



PIPING ENGINEER'S TECHNICAL DATA GUIDEBOOK

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(Revised October 2015)

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ENGINEERED PRODUCTS

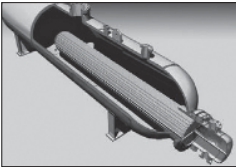
Extruded Outlet Headers

Single and Multiple Outlet Headers

Run size 12" and larger; outlet size
2" and larger

Flow Tees

*Pipeline and Station Piping
Components*



Shell & Tube Heat Exchangers

HTRI Thermal Ratings

RCS Mechanical Design

TEMA Design and Construction

ASME Code "U" Stamped

6" to 120" Diameter Shells



Pressure Vessels

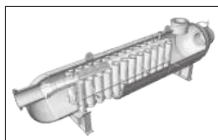
ASME Code Stamped
"U", "U2", "S" and "R"

Vortex Separators

Vortex Scrubbers

Contactors and Absorbers

Gaseous Storage Vessels



Fabricated Assemblies

Scraper Traps, Launchers & Receivers

Utilizing extruded outlets or fabricated from pipe and fittings



Pulsation Bottles

Extruded per DOT/B31.8 or ASME stamped

Slug Catcher Assemblies

Modularized shipments or field assembled manifolds



Meter Header Assemblies

Aftercooler Manifold Assemblies

Valve Settings

Skidded Packages

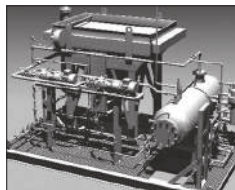
Pig Trap Skids

Manual or automated for onshore and offshore applications

Valve and Manifold Skids

High Pressure Meter Skids

Gas Processing Skids



ENGINEERED PRODUCTS (cont.)

Weld Fittings

Caps 16" to 42"

Reducers

Concentric or eccentric; 16" and larger

*High Yield Forged and
Machined Fittings*

Yield strength up to 80 ksi; Region 3,
up to 70 ksi; compliant with NACE
MR0175, per MSS SP-75, CSA Z245.11,
ASTM A-860, ISO I5590, API 6A



Miscellaneous

Weld Overlay (316L/625)

Pipe and Bottle Hold Down Clamps

Pulsation Bottle Repair

Partial Materials List:

- Carbon steel
- High strength low alloy
- Stainless steel
- Duplex and super duplex
- 1-1/4 Cr, 2-1/4 Cr, 9 Cr
- Nickel alloys

***For more information about our products, engineering and
fabrication services, please contact us at 913-294-5331
or email us at engineered@tfes.com.***

HIGH STRENGTH LOW ALLOY MATERIALS

Background

Over the past 45+ years, Taylor Forge has developed a suite of proprietary High Strength Low Alloy (HSLA) materials for use in high pressure applications requiring high strength, excellent toughness, good weldability and NACE compliance.

This HSLA material, in plate and forging product forms, is used as the starting material for components certified to MSS SP-75, CSA Z245.11, ASTM A-694, ASTM A-860, ISO 15590 and API 6A for grades up to 80 ksi yield strengths in non-sour service and 70 ksi yield strengths in sour service.

Since 2000, more than 1100 tons of HSLA forging material has been used for onshore and offshore high pressure applications in both non-sour and sour service.

	AG-80	IGS-70	IGS-70M
Yield Strength	80 ksi @ 4" 70 ksi @ 10" 65 ksi @ 12" 60 ksi @ 14"	70 ksi @ 3" 65 ksi @ 3.5" 60 ksi @ 6"	70 ksi @ 2" 65 ksi @ 3" 60 ksi @ 5.5"
Toughness (CVN'S) @ -50°F @ -20°F	15 ft/lbs (min) 25 ft/lbs (min)	60 ft/lbs (min) 100 ft/lbs (min)	60 ft/lbs (min) 100 ft/lbs (min)
Elongation	20% (min)	25% (min)	25% (min)
Shear Area @ -50°F @ -20°F	Info only 30% (min)	50% (min) 85% (min)	50% (min) 85% (min)
Hardness	HRC 23 (max)	230 HV10 (max)	230 HV10 (max)
Carbon Equivalents (max)	IIW 0.47 Pcm 0.23 CSA 0.40	IIW 0.45 Pcm 0.23 CSA 0.33	IIW 0.43 Pcm 0.21 CSA 0.33
Weldability	Excellent	Excellent	Excellent
Preheat Recommended	250°F (min)	250°F (min)	250°F (min)
Post-heat Recommended	No	No	No
PWHT Recommended	Yes	Yes	Yes
Weld Hardness in HAZ	275 HV10 (max)	250 HV10 (max)	250 HV10 (max)

HARDNESS CONVERSION TABLE FOR STEEL

Brinell, 10-mm Carbide Ball, 3000-Kg load	Diamond Pyramid Hardness Number	Rockwell		Tensile Strength 1000 psi
		C Scale 150-Kg Brale	B Scale 100-Kg 1/16 in. Ball	
555	591	54.5	—	298
534	569	53.5	—	288
514	547	52	—	274
495	528	51	—	264
477	508	49.5	—	252
461	491	48.5	—	242
444	472	47	—	230
429	455	45.5	—	219
415	440	44.5	—	212
401	425	43	—	202
388	410	42	—	193
375	396	40.5	—	184
363	383	39	—	177
352	372	38	(110)	171
341	360	36.5	(109)	164
331	350	35.5	(108.5)	159
321	339	34.5	(108)	154
311	328	33	(107.5)	149
302	319	32	(107)	146
293	309	31	(106)	141
285	301	30	(105.5)	138
277	292	29	(104.5)	134
269	284	27.5	(104)	130
262	276	26.5	(103)	127
255	269	25.5	(102)	123
248	261	24	(101)	120
241	253	23	100	116
235	247	21.5	99	114
229	241	20.5	98	111
223	234	(19)	97.5	-
217	228	(17.5)	96.5	105
207	218	(15)	94.5	100
197	207	(12.5)	93	95
187	196	(10)	90.5	90
179	188	(8)	89	87
170	178	(5)	87	83
163	171	(3)	85	79
156	163	(1)	83	76
143	150	—	78.5	71
131	137	—	74	65
121	127	—	70	60
111	117	—	65.5	56

(Values in parentheses are beyond normal range and are for information only.)

* Approximate – data from 1971 SAE Handbook

** Data from Roli Manufacturers Institute. D. G. Yorke, Metal Progress, 83, April 1963. P. 106

ENGINEERING CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
Barrels	5.6146	Cubic Feet
Bars	14.504	Pounds/Square Inch
British Thermal Units	1055.056	Joules
Centimeters	3.28080×10^{-2}	Feet
Centimeters	0.3937	Inches
Cubic Centimeters	3.53145×10^{-5}	Cubic Feet
Cubic Centimeters	6.102×10^{-2}	Cubic Inches
Cubic Feet	2.8317×10^{-4}	Cubic Centimeters
Cubic Feet	2.8317×10^{-2}	Cubic Meters
Cubic Feet	6.22905	Gallons, British Imperial
Cubic Inches	4.329×10^{-3}	Gallons, U.S. Liquid
Cubic Inches	3.604×10^{-3}	Gallons, British Imperial
Cubic Inches	16.38716	Cubic Centimeters
Cubic Meters	35.3145	Cubic Feet
Cubic Meters, Liquid	6.2898	Barrels
Degrees, Angular	0.0174533	Radians
Feet	30.48	Centimeters
Foot-Pounds	0.13826	Kilograms-Meters
Foot-Pounds	1.35582	Joules
Gallons, British Imperial	1.20094	Gallons, U.S.
Gallons, British Imperial	227.42	Cubic Inches
Gallons, U.S.	0.832702	Gallons British Imperial
Gallons, U.S. Liquid	231	Cubic Inches
Gallons, U.S. Liquid	3.78543	Liters
Grams, Metric	0.98632	Pounds, Avoirdupois
Horsepower, Metric	0.98632	Horsepower, U.S.
Horsepower, U.S.	0.74570	Kilowatts
Horsepower, U.S.	1.0138	Horsepower, Metric
Inches	2.54	Centimeters
Joules	0.73756	Foot Pounds
Kilogram-Meters	7.233	Foot Pounds
Kilograms	2.20462	Pounds
Kilograms/Sq Cm	14.2234	Pounds/Sq Inch
Kilogram/Cubic Meters	0.06243	Pounds/Cubic Foot
Kilopascals	0.145038	Pounds/Sq inch
Liters	3.53145×10^{-2}	Cubic Feet
Liters	0.26417	Gallons, U.S. Liquid
Pounds, Avoirdupois	453.592	Grams, Metric
Pounds	4.44822	Newton
Pounds/Sq Inch	7.031×10^{-2}	Kilograms/Sq Cm
Radians	57.29578	Degrees, Angular
Square Centimeters	0.1550	Square Inches
Square Meters	10.7639	Square Feet

STANDARD DIMENSIONS OF FITTINGS AND PIPE

Nom. Pipe Size	STUB ENDS (See note below)										Nom. Pipe Size					
	Weld Ell					CAPS						Type B, C ▲				
	90° LONG RAD. Weidell		90° REDUCING L.R. Weidell		45° LONG RAD. Weidell	180° LONG RAD. Weidell		180° SHORT RAD. Weidell		90° SHORT RAD. Weidell		180° SHORT RAD. Weidell		CAP	LAP JOINT	MSS LENGTH	STUB ENDS
	A	B	D	K	V	E	G O.D. of Lap	F (Length) ASME Std.	I (Length) MSS Std.	Corner Radius	F (Length) ASME Std.	I (Length) MSS Std.	Corner Radius	I (Length) MSS Std.	Corner Radius	
1/2	1-1/2	5/8	—	1-1/8	—	1	1-3/8	3	2	1/8	3	2	1/8	2	1/32	1/2
3/4	1-1/8	1-1/8	—	1-11/16	—	1	1-11/16	3	2	1/8	3	2	1/8	2	1/32	3/4
1	1-1/2	7/8	1	2-3/16	1-5/8	1-1/2	2	4	2	1/8	4	2	1/8	2	1/32	1
1-1/4	1-7/8	1	1-1/4	2-3/4	2-1/16	1-1/2	2-1/2	4	2	3/16	4	2	3/16	2	1/32	1-1/4
1-1/2	2-1/4	1-1/8	1-1/2	3-1/4	2-7/16	1-1/2	2-7/8	4	2	1/4	4	2	1/4	2	1/32	1-1/2
2	3	1-3/8	2	4-3/16	3-3/16	1-1/2	3-5/8	6	2-1/2	5/16	6	2-1/2	5/16	2-1/2	1/32	2
2-1/2	3-3/4	1-3/4	2-1/2	5-3/16	3-15/16	1-1/2	4-1/8	6	2-1/2	5/16	6	2-1/2	5/16	2-1/2	1/32	2-1/2
3	3-5/8	4-1/2	3	6-1/4	4-3/4	2	5	6	2-1/2	3/8	6	2-1/2	3/8	2-1/2	1/32	3
3-1/2	4-1/4	2-1/4	3-1/2	7-1/4	5-1/2	2-1/2	5-1/2	6	3	3/8	6	3	3/8	3	1/32	3-1/2
4	4-5/8	2-1/2	4	8-1/4	6-1/4	2-1/2	6-3/16	6	3	7/16	6	3	7/16	3	1/32	4
5	5-5/8	3-1/8	5	10-5/16	7-3/4	3	7-5/16	8	3	7/16	8	3	7/16	3	1/16	5
6	6-625	3-3/4	6	12-5/16	9-5/16	3-1/2	8-1/2	8	3-1/2	1/2	8	3-1/2	1/2	3-1/2	1/16	6
8	8-625	5	8	16-5/16	12-5/16	4	10-5/8	8	4	1/2	8	4	1/2	4	1/16	8
10	10-750	6-1/4	10	20-3/8	15-3/8	5	12-3/4	10	5	1/2	10	5	1/2	5	1/16	10
12	12-750	7-1/2	12	24-3/8	18-3/8	6	15	10	6	1/2	10	6	1/2	6	1/16	12
14	14-000	8-3/4	14	28	21	6-1/2	16-1/4	12	—	1/2	12	—	1/2	—	—	14
16	16-000	10	16	32	24	7	18-1/2	12	—	1/2	12	—	1/2	—	—	16
18	18-000	11-1/4	18	36	27	8	21	12	—	1/2	12	—	1/2	—	—	18
20	20-000	12-1/2	20	40	30	9	23	12	—	1/2	12	—	1/2	—	—	20
24	24-000	15	24	48	26	10-1/2	27-1/2	12	—	1/2	12	—	1/2	—	—	24
30	30-000	18-1/2	30	60	45	10-1/2	—	—	—	—	—	—	—	—	—	30

STRAIGHT TEE		REDUCING TEE				CONCENTRIC REDUCER				ECCENTRIC REDUCER				
Nom. Pipe Size	Outlet	C	M	H	Nom. Pipe Size	Outlet	C	M	H	Nom. Pipe Size	Outlet	C	M	H
3/4	3/4	...	...	1-1/2	3-1/2	3-1/2	3-3/4	...	...	10	10	8-1/2	...	...
	1/2	1-1/8	1-1/8	1-1/2		3	3-3/4	3-5/8	4		4	8	8-1/2	8-1/2	8	7
1	1	1-1/2	1-1/2	...	3-1/2	2-1/2	3-3/4	3-1/2	4	10	6	8-1/2	7-5/8	7
	3/4	1-1/2	1-1/2	2		2	3-3/4	3-1/4	4		4	5	8-1/2	7-1/2	7	7
1-1/4	1/2	1-1/2	1-1/2	2	1-1/2	1-1/2	3-3/4	3-1/8	4	12	4	8-1/2	7-1/4	7
	1-1/4	1-7/8		4	4-1/8	12	10	10
1-1/4	1	1-7/8	1-7/8	2	3-1/2	3-1/2	4-1/8	4	4	10	10	10	9-1/2	8
	3/4	1-7/8	1-7/8	2		3	4-1/8	3-7/8	4		4	8	10	10	9	8
1-1/2	1/2	1-7/8	1-7/8	2	4	2-1/2	4-1/8	3-3/4	4	12	6	10	8-5/8	8
	1-1/2	2-1/4	2-1/4	...		2	4-1/8	3-1/2	4		4	5	10	8-1/2	8	8
1-1/2	1-1/4	2-1/4	2-1/4	2-1/2	1-1/2	1-1/2	4-1/8	3-3/2	4	14	14	11	...	...
	1	2-1/4	2-1/4	2-1/2		5	4-7/8	12	11	10-5/8
1-1/2	3/4	2-1/4	2-1/4	2-1/2	5	3-1/2	4-7/8	4-1/2	5	14	10	11	10-1/8	13
	1-1/2	2-1/4	2-1/4	2-1/2		2	4-7/8	4-3/8	5		5	8	11	9-3/4	13	13
2	2	2-1/2	2-3/8	3	2-1/2	2-1/2	4-7/8	4-1/4	5	16	16	12	...	...
	1-1/4	2-1/2	2-1/4	3		2	4-7/8	4-1/2	5		5	14	12	12	14	14
2	1	2-1/2	2-1/4	3	6	6	5-5/8	4-1/2	5	16	14	12	12	14
	3/4	2-1/2	1-3/4	3		5	5-5/8	12	12	11-5/8	14	14
2-1/2	2	3	...	...	6	5	5-5/8	5-3/8	5-1/2	16	12	12	11-5/8	14
	1-1/2	3	2-3/4	3-1/2		4	5-5/8	5-1/8	5-1/2		5-1/2	10	10	11-1/8	14	14
2-1/2	1-1/2	3	2-5/8	3-1/2	6	3-1/2	5-5/8	5	5-1/2	18	8	12	10-3/4	14
	1-1/4	3	2-1/2	3-1/2		3	5-5/8	4-7/8	5-1/2		5-1/2	6	6	12	10-3/8	14
3	1	3	2-1/4	3-1/2	8	2-1/2	5-5/8	4-3/4	5-1/2	18	18	13-1/2	13	15
	3	3-3/8	3-1/4	3-1/2		8	7	6-5/8	6		6	16	16	13-1/2	13	15
3	2-1/2	3-3/8	3-1/4	3-1/2	8	6	7	6-5/8	6	18	14	13-1/2	13	15
	2	3-3/8	3	3-1/2		5	7	6-3/8	6		6	12	12	13-1/2	12-5/8	15
3	1-1/2	3-3/8	2-7/8	3-1/2	8	4	7	6-1/2	6	18	10	13-1/2	12-1/8	15
	1-1/4	3-3/8	2-3/4	3-1/2		3-1/2	7	6	6		6	8	8	13-1/2	11-3/4	15

STANDARD DIMENSIONS OF FITTINGS AND PIPE (cont.)

Nominal Size	Nom. Outside Diam.	NOMINAL WALL THICKNESS													Nominal Size			
		Sched. 10 T	Sched. 20	Sched. 30	Std. S Wall	Sched. 40	Sched. 60	Extra # Strong	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160	Dbl. Extra Strong				
1/2	0.840	0.083	—	0.095	0.109	0.109	0.109	0.109	0.109	0.109	0.147	0.147	—	—	—	0.188	0.294	1/2
3/4	1.050	0.083	—	0.095	0.113	0.113	0.113	0.113	0.113	0.113	0.154	0.154	—	—	—	0.219	0.308	3/4
1	1.315	0.109	—	0.114	0.133	0.133	0.133	0.133	0.133	0.133	0.179	0.179	—	—	—	0.250	0.358	1
1-1/4	1.660	0.109	—	0.117	0.140	0.140	0.140	0.140	0.140	0.140	0.191	0.191	—	—	—	0.250	0.382	1-1/4
1-1/2	1.900	0.109	—	0.125	0.145	0.145	0.145	0.145	0.145	0.145	0.200	0.200	—	—	—	0.281	0.400	1-1/2
2	2.375	0.109	—	0.125	0.154	0.154	0.154	0.154	0.154	0.154	0.218	0.218	—	—	—	0.344	0.436	2
2-1/2	2.875	0.120	—	0.188	0.203	0.203	0.203	0.203	0.203	0.203	0.276	0.276	—	—	—	0.375	0.552	2-1/2
3	3.500	0.120	—	0.188	0.216	0.216	0.216	0.216	0.216	0.216	0.300	0.300	—	—	—	0.438	0.600	3
3-1/2	4.000	0.120	—	0.188	0.226	0.226	0.226	0.226	0.226	0.226	0.318	0.318	—	—	—	—	—	3-1/2
4	4.500	0.120	—	0.188	0.237	0.237	0.237	0.237	0.237	0.237	0.337	0.337	—	—	—	0.531	0.674	4
5	5.563	0.134	—	—	0.258	0.258	0.258	0.258	0.258	0.258	0.375	0.375	—	—	—	0.625	0.750	5
6	6.625	0.134	—	—	0.280	0.280	0.280	0.280	0.280	0.280	0.432	0.432	—	—	—	0.719	0.864	6
8	8.625	0.148	0.250	0.277	0.322	0.322	0.322	0.322	0.322	0.322	0.406	0.500	0.594	0.719	0.812	0.906	0.875	8
10	10.750	0.165	0.250	0.307	0.365	0.365	0.365	0.365	0.365	0.365	0.500	0.594	0.719	0.844	1.000	1.125	1.000	10
12	12.750	0.180	0.250	0.330	0.375	0.375	0.375	0.375	0.375	0.375	0.406	0.688	0.844	1.000	1.125	1.312	1.000	12
14	14.000	0.250	0.312	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.438	0.500	0.938	1.094	1.250	1.406	—	14
16	16.000	0.250	0.312	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.500	0.844	1.031	1.219	1.438	1.594	—	16
18	18.000	0.250	0.312	0.438	0.375	0.375	0.375	0.375	0.375	0.375	0.562	0.938	1.156	1.375	1.562	1.781	—	18
20	20.000	0.250	0.375	0.500	0.375	0.375	0.375	0.375	0.375	0.375	0.594	1.031	1.281	1.500	1.750	1.969	—	20
22	22.000	0.250	0.375	0.500	0.375	0.375	0.375	0.375	0.375	0.375	—	1.125	1.375	1.625	1.875	2.125	—	22
24	24.000	0.250	0.375	0.562	0.375	0.375	0.375	0.375	0.375	0.375	0.688	1.219	1.531	1.812	2.062	2.344	—	24
26	26.000	0.312	0.500	—	0.375	—	0.375	—	0.375	—	—	—	—	—	—	—	—	26
30	30.000	0.312	0.500	0.625	0.375	—	0.375	—	0.375	—	—	—	—	—	—	—	—	30
36	36.000	0.312	0.500	0.625	0.375	—	0.375	—	0.375	—	—	—	—	—	—	—	—	36
40	40.000	—	—	—	0.375	—	0.375	—	0.375	—	—	—	—	—	—	—	—	40
42	42.000	—	—	—	0.375	—	0.375	—	0.375	—	—	—	—	—	—	—	—	42
48	48.000	—	—	—	0.375	—	0.375	—	0.375	—	—	—	—	—	—	—	—	48

ASME FORGED STEEL FLANGES

WELDING NECK FLANGE BORES ①③														
Nom. Pipe Size	Outside Diam.	Light Wall ⑥	Sched. 20	Sched. 30	Std. Wall	Sched. 40	Sched. 60	Sched. Extra Strong	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160	Dbl. Extra Strong
1/2	0.840	0.674	—	0.650	0.622	0.622	—	0.546	0.546	—	—	—	0.464	0.252
3/4	1.050	0.884	—	0.860	0.824	0.824	—	0.742	0.742	—	—	—	0.612	0.434
1	1.315	1.097	—	1.087	1.049	1.049	—	0.957	0.957	—	—	—	0.815	0.599
1-1/4	1.660	1.442	—	1.426	1.380	1.380	—	1.278	1.278	—	—	—	1.160	0.896
1-1/2	1.900	1.682	—	1.650	1.610	1.610	—	1.500	1.500	—	—	—	1.398	1.100
2	2.375	2.157	—	2.125	2.067	2.067	—	1.939	1.939	—	—	—	1.687	1.503
2-1/2	2.875	2.635	—	2.999	2.469	2.469	—	2.323	2.323	—	—	—	2.125	1.771
3	3.500	3.260	—	3.124	3.068	3.068	—	2.900	2.900	—	—	—	2.624	2.300
3-1/2	4.000	3.760	—	3.624	3.548	3.548	—	3.364	3.364	—	—	—	—	—
4	4.500	4.260	—	4.124	4.026	4.026	—	3.826	3.826	—	3.624	—	3.438	3.152
5	5.563	5.295	—	—	5.047	5.047	—	4.813	4.813	—	4.563	—	4.313	4.063
6	6.625	6.357	—	—	6.065	6.065	—	5.761	5.761	—	5.501	—	5.187	4.897
8	8.625	8.329	8.125	8.071	7.981	7.981	7.813	7.625	7.625	7.437	7.187	7.001	6.813	6.875
10	10.750	10.420	10.250	10.136	10.020	10.020	9.750	9.750	9.562	9.312	9.062	8.750	8.500	8.750
12	12.750	12.390	12.250	12.090	12.000	11.938	11.626	11.750	11.374	11.062	10.750	10.500	10.126	10.750
14	14.000	13.500	13.376	13.250	13.250	13.124	12.812	13.000	12.500	12.124	11.812	11.500	11.188	—
16	16.000	15.500	15.376	15.250	15.250	15.000	14.688	15.000	14.312	13.938	13.562	13.124	12.812	—
18	18.000	17.500	17.376	17.124	17.250	16.876	16.500	17.000	16.124	15.688	15.250	14.876	14.438	—
20	20.000	19.500	19.250	19.000	19.250	18.812	18.376	19.000	17.998	17.438	17.000	16.500	16.062	—
24	24.000	23.500	23.250	22.876	23.250	22.624	22.062	23.000	21.562	20.938	20.376	19.876	19.312	—
30	30.000	29.376	29.000	28.750	29.250	—	—	29.000	—	—	—	—	—	—
36	36.000	35.376	35.000	34.750	35.250	34.500	—	35.000	—	—	—	—	—	—
42	42.000	—	—	—	41.250	—	—	41.000	—	—	—	—	—	—
48	48.000	—	—	—	47.250	—	—	47.000	—	—	—	—	—	—

Notes:

- Always specify bore when ordering.
- Includes 1/16" raised face in 150 lbs and 300 lbs standards.
Does not include 1/4" raised face in 400 lbs and heavier standards.
- Inside pipe diameters are also provided by this table.
- Other types, sizes and facings on application.
- Stocked in carbon steel and a variety of other metals and alloys.
- Light Wall diameters are identical to stainless steel Schedule 10S in sizes through 12" and to Schedule 10 in sizes 14" and larger.

ASME FORGED STEEL FLANGES (cont.)

Nom. Pipe Size	150-LB FLANGES										300-LB FLANGES										400-LB FLANGES										Nom. Pipe Size
	WELDING NECK FLANGE ①					SLIP-ON FLANGE					THREADED FLANGE					LAP JOINT FLANGE					BLIND FLANGE										
	O	C ²	Weld Neck	Y ² Slip on Thrd.	Lap Joint	Bolt Circle	No. and Size of Holes	O	C ²	Weld Neck	Y ² Slip on Thrd.	Lap Joint	Bolt Circle	No. and Size of Holes	O	C ²	Weld Neck	Y ² Slip on Thrd.	Lap Joint	Bolt Circle	No. and Size of Holes	O	C ²	Weld Neck	Y ² Slip on Thrd.	Lap Joint	Bolt Circle	No. and Size of Holes			
1/2	3-1/2	7/16	1-7/8	3/8	3/8	2-3/8	4 x 5/8	3-3/4	9/16	2-1/16	7/8	7/8	2-5/8	4 x 5/8	3-3/4	9/16	2-1/16	7/8	7/8	2-5/8	4 x 5/8	3-3/4	9/16	2-1/16	7/8	7/8	2-5/8	4 x 5/8			
3/4	3-7/8	1/2	2-1/16	5/8	5/8	2-3/4	4 x 5/8	4-5/8	5/8	2-1/4	1	1	3-1/4	4 x 3/4	4-5/8	5/8	2-1/4	1	1	3-1/4	4 x 3/4	4-5/8	5/8	2-1/4	1	1	3-1/4	4 x 3/4			
1	4-1/4	9/16	2-3/16	11/16	11/16	3-1/8	4 x 5/8	4-7/8	11/16	2-7/16	1-1/16	1-1/16	3-1/2	4 x 3/4	4-7/8	11/16	2-7/16	1-1/16	1-1/16	3-1/2	4 x 3/4	4-7/8	11/16	2-7/16	1-1/16	1-1/16	3-1/2	4 x 3/4			
1-1/4	4-5/8	5/8	2-1/4	13/16	13/16	3-1/2	4 x 5/8	5-1/4	3/4	2-9/16	1-1/16	1-1/16	3-7/8	4 x 3/4	5-1/4	13/16	2-5/8	1-1/8	1-1/8	3-7/8	4 x 3/4	5-1/4	13/16	2-5/8	1-1/8	1-1/8	3-7/8	4 x 3/4			
1-1/2	5	11/16	2-7/16	7/8	7/8	3-7/8	4 x 5/8	6-1/8	13/16	2-11/16	1-3/16	1-3/16	4-1/2	4 x 7/8	6-1/8	7/8	2-3/4	1-1/4	1-1/4	4-1/2	4 x 7/8	6-1/8	7/8	2-3/4	1-1/4	1-1/4	4-1/2	4 x 7/8			
2	6	3/4	2-1/2	1	1	4-3/4	4 x 3/4	6-1/2	7/8	2-3/7	1-5/16	1-5/16	5	8 x 3/4	6-1/2	7/8	2-3/7	1-5/16	1-5/16	5	8 x 3/4	6-1/2	7/8	2-3/7	1-5/16	1-5/16	5	8 x 3/4			
2-1/2	7	7/8	2-3/4	1-1/2	1-1/2	5-1/2	4 x 3/4	7-1/2	1	3	1-1/2	1-1/2	5-7/8	8 x 7/8	7-1/2	1-1/8	3-1/8	1-5/8	1-5/8	5-7/8	8 x 7/8	7-1/2	1-1/8	3-1/8	1-5/8	1-5/8	5-7/8	8 x 7/8			
3	7-1/2	15/16	2-3/4	1-3/16	1-3/16	6	4 x 3/4	8-1/4	1-1/8	3-1/8	1-11/16	1-11/16	6-5/8	8 x 7/8	8-1/4	1-1/4	3-1/4	1-13/16	1-13/16	6-5/8	8 x 7/8	8-1/4	1-1/4	3-1/4	1-13/16	1-13/16	6-5/8	8 x 7/8			
3-1/2	8-1/2	15/16	2-13/16	1-1/4	1-1/4	7	8 x 3/4	9	1-3/16	3-3/16	1-3/4	1-3/4	7-1/4	8 x 7/8	9	1-3/8	3-3/8	1-15/16	1-15/16	7-1/4	8 x 7/8	9	1-3/8	3-3/8	1-15/16	1-15/16	7-1/4	8 x 1			
4	9	15/16	3	1-5/16	1-5/16	7-1/2	8 x 3/4	10	1-1/4	3-3/8	1-7/8	1-7/8	7-7/8	8 x 7/8	10	1-3/8	3-1/2	2	2	7-7/8	8 x 7/8	10	1-3/8	3-1/2	2	2	7-7/8	8 x 1			
5	10	15/16	3-1/2	1-7/16	1-7/16	8-1/2	8 x 7/8	11	1-3/8	3-7/8	2	2	9-1/4	8 x 7/8	11	1-1/2	4	2-1/8	2-1/8	9-1/4	8 x 7/8	11	1-1/2	4	2-1/8	2-1/8	9-1/4	8 x 1			
6	11	1	3-1/2	1-9/16	1-9/16	9-1/2	8 x 7/8	12-1/2	1-7/16	3-7/8	2-1/16	2-1/16	10-5/8	12 x 7/8	12-1/2	1-5/8	4-1/16	2-1/4	2-1/4	10-5/8	12 x 7/8	12-1/2	1-5/8	4-1/16	2-1/4	2-1/4	10-5/8	12 x 1			
8	13-1/2	1-1/2	4	1-3/4	1-3/4	11-3/4	8 x 7/8	15	1-5/8	4-3/8	2-7/16	2-7/16	13	12 x 1	15	1-7/8	4-5/8	2-11/16	2-11/16	13	12 x 1-1/8	15	1-7/8	4-5/8	2-11/16	2-11/16	13	12 x 1-1/8			
10	16	1-3/16	4	1-15/16	1-15/16	14-1/4	12 x 1	17-1/2	1-7/8	4-5/8	2-5/8	3-3/4	15-1/4	16 x 1-1/8	17-1/2	2-1/8	4-7/8	2-7/8	4	15-1/4	16 x 1-1/4	17-1/2	2-1/8	4-7/8	2-7/8	4	15-1/4	16 x 1-1/4			
12	19	1-1/4	4-1/2	2-3/16	2-3/16	17	12 x 1	20-1/2	2	5-1/8	2-7/8	4	17-3/4	16 x 1-1/4	20-1/2	2-1/4	5-3/8	3-1/8	4-1/4	17-3/4	16 x 1-1/4	20-1/2	2-1/4	5-3/8	3-1/8	4-1/4	17-3/4	16 x 1-3/8			
14	21	1-3/8	5	2-1/4	3-1/8	18-3/4	12 x 1-1/8	23	2-1/8	5-5/8	3	4-3/8	20-1/4	20 x 1-1/4	23	2-3/8	5-7/5	3-5/16	4-5/8	20-1/4	20 x 1-1/4	23	2-3/8	5-7/5	3-5/16	4-5/8	20 x 1-1/8	14			
16	23-1/2	1-7/16	5	2-1/2	3-7/16	21-1/4	16 x 1-1/8	25-1/2	2-1/4	5-3/4	3-1/4	4-3/4	22-1/4	20 x 1-3/8	25-1/2	2-1/2	6	3-11/16	5	22-1/4	20 x 1-1/2	25-1/2	2-1/2	6	3-11/16	5	22-1/4	20 x 1-1/2			
18	25	1-9/16	5-1/2	2-11/16	3-15/16	22-3/4	16 x 1-1/4	28	2-3/8	6-1/4	3-1/2	5-1/8	24-3/4	24 x 1-3/8	28	2-5/8	6-1/2	3-7/8	5-3/8	24-3/4	24 x 1-3/8	28	2-5/8	6-1/2	3-7/8	5-3/8	24 x 1-1/2	18			
20	27-1/2	1-11/16	5-11/16	2-7/8	4-1/16	25	20 x 1-1/4	30-1/2	2-1/2	6-3/8	3-3/4	5-1/2	27	24 x 1-3/8	30-1/2	2-3/4	6-5/8	4	5-3/4	27	24 x 1-3/8	30-1/2	2-3/4	6-5/8	4	5-3/4	27	24 x 1-5/8			
24	32	1-7/8	6	3-1/4	4-3/8	29-1/2	20 x 1-3/8	36	2-3/4	6-5/8	4-3/16	6	32	24 x 1-5/8	36	3	6-7/8	4-1/2	6-1/4	32	24 x 1-5/8	36	3	6-7/8	4-1/2	6-1/4	32	24 x 1-7/8			

600-LB FLANGES										900-LB FLANGES										1500-LB FLANGES									
1/2	3-3/4	9/16	2-1/16	7/8	7/8	2-5/8	4 x 5/8	4-3/4	7/8	2-3/8	1-1/4	3-1/4	4 x 7/8	4-3/4	7/8	2-3/8	1-1/4	3-1/4	4 x 7/8	4-3/4	7/8	2-3/8	1-1/4	3-1/4	4 x 7/8	1/2			
3/4	4-5/8	5/8	2-1/4	1	1	3-1/4	4 x 3/4	5-1/8	1	2-3/4	1-3/8	3-1/2	4 x 7/8	5-1/8	1	2-3/4	1-3/8	3-1/2	4 x 7/8	5-1/8	1	2-3/4	1-3/8	3-1/2	4 x 7/8	3/4			
1	4-7/8	1-1/16	2-7/16	1-1/16	1-1/16	3-1/2	4 x 3/4	5-7/8	1-1/8	2-7/8	1-5/8	4	4 x 1	5-7/8	1-1/8	2-7/8	1-5/8	4	4 x 1	5-7/8	1-1/8	2-7/8	1-5/8	4	4 x 1	1			
1-1/4	5-1/4	13/16	2-5/8	1-1/8	1-1/8	3-7/8	4 x 3/4	6-1/4	1-1/8	2-7/8	1-5/8	4-3/8	4 x 1	6-1/4	1-1/8	2-7/8	1-5/8	4-3/8	4 x 1	6-1/4	1-1/8	2-7/8	1-5/8	4-3/8	4 x 1	1-1/4			
1-1/2	6-1/8	7/8	2-3/4	1-1/4	1-1/4	4-1/2	4 x 7/8	7	1-1/4	3-1/4	1-3/4	4-7/8	4 x 1-1/8	7	1-1/4	3-1/4	1-3/4	4-7/8	4 x 1-1/8	7	1-1/4	3-1/4	1-3/4	4-7/8	4 x 1-1/8	1-1/2			
2	6-1/2	1	2-7/8	1-7/16	1-7/16	5	8 x 3/4	8-1/2	1-1/2	4	2-1/4	6-1/2	8 x 1	8-1/2	1-1/2	4	2-1/4	6-1/2	8 x 1	8-1/2	1-1/2	4	2-1/4	6-1/2	8 x 1	2			
2-1/2	7-1/2	1-1/8	3-1/8	1-5/8	1-5/8	5-7/8	8 x 7/8	9-3/8	1-3/8	4-1/8	2-1/2	7-1/2	8 x 1-1/8	9-3/8	1-3/8	4-1/8	2-1/2	7-1/2	8 x 1-1/8	9-3/8	1-3/8	4-1/8	2-1/2	7-1/2	8 x 1-1/8	2-1/2			
3	8-1/4	1-1/4	3-1/4	1-13/16	1-13/16	6-5/8	8 x 7/8	9-1/2	1-1/2	4	2-1/8	7-1/2	8 x 1	9-1/2	1-1/2	4	2-1/8	7-1/2	8 x 1	10-1/2	1-7/8	4-5/8	2-7/8	8	8 x 1-1/4	3			
3-1/2	9	1-3/8	3-3/8	1-15/16	1-15/16	7-1/4	8 x 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3-1/2			
4	10-3/4	1-1/2	4	2-1/8	2-1/8	8-1/2	8 x 1	11-1/2	1-3/4	4-1/2	2-3/4	9-1/4	8 x 1-1/4	12-1/4	2-1/8	4-7/8	3-9/16	9-1/2	8 x 1-3/8	4	—	—	—	—	—	4			
5	13	1-3/4	4-1/2	2-3/8	2-3/8	10-1/2	8 x 1-1/8	13-3/4	2	5	3-1/8	3-1/8	11	8 x 1-3/8	14-3/4	2-7/8	6-1/8	4-1/8	11-1/2	8 x 1-5/8	5	—	—	—	—	5			
6	14	1-7/8	4-5/8	2-5/8	2-5/8	11-1/2	12 x 1-1/8	15	2-3/16	5-1/2	3-3/8	3-3/8	12-1/2	12 x 1-1/4	15-1/2	3-1/4	6-3/4	4-11/16	12-1/2	12 x 1-1/2	6	—	—	—	—	6			
8	16-1/2	2-3/16	5-1/4	3	3	13-3/4	12 x 1-1/4	18-1/2	2-1/2	6-3/8	4	4-1/2	15-1/2	12 x 1-1/2	19	3-5/8	8-1/2	5-5/8	15-1/2	12 x 1-3/4	8	—	—	—	—	8			
10	20	2-1/2	6	3-3/8	4-3/8	17	16 x 1-3/8	21-1/2	2-3/4	7-1/4	4-1/4	5	18-1/2	16 x 1-1/2	23	4-1/4	10	6-1/4	7	19	12 x 2	10	—	—	—	10			
12	22	2-5/8	6-1/8	3-5/8	4-5/8	19-1/4	20 x 1-3/8	24	3-1/8	7-7/8	4-5/8	5-5/8	21	20 x 1-1/2	26-1/2	4-7/8	11-1/2	7-1/8	8-5/8	22-1/2	16 x 2-1/8	12	—	—	—	12			
14	23-3/4	2-3/4	6-1/2	3-11/16	5	20-3/4	20 x 1-1/2	25-1/4	3-3/8	8-3/8	5-1/8	6-1/8	22	20 x 1-5/8	29-1/2	5-1/4	11-3/4	—	9-1/2	25	16 x 2-3/8	14	—	—	—	14			
16	27	3	7	4-3/16	5-1/2	23-3/4	20 x 1-5/8	27-3/4	3-1/2	8-1/2	5-1/4	6-1/2	24-1/4	20 x 1-3/4	32-1/2	5-3/4	12-1/4	—	10-1/4	27-3/4	16 x 2-5/8	16	—	—	—	16			
18	29-1/4	3-1/4	7-1/4	4-5/8	6	25-3/4	20 x 1-3/4	31	4	9	6	7-1/2	27	20 x 2	36	6-1/8	12-7/8	—	10-7/8	30-1/2	16 x 2-7/8	18	—	—	—	18			
20	32	3-1/2	7-1/2	5	6-1/2	28-1/2	24 x 1-3/4	33-3/4	4-1/4	9-3/4	6-1/4	8-1/4	29-1/2	20 x 2-1/8	38-3/4	7	14	—	11-1/2	32-3/4	16 x 3-1/8	20	—	—	—	20			
24	37	4	8	5-1/2	7-1/4	33	24 x 2	41	5-1/2	11-1/2	8	10-1/2	35-1/2	20 x 2-5/8	46	8	16	—	13	39	16 x 3-3/8	24	—	—	—	24			

2500-LB FLANGES

1/2	5-1/4	1-3/16	2-7/8	1-9/16	1-9/16	3-1/2	4 x 7/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3/4	5-1/2	1-1/4	3-1/8	1-11/16	1-11/16	3-3/4	4 x 7/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	6-1/4	1-3/8	3-1/2	1-7/8	1-7/8	4-1/4	4 x 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1-1/4	7-1/4	1-1/2	3-3/4	2-1/16	2-1/16	5-1/8	4 x 1-1/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1-1/2	8	1-3/4	4-3/8	2-3/8	2-3/8	6-3/4	4 x 1-1/4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	9-1/4	2	5	2-3/4	2-3/4	8-3/4	8 x 1-1/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2-1/2	10-1/2	2-1/4	5-5/8	3-1/8	3-1/8	7-3/4	8 x 1-1/4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	12	2-5/8	6-5/8	3-5/8	3-5/8	9	8 x 1-3/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	14	3	7-1/2	4-1/4	4-1/4	10-3/4	8 x 1-5/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5	16-1/2	3-5/8	9	5-1/8	5-1/8	12-3/4	8 x 1-7/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	19	4-1/4	10-3/4	6	6	14-1/2	8 x 2-1/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	21-3/4	5	12-1/2	7	7	17-1/4	12 x 2-1/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	26-1/2	6-1/2	16-1/2	9	9	21-1/4	12 x 2-5/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	30	7-1/4	18-1/4	10	10	24-3/8	12 x 2-7/8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

ASME FLANGE RATING TABLES

Notes for Following Tables

Material Group	Materials (a) (Spec-Grade)	See Notes
1.1	A105, A350-LF2, A216-WCB, A515-70	(a)
	A516-70	(a) (i)
	A350-LF6-Cl.1	(d)
	A537-Cl.1	(g)
	A350-LF3	—
1.2	A203-B, A203-E, A216-WCC	(a)
	A352-LCC, A352-LC3	(e)
	A350-LF6-Cl.2	(d)
	A352-LC2	—
1.3	A352-LCB, A352-LC1	(e)
	A203-A, A203-D, A515-65	(a)
	A516-65	(a) (i)
	A217-WC1	(b) (v) (w)
1.4	A350-LF1-Cl.1, A515-60	(a)
	A516-60	(a) (i)
1.5	A182-F1, A204-A, A204-B	(b)
1.7	A182-F2	(j)
	A217-WC4	(j) (v) (w)
	A217-WC5	(v) (w)
1.9	A182-F11-Cl.2	(c) (v)
	A217-WC6	(m) (v) (w)
	A387-11-Cl.2	(c)
1.10	A182-F22, A387-22-Cl.2	(c)
	A217-WC9	(m) (v) (w)
1.11	A204-C	(b)
1.13	A217-C5	(v) (w)
	A182-F5a	—
1.14	A217-C12	(v) (w)
	A182-F9	—
1.15	A217-C12A	(w)
	A182-F91, A387-91-Cl.2	—
1.17	A182-F12-Cl.2	(c) (v)
	A182-F5	—
1.18	A182-F92	(y)
2.1	A182-F304, A240-304, A351-CF8	(r)
	A351-CF3	(h)
	A182-F304H, A240-304H	—
2.2	A182-F316, A182-F317, A240-316, A240-317, A351-CF8M	(r)
	A351-CF3M	(i)
	A351-CG8M	(j)
	A182-F316H, A240-316H	—
2.3	A182-F304L, A240-304L	(h)
	A182-F316L, A240-316L, A182-F317L	—
2.4	A182-F321, A240-321	(j)
	A182-F321H, A240-321H	(s)
2.5	A182-F347, A240-347, A182-F348, A240-348	(j)
	A182-F347H, A240-347H, A182-F348H, A240-F348H	(s)
2.6	A240-309H	—
2.7	A182-F310	(a) (r)
	A240-310H	—
2.8	A182-F44, A351-CK3MCuN, A240-S31254	—
	A182-F51, A182-F53, A182-F55	(f)
	A351-CE8MN, A351-CD4MCu, A351-CD3MWCuN	(f)
	A240-S31803, A240-S32750, A240-S32760	(f)
		—

2.9	A240-309S, A240-310S	(q) (r) (x)
2.10	A351-CH8, A351-CH20	(r)
2.11	A351-CF8C	(r)
2.12	A351-CK20	(r)
3.1	B462-N08020, B463-N08020	(t)
3.2	B564-N02200, B162-N02200	(t)
3.3	B162-N02201	(t)
3.4	B564-N04400, B127-N04400	(t)
3.5	B564-N06600, B168-N06600	(t)
3.6	B564-N08800, B409-N08800	(t)
3.7	B333-N10665, B462-N10665, B333-N10675, B462-N10675	(u)
3.8	B462-N10276, B575-N10276,	(p) (u)
	B462-N06022, B575-N06022	(p) (u) (aa)
	B564-N06625, B443-N06625	(n) (t) (z)
	B333-N10001, B462-N06200, B575-N06455, B575-N06200	(h) (u)
	B434-N10003	(t)
	B564-N08825, B424-N08825	(t) (j)
3.9	B572-R30556, B435-N06002, B435-R30556	(u)

Notes:

- Provisions of Section 2 apply to all ratings.
 - Temperature notes for all Material Groups, Tables 2-150 through 2-2500
 - See Table 1A for additional information and notes relating to specific materials.
- (a) permissible but not recommended for prolonged use above about 800°F
- (b) permissible but not recommended for prolonged use above about 875°F
- (c) permissible but not recommended for prolonged use above about 1100°F
- (d) not to be used over 500°F
- (e) not to be used over 650°F
- (f) not to be used over 600°F
- (g) not to be used over 700°F
- (h) not to be used over 800°F
- (i) not to be used over 850°F
- (j) not to be used over 1000°F
- (k) not to be used over 1050°F
- (m) not to be used over 1100°F
- (n) not to be used over 1200°F, alloy N06625 in the annealed condition is subject to severe loss of impact strength at room temperatures after exposure in the range of 1000°F to 1400°F
- (p) not to be used over 1250°F
- (q) for service temperature 1050°F and above, should be used only when assurance is provided that grain size is not finer than ASTM No. 6
- (r) at temperature over 1000°F, use only when the carbon content is 0.04% or higher
- (s) for temperatures over 1000°F, use only if the material is heat treated by heating to a minimum temperature of 2000°F
- (t) use annealed material only
- (u) use solution annealed material only
- (v) use normalized and tempered material only
- (w) the deliberate addition of any element not listed in ASTM A217, Table 1 is prohibited, except that calcium (Ca) and manganese (Mn) may be added for deoxidation
- (x) at temperatures above 1000°F, use only if the material is solution heat treated to the minimum temperature specified in the specifications, but no lower than 1900°F, and quenching in water or rapidly cooling by other means
- (y) application above 1150°F is limited to tubing of maximum outside diameter of 3-1/2 in
- (z) Grade 1
- (aa) alloy N06022 in the solution annealed condition is subject to severe loss of impact strength at room temperature after exposure to temperatures in the range of 1000°F to 1250°F

CLASS 150 PRESSURE-TEMPERATURE RATINGS

Pressures are in pounds per square inch, gauge (psig)

Mat'l Group	Temp. °F																																			
	1.1	1.2	1.3	1.4	1.5	1.7	1.9	1.10	1.11	1.13	1.14	1.15	1.17	1.18	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	
Materials	Temp. °F																																			
	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	1/2Cr-Mo	
-20 to 100	285	290	265	235	265	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290
200	260	260	255	215	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	
300	230	230	230	210	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	
400	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	
500	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	
600	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	
650	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	
700	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	
750	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	
800	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	
850	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	
900	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	
950	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	
1000	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
1050																																				
1100																																				
1150																																				
1200																																				

Mat'l Group	Materials	1.1	1.2	1.3	1.4	1.5	1.7	1.9	1.10	1.11	1.13	1.14	1.15	1.17	1.18	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9				
		Temp. °F	Carbon Steel	C-1/2 Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo	1/2Cr-1/2Mo				
		985	1000	930	825	930	1000	1000	1000	1000	1000	1000	1000	1000	1000	960	960	800	960	960	960	960	1000	1000	960	895	960	895	1000	640	320	800	1000	960	1000	1000	1000			
		905	1000	880	755	930	1000	1000	1000	1000	1000	1000	1000	980	1000	1000	825	680	865	885	885	990	840	305	700	1000	885	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000			
		870	970	850	725	915	970	965	970	970	970	970	970	935	970	715	610	795	820	775	775	890	775	640	300	655	970	850	970	970	920	300	300	300	300	300	300	300	300	
		845	940	820	700	885	940	925	940	940	940	940	940	890	940	660	685	560	735	770	725	725	820	725	645	300	630	940	825	940	930	850	400	400	400	400	400	400	400	
		805	885	780	670	855	885	885	885	885	885	885	885	860	885	620	635	525	690	725	690	685	775	685	625	725	625	875	605	300	630	885	805	885	885	795	500	500	500	
		755	805	735	630	805	805	805	805	805	805	805	805	805	805	590	600	495	650	690	665	660	740	660	610	690	610	805	550	300	630	805	785	805	805	750	600	600	600	
		730	785	710	610	785	785	785	785	785	785	785	785	785	785	575	590	485	635	675	655	645	730	645	595	675	595	785	300	630	785	770	785	785	735	650	650	650		
		700	740	685	590	755	755	755	755	755	755	755	755	755	755	565	580	480	620	660	645	635	725	635	725	660	580	755	300	625	755	755	755	755	725	700	700	700		
		675	675	635	570	710	710	710	710	710	710	710	710	710	710	550	570	470	610	655	640	625	710	625	565	655	565	710	295	620	710	710	710	710	710	710	710	750	750	
		550	550	520	495	675	675	675	675	675	675	675	675	675	675	540	565	460	600	650	630	620	620	620	545	650	545	675	290	610	675	675	675	675	675	675	675	800	800	
		425	425	400	400	650	650	650	650	650	650	650	650	650	650	530	555	450	595	645	620	610	610	610	530	645	530	280	280	505	650	650	650	650	650	650	650	850	850	
		305	295	270	230	600	600	600	600	600	600	600	600	600	600	520	555	590	600	600	600	600	600	600	600	510	600	510	275	365	600	600	600	600	600	600	600	900	900	
		185	185	185	375	420	425	515	375	365	505	515	365	515	510	515	515	515	515	515	515	515	515	515	495	515	495	260	485	485	515	515	515	515	515	515	515	950	950	
		115	115	115	115	220	270	290	355	220	265	340	485	265	485	470	485	485	485	485	485	485	485	485	485	485	485	255	320	485	485	485	485	485	485	485	1000	1000		
		1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	
		1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	
		1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	
		1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
		1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	
		1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
		1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350	
		1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	
		1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	
		1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500

**CLASS 400
PRESSURE-TEMPERATURE
RATINGS**

Mat'l Group Materials	Temp. °F -20 to 100	1.1	1.2	1.3	1.4	1.5	1.7	1.9	1.10	1.11	1.13	1.14	1.15	1.17	1.18	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9			
		Carbon Steel	1/2 C-1/2 Mo	1/4 C-1/2 Ni-Cr-1/4 Mo	1/2 C-1/2 Mo	50C-1/2 Mo	90C-1/2 Mo	90C-1/2 Mo	90C-1/2 Mo	21/4 C-1/2 Ni-Cr-1/4 Mo	C-1/2 Mo	1/2 C-1/2 Mo	90C-1/2 Mo	90C-1/2 Mo	90C-1/2 Mo	30-4L Type 304 316 321	Type 304 309 310	20C-18Ni-12Ni 6Mo	23C-25C-12Ni 2Ni	18Cr-10Ni-25C-20Ni 1Cb	99.0 Ni-Ni-Low C	Ni-Cu-Alloys 400 405	Ni-Fe-Cr-Alloy 600 600 B2	Ni-Fe-Cr-Alloy 600	Ni-Fe-Cr-Alloy 600	Ni-Fe-Cr-Alloy 600	99.0 Ni-Ni-Low C	Cr-Ni-Cu Alloy 200Cb	Cr-Fe-Mo-Cu-Ch 200Cb	99.0 Ni-Ni-Low C	Ni-Cu-Alloys 400 405	Ni-Fe-Cr-Alloy 600	Ni-Fe-Cr-Alloy 600	Ni-Fe-Cr-Alloy 600	Ni-Cr-Alloy Fe-Nickel	Ni-Cr-Alloy Fe-Nickel			
200	1480	1500	1395	1235	1395	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1440	1440	1200	1440	1440	1440	1440	1440	1440	1440	1345	1500	960	480	1200	1500	1440	1500	1500	1500				
300	1360	1500	1320	1130	1395	1500	1500	1500	1500	1500	1500	1500	1470	1500	1200	1240	1020	1295	1235	1260	1270	1490	1260	1100	1325	1100	1485	960	460	1050	1500	1330	1500	1500	1500				
400	1265	1405	1230	1055	1325	1410	1385	1410	1410	1410	1410	1410	1410	1335	1410	995	1025	840	1105	1150	1090	1085	1230	1085	970	1150	970	450	945	1410	1240	1410	1395	1275	400				
500	1205	1330	1175	1005	1285	1330	1330	1330	1330	1330	1330	1330	1290	1330	930	955	785	1030	1085	1035	1025	1160	1025	940	1085	940	905	450	945	1330	1205	1330	1330	1190	500				
600	1135	1210	1105	945	1210	1210	1210	1210	1210	1210	1210	1210	1210	1210	885	900	745	975	1030	1000	990	1115	990	910	1030	910	825	450	945	1210	1175	1210	1210	1130	600				
650	1100	1175	1065	915	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	865	885	730	960	1015	985	970	1095	970	895	1015	885	1175	445	945	1175	1155	1175	1175	1105	650				
700	1060	1110	1025	885	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	845	870	720	930	995	970	955	1085	955	870	995	870	1135	445	940	1135	1135	1135	1135	1085	700				
750	1015	1015	955	855	1065	1065	1065	1065	1065	1065	1065	1065	1065	1065	825	855	705	915	985	960	940	1065	940	845	985	845	1065	440	930	1065	1065	1065	1065	1065	750				
800	825	825	780	740	1015	1015	1015	1015	1015	1015	1015	1015	1015	1015	810	845	690	900	975	945	930	930	820	975	820	1015	430	915	1015	1015	1015	1015	1015	1015	800				
850	640	640	595	595	975	975	975	975	975	975	975	975	975	975	790	835	675	885	970	930	915	915	795	970	795	915	420	755	975	975	975	975	975	975	850				
900	460	445	405	345	900	900	900	900	900	900	900	900	900	900	780	830	685	885	900	900	900	900	770	900	770	915	415	550	900	900	900	900	900	900	900	900			
950	275	275	275	275	560	630	640	775	560	560	560	755	775	550	775	765	775	775	775	775	775	775	740	775	740	395	395	725	775	775	775	775	775	775	950	950			
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1300													225	235	220	275	150	150	150	150	150	55	160	150	240	135	135	135	135	135	135	135	135	135	135	1300	1300		
1350													185	190	170	205	115	115	115	115	115	35	125	105	165	110	110	110	110	110	110	110	110	110	110	1350	1350		
1400													150	150	130	150	90	90	90	90	90	25	90	80	110	75	75	75	75	75	75	75	75	75	75	1400	1400		
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CLASS 600
PRESSURE-TEMPERATURE
RATINGS

Design Standards

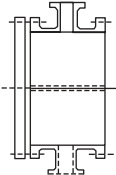
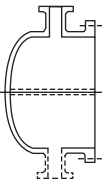
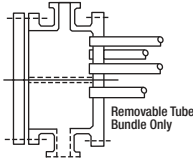
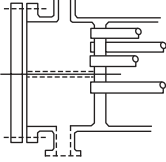
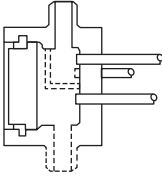
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Materials	C-1/2 Mo		C-1/2 Ni-Cr		1/2Cr-1/2 Ni-Cr		1/2Cr-1/4 Cr-1 Mo		C-1/2 Mo		90C-1/2 Mo		90C-1/2 Mo		90C-2W-1/2 Mo		Type 304L		Types 347 348 309 310		20Cr-18Ni-6Mo		18Cr-25Cr-12Ni		18Cr-25Cr-12Ni		99.0 Ni-400 Alloys		Ni Fe Cr Alloy		Ni Fe Cr Alloy		Ni Cr Mo Fe Alloy				
	Temp. °F	2090	2090	2090	2090	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250		
200	2035	2250	1980	1695	2090	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	
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750	1520	1520	1430	1285	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595	1595
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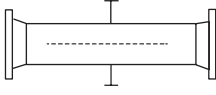
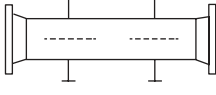
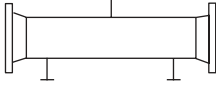
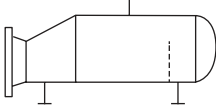
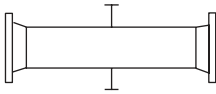
**CLASS 900
PRESSURE-TEMPERATURE
RATINGS**

Mat'l Group	Materials	Temp. °F	1.1	1.2	1.3	1.4	1.5	1.7	1.9	1.10	1.11	1.13	1.14	1.15	1.17	1.18	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9			
			Carbon Steel																Type 304L	Type 304	Type 316	Type 321	Types 347, 348, 349	Type 310	200Cr-18Ni-12Ni	23Cr-12Ni	25Cr-12Ni	18Cr-10Ni-25Cr	Cr Fe Mo Cu Ni Alloy 200Cb	99.0 Ni- Low C	Ni Cu Alloys 400	Ni Fe Cr Alloy 600	Ni Fe Cr Alloy 600 B2	Ni Fe Cr Alloy 600	Ni Fe Cr Alloy 600	Ni Cr Fe Alloy 800	Ni Cr Fe Alloy 800			
		-20 to 100	3705	3750	3480	3065	3480	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	Type 304	Type 316	Type 321	Types 347, 348, 349	Type 310	200Cr-18Ni-12Ni	23Cr-12Ni	25Cr-12Ni	18Cr-10Ni-25Cr	Cr Fe Mo Cu Ni Alloy 200Cb	99.0 Ni- Low C	Ni Cu Alloys 400	Ni Fe Cr Alloy 600	Ni Fe Cr Alloy 600 B2	Ni Fe Cr Alloy 600	Ni Fe Cr Alloy 600	Ni Cr Fe Alloy 800	Ni Cr Fe Alloy 800					
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400		3170	3520	3075	2635	3310	3530	3465	3530	3530	3530	3530	3530	3530	3530	3530	2485	2570	2100	2760	2880	2725	2710	3070	2710	2425	2880	2425	3410	2400	1130	2365	3530	3095	3530	3490	3190	400		
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950		685	685	685	1405	1575	1595	1930	1405	1370	1885	1930	1405	1370	1930	1910	1930	1930	1930	1930	1930	1930	1930	1930	1930	1850	1930	1850	985	1875	1930	1830	1930	1930	1930	1930	950			
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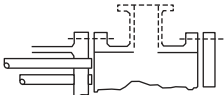
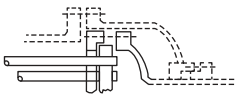
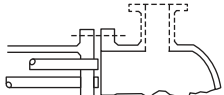
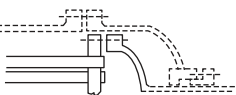
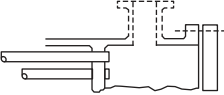
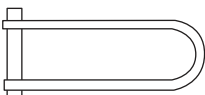
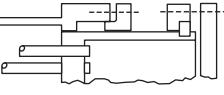
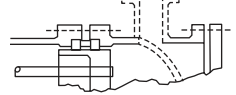
**CLASS 1500
PRESSURE-TEMPERATURE
RATINGS**

TEMA NOMENCLATURE FOR SHELL & TUBE HEAT EXCHANGERS

	FRONT END STATIONERY HEAD TYPES
A	 <p style="text-align: center;">Channel & Removable Cover</p>
B	 <p style="text-align: center;">Bonnet (Integral Cover)</p>
C	 <p style="text-align: center;">Channel Integral with Tubesheet and Removable Cover</p> <p style="text-align: right; font-size: small;">Removable Tube Bundle Only</p>
N	 <p style="text-align: center;">Channel Integral with Tubesheet and Removable Cover</p>
D	 <p style="text-align: center;">Special High Pressure Closure</p>

	SHELL TYPES
E	 <p style="text-align: center;">One Pass Shell</p>
F	 <p style="text-align: center;">Two Pass Shell with Longitudinal Baffle</p>
G	 <p style="text-align: center;">Split Flow</p>
H	 <p style="text-align: center;">Double Split Flow</p>
J	 <p style="text-align: center;">Divided Flow</p>
K	 <p style="text-align: center;">Kettle Type Reboiler</p>
X	 <p style="text-align: center;">Cross Flow</p>

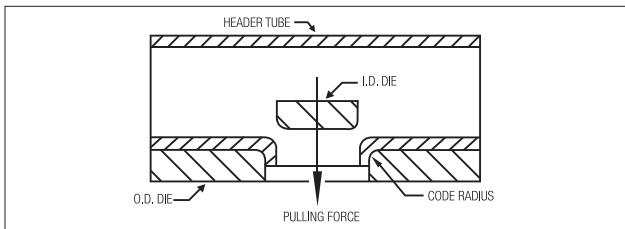
TEMA NOMENCLATURE FOR SHELL & TUBE HEAT EXCHANGERS (cont.)

REAR END HEAD TYPES			
L	 <p style="text-align: center;">Fixed Tubesheet Like "A" Stationery Head</p>	S	 <p style="text-align: center;">Floating Head with Backing Device</p>
M	 <p style="text-align: center;">Fixed Tubesheet Like "B" Stationery Head</p>	T	 <p style="text-align: center;">Pull Through Floating Head</p>
N	 <p style="text-align: center;">Fixed Tubesheet Like "N" Stationery Head</p>	U	 <p style="text-align: center;">U-tube Bundle</p>
P	 <p style="text-align: center;">Outside Packed Floating Head</p>	W	 <p style="text-align: center;">Externally Sealed Floating Tubesheet</p>

EXTRUDED OUTLET HEADERS

Standard Design Sequence

The following excerpts are from the ASME B31 codes. The paragraphs referenced under each section note the special allowables, and the design requirements for die forming outlets. Therefore, a complete specification could be written by using the following information and noting the paragraphs indicated below for the proper ASME code required to meet the design criteria.



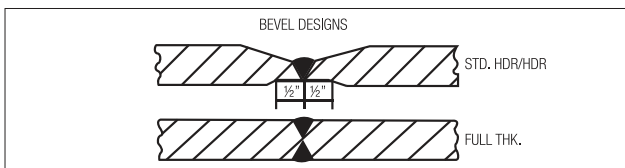
Extruded outlet headers shall be die-formed utilizing dies inside and outside of the outlet to control flow material and shape. Outside outlet radii shall conform to:

Para. 104.3.1.G.4.1 & 2	ASME B31.1
Para. 304.3.4(d)	ASME B31.3
Para. 404.3.3.2	ASME B31.4
Appendix F	ASME B31.8

Outlet heights shall be manufacturer's standard, but in no case shall they be less than required by paragraph above.

Machining may be used to taper outlet I.D. and/or O.D. from as-formed size to size desired, but machining will not be used to form the outside radius, in conformance with:

Para. 104.3.1.G.4.4	ASME B31.1
Para. 304.3.4(a) & 304.3.4(c)(4)	ASME B31.3
Para. 404.3.3.2	ASME B31.4
Appendix F	ASME B31.8



EXTRUDED OUTLET HEADERS

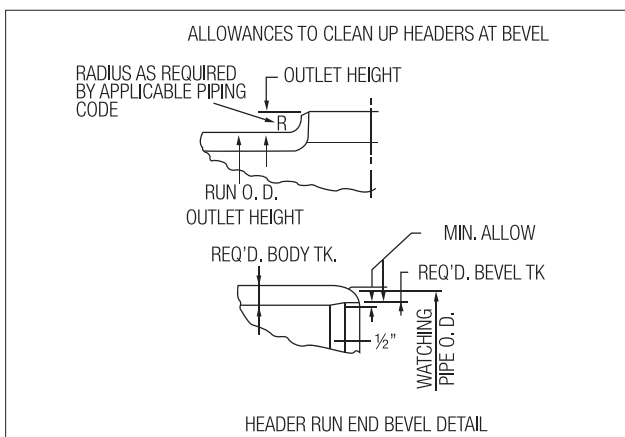
Standard Design Sequence (cont.)

Standard Outlet Heights (H)

Outlet Size (I.P.S.)	Outlet Height Above Run O.D.
1-1/2"	5/16"
2"	1/2"
2-1/2"	1/2"
3"	5/8"
3-1/2"	5/8"
4"	11/16"
5"	15/16"
6"	1"
8"	1-1/16"
10"	1-1/8"
12"	1-3/16"
14"	1-1/4"
16"	1-5/16"
18"	1-3/8"
20"	1-3/4"
22"	1-7/8"

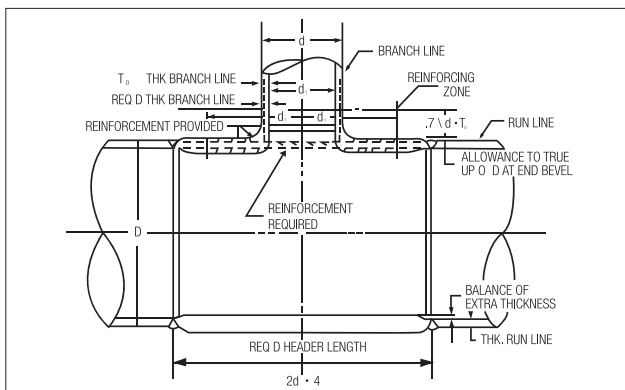
Outlet Size (I.P.S.)	Outlet Height Above Run O.D.
24"	1-7/8"
26"	2"
28"	2"
30"	2-1/16"
32"	2-1/8"
34"	2-1/4"
36"	2-3/8"
38"	2-3/8"
40"	2-1/2"
42"	2-1/2"
44"	2-5/8"
48"	2-3/4"
54"	3"
60"	3-1/4"
72"	3-1/2"

NOTE: For special applications, please contact Taylor Forge.



Extruded outlet headers shall be designed, manufactured and tested per ASME B16.9 (carbon steel) or MSS SP-75 (high yield) and shall be capable of meeting the burst test requirements of said specification or, when ordered to a specified pressure and temperature, be designed in accordance with:

- Para. 104.3.1.G ASME B31.1
- Para. 304.3.4 ASME B31.3
- Para. 404.3.3 ASME B31.4
- Para. 831.6 ASME B31.8



Standard Design Stress Requirements for ASME Extruded Headers

Code		Design Stress
ASME B31.1 (Power)	Lower of	1/3.5 x ultimate strength 2/3 x yield strength or creep or stress rupture at high temperature
ASME B31.3 (Process)	Lower of	1/3 x ultimate strength 2/3 x yield strength or creep or stress rupture at high temperature
ASME B31.4 (Liquids)		0.72 x yield strength
ASME B31.8 (Gas)	CL1, D1	0.80 x yield strength
	CL1, D2	0.72 x yield strength
	CL2	0.60 x yield strength
	CL3	0.50 x yield strength
	CL4	0.40 x yield strength

EXTRUDED OUTLET HEADERS

Typical Header Calculations Per Federal Rules & Regulations, Part 192

Pressure: 1,000 psi

Temperature: 250°F

Construction: Compressor Station

S (Specific Minimum Yield Strength) = 60,000 psi

F (construction type factor) = 0.50

E (longitudinal joint factor) = 1.0

T (temperature derating factor) = 1.000

D (nominal outside diameter, pipe) = 30.000"

d (outside diameter of branch pipe) = 20.000"

$$t_b \text{ (required thickness of branch pipe)} = \frac{Pd}{2SFET}$$

$$t_r \text{ (required thickness of run)} = \frac{PD}{2SFET}$$

T_b (nominal thickness of branch)

T_r (nominal thickness of run)

$$t_r = \frac{PD}{2SFET} = 0.5000$$

$$t_b = \frac{Pd}{2SFET} = 0.3333$$

$$K = 0.6 + \frac{2d}{3D} = 1.0444$$

But: $0.7 < K < 1.0$

$$2L = 2 \times 0.7 \sqrt{dT_b} = 3.6148$$

$$d_1 = d - 2T_b = 19.3334$$

$$T_r \text{ (min.)} = \frac{Kt_r d_1 - 2L(T_b - t_b)}{d_1} + t_r = 1.000"$$

Note: Area A_3 has been neglected, since its use would only result in a very slight reduction in T_r (min).

DESIGN PROPERTIES OF PIPE

The following tables are the most generally required data used in piping design. This table is believed to be the most comprehensive published to date. Many thicknesses traditionally included in such tables have been omitted because of their having become obsolete through disuse and lack of coverage by any Standard.

Sizes and thicknesses listed herein are covered by the following Standards:

1. American Society of Mechanical Engineers (ASME) B36.10
2. American Society of Mechanical Engineers (ASME) B36.19
3. American Petroleum Institute Standard API 5L
4. American Petroleum Institute Standard API 5LX
5. New United States Legal Standard for Steel Plate Gauges

All data is computed from the nominal dimensions listed and the effect of tolerances is not taken into account. Values are computed by application of the following formulas

Radius of Gyration: $R = 0.25 \sqrt{D^2 + d^2}$

Moment of Inertia: $I = R^2 A$

Section of Modulus: $Z = \frac{I}{0.5D}$

TABLE OF PROPERTIES OF PIPE

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) ²	Area of Metal (in.) ²	Moment of Inertia (in.) ⁴	Section Modulus (in.) ³	Radius of Gyration (in.) ²
1/4	0.540	Std.	0.088	0.364	0.424	0.0451	0.141	0.0955	0.1041	0.1250	0.00331	0.01230	0.1628
		X-Stg.	0.119	0.302	0.535	0.0910	0.141	0.7094	0.0716	0.1574	0.00378	0.01395	0.1547
		10S	0.065	0.545	0.423	0.1010	0.177	0.1427	0.2333	0.1245	0.00590	0.01740	0.2160
3/8	0.675	Std.	0.091	0.493	0.567	0.0827	0.177	0.1295	0.1910	0.1670	0.00730	0.02160	0.2090
		X-Stg.	0.126	0.423	0.738	0.0609	0.177	0.1106	0.1405	0.2173	0.00862	0.02554	0.1991
		10S	0.083	0.670	0.671	0.1550	0.220	0.1764	0.3568	0.1974	0.01430	0.03410	0.2692
1/2	0.840	Std.	0.109	0.622	0.850	0.1316	0.220	0.1637	0.3040	0.2503	0.01710	0.04070	0.2613
		X-Stg.	0.147	0.546	1.087	0.1013	0.220	0.1433	0.2340	0.3200	0.02010	0.4780	0.2505
		160	0.138	0.464	1.310	0.0740	0.220	0.1220	0.1706	0.3836	0.02213	0.05269	0.2402
3/4	1.050	XX-Stg.	0.294	0.252	1.714	0.0216	0.220	0.0660	0.0499	0.5043	0.02424	0.05772	0.2192
		10S	0.083	0.884	0.857	0.2660	0.275	0.2314	0.6138	0.2522	0.02970	0.05660	0.3430
		Std.	0.113	0.824	1.130	0.2301	0.275	0.2168	0.5330	0.3326	0.03704	0.07055	0.3337
1	1.315	X-Stg.	0.154	0.742	1.473	0.1875	0.275	0.1948	0.4330	0.4335	0.04479	0.08531	0.3214
		160	0.219	0.612	1.940	0.1280	0.275	0.1607	0.2961	0.5698	0.05270	0.10038	0.3041
		XX-Stg.	0.308	0.434	2.440	0.0633	0.275	0.1137	0.1479	0.718	0.05792	0.11030	0.2840

	10S	0.109	1.097	1.404	0.4090	0.344	0.2872	0.9448	0.4129	0.07560	0.1150	0.4282	
	Std.	0.133	1.049	1.678	0.3740	0.344	0.2740	0.8640	0.4939	0.08734	0.1328	0.4205	
1	1.315	X-Stg.	0.179	0.957	2.171	0.3112	0.344	0.2520	0.7190	0.6388	0.10560	0.1606	0.4066
	160	0.250	0.815	2.850	0.2261	0.344	0.2134	0.5217	0.8364	0.12516	0.1903	0.3868	
	XX-Stg.	0.358	0.599	3.659	0.1221	0.344	0.1570	0.2818	1.0760	0.14050	0.2136	0.3613	
	10S	0.109	1.442	1.806	0.7080	0.434	0.3775	1.633	0.5314	0.1606	0.1934	0.5499	
	Std.	0.140	1.380	2.272	0.6471	0.434	0.3620	1.495	0.6685	0.1947	0.2346	0.5397	
1-1/4	1.660	-	0.191	1.278	2.996	0.5553	0.434	0.3356	1.283	0.8815	0.2418	0.2913	0.5237
	-	0.250	1.160	3.764	0.4575	0.434	0.3029	1.057	1.1070	0.2833	0.3421	0.5063	
	-	0.382	0.896	5.214	0.2732	0.434	0.2331	0.6305	1.5340	0.3411	0.4110	0.4716	
	10S	0.109	1.682	2.085	0.9630	0.497	0.4403	2.221	0.613	0.2469	0.2599	0.6344	
	Std.	0.145	1.610	2.717	0.8820	0.497	0.4213	2.036	0.800	0.3099	0.3262	0.6226	
1-1/2	1.900	X-Stg.	0.200	1.500	3.631	0.7648	0.497	0.3927	1.767	1.068	0.3912	0.4118	0.6052
	160	0.281	1.337	4.862	0.6082	0.497	0.3519	1.405	1.430	0.4826	0.5080	0.5809	
	XX-Stg.	0.400	1.100	6.408	0.4117	0.497	0.2903	0.950	1.885	0.5678	0.5977	0.5489	
	10S	0.109	2.157	2.638	1.583	0.622	0.5647	3.654	0.775	0.5003	0.4213	0.8034	
	Std.	0.154	2.067	3.652	1.452	0.622	0.5401	3.355	1.075	0.6657	0.5606	0.7871	
2	2.375	X-Stg.	0.218	1.939	5.022	1.279	0.622	0.5074	2.953	1.477	0.8679	0.7309	0.7665
	-	0.250	1.875	5.673	1.196	0.622	4=0.4920	2.761	1.669	0.9555	0.8046	0.7565	
	160	0.344	1.687	7.450	0.970	0.622	0.4422	2.240	2.190	1.162	0.9790	0.7286	
	XX-Stg.	0.436	1.503	9.029	0.769	0.622	0.3929	1.774	2.656	1.311	1.1040	0.7027	

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft. of Pipe	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
2-1/2	2.875	10S	0.120	2.635	3.53	2.360	0.753	0.6900	5.453	1.038	0.9878	0.6872	0.9755
		Std.	0.203	2.469	5.79	2.072	0.753	0.6462	4.788	1.704	1.530	1.064	0.9474
		X-Stg.	0.276	2.323	7.66	1.834	0.753	0.6095	4.238	2.254	1.924	1.339	0.9241
		160	0.375	2.125	10.01	1.535	0.753	0.5564	3.547	2.945	2.353	1.638	0.8938
3	3.500	XX-Stg.	0.552	1.771	13.69	1.067	0.753	0.4627	2.464	4.028	2.871	1.997	0.8442
		10S	0.120	3.260	4.33	3.62	0.916	0.853	8.346	1.272	1.821	1.041	1.196
		API	0.125	3.250	4.52	3.60	0.916	0.851	8.300	1.329	1.900	1.086	1.195
		API	0.156	3.188	5.58	3.46	0.916	0.835	7.982	1.639	2.298	1.313	1.184
3	3.500	API	0.188	3.125	6.65	3.34	0.916	0.819	7.700	1.958	2.700	1.545	1.175
		Std.	0.216	3.068	7.57	3.20	0.916	0.802	7.393	2.228	3.017	1.724	1.164
		API	0.250	3.000	8.68	3.06	0.916	0.785	7.184	2.553	3.388	1.936	1.152
		API	0.281	2.938	9.65	2.94	0.916	0.761	6.605	3.016	3.892	2.225	1.136
3	3.500	X-Stg.	0.300	2.900	10.25	2.86	0.916	0.761	6.605	3.016	3.892	2.225	1.136
		160	0.438	2.624	14.32	2.34	0.916	0.687	5.407	4.214	5.044	2.882	1.094
		XX-Stg.	0.600	2.300	18.58	1.80	0.916	0.601	4.155	5.466	5.993	3.424	1.047

10S	0.120	3.760	4.97	4.81	1.047	0.984	11.10	1.46	2.754	1.377	1.372
API	0.125	3.750	5.18	4.79	1.047	0.982	11.04	1.52	2.859	1.430	1.371
API	0.156	3.688	6.41	4.63	1.047	0.966	10.68	1.88	3.485	1.743	1.360
API	0.188	3.624	7.71	4.48	1.047	0.950	10.32	2.27	4.130	2.065	1.350
Std.	0.226	3.548	9.11	4.28	1.047	0.929	9.89	2.68	4.788	2.394	1.337
API	0.250	3.50	10.02	4.17	1.047	0.916	9.62	2.94	5.201	2.601	1.329
API	0.281	3.438	11.17	4.02	1.047	0.900	9.28	3.29	5.715	2.858	1.319
X-Stg.	0.318	3.364	12.51	3.85	1.047	0.880	8.89	3.68	6.280	3.140	1.307
XX-Stg.	0.636	2.728	22.85	2.53	1.047	0.716	5.84	6.72	9.848	4.924	1.210
10S	0.120	4.260	5.61	6.18	1.178	1.115	14.25	1.65	3.97	1.761	1.550
API	0.125	4.250	5.84	6.15	1.178	1.113	14.19	1.72	4.12	1.829	1.548
API	0.156	4.188	7.24	5.97	1.178	1.096	13.77	2.13	5.03	2.235	1.537
API	0.188	4.124	8.56	5.80	1.178	1.082	13.39	2.52	5.86	2.600	1.525
API	0.219	4.062	10.02	5.62	1.178	1.063	12.96	2.94	6.77	3.867	1.516
Std.	0.237	4.026	10.79	5.51	1.178	1.055	12.73	3.17	7.23	3.214	1.510
API	0.250	4.000	11.35	5.45	1.178	1.049	12.57	3.34	7.56	3.360	1.505
API	0.281	3.938	12.67	5.27	1.178	1.031	12.17	3.73	8.33	3.703	1.495
API	0.312	3.876	14.00	5.12	1.178	1.013	11.80	4.11	9.05	4.020	1.482
X-Stg.	0.337	3.826	14.98	4.98	1.178	1.002	11.50	4.41	9.61	4.271	1.477
120	0.438	3.624	19.00	4.47	1.178	0.949	10.32	5.59	11.65	5.177	1.444
-	0.500	3.500	21.36	4.16	1.178	0.916	9.62	6.28	12.77	5.676	1.425
160	0.531	3.438	22.60	4.02	1.178	0.900	9.28	6.62	13.27	5.900	1.416
XX-Stg.	0.674	3.152	27.54	3.38	1.178	0.826	7.80	8.10	15.28	6.793	1.374

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
5		Std.	0.258	5.047	14.62	8.66	1.456	1.321	20.01	4.30	15.16	5.451	18.78
		API	0.281	5.001	15.86	8.52	1.456	1.309	19.64	4.66	16.31	5.862	1.870
		API	0.312	4.939	17.51	8.31	1.456	1.293	19.16	5.15	17.81	6.402	1.860
		API	0.344	4.875	19.19	8.09	1.456	1.276	18.67	5.64	19.28	6.932	1.849
		X-Stg.	0.375	4.813	20.78	7.87	1.456	1.260	18.19	6.11	20.67	7.431	1.839
		120	0.500	4.563	27.10	7.08	1.456	1.195	16.35	7.95	25.74	9.253	1.799
		XX-Stg.	0.875	6.875	72.42	16.1	2.26	1.800	37.1	21.30	162.0	37.56	2.76
		160	0.906	6.813	74.70	15.8	2.26	1.784	36.4	21.97	165.9	38.48	2.76
		12 Ga.	0.104	10.542	11.83	37.8	2.81	2.76	87.3	3.48	49.3	9.16	3.76
		10S	0.134	6.357	9.29	13.70	1.734	1.660	31.75	2.73	14.38	4.34	2.29
6		8 Ga.	0.164	6.297	11.33	13.50	1.734	1.649	31.14	3.33	17.38	5.25	2.28
		API	0.188	6.249	12.93	13.31	1.734	1.639	30.70	3.80	19.71	5.95	2.28
		6 Ga.	0.194	6.237	13.34	13.25	1.734	1.633	30.55	3.92	20.29	6.12	2.27
		API	0.219	6.187	15.02	13.05	1.734	1.620	30.10	4.41	22.66	6.84	2.27
		API	0.250	6.125	17.02	12.80	1.734	1.606	29.50	5.01	25.55	7.71	2.26
		API	0.277	6.071	18.86	12.55	1.734	1.591	28.95	5.54	28.00	8.46	2.25
		Std.	0.280	6.065	18.97	12.51	1.734	1.587	28.90	5.58	28.14	8.50	2.24

API	0.312	6.01	21.05	12.26	1.734	1.571	28.28	6.19	30.91	9.33	2.23
API	0.344	5.937	23.09	12.00	1.734	1.554	27.68	6.79	33.51	10.14	2.22
API	0.375	5.875	25.10	11.75	1.734	1.540	27.10	7.37	26.20	10.90	2.21
X-Stg.	0.432	5.761	28.57	11.29	1.734	1.510	26.07	8.40	40.49	12.22	2.19
-	0.500	5.625	32.79	10.85	1.734	1.475	24.85	9.63	45.60	13.78	2.16
120	0.562	5.501	36.40	10.30	1.734	1.470	23.77	10.74	49.91	15.07	2.15
160	0.719	5.187	45.30	9.16	1.734	1.359	21.15	13.36	58.99	17.81	2.10
XX-Stg.	0.864	4.897	53.16	8.14	1.734	1.280	18.83	15.64	66.33	20.02	2.06
12 Ga.	0.104	8.417	9.47	24.1	2.26	2.204	55.6	2.78	25.3	5.86	3.01
10 Ga.	0.134	8.357	12.16	23.8	2.26	2.188	54.8	3.57	32.2	7.46	3.00
10S	0.148	8.329	13.40	23.6	2.26	2.180	54.5	3.94	35.4	8.22	3.00
8 Ga.	0.164	8.297	14.83	23.4	2.26	2.172	54.1	4.36	39.1	9.06	2.99
API	0.188	8.249	16.90	23.2	2.26	2.161	53.5	5.00	44.5	10.30	2.98
6 Ga.	0.194	8.237	17.48	23.1	2.26	2.156	53.3	5.14	45.7	10.60	2.98
API	0.203	8.219	18.30	23.1	2.26	2.152	53.1	5.38	47.7	11.05	2.98
API	0.219	8.187	19.64	22.9	2.26	2.148	52.7	5.80	51.3	11.90	2.97
3 Ga.	0.239	8.147	21.42	22.6	2.26	2.133	52.1	6.30	55.4	12.84	2.96
20	0.250	8.125	22.40	22.5	2.26	2.127	51.8	6.58	57.7	13.39	2.96
30	0.277	8.071	24.70	22.2	2.26	2.115	51.2	7.26	63.3	14.69	2.95
Std.	0.322	7.981	28.55	21.6	2.26	2.090	50.0	8.40	72.5	16.81	2.94
API	0.438	7.749	38.33	20.4	2.26	2.029	47.2	11.27	94.7	21.97	2.90
X-Stg.	0.500	7.625	43.39	19.8	2.26	2.006	45.6	12.76	105.7	24.51	2.88

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
8	8.625	100	0.594	7.437	50.90	18.8	2.26	1.947	43.5	14.96	121.4	28.14	2.85
		-	0.625	7.375	53.40	18.5	2.26	1.931	42.7	15.71	126.5	29.33	2.84
		120	0.719	7.187	60.70	17.6	2.26	1.882	40.6	17.84	140.6	32.61	2.81
		140	0.812	7.001	67.80	16.7	2.26	1.833	38.5	19.93	153.8	35.65	2.78
	XX-Stg.	0.875	6.875	72.42	16.1	2.26	1.800	37.1	21.30	162.0	37.56	2.76	
	160	0.906	6.813	74.70	15.8	2.26	1.784	36.4	21.97	165.9	38.48	2.76	
	12 Ga.	0.104	10.542	11.83	37.8	2.81	2.76	87.3	3.48	49.3	9.16	3.76	
	10 Ga.	0.134	10.482	15.21	37.4	2.81	2.74	86.3	4.47	63.0	11.71	3.75	
	8 Ga.	0.164	10.422	18.56	37.0	2.81	2.73	85.3	5.45	76.4	14.22	3.74	
	10	10.750	10S	0.165	10.420	18.65	36.9	2.81	2.73	85.3	5.50	76.8	14.29	3.74
API			0.188	10.374	21.12	36.7	2.81	2.72	84.5	6.20	86.5	16.10	3.74
6 Ga.			0.194	10.362	21.89	36.6	2.81	2.71	84.3	6.43	89.7	16.68	3.73
API			0.203	10.344	22.86	36.5	2.81	2.71	84.0	6.71	93.3	17.35	3.73
API		0.219	10.310	24.60	36.2	2.81	2.70	83.4	7.24	100.5	18.70	3.72	
3 Ga.		0.239	10.272	28.05	35.9	2.81	2.69	82.9	7.89	109.2	20.32	3.72	
20		0.250	10.250	28.03	35.9	2.81	2.68	82.6	8.26	113.6	21.12	3.71	
API		0.279	10.192	31.20	35.3	2.81	2.66	81.6	9.18	125.9	23.42	3.70	

30	0.307	10.136	34.24	35.0	2.81	2.65	80.7	10.07	137.4	25.57	3.69
API	0.344	10.062	38.26	34.5	2.81	2.63	79.5	11.25	152.3	28.33	3.68
Std.	0.365	10.020	40.48	34.1	2.81	2.62	78.9	11.91	160.7	29.90	3.67
API	0.438	9.874	48.28	33.2	2.81	2.58	76.6	14.19	188.8	35.13	3.65
X-Stg.	0.500	9.750	54.74	32.3	2.81	2.55	74.7	16.10	212.0	39.43	3.63
80	0.594	9.562	64.40	31.1	2.81	2.50	71.8	18.91	244.9	45.56	3.60
100	0.719	9.312	77.00	29.5	2.81	2.44	68.1	22.62	286.2	53.25	3.56
-	0.750	9.250	80.10	29.1	2.81	2.42	67.2	23.56	296.2	55.10	3.54
120	0.844	9.062	89.20	27.9	2.81	2.37	64.5	26.23	324.3	60.34	3.51
140	1.000	8.750	104.20	26.1	2.81	2.29	60.1	30.63	367.8	68.43	3.46
160	1.125	8.500	116.00	24.6	2.81	2.22	56.7	34.01	399.4	74.31	3.43
12 Ga.	0.104	12.542	14.1	53.6	3.34	3.28	123.5	4.13	82.6	12.9	4.47
10 Ga.	0.134	12.482	18.1	53.0	3.34	3.27	122.4	5.31	105.7	16.6	4.46
8 Ga.	0.164	12.422	22.1	52.5	3.34	3.25	121.2	6.48	128.4	20.1	4.45
10S	0.180	12.390	24.2	52.2	3.34	3.24	120.6	7.11	140.4	22.0	4.44
6 Ga.	0.194	12.362	26.0	52.0	3.34	3.23	120.0	7.65	150.9	23.7	4.44
API	0.203	12.344	27.2	52.0	3.34	3.23	119.9	7.99	157.2	24.7	4.43
API	0.219	12.312	29.3	51.7	3.34	3.22	119.1	8.52	167.6	26.3	4.43
3 Ga.	0.239	12.272	32.0	51.3	3.34	3.21	118.3	9.39	183.8	28.3	4.42
20	0.250	12.250	33.4	51.3	3.34	3.12	118.0	9.84	192.3	30.2	4.42

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	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
		API	0.281	12.188	37.4	50.6	3.19	116.7	11.01	214.1	33.6	4.41
		API	0.312	12.126	41.5	50.1	3.17	115.5	12.19	236.0	37.0	4.40
		30	0.330	12.090	43.8	49.7	3.16	114.8	12.88	248.5	39.0	4.39
		API	0.344	12.062	45.5	49.7	3.16	114.5	13.46	259.0	40.7	4.38
		Std.	0.375	12.000	49.6	48.9	3.14	113.1	14.58	279.3	43.8	4.37
		40	0.406	11.938	53.6	48.5	3.13	111.9	15.74	300.3	47.1	4.37
		API	0.438	11.874	57.5	48.2	3.11	111.0	16.95	321.0	50.4	4.35
		X-Stg.	0.500	11.750	65.4	46.9	3.08	108.4	19.24	361.5	56.7	4.33
		60	0.562	11.626	73.2	46.0	3.04	106.2	21.52	400.5	62.8	4.31
12	12.750	-	0.625	11.500	80.9	44.9	3.01	103.8	23.81	438.7	68.8	4.29
		80	0.688	11.374	88.6	44.0	2.98	101.6	23.03	475.2	74.6	4.27
		-	0.750	11.250	96.2	43.1	2.94	99.4	28.27	510.7	80.1	4.25
		100	0.844	11.062	108.0	41.6	2.90	96.1	31.53	561.8	88.1	4.22
		-	0.875	11.000	110.9	41.1	2.88	95.0	32.64	578.5	90.7	4.21
		120	1.000	10.750	125.5	39.3	2.81	90.8	36.91	641.7	100.7	4.17
		140	1.125	10.500	140.0	37.5	2.75	86.6	41.08	700.7	109.9	4.13
		-	1.250	10.250	153.6	35.8	2.68	82.5	45.16	755.5	118.5	4.09
		160	1.312	10.126	161.0	34.9	2.65	80.5	47.14	781.3	1226	4.07

10 Ga.	0.134	13.732	20	64.2	3.67	3.59	148.1	5.84	140.4	20.1	4.90
8 Ga.	0.164	13.672	24	63.6	3.67	3.58	146.8	7.13	170.7	24.4	4.89
6 Ga.	0.194	13.612	29	63.1	3.67	3.56	145.5	8.41	200.6	28.7	4.88
API	0.210	13.580	31	62.8	3.67	3.55	144.8	9.10	216.2	30.9	4.87
API	0.219	13.562	32	62.6	3.67	3.55	144.5	9.48	225.1	32.2	4.87
3 Ga.	0.239	13.522	35	62.3	3.67	3.54	143.6	10.33	244.9	35.0	4.87
10	0.250	13.500	37	62.1	3.67	3.54	143.0	10.82	256.0	36.6	4.86
API	0.281	13.438	41	61.5	3.67	3.52	141.8	12.1	285.2	40.7	4.85
20	0.312	13.375	46	60.8	3.67	3.50	140.5	13.44	314.9	45.0	4.85
API	0.344	13.312	50	60.3	3.67	3.48	139.2	14.76	344.3	49.2	4.83
Std.	0.375	13.250	55	59.7	3.67	3.47	137.9	16.05	372.8	53.2	4.82
40	0.438	13.124	63	58.5	3.67	3.44	135.3	18.66	429.6	61.4	4.80
X-Stg.	0.500	13.000	72	57.4	3.67	3.40	132.7	21.21	483.8	69.1	4.75
60	0.594	12.812	85	55.9	3.67	3.35	129.0	24.98	562.4	80.3	4.74
-	0.625	12.750	89	55.3	3.67	3.34	127.7	26.26	588.5	84.1	4.73
80	0.750	12.500	107	51.2	3.67	3.27	122.7	31.22	687.5	98.2	4.69
-	0.875	12.25	123	51.1	3.67	3.21	117.9	36.08	780.1	111.4	4.65
100	0.938	12.124	131	50.0	3.67	3.17	115.5	38.47	820.5	117.2	4.63
-	1.000	12.000	139	49.0	3.67	3.14	113.1	40.84	868.0	124.0	4.61
120	1.094	11.812	151	47.5	3.67	3.09	109.6	44.32	929.8	132.8	4.58
-	1.125	11.75	155	47	3.67	3.08	108.4	45.5	950.3	135.8	4.57
140	1.25	11.5	171	45	3.67	3.01	103.9	50.07	1027.5	146.8	4.53
-	1.375	11.25	186	43.1	3.67	2.94	99.4	54.54	1099.5	157.1	4.49
180	1.406	11.188	190	42.6	3.67	2.93	98.3	55.63	116.9	159.6	4.48
-	1.5	11	200	41.2	3.67	2.88	95	58.9	116.5	166.6	4.45

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
	10 Ga.		0.134	15.732	23	84.3	4.19	194.4	6.68	210	26.3	5.61
	8 Ga.		0.164	15.672	28	83.6	4.19	192.9	8.16	256	32.0	5.60
	-		0.188	15.624	32	83.3	4.19	192.0	9.39	294	36.7	5.59
	6 Ga.		0.194	15.612	33	83.0	4.19	191.4	9.63	301	37.6	5.59
	API		0.219	15.562	37	82.5	4.19	190.2	10.86	338	42.3	5.58
	3 Ga.		0.239	15.522	40	82.0	4.19	189.2	11.83	368	45.9	5.57
	10		0.250	15.500	42	82.1	4.19	189.0	12.40	385	48.1	5.57
	API		0.281	15.438	47	81.2	4.19	187.0	13.90	430	53.8	5.56
	20		0.312	15.375	52	80.1	4.19	185.6	15.40	474	59.2	5.55
16	16.000		0.344	15.312	57	80.0	4.19	184.1	16.94	519	64.9	5.54
	Std.		0.375	15.250	63	79.1	4.19	182.6	18.41	562	70.3	5.53
	API		0.438	15.124	73	78.2	4.19	180.0	21.42	650	81.2	5.51
	X-Stg.		0.500	15.000	83	76.5	4.19	176.7	24.35	732	91.5	5.48
	-		0.625	14.750	103	74.1	4.19	170.9	30.19	893	111.7	5.44
	60		0.656	14.688	108	73.4	4.19	169.4	31.62	933	116.6	5.43
	-		0.750	14.500	122	71.5	4.19	165.1	35.93	1047	130.9	5.40
	80		0.844	14.312	137	69.7	4.19	160.9	40.14	1157	144.6	5.37
	-		0.875	14.250	141	69.1	4.19	159.5	41.58	1192	147.0	5.35

-	1.000	14.000	160	66.7	4.19	3.66	153.9	47.12	1331	166.4	5.31
100	1.031	13.938	165	66.0	4.19	3.65	152.6	48.49	1366	170.7	5.30
-	1.125	13.750	179	64.4	4.19	3.60	148.5	52.57	14.63	182.9	5.27
120	1.219	13.562	193	62.6	4.19	3.55	144.5	56.56	1556	194.5	5.24
-	1.250	13.500	197	62.1	4.19	3.53	143.1	57.92	1586	198.3	5.23
-	1.375	13.250	215	59.8	4.19	3.47	137.9	63.17	1704	213.0	5.19
140	1.438	13.124	224	58.6	4.19	3.44	135.3	65.79	1761	220.1	5.17
-	1.500	13.000	232	57.4	4.19	3.40	132.7	68.33	1816	227.0	5.15
160	1.594	12.812	245	55.9	4.19	3.35	129.0	72.10	1893	236.6	5.12
10 Ga.	0.134	17.732	26	107.1	4.71	4.64	246.9	7.52	300	33.4	6.32
8 Ga.	0.164	17.672	31	106.3	4.71	4.63	245.3	9.19	366	40.6	6.31
6 Ga.	0.194	17.612	37	105.6	4.71	4.61	243.6	10.85	430	47.8	6.29
3 Ga.	0.239	17.522	45	104.5	4.71	4.59	241.1	13.34	526	58.4	6.28
10	0.250	17.500	47	104.6	4.71	4.58	241.0	13.96	550	61.1	6.28
API	0.281	17.438	49	104.0	4.71	4.56	240.0	14.49	570	63.4	6.27
20	0.312	17.375	59	102.5	4.71	4.55	237.1	17.36	679	75.5	6.25
API	0.344	17.312	65	102.0	4.71	4.53	235.4	19.08	744	82.6	6.24
Std.	0.375	17.250	71	101.2	4.71	4.51	233.7	20.76	807	89.6	6.23
API	0.406	17.188	76	100.6	4.71	4.50	232.0	22.44	869	96.6	6.22
30	0.438	17.124	82	99.5	4.71	4.48	229.5	24.95	963	107.0	6.21
X-Stg.	0.500	17.000	93	98.2	4.71	4.45	227.0	27.49	1053	117.0	6.19
40	0.562	16.876	105	97.2	4.71	4.42	224.0	30.85	1177	130.9	6.17
-	0.625	16.750	116	95.8	4.71	4.38	220.5	34.15	1290	143.2	6.14
60	0.750	16.500	138	92.5	4.71	4.32	213.8	40.64	1515	168.3	6.10
16	16.000										
18	18.000										

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft. per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
18	18.000	-	0.875	16.250	160	89.9	4.71	4.25	207.4	47.07	1730	192.30	6.06
		80	0.938	16.124	171	88.5	4.71	4.22	204.2	50.23	1834	203.8	6.04
		-	1.000	16.000	182	87.2	4.71	4.19	201.1	53.41	1935	215.0	6.02
		-	1.125	15.750	203	84.5	4.71	74.12	194.8	59.64	21.33	237.0	5.98
		100	1.156	15.688	208	83.7	4.71	4.11	193.3	61.18	2182	242.3	5.97
		-	1.250	15.500	224	81.8	4.71	4.06	188.7	65.78	2319	257.7	5.94
		120	1.375	15.250	244	79.2	4.71	3.99	182.7	71.82	2498	277.5	5.90
		-	1.500	15.000	265	76.6	4.71	3.93	176.7	77.75	2668	296.5	5.86
		140	1.562	14.876	275	75.3	4.71	3.89	173.8	80.66	2750	305.5	5.84
		160	1.781	14.438	309	71.0	4.71	3.78	163.7	90.75	3020	335.5	5.77
20	20.000	10 Ga.	0.134	19.732	28	132.6	5.24	5.17	305.8	8.36	413	41.3	7.02
		8 Ga.	0.164	19.672	35	131.8	5.24	5.15	303.9	10.22	503	50.3	7.01
		6 Ga.	0.194	19.612	41	131.0	5.24	5.13	302.1	12.07	592	59.2	7.00
		3 Ga.	0.239	19.522	50	129.8	5.24	5.11	299.3	14.84	725	72.5	6.99
		10	0.250	19.500	53	130.0	5.24	5.11	299.0	15.52	759	75.9	6.98
		API	0.281	19.438	59	128.6	5.24	5.09	296.8	17.41	846	84.6	6.97
		API	0.312	19.374	66	128.1	5.24	5.08	295.0	19.36	937	93.7	6.95
		API	0.344	19.312	72	127.0	5.24	5.06	292.9	21.24	1026	102.6	6.95

Std.	0.375	19.250	79	126.0	5.24	5.04	291.1	23.12	1113	111.3	6.94
API	0.406	19.188	85	125.4	5.24	5.02	289.2	24.99	1200	120.0	6.92
API	0.438	19.124	92	125.1	5.24	5.01	288.0	26.95	1290	129.0	6.92
X-Stg.	0.500	19.000	105	122.8	5.24	4.97	283.5	30.63	1457	145.7	6.90
40	0.594	18.812	123	120.4	5.24	4.93	278.0	36.15	1704	170.4	6.86
-	0.625	18.750	129	119.5	5.24	4.91	276.1	38.04	1787	178.7	6.85
60	0.812	18.376	167	114.9	5.24	4.81	265.2	48.95	2257	225.7	63.79
-	0.875	18.250	179	113.2	5.24	4.78	261.6	52.57	2409	24.09	6.77
-	1.000	18.000	203	110.3	5.24	4.71	254.5	59.69	2702	270.2	6.73
20 20.000											
80	1.031	17.938	209	109.4	5.24	4.80	252.7	61.44	2771	277.1	6.72
-	1.125	17.750	227	107.3	5.24	4.65	247.4	66.71	2981	298.1	6.68
-	1.250	17.500	250	104.3	5.24	4.58	240.5	73.63	3249	324.9	6.64
100	1.281	17.438	256	103.4	5.24	4.56	238.8	75.34	3317	331.7	6.63
-	1.375	17.250	274	101.3	5.24	4.52	233.7	80.45	3508	350.8	6.60
120	1.500	17.000	297	98.3	8.24	4.45	227.0	87.18	3755	375.5	6.56
140	1.750	16.500	342	92.6	5.24	4.32	213.8	100.3	4217	421.7	6.48
160	1.969	16.062	379	87.9	5.24	4.21	202.7	111.49	4586	458.6	6.41
8 Ga.	0.164	21.672	38	159.9	5.76	5.67	368.9	11.25	671	61.0	7.72
6 Ga.	0.194	21.612	45	159.0	5.76	5.66	366.8	13.29	790	71.8	7.71
6 Ga.	0.239	21.522	56	157.7	5.76	5.63	363.8	16.34	967	87.9	7.69
API	0.250	21.500	58	157.4	5.76	5.63	363.1	17.18	1010	91.8	7.69
API	0.281	21.438	65	156.5	5.76	5.61	361.0	19.17	1131	102.8	7.68
API	0.312	21.376	72	155.6	5.76	5.60	358.9	21.26	1250	113.6	7.67
22 22.000											

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
22	22.000	API	0.344	21.312	80	154.7	5.76	356.7	23.40	1373	124.8	7.66
		API	0.375	21.250	87	153.7	5.76	354.7	25.48	1490	135.4	7.65
		API	0.406	21.188	94	152.9	5.76	352.6	27.54	1607	146.1	7.64
		API	0.438	21.124	101	151.9	5.76	350.5	29.67	1725	156.8	7.62
		API	0.500	21.000	115	150.2	5.76	346.4	33.77	1953	177.5	7.61
		-	0.625	20.750	143	146.6	5.76	338.2	41.97	2400	218.2	7.56
		-	0.750	20.500	170	143.1	5.76	330.1	50.07	2829	257.2	7.52
		-	0.875	20.250	198	139.6	5.76	322.1	58.07	3245	324.5	7.47
		-	1.000	20.000	224	136.2	5.76	314.2	65.97	3645	331.4	7.43
		10	0.250	23.500	63	189.0	6.28	435.0	18.67	1320	110.0	8.40
24	24.000	API	0.281	23.438	71	187.0	6.28	431.5	20.94	1472	122.7	8.38
		API	0.312	23.376	79	186.9	6.28	430.0	23.20	1630	136.0	8.38
		API	0.344	23.312	87	185.0	6.28	426.8	25.57	1789	149.1	8.36
		Std.	0.375	23.250	95	183.8	6.28	424.6	27.83	1942	161.9	8.35
		API	0.406	23.188	102	183.1	6.28	422.3	30.09	2095	174.6	8.34
		API	0.438	23.124	110	182.1	6.28	420.0	32.42	2252	187.7	8.33
		X-Stg.	0.500	23.000	125	181.0	6.28	416.0	36.90	2550	213.0	8.31
		30	0.562	22.876	141	178.5	6.28	411.0	41.40	2840	237.0	8.28

-	0.625	22.750	156	175.9	6.28	5.96	406.5	45.90	3137	261.4	8.27
40	0.688	22.624	171	174.2	6.28	5.92	402.1	50.30	3422	285.2	8.25
-	0.750	22.500	186	172.1	6.28	5.89	397.6	54.78	3705	308.8	8.22
-	0.875	22.250	216	168.6	6.28	5.82	388.8	63.57	4257	354.7	8.18
60	0.969	22.062	238	165.8	6.28	5.78	382.3	70.04	4652	387.7	8.15
-	1.000	22.000	246	164.8	6.28	5.76	380.1	72.26	4788	399.0	8.14
-	1.125	21.750	275	161.1	6.28	5.69	371.5	80.85	5302	441.8	8.10
24	24.000										
80	1.219	21.562	297	158.2	6.28	5.65	365.2	87.17	5673	472.8	8.07
-	1.250	21.500	304	157.4	6.28	5.63	363.1	89.34	5797	483.0	8.05
-	1.375	21.250	332	153.8	6.28	5.56	354.7	97.73	6275	522.9	8.01
-	1.500	21.000	361	150.2	6.28	5.50	346.4	106.03	6740	561.7	7.97
100	1.531	20.938	367	149.3	6.28	5.48	344.3	108.07	6847	570.6	7.96
120	1.812	20.376	429	141.4	6.28	5.33	326.1	126.30	7823	651.9	7.87
140	2.062	19.876	484	134.4	6.28	5.20	310.3	142.10	8627	718.9	7.79
160	2.344	19.312	542	127.0	6.28	5.06	293.1	159.4	9457	788.1	7.70
8 Ga.	0.164	25.672	45	224.4	6.81	6.72	517.6	13.31	1111	85.4	9.13
6 Ga.	0.194	25.612	54	223.4	6.81	6.70	515.2	15.73	1310.	100.7	9.12
6 Ga.	0.239	25.522	66	221.8	6.81	6.68	511.6	19.34	1605	123.4	9.11
26	26.000										
API	0.250	25.500	67	221.4	6.81	6.68	510.7	19.85	1646	126.6	9.10
API	0.281	25.438	77	220.3	6.81	6.66	508.2	22.70	1877	144.4	9.09
API	0.312	25.376	84	219.2	6.81	6.64	505.8	25.18	2076	159.7	9.08

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft. per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
26	26.000	API	0.344	25.312	94	218.2	6.81	6.63	503.2	27.73	2280	175.4	9.07
		API	0.375	25.250	103	217.1	6.81	6.61	500.7	30.19	2478	190.6	9.06
		API	0.406	25.188	111	216.0	6.81	6.59	498.3	32.64	2673	205.6	9.05
		API	0.438	25.124	120	214.9	6.81	6.58	495.8	35.17	2874	221.1	9.04
		API	0.500	25.000	136	212.8	6.81	6.54	490.9	40.06	3259	250.7	9.02
		-	0.625	24.750	169	208.6	6.81	6.48	481.1	49.82	4013	308.7	8.98
		-	0.750	24.500	202	204.4	6.81	6.41	471.4	59.49	4744	364.9	8.93
		-	0.875	24.250	235	200.2	6.81	6.35	461.9	69.07	5458	419.9	8.89
		-	1.000	24.000	267	196.1	6.81	6.28	452.4	78.54	6149	473.0	8.85
		-	1.125	23.750	299	192.1	6.81	6.22	443.0	87.91	6813	524.1	8.80
30	30.000	API	0.250	29.500	79	296.3	7.85	7.72	683.4	23.37	2585	172.3	10.52
		API	0.281	29.438	89	295.1	7.85	7.70	680.5	26.24	2897	193.1	10.51
		10	0.312	29.376	99	293.7	7.85	7.69	677.8	29.19	3207	213.4	10.50
		API	0.344	29.312	109	292.6	7.85	7.67	674.8	32.04	3524	235.0	10.49
		API	0.375	29.250	119	291.2	7.85	7.66	672.0	34.90	3823	254.8	10.48
		API	0.406	29.188	130	290.7	7.85	7.64	669.0	37.75	4132	275.5	10.46

API	0.438	29.124	138	288.8	7.85	7.62	666.1	40.68	442	296.2	10.45
20	0.500	29.000	158	286.2	7.85	7.59	660.5	46.34	5033	335.5	10.43
30	0.625	28.750	196	281.3	7.85	7.53	649.2	57.68	6213	414.2	10.39
-	0.750	28.500	234	276.6	7.85	7.46	637.9	68.92	7371	491.4	10.34
-	0.875	28.250	272	271.8	7.85	7.39	620.7	80.06	84.94	566.2	10.30
-	1.000	28.000	310	367.0	7.85	7.33	615.7	91.11	9591	639.4	10.26
-	1.125	27.750	347	262.2	7.85	7.26	604.7	102.05	10653	710.2	10.22
-	1.250	27.500	384	257.5	7.85	7.20	593.9	112.90	11682	778.8	10.17
-	1.375	27.250	421	252.9	7.85	7.13	583.1	123.65	12694	846.2	10.13
-	1.500	27.000	457	248.2	7.85	7.07	572.5	134.30	13673	911.5	10.09
API	0.250	31.500	85	337.8	8.38	8.25	779.2	24.93	3141	196.3	11.22
API	0.281	31.438	95	336.5	8.38	8.23	776.2	28.04	3525	220.3	11.21
API	0.312	31.376	106	335.2	8.38	8.21	773.2	31.02	3891	243.2	11.19
API	0.344	31.312	116	333.8	8.38	8.20	770.0	34.24	4287	268.0	11.19
API	0.375	31.250	127	332.5	8.38	8.18	766.9	37.25	4656	291.0	11.18
API	0.406	31.188	137	331.2	8.38	8.16	764.0	40.29	5025	314.1	11.17
API	0.438	31.124	148	329.8	8.38	8.15	760.8	43.43	5407	337.9	11.16
API	0.500	31.000	168	327.2	8.38	8.11	754.7	49.48	6140	383.8	11.14
-	0.625	30.750	209	321.9	8.38	8.05	742.5	61.59	7578	473.6	11.09
-	0.750	30.500	250	316.7	8.38	7.98	730.5	73.63	8990	561.9	11.05
-	0.875	30.250	291	311.5	8.38	7.92	718.6	85.53	10368	648.0	11.01
-	1.000	30.000	331	306.4	8.38	7.85	706.8	97.38	11680	730.0	10.95

30 30.000

32 32.000

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
32	32.000	-	1.125	29.750	371	301.3	8.38	7.79	695.0	109.0	13003	812.7	10.92
		-	1.250	29.500	410	296.3	8.38	7.72	680.5	120.7	14398	899.9	10.88
		-	1.375	29.250	450	291.2	8.38	7.66	671.9	132.2	15526	970.4	10.84
		-	1.500	29.000	489	286.3	8.38	7.59	660.5	143.7	16752	1047.0	10.80
34	34.000	API	0.250	33.500	90	382.0	8.90	8.77	881.2	26.50	3773	221.9	11.93
		API	0.281	33.438	101	380.7	8.90	8.75	878.2	29.77	4230	248.8	11.92
		API	0.312	33.376	112	379.3	8.90	8.74	874.9	32.99	4680	275.3	11.91
		API	0.344	33.312	124	377.8	8.90	8.72	871.6	36.36	5147	302.8	11.90
34	34.000	API	0.375	33.250	135	376.2	8.90	8.70	867.8	39.61	5597	329.2	11.89
		API	0.406	33.188	146	375.0	8.90	8.69	865.0	42.88	6047	355.7	11.87
		API	0.438	33.124	157	373.6	8.90	8.67	861.7	46.18	6501	382.4	11.86
		API	0.500	33.000	179	370.8	8.90	8.64	855.3	52.62	7385	434.4	11.85
34	34.000	-	0.625	32.750	223	365.0	8.90	8.57	841.9	65.53	9124	536.7	11.80
		-	0.750	32.500	266	359.5	8.90	8.51	829.3	78.34	10829	637.0	11.76
		-	0.875	32.250	308	354.1	8.90	8.44	816.8	90.66	12442	731.9	11.71
		-	1.000	32.000	353	348.6	8.90	8.38	804.2	103.6	14114	830.2	11.67

-	1.125	31.750	395	343.2	8.90	8.31	791.6	116.1	15703	923.7	11.63
-	1.250	31.500	437	337.8	8.90	8.25	779.2	128.5	17246	1014.5	11.58
-	1.375	31.25	479	332.4	8.90	8.18	766.9	140.9	18770	1104.1	11.54
-	1.500	31.000	527	327.2	8.90	8.11	754.7	153.1	20247	1191.0	11.50
API	0.250	33.500	96	429.1	9.42	9.29	989.7	28.11	4491	249.5	12.64
API	0.281	35.438	107	427.6	9.42	9.28	986.4	31.49	5023	279.1	12.63
API	0.312	35.376	119	426.1	9.42	9.26	982.9	34.95	5565	309.1	12.62
API	0.344	35.312	131	424.6	9.42	9.24	979.3	38.56	6127	340.4	12.60
API	0.375	35.250	143	423.1	9.42	9.23	975.8	42.01	6664	370.2	12.59
API	0.406	35.188	154	421.6	9.42	9.21	972.5	45.40	7191	399.5	12.58
API	0.438	35.124	166	420.1	9.42	9.19	968.9	48.93	7737	429.9	12.57
API	0.500	35.000	190	417.1	9.42	9.16	962.1	55.76	8785	488.1	12.55
-	0.625	34.750	236	411.1	9.42	9.10	948.3	69.5	10872	604.0	12.51
-	0.750	34.500	282	405.3	9.42	9.03	934.7	83.01	12898	716.5	12.46
-	0.875	34.250	329	399.4	9.42	8.97	921.2	96.60	14906	828.1	12.42
-	1.000	34.000	374	393.6	9.42	8.90	907.9	109.90	16851	936.2	12.38
-	1.125	33.750	419	387.8	9.42	8.83	894.5	123.3	18766	1042.6	12.34
-	1.250	33.500	464	382.1	9.42	8.77	881.3	136.5	20624	1145.8	12.29
-	1.375	33.250	509	376.4	9.42	8.70	868.2	149.6	22451	1247.3	12.25
-	1.500	33.000	553	370.8	9.42	8.64	855.3	162.6	24237	1346.5	12.21
34		34.000									
36		36.000									

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) a	Area of Metal (in.) A	Moment of Inertia (in.) I	Section Modulus (in.) Z	Radius of Gyration (in.) R
		-	0.250	41.500	112	586.4	10.99	10.86	1352.6	32.82	7126	339.3	14.73
		-	0.375	41.250	167	579.3	10.99	10.80	1336.3	49.08	10627	506.1	14.71
		-	0.500	41.000	222	572.3	10.99	10.73	1320.2	65.18	14037	668.4	14.67
		-	0.625	40.750	276	565.4	10.99	10.67	1304.1	81.28	17373	827.3	14.62
		-	0.750	40.500	331	558.4	10.99	10.60	1288.2	97.23	20689	985.2	14.59
42	42.000	-	0.875	40.250	385	551.6	10.99	10.54	1272.3	113.00	23896	1137.9	14.54
		-	1.000	40.000	438	544.8	10.99	10.47	1256.6	128.8	27080	1289.5	14.50
		-	1.125	39.750	492	537.9	10.99	10.41	1240.9	144.5	30193	1437.8	14.45
		-	1.250	39.500	544	531.2	10.99	10.34	1225.3	160.0	33233	1582.5	14.41
		-	1.375	39.250	597	524.4	10.99	10.27	1209.9	175.5	36240	1725.7	14.37
		-	1.500	39.000	649	517.9	10.99	10.21	1194.5	190.8	39181	1865.7	14.33
		-	0.250	43.500	117	644.0	11.52	11.39	1486.2	34.36	8221	373.7	15.47
		-	0.375	43.250	175	636.6	11.52	11.32	1469.1	51.39	12227	555.8	15.42
		-	0.500	43.000	233	629.3	11.52	11.26	1452.2	68.33	16164	734.7	15.38
44	44.000	-	0.625	42.750	290	622.0	11.52	11.19	1435.4	85.17	20033	910.6	15.34
		-	0.750	42.500	347	614.7	11.52	11.13	1418.6	101.91	23835	1083.4	15.29
		-	0.875	42.250	403	607.5	11.52	11.06	1402.0	118.55	27570	1253.2	15.25

	-	1.000	42.000	460	600.4	11.52	11.00	1385.4	135.09	31239	1420.0	15.21
	-	1.125	41.750	516	593.2	11.52	10.93	1369.0	151.53	34844	1583.8	15.16
44	44.000	-	1.250	41.500	571	586.1	11.52	1352.7	167.88	38384	1744.7	15.12
	-	1.375	41.250	627	579.1	11.52	10.80	1336.4	184.13	41861	1902.8	15.08
	-	1.500	41.000	681	572.1	11.52	10.73	1320.3	200.28	45275	2058.0	15.04
	-	0.250	45.500	122	704.6	12.04	11.91	1626.0	35.93	9401	408.8	16.18
	-	0.375	45.250	183	696.9	12.04	11.85	1608.2	53.75	13987	608.1	16.13
	-	0.500	45.000	243	689.2	12.04	11.78	1590.4	71.47	18498	804.2	16.09
	-	0.625	44.750	303	681.6	12.04	11.72	1572.8	89.09	22934	997.1	16.04
	-	0.750	44.500	363	674.0	12.04	11.65	1555.3	106.62	27296	1186.8	16.00
46	46.000	-	0.875	44.250	422	666.4	12.04	1537.9	124.04	31585	1373.3	15.96
	-	1.000	44.000	481	658.9	12.04	11.52	1520.5	141.37	35802	1556.6	15.91
	-	1.125	43.750	540	651.4	12.04	11.45	1503.3	158.60	39948	1736.9	15.87
	-	1.250	43.500	598	644.0	12.04	11.39	1486.2	175.73	44024	1914.1	15.83
	-	1.375	43.250	656	636.6	12.04	11.32	1469.1	192.77	48030	2088.2	15.78
	-	1.500	43.000	714	629.3	12.04	11.26	1452.2	209.70	51967	2259.4	15.74
	-	0.250	47.500	128	767.9	12.57	12.44	1772.1	37.50	10689	445.4	16.88
	-	0.375	47.250	191	759.8	12.57	12.37	1753.5	56.11	15908	662.8	16.84
	-	0.500	47.000	254	751.8	12.57	12.30	1734.9	74.61	21045	876.9	16.79
48	48.000	-	0.625	46.750	317	743.8	12.57	1716.5	93.02	26101	1087.6	16.75
	-	0.750	46.500	379	735.9	12.57	12.17	1698.2	111.33	31077	1294.9	16.71
	-	0.875	46.250	441	728.0	12.57	12.11	1680.0	129.54	35973	1498.9	16.66

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	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
48	48.000	-	1.000	46.000	720.2	12.57	12.04	1661.9	147.65	40790	1699.6	16.62
		-	1.125	45.750	712.4	12.57	11.98	1643.9	165.67	45529	1897.0	16.58
		-	1.250	45.500	704.6	12.57	11.91	1626.0	183.59	50191	2091.3	16.53
		-	1.375	45.250	685	12.57	11.85	1608.2	201.41	54777	2282.4	16.49
		-	1.500	45.000	746	12.57	11.78	1590.4	219.13	59287	2470.3	16.45
50	50.000	-	0.250	49.500	133	13.09	12.96	1924.4	39.07	12089	483.6	17.59
		-	0.375	49.250	199	13.09	12.89	1905.0	58.46	17998	719.9	17.55
		-	0.500	49.000	265	13.09	12.83	1885.7	77.75	23817	952.7	17.50
		-	0.625	48.750	330	13.09	12.76	1866.5	96.95	29548	1181.9	17.46
		-	0.750	48.500	395	13.09	12.70	1847.5	116.04	35192	1407.7	17.41
50	50.000	-	0.875	48.250	460	13.09	12.63	1828.5	135.04	40749	1629.9	17.37
		-	1.000	48.000	524	13.09	12.57	1809.6	153.94	46220	1848.8	17.33
		-	1.125	47.750	588	13.09	12.50	1790.8	172.74	51606	2064.3	17.28
		-	1.250	47.500	651	13.09	12.44	1772.1	191.44	56909	2276.4	17.24
		-	1.375	47.250	715	13.09	12.37	1753.5	210.04	62128	2485.1	17.20
-	1.500	47.000	778	13.09	12.30	1734.9	228.55	67265	2690.6	17.16		

-	0.250	51,500	138	902.7	13.61	13.48	2083.1	40.64	13606	523.3	18.30
-	0.375	51,250	207	893.9	13.61	13.42	2062.9	60.82	20263	779.3	18.25
-	0.500	51,000	275	885.2	13.61	13.35	2042.8	80.90	26822	1031.6	18.21
-	0.625	50,750	343	876.6	13.61	13.29	2022.8	100.87	33286	1280.2	18.17
-	0.750	50,500	411	868.0	13.61	13.22	2003.0	120.75	39655	1525.2	18.12
-	0.875	50,250	478	859.4	13.61	13.16	1983.2	140.54	45930	1766.5	18.08
52		52,000									
-	1.000	50,000	545	850.8	13.61	13.09	1963.5	160.22	52112	2004.3	18.03
-	1.125	49,750	612	842.4	13.61	13.02	1943.9	179.81	58202	2238.5	17.99
-	1.250	49,500	678	833.9	13.61	12.96	1924.4	199.29	64201	2469.3	17.95
-	1.375	49,250	744	825.5	13.61	12.89	1905.0	218.68	70110	2696.5	17.91
-	1.500	49,000	810	817.2	13.61	12.83	1885.7	237.98	75929	2920.4	17.86
-	0.250	53,500	144	974.1	14.14	14.01	2248.0	42.22	15246	564.7	19.00
-	0.375	53,250	215	965.1	14.14	13.94	2227.0	63.18	22710	841.1	18.96
-	0.500	53,000	286	956.0	14.14	13.88	2206.2	84.04	30070	1113.7	18.92
-	0.625	52,750	357	947.0	14.14	13.81	2185.4	104.80	37326	1382.4	18.87
-	0.750	52,500	427	938.1	14.14	13.74	2164.8	125.47	44480	1647.4	18.83
-	0.875	52,250	497	929.1	14.14	13.68	2144.2	146.03	51533	1908.6	18.79
54		54,000									
-	1.000	52,000	567	920.3	14.14	13.61	2123.7	166.50	58485	2166.1	18.74
-	1.125	51,750	636	911.4	14.14	13.55	2103.3	186.88	65337	2419.9	18.70
-	1.250	51,500	705	902.7	14.14	13.48	2083.1	207.15	72091	2670.0	18.66
-	1.375	51,250	774	893.9	14.14	13.42	2062.9	227.32	78747	2916.6	18.61
-	1.500	51,000	842	885.2	14.14	13.35	2042.8	247.40	85307	3159.5	18.57

TABLE OF PROPERTIES OF PIPE (cont.)

Nominal Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Ft.	Weight of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area (in.) ^a	Area of Metal (in.) ^A	Moment of Inertia (in.) ^I	Section Modulus (in.) ^Z	Radius of Gyration (in.) ^R
		-	0.250	55.500	149	1048.3	14.66	14.53	2419.2	43.79	17012	607.6	19.71
		-	0.375	55.250	223	1038.9	14.66	14.46	2397.5	65.53	25347	905.2	19.67
		-	0.500	55.000	297	1029.5	14.66	14.40	2375.8	87.18	33569	1198.9	19.62
		-	0.625	54.750	370	1020.2	14.66	14.33	2354.3	108.73	41681	1488.6	19.58
		-	0.750	54.500	443	1010.9	14.66	14.27	2332.8	130.18	49682	1774.4	19.54
56	56.000	-	0.875	54.250	516	1001.6	14.66	14.20	2311.5	151.53	57574	2056.2	19.49
		-	1.000	54.000	588	992.4	14.66	14.14	2290.2	172.79	65357	2334.2	19.45
		-	1.125	53.750	660	983.3	14.66	14.07	2269.1	193.94	73033	2608.3	19.41
		-	1.250	53.500	732	974.1	14.66	14.01	2248.0	215.00	80603	2878.7	19.36
		-	1.375	53.250	803	965.1	14.66	13.94	2227.0	235.96	88067	3145.2	19.32
		-	1.500	53.000	874	956.0	14.66	13.88	2206.2	256.83	95427	3408.1	19.28
		-	0.250	57.500	154	1125.2	15.18	15.05	2596.7	45.36	18909	652.0	20.42
		-	0.375	57.250	231	1115.5	15.18	14.99	2574.2	67.89	28180	971.7	20.37
		-	0.500	57.000	307	1105.8	15.18	14.92	2551.8	90.32	37331	1287.3	20.33
58	58.000	-	0.625	56.750	383	1096.1	15.18	14.86	2529.4	112.66	46362	1598.7	20.29
		-	0.750	56.500	459	1086.4	15.18	14.79	2507.2	134.89	55274	1906.0	20.24
		-	0.875	56.250	534	1076.9	15.18	14.73	2485.0	157.03	64069	2209.3	20.20

-	1.000	56.000	609	1067.3	15.18	14.66	2463.0	179.07	72748	2508.5	20.16
-	1.125	55.750	684	1057.8	15.18	14.60	2441.1	201.01	81310	2803.8	20.11
-	1.250	55.500	758	1048.3	15.18	14.53	2419.2	222.86	89759	3095.1	20.07
-	1.375	55.250	832	1038.9	15.18	14.46	2397.5	244.60	98094	3382.6	20.03
-	1.500	55.000	906	1029.5	15.18	14.40	2375.8	266.25	106317	3666.1	19.98
-	0.250	59.500	160	1204.9	15.71	15.58	2780.5	46.93	20942	698.1	21.13
-	0.375	59.250	239	1194.8	15.71	15.51	2757.2	70.24	31217	1040.6	21.08
-	0.500	59.000	318	1184.7	15.71	15.45	2734.0	93.46	41363	1378.8	21.04
-	0.625	58.750	397	1174.7	15.71	15.38	2710.9	116.58	51381	1712.7	20.99
-	0.750	58.500	475	1164.7	15.71	15.32	2687.8	139.60	61271	2042.4	20.95
-	0.875	58.250	553	1154.8	15.71	15.25	2664.9	162.53	71036	2367.9	20.91
-	1.000	58.000	631	1144.9	15.71	15.18	2642.1	185.35	80675	2689.2	20.86
-	1.125	57.750	708	1135.1	15.71	15.12	2619.4	208.08	90191	3006.4	20.82
-	1.250	57.500	785	1125.2	15.71	15.05	2596.7	230.71	99584	3319.5	20.78
-	1.375	57.250	862	1115.5	15.71	14.99	2574.2	253.24	108855	3628.5	20.73
-	1.500	57.000	938	1105.8	15.71	14.92	2551.8	275.67	118006	3933.5	20.69
58	58.000										
60	60.000										

DESIGN STANDARDS FOR ASME PIPING AND PRESSURE VESSEL CODES

ASME Piping Code Standards

B31.1 (Power) –

Design stress is lowest of:

1/3.5 X ultimate strength

2/3 X yield strength

or creep or stress rupture at high temp

B31.3 (Process) –

Design stress is lowest of:

1/3 X ultimate strength

2/3 X yield strength

or creep or stress rupture at high temp

B31.4 (Liquids) –

0.72 X yield strength

B31.8 (Gas) –

Class 1, Div. 1 0.80 X yield strength

Class 1, Div. 2 0.72 X yield strength

Class 2 0.60 X yield strength

Class 3 0.50 X yield strength

Class 4 0.40 X yield strength

ASME Pressure Vessel Code Standards

Section I (Power Boilers)

1/3.5 X ultimate strength

2/3 X yield strength

at high temp, creep or stress rupture may govern

Section III (Nuclear Power Plant Components)

Design stress lowest in all cases:

Class 1,

1/3 X ultimate strength

2/3 X yield strength

Classes 2 and 3,

1/3.5 X ultimate strength

2/3 X yield strength

at high temp, creep or stress rupture may govern

Section VIII (Unfired Pressure Vessels)

Design stress lowest in all cases:

Division 1,

1/3.5 X ultimate strength

2/3 X yield strength

at high temp, creep or stress rupture

may govern

Division 2,

1/2.4 X ultimate strength

2/3 X yield strength

high temp, Division 2 reverts to Division 1

CONDENSED REQUIREMENTS (FERROUS)

IDENTIFICATION		MECHANICALS				
Fitting Grade	ASTM Pipe Grade	Tensile Strength PSI (Min.)	Yield Strength PSI (Min.)	El. 2 in. (%) Long◆	RA (%) (Min.)	Impact
A234 WPA	A106A	48.000	30.000	35.00	.....	.....
A234 WPB	A106B	60.000	35.000	30.00	.....	.....
A234 WPC	A106C	70.000	40.000	30.00	.....	.....
A420 WPL3	A333 Gr 3	65.000	35.000	30.00	.....	13 ft lbs @ -150°F
A420 WPL6	A333 Gr 6	60.000	35.000	35.00	.....	13 ft lbs @ -50°F
Yoloy (low temp)	A333 Gr 9	63.000	46.000	28.00	.....	13 ft lbs @ -100°F (Charpy v. Notch)
A234 WP1	A335 P1	55.000	30.000	30.00	.....	.....
A234 WP12	A335 P12	60.000	30.000	30.00	.....	.....
A234 WP11	A335 P11	60.000	30.000	30.00	.....	.....
A234 WP22	A335 P22	60.000	30.000	30.00	.....	.....
A234 WP5	A335 P5	60.000	30.000	30.00	.....	.....
A234 WP7	A335 P7	60.000	30.000	30.00	.....	.....
A234 WP9	A335 P9	60.000	30.000	30.00	.....	.....
Yoloy (corrosion resist)	A333 Gr 9 (chem only)	63.000	46.000	28.00	.....	.....

IDENTIFICATION		MECHANICALS				
Flange Grade	ASTM Pipe Grade	Tensile Strength PSI (Min.)	Yield Strength PSI (Min.)	El. 2 in. (%) Long◆	RA (%) (Min.)	Impact
A181 Gr I	60.000	30.000	22.00	35.00	.....
A181 Gr II	70.000	36.000	18.00	24.00	.....
A105	70.000	36.000	22.00	30.00	.....
A350 LF1	60-85.000	30.000	25.00	38.00	13 ft lbs @ -50°F
A350 LF2	70-95.000	36.000	22.00	30.00	15 ft lbs @ -50°F
A350 LF3	70-95.000	37.500	22.00	35.00	15 ft lbs @ -150°F
Yoloy (low temp)	A350 Gr 9	63-88.000	46.000	25.00	38.00	13 ft lbs @ -100°F
A182 F1	70.000	40.000	25.00	35.00	.....
A182 F12	70.000	40.000	20.00	30.00	.....
A182 F11	70.000	40.000	20.00	30.00	.....
A182 F22	75.000	45.000	20.00	30.00	.....
A182 F5	70.000	40.000	22.00	35.00	.....
A182 F7	70.000	40.000	20.00	35.00	.....
A182 F9	85.000	55.000	20.00	40.00	.....
Yoloy (corrosion resist)	A350 Gr 9 (chem only)	63-88.000	46.000	25.00	38.00	.....

IDENTIFICATION		MECHANICALS				
Plate Grade	ASTM Pipe Grade	Tensile Strength PSI (Min.)	Yield Strength PSI (Min.)	El. 2 in. (%) Long◆	RA (%) (Min.)	Impact
A515 Gr 70	70-90.000	38.000	21%	.....	.....
A516 Gr 70	70-80.000	38.000	21%	.....	.....
A537 Cl 1	70-90.000	50.000	22%	.....	.....
A633-E	90-100.000	60.000	23%	.....	-75°F
A738-B	85-100.000	60.000	23%	.....	.....

a Add when necessary – 35% max. (See spec.)

◆ See appropriate spec. for exact values

OF MATERIALS SPECIFICATIONS (METALS)

CHEMICALS [†]								
C	MN	P	S	SI	CR	NI	MO	CU
0.25	27.93	0.048	0.058	0.10 min	.....	.....	.....	.....
0.30	0.29-1.06	0.048	0.058	0.10 min	.....	.....	.....	.....
0.35	0.29-1.06	0.048	0.058	0.10 min	.....	.....	.....	.....
0.19	0.31-.64	0.050	0.050	0.18-0.37	.....	3.18-3.82	.....	.....
0.30	0.29-1.06	0.048	0.058	0.10 min	.....	.....	.....	.....
0.20	0.40-1.06	0.045	0.050	.....	.....	1.60-2.24	.....	0.75-1.25
0.10-0.20	0.30-0.80	0.045	0.045	0.10-0.50	.....	.....	0.44-0.65	.....
0.15	0.30-0.61	0.045	0.045	0.50	0.80-1.25	.....	0.44-0.65	.....
0.15	0.30-0.60	0.030	0.030	0.50-1.00	1.00-1.50	.....	0.44-0.65	.....
0.15	0.30-0.60	0.030	0.030	0.50	1.90-2.60	.....	0.87-1.13	.....
0.15	0.30-0.60	0.030	0.030	0.50	4.00-6.00	.....	0.44-0.65	.....
0.15	0.30-0.60	0.030	0.030	0.50-1.00	6.00-8.00	.....	0.44-0.65	.....
0.15	0.30-0.60	0.030	0.030	0.25-1.00	8.00-10.00	.....	0.44-0.65	.....
0.20	0.40-1.06	0.045	0.050	.....	.....	1.60-2.24	.....	0.75-1.25

CHEMICALS [†]								
C	MN	P	S	SI	CR	NI	MO	CU
0.35	0.90	0.050	0.050	a	.....	.....	.....	.....
0.35	0.90	0.050	0.050	a	.....	.....	.....	.....
0.22-0.35	0.60-1.05	0.040	0.050	0.35	.....	.....	.....	.....
0.30	0.75-1.05	0.035	0.040	0.15-0.30	.....	.....	.....	.....
0.30	1.35	0.035	0.040	0.15-0.30	.....	.....	.....	.....
0.20	0.90	0.035	0.040	0.20-0.35	.....	3.25-3.75	.....	.....
0.20	0.10-1.06	0.045	0.050	0.20-0.35	.....	1.60-2.24	.....	0.75-1.25
0.28	0.60-0.90	0.045	0.045	0.15-0.35	.....	.....	0.44-0.65	.....
0.10-0.20	0.30-0.80	0.040	0.040	0.10-0.60	0.80-1.25	.....	0.44-0.65	.....
0.10-0.20	0.30-0.80	0.040	0.040	0.50-1.00	1.00-1.50	.....	0.44-0.65	.....
0.15	0.30-0.60	0.040	0.040	0.50	2.00-2.50	.....	0.87-1.13	.....
0.15	0.30-0.60	0.030	0.030	0.50	4.00-6.00	.....	0.44-0.65	.....
0.15	0.30-0.60	0.030	0.030	0.50-1.00	6.00-8.00	.....	0.44-0.65	.....
0.15	0.30-0.60	0.030	0.030	0.50-1.00	8.00-10.00	.....	0.90-1.10	.....
0.20	0.40-1.06	0.035	0.040	0.20-0.35	.....	1.60-2.24	.....	0.75-1.25

CHEMICALS [†]								
C	MN	P	S	SI	CR	NI	MO	CU
0.31	0.90	0.035	0.040	0.15-0.30	.....	.....	.....	.....
0.28	0.85-1.20	0.035	0.040	0.15-0.30	.....	.....	.....	.....
0.24	0.70-1.35	0.035	0.040	0.15-0.30	.....	.....	.....	.....
0.22	1.15-1.50	0.040	0.035	0.15-0.50	.....	.....	.....	.....
0.22	1.15-1.50	0.035		0.15-0.50	.....	.....	.....	.....

† Max. values except as indicated

CONDENSED REQUIREMENTS (NONFERROUS)

IDENTIFICATION		MECHANICALS				
Fitting Grade	ASTM Pipe Grade	Tensile Strength PSI (Min.)	Yield Strength PSI (Min.)	El. 2 in. (%) Long	RA (%) (Min.)	Impact
A403 WP304L	A312 TP304L	70,000	25,000	.....	.....	.....
A403 WP304	A312 TP304	75,000	30,000	.....	.....	.....
A403 WP316L	A312 TP316L	70,000	25,000	.....	.....	.....
A403 WP316	A312 TP316	75,000	30,000	.....	.....	.....
A403 WP321	A312 TP321	75,000	30,000	.....	.....	.....
A403 WP347	A312 TP347	75,000	30,000	.....	.....	.....

Heat Treat	B163 400	70-86,000	28-55,000	35-15	.....	.....
Anneal Str	B163 600	80,000	35,000	30	.....	.....
Relieved	B163 800	75,000	30,000	30	.....	.....
	B163 800H	85,000	25,000	30	.....	.....
	B163 825	85,000	35,000	30	.....	.....

IDENTIFICATION		MECHANICALS				
Forge Grade	ASTM Pipe Grade	Tensile Strength PSI (Min.)	Yield Strength PSI (Min.)	El. 2 in. (%) Long	RA (%) (Min.)	Impact
A182 F304L	65,000	25,000	30	50	.....
A182 F304	75,000	30,000	30	50	.....
A182 F316L	65,000	25,000	20	50	.....
A182 F316	75,000	30,000	30	50	.....
A182 F321	75,000	30,000	30	50	.....
A182 F347	75,000	30,000	30	50	.....

B164 400	.....	70,000	25,000	30	.....	.....
B166 800	.....	80,000	35,000	30	.....	.....
B408 800	.....	75,000	30,000	30	.....	.....
B408 800H	.....	75,000	25,000	30	.....	.....
B425 825	.....	75,000	30,000	30	.....	.....

IDENTIFICATION		MECHANICALS				
Plate Grade	ASTM Pipe Grade	Tensile Strength PSI (Min.)	Yield Strength PSI (Min.)	El. 2 in. (%) Long	RA (%) (Min.)	Impact
A240 304L	70,000	25,000	40	.....	.....
A240 304	75,000	30,000	40	.....	.....
A204 316L	70,000	30,000	40	.....	.....
A204 316	70,000	30,000	40	.....	-75°F
A240 321	70,000	30,000	40	.....	.....
A240 347	75,000	30,000	40	.....	.....

Heat Treat						
B127 400	Anneal Hot Roll	70-75,000	28-40,000	36-25	.....	.....
B166 600	Anneal Hot Roll	80-85,000	35,000	30	.....	.....
B409 800		75,000	30,000	30	.....	.....
B409 800H		65,000	25,000	30	.....	.....
B424 825		85,000	35,000	30	.....	.....

OF MATERIALS SPECIFICATIONS (METALS)

CHEMICALS [†]									
C	MN	P	S	SI	CR	NI	MO	CU	
0.035	2.0	0.04	0.03	0.75	18-20.0	8-13.0	.....	.....	.....
0.06	2.0	0.04	0.03	0.75	18-20.0	8-11.0	2-3.0	.....	.....
0.035	2.0	0.04	0.03	0.75	16-18.0	10-15.0	2-3.0	.....	.....
0.06	2.0	0.04	0.03	0.75	16-18.0	11-14.0	.....	.....	Ti = 4 x C (min), 0.70 max
0.06	2.0	0.04	0.03	0.75	17-20.0	9-13.0	.....	.....	Co+Ta = 10 x C (min), 1.0 max
0.06	2.0	0.04	0.03	0.75	17-20.0	9-13.0	.....	.....	.....

								Fe	Al	Ti
0.30	2.0	.....	0.024	0.50	.....	63.0 min	.....	28-34.0	2.50	.....
0.15	1.0	.....	0.015	0.50	14-17.0	72.0 min	.....	0.50	6.0-10.0	.....
0.10	1.5	.....	0.015	1.00	19-23.0	30-35.0	.....	0.75	39.5 min	0.15-0.60
0.05-0.10	1.5	.....	0.015	1.00	19-23.0	30-35.0	.....	0.75	39.5 min	0.15-0.60
0.05	1.0	.....	0.030	0.50	19.5-23.5	38-46.0	.....	1.5-3.0	22.0 min	0.20

CHEMICALS [†]									
C	MN	P	S	SI	CR	NI	MO	CU	Col. + Tant.
0.35	2.0	0.04	0.03	1.00	18-20.0	8-13.0	.....	.....	.....
0.06	2.0	0.04	0.03	1.00	18-20.0	8-11.0	.....	.....	.....
0.036	2.0	0.04	0.03	1.00	16-18.0	10-15.0	2-3.0	.....	.....
0.06	2.0	0.04	0.03	1.00	16-18.0	10-14.0	2-3.0	.....	.....
0.06	2.0	0.03	0.03	1.00	17 min	9-12.0	.....	.....	.....
0.06	2.0	0.03	0.03	1.00	17-20.0	9-13.0	.....	.....	1.00

									Fe	Al	Ti
0.30	2.0	.....	0.024	0.50	.....	63.0 min	.....	28-34.0	2.50	.....
0.15	1.0	.....	0.015	0.50	14-17.0	72.0 min	.....	.050	6.0-10.0	.....
0.10	1.5	.....	0.015	1.00	19-23.0	30-35.0	.....	0.75	39.5 min	0.15-0.60
0.05-0.10	1.5	.....	0.015	1.00	30-35.0	30-35.0	.....	0.75	39.5 min	0.15-0.60
0.05	1.0	.....	0.03	0.50	36-46.0	38-46.0	2.5-3.5	1.5-3.0	22.0 min	0.20

CHEMICALS [†]									
C	MN	P	S	SI	CR	NI	MO	CU	Other
0.03	2.0	0.045	0.03	1.00	18-20.0	8-12.0	.....	.....	N = 0.10 max
0.08	2.0	0.045	0.03	1.00	18-20.0	8-12.0	.....	.....	N = 0.10 max
0.03	2.0	0.045	0.03	1.00	16-18.0	10-14.0	2-3.0	.....	N = 0.10 max
0.08	2.0	0.045	0.03	1.00	16-18.0	10-14.0	2-3.0	.....	.....
0.08	2.0	0.045	0.03	1.00	17-19.0	9-12.0	.....	.....	Ti = 5 x C (min), 0.70 max
0.08	2.0	0.045	0.03	1.00	17-19.0	9-13.0	.....	.....	Cb+Ta = 10 x C (min), 1.10 max

									Fe	Al	Ti
0.30	2.0	.....	0.024	0.50	.....	63.0 min	.....	28-34.0	2.50	.....
0.15	1.0	.....	0.015	0.50	14-17.0	72.0 min	.....	.050	6.0-10.0	.....
0.10	1.5	.....	0.015	1.00	19-23.0	30-36.0	.....	0.75	39.5 min	0.15-0.60
0.05-0.10	1.5	.....	0.015	1.00	19-23.0	30-36.0	.....	0.75	39.5 min	0.15-0.60
0.05	1.0	.....	0.030	0.50	19.5-23.5	38-46.0	2.5-3.5	1.5-3.0	22.0 min	0.20

WELDING INFORMATION

The purpose of this section is to provide general information on those welding processes and electrodes most used in construction piping systems. The shielded metal arc process section has been expanded to explain differences between electrodes.

AWS Classification Designators (Carbon Steel)

Examples: E70T-5C, E71T-9M-JH4

Mandatory Designators:

-
- Current Carrying Electrode ———→ E
- Minimum Tensile Strength ———→ X
(*"x" x 10 ksi: "7" = 70 ksi or 70,000 psi*)
- Welding Position ———→ X
(*"0" = Flat & horizontal only, "1" = All position*)
- Tubular Electrode (Flux Cored) ———→ T
- Usability ———→ -
- Shielding Gas Type ———→ X
(*"M" = 75 – 80% Ar/Balance CO₂ mixed gas,
"C" = 100% CO₂, Blank = No shielding gas*)

Optional Supplemental Designators:

- Improved Toughness ———→ J
(*"J" = Electrode will produce welds with CVN values at least 20 ft-lbf at -40°F [27 J @ -40°C]*)
- Supplemental Mechanical Property Requirements ———→ H
(*"D" or "Q" = Will meet requirements when welded with high heat input and low heat producers*)
- Diffusible Hydrogen Levels ———→ 4
(*"H4," "H8," or "H16" = There will be a maximum of 4 mi [or 8 or 16] hydrogen per 100 grams weld metal*)

Shielded Metal Arc Welding (SMAW) (Stick)

SMAW is the most versatile process available for joining piping components made of carbon, alloy and stainless steels. A great variety of proven electrodes exist, the choice of which depends on the desired result.

Gas Tungsten Arc Welding (GTAW or TIG)

GTAW is the best process choice where a high quality weld deposit is mandatory. It is applicable to all component steels. The major drawbacks in choosing GTAW are welding speed and the requirements for greater operator skill.

The process is widely used for welding the root (first) pass, even though the joint may be welded out with another process.

There are three main variables that must be considered in instituting GTAW:

1. Filler Metal. Choice of filler metal is relatively easy, since usually the weld deposit should match the chemistry of the base material.
2. Shielding Gas. Choosing the proper shielding gas is more difficult since a variety of gases and gas mixtures are available for specific applications. The major ones used are argon, helium and mixtures of these two gases.
3. Electrode Polarity. AC, DCS and DCR polarities are available to suit the needs of the situation.

Oxy Fuel Weld (Gas)

The Oxy fuel welding process makes use of a combustible gas and oxygen to melt the base metal and filler rod. It is a tried and true method and is very versatile, still used considerably in joining smaller diameter components.

Gas Metal Arc Welding (GMAW or MIG)

The GMAW or MIG process is widely used because of welding speed, ease of use and considerable adaptability to all position welding of piping components. It is relatively simple to automate the process where a volume of repeat applications warrants. Care must be exercised in manipulation of the welding arc to avoid lack of fusion or cold laps.

Shielding gases are primarily carbon dioxide or carbon dioxide/argon mixtures for carbon steel and low alloys, while argon, helium and mixtures are available for use on stainless and higher alloyed steels. The process is generally restricted to DCEP.

WELDING INFORMATION (cont.)

Flux Cored Arc Welding (FCAW)



















FCAW is very similar in operation to GMAW (MIG) but offers some advantages. Alloying ingredients, slag formers and weld metal purifiers are built into the core of the wire. Thus, in many cases, the wire can be tailored by the manufacturer to weld most piping steels. The process is applicable to all positions. Disadvantages exist in the presence of a slag that must be removed, but lack of fusion is generally not a problem.
































Submerged Arc Welding (SAW)

Similar to MIG welding, SAW involves formation of an arc between a continuously-fed bare wire electrode and the workpiece. The process utilizes a neutral or active flux to protect the weld from the atmosphere, in which a slag is formed. SAW is ideal for high deposition rates in the flat and horizontal positions for longitudinal and circumferential butt and fillet welds. For circumferential joints, the workpiece is rotated under a fixed welding head with welding taking place in the flat position.

Depending on material thickness, either single-pass or multi-pass weld procedures can be used. With modern programmable technology, variable waveforms have been created. This results in high deposition rates with lower heat inputs of single large diameter wires and better mechanical properties. SAW is also used in overlay applications from small diameter wire to large width (60mm) strips.

BASIC WELDING SYMBOLS

BASIC WELDING SYMBOLS AND THEIR LOCATION SIGNIFICANCE								
Location Significance	Fillet	Plug or Slot	Spot or Projection	Seam	Back or Backing	Surfacing	Flange	
							Edge	Corner
Arrow side								
Other side						Not used		
Both sides		Not used	Not used	Not used	Not used	Not used	Not used	Not used
No arrow side or other side significance	Not used	Not used			Not used	Not used	Not used	Not used

BASIC WELDING SYMBOLS AND THEIR LOCATION SIGNIFICANCE							SUPPLEMENTARY SYMBOLS			
Square	V	Bevel	Groove			Flare-V	Flare-Bevel	Weird-all-around	Field Weld	Melt-thru
			U	J	Flare-V						Flare-Bevel	Flare-V	Flare-Bevel	Field Weld	Melt-thru
										
										
										
	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used	Not used	



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