
2.86	.160	.224
3.06	.178	.249
3.26	.204	.286
3.47	.226	.316
3.67	.254	.356
3.88	.282	.395
4.08	.310	.434
4.49	.370	.518
4.90	.435	.609
5.31	.503	.704
5.71	.576	.806
6.12	.655	.917
6.53	.740	1.036
7.35	.918	1.285
8.16	1.11	1.55
8.98	1.33	1.86
9.80	1.56	2.18
10.61	1.81	2.53
11.41	2.08	2.91
12.24	2.36	3.30
13.05	2.66	3.72
14.30	3.20	4.48
15.51	3.66	5.12
17.10	4.22	5.91
18.30	5.00	7.00
20.40	6.08	8.51
22.40	7.25	10.15
24.50	8.53	11.94
26.50	9.87	13.82
28.60	11.30	15.82

12" PIPE 12" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.85	.0137	.0192
.905	.0157	.022
.960	.0175	.0245
1.02	.0195	.0273
1.08	.021	.0294
1.14	.024	.0336
1.28	.029	.0406
1.42	.036	.0504
1.56	.042	.059
1.70	.050	.070
1.84	.059	.083
1.99	.067	.094
2.13	.075	.105
2.27	.085	.119
2.41	.095	.133
2.56	.106	.148
2.70	.117	.164
2.84	.129	.181
3.13	.154	.216
3.41	.180	.252
3.69	.210	.294
3.98	.240	.336
4.26	.273	.382
4.55	.308	.431
5.11	.380	.532
5.68	.465	.651
6.25	.550	.770
6.81	.650	.910
7.38	.755	1.057
7.95	.860	1.204
8.52	.985	1.379
9.10	1.11	1.554
9.95	1.31	1.834
10.80	1.52	2.128
11.92	1.85	2.59
12.78	2.08	2.91
14.20	2.53	3.54
15.60	3.00	4.20
17.0	3.54	4.96
18.4	4.10	5.74
19.9	4.70	6.58
22.8	6.00	8.40
25.5	7.50	10.50
28.3	9.10	12.74
34.1	12.80	17.92

14" PIPE 13.25" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.93	.015	.021
1.05	.019	.027
1.16	.022	.031
1.28	.027	.038
1.40	.031	.043
1.51	.037	.052
1.63	.041	.057
1.74	.050	.070
1.86	.055	.077
1.97	.061	.085
2.09	.068	.095
2.20	.075	.105
2.33	.086	.120
2.56	.098	.137
2.79	.116	.162
3.02	.135	.189
3.26	.148	.207
3.49	.173	.242
3.72	.198	.277
4.19	.247	.346
4.65	.296	.414
5.10	.352	.493
5.58	.400	.560
6.05	.478	.669
6.52	.550	.770
6.98	.633	.886
7.44	.679	.951
8.15	.834	1.168
8.85	.969	1.357
9.76	1.16	1.624
10.5	1.31	1.834
11.6	1.60	2.24
12.8	1.90	2.66
14.0	2.29	3.21
15.1	2.63	3.68
16.3	3.04	4.26
18.6	3.88	5.43
20.9	4.84	6.78
23.3	5.90	8.26
27.9	8.34	11.68

16" PIPE 15.25" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
1.23	.021	.029
1.31	.023	.032
1.41	.026	.036
1.49	.029	.041
1.58	.0328	.046
1.66	.0363	.051
1.76	.0395	.055
1.92	.0468	.066
2.11	.055	.077
2.28	.064	.090
2.46	.0716	.100
2.63	.0838	.117
2.81	.0951	.133
3.16	.118	.165
3.51	.133	.186
3.85	.170	.238
4.20	.199	.279
4.55	.219	.307
4.90	.266	.372
5.27	.306	.428
5.60	.328	.459
6.15	.405	.567
6.65	.468	.655
7.35	.565	.791
7.91	.632	.885
8.79	.775	1.085
9.63	.915	1.281
10.5	1.09	1.526
11.4	1.26	1.764
12.3	1.45	2.03
14.1	1.86	2.60
15.8	2.30	3.22
17.6	2.78	3.89
21.1	3.98	5.57

18" PIPE 17.25" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
1.25	.0177	.0248
1.30	.0197	.0276
1.38	.023	.0322
1.51	.0258	.0361
1.66	.030	.0420
1.78	.035	.049
1.94	.039	.055
2.06	.0458	.064
2.21	.052	.073
2.49	.0646	.0904
2.77	.078	.109
3.00	.0926	.130
3.30	.109	.153
3.57	.126	.176
3.84	.144	.202
4.15	.164	.230
4.40	.186	.260
4.85	.220	.308
5.22	.256	.358
5.77	.306	.428
6.23	.347	.486
6.92	.428	.599
7.55	.500	.700
8.31	.596	.828
8.90	.690	.966
9.70	.790	1.106
11.1	1.01	1.414
12.5	1.26	1.764
13.8	1.55	2.17
16.6	2.19	3.07

Friction Losses in Pounds per Square Inch per 100 Feet Length of STANDARD Weight Pipe Carrying Water

C = 120 — SMOOTH NEW STEEL PIPE C = 100 — ORDINARY 15 YEAR OLD STEEL PIPE

Gallons Per Minute	2½" PIPE 2.469" I. D.			3" PIPE 3.068" I. D.			3½" PIPE 3.548" I. D.			4" PIPE 4.026" I. D.			5" PIPE 5.047" I. D.			6" PIPE 6.065" I. D.			Gallons Per Minute
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	
1																			1
2																			2
3																			3
4																			4
5																			5
6																			6
7																			7
8	.52	.037	.052																8
9	.60	.045	.063																9
10	.65	.056	.078	.43	.019	.027													10
12	.78	.078	.109	.52	.027	.038													12
15	.98	.120	.168	.65	.036	.050	.49	.013	.018										15
18	1.18	.158	.221	.78	.057	.080	.58	.029	.041										18
20	1.31	.203	.284	.87	.070	.098	.65	.035	.049	.51	.019	.027							20
25	1.63	.285	.399	1.09	.107	.150	.81	.053	.074	.64	.028	.039							25
30	1.96	.43	.602	1.30	.159	.223	.97	.074	.104	.77	.040	.056	.49	.012	.017				30
35	2.35	.570	.798	1.52	.198	.277	1.14	.098	.137	.89	.0526	.074	.57	.019	.027				35
40	2.68	.73	1.02	1.74	.254	.356	1.30	.125	.175	1.02	.067	.094	.65	.025	.035				40
45	3.02	.91	1.27	1.95	.316	.442	1.46	.156	.218	1.15	.0838	.117	.73	.028	.039				45
50	3.35	1.10	1.54	2.17	.384	.538	1.62	.179	.251	1.28	.102	.143	.82	.034	.048	.57	.012	.017	50
55	3.69	1.32	1.85	2.39	.455	.637	1.70	.222	.311	1.41	.120	.168	.90	.040	.056	.62	.016	.022	55
60	4.02	1.54	2.16	2.60	.540	.756	1.95	.271	.379	1.53	.140	.196	.98	.049	.069	.68	.019	.027	60
65	4.36	1.79	2.51	2.82	.623	.872	2.00	.298	.417	1.66	.164	.230	1.06	.056	.078	.74	.024	.034	65
70	4.69	2.06	2.88	3.04	.715	1.00	2.27	.354	.496	1.79	.189	.265	1.14	.065	.091	.79	.025	.035	70
75	5.03	2.34	3.28	3.25	.812	1.137	2.32	.399	.550	1.91	.216	.302	1.22	.075	.105	.85	.031	.043	75
80	5.36	2.64	3.70	3.47	.916	1.282	2.60	.453	.634	2.04	.242	.339	1.31	.084	.118	.91	.034	.048	80
85	5.70	2.95	1.28	3.69	1.03	1.44	2.62	.504	.706	2.17	.270	.378	1.39	.094	.132	.96	.037	.052	85
90	6.03	3.29	4.606	3.91	1.14	1.60	2.92	.554	.776	2.30	.301	.421	1.47	.105	.147	1.02	.044	.062	90
95	6.37	3.63	5.08	4.12	1.26	1.76	2.93	.618	.865	2.42	.333	.466	1.55	.118	.165	1.08	.047	.066	95
100	6.70	3.97	5.56	4.34	1.39	1.95	3.25	.683	.956	2.55	.369	.517	1.63	.127	.178	1.13	.053	.074	100
110	7.37	4.75	6.65	4.77	1.65	2.31	3.57	.815	1.141	2.81	.440	.616	1.79	.152	.213	1.25	.065	.091	110
120	8.04	5.58	7.81	5.21	1.94	2.72	3.99	.955	1.433	3.06	.518	.725	1.96	.180	.252	1.36	.075	.105	120
130	8.71	6.48	9.07	5.64	2.25	3.15	4.22	1.11	1.55	3.31	.598	.837	2.12	.208	.291	1.47	.084	.118	130
140	9.38	7.40	10.36	6.08	2.58	3.61	4.54	1.27	1.78	3.57	.687	.962	2.29	.238	.333	1.59	.094	.132	140
150	10.00	8.46	11.84	6.51	2.94	4.12	4.87	1.42	1.99	3.82	.785	1.10	2.45	.273	.382	1.70	.112	.157	150
160	10.7	9.50	13.30	6.94	3.32	4.65	5.19	1.63	2.28	4.08	.903	1.26	2.61	.304	.426	1.80	.124	.174	160
170	11.4	10.65	14.91	7.36	3.65	5.11	5.52	1.81	2.53	4.33	1.01	1.414	2.77	.340	.476	1.92	.140	.196	170
180	12.1	11.8	16.52	7.81	4.08	5.71	5.85	2.02	2.83	4.60	1.12	1.57	2.94	.378	.529	2.04	.155	.217	180
190	12.7	13.1	18.34	8.24	4.50	6.30	6.17	2.24	3.14	4.84	1.24	1.74	3.10	.418	.585	2.16	.171	.239	190
200	13.4	14.4	20.2	8.68	5.00	7.00	6.50	2.46	3.44	5.11	1.36	1.904	3.27	.460	.644	2.27	.182	.255	200
220	14.7	17.2	24.1	9.55	5.95	8.33	7.14	2.93	4.10	5.62	1.61	2.25	3.59	.550	.770	2.44	.216	.302	220
240	16.1	20.2	28.3	10.4	6.80	9.52	7.79	3.44	4.82	6.13	1.86	2.604	3.92	.635	.889	2.67	.254	.356	240
260	17.4	23.4	32.8	11.3	8.13	11.38	8.44	4.00	5.60	6.64	2.16	3.024	4.25	.720	1.008	2.89	.294	.412	260
280	18.8	26.8	37.5	12.2	9.10	12.74	9.09	4.58	6.41	7.15	2.48	3.47	4.50	.825	1.155	3.11	.338	.473	280
300	20.1	30.4	42.6	13.0	10.40	14.56	9.74	5.20	7.28	7.66	2.82	3.95	4.90	.930	1.302	3.33	.384	.538	300
320	21.6	34.1	47.7	13.9	11.90	16.66	10.40	5.86	8.20	8.17	3.16	4.42	5.13	1.05	1.47	3.56	.437	.612	320
340	22.9	38.0	53.2	14.8	13.35	18.69	11.00	6.57	9.19	8.58	3.56	4.98	5.44	1.18	1.65	3.78	.484	.678	340
360	24.2	42.3	59.2	15.6	14.8	20.7	11.70	7.28	10.19	9.10	3.94	5.52	5.77	1.33	1.86	4.00	.547	.766	360
380	25.6	46.9	65.7	16.5	16.4	22.96	12.3	8.05	11.27	9.59	4.35	6.09	6.19	1.46	2.04	4.22	.590	.826	380
400	26.8	51.8	72.5	17.4	18.0	25.2	13.0	8.86	12.40	10.10	4.80	6.72	6.44	1.60	2.24	4.43	.655	.917	400
450	30.2	64.5	90.3	19.5	22.3	31.2	13.9	11.2	15.7	11.49	6.14	8.60	7.20	1.80	2.52	5.00	.812	1.137	450
500	33.5	78.0	109.2	21.7	27.4	38.4	16.2	13.4	18.8	12.60	7.25	10.15	8.02	2.32	3.25	5.56	.990	1.39	500
550				23.9	32.6	45.6	17.9	16.0	22.4	13.60	8.90	12.46	8.82	2.80	3.92	6.11	1.18	1.65	550
600				26.0	38.1	53.3	19.5	18.8	26.3	15.10	10.20	14.28	9.62	3.38	4.73	6.65	1.39	1.95	600
650				28.2	44.3	62.0	21.1	21.8	30.5	16.40	11.80	16.5	10.40	3.90	5.46	7.22	1.60	2.24	650
700							22.7	25.0	35.0	17.60	13.50	18.9	11.2	4.50	6.30	7.78	1.84	2.58	700
750							24.4	28.4	39.8	18.90	15.8	22.1	12.0	5.15	7.21	8.34	2.09	2.93	750
800							26.0	31.9	44.7	20.20	17.3	24.2	12.8	5.77	8.08	8.90	2.35	3.29	800
850							27.6	35.6	49.8	21.40	19.5	27.3	13.6	6.45	9.03	9.45	2.63	3.68	850
900										22.70	21.5	30.1	14.4	7.20	10.08	10.00	2.92	4.09	900
950													15.2	7.90	11.06	10.50	3.16	4.42	950
1000													16.0	8.70	12.2	11.1	3.56	4.98	1000
1100													17.6	10.3	14.4	12.2	4.25	5.95	1100
1200													19.61	12.2	17.1	13.3	5.00	7.00	1200
1300													20.8	14.2	19.9	14.4	5.77	8.08	1300
1400													22.4	16.3	22.8	15.6	6.65	9.31	1400
1500													24.0	18.4	25.8	16.7	7.55	10.57	1500
1600													25.6	20.7	29.0	17.8	8.50	11.90	1600
1800																20.0	10.6	14.84	1800
2000																22.2	12.8	17.92	2000
2200																24.4	15.3	21.4	2200
2400																26.7	18.0	25.2	2400
2600																			2600
2800																			2800
3000																			3000
3200																			3200
3500																			3500
3800																			3800
4200																			4200
4500																			4500
5000																			5000
5500																			5500
6000																			6000
6500																			6500
7000																			7000
8000																			8000
9000																			9000
10000																			10000
12000																			12000

Gallons Per Minute	20" PIPE 19.25" I. D.			24" PIPE 23.25" I. D.			30" PIPE 29.25" I. D.		
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
900									
950									
1000	1.11	.0127	.0178						
1100	1.21	.015	.0210						
1200	1.33	.0179	.0251						
1300	1.43	.0206	.0288						
1400	1.55	.023	.0322	.97	.009	.0116			
1500	1.65	.027	.0378	1.04	.011	.0153			
1600	1.78	.030	.0420	1.10	.012	.0168			
1800	2.00	.037	.0518	1.25	.015	.0210			
2000	2.22	.045	.0630	1.39	.019	.0266	.95	.006	.0084
2200	2.42	.0548	.0767	1.52	.022	.0308	1.05	.0073	.0102
2400	2.64	.064	.0896	1.66	.026	.0364	1.14	.0087	.0122
2600	2.86	.074	.104	1.82	.030	.0420	1.24	.0100	.0140
2800	3.08	.0858	.120	1.94	.035	.0490	1.33	.0115	.0160
3000	3.33	.0965	.135	2.08	.039	.0546	1.43	.0130	.0182
3200	3.52	.109	.153	2.22	.044	.0616	1.52	.0146	.0204
3500	3.89	.128	.179	2.42	.052	.0728	1.67	.0172	.0241
3800	4.17	.146	.204	2.64	.061	.0854	1.81	.0200	.0280
4200	4.62	.178	.249	2.91	.073	.1022	2.00	.0242	.0339
4500	4.95	.205	.287	3.12	.085	.119	2.14	.0276	.0386
5000	5.54	.250	.350	3.47	.103	.144	2.38	.0335	.0469
5500	6.05	.295	.413	3.81	.122	.171	2.62	.040	.0560
6000	6.67	.347	.486	4.16	.143	.200	2.86	.047	.0658
6500	7.15	.399	.559	4.50	.167	.234	3.10	.054	.0756
7000	7.78	.460	.644	4.85	.185	.259	3.34	.062	.0868
8000	8.89	.598	.829	5.55	.240	.336	3.81	.08	.112
9000	9.90	.733	1.026	6.25	.300	.420	4.28	.10	.140
10000	11.1	.908	1.271	6.94	.36	.504	4.76	.12	.168
12000	13.3	1.27	1.178	8.30	.52	.728	5.72	.17	.238

Friction Losses in Pounds per Square Inch per 100 Feet Length of EXTRA STRONG Pipe Carrying Water

C = 120 — SMOOTH NEW STEEL PIPE C = 100 — ORDINARY 15 YEAR OLD STEEL PIPE

Gallons Per Minute	½" PIPE .546" I. D.			¾" PIPE .742" I. D.			1" PIPE .957" I. D.			1¼" PIPE 1.278" I. D.			1½" PIPE 1.500" I. D.			2" PIPE 1.939" I. D.			Gallons Per Minute
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. F /Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	
1	1.37	1.23	1.72																1
2	2.74	4.40	6.16	1.48	1.00	1.40	.892	.29	.41										2
3	4.11	9.37	13.1	2.23	2.10	2.94	1.34	.61	.85										3
4	5.48	15.9	22.3	2.97	3.60	5.04	1.79	1.02	1.43	1.00	.255	.357	.73	.117	.164				4
5	6.86	24.1	33.7	3.71	5.43	7.60	2.23	1.57	2.20	1.25	.384	.538	.91	.176	.246				5
6	8.23	33.8	47.3	4.45	7.6	10.6	2.68	2.20	3.08	1.50	.540	.756	1.09	.247	.346	.65	.071	.099	6
7	9.60	45.0	63.0	5.20	10.2	14.3	3.12	2.69	3.77	1.75	.715	1.00	1.27	.328	.459	.76	.094	.132	7
8	11.00	57.4	80.4	5.94	12.9	18.1	3.57	3.75	5.25	2.00	.917	1.28	1.45	.422	.591	.87	.120	.168	8
9	12.3	71.7	100.	6.68	16.1	22.5	4.02	4.23	5.92	2.26	1.11	1.55	1.63	.524	.734	.98	.150	.210	9
10	13.7	87.0	122.	7.42	19.5	27.3	4.46	5.67	7.94	2.50	1.39	1.95	1.82	.635	.889	1.09	.182	.255	10
12				8.91	27.4	38.4	5.36	7.93	11.1	3.00	1.94	2.72	2.18	.890	1.25	1.30	.255	.357	12
15				11.1	41.3	57.8	6.7	11.0	15.4	3.76	2.84	3.98	2.72	1.36	1.90	1.63	.384	.538	15
18				13.4	58.0	81.2	8.03	16.8	23.5	4.50	4.12	5.77	3.27	1.88	2.63	1.96	.540	.756	18
20				14.8	70.4	98.6	8.92	20.4	28.6	5.00	5.00	7.00	3.63	2.29	3.21	2.17	.657	.920	20
25							11.2	27.5	38.6	6.25	7.73	10.8	4.55	3.43	4.80	2.71	1.03	1.44	25
30							13.4	43.2	60.5	7.50	10.60	14.8	5.45	4.86	6.80	3.26	1.39	1.95	30
35							15.6	57.3	80.2	8.75	14.1	19.7	6.38	6.36	8.90	3.80	1.85	2.59	35
40							17.9	73.5	103.	10.00	18.0	25.2	7.26	8.28	11.6	4.35	2.37	3.32	40
45							20.1	91.5	128.	11.2	22.4	31.4	8.2	10.32	14.4	4.89	2.94	4.12	45
50										12.5	27.2	38.1	9.08	12.5	17.5	5.43	3.56	4.98	50
55										13.7	32.4	45.4	10.0	15.2	21.3	5.98	4.25	5.95	55
60										15.0	38.2	53.5	10.9	17.5	24.5	6.52	5.02	7.03	60
65										16.1	44.6	62.4	11.8	20.2	28.3	7.06	5.83	8.12	65
70										17.5	50.8	71.1	12.7	23.3	32.6	7.61	6.66	9.32	70
75										18.8	56.7	79.4	13.6	26.4	37.0	8.15	7.60	10.6	75
80										20.0	64.8	90.7	14.5	29.8	41.7	8.69	8.55	12.0	80
85										21.2	72.3	101.	15.4	33.2	46.5	9.03	9.56	13.4	85
90										22.5	80.5	113.	16.3	36.9	51.7	9.78	10.6	14.8	90
95													17.2	41.0	57.4	10.3	11.7	16.4	95
100													18.2	44.9	62.9	10.9	12.9	18.1	100
110													20.0	53.7	75.2	12.0	15.4	21.6	110
120													21.8	63.0	88.2	13.0	18.1	25.3	120
130	.91	.027	.038										23.6	73.0	102.	14.1	21.0	29.4	130
140	.98	.031	.043										25.4	81.0	113.	15.2	24.1	33.7	140
150	1.05	.036	.050										27.2	95.5	134.	16.3	27.4	38.4	150
160	1.12	.039	.055										29.0	107.2	150.	17.4	30.8	43.1	160
170	1.19	.044	.062										30.9	120.0	168.	18.5	34.4	48.2	170
180	1.26	.049	.069										32.7	133.8	187.	19.6	38.4	53.8	180
190	1.33	.054	.076													20.6	42.5	59.5	190
200	1.41	.0595	.083													21.7	46.5	65.1	200
220	1.55	.071	.099													23.9	55.5	77.7	220
240	1.69	.0835	.117	1.03	.025	.035										26.1	65.0	91.0	240
260	1.83	.097	.136	1.12	.029	.041										28.3	75.7	106.	260
280	1.97	.11	.154	1.20	.0337	.047										30.4	86.8	122.	280
300	2.11	.126	.176	1.29	.038	.053										32.6	98.6	138.	300
320	2.24	.14	.196	1.37	.044	.062													320
340	2.39	.158	.221	1.46	.049	.069													340
360	2.64	.176	.246	1.54	.055	.077	1.06	.021	.029										360
380	2.68	.193	.270	1.62	.061	.085	1.12	.0235	.033										380
400	2.81	.215	.301	1.72	.065	.091	1.18	.026	.036										400
450	3.16	.267	.374	1.93	.08	.112	1.33	.0326	.046										450
500	3.51	.325	.455	2.15	.097	.135	1.48	.0397	.056										500
550	3.86	.388	.543	2.36	.116	.162	1.63	.046	.064										550
600	4.22	.45	.630	2.58	.137	.192	1.77	.0556	.078	1.44	.0362	.051							600
650	4.57	.53	.742	2.79	.159	.223	1.93	.063	.088	1.57	.0428	.060							650
700	4.92	.605	.847	3.01	.183	.256	2.07	.074	.104	1.61	.0483	.068							700
750	5.27	.69	.966	3.22	.21	.294	2.21	.081	.113	1.81	.0534	.075							750
800	5.62	.77	1.08	3.46	.234	.328	2.37	.094	.132	1.92	.0615	.086							800
850	5.97	.865	1.21	3.64	.269	.377	2.51	.104	.146	2.02	.067	.094							850
900	6.32	.96	1.34	3.87	.292	.409	2.66	.117	.164	2.16	.0766	.107	1.63	.0358	.050				900
950	6.67	1.06	1.48	4.07	.338	.473	2.81	.129	.181	2.28	.0855	.120	1.72	.0398	.056				950
1000	7.03	1.17	1.64	4.30	.354	.496	2.96	.143	.200	2.4	.094	.132	1.8	.042	.059				1000
1100	7.83	1.39	1.95	4.73	.42	.588	3.25	.170	.238	2.64	.112	.157	2.0	.051	.071				1100
1200	8.43	1.63	2.28	5.16	.497	.696	3.55	.199	.279	2.9	.131	.183	2.16	.061	.085				1200
1300	9.13	1.9	2.66	5.59	.574	.804	3.84	.232	.325	3.14	.151	.211	2.36	.071	.099				1300
1400	9.83	2.18	3.05	6.01	.657	.920	4.14	.265	.371	3.37	.168	.235	2.5	.079	.111	1.97	.044	.062	1400
1500	10.5	2.47	3.46	6.44	.75	1.05	4.44	.299	.419	3.52	.195	.273	2.66	.093	.130	2.07	.051	.071	1500
1600	11.2	2.78	3.89	6.88	.844	1.18	4.73	.34	.476	3.84	.222	.311	2.9	.105	.147	2.26	.0576	.081	1600
1800	12.6	3.44	4.82	7.74	1.05	1.47	5.33	.42	.588	4.35	.28	.392	3.26	.13	.182	2.54	.072	.101	1800
2000	14.1	4.2	5.88	8.60	1.27	1.78	5.92	.515	.721	4.8	.339	.475	3.6	.158	.221	2.82	.087	.122	2000
2200	15.5	5.15	7.21	9.45	1.51	2.11	6.51	.614	.860	5.3	.417	.584	4.0	.189	.265	3.1	.104	.146	2200
2400	16.9	5.9	8.26	10.3	1.78	2.49	7.10	.72	1.01	5.77	.464	.650	4.3	.219	.307	3.38	.121	.169	2400
2600	18.3	6.87	9.62	11.2	2.07	2.90	7.69	.83	1.16	6.25	.538	.753	4.7	.253	.354	3.67	.141	.197	2600
2800	19.7	7.84	10.98	12.0	2.37	3.32	8.28	.955	1.34	6.73	.632	.885	5.05	.296	.414	3.93	.162	.227	2800
3000	21.1	8.93	12.5	12.9	2.70	3.78	8.88	1.09	1.53	7.2	.71	.994	5.43	.332	.465	4.23	.186	.260	3000
3200	22.5	10.01	14.0	13.8	3.04	4.26	9.5	1.20	1.68	7.7	.748	1.05	5.8	.375	.525	4.5	.208	.291	3200
3500	24.6	11.7	16.4	15.0	3.7	5.18	10.3	1.45	2.03	8.4	.953	1.33	6.3	.44	.616	4.93	.246	.344	3500
3800	26.7	13.6	19.0	16.3	4.26	5.96	11.3	1.68	2.35	9.13	1.10	1.54	6.87	.515	.721	5.35	.287	.402	3800
4200	29.5	16.3	22.8	18.1	5.2	7.28	12.5	2.0	2.80	10.2	1.36	1.90	7.63	.633	.886	5.94	.348	.487	4200
4500	31.6	18.8	26.3	19.3	5.7	7.98	13.3	2.3	3.22	10.8	1.52	2.13	8.13	.70	.980	6.35	.39	.546	4500
5000	35.1	22.95	32.1	21.5	6.95	9.73	14.8	2.8	3.92	12.0	1.82	2.55	9.04	.85	1.19	7.05	.478	.669	5000
5500	38.6	27.3	38.2	23.6	8.05	11.27	16.3	3.35	4.69	13.2	2.16	3.02	9.95	1.02	1.43	7.76	.564	.790	5500
6000				25.8	9.6	13.4	17.7	3.9	5.46	14.4	2.59	3.63	10.9	1.21	1.69	8.46	.67	.938	6000
6500				27.9	11.3	15.8	19.2	4.56	6.38	15.6	3.0	4.20	11.7	1.39	1.95	9.18	.778	1.09	6500
7000				30.1	12.95	18.1	20.7	5.2	7.28	16.9	3.32	4.65	12.7	1.58	2.21	9.88	.896	1.25	7000
8000							23.7	6.68	9.35	19.3	4.13	5.78	14.5	2.03	2.84	11.3	1.14	1.60	8000
9000							26.6	8.3	11.6	21.6	5.16	7.22	16.2	2.52	3.53	12.7	1.41	1.97	9000
10000							29.6	9.9	13.9	24.1	6.77	9.48	18.1	3.14	4.40	14.1	1.71	2.39	10000
12000							35.5	14.3	20.0	28.9	9.35	13.09	21.6	4.3	6.02	16.9	2.4	3.36	12000

8" PIPE 7.625" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.77	.0149	.021
.815	.0165	.023
.86	.018	.025
.95	.021	.029

10" PIPE 9.75" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.89	.0155	.022
.944	.0172	.024
1.01	.019	.027

12" PIPE 11.75" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.963	.0172	.024
1.08	.0213	.030
1.2	.0259	.036
1.32	.0326	.046

14" PIPE 13.00" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
1.21	.0226	.032
1.35	.0255	.036
1.44	.029	.041
1.54	.0325	.046

16" PIPE 15.00" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
1.27	.0199	.028
1.34	.022	.031
1.41	.024	.034
1.55	.0286	.040
1.69	.0338	.047
1.84	.04	.056

18" PIPE 17.00" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
1.97	.044	.062
2.07	.051	.071
2.26	.0576	.081
2.54	.072	.101
2.82	.087	.122
3.1	.104	.146

Friction Losses in Pounds per Square Inch per 100 Feet Length of EXTRA STRONG Pipe Carrying Water

C = 120 — SMOOTH NEW STEEL PIPE C = 100 — ORDINARY 15 YEAR OLD STEEL PIPE

Gallons Per Minute	2½" PIPE 2.323" I. D.			3" PIPE 2.900" I. D.			3½" PIPE 3.364" I. D.			4" PIPE 3.826" I. D.			5" PIPE 4.813" I. D.			6" PIPE 5.761" I. D.			Gallons Per Minute
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	
1																			1
2																			2
3																			3
4																			4
5																			5
6																			6
7																			7
8	.61	.051	.071																8
9	.68	.0615	.086																9
10	.76	.077	.108	.485	.0257	.036													10
12	.91	.106	.148	.572	.035	.049													12
15	1.14	.158	.221	.727	.054	.0756	.54	.023	.032										15
18	1.36	.224	.314	.873	.0756	.1058	.65	.037	.052										18
20	1.51	.272	.381	.97	.0928	.130	.72	.045	.063	.56	.024	.034							20
25	1.9	.413	.578	1.21	.14	.196	.90	.068	.095	.695	.036	.051							25
30	2.27	.577	.808	1.44	.196	.274	1.08	.095	.133	.84	.051	.071	.53	.0167	.023				30
35	2.65	.770	1.08	1.7	.261	.365	1.26	.126	.176	.973	.067	.094	.62	.022	.038				35
40	3.03	.983	1.38	1.94	.338	.473	1.44	.162	.227	1.12	.0878	.123	.71	.0285	.040				40
45	3.41	1.22	1.71	2.18	.416	.582	1.63	.202	.283	1.25	.107	.150	.795	.0344	.048				45
50	3.79	1.48	2.07	2.42	.505	.707	1.80	.245	.343	1.40	.131	.183	.88	.043	.060	.62	.018	.025	50
55	4.16	1.77	2.48	2.67	.603	.844	1.99	.29	.406	1.53	.154	.216	.973	.051	.071	.676	.0209	.029	55
60	4.54	2.08	2.91	2.92	.707	.990	2.17	.342	.479	1.67	.185	.259	1.06	.06	.084	.74	.025	.035	60
65	4.92	2.42	3.39	3.14	.82	1.15	2.35	.384	.538	1.81	.21	.294	1.15	.0688	.096	.80	.0288	.040	65
70	5.30	2.77	3.88	3.39	.94	1.32	2.53	.455	.637	1.95	.244	.342	1.23	.08	.112	.86	.0335	.047	70
75	5.68	3.13	4.38	3.64	1.07	1.50	2.7	.51	.714	2.08	.273	.382	1.33	.0889	.124	.923	.0369	.052	75
80	6.05	3.53	4.94	3.88	1.2	1.68	2.89	.585	.819	2.23	.313	.438	1.41	.102	.143	.98	.0427	.060	80
85	6.43	3.97	5.56	4.1	1.35	1.89	3.05	.65	.910	2.34	.347	.486	1.50	.114	.160	1.04	.0467	.065	85
90	6.81	4.30	6.02	4.33	1.5	2.10	3.25	.73	1.02	2.51	.39	.546	1.59	.127	.178	1.11	.053	.074	90
95	7.19	4.86	6.80	4.57	1.65	2.31	3.4	.80	1.12	2.64	.425	.595	1.67	.143	.200	1.20	.0576	.081	95
100	7.57	5.36	7.50	4.85	1.82	2.55	3.67	.88	1.23	2.79	.474	.664	1.76	.155	.217	1.23	.0645	.090	100
110	8.33	6.4	8.96	5.33	2.17	3.04	3.97	1.05	1.47	3.07	.564	.790	1.95	.181	.253	1.36	.076	.106	110
120	9.08	7.5	10.5	5.8	2.55	3.57	4.33	1.24	1.74	3.35	.66	.924	2.11	.217	.304	1.48	.091	.127	120
130	9.84	8.7	12.2	6.3	2.96	4.14	4.69	1.44	2.02	3.63	.766	1.07	2.3	.252	.353	1.6	.104	.145	130
140	10.6	10.0	14.0	6.8	3.38	4.39	5.05	1.65	2.31	3.91	.88	1.23	2.47	.288	.403	1.72	.12	.168	140
150	11.3	11.4	16.0	7.27	3.88	5.43	5.41	1.88	2.63	4.19	1.0	1.40	2.65	.326	.456	1.85	.136	.190	150
160	12.1	12.8	17.9	7.75	4.34	6.08	5.78	2.1	2.94	4.47	1.12	1.57	2.82	.369	.516	1.97	.154	.216	160
170	12.9	14.3	20.0	8.2	4.80	6.72	6.14	2.35	3.30	4.75	1.26	1.76	3.0	.40	.560	2.08	.169	.237	170
180	13.6	15.9	22.3	8.6	5.4	7.56	6.50	2.62	3.67	5.02	1.4	1.96	3.16	.458	.641	2.22	.19	.266	180
190	14.4	17.6	24.6	9.2	5.9	8.26	6.85	2.9	4.06	5.30	1.55	2.17	3.36	.50	.700	2.34	.206	.364	190
200	15.1	19.3	27.0	9.7	6.57	9.20	7.22	3.19	4.47	5.58	1.7	2.38	3.52	.56	.784	2.46	.232	.325	200
220	16.7	23.0	32.2	10.6	7.85	11.0	7.94	3.8	5.32	6.14	2.03	2.84	3.88	.666	.932	2.71	.277	.388	220
240	18.2	27.1	37.9	11.6	.92	12.9	8.66	4.46	6.24	6.70	2.38	3.33	4.23	.78	1.09	2.96	.32	.448	240
260	19.7	31.3	43.8	12.6	10.66	14.9	9.38	5.18	7.25	7.26	2.77	3.88	4.58	.905	1.27	3.20	.378	.529	260
280	21.2	35.9	50.3	13.5	12.2	17.1	10.1	5.95	8.33	7.82	3.15	4.41	4.94	1.04	1.46	3.45	.434	.608	280
300	22.7	40.8	57.1	14.4	13.9	19.5	10.8	6.75	9.45	8.38	3.6	5.04	5.29	1.18	1.65	3.69	.493	.690	300
320	24.2	44.8	62.7	15.5	15.7	22.0	11.5	7.6	10.6	8.94	4.07	5.70	5.64	1.33	1.86	3.94	.555	.777	320
340	25.8	51.3	71.8	16.3	17.5	24.5	12.3	8.5	11.9	9.50	4.56	6.38	5.99	1.49	2.09	4.19	.62	.868	340
360	27.2	57.4	80.4	17.4	19.1	26.7	13.0	9.5	13.3	10.0	5.05	7.07	6.35	1.65	2.31	4.43	.69	.966	360
380	28.8	62.9	88.1	18.6	21.5	30.1	13.7	10.4	14.6	10.6	5.58	7.81	6.70	1.83	2.56	4.68	.76	1.06	380
400	30.3	69.7	97.6	19.4	23.6	33.0	14.4	11.5	16.1	11.2	6.14	8.60	7.05	2.0	2.80	4.93	.84	1.18	400
450	34.1	86.5	121.	21.8	29.6	41.4	16.2	14.2	19.9	12.5	7.6	10.6	7.95	2.5	3.50	5.54	1.04	1.46	450
500	37.9	105.4	148.	23.2	35.6	49.8	18.1	17.4	24.4	14.0	9.3	13.0	8.82	3.04	4.26	6.16	1.26	1.76	500
550				26.5	42.7	59.8	19.9	20.7	29.0	15.3	11.0	15.4	9.70	3.63	5.08	6.77	1.51	2.11	550
600				29.1	50.3	70.4	21.7	24.4	34.2	16.7	13.0	18.2	10.6	4.25	5.95	7.39	1.77	2.48	600
650				31.4	58.0	81.2	23.5	28.2	39.5	18.1	15.1	21.1	11.5	4.94	6.92	8.00	2.05	2.87	650
700							25.3	32.2	45.1	19.5	17.2	24.1	12.3	5.67	7.94	8.63	2.37	3.32	700
750							27.1	36.8	51.5	20.9	19.6	27.4	13.2	6.46	9.04	9.24	2.68	3.75	750
800							28.9	40.6	56.8	22.3	22.2	31.1	14.1	7.26	10.2	9.85	3.02	4.23	800
850							30.7	46.5	65.1	23.7	24.8	34.7	15.0	8.1	11.3	10.5	3.38	4.73	850
900										25.1	27.5	38.5	15.9	9.0	12.6	11.1	3.76	5.26	900
950										26.5	30.4	42.6	16.7	10.0	14.0	11.7	4.16	5.82	950
1000										27.9	33.4	46.8	17.6	10.9	15.3	12.3	4.56	6.38	1000
1100										30.7	40.0	56.0	19.4	12.7	17.8	13.5	5.46	7.64	1100
1200													21.1	15.3	21.4	14.8	6.42	8.99	1200
1300													22.9	17.7	24.8	16.0	7.41	10.4	1300
1400													24.7	20.4	28.6	17.2	8.2	11.5	1400
1500													26.4	23.2	32.5	18.5	9.7	13.6	1500
1600													28.2	26.0	36.4	19.7	10.9	15.3	1600
1800																22.2	13.5	18.9	1800
2000																24.6	16.4	23.0	2000
2200																27.1	19.6	27.4	2200
2400																29.6	23.0	32.2	2400
2600																			2600
2800																			2800
3000																			3000
3200																			3200
3500																			3500
3800																			3800
4200																			4200
4500																			4500
5000																			5000
5500																			5500
6000																			6000
6500																			6500
7000																			7000
8000																			8000
9000																			9000
10000																			10000
12000																			12000

Gallons Per Minute	20" PIPE 19.00" I. D.			24" PIPE 23.00" I. D.		
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
900						
950						
1000	1.13	.0134	.0188			
1100	1.25	.0167	.0234			
1200	1.35	.019	.027			
1300	1.48	.022	.031			
1400	1.59	.0247	.035	1.08	.0097	.014
1500	1.66	.029	.041	1.13	.0113	.016
1600	1.81	.0327	.046	1.23	.0128	.018
1800	2.04	.041	.057	1.39	.016	.022
2000	2.26	.0495	.069	1.54	.019	.027
2200	2.5	.059	.083	1.69	.023	.032
2400	2.7	.0688	.096	1.85	.0269	.038
2600	2.94	.08	.112	2.0	.031	.043
2800	3.13	.0916	.128	2.15	.036	.050
3000	3.4	.104	.146	2.3	.041	.057
3200	3.62	.114	.160	2.48	.044	.062
3500	3.96	.14	.196	2.7	.0555	.078
3800	4.3	.159	.223	2.92	.063	.088
4200	4.8	.192	.269	3.25	.076	.106
4500	5.1	.22	.308	3.37	.0867	.121
5000	5.66	.26	.364	3.85	.101	.141
5500	6.2	.319	.447	4.24	.125	.175
6000	6.8	.382	.535	4.63	.147	.206
6500	7.36	.437	.612	5.0	.171	.239
7000	7.94	.504	.706	5.4	.198	.277
8000	9.06	.66	.924	6.15	.250	.350
9000	10.02	.797	1.116	6.94	.313	.438
10000	11.3	.98	1.37	7.7	.382	.535
12000	13.6	1.35	1.89	9.24	.530	.742

Friction Losses in Pounds per Square Inch per 100 Feet Length of DOUBLE EXTRA STRONG Pipe Carrying Water

C = 120 — SMOOTH NEW STEEL PIPE C = 100 — ORDINARY 15 YEAR OLD STEEL PIPE

Gallons Per Minute	½" PIPE .252" I. D.			¾" PIPE .434" I. D.			1" PIPE .599" I. D.			1¼" PIPE .896" I. D.			1½" PIPE 1.10" I. D.			Gallons Per Minute
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	
1	6.44	52.7	73.78													1
2	12.9	190.0	266.	4.34	13.6	19.0	2.28	2.8	3.92							2
3	19.2	375.	525.	6.51	28.5	39.9	3.42	5.93	8.30							3
4				8.68	48.7	68.2	4.56	10.3	14.4	2.04	1.43	2.00	1.35	.527	.738	4
5				10.9	73.2	102.5	5.69	15.1	21.1	2.54	2.16	3.02	1.69	.795	1.11	5
6				13.0	103.	144.	6.83	21.4	29.96	3.05	3.03	4.24	2.03	1.09	1.53	6
7				15.2	136.	190.	8.0	27.6	38.6	3.56	4.04	5.66	2.36	1.49	2.09	7
8				17.4	176.	240.	9.11	36.6	51.2	4.07	5.17	7.24	2.70	1.9	2.66	8
9				19.5	218.	305.	10.3	45.0	63.0	4.57	6.33	8.86	3.04	2.37	3.32	9
10				21.7	265.	371.	11.4	55.0	77.0	5.09	7.77	10.88	3.38	2.88	4.03	10
12							13.7	77.7	108.8	6.11	10.9	15.3	4.05	4.03	5.64	12
15							17.2	117.	163.8	7.6	16.3	22.8	5.1	6.19	8.67	15
18							20.5	164.	229.6	9.16	23.2	32.5	6.08	8.37	11.7	18
20							22.7	201.	281.4	10.2	28.2	39.5	6.75	10.4	14.6	20
25							28.6	296.	414.4	12.7	42.5	59.5	8.5	15.5	21.7	25
30										15.3	59.5	83.3	10.1	22.0	30.8	30
35										17.8	79.0	110.	11.9	28.6	40.0	35
40										20.4	100.1	140.	13.5	37.5	52.5	40
45										23.0	126.	176.	15.3	44.7	62.6	45
50										25.4	153.	214.	16.9	56.4	79.0	50
55										28.0	178.	249.	18.6	67.3	94.2	55
60										30.5	214.	300.	20.3	79.0	110.6	60
65										33.0	252.	353.	21.9	92.0	129.	65
70										35.6	286.	400.	23.6	105.0	147.	70
75													25.3	119.5	167.	75
80													27.0	135.0	189.	80
85													28.7	150.	210.	85
90													30.4	167.	234.	90
95													32.1	185.	259.	95
100													33.8	203.	284.	100
110																110
120																120
130																130
140																140
150																150
160																160
170																170
180																180
190																190
200																200
220																220
240																240
260																260
280																280
300																300
320																320
340																340
360																360
380																380
400																400
450																450
500																500
550																550
600																600
650																650
700																700
750																750
800																800
850																850
900																900
950																950
1000																1000
1100																1100
1200																1200
1300																1300
1400																1400
1500																1500
1600																1600
1800																1800
2000																2000
2200																2200
2400																2400
2600																2600
2800																2800
3000																3000
3200																3200
3500																3500
3800																3800
4200																4200
4500																4500
5000																5000
5500																5500

5" PIPE 4.063" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.75	.0384	.0538
.87	.0495	.0693
1.00	.0657	.0920
1.12	.080	.112
1.24	.099	.139
1.37	.111	.155
1.49	.139	.195
1.61	.157	.220
1.74	.185	.259
1.86	.202	.283
1.99	.236	.330
2.10	.254	.356
2.24	.294	.412
2.36	.318	.445
2.49	.356	.498
2.72	.41	.574
2.98	.500	.700
3.22	.564	.790
3.48	.667	.934
3.72	.726	1.02
3.98	.853	1.19
4.20	.92	1.29
4.48	1.05	1.47
4.70	1.13	1.58
4.98	1.28	1.79
5.47	1.53	2.14
5.97	1.81	2.53
6.47	2.09	2.93
6.97	2.39	3.35
7.46	2.72	3.81
7.96	3.08	4.31
8.46	3.44	4.82
8.96	3.82	5.35
9.45	4.22	5.91
9.95	4.65	6.51
11.10	5.67	7.94
12.4	7.00	9.80
13.7	8.37	11.7
14.9	9.84	13.8
16.2	11.40	16.0
17.4	13.10	18.3
18.7	14.8	20.7
19.9	16.7	23.4
21.1	18.6	26.0
22.4	20.8	29.1
23.6	23.5	32.9
24.9	25.3	35.4
27.4	30.2	42.3
29.8	35.4	49.6
32.3	41.2	57.7
34.8	47.2	66.1
37.3	53.6	75.0
39.8	60.5	84.7
44.5	73.8	103.

6" PIPE 4.897" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
.85	.0394	.0552
.934	.0467	.0654
1.02	.055	.077
1.10	.063	.088
1.19	.0735	.103
1.27	.0824	.115
1.36	.094	.132
1.44	.103	.144
1.53	.117	.164
1.61	.128	.179
1.70	.142	.199
1.86	.167	.234
2.04	.202	.283
2.20	.229	.321
2.38	.265	.371
2.54	.301	.421
2.72	.341	.477
2.90	.372	.521
3.06	.423	.592
3.13	.458	.641
3.40	.513	.718
3.74	.610	.854
4.08	.720	1.01
4.42	.835	1.17
4.77	.956	1.34
5.11	1.09	1.53
5.45	1.23	1.72
5.79	1.37	1.92
6.13	1.52	2.13
6.47	1.68	2.35
6.81	1.85	2.59
7.66	2.30	3.22
8.51	2.80	3.92
9.37	3.35	4.69
10.2	3.91	5.47
11.10	4.54	6.36
11.9	5.20	7.28
12.8	5.93	8.30
13.6	6.67	9.34
14.5	7.48	10.5
15.3	8.30	11.6
16.2	9.20	12.9
17.0	10.10	14.1
18.7	12.0	16.8
20.4	14.1	19.7
22.1	16.4	23.0
23.8	18.8	26.3
25.5	21.3	29.8
27.2	24.1	33.7
30.6	29.9	41.9
34.0	36.3	50.8
37.4	43.4	60.8
40.8	50.8	71.1

8" PIPE 6.875" I. D.		
Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100
1.12	.044	.062
1.21	.051	.071
1.30	.058	.081
1.38	.065	.091
1.47	.073	.102
1.56	.081	.113
1.64	.089	.125
1.73	.098	.137
1.90	.117	.164
2.07	.138	.193
2.25	.160	.224
2.42	.184	.258
2.59	.209	.293
2.77	.230	.322
2.93	.259	.363
3.11	.287	.402
3.29	.323	.452
3.46	.354	.496
3.89	.440	.616
4.32	.536	.750
4.75	.640	.896
5.19	.750	1.05
5.62	.860	1.20
6.05	.990	1.39
6.49	1.13	1.58
6.91	1.28	1.79
7.35	1.43	2.00
7.78	1.59	2.23
8.21	1.76	2.46
8.64	1.93	2.70
9.50	2.30	3.22
10.4	2.70	3.78
11.2	3.20	4.48
12.1	3.60	5.04
13.0	4.10	5.74
13.8	4.63	6.48
15.6	5.74	8.04
17.3	7.00	9.80
19.0	8.32	11.6
20.7	9.8	12.9
22.5	11.3	15.8
24.2	13.0	18.2
25.9	14.8	20.7
27.7	16.3	22.8
30.2	19.6	27.4
32.8	22.4	31.4
36.3	27.0	37.8
38.9	31.4	44.0
43.2	38.0	53.2
47.5	45.3	63.4

Friction Losses in Pounds per Square Inch per 100 Feet Length of DOUBLE EXTRA STRONG Pipe Carrying Water

C = 120 — SMOOTH NEW STEEL PIPE C = 100 — ORDINARY 15 YEAR OLD STEEL PIPE

Gallons Per Minute	2" PIPE 1.503" I. D.			2½" PIPE 1.771" I. D.			3" PIPE 2.30" I. D.			3½" PIPE 2.728" I. D.			4" PIPE 3.152" I. D.			Gallons Per Minute
	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	Vel. Ft/Sec	Loss Pounds C=120	Loss Pounds C=100	
1																1
2																2
3																3
4																4
5	.90	.174	.244													5
6	1.09	.244	.342													6
7	1.27	.325	.455													7
8	1.45	.415	.581	1.04	.185	.259										8
9	1.63	.517	.724	1.17	.228	.319										9
10	1.81	.63	.882	1.30	.283	.396	.77	.0795	.111							10
12	2.17	.883	1.24	1.56	.396	.554	.926	.110	.143							12
15	2.71	1.32	1.85	1.96	.593	.830	1.16	.168	.235	.82	.0645	.0903				15
18	3.25	1.87	2.62	2.34	.84	1.18	1.39	.234	.328	.984	.101	.141				18
20	3.62	2.27	3.18	2.73	1.02	1.43	1.54	.286	.400	1.10	.125	.175	.82	.0616	.086	20
25	4.5	3.38	4.73	3.27	1.52	2.13	1.98	.434	.608	1.37	.188	.263	1.02	.085	.119	25
30	5.43	4.8	6.72	4.00	2.16	3.02	2.32	.606	.848	1.65	.264	.370	1.23	.131	.183	30
35	6.33	6.4	8.96	4.56	2.88	4.03	2.7	.805	1.13	1.92	.35	.490	1.43	.171	.239	35
40	7.23	8.2	11.5	5.21	3.68	5.15	3.09	1.04	1.46	2.2	.45	.630	1.65	.222	.311	40
45	8.14	10.1	14.1	5.86	4.58	6.41	3.47	1.28	1.79	2.47	.56	.784	1.84	.27	.378	45
50	9.04	12.3	17.2	6.51	5.57	7.80	3.86	1.56	2.18	2.74	.68	.952	2.06	.338	.473	50
55	9.95	14.7	20.6	7.16	6.64	9.30	4.25	1.85	2.59	3.0	.815	1.14	2.26	.398	.557	55
60	10.9	16.9	23.7	7.81	7.76	10.9	4.63	2.18	3.05	3.29	.95	1.28	2.47	.47	.658	60
65	11.8	20.0	28.0	8.47	9.05	12.7	5.02	2.54	3.56	3.64	1.07	1.50	2.66	.528	.739	65
70	12.7	23.0	32.2	9.12	10.4	14.6	5.40	2.9	4.06	3.84	1.27	1.78	2.88	.625	.875	70
75	13.6	26.1	36.5	9.77	11.8	16.5	5.79	3.32	4.65	4.1	1.41	1.97	3.08	.70	.980	75
80	14.5	29.5	41.3	10.4	13.0	18.2	6.18	3.7	5.18	4.39	1.62	2.27	3.29	.803	1.12	80
85	15.4	32.8	45.9	11.1	14.8	20.7	6.56	4.15	5.81	4.65	1.79	2.51	3.48	.866	1.21	85
90	16.3	36.6	51.2	11.7	16.5	23.1	6.95	4.6	6.44	4.94	2.02	2.83	3.70	1.01	1.41	90
95	17.2	40.5	56.7	12.4	18.2	25.5	7.34	5.1	7.14	5.2	2.2	3.08	3.88	1.10	1.54	95
100	18.1	44.6	62.4	13.0	20.0	28.0	7.72	5.6	7.84	5.49	2.45	3.43	4.11	1.21	1.69	100
110	19.9	53.3	74.6	14.3	23.9	33.5	8.49	6.7	9.38	6.04	2.92	4.09	4.52	1.47	2.06	110
120	21.7	62.0	86.8	15.6	28.1	39.3	9.27	7.9	11.06	6.59	3.42	4.79	4.94	1.70	2.38	120
130	23.5	72.5	101.5	16.9	32.5	45.5	10.0	9.15	12.8	7.13	3.98	5.49	5.35	1.97	2.76	130
140	25.3	83.0	116.	18.2	37.5	52.5	10.8	10.5	14.7	7.68	4.60	6.44	5.76	2.26	3.16	140
150	27.1	94.5	132.	19.5	42.5	59.5	11.6	11.9	16.7	8.23	5.20	7.28	6.17	2.57	3.60	150
160	28.9	106.	148.	20.8	47.7	66.8	12.4	13.4	18.8	8.78	5.86	8.20	6.58	2.90	4.06	160
170	30.7	119.	167.	22.2	53.6	75.	13.1	14.8	20.7	9.33	6.55	9.17	6.99	3.25	4.55	170
180	32.5	132.	185.	23.4	59.5	83.3	13.9	16.3	22.8	9.88	7.10	9.94	7.40	3.6	5.04	180
190	34.4	146.	204.	24.7	65.7	92.0	14.6	18.2	25.5	10.4	8.05	11.3	7.82	3.97	5.56	190
200	36.2	160.	224.	26.1	72.3	101.	15.4	20.2	28.3	11.	8.85	12.4	8.23	4.37	6.12	200
220	39.8	190.	266.	28.7	86.	120.	17.	24.2	33.9	12.1	10.5	14.7	9.05	5.2	7.28	220
240	43.4	225.	315.	31.3	101.	141.	18.5	28.4	39.8	13.2	12.4	17.4	9.87	6.14	8.60	240
260	47.0	260.	364.	33.9	117.	164.	20.1	32.8	45.9	14.3	14.3	20.	10.7	7.10	9.94	260
280				36.5	135.	189.	21.6	38.0	53.	15.4	16.4	23.	11.5	7.84	10.98	280
300				39.1	153.	214.	23.2	42.8	59.9	16.5	18.7	26.2	12.3	9.26	13.	300
320				41.8	170.	238.	24.7	48.4	67.8	17.6	21.	29.4	13.2	10.5	14.7	320
340				44.4	188.	263.	26.3	54.3	76.	18.7	23.6	33.	14.	11.7	16.4	340
360				47.	206.	288.	27.8	60.3	84.4	19.8	26.2	36.7	14.8	13.0	18.2	360
380				49.5	233.	326.	29.3	66.4	93.	20.9	29.0	40.8	15.6	14.	19.6	380
400				52.1	261.	365.	30.9	73.2	102.	22.	32.	44.8	16.5	15.8	22.1	400
450							34.7	89.4	125.	24.6	39.6	55.4	18.6	19.5	27.3	450
500							38.6	110.	154.	27.4	47.	65.8	20.6	23.8	33.3	500
550							42.5	132.	185.	30.2	57.4	80.4	22.6	28.5	39.9	550
600							46.3	154.	216.	32.9	67.6	94.6	24.7	33.5	46.9	600
650							50.2	179.	251.	37.5	78.	109.	26.7	38.8	54.3	650
700										38.4	89.5	125.	28.8	44.4	62.2	700
750										41.2	102.	143.	30.8	50.6	70.8	750
800										43.9	115.	161.	32.9	56.8	79.5	800
850										46.7	128.	179.	35.	63.7	89.2	850
900													37.	70.8	99.1	900
950													39.1	78.5	110.	950
1000													41.1	86.	120.	1000
1100													45.2	103.	144.	1100
1200																1200
1300																1300
1400																1400
1500																1500
1600																1600
1800																1800
2000																2000
2200																2200
2400																2400
2600																2600
2800																2800
3000																3000
3200																3200
3500																3500
3800																3800
4200																4200
4500																4500
5000																5000
5500																5500

FLOW THROUGH ORIFICES, NOZZLES AND SHORT TUBES

Where $\frac{d}{D}$ is greater than 0.3

$$Q = 19.636\, Kd^2 \sqrt{h} \sqrt{\frac{1}{1-\left(\frac{d}{D}\right)^4}}$$

or

$$Q = 29.81\, Kd^2 \sqrt{p} \sqrt{\frac{1}{1-\left(\frac{d}{D}\right)^4}}$$

Where $\frac{d}{D}$ is less than 0.3

$$Q = 19.636\, Kd^2 \sqrt{h}$$

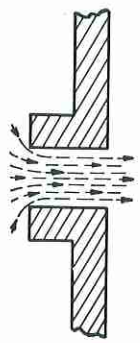
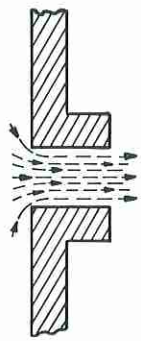
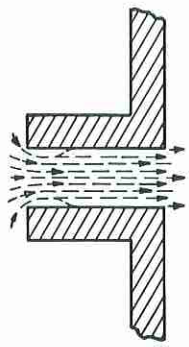
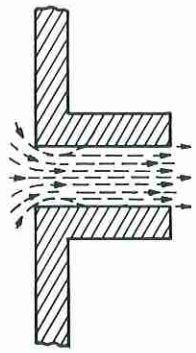
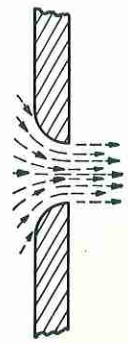
or

$$Q = 29.81\, Kd^2 \sqrt{p}$$

The approximate discharge or flow of water through pipe orifices can be calculated by the formulas given above, where,

- Q = Flow of water, in U.S. gallons per minute.
- d = Diameter of orifice, in inches.
- D = Inside diameter of pipe in which orifice is placed, in inches.
- h = Differential head across orifice in feet of water.
- p = Differential pressure across orifice in pounds per square inch gage.
- K = Average coefficient of discharge.

The approximate discharge of water flowing through orifices, short tubes, or nozzles freely to the atmosphere is customarily determined by multiplying the theoretical discharge by the average discharge coefficient (K) which varies between 0.52 for short re-entrant tubes to 0.98 for well-rounded orifices and smooth, well tapered nozzles. Several such types are illustrated below, followed by the table of theoretical discharges in U. S. Gallons per minute.

RE-ENTRANT TUBE	THIN PLATE SHARP EDGE	SQUARE EDGE	RE-ENTRANT TUBE	SQUARE EDGE	WELL ROUNDED
					
Length = ½ to 1 Dia.		Stream Clears Sides	Length = 2½ Dia.	Tube Flows Full	
K = .52	K = .61	K = .61	K = .73	K = .82	K = .98

THEORETICAL DISCHARGE OF WATER IN U. S. GALLONS PER MINUTE

POUNDS P. S. I.	VELOCITY OF DISCHARGE FT./SEC.	DIAMETER OF ORIFICE OR NOZZLE IN INCHES													
		1/64	1/32	1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
1	12.20	.0076	.0320	.118	.470	1.05	1.90	4.20	7.45	11.72	16.8	20.3	29.9	37.8	46.7
2	17.26	.0102	.0430	.167	.664	1.49	2.71	5.95	10.50	16.55	23.8	32.4	42.3	53.5	66.0
3	21.12	.0132	.0527	.205	.814	1.82	3.32	7.30	12.90	20.30	29.1	39.7	51.6	65.5	80.9
4	24.41	.0152	.0610	.237	.938	2.10	3.84	8.45	14.90	23.40	33.6	45.8	59.8	75.6	93.5
5	27.22	.0170	.0680	.264	1.050	2.34	4.27	9.40	16.60	26.10	37.6	51.1	66.7	84.3	104.0
6	29.87	.0187	.0745	.289	1.150	2.57	4.68	10.30	18.20	28.60	41.2	56.0	73.0	92.5	114.0
7	32.36	.0202	.0808	.314	1.250	2.79	5.08	11.15	19.60	31.20	44.6	60.8	79.2	100.5	124.0
8	34.53	.0216	.0862	.335	1.330	2.98	5.42	11.90	21.20	33.10	47.7	65.0	84.6	107.0	132.0
9	36.70	.0230	.0917	.354	1.410	3.16	5.77	12.70	21.80	35.20	50.6	69.0	89.8	114.0	141.0
10	38.62	.0242	.0965	.374	1.480	3.32	5.91	13.30	23.60	36.90	53.1	72.4	94.5	120.0	148.0

FLOW THROUGH ORIFICES, NOZZLES AND SHORT TUBES (Cont.)

THEORETICAL DISCHARGE OF WATER IN U. S. GALLONS PER MINUTE

POUNDS P. S. I.	VELOCITY OF DISCHARGE FT./SEC.	DIAMETER OF ORIFICE OR NOZZLE IN INCHES													
		1/64	1/32	1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
20	54.60	.0342	.137	.530	2.09	4.69	8.35	19.8	33.4	52.2	75.	102.	134.	169.	209.
30	66.80	.0418	.167	.649	2.56	5.75	10.20	23.0	40.9	63.9	92.	125.	164.	207.	256.
40	77.09	.0483	.192	.746	2.96	6.64	11.80	26.6	47.3	73.8	106.	145.	188.	239.	296.
50	86.32	.0540	.216	.836	3.30	7.41	13.20	29.7	52.8	82.5	119.	162.	211.	267.	330.
60	94.75	.0593	.237	.918	3.62	8.12	14.50	32.5	57.8	90.4	130.	177.	231.	293.	362.
70	101.98	.0638	.252	.990	3.91	8.78	15.70	35.2	62.5	97.7	141.	191.	250.	317.	391.
80	109.21	.0684	.272	1.050	4.18	9.39	16.70	37.6	66.8	104.0	150.	205.	267.	338.	418.
90	116.03	.0725	.291	1.110	4.43	9.95	17.70	39.9	70.8	111.0	159.	217.	284.	359.	443.
100	122.06	.0764	.305	1.17	4.67	10.50	18.6	42.1	75.	117.	168.	229.	299.	378.	467.
200	172.64	.1080	.432	1.65	6.61	14.80	26.4	59.5	106.	165.	238.	323.	422.	535.	660.
300	211.19	.1320	.528	2.02	8.08	18.20	32.4	72.8	129.	202.	291.	396.	517.	655.	808.
400	244.11	.1525	.610	2.37	9.40	21.00	38.3	84.3	149.	234.	336.	458.	598.	756.	935.
500	267.40	.1670	.667	2.59	10.30	23.10	41.9	92.4	163.	261.	368.	502.	654.	827.	1025.
600	298.72	.1862	.745	2.89	11.50	25.70	46.7	103.0	182.	286.	411.	560.	730.	924.	1140.
700	322.81	.2018	.808	3.13	12.40	27.90	50.5	112.0	196.	312.	446.	607.	792.	1000.	1240.
800	345.30	.2160	.863	3.34	13.30	29.80	54.2	119.0	212.	331.	476.	649.	845.	1070.	1322.
900	366.97	.2295	.918	3.54	14.10	31.60	57.4	126.5	218.	352.	506.	690.	898.	1138.	1408.
1000	385.44	.241	.96	3.73	14.80	33.2	60.5	133.0	235.	369.	532.	725.	943.	1192.	1475.
1100	404.71	.252	1.01	3.92	15.55	34.9	63.5	140.0	248.	388.	557.	760.	990.	1252.	1550.
1200	422.38	.264	1.05	4.10	16.20	36.4	66.0	146.5	258.	405.	582.	782.	1030.	1310.	1620.
1300	441.65	.276	1.10	4.28	16.95	38.1	69.3	152.5	270.	423.	608.	827.	1080.	1365.	1685.
1400	456.10	.285	1.14	4.42	17.55	39.3	71.5	157.5	279.	438.	630.	857.	1115.	1410.	1740.
1500	473.77	.296	1.18	4.59	18.20	40.8	74.3	164.0	288.	454.	653.	894.	1160.	1465.	1810.
1600	488.23	.306	1.22	4.74	18.80	42.2	76.5	169.0	299.	467.	674.	923.	1195.	1510.	1870.
1700	503.48	.315	1.26	4.89	19.40	43.5	79.0	174.0	308.	483.	695.	952.	1230.	1560.	1930.
1800	518.74	.325	1.29	5.03	19.95	44.7	81.4	179.5	318.	498.	715.	980.	1270.	1606.	1970.
1900	531.59	.333	1.33	5.15	20.40	46.0	83.5	183.5	326.	510.	732.	1002.	1300.	1645.	2030.
2000	546.04	.342	1.36	5.30	21.0	47.2	85.8	189.	335.	524.	753.	1033.	1337.	1695.	2080.
2200	571.73	.357	1.43	5.56	22.0	49.3	89.0	197.	350.	549.	788.	1080.	1400.	1770.	2185.
2400	598.24	.375	1.49	5.80	23.2	51.6	93.7	207.	366.	574.	825.	1130.	1465.	1855.	2290.
2600	623.13	.390	1.56	6.05	24.0	53.8	97.8	216.	382.	598.	860.	1180.	1525.	1930.	2380.
2800	644.81	.403	1.61	6.25	24.8	55.6	101.0	223.	394.	617.	890.	1220.	1575.	1995.	2460.
3000	669.70	.418	1.67	6.50	25.7	57.7	105.0	231.	409.	642.	923.	1260.	1635.	2080.	2570.
3200	690.58	.432	1.72	6.70	26.5	59.5	108.5	238.	422.	664.	952.	1305.	1690.	2140.	2665.
3400	711.46	.445	1.78	6.90	27.4	61.4	112.0	246.	436.	683.	982.	1345.	1740.	2200.	2720.
3600	730.73	.462	1.83	7.08	28.2	63.2	115.0	253.	448.	700.	1010.	1380.	1790.	2265.	2800.
3800	750.80	.475	1.87	7.30	28.9	64.8	118.0	260.	458.	722.	1048.	1418.	1840.	2330.	2870.
4000	770.88	.483	1.93	7.50	29.7	66.5	121.0	267.	472.	741.	1064.	1457.	1880.	2390.	2950.
4200	790.95	.495	1.98	7.69	30.4	68.4	124.0	274.	485.	760.	1092.	1495.	1935.	2450.	3030.
4400	803.00	.504	2.01	7.80	31.0	69.3	126.0	278.	492.	770.	1110.	1520.	1970.	2490.	3070.
4600	827.09	.518	2.07	8.03	31.8	71.3	130.0	286.	507.	795.	1142.	1562.	2023.	2560.	3160.
4800	843.15	.527	2.11	8.18	32.4	72.7	132.5	292.	516.	809.	1163.	1591.	2060.	2610.	3230.
5000	859.21	.536	2.14	8.32	33.1	74.0	135.0	297.	526.	825.	1185.	1622.	2100.	2685.	3280.

PROPERTIES OF SUPERHEATED STEAM*

ABS. PRESS PSI (Sat. Temp.)		TEMPERATURE—DEGREES FAHRENHEIT												
		200	300	400	500	600	700	800	900	1000	1100	1200	1400	1600
1 (101.74)	v....	392.6	452.3	512.0	571.6	631.2	690.8	750.4	809.9	869.5	929.1	988.7	1107.8	1227.0
	h....	1150.4	1195.8	1241.7	1288.3	1335.7	1383.8	1432.8	1482.7	1533.5	1585.2	1637.7	1745.7	1857.5
	s....	2.0512	2.1153	2.1720	2.2233	2.2702	2.3137	2.3542	2.3923	2.4283	2.4625	2.4952	2.5566	2.6137
5 (162.24)	v....	78.16	90.25	102.26	114.22	126.16	138.10	150.03	161.95	173.87	185.79	197.71	221.6	245.4
	h....	1148.8	1195.0	1241.2	1288.0	1335.4	1383.6	1432.7	1482.6	1533.4	1585.1	1637.7	1745.7	1857.4
	s....	1.8718	1.9370	1.9942	2.0456	2.0927	2.1361	2.1767	2.2148	2.2509	2.2851	2.3178	2.3792	2.4363
10 (193.21)	v....	38.85	45.00	51.04	57.05	63.03	69.01	74.98	80.95	86.92	92.88	98.84	110.77	122.69
	h....	1146.6	1193.9	1240.6	1287.5	1335.1	1383.4	1432.5	1482.4	1533.2	1585.0	1637.6	1745.6	1857.3
	s....	1.7927	1.8595	1.9172	1.9689	2.0160	2.0596	2.1002	2.1383	2.1744	2.2086	2.2413	2.3028	2.3598
14.696 (212.00)	v....	.....	30.53	34.68	38.78	42.86	46.94	51.00	55.07	59.13	63.19	67.25	75.37	83.48
	h....	.....	1192.8	1239.9	1287.1	1334.8	1383.2	1432.3	1482.3	1533.1	1584.8	1637.5	1745.5	1857.3
	s....	.....	1.8160	1.8743	1.9261	1.9734	2.0170	2.0576	2.0958	2.1319	2.1662	2.1989	2.2603	2.3174
20 (227.96)	v....	.....	22.36	25.43	28.46	31.47	34.47	37.46	40.45	43.44	46.42	49.41	55.37	61.34
	h....	.....	1191.6	1239.2	1286.6	1334.4	1382.9	1432.1	1482.1	1533.0	1584.7	1637.4	1745.4	1857.2
	s....	.....	1.7808	1.8396	1.8918	1.9392	1.9829	2.0235	2.0618	2.0978	2.1321	2.1648	2.2263	2.2834
40 (267.25)	v....	.....	11.040	12.628	14.168	15.688	17.198	18.702	20.20	21.70	23.20	24.69	27.68	30.66
	h....	.....	1186.8	1236.5	1284.8	1333.1	1381.9	1431.3	1481.4	1532.4	1584.3	1637.0	1745.1	1857.0
	s....	.....	1.6994	1.7608	1.8140	1.8619	1.9058	1.9467	1.9850	2.0212	2.0555	2.0883	2.1498	2.2069
60 (292.71)	v....	.....	7.259	8.357	9.403	10.427	11.441	12.449	13.452	14.454	15.453	16.451	18.446	20.44
	h....	.....	1181.6	1233.6	1283.0	1331.8	1380.9	1430.5	1480.8	1531.9	1583.8	1636.6	1744.8	1856.7
	s....	.....	1.6492	1.7135	1.7678	1.8162	1.8605	1.9015	1.9400	1.9762	2.0106	2.0434	2.1049	2.1621
80 (312.03)	v....	.....	.....	6.220	7.020	7.797	8.562	9.322	10.077	10.830	11.582	12.332	13.830	15.325
	h....	.....	.....	1230.7	1281.1	1330.5	1379.9	1429.7	1480.1	1531.3	1583.4	1636.2	1744.5	1856.5
	s....	.....	.....	1.6791	1.7346	1.7836	1.8281	1.8694	1.9079	1.9442	1.9787	2.0115	2.0731	2.1303
100 (327.81)	v....	.....	.....	4.937	5.589	6.218	6.835	7.446	8.052	8.656	9.259	9.860	11.060	12.258
	h....	.....	.....	1227.6	1279.1	1329.1	1378.9	1428.9	1479.5	1530.8	1582.9	1635.7	1744.2	1856.2
	s....	.....	.....	1.6518	1.7085	1.7581	1.8029	1.8443	1.8829	1.9193	1.9538	1.9867	2.0484	2.1056
120 (341.25)	v....	.....	.....	4.081	4.636	5.165	5.683	6.195	6.702	7.207	7.710	8.212	9.214	10.213
	h....	.....	.....	1224.4	1277.2	1327.7	1377.8	1428.1	1478.8	1530.2	1582.4	1635.3	1743.9	1856.0
	s....	.....	.....	1.6287	1.6869	1.7370	1.7822	1.8237	1.8625	1.8990	1.9335	1.9664	2.0281	2.0854
140 (353.02)	v....	.....	.....	3.468	3.954	4.413	4.861	5.301	5.738	6.172	6.604	7.035	7.895	8.752
	h....	.....	.....	1221.1	1275.2	1326.4	1376.8	1427.3	1478.2	1529.7	1581.9	1634.9	1743.5	1855.7
	s....	.....	.....	1.6087	1.6683	1.7190	1.7645	1.8063	1.8451	1.8817	1.9163	1.9493	2.0110	2.0683
160 (363.53)	v....	.....	.....	3.008	3.443	3.849	4.244	4.631	5.015	5.396	5.775	6.152	6.906	7.656
	h....	.....	.....	1217.6	1273.1	1325.0	1375.7	1426.4	1477.5	1529.1	1581.4	1634.5	1743.2	1855.5
	s....	.....	.....	1.5908	1.6519	1.7033	1.7491	1.7911	1.8301	1.8667	1.9014	1.9344	1.9962	2.0535
180 (373.06)	v....	.....	.....	2.649	3.044	3.411	3.764	4.110	4.452	4.792	5.129	5.466	6.136	6.804
	h....	.....	.....	1214.0	1271.0	1323.5	1374.7	1425.6	1476.8	1528.6	1581.0	1634.1	1742.9	1855.2
	s....	.....	.....	1.5745	1.6373	1.6894	1.7355	1.7776	1.8167	1.8534	1.8882	1.9212	1.9831	2.0404
200 (381.79)	v....	.....	.....	2.361	2.726	3.060	3.380	3.693	4.002	4.309	4.613	4.917	5.521	6.123
	h....	.....	.....	1210.3	1268.9	1322.1	1373.6	1424.8	1476.2	1528.0	1580.5	1633.7	1742.6	1855.0
	s....	.....	.....	1.5594	1.6240	1.6767	1.7232	1.7655	1.8048	1.8415	1.8763	1.9094	1.9713	2.0287
250 (400.59)	v....	.....	.....	.....	2.151	2.427	2.688	2.942	3.192	3.439	3.684	3.928	4.413	4.896
	h....	.....	.....	.....	1263.4	1318.5	1371.0	1422.7	1474.5	1526.6	1579.3	1632.7	1741.8	1854.4
	s....	.....	.....	.....	1.5949	1.6495	1.6969	1.7397	1.7793	1.8162	1.8512	1.8843	1.9404	2.0039
300 (417.33)	v....	.....	.....	.....	1.7675	2.005	2.227	2.442	2.652	2.859	3.065	3.269	3.674	4.078
	h....	.....	.....	.....	1257.6	1314.7	1368.3	1420.6	1472.8	1525.2	1578.1	1631.7	1741.0	1853.7
	s....	.....	.....	.....	1.5701	1.6268	1.6751	1.7184	1.7582	1.7954	1.8305	1.8638	1.9260	1.9835
350 (431.72)	v....	.....	.....	.....	1.4923	1.7036	1.8980	2.084	2.266	2.445	2.622	2.798	3.147	3.493
	h....	.....	.....	.....	1251.5	1310.9	1365.5	1418.5	1471.1	1523.8	1577.0	1630.7	1740.3	1853.1
	s....	.....	.....	.....	1.5481	1.6070	1.6563	1.7002	1.7403	1.7777	1.8130	1.8463	1.9086	1.9663
400 (444.59)	v....	.....	.....	.....	1.2851	1.4770	1.6508	1.8161	1.9767	2.134	2.290	2.445	2.751	3.055
	h....	.....	.....	.....	1245.1	1306.9	1362.7	1416.4	1469.4	1522.4	1575.8	1629.6	1739.5	1852.5
	s....	.....	.....	.....	1.5281	1.5894	1.6398	1.6842	1.7247	1.7623	1.7977	1.8311	1.8936	1.9513
450 (456.28)	v....	.....	.....	.....	1.1231	1.3005	1.4584	1.6074	1.7516	1.8928	2.032	2.170	2.443	2.714
	h....	.....	.....	.....	1238.4	1302.8	1359.9	1414.3	1467.7	1521.0	1574.6	1628.6	1738.7	1851.9
	s....	.....	.....	.....	1.5095	1.5735	1.6250	1.6699	1.7108	1.7486	1.7841	1.8177	1.8803	1.9381
500 (467.01)	v....	.....	.....	.....	0.9927	1.1591	1.3044	1.4405	1.5715	1.6996	1.8256	1.9504	2.197	2.442
	h....	.....	.....	.....	1231.3	1298.6	1357.0	1412.1	1466.0	1519.6	1573.4	1627.6	1737.9	1851.3
	s....	.....	.....	.....	1.4919	1.5588	1.6115	1.6571	1.6982	1.7363	1.7719	1.8056	1.8683	1.9262
550 (476.94)	v....	.....	.....	.....	0.8852	1.0431	1.1783	1.3038	1.4241	1.5414	.....	1.7706	1.9957	2.219
	h....	.....	.....	.....	1223.7	1294.3	1354.0	1409.9	1464.3	1518.2	.....	1626.6	1737.1	1850.6
	s....	.....	.....	.....	1.4751	1.5451	1.5991	1.6452	1.6868	1.7250	.....	1.7946	1.8575	1.9155
600 (486.21)	v....	.....	.....	.....	0.7947	0.9463	1.0732	1.1899	1.3013	1.4096	.....	1.6208	1.8279	2.033
	h....	.....	.....	.....	1215.7	1289.9	1351.1	1407.7	1462.5	1516.7	.....	1625.5	1736.3	1850.0
	s....	.....	.....	.....	1.4586	1.5323	1.5875	1.6343	1.6762	1.7147	.....	1.7846	1.8476	1.9056

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v – specific volume, cu. ft. per lb.
h – enthalpy, Btu per lb.
s – entropy, Btu per deg. F. per lb.

PROPERTIES OF SUPERHEATED STEAM*

ABS. PRESS. PSI (Sat. Temp.)		TEMPERATURE — DEGREES FAHRENHEIT												
		500	540	560	600	640	660	700	800	900	1000	1200	1400	1600
650 (494.90)	v....	0.7173	0.7814	0.8103	0.8641	0.9140	0.9379	0.9841	1.0934	1.1973	1.2981	1.4940	1.6858	1.8753
	h....	1207.2	1241.7	1257.0	1285.3	1311.4	1323.9	1348.0	1405.4	1460.8	1515.3	1624.5	1735.5	1849.4
	s....	1.4424	1.4776	1.4928	1.5201	1.5443	1.5555	1.5767	1.6242	1.6665	1.7052	1.7753	1.8384	1.8966
700 (503.10)	v....	.....	0.7134	0.7416	0.7934	0.8411	0.8639	0.9077	1.0108	1.1082	1.2024	1.3853	1.5641	1.7405
	h....	.....	1235.0	1251.1	1280.6	1307.5	1320.3	1345.0	1403.2	1459.0	1513.9	1623.5	1734.8	1848.8
	s....	.....	1.4640	1.4800	1.5084	1.5333	1.5449	1.5665	1.6147	1.6573	1.6963	1.7666	1.8299	1.8881
750 (510.86)	v....	.....	0.6540	0.6816	0.7319	0.7778	0.7996	0.8414	0.9391	1.0310	1.1196	1.2912	1.4586	1.6236
	h....	.....	1227.9	1245.0	1275.7	1303.5	1316.6	1341.8	1400.9	1457.2	1512.4	1622.4	1734.0	1848.1
	s....	.....	1.4507	1.4676	1.4972	1.5229	1.5347	1.5568	1.6057	1.6487	1.6879	1.7586	1.8220	1.8803
800 (518.23)	v....	.....	0.6015	0.6288	0.6779	0.7223	0.7433	0.7833	0.8763	0.9633	1.0470	1.2088	1.3662	1.5214
	h....	.....	1220.5	1238.6	1270.7	1299.4	1312.9	1338.6	1398.6	1455.4	1511.0	1621.4	1733.2	1847.5
	s....	.....	1.4375	1.4553	1.4863	1.5129	1.5250	1.5476	1.5972	1.6407	1.6801	1.7510	1.8146	1.8729
850 (525.26)	v....	.....	0.5546	0.5818	0.6301	0.6732	0.6934	0.7320	0.8209	0.9037	0.9830	1.1360	1.2848	1.4311
	h....	.....	1212.7	1231.9	1265.5	1295.2	1309.0	1335.4	1396.3	1453.6	1509.5	1620.4	1732.4	1846.9
	s....	.....	1.4243	1.4433	1.4756	1.5032	1.5157	1.5388	1.5892	1.6330	1.6727	1.7438	1.8075	1.8660
900 (531.98)	v....	.....	0.5124	0.5396	0.5873	0.6294	0.6491	0.6863	0.7716	0.8506	0.9262	1.0714	1.2124	1.3509
	h....	.....	1204.4	1224.9	1260.1	1290.9	1305.1	1332.1	1393.9	1451.8	1508.1	1619.3	1731.6	1846.3
	s....	.....	1.4111	1.4313	1.4653	1.4938	1.5066	1.5303	1.5814	1.6257	1.6656	1.7371	1.8009	1.8595
950 (538.42)	v....	.....	0.4740	0.5015	0.5489	0.5901	0.6092	0.6453	0.7275	0.8031	0.8753	1.0136	1.1476	1.2792
	h....	.....	1195.5	1217.5	1254.6	1286.4	1301.1	1328.7	1391.6	1450.0	1506.6	1618.3	1730.8	1845.6
	s....	.....	1.3976	1.4194	1.4551	1.4846	1.4978	1.5221	1.5741	1.6187	1.6589	1.7306	1.7946	1.8532
1000 (544.61)	v....	.....	.....	0.4668	0.5140	0.5546	0.5733	0.6084	0.6878	0.7604	0.8294	0.9615	1.0893	1.2146
	h....	.....	.....	1209.7	1248.8	1281.9	1297.0	1325.3	1389.2	1448.2	1505.1	1617.3	1730.0	1845.0
	s....	.....	.....	1.4073	1.4450	1.4757	1.4893	1.5141	1.5670	1.6121	1.6525	1.7245	1.7886	1.8474
1100 (556.31)	v....	.....	.....	0.4053	0.4532	0.4929	0.5110	0.5445	0.6191	0.6866	0.7503	0.8716	0.9885	1.1031
	h....	.....	.....	1192.6	1236.7	1272.4	1288.5	1318.3	1384.3	1444.5	1502.2	1615.2	1728.4	1843.8
	s....	.....	.....	1.3827	1.4251	1.4583	1.4728	1.4989	1.5535	1.5995	1.6405	1.7130	1.7775	1.8363
1200 (567.22)	v....	.....	.....	.....	0.4016	0.4410	0.4586	0.4909	0.5617	0.6250	0.6843	0.7967	0.9046	1.0101
	h....	.....	.....	.....	1223.5	1262.4	1279.6	1311.0	1379.3	1440.7	1499.2	1613.1	1726.9	1842.5
	s....	.....	.....	.....	1.4052	1.4413	1.4568	1.4843	1.5409	1.5879	1.6293	1.7025	1.7672	1.8263
1400 (587.10)	v....	.....	.....	.....	0.3174	0.3580	0.3753	0.4062	0.4714	0.5281	0.5805	0.6789	0.7727	0.8640
	h....	.....	.....	.....	1193.0	1240.4	1260.3	1295.5	1369.1	1433.1	1493.2	1608.9	1723.7	1840.0
	s....	.....	.....	.....	1.3639	1.4079	1.4258	1.4567	1.5177	1.5666	1.6093	1.6836	1.7489	1.8083
1600 (604.90)	v....	.....	.....	.....	.....	0.2936	0.3112	0.3417	0.4034	0.4553	0.5027	0.5906	0.6738	0.7545
	h....	.....	.....	.....	.....	1215.2	1238.7	1278.7	1358.4	1425.3	1487.0	1604.6	1720.5	1837.5
	s....	.....	.....	.....	.....	1.3741	1.3952	1.4303	1.4964	1.5476	1.5914	1.6669	1.7328	1.7926
1800 (621.03)	v....	.....	.....	.....	.....	0.2407	0.2597	0.2907	0.3502	0.3986	0.4421	0.5218	0.5968	0.6693
	h....	.....	.....	.....	.....	1185.1	1214.0	1260.3	1347.2	1417.4	1480.8	1600.4	1717.3	1835.0
	s....	.....	.....	.....	.....	1.3377	1.3638	1.4044	1.4765	1.5301	1.5752	1.6520	1.7185	1.7786
2000 (635.82)	v....	.....	.....	.....	.....	0.1936	0.2161	0.2489	0.3074	0.3532	0.3935	0.4668	0.5352	0.6011
	h....	.....	.....	.....	.....	1145.6	1184.9	1240.0	1335.5	1409.2	1474.5	1596.1	1714.1	1832.5
	s....	.....	.....	.....	.....	1.2945	1.3300	1.3783	1.4576	1.5139	1.5603	1.6384	1.7055	1.7660
2500 (668.13)	v....	.....	.....	.....	.....	.....	.....	0.1686	0.2294	0.2710	0.3061	0.3678	0.4244	0.4784
	h....	.....	.....	.....	.....	.....	.....	1176.8	1303.6	1387.8	1458.4	1585.3	1706.1	1826.2
	s....	.....	.....	.....	.....	.....	.....	1.3073	1.4127	1.4772	1.5273	1.6088	1.6775	1.7389
3000 (695.36)	v....	.....	.....	.....	.....	.....	.....	0.0984	0.1760	0.2159	0.2476	0.3018	0.3505	0.3966
	h....	.....	.....	.....	.....	.....	.....	1060.7	1267.2	1365.0	1441.8	1574.3	1698.0	1819.9
	s....	.....	.....	.....	.....	.....	.....	1.1966	1.3690	1.4439	1.4984	1.5837	1.6540	1.7163
3206.2 (705.40)	v....	.....	.....	.....	.....	.....	.....	.....	0.1583	0.1981	0.2288	0.2806	0.3267	0.3703
	h....	.....	.....	.....	.....	.....	.....	.....	1250.5	1355.2	1434.7	1569.8	1694.6	1817.2
	s....	.....	.....	.....	.....	.....	.....	.....	1.3508	1.4309	1.4874	1.5742	1.6452	1.7080
3500	v....	.....	.....	.....	.....	.....	.....	0.0306	0.1364	0.1762	0.2058	0.2546	0.2977	0.3381
	h....	.....	.....	.....	.....	.....	.....	780.5	1224.9	1340.7	1424.5	1563.3	1689.8	1813.6
	s....	.....	.....	.....	.....	.....	.....	0.9515	1.3241	1.4127	1.4723	1.5615	1.6336	1.6968
4000	v....	.....	.....	.....	.....	.....	.....	0.0287	0.1052	0.1462	0.1743	0.2192	0.2581	0.2943
	h....	.....	.....	.....	.....	.....	.....	763.8	1174.8	1314.4	1406.8	1552.1	1681.7	1807.2
	s....	.....	.....	.....	.....	.....	.....	0.9347	1.2757	1.3827	1.4482	1.5417	1.6154	1.6795
4500	v....	.....	.....	.....	.....	.....	.....	0.0276	0.0798	0.1226	0.1500	0.1917	0.2273	0.2602
	h....	.....	.....	.....	.....	.....	.....	753.5	1113.9	1286.5	1388.4	1540.8	1673.5	1800.9
	s....	.....	.....	.....	.....	.....	.....	0.9235	1.2204	1.3529	1.4253	1.5235	1.5990	1.6640
5000	v....	.....	.....	.....	.....	.....	.....	0.0268	0.0593	0.1036	0.1303	0.1696	0.2027	0.2329
	h....	.....	.....	.....	.....	.....	.....	746.4	1047.1	1256.5	1369.5	1529.5	1665.3	1794.5
	s....	.....	.....	.....	.....	.....	.....	0.9152	1.1622	1.3231	1.4034	1.5066	1.5839	1.6499
5500	v....	.....	.....	.....	.....	.....	.....	0.0262	0.0463	0.0880	0.1143	0.1516	0.1825	0.2106
	h....	.....	.....	.....	.....	.....	.....	741.3	985.0	1224.1	1349.3	1518.2	1657.0	1788.1
	s....	.....	.....	.....	.....	.....	.....	0.9090	1.1093	1.2930	1.3821	1.4908	1.5699	1.6369

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v – specific volume, cu. ft. per lb.
h – enthalpy, Btu per lb.
s – entropy, Btu per deg. F. per lb.

PROPERTIES OF SATURATED STEAM*

ABSOLUTE PRESSURE PSI	TEMP. DEG. FAHR.	SPECIFIC VOLUME CU. FT. PER LB.		ENTHALPY B. T. U. PER LB.			ENTROPY B. T. U. PER DEG. FAHR. PER LB.			INTERNAL ENERGY B. T. U. PER LB.		ABSOLUTE PRESSURE PSI
		SAT. LIQUID	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	SAT. VAPOR	
	t	V_f	V_g	h_f	h_{fg}	h_g	S_f	S_{fg}	S_g	U_f	U_g	
1.0	101.74	0.01614	333.6	69.70	1036.3	1106.0	0.1326	1.8456	1.9782	69.70	1044.3	1.0
2.0	126.08	0.01623	173.73	93.99	1022.2	1116.2	0.1749	1.7451	1.9200	93.98	1051.9	2.0
3.0	141.48	0.01630	118.71	109.37	1013.2	1122.6	0.2008	1.6855	1.8863	109.36	1056.7	3.0
4.0	152.97	0.01636	90.63	120.86	1006.4	1127.3	0.2198	1.6427	1.8625	120.85	1060.2	4.0
5.0	162.24	0.01640	73.52	130.13	1001.0	1131.1	0.2347	1.6094	1.8441	130.12	1063.1	5.0
6.0	170.06	0.01645	61.98	137.96	996.2	1134.2	0.2472	1.5820	1.8292	137.94	1065.4	6.0
7.0	176.85	0.01649	53.64	144.76	992.1	1136.9	0.2581	1.5586	1.8167	144.74	1067.4	7.0
8.0	182.86	0.01653	47.34	150.79	988.5	1139.3	0.2674	1.5383	1.8057	150.77	1069.2	8.0
9.0	188.28	0.01656	42.40	156.22	985.2	1141.4	0.2759	1.5203	1.7962	156.19	1070.8	9.0
10	193.21	0.01659	38.42	161.17	982.1	1143.3	0.2835	1.5041	1.7876	161.14	1072.2	10
14.696	212.00	0.01672	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566	180.02	1077.5	14.696
15	213.03	0.01672	26.29	181.11	969.7	1150.8	0.3135	1.4415	1.7549	181.06	1077.8	15
20	227.96	0.01683	20.089	196.16	960.1	1156.3	0.3356	1.3962	1.7319	196.10	1081.9	20
25	240.07	0.01692	16.303	208.42	952.1	1160.6	0.3533	1.3606	1.7139	208.34	1085.1	25
30	250.33	0.01701	13.746	218.82	945.3	1164.1	0.3680	1.3313	1.6993	218.73	1087.8	30
35	259.28	0.01708	11.898	227.91	939.2	1167.1	0.3807	1.3063	1.6870	227.80	1090.1	35
40	267.25	0.01715	10.498	236.03	933.7	1169.7	0.3919	1.2844	1.6763	235.90	1092.0	40
45	274.44	0.01721	9.401	243.36	928.6	1172.0	0.4019	1.2650	1.6669	243.22	1093.7	45
50	281.01	0.01727	8.515	250.09	924.0	1174.1	0.4110	1.2474	1.6585	249.93	1095.3	50
55	287.07	0.01732	7.787	256.30	919.6	1175.9	0.4193	1.2316	1.6509	256.12	1096.7	55
60	292.71	0.01738	7.175	262.09	915.5	1177.6	0.4270	1.2168	1.6438	261.90	1097.9	60
65	297.97	0.01743	6.655	267.50	911.6	1179.1	0.4342	1.2032	1.6374	267.29	1099.1	65
70	302.92	0.01748	6.206	272.61	907.9	1180.6	0.4409	1.1906	1.6315	272.38	1100.2	70
75	307.60	0.01753	5.816	277.43	904.5	1181.9	0.4472	1.1787	1.6259	277.19	1101.2	75
80	312.03	0.01757	5.472	282.02	901.1	1183.1	0.4531	1.1676	1.6207	281.76	1102.1	80
85	316.25	0.01761	5.168	286.39	897.8	1184.2	0.4587	1.1571	1.6158	286.11	1102.9	85
90	320.27	0.01766	4.896	290.56	894.7	1185.3	0.4641	1.1471	1.6112	290.27	1103.7	90
95	324.12	0.01770	4.652	294.56	891.7	1186.2	0.4692	1.1376	1.6068	294.25	1104.5	95
100	327.81	0.01774	4.432	298.40	888.8	1187.2	0.4740	1.1286	1.6026	298.08	1105.2	100
110	334.77	0.01782	4.049	305.66	883.2	1188.9	0.4832	1.1117	1.5948	305.30	1106.5	110
120	341.25	0.01789	3.728	312.44	877.9	1190.4	0.4916	1.0962	1.5878	312.05	1107.6	120
130	347.32	0.01796	3.455	318.81	872.9	1191.7	0.4995	1.0817	1.5812	318.38	1108.6	130
140	353.02	0.01802	3.220	324.82	868.2	1193.0	0.5069	1.0682	1.5751	324.35	1109.6	140
150	358.42	0.01809	3.015	330.51	863.6	1194.1	0.5138	1.0556	1.5694	330.01	1110.5	150
160	363.53	0.01815	2.834	335.93	859.2	1195.1	0.5204	1.0436	1.5640	335.39	1111.2	160
170	368.41	0.01822	2.675	341.09	854.9	1196.0	0.5266	1.0324	1.5590	340.52	1111.9	170
180	373.06	0.01827	2.532	346.03	850.8	1196.9	0.5325	1.0217	1.5542	345.42	1112.5	180
190	377.51	0.01833	2.404	350.79	846.8	1197.6	0.5381	1.0116	1.5497	350.15	1113.1	190
200	381.79	0.01839	2.288	355.36	843.0	1198.4	0.5435	1.0018	1.5453	354.68	1113.7	200
250	400.95	0.01865	1.8438	376.00	825.1	1201.1	0.5675	0.9588	1.5263	375.14	1115.8	250
300	417.33	0.01890	1.5433	393.84	809.0	1202.8	0.5879	0.9225	1.5104	392.79	1117.1	300
350	431.72	0.01913	1.3260	409.69	794.2	1203.9	0.6056	0.8910	1.4966	408.45	1118.0	350
400	444.59	0.0193	1.1613	424.0	780.5	1204.5	0.6214	0.8630	1.4844	422.6	1118.5	400
450	456.28	0.0195	1.0320	437.2	767.4	1204.6	0.6356	0.8378	1.4734	435.5	1118.7	450
500	467.01	0.0197	0.9278	449.4	755.0	1204.4	0.6487	0.8147	1.4634	447.6	1118.6	500
600	486.21	0.0201	0.7698	471.6	731.6	1203.2	0.6720	0.7734	1.4454	469.4	1117.7	600
700	503.10	0.0205	0.6554	491.5	709.7	1201.2	0.6925	0.7371	1.4296	488.8	1116.3	700
800	518.23	0.0209	0.5687	509.7	688.9	1198.6	0.7108	0.7045	1.4153	506.6	1114.4	800
900	531.98	0.0212	0.5006	526.6	668.8	1195.4	0.7275	0.6744	1.4020	523.1	1112.1	900
1000	544.61	0.0216	0.4456	542.4	649.4	1191.8	0.7430	0.6467	1.3897	538.4	1109.4	1000
1100	556.31	0.0220	0.4001	557.4	630.4	1187.8	0.7575	0.6205	1.3780	552.9	1106.4	1100
1200	567.22	0.0223	0.3619	571.7	611.7	1183.4	0.7711	0.5956	1.3667	566.7	1103.0	1200
1300	577.46	0.0227	0.3293	585.4	593.2	1178.6	0.7840	0.5719	1.3559	580.0	1099.4	1300
1400	587.10	0.0231	0.3012	598.7	574.7	1173.4	0.7963	0.5491	1.3454	592.7	1095.4	1400
1500	596.23	0.0235	0.2765	611.6	556.3	1167.9	0.8082	0.5269	1.3351	605.1	1091.2	1500
2000	635.82	0.0257	0.1878	671.7	463.4	1135.1	0.8619	0.4230	1.2849	662.2	1065.6	2000
2500	668.13	0.0287	0.1307	730.6	360.5	1091.1	0.9126	0.3197	1.2322	717.3	1030.6	2500
3000	695.36	0.0346	0.0858	802.5	217.8	1020.3	0.9731	0.1885	1.1615	783.4	972.7	3000
3206.2	705.40	0.0503	0.0503	902.7	0	902.7	1.0580	0	1.0580	872.9	872.9	3206.2

*Abridged by permission from "Thermodynamic Properties of Steam" by J. H. Keenan and F. G. Keyes, published by John Wiley & Sons, Inc.

v–specific volume, cu. ft. per lb.
h–enthalpy, B.T.U. per lb.
s–entropy, B.T.U. per deg. F. per lb.
u–internal energy, B.T.U. per lb.

f (subscript)–refers to a property of the saturated liquid.
g (subscript)–refers to a property of the saturated vapor.
fg (subscript)–refers to a change by evaporation.

USEFUL INFORMATION

A gallon (U. S. Standard) of water contains 231 cubic inches and weighs 8.345 pounds (avoirdupois) at maximum density and at normal temperatures.

A gallon (British Imperial) of water contains 277.418 cubic inches and weighs 10.022 pounds (avoirdupois) at maximum density.

To find British Imperial gallons, multiply the U. S. gallons by 0.833.

To find U. S. gallons, multiply the British Imperial gallons by 1.201.

A cubic foot of water contains 7.482 gallons or approximately 7½ gallons, 1728 cubic inches, and weighs 62.428 pounds (avoirdupois) at maximum density and at 39.2 degrees Fahrenheit.

The height of a column of water necessary to produce a pressure of one pound per square inch is 2.309 feet.

To find the pressure in pounds per square inch of a column of fresh water, multiply the height in feet by 0.433.

1,000,000 U. S. gallons per day = 695 U. S. gallons per minute.

$$\text{Gallons per Minute (GPM)} = \begin{cases} \dfrac{\text{Pounds per hour}}{500 \times \text{Specific gravity}} \\[2ex] \dfrac{\text{Pounds per minute}}{8.33 \times \text{Specific gravity}} \\[2ex] 0.069 \times \text{Boiler horsepower (approx.)} \\[2ex] \dfrac{\text{Cubic feet per minute}}{7.5} \\[2ex] 449 \times \text{Cubic feet per second} \\[2ex] 0.0292 \times \text{Bbl. per day} \\[2ex] 0.7 \times \text{Bbl. per hour} \end{cases}$$

$$\text{Head in Feet} = \begin{cases} \dfrac{\text{Pressure in Pounds Per Sq. In.} \times 2.31}{\text{Specific Gravity}} \\[2ex] \dfrac{1.13 \times \text{Inches of Mercury}}{\text{Specific Gravity}} \end{cases}$$

$$\text{Pressure in Pounds Per Sq. In.} = \frac{\text{Head in Feet} \times \text{Sp. Gr.}}{2.31}$$

$$\text{Brake Horsepower (BHP)} = \begin{cases} \dfrac{\text{GPM} \times \text{Head in Feet} \times \text{Sp. Gr.}}{3960 \times \text{Pump Efficiency}} \\[2ex] \dfrac{\text{GPM} \times \text{Pounds Per Sq. In.}}{1715 \times \text{Pump Efficiency}} \\[2ex] \dfrac{\text{Theoretical Horsepower}}{\text{Pump Efficiency}} \end{cases}$$

One Horsepower = 33,000 ft. pounds per minute

$$\text{Cubic Feet per Second} = \frac{\text{Gallons per minute}}{449}$$

$$\text{Velocity in Feet per Second} = \frac{\text{U.S. GPM} \times .408}{(\text{Diameter of Pipe in Inches})^2} = \frac{\text{GPM} \times 0.32}{\text{Area of Pipe in Sq. Inches}}$$

$$\text{Velocity in Feet per Minute Necessary to Discharge a Given Volume of Water in a Given Time} = \frac{\text{Cu. Ft.} \times 144}{\text{Area of Pipe in Sq. Inches}}$$

$$\text{Area of Required Pipe, the Volume and Velocity of Water Being Given} = \frac{\text{Cu. Ft.} \times 144}{\text{Vel. in Ft. Per Minute}}$$

$$\text{Velocity Head (or head due to velocity) } H = \frac{V^2}{2G} \qquad V = \sqrt{2GH}$$

G = Acceleration Due to Gravity or 32.16 Feet per Second per Second.

CONVERSION TABLES

INCHES INTO MILLIMETERS

(1 inch = 25.40000 millimeters)

in.	mm.	in.	mm.	in.	mm.	in.	mm.
1/64	0.397	1½	38.10	15	381.0	36	914.4
1/32	0.794	1¾	44.45	16	406.4	38	965.2
3/64	1.191	2	50.80	17	431.8	40	1016
1/16	1.588	2½	63.50	18	457.2	42	1067
3/32	2.381	3	76.20	19	482.6	44	1118
1/8	3.175	3½	88.90	20	508.0	46	1168
5/32	3.969	4	101.6	21	533.4	48	1219
3/16	4.763	4½	114.3	22	558.8	50	1270
1/4	6.350	5	127.0	23	584.2	55	1397
5/16	7.938	6	152.4	24	609.6	60	1524
3/8	9.525	7	177.8	25	635.0	65	1651
7/16	11.11	8	203.2	26	660.4	70	1778
1/2	12.70	9	228.6	27	685.8	75	1905
5/8	15.88	10	254.0	28	711.2	80	2032
3/4	19.05	11	279.4	29	736.6	85	2159
7/8	22.23	12	304.8	30	762.0	90	2286
1	25.40	13	330.2	32	812.8	95	2413
1¼	31.75	14	355.6	34	863.6	100	2540

MILLIMETERS INTO INCHES

(1 millimeter = 0.03937008 inches)

mm.	in.	mm.	in.	mm.	in.	mm.	in.
1	0.039	28	1.102	130	5.118	750	29.53
2	0.079	30	1.181	140	5.512	800	31.50
3	0.118	35	1.378	150	5.906	850	33.46
4	0.158	40	1.575	160	6.299	900	35.43
5	0.197	45	1.772	170	6.693	950	37.40
6	0.236	50	1.969	180	7.087	1000	39.37
7	0.276	55	2.165	190	7.480	1250	49.21
8	0.315	60	2.362	200	7.874	1500	59.05
9	0.354	65	2.559	250	9.842	1750	68.90
10	0.394	70	2.756	300	11.81	2000	78.74
12	0.472	75	2.953	350	13.78	2500	98.43
14	0.551	80	3.150	400	15.75	3000	118.1
16	0.630	85	3.346	450	17.72	3500	137.8
18	0.709	90	3.543	500	19.69	4000	157.5
20	0.787	95	3.740	550	21.65	4500	177.2
22	0.866	100	3.937	600	23.62	5000	196.9
24	0.945	110	4.331	650	25.59	7500	295.3
26	1.024	120	4.724	700	27.56	10000	393.7

SQUARE INCHES INTO SQUARE CENTIMETERS

(1 square inch = 6.45160 square centimeters)

sq. in.	sq. cm.	sq. in.	sq. cm.	sq. in.	sq. cm.	sq. in.	sq. cm.
1/4	1.613	7	45.16	45	290.3	200	1290
1/2	3.226	8	51.61	50	322.6	250	1613
3/4	4.839	9	58.06	55	354.8	300	1935
1	6.452	10	64.52	60	387.1	350	2258
1½	9.677	12	77.42	65	419.4	400	2581
2	12.90	14	90.32	70	451.6	450	2903
2½	16.13	16	103.2	75	483.9	500	3226
3	19.35	18	116.1	80	516.1	600	3871
3½	22.58	20	129.0	85	548.4	700	4516
4	25.81	25	161.3	90	580.6	800	5161
4½	29.03	30	193.5	95	612.9	900	5806
5	32.26	35	225.8	100	645.2	1000	6452
6	38.71	40	258.1	150	967.7		

SQUARE CENTIMETERS INTO SQUARE INCHES

(1 square centimeter = 0.155000 square inches)

sq. cm.	sq. in.	sq. cm.	sq. in.	sq. cm.	sq. in.	sq. cm.	sq. in.
1	0.155	18	2.790	80	12.40	600	93.00
2	0.310	20	3.100	85	13.18	700	108.5
3	0.465	25	3.875	90	13.95	800	124.0
4	0.620	30	4.650	95	14.73	900	139.5
5	0.775	35	5.425	100	15.50	1000	155.0
6	0.930	40	6.200	150	23.25	1500	232.5
7	1.085	45	6.975	200	31.00	2000	310.0
8	1.240	50	7.750	250	38.75	2500	387.5
9	1.395	55	8.525	300	46.50	3000	465.0
10	1.550	60	9.300	350	54.25	3500	542.5
12	1.860	65	10.08	400	62.00	4000	620.0
14	2.170	70	10.85	450	69.75	5000	775.0
16	2.480	75	11.63	500	77.50		

GALLONS* INTO LITERS

(1 liter = 0.2641775 gallons*)

gal.	liters	gal.	liters	gal.	liters	gal.	liters
1	3.785	10	37.85	100	378.5	500	1893
2	7.571	20	75.71	120	454.2	600	2271
3	11.36	30	113.6	140	529.9	700	2650
4	15.14	40	151.4	160	605.7	800	3028
5	18.93	50	189.3	180	681.4	900	3407
6	22.71	60	227.1	200	757.1	1000	3785
7	26.50	70	265.0	250	946.3		
8	30.28	80	302.8	300	1136		
9	34.07	90	340.7	400	1514		

LITERS INTO GALLONS*

(1 gallon* = 3.785334 liters)

liters	gal.	liters	gal.	liters	gal.	liters	gal.
1	0.264	10	2.642	300	79.25	3000	792.5
2	0.528	20	5.284	400	105.7	4000	1057
3	0.793	30	7.925	500	132.1	5000	1321
4	1.057	40	10.57	600	158.5	6000	1585
5	1.321	50	13.21	700	184.9	8000	2113
6	1.585	100	26.42	800	211.3	10000	2642
7	1.849	150	39.63	900	237.8		
8	2.113	200	52.84	1000	264.2		
9	2.378	250	66.04	2000	528.4		

CUBIC FEET INTO GALLONS*

(1 cubic foot = 7.48052 gallons*)

cu. ft.	gal.	cu. ft.	gal.	cu. ft.	gal.	cu. ft.	gal.
1	7.481	10	74.81	100	748.1	500	3740
2	14.96	20	149.6	120	897.7	600	4488
3	22.44	30	224.4	140	1047	700	5236
4	29.92	40	299.2	160	1197	800	5984
5	37.40	50	374.0	180	1346	900	6732
6	44.88	60	448.8	200	1496	1000	7481
7	52.36	70	523.6	250	1870		
8	59.84	80	598.4	300	2244		
9	67.32	90	673.2	400	2992		

GALLONS* INTO CUBIC FEET

(1 gallon* = 0.133685 cubic feet)

gal.	cu. ft.	gal.	cu. ft.	gal.	cu. ft.	gal.	cu. ft.
1	0.134	10	1.337	300	40.11	3000	401.1
2	0.267	20	2.674	400	53.47	4000	534.7
3	0.401	30	4.011	500	66.84	5000	668.4
4	0.535	40	5.347	600	80.21	6000	802.1
5	0.668	50	6.684	700	93.58	8000	1069
6	0.802	100	13.37	800	106.9	10000	1337
7	0.934	150	20.05	900	120.3		
8	1.069	200	26.74	1000	133.7		
9	1.203	250	33.42	2000	267.4		

*U. S. liquid gallon (231 inches^3).

CONVERSION TABLES (Cont.)

FEET PER SECOND INTO METERS PER SECOND

(1 foot per second = 0.3048000 meters per second)

ft./sec.	m./sec.	ft./sec.	m./sec.	ft./sec.	m./sec.	ft./sec.	m./sec.
1	0.305	9	2.743	24	7.315	60	18.29
2	0.610	10	3.048	26	7.925	70	21.34
3	0.914	12	3.658	28	8.534	75	22.86
4	1.219	14	4.267	30	9.144	80	24.38
5	1.524	16	4.877	35	10.67	90	27.43
6	1.829	18	5.486	40	12.19	100	30.48
7	2.134	20	6.096	45	13.72		
8	2.438	22	6.706	50	15.24		

METERS PER SECOND INTO FEET PER SECOND

(1 meter per second = 3.280840 feet per second)

m./sec.	ft./sec.	m./sec.	ft./sec.	m./sec.	ft./sec.	m./sec.	ft./sec.
0.5	1.640	8	26.25	16	52.49	28	91.86
1	3.281	9	29.53	17	55.77	30	98.42
2	6.562	10	32.81	18	59.05	35	114.8
3	9.842	11	36.09	19	62.34	40	131.2
4	13.12	12	39.37	20	65.62	45	147.6
5	16.40	13	42.65	22	72.18	50	164.0
6	19.68	14	45.93	24	78.74		
7	22.97	15	49.21	26	85.30		

POUNDS* INTO KILOGRAMS

(1 pound* = 0.45359243 kilograms)

lb.	kg.	lb.	kg.	lb.	kg.	lb.	kg.
1	0.454	10	4.536	300	136.1	3000	1361
2	0.907	20	9.072	400	181.4	4000	1814
3	1.361	30	13.61	500	226.8	5000	2268
4	1.814	40	18.14	600	272.2	6000	2722
5	2.268	50	22.68	700	317.5	8000	3629
6	2.722	100	45.36	800	362.9	10000	4536
7	3.175	150	68.04	900	408.2		
8	3.629	200	90.72	1000	453.6		
9	4.082	250	113.4	2000	907.2		

KILOGRAMS INTO POUNDS*

(1 kilogram = 2.2046223 pounds*)

kg.	lb.	kg.	lb.	kg.	lb.	kg.	lb.
1	2.205	10	22.05	100	220.5	500	1102
2	4.409	20	44.09	120	264.5	600	1323
3	6.614	30	66.14	140	308.6	700	1543
4	8.818	40	88.18	160	352.7	800	1764
5	11.02	50	110.2	180	396.8	900	1984
6	13.23	60	132.3	200	440.9	1000	2205
7	15.43	70	154.3	250	551.2		
8	17.64	80	176.4	300	661.4		
9	19.84	90	198.4	400	881.8		

POUNDS PER SQUARE INCH INTO KILOGRAMS PER SQUARE CENTIMETER

(1 pound per square inch = 0.070307 kilograms per centimeter²)

lb./in.²	kg./cm.²	lb./in.²	kg./cm.²	lb./in.²	kg./cm.²	lb./in.²	kg./cm.²
1	0.070	20	1.406	140	9.843	600	42.18
2	0.141	30	2.109	160	11.25	700	49.21
3	0.211	40	2.812	180	12.66	800	56.25
4	0.281	50	3.515	200	14.06	900	63.28
5	0.352	60	4.218	250	17.58	1000	70.31
6	0.422	70	4.921	300	21.09	2500	175.8
7	0.492	80	5.625	350	24.61	5000	351.5
8	0.562	90	6.328	400	28.12	7500	527.3
9	0.633	100	7.031	450	31.64	10000	703.1
10	0.703	120	8.437	500	35.15		

KILOGRAMS PER SQUARE CENTIMETER INTO POUNDS PER SQUARE INCH

(1 kilogram per centimeter² = 14.2233 pounds per square inch)

kg./cm.²	lb./in.²	kg./cm.²	lb./in.²	kg./cm.²	lb./in.²	kg./cm.²	lb./in.²
0.25	3.556	8	113.8	35	497.8	85	1209
0.50	7.112	9	128.0	40	568.9	90	1280
0.75	10.67	10	142.2	45	640.0	95	1351
1	14.22	12	170.7	50	711.2	100	1422
2	28.45	14	199.1	55	782.3	200	2845
3	42.67	16	227.6	60	853.4	300	4267
4	56.89	18	256.0	65	924.5	400	5689
5	71.12	20	284.5	70	995.6	500	7112
6	85.34	25	355.6	75	1067	600	8534
7	99.56	30	426.7	80	1138		

HORSEPOWER INTO KILOWATTS

(1 horsepower = 0.74571 kilowatts)

hp.	kw.	hp.	kw.	hp.	kw.	hp.	kw.
1	0.746	9	6.711	24	17.90	60	44.74
2	1.491	10	7.457	26	19.39	70	52.20
3	2.237	12	8.948	28	20.88	75	55.93
4	2.983	14	10.44	30	22.37	80	59.66
5	3.729	16	11.93	35	26.10	90	67.11
6	4.474	18	13.42	40	29.83	100	74.57
7	5.220	20	14.91	45	33.56		
8	5.966	22	16.41	50	37.29		

KILOWATTS INTO HORSEPOWER

(1 kilowatt = 1.3410 horsepower)

kw.	hp.	kw.	hp.	kw.	hp.	kw.	hp.
1	1.341	9	12.07	24	32.18	60	80.46
2	2.682	10	13.41	26	34.87	70	93.87
3	4.023	12	16.09	28	37.55	75	100.6
4	5.364	14	18.77	30	40.23	80	107.3
5	6.705	16	21.46	35	46.94	90	120.7
6	8.046	18	24.14	40	53.64	100	134.1
7	9.387	20	26.82	45	60.35		
8	10.73	22	29.50	50	67.05		

PRESSURE

One atmosphere	= 14.70 lbs. per sq. in.
One lb. per sq. in.	= 0.06804 atmosphere.
One cm. mercury	= 0.1934 lbs. per sq. in.
One in. mercury	= 0.4912 lbs. per sq. in.
One meter water†	= 1.421 lbs. per sq. in.
One foot water†	= 0.4332 lbs. per sq. in.

DENSITY

One lb. per cu. in.	= 27.68 grams per cu. cm.
One gram per cu. cm.	= 0.03613 lbs. per cu. in.

ENERGY OF WORK

One British Thermal Unit	= 777.52 ft. lbs.
One kilogram calorie	= 3086 ft. lbs.
One foot lb.	= 0.1383 kg. m.
One kg. m.	= 7.233 ft. lbs.

LENGTH

One mile (statute)	= 1.609 kilometers
One kilometer	= 0.6214 mile
One mile (statute)	= 5280 ft.

*Avoirdupois

†15° C and g = 32.1740 ft. per sec. per sec.

EQUIVALENT FAHRENHEIT AND CENTIGRADE SCALES

$$F^\circ = \frac{9}{5}C^\circ + 32^\circ$$

$$C^\circ = \frac{5}{9}\left(F^\circ - 32^\circ\right)$$

FAHRENHEIT DEG.	CENTIGRADE DEG.	FAHRENHEIT DEG.	CENTIGRADE DEG.	FAHRENHEIT DEG.	CENTIGRADE DEG.	FAHRENHEIT DEG.	CENTIGRADE DEG.	FAHRENHEIT DEG.	CENTIGRADE DEG.	FAHRENHEIT DEG.	CENTIGRADE DEG.	FAHRENHEIT DEG.	CENTIGRADE DEG.	FAHRENHEIT DEG.	CENTIGRADE DEG.
−459.4	−273.	−21.	−29.4	+17.6	− 8.	+56.	+13.3	+ 95.	+35.	+134.	+56.7	+172.4	+78.	+211.	+ 99.4
−436.	−260.	−20.2	−29.	+18.	− 7.8	+57.	+13.9	+ 96.	+35.6	+134.6	+57.	+173.	+78.3	+212.	+100.
−418.	−250.	−20.	−28.9	+19.	− 7.2	+57.2	+14.	+ 96.8	+36.	+135.	+57.2	+174.	+78.9	+213.	+100.6
−400.	−240.	−19.	−28.3	+19.4	− 7.	+58.	+14.4	+ 97.	+36.1	+136.	+57.8	+174.2	+79.	+213.8	+101.
−382.	−230.	−18.4	−28.	+20.	− 6.7	+59.	+15.	+ 98.	+36.7	+136.4	+58.	+175.	+79.4	+214.	+101.1
−364.	−220.	−18.	−27.8	+21.	− 6.1	+60.	+15.6	+ 98.6	+37.	+137.	+58.3	+176.	+80.	+215.	+101.7
−346.	−210.	−17.	−27.2	+21.2	− 6.	+60.8	+16.	+ 99.	+37.2	+138.	+58.9	+177.	+80.6	+215.6	+102.
−328.	−200.	−16.6	−27.	+22.	− 5.6	+61.	+16.1	+100.	+37.8	+138.2	+59.	+177.8	+81.	+216.	+102.2
−310.	−190.	−16.	−26.7	+23.	− 5.	+62.	+16.7	+100.4	+38.	+139.	+59.4	+178.	+81.1	+217.	+102.8
−292.	−180.	−15.	−26.1	+24.	− 4.4	+62.6	+17.	+101.	+38.3	+140.	+60.	+179.	+81.7	+217.4	+103.
−274.	−170.	−14.8	−26.	+24.8	− 4.	+63.	+17.2	+102.	+38.9	+141.	+60.6	+179.6	+82.	+218.	+103.3
−256.	−160.	−14.	−25.6	+25.	− 3.9	+64.	+17.8	+102.2	+39.	+141.8	+61.	+180.	+82.2	+219.	+103.9
−238.	−150.	−13.	−25.	+26.	− 3.3	+64.4	+18.	+103.	+39.4	+142.	+61.1	+181.	+82.8	+219.2	+104.
−220.	−140.	−12.	−24.4	+26.6	− 3.	+65.	+18.3	+104.	+40.	+143.	+61.7	+181.4	+83.	+220.	+104.4
−202.	−130.	−11.2	−24.	+27.	− 2.8	+66.	+18.9	+105.	+40.6	+143.6	+62.	+182.	+83.3	+221.	+105.
−184.	−120.	−11.	−23.9	+28.	− 2.2	+66.2	+19.	+105.8	+41.	+144.	+62.2	+183.	+83.9	+222.	+105.6
−166.	−110.	−10.	−23.3	+28.4	− 2.	+67.	+19.4	+106.	+41.1	+145.	+62.8	+183.2	+84.	+222.8	+106.
−148.	−100.	− 9.4	−23.	+29.	− 1.7	+68.	+20.	+107.	+41.7	+145.4	+63.	+184.	+84.4	+223.	+106.1
−139.	− 95.	− 9.	−22.8	+30.	− 1.1	+69.	+20.6	+107.6	+42.	+146.	+63.3	+185.	+85.	+224.	+106.7
−130.	− 90.	− 8.	−22.2	+30.2	− 1.	+69.8	+21.	+108.	+42.2	+147.	+63.9	+186.	+85.6	+224.6	+107.
−121.	− 85.	− 7.6	−22.	+31.	− 0.6	+70.	+21.1	+109.	+42.8	+147.2	+64.	+186.8	+86.	+225.	+107.2
−112.	− 80.	− 7.	−21.7	+32.	0.	+71.	+21.7	+109.4	+43.	+148.	+64.4	+187.	+86.1	+226.	+107.8
−103.	− 75.	− 6.	−21.1	+33.	+ 0.6	+71.6	+22.	+110.	+43.3	+149.	+65.	+188.	+86.7	+226.4	+108.
− 94.	− 70.	− 5.8	−21.	+33.8	+ 1.	+72.	+22.2	+111.	+43.9	+150.	+65.6	+188.6	+87.	+227.	+108.3
− 85.	− 65.	− 5.	−20.6	+34.	+ 1.1	+73.	+22.8	+111.2	+44.	+150.8	+66.	+189.	+87.2	+228.	+108.9
− 76.	− 60.	− 4.	−20.	+35.	+ 1.7	+73.4	+23.	+112.	+44.4	+151.	+66.1	+190.	+87.8	+228.2	+109.
− 67.	− 55.	− 3.	−19.4	+35.6	+ 2.	+74.	+23.3	+113.	+45.	+152.	+66.7	+190.4	+88.	+229.	+109.4
− 58.	− 50.	− 2.2	−19.	+36.	+ 2.2	+75.	+23.9	+114.	+45.6	+152.6	+67.	+191.	+88.3	+230.	+110.
− 49.	− 45.	− 2.	−18.9	+37.	+ 2.8	+75.2	+24.	+114.8	+46.	+153.	+67.2	+192.	+88.9	+231.	+110.6
− 40.	− 40.	− 1.	−18.3	+37.4	+ 3.	+76.	+24.4	+115.	+46.1	+154.	+67.8	+192.2	+89.	+231.8	+111.
− 39.	− 39.4	− 0.4	−18.	+38.	+ 3.3	+77.	+25.	+116.	+46.7	+154.4	+68.	+193.	+89.4	+232.	+111.1
− 38.2	− 39.	0.	−17.8	+39.	+ 3.9	+78.	+25.6	+116.6	+47.	+155.	+68.3	+194.	+90.	+233.	+111.7
− 38.	− 38.9	+ 1.	−17.2	+39.2	+ 4.	+78.8	+26.	+117.	+47.2	+156.	+68.9	+195.	+90.6	+233.6	+112.
− 37.	− 38.3	+ 1.4	−17.	+40.	+ 4.4	+79.	+26.1	+118.	+47.8	+156.2	+69.	+195.8	+91.	+234.	+112.3
− 36.4	− 38.	+ 2.	−16.7	+41.	+ 5.	+80.	+26.7	+118.4	+48.	+157.	+69.4	+196.	+91.1	+235.	+112.8
− 36.	− 37.8	+ 3.	−16.1	+42.	+ 5.6	+80.6	+27.	+119.	+48.3	+158.	+70.	+197.	+91.7	+235.4	+113.
− 35.	− 37.2	+ 3.2	−16.	+42.8	+ 6.	+81.	+27.2	+120.	+48.9	+159.	+70.6	+197.6	+92.	+236.	+113.3
− 34.6	− 37.	+ 4.	−15.6	+43.	+ 6.1	+82.	+27.8	+120.2	+49.	+159.8	+71.	+198.	+92.2	+237.	+113.9
− 34.	− 36.7	+ 5.	−15.	+44.	+ 6.7	+82.4	+28.	+121.	+49.4	+160.	+71.1	+199.	+92.8	+237.2	+114.
− 33.	− 36.1	+ 6.	−14.4	+44.6	+ 7.	+83.	+28.3	+122.	+50.	+161.	+71.7	+199.4	+93.	+238.	+114.4
− 32.8	− 36.	+ 6.8	−14.	+45.	+ 7.2	+84.	+28.9	+123.	+50.6	+161.6	+72.	+200.	+93.3	+239.	+115.
− 32.	− 35.6	+ 7.	−13.9	+46.	+ 7.8	+84.2	+29.	+123.8	+51.	+162.	+72.2	+201.	+93.9	+240.	+115.6
− 31.	− 35.	+ 8.	−13.3	+46.4	+ 8.	+85.	+29.4	+124.	+51.1	+163.	+72.8	+201.2	+94.	+240.8	+116.
− 30.	− 34.4	+ 8.6	−13.	+47.	+ 8.3	+86.	+30.	+125.	+51.7	+163.4	+73.	+202.	+94.4	+241.	+116.1
− 29.2	− 34.	+ 9.	−12.8	+48.	+ 8.9	+87.	+30.6	+125.6	+52.	+164.	+73.3	+203.	+95.	+242.	+116.7
− 29.	− 33.9	+10.	−12.2	+48.2	+ 9.	+87.8	+31.	+126.	+52.2	+165.	+73.9	+204.	+95.6	+242.6	+117.
− 28.	− 33.3	+10.4	−12.	+49.	+ 9.4	+88.	+31.1	+127.	+52.8	+165.2	+74.	+204.8	+96.	+243.	+117.2
− 27.4	− 33.	+11.	−11.7	+50.	+10.	+89.	+31.7	+127.4	+53.	+166.	+74.4	+205.	+96.1	+244.	+117.8
− 27.	− 32.8	+12.	−11.1	+51.	+10.6	+89.6	+32.	+128.	+53.3	+167.	+75.	+206.	+96.7	+244.4	+118.
− 26.	− 32.2	+12.2	−11.	+51.8	+11.	+90.	+32.2	+129.	+53.9	+168.	+75.6	+206.6	+97.	+245.	+118.3
− 25.6	− 32.	+13.	−10.6	+52.	+11.1	+91.	+32.8	+129.2	+54.	+168.8	+76.	+207.	+97.2	+246.	+118.9
− 25.	− 31.7	+14.	−10.	+53.	+11.7	+91.4	+33.	+130.	+54.4	+169.	+76.1	+208.	+97.8	+246.2	+119.
− 24.	− 31.1	+15.	− 9.4	+53.6	+12.	+92.	+33.3	+131.	+55.	+170.	+76.7	+208.4	+98.	+247.	+119.4
− 23.8	− 31.	+15.8	− 9.	+54.	+12.2	+93.	+33.9	+132.	+55.6	+170.6	+77.	+209.	+98.3	+248.	+120.
− 23.	− 30.6	+16.	− 8.9	+55.	+12.8	+93.2	+34.	+132.8	+56.	+171.	+77.2	+210.	+98.9	+249.	+120.6
− 22.	− 30.	+17.	− 8.3	+55.4	+13.	+94.	+34.4	+133.	+56.1	+172.	+77.8	+210.2	+99.	+249.8	+121.

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LADISH CATALOG NO. 55

Printed in the United States

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