5th Edition 11

PIONEER PIPE

1.800.525.1266

5th Edition
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Our Customers Come First

Pioneer Pipe was founded in Denver, Colorado in 1974, and has become one of the leading distributors of standard and line pipe in the United States. Pioneer's foundation is built on an extensive inventory of quality products, competitive pricing, excellent service, and friendly, experienced salespeople. Bringing these elements into unified focus helps to meet or exceed the expectations of customers in nearly every state and in several foreign counties.

We sincerely believe the most important reason for our continued success is that our customers are our number one priority. We continue to serve our well-established customer base, in addition to building new customer relationships, by making it easy to do business with Pioneer at every point of contact. Whether you need line pipe or standard pipe in various grades, sizes, coatings, and end finishes; we will customize any order to meet your needs.

Pioneer has proven ability to handle massive projects or small orders. Our pipe products have helped to build numerous oil & natural gas pipelines both domestic and international, international airports, the Luge Run for the 2002 Olympics, convention centers, snow-making pipelines, fiber-optic lines, and stadiums. We also provide pipe for plumbing in schools, churches, and community centers.

In order to position the company for continued success and profitable growth, Pioneer became part of Russel Metals, Inc. in July of 1994. Based in Toronto, Canada, Russel Metals is one of the largest steel Service Center Operations in North America, with sales exceeding $3.4 billion. Joining Russel Metals enabled Pioneer to combine over 38 years of excellence in pipe manufacturing and distribution with Russel Metals' heritage as a leader since 1784 in the North American Metals Industry.

www.pioneerpipe.com
sales@pioneerpipe.com

Phone: 303 289-3201
Toll Free: 800 525-1266
Fax: 303 289-6381

1660 Lincoln, Suite 1950, Denver, CO 80264

Table of Contents

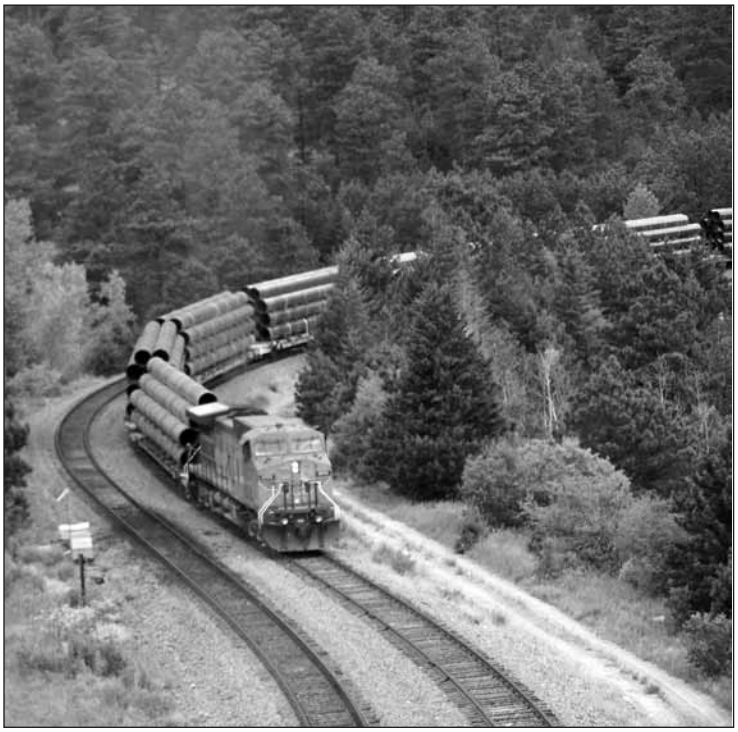
Standards & Specifications

ASTM A 120-84 Standard Specification for Pipe, Steel, Black and Hot Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses

This specification covers black and hot-dipped galvanized welded and seamless steel pipe in NPS 1/8" to NPS 16" inclusive. Formerly under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys, **this specification was discontinued in 1988 and replaced by Specification A 53,** for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

AWWA Standard for Steel Pipe Six Inches and Larger

By reference, the former AWWA C202 included API 5L and 5LX pipe grades manufactured to the American Petroleum Institute (API) standards for high pressure applications. With the advent of ASTM A570 and A572 high strength steels being included in AWWA C200, API high pressure pipe was omitted from AWWA C200 as being redundant. However, API 5L and 5LX pipe grades fully meet all requirements of AWWA C200 and can be used for water works applications if dictated by availability or other economic considerations.



American National Standards Institute (ANSI)

ANSI B2.1	Basic standard for steel pipe threads
ANSI B36.10	Basic dimensional standard for all steel pipe
ANSI B31	Code for design and construction of pressure piping systems, consisting of the following sections:
ANSI B31.1	Power Piping Systems
ANSI B31.2	Industrial Gas and Air Piping Systems
ANSI B31.3	Petroleum Refinery Piping
ANSI B31.4	Liquid Petroleum Transportation Piping
ANSI B31.5	Refrigeration Piping Systems
ANSI B31.6	Chemical Process Piping
ANSI B31.7	Nuclear Power Piping
ANSI B31.8	Gas Transmission and Distribution Piping

American Petroleum Institute (API)

API 5L	Specification for Line Pipe
API 5LX	Specification for High-Test Line Pipe
PSL	Specification for High-Test Line Pipe

American Society for Testing and Materials (ASTM)

ASTM A53	Welded and Seamless Steel Pipe
ASTM A106	Seamless Carbon Steel Pipe for High Temperature Service
ASTM A135	Electric-Resistance-Welded Pipe, 30 inch and under, intended for conveying liquid, gas, or vapor
ASTM A252	Welded and Seamless Steel Pipe Piles
ASTM A333	Seamless and Welded Steel Pipe for Low Temperature Service

American Water Works Association (AWWA)

AWWA C200	AWWA Standard and Welded Carbon Steel Water Well Pipe

ASTM A53 Type F Grade A Pipe

Scope

Covers black and hot-dipped galvanized furnace butt-welded (continuous welded) Grade A pipe. 1/8"-4" Pipe is intended for mechanical and pressure applications and is acceptable for ordinary uses in steam, water, gas and air lines. Pipe is suitable for welding, threading, grooving and bending.

Hot-Dipped Galvanized

The average weight of zinc coating shall be not less than 1.8 oz. per sq. ft. of surface (inside and outside).

When galvanized pipe is bent or otherwise fabricated to a degree which causes zinc coating to stretch or compress beyond the limit of elasticity, some flaking of the coating may occur.

Hydrostatic Testing

Hydrostatic test pressures for plain-end pipe are indicated below.

NPS	Std. Weight	Extra Strong
⅛" through 1"	700 psi	850 psi
1¼" through 3"	1000 psi	1300 psi
3½" through 4"	1200 psi	1700 psi

Chemical Requirements

Composition, max. %

Carbon	Manganese	Phosphorus	Sulfur
.30	1.20	.05	.045

*Copper	*Nickel	*Chromium	*Molybdenum	*Vanadium
.40	.40	.40	.15	.08

*The combination of these five elements shall not exceed 1.00%.

Tensile Requirements

Tensile Strength, min.	48,000 psi
Yield Strength, min.	30,000 psi

Flattening Test

As a test for quality of the weld for pipe 2½" NPS and larger, position the weld at 90° from the direction of force and flatten until the OD is ¾ of the original outside diameter. No cracks shall occur along the inside or outside surface of the weld.

Frequency of Tests

Tensile tests are required on each lot of 25 tons or fraction thereof of pipe NPS 1½" and smaller and from each lot of 50 tons or fraction thereof of pipe NPS 2 and larger.

For NPS 2½" and larger, a flattening test is also required on each lot of 50 tons.

Dimensions and Weights

The dimensions and weights furnished under this specification are in agreement with the standardized dimensions and weights specified in ASME B 36.10.

Permissible Variations in Wall Thickness

Minimum wall thickness at any point shall not be more than 12.5% under nominal wall thickness specified.

Black Plain End

		Sch. 40		Sch. 80	
Nominal Size	OD Inches	Wall	Weight Lb./Ft.	Wall	Weight Lbs./Ft.
⅛"	.405	.068	.24	.095	.31
¼"	.540	.088	.43	.119	.54
⅜"	.675	.091	.57	.126	.74
½"	.840	.109	.85	.147	1.09
¾"	1.050	.113	1.13	.154	1.48
1"	1.315	.133	1.68	.179	2.17
1¼"	1.660	.140	2.27	.191	3.00
1½"	1.900	.145	2.72	.200	3.63
2"	2.375	.154	3.66	.218	5.03
2½"	2.875	.203	5.80	.276	7.67
3"	3.500	.216	7.58	.300	10.26
3½"	4.000	.226	9.12	.318	12.52
4"	4.500	.237	10.80	.337	15.00

Permissible Variations in Outside Diameter

NPS 1½" and under: ± 1/64"

NPS 2" and over: ± 1%

Permissible Variations Weight Per Foot

Pipe shall not vary more than ± 10% from the standard specified.

Product Marking

Each length of pipe ½" NPS and larger is continuously stenciled to show the manufacturer, the grade of pipe (ASTM A53), the kind of pipe (F for continuous weld, A for Grade A), the size, XS for extra strong, and length.

ASTM A53 Type E Grade B Pipe

Scope

Covers black and hot-dipped galvanized electric-resistance welded Grade B pipe in NPS 2" - 26". Pipe is intended for mechanical and pressure applications and is acceptable for ordinary uses in steam, water, gas and air lines. Pipe is suitable for welding, threading, grooving.

Manufacture

The weld seam shall be heat treated after welding to a minimum of 1000˚ F or be otherwise processed in such a manner that no untempered martensite remains.

Hot-Dipped Galvanized

The average weight of zinc coating shall be not less than 1.8 oz. per sq. ft. of surface (inside and outside).

When galvanized pipe is bent or otherwise fabricated to a degree which causes zinc coating to stretch or compress beyond the limit of elasticity, some flaking of the coating may occur.

Hydrostatic and Nondestructive Testing

Hydrostatic inspection test pressures for plain-end pipe are listed in Table X2.2 of the A53 specification. Test pressures shall be maintained for a minimum of five seconds.

Nondestructive testing of the weld seam is required on each length of ERW pipe NPS 2" and larger.

Chemical Requirements

Composition, max. %

Carbon	Manganese	Phosphorus	Sulfur
.30	1.20	.05	.045

*Copper	*Nickel	*Chromium	*Molybdenum	*Vanadium
.40	.40	.40	.15	.08

*The combination of these five elements shall not exceed 1.00%.

Tensile Requirements

Tensile Strength, min.	60,000 psi
Yield Strength, min.	35,000 psi

Note: A transverse test is required on pipe NPS 8 and larger.

Flattening Test

As a test for quality of the weld for pipe 2" NPS and larger, position the weld at 0˚ to the direction of force and flatten until the OD is ⅔ of the original outside diameter. No cracks shall occur along the inside or outside surface of the weld.

Frequency of Tests

Tensile tests are required on one length of pipe each lot of 500 lengths or fraction thereof for each size. Refer to A53 specification for frequency of flattening tests.

Dimensions and Weights

The dimensions and weights furnished under this specification are in agreement with the standardized dimensions and weights specified in ASME B 36.10.

Permissible Variations in Wall Thickness

Minimum wall thickness at any point shall not be more than 12.5% under nominal wall thickness specified.

Standard (Sch.40) Black Plain End

Nominal Size	OD Inches	Wall	Weight Lbs./Ft.
2"	2.375	.154	3.66
2½"	2.875	.203	5.80
3"	3.500	.216	7.58
3½"	4.000	.226	9.12
4"	4.500	.237	10.80
5"	5.563	.258	14.63
6"	6.625	.280	18.99
8"	8.625	.322	28.58

Extra Strong (Sch.80) Black Plain End

Nominal Size	OD Inches	Wall	Weight Lbs./Ft.
2"	2.375	.218	5.03
2½"	2.875	.276	7.67
3"	3.500	.300	10.26
3½"	4.000	.318	12.52
4"	4.500	.337	15.00

*For additional sizes and wall see pages 23-40.

Permissible Variations in Outside Diameter

Pipe 2" NPS and larger shall not vary more than ± 1% from the standard specified.

Permissible Variations in Weight per Foot

Pipe shall not vary more than ± 10% from the standard specified.

Product Marking

Each length of pipe is continuously stenciled to show the manufacturer, the grade of pipe (ASTM A53), the kind of pipe (E for electric-resistance welded, B for Grade B), the size, XS for extra strong, and length.

API 5L API 5L Specifications 44th Edition

Scope
Covers WELDED and SEAMLESS pipe suitable for use in conveying gas, water, and oil in both the oil and natural gas industries.

Product Specification Level
This specification establishes requirements for two product specification levels (PSL 1 and PSL 2). These two PSL designations define different levels of standard technical requirements. PSL 2 has mandatory requirements for carbon equivalent, notch toughness, maximum yield strength, and maximum tensile strength. Requirements that apply to only PSL 1 or only PSL 2 are so designated. Requirements that are not designated to a specific PSL apply to both PSL 1 and PSL 2.

Grades and Dimensions
PSL 1 can be supplied in grades A25 - X70 and sizes ranging from 1/8" through 80".

PSL 2 can be supplied in grades B - X80 and sizes ranging from 4½" through 80".

Chemical Requirements
(See tables 4 & 5)

Hydrostatic Testing
(See 9.4 on page 12)

Test Pressures are held for not less than:
Seamless (all sizes) — 5 seconds
Welded (NPS 18" and smaller) — 5 seconds
(NPS 20" and larger) — 10 seconds

Tensile Requirements
Lists minimum yield and tensile strength for all grades as well as a maximum tensile strength for X80. Maximum yield-to-tensile ratios outlined for cold-expanded pipe may be waived when a fracture toughness requirement is specified.
(See tables 6 & 7)

Mechanical Test Specified
Tensile Test:
Buttweld: All sizes- Longitudinal specimens
Seamless and Electric Weld: Under 8 5/8"- Longitudinal
8 5/8" and Larger - Transverse

Bending Test: 9.5 API 44th Edition
No cracks shall occur in any portion of the test piece and no opening of the weld shall occur. ***(See page 12)***

Flattening Test:
Buttweld: NPS 2½" and larger.
Electric-Weld: All sizes. ***(See page 12)***

Fracture Toughness Tests
Charpy Impact tests
PSL 1- Not required
PSL 2-Required for pipe specified
wall thicknesses in the table below
(See Chart on page 11)

Abbreviated Terms

COWH	combination helical welding process for pipe during manufacturing
COWL	combination longitudinal welding process for pipe during manufacturing
CTOD	crack tip opening displacement
CVN	Charpy V-notch
CW	continuous welding process for pipe during manufacturing
DWT	drop-weight tear
EDI	electronic data interchange
EW	electronic resistance or electric induction welding process for pipe during manufacturing
HAZ	heat-affected zone
HBW	Brinell hardness
HFW	high-frequency electric welding process for pipe during manufacturing
HIC	hydrogen-induced cracking
HRC	Rockwell hardness, C scale
HV	Vickers hardness
IQI	image quality indicator
LFW	low-frequency electric welding process for pipe during manufacturing
LW	laser welding process for pipe during manufacturing
NDT	non-destructive testing
PSL	product specification level
SAWH	submerged-arc helical welding process for pipe during manufacture
SAWL	submerged-arc longitudinal welding process for pipe during manufacture
SSC	sulfide stress cracking
SWC	step-wise cracking
TFL	through the flowline
T2, T3	radiographic film classification
USC	United States customary

Pipe Grades, Steel Grades & Acceptable Delivery Conditions

Table 1

PSL	Delivery Condition	Pipe grade/steel grade [a,b]
PSL 1	As-rolled, normalizing rolled, normalized or normalizing formed	L175 or A25
		L175P or A25P
		L210 or A
	As-rolled, normalizing rolled, thermomechanical rolled, thermomechanical formed, normalizing formed, normalized, normalized and tempered; or, if agreed, quenched and tempered for SMLS pipe only	L245 or B
	As-rolled, normalizing rolled, thermomechanical rolled, thermomechanical formed, normalizing formed, normalized, normalized and tempered or quenched and tempered	L290 or X42
		L320 or X46
		L360 or X52
		L390 or X56
		L415 or X60
		L450 or X65
		L485 or X70
PSL 2	**As-Rolled** delivery condition without any special rolling and/or heat-treatment	L245R or BR
		L290R or X42R
	Normalizing rolled, normalizing formed, normalized or normalized and tempered *Formed:* pipe delivery condition resulting from the forming process in which the final deformation is carried out within a certain temperature range, leading to a material condition equivalent to that obtained after normalizing, such that the specified mechanical properties would still be met in the event of any subsequent normalizing. *Rolled:* pipe delivery condition resulting from the rolling process in which the final deformation is carried out within a certain temperature range, leading to a material condition equivalent to that obtained after normalizing, such that the specified mechanical properties would still be met in the event of any subsequent normalizing.	L245N or BN
		L290N or X42N
		L320N or X46N
		L360N or X52N
		L390N or X56N
		L415N or X60N
	Quenched and Tempered heat treatment consisting of quench hardening followed by tempering	L245Q or BQ
		L290Q or X42Q
		L320Q or X46Q
		L360Q or X52Q
		L390Q or X56Q
		L415Q or X60Q
		L450Q or X65Q
		L485Q or X70Q
		L555Q or X80Q
	Thermomechanical Rolled or Thermomechanical Formed *Rolled:* pipe delivery condition resulting from the hot-rolling process for strip or plate, in which the final deformation is carried out in a certain temperature range, leading to a material condition with certain properties that cannot be achieved or repeated by heat treatment alone, and such deformation is followed by cooling, possibly with increased cooling rates, with or without tempering, self-tempering included *Formed:* hot-forming process for pipe, in which the final deformation is carried out in a certain temperature range, leading to a material condition with certain properties that cannot be achieved or repeated by heat treatment alone, and such deformation is followed by cooling, possibly with increased cooling rates, with or without tempering, self-tempering included	L245M or BM
		L290M or X42M
		L320M or X46M
		L360M or X52M
		L390M or X56M
		L415M or X60M
		L450M or X65M
		L485M or X70M
		L555M or X80M
	Thermomechanical Rolled	L625M or X90M
		L690M or X100M
		L830M or X120M

[a] For intermediate grades, the steel grades shall be as agreed, but consistent with the above format.

[b] The suffix (R, N, Q or M) for PSL 2 grades belongs to the steel grade.

Chemical Composition for PSL 1 Pipe with $t \leq 25.0$ mm (0.984")

Table 4

Steel grade (Steel name)	Mass fraction, based upon heat and product analyses[a] %							
	C max.[b]	Mn max.[b]	P min.	P max.	S max.	V max.	Nb max.	Ti max.
Seamless pipe								
L175 or A25	0.21	0.60	—	0.030	0.030	—	—	—
L175P or A25P	0.21	0.60	0.045	0.080	0.030	—	—	—
L210 or A	0.22	0.90	—	0.030	0.030	—	—	—
L245 or B	0.28	1.20	—	0.030	0.030	c,d	c,d	d
L290 or X42	0.28	1.30	—	0.030	0.030	d	d	d
L320 or X46	0.28	1.40	—	0.030	0.030	d	d	d
L360 or X52	0.28	1.40	—	0.030	0.030	d	d	d
L390 or X56	0.28	1.40	—	0.030	0.030	d	d	d
L415 or X60	0.28[e]	1.40[e]	—	0.030	0.030	f	f	f
L450 or X65	0.28[e]	1.40[e]	—	0.030	0.030	f	f	f
L485 or X70	0.28[e]	1.40[e]	—	0.030	0.030	f	f	f
Welded pipe								
L175 or A25	0.21	0.60	—	0.030	0.030	—	—	—
L175P or A25P	0.21	0.60	0.045	0.080	0.030	—	—	—
L210 or A	0.22	0.90	—	0.030	0.030	—	—	—
L245 or B	0.26	1.20	—	0.030	0.030	c,d	c,d	d
L290 or X42	0.26	1.30	—	0.030	0.030	d	d	d
L320 or X46	0.26	1.40	—	0.030	0.030	d	d	d
L360 or X52	0.26	1.40	—	0.030	0.030	d	d	d
L390 or X56	0.26	1.40	—	0.030	0.030	d	d	d
L415 or X60	0.26[e]	1.40[e]	—	0.030	0.030	f	f	f
L450 or X65	0.26[e]	1.45[e]	—	0.030	0.030	f	f	f
L485 or X70	0.26[e]	1.65[e]	—	0.030	0.030	f	f	f

[a] 0.50% maximum for copper; 0.50 maximum for nickel; 0.50% maximum for chromium; and 0.15% maximum for molybdenum. For grades up to and including L360/X52, Cu, Cr and Ni shall not be added intentionally.

[b] For each reduction of 0.01% below the specified maximum concentration for carbon, an increase of 0.05% above the specified maximum concentration for manganese is permissible, up to maximum of 1.65% for grades ≥ L245 or B, but ≤ L360 or X52; up to a maximum of 1.75% for grades > L360 or X52, but < L485 or X70; and up to a maximum of 2.00% for grade L485 or X70.

[c] Unless otherwise agreed, the sum of the niobium and vanadium contents shall be ≤ 0.06%.

[d] The sum of the niobium, vanadium and titanium concentrations shall be ≤ 0.15%.

[e] Unless otherwise agreed.

[f] Unless otherwise agreed, the sum of the niobium and titanium concentrations shall be ≤ 0.15%.

Chemical Composition for PSL 2 Pipe with $t \leq 25.0$ mm (0.984")

Table 5

Steel grade (Steel name)	Mass fraction, based upon heat and product analyses % maximum									Carbon equivalent[a] % maximum	
	C[b]	Si	Mn[b]	P	S	V	Nb	Ti	Other	CE_{IIW}	CE_{Pcm}
Seamless pipe and welded pipes											
L245R or BR	0.24	0.40	1.20	0.025	0.015	[c]	[c]	0.04	[e]	0.43	0.25
L290R or X42R	0.24	0.40	1.20	0.025	0.015	0.06	0.05	0.04	[e]	0.43	0.25
L245N or BN	0.24	0.40	1.20	0.025	0.015	[c]	[c]	0.04	[e]	0.43	0.25
L290N or X42N	0.24	0.40	1.20	0.025	0.015	0.06	0.05	0.04	[e]	0.43	0.25
L320N or X46N	0.24	0.40	1.40	0.025	0.015	0.07	0.05	0.04	[d,e]	0.43	0.25
L360N or X52N	0.24	0.45	1.40	0.025	0.015	0.10	0.05	0.04	[d,e]	0.43	0.25
L390N or X56N	0.24	0.45	1.40	0.025	0.015	0.10[f]	0.05	0.04	[d,e]	0.43	0.25
L415N or X60N	0.24[f]	0.45[f]	1.40[f]	0.025	0.015	0.10[f]	0.05[f]	0.04[f]	[g,h]	as agreed	
L245Q or BQ	0.18	0.45	1.40	0.025	0.015	0.05	0.05	0.04	[e]	0.43	0.25
L290Q or X42Q	0.18	0.45	1.40	0.025	0.015	0.05	0.05	0.04	[e]	0.43	0.25
L320Q or X46Q	0.18	0.45	1.40	0.025	0.015	0.05	0.05	0.04	[e]	0.43	0.25
L360Q or X52Q	0.18	0.45	1.50	0.025	0.015	0.05	0.05	0.04	[e]	0.43	0.25
L390Q or X56Q	0.18	0.45	1.50	0.025	0.015	0.07	0.05	0.04	[d,e]	0.43	0.25
L415Q or X60Q	0.18[f]	0.45[f]	1.70[f]	0.025	0.015	[g]	[g]	[g]	[h]	0.43	0.25
L450Q or X65Q	0.18[f]	0.45[f]	1.70[f]	0.025	0.015	[g]	[g]	[g]	[h]	0.43	0.25
L485Q or L70Q	0.18[f]	0.45[f]	1.80[f]	0.025	0.015	[g]	[g]	[g]	[h]	0.43	0.25
L555Q or X80Q	0.18[f]	0.45[f]	1.90[f]	0.025	0.015	[g]	[g]	[g]	[i,j]	as agreed	
Welded pipe											
L245M or BM	0.22	0.45	1.20	0.025	0.015	0.05	0.05	0.04	[e]	0.43	0.25
L290M or X42M	0.22	0.45	1.30	0.025	0.015	0.05	0.05	0.04	[e]	0.43	0.25
L320M or X46M	0.22	0.45	1.30	0.025	0.015	0.05	0.05	0.04	[e]	0.43	0.25
L360M or X52M	0.22	0.45	1.40	0.025	0.015	[d]	[d]	[d]	[e]	0.43	0.25
L390M or X56M	0.22	0.45	1.40	0.025	0.015	[d]	[d]	[d]	[e]	0.43	0.25
L415M or X60M	0.12[f]	0.45[f]	1.60[f]	0.025	0.015	[g]	[g]	[g]	[h]	0.43	0.25
L450M or X65M	0.12[f]	0.45[f]	1.60[f]	0.025	0.015	[g]	[g]	[g]	[h]	0.43	0.25
L485M or X70M	0.12[f]	0.45[f]	1.70[f]	0.025	0.015	[g]	[g]	[g]	[h]	0.43	0.25
L555M or X80M	0.12[f]	0.45[f]	1.85[f]	0.025	0.015	[g]	[g]	[g]	[i]	0.43[f]	0.25
L625M or X90M	0.10	0.55[f]	2.10[f]	0.020	0.010	[g]	[g]	[g]	[i]	—	0.25
L690M or X100M	0.10	0.55[f]	2.10[f]	0.020	0.010	[g]	[g]	[g]	[i,j]	—	0.25
L830M or X120M	0.10	0.55[f]	2.10[f]	0.020	0.010	[g]	[g]	[g]	[i,j]	—	0.25

[a] Based upon product analysis. For seamless pipe with $t > 20.0$ mm (0.787 in), the carbon equivalent limits shall be as agreed. The CE_{IIW} limits apply if the carbon mass fraction is greater that 0.12% and the CE_{Pcm} limits apply if the carbon mass fraction is less than or equal to 0.12%.

[b] For each reduction of 0.01% below the specified maximum for carbon, an increase of 0.05% above the specified maximum for manganese is permissible, up to a maximum of 1.65% for grades ≥ L245 or B but ≤ L360 or X52; up to maximum of 1.75% for grades > L360 or X52 < L485 or X70; up to a maximum of 2.00% for grades ≥ L485 or X70, but ≤ L555 or X80; and up to a maximum of 2.20% for grades > L555 or X80.

[c] Unless otherwise agreed, the sum of the niobium and vanadium concentrations shall be ≤ 0.06%.

[d] The sum of the niobium, vanadium and titanium concentrations shall be ≤ 0.15%.

[e] Unless otherwise agreed, 0.50% maximum for copper, 0.30% maximum for nickel, 0.30% maximum for chromium and 0.15% maximum for molybdenum.

[f] Unless otherwise agreed.

[g] Unless otherwise agreed, the sum of the niobium, vanadium and titanium concentrations shall be ≤ 0.15%.

[h] Unless otherwise agreed, 0.50% maximum for copper, 0.50% maximum for nickel, 0.50% maximum for chromium and 0.50% maximum for molybdenum.

[i] Unless otherwise agreed, 0.50% maximum for copper, 1.00% maximum for nickel, 0.50% maximum for chromium and 0.50% maximum for molybdenum.

[j] 0.004% maximum for boron.

Requirements for the Results of Tensile Tests for PSL 1 Pipe

Table 6

Pipe grade	Pipe body of seamless and welded pipes			Weld seam of EW, SAW and COW pipes
	Yield strength[a] $R_{t\,0,5}$ MPa (psi) minimum	Tensile strength[a] R_m MPa (psi) minimum	Elongation A_f % minimum	Tensile strength[b] R_m MPa (psi) minimum
L175 or A25	175 (25,400)	310 (45,000)	[c]	310 (45,000)
L175P or A25P	175 (25,400)	310 (45,000)	[c]	310 (45,000)
L210 or A	210 (30,500)	335 (48,600)	[c]	335 (48,600)
L245 or B	245 (35,500)	415 (60,200)	[c]	415 (60,200)
L290 or X42	290 (42,100)	415 (60,200)	[c]	415 (60,200)
L320 or X46	320 (46,400)	435 (63,100)	[c]	435 (63,100)
L360 or X52	360 (52,200)	460 (66,700)	[c]	460 (66,700)
L390 or X56	390 (56,600)	490 (71,100)	[c]	490 (71,100)
L415 x X60	415 (60,200)	520 (75,400)	[c]	520 (75,400)
L450 or x65	450 (65,300)	535 (77,600)	[c]	535 (77,600)
L485 or X70	485 (70,300)	570 (82,700)	[c]	570 (82,700)

[a] For intermediate grades, the difference between the specified minimum tensile strength and the specified minimum yield strength for the pipe body shall be given in the table for the next higher grade.

[b] For intermediate grades, the specified minimum tensile strength for the weld seam shall be the same value as was determined for the pipe body using footnote a).

[c] The specified minimum elongation, A_f, expressed in percent and rounded to the nearest percent, shall be as determined using the following equation:

$$A_f = C \frac{A_{xc}^{0.2}}{U^{0.9}}$$

where

C is 1,940 for calculations using SI units and 625,000 for calculations using USC units;

A_{XC} is the applicable tensile test piece cross-sectional area, expressed in square millimetres (square inches), as follows:

- for circular cross-section test pieces, 130 mm² (0.20 in²) for 12.5 mm (0.500 in) and 8.9 mm (0.350 in) diameter test pieces; and 65 mm² (0.10 in²) for 6.4 mm (0.250 in) diameter test pieces;
- for full-section test pieces, the lesser of a) 485 mm² (0.75 in²) and b) the cross-sectional area of the test piece, derived using the specified outside diameter and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in²);
- for strip test pieces, the lesser of a) 485 mm² (0.75 in²) and b) the cross-sectional area of the test price, derived using the specified width of the test piece and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in²);

U is the specified minimum tensile strength, expressed in megapascals (pounds per square inch).

Requirements for the results of tensile tests for PSL 2 pipe

Table 7

Pipe grade	Pipe body of seamless and welded pipes						Weld seam of HFW, SAW and COW pipes
	Yield strength[a] $R_{t\,0,5}$[b] MPa (psi)		Tensile strength[a] R_m MPa (psi)		Ratio[a, b, c] $R_{t0,5}/R_m$	Elongation A_f %	Tensile strength[d] R_m MPa (psi)
	minimum	maximum	minimum	maximum	maximum	minimum	minimum
L245R or BR L245N or BN L245Q or BQ L245M or BM	245 (35,500)	450[e] (65,300)[e]	415 (60,200)	760 (110,200)	0.93	[f]	415 (60,200)
L290R or X42R L290N or X42N L290Q or X42Q L290M or X42M	290 (42,100)	495 (71,800)	415 (60,200)	760 (110,200)	0.93	[f]	415 (60,200)
L320N or X46N L320Q or X46Q L320M or X46M	320 (46,400)	525 (76,100)	435 (63,100)	760 (110,200)	0.93	[f]	435 (63,100)
L360N or X52N L360Q or X52Q L360M or X52M	360 (52,200)	530 (76,900)	460 (66,700)	760 (110,200)	0.93	[f]	460 (66,100)
L390N or X56N L390Q or X56Q L390M or X56M	390 (56,600)	545 (79,000)	490 (71,100)	760 (110,200)	0.93	[f]	490 (71,100)
L415N or X60N L415Q or X60Q L415M or X60M	415 (60,200)	565 (81,900)	520 (75,400)	760 (110,200)	0.93	[f]	520 (75,400)
L450Q or X65Q L450M or X65M	450 (65,300)	600 (87,000)	535 (77,600)	760 (110,200)	0.93	[f]	535 (77,600)
L485Q or X70Q L485M or X70M	485 (70,300)	635 (92,100)	570 (82,700)	760 (110,200)	0.93	[f]	570 (82,700)
L555Q or X80Q L555M or X80M	555 (80,500)	705 (102,300)	625 (90,600)	825 (119,700)	0.93	[f]	625 (90,600)
L625M or X90M	625 (90,600)	775 (112,400)	695 (100,800)	915 (132,700)	0.95	[f]	695 (100,800)
L690M or X100M	690 (100,100)	840 (121,800)	760 (110,200)	990 (143,600)	0.97[g]	[f]	760 (110,200)
L830M or X120M	830 (120,400)	1 050 (152,300)	915 (132,700)	1 145 (166,100)	0.99[g]	[f]	915 (132,700)

[a] For intermediate grades, the difference between the specified maximum yield strength and the specified minimum yield strength shall be as given in the table for the next higher grade, and the difference between the specified minimum tensile strength and the specified minimum yield strength shall be as given in the table for the next higher grade. For intermediate grades lower than Grade L555 or X80, the tensile strength shall be ≤ 760 MPa (110,200 psi). For intermediate grades higher than Grade L555 or X80, the maximum permissible tensile strength shall be obtained by interpolation. For SI units, the calculated value shall be rounded to the nearest 5 MPa. For USC units, the calculated value shall be rounded to the nearest 100 psi.

[b] For grades > L625 or X90, $R_{p0.2}$ applies.

[c] This limit applies for pipe with D > 323.9 mm (12.750 in).

[d] For intermediate grades, the specified minimum tensile strength for the weld seam shall be the same value as was determined for pipe body using footnote a).

[e] For pipe with D < 219.1 mm (8.625 in), the maximum yield strength shall be ≤ 495 MPa (71,800 psi).

[f] The specified minimum elongation, A_f, shall be as determined using the following equation:

$$A_f = C \frac{A_{xc}^{0.2}}{U^{0.9}}$$

where

C is 1,940 for calculations using SI units and 625,000 for calculations using USC units;

A_{xc} is the applicable tensile test piece cross-sectional area, expressed in square millimetres (square inches), as follows:
- for circular cross-section test pieces, 130 mm² (0.20 in²) for 12.5 mm (0.500 in) and 8.9 mm (0.350 in) diameter test pieces; and 65 mm² (0.10 in²) for 6.4 mm (0.250 in) diameter test pieces;
- for full-section test pieces, the lesser of a) 485 mm² (0.75 in²) and b) the cross-sectional area of the test piece, derived using the specified outside diameter and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in²);
- for strip test pieces, the lesser of a) 485 mm² (0.75 in²) and b) the cross-sectional area of the test price, derived using the specified width of the test piece and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in²);

U is the specified minimum tensile strength, expressed in megapascals (pounds per square inch).

[g] Lower $R_{t0,5}/R_m$ ratio values may be specified by agreement for L690 or X100 and L830 or X120 pipe.

CVN absorbed energy requirements for pipe body of PSL 2 pipe

Table 8

Specified outside diameter D mm (in)	Full-size CVN absorbed energy, minimum K_V J (ft·lbf)						
	Grade						
	≤ L415 or X60	> L415 or X60 ≤ L450 or X65	> L450 or X65 ≤ L485 or X70	> L485 or X70 ≤ L555 or X80	> L555 or X80 ≤ L625 or X90	> L625 or X90 ≤ L690 or X100	L690 or X100 ≤ L830 or X120
≤ 508 (20.000)	27 (20)	27 (20)	27 (20)	40 (30)	40 (30)	40 (30)	40 (30)
> 508 (20.000) to ≤ 762 (30.000)	27 (20)	27 (20)	27 (20)	40 (30)	40 (30)	40 (30)	40 (30)
> 762 (30.000) to ≤ 914 (36.000)	40 (30)	40 (30)	40 (30)	40 (30)	40 (30)	54 (40)	54 (40)
> 914 (36.000) to ≤ 1,219 (48.000)	40 (30)	40 (30)	40 (30)	40 (30)	40 (30)	54 (40)	68 (50)
> 1,219 (48.000) to ≤ 1,422 (56.000)	40 (30)	54 (40)	54 (40)	54 (40)	54 (40)	68 (50)	81 (60)
> 1,422 (56.000) to ≤ 2,134 (84.000)	40 (30)	54 (40)	68 (50)	68 (50)	81 (60)	95 (70)	108 (80)

Tolerances for Diameter and Out-of-Roundness

Table 10

Specified outside diameter D mm (in)	Diameter tolerances mm (in)				Out-of-roundness tolerances mm (in)	
	Pipe except the end [a]		Pipe end [a, b c]		Pipe except the end [a]	Pipe end [a, b, c]
	SMLS pipe	Welded pipe	SMLS pipe	Welded pipe		
< 60.3 (2.375)	– 0.8 (0.031) to + 0.4 (0.016)		– 0.4 (0.016) to + 1.6 (0.063)		[d]	
≥ 60.3 (2.375) to ≤ 168.3 (6.625)	± 0.007 5 D				0.020 D	0.015 D
> 168.3 (6.625) to ≤ 610 (24.000)	± 0.007 5 D	± 0.007 5 D but maximum of ± 3.2 (0.125)	± 0,0005 D, but maximum of ± 1.6 (0.063)			
> 610 (24.000) to ≤ 1,422 (56.000)	± 0.001 D	± 0.005 D, but maximum of ± 4.0 (0.160)	± 2.0 (0.079)	± 1.6 (0.063)	0.015 D, but maximum of 15 (0.6), for $\frac{D}{t}$ ≤75 by agreement for $\frac{D}{t}$ ≤75	0.01 D, but maximum of 13 (0.5), for $\frac{D}{t}$ ≤75 by agreement for $\frac{D}{t}$ ≤75
> 1,422 (56.000)			as agreed			

[a] The pipe end includes a length of 100 mm (4.0 in) at each of the pipe extremities.
[b] For SMLS pipe, the tolerances apply for t ≤ 25.0 mm (0.984 in), and the tolerances for thicker pipe shall be as agreed.
[c] For expanded pipe with D ≥ 219.1 mm (8.625 in), and for non-expanded pipe, the diameter tolerance and the out-of-roundness tolerance may be determined using the calculated inside diameter (the specified outside diameter minus two times the specified wall thickness) or measured inside diameter rather than the specified outside diameter. (See 10.2.8.3.)
[d] Included in the diameter tolerance.

9.4 Hydrostatic test

9.4.1 Except as allowed by 9.4.2, the pipe shall withstand the hydrostatic test without leakage through the weld seam or the pipe body.

9.4.2 Jointers need not be hydrostatically tested, provided that the portions of pipe used in making the jointers were successfully hydrostatically tested prior to the joining operation.

9.5 Bend test

No cracks shall occur in any portion of the test piece and no opening of the weld shall occur.

NOTE For all bend tests, the weld extends to a distance of 6.4 mm (0.25 in) on each side of the fusion line.

9.6 Flattening test

Acceptance criteria for flattening tests shall be as follows:

a) EW pipe grades ≥ L210 or A and LW pipe with D < 323.9 mm (12.750 in):

   1) For grades ≥ L415 or X60 with t ≥ 12.7 mm (0.500 in), there shall be no opening of the weld before the distance between the plates is less than 66% of the original outside diameter. For all other combinations of pipe grade and specified wall thickness, there shall be no opening of the weld before the distance between the plates is less than 50% of the original outside diameter.

b) EW and CW pipes in Grade L175, L175P, A25 or A25P:

   1) There shall be no opening of the weld before the distance between the plates is less than 75% of the original outside diameter.

   2) There shall be no cracks or breaks other than in the weld before the distance between the plates is less than 60% of the original outside diameter.

NOTE 1 The weld extends to a distance, on each side of the weld line, of 6.4 mm (0.25 in) for D < 60.3 mm (2.375 in) and 13 mm (0.5 in) for D ≥ 60.3 mm (2.375 in).

NOTE 2 For EW pipe that is processed through a hot-stretch mill and is flattened prior to such treatment, the original outside diameter is as designated by the manufacturer; for all other cases, the original outside diameter is the specified outside diameter.

9.7 Guided-bend test

9.7.1 Except as allowed by 9.7.2, the test pieces shall not

a) fracture completely,

b) reveal any cracks or ruptures in the weld metal longer than 3.2 mm (0.125 in), regardless of depth, or

c) reveal any cracks or ruptures in the parent metal, HAZ or fusion line longer than 3.2 mm (0.125 in) or deeper than 12.5% of the specified wall thickness.

9.7.2 Cracks that occur at the edges of the test piece during testing shall not be cause for rejection, provided that they are not longer than 6.4 mm (0.250 in).

9.8 CVN impact test for PSL 2 pipe

9.8.1 General

9.8.1.1 If subsize test pieces are used, the required minimum average (set of three test pieces) absorbed energy values shall be the required values for full-size test pieces times the ratio of the specified width of the subsize test piece to the specified width of the full-size test piece, with such derived values rounded to the nearest joule (foot-pound force).

9.8.1.2 Individual test values for any test piece shall be ≥ 75% of the required minimum average (of a set of three test pieces) absorbed energy values.

9.8.1.3 Tests conducted at temperatures lower than the specified test temperature shall be acceptable if the applicable requirements for energy absorption and shear fracture area are met at such lower temperatures.

9.8.2 Pipe body tests

9.8.2.1 The minimum average (of a set of three test pieces) absorbed energy for each pipe body test shall be as given in Table 8, based upon full-size test pieces and a test temperature of 0° C (32° F) or, if agreed, a lower test temperature.

NOTE The energy values specified in Table 8 provide sufficient fracture-initiation resistance for most pipeline designs.

9.8.2.2 For welded pipe with D ≤ 508 mm (20.000 in), if agreed, the minimum average (set of three test pieces) shear fracture area for each test shall be at least 85%, based upon a test temperature of 0° C (32° F) or, if agreed, a lower test temperature.

NOTE This percentage of shear fracture area ensures sufficiently ductile fracture at or above the test temperature.

9.8.2.3 If 9.8.2.2 does not apply for the order item, for welded pipe with D ≤ 508 mm (20.000 in), the shear fracture area should be estimated and reported for information purposes, unless otherwise agreed.

Tolerances for Wall Thickness

Table 11

Wall thickness t mm (in)	Tolerances [a] mm (in)
SMLS pipe [b]	
≤ 4.0 (0.157)	+ 0.6 (0.024) – 0.5 (0.020)
> 4.0 (0.157) to < 25.0 (0.984)	+ 0.150 t – 0.125 t
≥ 25.0 (0.984)	+ 3.7 (0.146) or + 0.1 t, whichever is the greater – 3.0 (0.120) or – 0.1 t, whichever is the greater
Welded pipe [c, d]	
≤ 5.0 (0.197)	± 0.5 (0.020)
> 5.0 (0.197) to < 15.0 (0.591)	± 0.1 t
≥ 15.0 (0.591)	± 1.5 (0.060)

[a] If the purchase order specifies a minus tolerance for wall thickness smaller than the applicable value given in this table, the plus tolerance for wall thickness shall be increased by an amount sufficient to maintain the applicable tolerance range.

[b] For pipe with D ≥ 355.6 mm (14.000 in) and t ≥ 25.0 mm (0.984 in), the wall-thickness tolerance locally may exceed the plus tolerance for wall thickness by an additional 0.05 t, provided that the plus tolerance for mas (see 9.14) is not exceeded.

[c] The plus tolerance for wall thickness does not apply to the weld area.

[d] See 9.13.2 for additional restrictions.

Tolerances for Random Length Pipe

Table 12

Random length designation m (ft)	Minimum length m (ft)	Minimum average length for each order item m (ft)	Maximum length m (ft)
Threaded-and-coupled pipe			
6 (20)	4.88 (16.0)	5.33 (17.5)	6.86 (22.5)
9 (30)	4.11 (13.5)	8.00 (26.2)	10.29 (33.8)
12 (40)	6.71 (22.0)	10.67 (35.0)	13.72 (45.0)
Plain-end pipe			
6 (20)	2.74 (9.0)	5.33 (17.5)	6.86 (22.5)
9 (30)	4.11 (13.5)	8.00 (26.2)	10.29 (33.8)
12 (40)	4.27 (14.0)	10.67 (35.0)	13.72 (45.0)
15 (50)	5.33 (17.5)	13.35 (43.8)	16.76 (55.0)
16 (60)	6.40 (21.0)	16.00 (52.5)	19.81 (65.0)
24 (80)	8.53 (28.0)	21.34 (70.0)	25.91 (85.0)

Inspection Frequency for PSL 1 Pipe

Table 17

Type of Inspection	Type of pipe	Frequency of inspection
Heat analysis	All pipe	One analysis per heat of steel
Product analysis	SMLS, CW, LFW, HFW, LW, SAWL, SAWH, COWL or COWH	Two analyses per heat of steel (taken from separate product items)
Tensile testing of the pipe body of welded pipe with $D \leq 48.3$ mm (1.900 in), in Grade L175 or A25	CW, LFW or HFW	Once per test unit[e] of not more than 25 tonnes (28 tons) of pipe
Tensile testing of the pipe body of welded pipe with $D \leq 48.3$ mm (1.900 in), in Grade L175P or A25P	CW	
Tensile testing of the pipe body of welded pipe with $D > 48.3$ mm (1.900 in), in Grade L175 or A25	CW, LFW or HFW	Once per test unit of not more than 50 tonnes (55 tons) of pipe
Tensile testing of the pipe body of welded pipe with $D > 48.3$ mm (1.900 in), in Grade L175P or A25P	CW	
Tensile testing of the pipe body of seamless pipe	SMLS	Once per test unit of pipe with the same cold-expansion ratio [a]
Tensile testing of the pipe body of welded pipe in grades higher than Grade L175 or A25	LFW, HFW, LW, SAWL, SAWH, COWL, or COWH	
Tensile testing of the longitudinal or helical seam weld of welded pipe with $D \geq 219.1$ mm (8.625 in)	LFW, HFW, LW, SAWL, SAWH COWL or COWH	Once per test unit of pipe with the same cold-expansion ratio [a, b, c]
Tensile testing of the strip/plate end weld of welded pipe with $D \geq 219.1$ mm (8.625 in)	SAWH or COWH	Once per test unit or not more than 100 lengths of pipe with the same cold-expansion ratio [a, c, d]
Bend testing of the longitudinal seam weld of welded pipe with $D \geq 48.3$ mm (1.900 in), in Grade L175, L175P, A25 or A25P	CW, LFW, HFW or LW	Once per test unit of not more than 25 tonnes (28 tons) of pipe
Bend testing of the longitudinal seam weld of welded pipe with 48,3 mm (1.900 in) $< D \leq 60.3$ mm (2.375 in), in Grade L175, L175P, A25 or A25P	CW, LFW, HFW or LW	Once per test unit of not more than 50 tonnes (55 tons) of pipe
Guided-bend testing of the longitudinal or helical-seam weld of welded pipe	SAWL, SAWH, COWL or COWH	Once per test unit of not more than 50 lengths of pipe of the same grade
Guided-bend testing of the strip/plate end weld of welded pipe	SAWH or COWH	Once per test unit of not more than 50 lengths of pipe of the same grade[d]
Guided-bend testing of the longitudinal seam weld of welded pipe with $D \geq 323.9$ mm (12.750 in)	LW	Once per test unit of not more than 50 lengths of pipe of the same grade
Flattening test of welded pipe	CW, LFW, HFW or LW	As shown in Figure 6
Hardness testing of hard spots in cold-formed welded pipe	LFW, HFW, LW, SAWL, SAWH, COWL or COWH	Any hard spot exceeding 50 mm (2.0 in) in any direction
Hydrostatic testing	SMLS, CW, LFW, LW, SAWL, SAWH, COWL or COWH	Each pipe
Macrographic testing of the longitudinal or helical-seam weld of welded pipe	SAWL, SAWH, COWL or COWH	At least once per operating shift plus whenever any change of pipe size occurs during the operating shift; or, if 10.2.5.3 applies, at the beginning of the production of each combination of specified outside diameter and specified wall thickness
Metallographic testing of the longitudinal seam weld of welded pipe	LFW or HFW	At least once per operating shift plus whenever changes of grade, specified outside diameter or specified wall thickness are made; plus whenever significant excursions from operating heat treatment conditions are encountered
Visual inspection	SMLS, CW, LFW, HFW, LW, SAWL, SAWH, COWL or COWH	Each pipe, except as allowed by 10.2.7.2
Pipe diameter and out-of-roundness	SMLS, CW, LFW, HFW, LW, SAWL, SAWH, COWL or COWH	At least once per 4 h per operating shift plus whenever any change of pipe size occurs during the operating shift

Continued on next page...

Inspection Frequency for PSL 1 Pipe

Table 17 Cont...

Type of Inspection	Type of pipe	Frequency of inspection
Wall thickness measurement	All pipes	Each pipe (see 10.2.8.5)
Weighing of pipe with D < 141.3 mm (5.563 in)	SMLS, CW, LFW, HFW, LW, SAWL, SAWH, COWL, or COWH	Each pipe or each convenient group of pipes, with the choice being at the discretion of the manufacturer
Weighing of pipe with D ≥ 141.3 mm (5.563 in)	SMLS, CW, LFW, HFW, LW, SAWL, SAWH, COWL or COWH	Each pipe
Non-destructive inspection	SMLS, CW, LFW, HFW, LW, SAWL, SAWH, COWL or COWH	In accordance with Annex E

[a] The cold-expansion ratio is designed by the manufacturer, and is derived using the designated before-expansion outside diameter or circumference and the after-expansion outside diameter or circumference. An increase or decrease in the cold-expansion ratio of more than 0.002 requires the creation of a new test unit.

[b] For double-seam pipe, both longitudinal weld seams in the pipe selected to represent the test unit shall be tested.

[c] In addition, for each welding machine, at least one pipe per week shall be tested.

[d] Applies only to finished helical-seam pipe containing strip/plate and welds.

[e] "Test unit" is as defined in 4.49.

Inspection Frequency for PSL 2 Pipe

Table 18

Type of Inspection	Type of pipe	Frequency of inspection
Heat analysis	All pipe	One analysis per heat of steel
Product analysis	SMLS, HFW, SAWL, SAWH, COWL or COWH	Two analyses per heat of steel (taken from separate product items)
Tensile testing of the pipe body	SMLW, HFW, SAWL, SAWH, COWL or COWH	Once per test unit[e] of pipe with the same cold-expansion ratio [a]
Tensile testing of the longitudinal or helical seam weld of welded pipe with $D \geq 219.1$ mm (8.625 in)	HFW, SAWL, SAWH, COWL or COWH	Once per test unit of pipe with the same cold-expansion ratio [a,b,c]
Tensile testing of the strip/plate end weld of weled pipe with D ≥ 219.1 mm (8.625 in)	SAWH or COWH	Once per test unit of not more than 100 lengths of pipe with the same cold-expansion ratio [a,b,d]
CVN impact testing of the pipe body of pipe with specified outside diameter and specified wall thickness as given in Table 22	SMLS, HFW, SAWL, SAWH, COWL or COWH	Once per test unit of pipe with the same cold-expansion ratio [a]
If agreed, CVN impact testing of the longitudinal seam weld of welded pipe with specified outside diameter and specified wall thickness as given in Table 22	HFW	Once per test unit of pipe with the same cold-expansion ratio [a,b]
CVN impact testing of the longitudinal or helical seam weld or welded pipe with specified outside diameter and specified wall thickness as given in Table 22	SAWL, SAWH, COWL or COWH	Once per test unit of pipe with the same cold-expansion ratio [a,b,c]
CVN impact testing of the strip/plate end weld of welded pipe with specified outside diameter and specified wall thickness as given in Table 22	SAWH or COWH	Once per test unit nor more than 10 lengths of pipe with the same cold-expansion ratio [a,b,d]
if agreed, DWT testing of the pipe body of welded pipe with $D \geq 508$ mm (20.000 in)	HFW, SAWL, SAWH, COWL or COWH	Once per test unit of pipe with the same cold-expansion ratio [a]
Guided-bend testing of the longitudinal or helical seam weld of welded pipe	SAWL, SAWH, COWL or COWH	Once per test unit of not more than 50 lengths of pipe with the same cold-expansion ratio [a]
Guided-bend testing of the strip/plate end weld of welded pipe	SAWH or COWH	Once per test unit of not more than 50 lengths of pipe with the same cold-expansion ratio [a.b.d]
Flattening test of welded pipe	HFW	As shown in Figure 6
Hardness testing of hard spots in cold-formed welded pipe	HFW, SAWL, SAWH, COWL or COWH	Any hard spot exceeding 50 mm (2.0 in) in any direction
Hydrostatic testing	SMLS, HFW, SAWL, SAWH, COWL or COWH	Each pipe
Macrographic testing of the longitudinal or helical seam weld of welded pipe	SAWL, SAWH, COWL or COWH	At least once per operating shift plus whenever any change of pipe size occurs during the operating shift; or, if 10.2.5.3 applies, at the beginning of the production of each combination of specified outside diameter and specified wall thickness
Metallographic testing (or optional hardness test in lieu of metallography) of the longitudinal seam weld of welded pipe	HFW	At least once per operating shift plus whenever changes of grade, specified outside diameter or specified wall thickness are made; plus whenever significant excursions from operating heat treatment conditions are encountered
Visual inspection	SMLS, HFW, SAWL, SAWH, COWL or COWH	Each pipe, except at allowed by 10.2.7.2
Pipe diameter and out-of-roundness	SMLS, HFW, SAWL, SAWH, COWL or COWH	At least once per 4 h per operating shift plus whenever any change of pipe size occurs during the operating shift
Wall thickness measurement	All pipes	Each pipe (see 10.2.8.5)

Continued on next page...

Inspection Frequency for PSL 2 Pipe

Table 18 Cont...

Type of Inspection	Type of pipe	Frequency of inspection
Other dimensional testing	SMLS, HFW, SAWL, SAWH, COWL or COWH	Random testing, with the details left to the discretion of the manufacturer
Weighing of pipe with D < 141.3 mm (5.563 in)	SMLS, HFW, SAWL, SWH, COWL or COWH	Each pipe or each convenient group of pipes, with the choice being at the discretion of the manufacturer
Weighing of pipe with D ≥ 141.3 mm (5.563 in)	SMLS, HFW, SAWL, SAWH, COWL or COWH	Each pipe
Non-destructive inspection	SMLS, HFW, SAWL, SAWH, COWL or COWH	In accordance with Annex E

[a] The cold-expansion ratio is designed by the manufacturer, and is derived using the designed before-expansion outside diameter or circumference and the after-expansion outside diameter or circumference. An increase or decrease in the cold-expansion ratio of more than 0,002 requires the creation of a new test unit.

[b] In addition, pipe produced by each welding machine shall be tested at least once per week.

[c] For double-seam pipe, both longitudinal weld seams in the pipe selected to represent the test unit shall be tested.

[d] Applies only to finished helical seam pipe containing strip/plate end welds.

[e] "Test unit" is as defined in 4.49.

ASTM A106 Type S Grade B Pipe

Scope

Covers SEAMLESS carbon steel nominal wall pipe for high-temperature service, suitable for bending, flanging and similar forming operations.

Manufacture

Sizes 1½" and under may be either hot finished or cold drawn. Sizes 2" and larger shall be hot finished unless otherwise specified.

Hydrostatic and Nondestructive

Inspection test pressures produce a stress in the pipe wall equal to 60% of minimum specified Yield Point at room temperature. Maximum Pressures are not to exceed 2500 psi for sizes 3" and under, and 2800 psi for the larger sizes. Pressure is maintained for not less than 5 seconds.

Tensile Requirements

Tensile Strength, min.	60,000 psi
Yield Point, min.	35,000 psi

End Finish

NPS 1½" and Smaller: All walls shall be either plain-end square cut, or plain-end beveled at the option of the manufacturer.

NPS 2" and Larger: Walls through extra strong weights, shall be plain-end beveled.

NPS 2" and Larger: Walls over extra strong weights, shall be plain-end square cut.

Plain-end beveled is defined as plain-end pipe having a bevel angle of 30˚, +5˚ -0˚, as measured from a line drawn perpendicular to the axis of the pipe with a root face of 1/16 in. ± 1/32 in.

Dimensions and Weights

The dimensions and weights furnished under this specification are in agreement with the standardized dimensions and weights specified in ASME B 36.10.

Lengths

Single Random: 16'-22'.

Double Random: Minimum length 22', Minimum average 35'.

Chemical Requirements

Carbon, max[A]	0.30
Manganese	0.29-1.06
Phosphorus, max	0.035
Sulfur, max	0.035
Silicon, min	0.10
Chrome, max[B]	0.40
Copper, max[B]	0.40
Molybdenum, max[B]	0.15
Nickel, max[B]	0.40
Vanadium, max[B]	0.08

[A] For each reduction of 0.01% below the specified carbon maximum, an increase of 0.06% manganese above the specified maximum will be permitted up to a maximum of 1.35%.

[B] These five elements combined shall not exceed 1%.

Permissible Variations in Outside Diameter

Outside Diameter at any point shall not vary from standard specified more than—

		Over	Under
Sizes	1½" and smaller	1/64"	1/64"
	2"–4"	1/32"	1/32"
	5"–8"	1/16"	1/32"
	10"–18"	3/32"	1/32"
	20"–24"	1/8"	1/32"

Permissible Variations in Weights per Foot

Weight of any length shall not vary more than 10% over and 3.5% under.

Note—Size 4" and smaller—weighed in lots. Larger sizes—by length.

Permissible Variations in Wall Thickness

The minimum wall thickness at any point shall not be more than 12.5% under the nominal wall thickness specified.

Required Markings on Each Length

(On tags attached to each bundle in case of bundled pipe)

Rolled, Stamped or Stenciled (Manufacturer's option)

- Manufacturer's private identifying mark.
- ASTM A106 A, A106 B, or A106 C.
- Hydrostatic test pressure.
- Length of pipe.
- ASA schedule number.
- Weight (4" and larger).
- Additional "S" if tested to supplementary requirements.

ASTM A-500

Scope

This specification covers cold-formed welded and seamless carbon steel round, square, rectangular, or special shape structural tubing for general construction and structural purposes.

Size Range

Maximum O.D. of 64" and a maximum wall of .625 inch.

Type

Welded or seamless.

Grades

A, B, C

Process Manufacture

Steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric-furnace. Steel may be strand cast.

The longitudinal butt joint of welded tubing shall be welded across its thickness in such a manner that the structural design strength of the tubing section is assured.

Structural tubing welded by electric-resistance methods is normally furnished without removal of inside flash.

Chemistry

	Max%			
	Carbon	Manganese	Phosphorus	Sulfur
Grade A	.30	1.40	.045	.045
Grade B	.30	1.40	.045	.045
Grade C	.27	1.40	.045	.045

Physical Properties

	Tensile Strength (min psi)	Yield Strength (min psi)
Grade A	45,000	33,000
Grade B	58,000	42,000
Grade C	62,000	46,000

Hydrostatic Test

None specified.

Flattening Test

The flattening test is required on round structural tubing.

Bend Test

None specified.

Dimensions

Diameter: The outside diameter shall not vary more than ± .75% of the nominal outside diameter specified.
Wall: The wall thickness shall not vary more than ± 10% of the nominal wall thickness specified.

Lengths

Structural tubing is normally produced in random mill lengths 5 ft. and over, in multiple lengths, and in specified mill lengths.

The permissible variation for straightness shall be ⅛ inch times the number of feet of total length divided by 5.

Ends

The ends of structural tubing, unless otherwise specified, shall be furnished square cut and burr held to a minimum.

General Information

Each length of structural tubing shall be marked to show the following information: manufacturer's name, brand, or trademark; the specification number; and grade letter.

For tubing 4" or less, this information may be marked on a tag securely attached to each bundle.

ASTM A252 Piling Pipe

Scope

Covers nominal (average) wall steel pipe piles of cylindrical shape and applies to pipe piles in which the steel cylinder acts as a permanent load-carrying member or as a shell to form cast-in-place concrete piles.

Hydrostatic Testing

None specified.

Mechanical Test Specified

Tensile Test:

Either longitudinal or transverse at option of manufacturer. Minimum yield determined by the drop of the beam, by the halt in the gauge of the testing machine, or by the use of dividers.

Tensile Requirements

	Grade 1	Grade 2	Grade 3
Tensile Strength, min., psi	50,000	60,000	66,000
Yield Strength, min., psi	30,000	35,000	45,000

Lengths

May be ordered in single or double random lengths or in uniform lengths:

Single Random: 16'-25' incl.

Double Random: Over 25' (min. avg. of 35').

Uniform: Plus or minus 1" on length specified.

Chemistry Requirements

Seamless and Welded Pipe:	Phosphorus Max %
Open-hearth, Electric-furnace or Basic-oxygen	.05

Permissible Variations in Wall Thickness

Not more than 12.5% under the nominal wall thickness specified.

Permissible Variations in Outside Diameter

Shall not vary more than plus or minus 1% from the diameter specified.

Permissible Variations Weight Per Foot

The weight of any length of pile shall not vary more than 15% over or 5% under the weight specified. Each length shall be weighed separately.

Required Markings on Each Length

(On tags attached to each bundle in case of bundled pipe)

Rolled, Stamped or Stenciled (Manufacturer's option)

Manufacturer's name, brand or trademark, heat number, method of pipe manufacture, size, weight, length, wall thickness and ASTM A252 and the Grade.

General Information

Surface imperfections exceeding 25% of the nominal wall in depth are considered defects. Defects not exceeding 33.5% of the nominal wall in depth may be repaired by welding. Before welding, the defect shall be completely removed.

Reject, Structural Grade, Limited Service Pipe

Producing mills, at the time of manufacturing, reject pipe which cannot be classified as a prime product because of some physical or chemical defect. This material is sold by the mills to steel pipe distributors, distributors of steel products, fabricators, and consumers.

Mill rejects are sold on an as is basis and carry no warranty of any kind either expressed or implied.

Reject pipe is available in CW, ERW, DSAW and Seamless, in all sizes, weights, and classes of material. Although reject pipe carries no warranty whatsoever, it can have application for structural purpose. Some typical examples where reject pipe has been used are: handrails, columns, posts, piling, sandwash, casing, culverts, fence, caissons, sign poles, bumpers, bracing, parking meter posts, towers, supports, rollers, etc. Reject pipe is normally priced substantially under prime pipe and can affect large savings in the right application. However, the buyer should be kept continually aware that this material carries no warranty of any kind, either expressed or implied, from the producing mill or the pipe distributor.

Reject pipe is also known in the trade as structural grade pipe and/or Limited Service Pipe. Limited Service Pipe, in certain instances, encompasses pipe which is manufactured to a specific ASTM or API specification, but because of some chemical or physical flaw does not meet the rigid requirements of the intended specification. This pipe could be subjected to lesser hydrostatic test pressures than the original specification required and this product could be classified as Limited Service or Minimum Test Pipe. Limited Service or Minimum Test Pipe of this description can have application in low pressure situations such as water well or surface casing. Generally, when Limited Service Pipe has been subjected to a minimum test it will be clearly marked on the product.

Size		Nom. Wall Thickness, Inches	Weight Lb/Ft Plain End	Mill Hydrostatic Test Pressure* — psi			
NPS	OD Inches			Class	Sched. No.	Buttweld	A106 SMLS
1/8	0.405	0.068	0.24	STD	40	700	2500
		0.095	0.31	XS	80	850	2500
1/4	0.540	0.088	0.42	STD	40	700	2500
		0.119	0.54	XS	80	850	2500
3/8	0.675	0.091	0.57	STD	40	700	2500
		0.126	0.74	XS	80	850	2500
1/2	0.84	0.109	0.85	STD	40	700	2500
		0.147	1.09	XS	80	850	2500
		0.187	1.31		160	900	2500
		0.294	1.71	XXS		1000	2500
3/4	1.050	0.113	1.13	STD	40	700	2500
		0.154	1.47	XS	80	850	2500
		0.218	1.94		160	900	2500
		0.308	2.44	XXS		1000	2500
1	1.315	0.133	1.68	STD	40	700	2500
		0.179	2.17	XS	80	850	2500
		0.250	2.85		160	900	2500
		0.358	3.66	XXS		1000	2500
1 1/4	1.660	0.140	2.27	STD	40	1000	2500
		0.191	3.00	XS	80	1300	2500
		0.250	3.77		160	1350	2500
		0.382	5.21	XXS		1400	2500
1 1/2	1.900	0.145	2.72	STD	40	1000	2500
		0.200	3.63	XS	80	1300	2500
		0.281	4.86		160	1350	2500
		0.400	6.41	XXS		1400	2500
2	2.375	0.154	3.66	STD	40	1000	2500
		0.218	5.03	XS	80	1300	2500
		0.344	7.47		160	1400	2500
		0.436	9.04	XXS		1400	2500
2 1/2	2.875	0.203	5.80	STD	40	1000	2500
		0.276	7.67	XS	80	1300	2500
		0.375	10.01		160	1400	2500
		0.552	13.70	XXS		1400	2500
3	3.500	0.216	7.58	STD	40	1000	2500
		0.300	10.26	XS	80	1300	2500
3 1/2	4.00	0.226	9.12	STD	40	1200	2500
		0.318	12.52	XS	80	1700	2500
4	4.500	0.237	10.80	STD	40	1200	2500
		0.337	15.00	XS	80	1700	2500

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi						
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60
2	2.375 (SMLS & ERW)	0.154	3.66	STD	40	2330	2500	3000	3000	3000	3000	3000
		0.218	5.03	XS	80	2500	2500	3000	3000	3000	3000	3000
		0.344	7.47		160	2500	2500	3000	3000	3000	3000	3000
		0.436	9.04	XXS		2500	2500	3000	3000	3000	3000	3000
2½	2.875 (SMLS & ERW)	0.203	5.80	STD	40	2500	2500	3000	3000	3000	3000	3000
		0.276	7.67	XS	80	2500	2500	3000	3000	3000	3000	3000
		0.375	10.02		160	2500	2500	3000	3000	3000	3000	3000
		0.552	13.71	XXS		2500	2500	3000	3000	3000	3000	3000
3	3.500 (Seamless and Electric Resistance Weld)	0.156	5.58			1600	1870	2810	3000	3000	3000	3000
		0.188	6.66			1930	2260	3000	3000	3000	3000	3000
		0.216	7.58	STD	40	2220	2500	3000	3000	3000	3000	3000
		0.300	10.26	XS	80	2500	2500	3000	3000	3000	3000	3000
		0.438	14.34		160	2500	2500	3000	3000	3000	3000	3000
		0.600	18.60	XXS		2500	2500	3000	3000	3000	3000	3000
3½	4.000 (SMLS & ERW)	0.226	9.12	STD	40	2030	2370	3000	3000	3000	3000	3000
		0.318	12.52	XS	80	2800	2800	3000	3000	3000	3000	3000
		0.636	22.87	XXS		2800	2800	3000	3000	3000	3000	3000
4	4.500 (Seamless and Electric Resistance Weld)	0.156	7.24			1250	1460	2190	2410	2710	2940	3000
		0.188	8.67			1500	1750	2640	2910	3000	3000	3000
		0.203	9.32			1620	1890	2850	3000	3000	3000	3000
		0.219	10.02			1750	2040	3000	3000	3000	3000	3000
		0.237	10.80	STD	40	1900	2210	3000	3000	3000	3000	3000
		0.312	13.97			2500	2800	3000	3000	3000	3000	3000
		0.337	15.00	XS	80	2700	2800	3000	3000	3000	3000	3000
		0.438	19.02		120	2800	2800	3000	3000	3000	3000	3000
		0.531	22.53		160	2800	2800	3000	3000	3000	3000	3000
		0.674	27.57	XXS		2800	2800	3000	3000	3000	3000	3000
5	5.563 (Seamless and Electric Resistance Weld)	0.188	10.80			1220	1420	2130	2350	2650	2870	3000
		0.258	14.63	STD	40	1670	1950	2930	3000	3000	3000	3000
		0.312	17.51			2020	2360	3000	3000	3000	3000	3000
		0.375	20.80	XS	80	2430	2800	3000	3000	3000	3000	3000
		0.500	27.06		120	2800	2800	3000	3000	3000	3000	3000
		0.625	32.99		160	2800	2800	3000	3000	3000	3000	3000
		0.750	38.59	XXS		2800	2800	3000	3000	3000	3000	3000

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi						
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60
		0.156	10.79			850	990	1490	1640	1840	2000	2130
		0.172	11.87			930	1090	1640	1810	2030	2200	2340
		0.188	12.94			1020	1190	1790	1980	2220	2410	2560
		0.203	13.94			1100	1290	1940	2130	2400	2600	2770
		0.219	15.00			1190	1390	2090	2300	2590	2810	2990
		0.250	17.04			1360	1580	2380	2630	2950	3000	3000
		0.280	18.99	STD	40	1520	1780	2670	2940	3000	3000	3000
		0.312	21.06			1700	1980	2970	3000	3000	3000	3000
6	6.625 (Seamless and Electric Resistance Weld)	0.344	23.10			1870	2180	3000	3000	3000	3000	3000
		0.375	25.05			2040	2380	3000	3000	3000	3000	3000
		0.432	28.60	XS	80	2350	2740	3000	3000	3000	3000	3000
		0.500	32.74			2720	2800	3000	3000	3000	3000	3000
		0.562	36.43		120	2800	2800	3000	3000	3000	3000	3000
		0.625	40.09			2800	2800	3000	3000	3000	3000	3000
		0.719	45.39		160	2800	2800	3000	3000	3000	3000	3000
		0.750	47.10			2800	2800	3000	3000	3000	3000	3000
		0.864	53.21	XXS		2800	2800	3000	3000	3000	3000	3000
		0.875	53.78			2800	2800	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
		0.156	14.12			650	760	1140	1260	1420	1540	1630	1770	1910
		0.188	16.96			780	920	1380	1520	1710	1850	1970	2140	2300
		0.203	18.28			850	990	1490	1640	1840	2000	2130	2310	2480
		0.219	19.68			910	1070	1600	1770	1990	2160	2290	2490	2680
		0.250	22.38		20	1040	1220	1830	2020	2270	2460	2620	2840	3000
		0.277	24.72		30	1160	1350	2030	2240	2510	2730	2900	3000	3000
		0.312	27.73			1300	1520	2280	2520	2830	3000	3000	3000	3000
		0.322	28.58	STD	40	1340	1570	2360	2600	2920	3000	3000	3000	3000
		0.344	30.45			1440	1680	2520	2780	3000	3000	3000	3000	3000
		0.375	33.07			1570	1830	2750	3000	3000	3000	3000	3000	3000
		0.406	35.67		60	1700	2000	2970	3000	3000	3000	3000	3000	3000
8	8.625	0.438	38.33			1830	2130	3000	3000	3000	3000	3000	3000	3000
	(Seamless and Electric Resistance Weld)	0.500	43.43	XS	80	2090	2430	3000	3000	3000	3000	3000	3000	3000
		0.562	48.44			2350	2740	3000	3000	3000	3000	3000	3000	3000
		0.594	51.00		100	2500	2800	3000	3000	3000	3000	3000	3000	3000
		0.625	53.45			2610	2800	3000	3000	3000	3000	3000	3000	3000
		0.719	60.77		120	2800	2800	3000	3000	3000	3000	3000	3000	3000
		0.750	63.14			2800	2800	3000	3000	3000	3000	3000	3000	3000
		0.812	67.82		140	2800	2800	3000	3000	3000	3000	3000	3000	3000
		0.875	72.49	XXS		2800	2800	3000	3000	3000	3000	3000	3000	3000
		0.906	74.76		160	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.000	81.51			2800	2800	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness, Inches	Weight Lb/Ft Plain End	Class	Sched. No.	Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches					Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
10	10.750 (Seamless and Electric Resistance Weld)	0.188	21.23			630	730	1250	1380	1550	1680	1790	1940	2090
		0.203	22.89			680	790	1350	1490	1680	1820	1930	2100	2260
		0.219	24.65			730	860	1460	1610	1810	1960	2080	2260	2430
		0.250	28.06		20	840	980	1660	1830	2060	2240	2380	2580	2780
		0.279	31.23			930	1090	1860	2050	2300	2500	2660	2880	3000
		0.307	34.27		30	1030	1200	2040	2250	2530	2750	2920	3000	3000
		0.344	38.27			1150	1340	2290	2520	2840	3000	3000	3000	3000
		0.365	40.52	STD	40	1220	1430	2430	2680	3000	3000	3000	3000	3000
		0.438	48.28			1470	1710	2920	3000	3000	3000	3000	3000	3000
		0.500	54.79	XS	60	1670	1950	3000	3000	3000	3000	3000	3000	3000
		0.562	61.21			1880	2200	3000	3000	3000	3000	3000	3000	3000
		0.594	64.49		80	1990	2320	3000	3000	3000	3000	3000	3000	3000
		0.625	67.65			2090	2440	3000	3000	3000	3000	3000	3000	3000
		0.719	77.10		100	2410	2800	3000	3000	3000	3000	3000	3000	3000
		0.812	86.26			2720	2800	3000	3000	3000	3000	3000	3000	3000
		0.844	89.38		120	2800	2800	3000	3000	3000	3000	3000	3000	3000
		0.875	92.37			2800	2800	3000	3000	3000	3000	3000	3000	3000
		0.938	98.39			2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.000	104.23	XXS	140	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.125	115.75		160	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.250	126.94			2800	2800	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness, Inches	Weight Lb/Ft Plain End			Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches			Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
12	12.750 (Seamless and Electric Resistance Weld)	0.188	25.25			530	620	1050	1160	1310	1420	1510	1640	1760
		0.203	27.23			570	670	1140	1260	1410	1530	1630	1770	1900
		0.219	29.34			620	720	1230	1350	1520	1650	1760	1910	2050
		0.250	33.41		20	710	820	1400	1550	1740	1890	2010	2180	2340
		0.281	37.46			790	930	1580	1740	1960	2120	2260	2450	2630
		0.312	41.48			880	1030	1750	1930	2170	2350	2500	2720	2920
		0.330	43.81		30	930	1090	1850	2040	2300	2490	2650	2870	3000
		0.344	45.62			970	1130	1930	2130	2390	2600	2760	3000	3000
		0.375	49.61	STD		1060	1240	2110	2320	2610	2830	3000	3000	3000
		0.406	53.57		40	1150	1340	2280	2510	2830	3000	3000	3000	3000
		0.438	57.65			1240	1440	2460	2710	3000	3000	3000	3000	3000
		0.500	65.48	XS		1410	1650	2810	3000	3000	3000	3000	3000	3000
		0.562	73.22		60	1590	1850	3000	3000	3000	3000	3000	3000	3000
		0.625	81.01			1760	2060	3000	3000	3000	3000	3000	3000	3000
		0.688	88.71		80	1940	2270	3000	3000	3000	3000	3000	3000	3000
		0.750	96.21			2120	2470	3000	3000	3000	3000	3000	3000	3000
		0.812	103.63			2290	2670	3000	3000	3000	3000	3000	3000	3000
		0.844	107.42		100	2390	2780	3000	3000	3000	3000	3000	3000	3000
		0.875	111.08			2470	2800	3000	3000	3000	3000	3000	3000	3000
		0.938	118.44			2650	2800	3000	3000	3000	3000	3000	3000	3000
		1.000	125.61	XXS	120	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.125	139.81		140	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.250	153.67			2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.312	160.42		160	2800	2800	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness, Inches	Weight Lb/Ft Plain End	Class	Sched. No.	Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches					Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
14	14.000 (Seamless and Electric Resistance Weld)	0.219	32.26			560	660	1120	1230	1390	1510	1600	1740	1870
		0.250	36.75		10	640	750	1280	1410	1580	1720	1830	1980	2130
		0.281	41.21			720	840	1440	1580	1780	1930	2050	2230	2400
		0.312	45.65		20	800	940	1600	1760	1980	2140	2280	2470	2660
		0.344	50.22			880	1030	1760	1940	2180	2360	2510	2730	2940
		0.375	54.62	STD	30	960	1130	1920	2120	2380	2580	2740	2970	3000
		0.406	59.00			1040	1220	2080	2290	2570	2790	2970	3000	3000
		0.438	63.50		40	1130	1310	2240	2470	2780	3000	3000	3000	3000
		0.469	67.84			1210	1410	2400	2640	2970	3000	3000	3000	3000
		0.500	72.16	XS		1290	1500	2560	2820	3000	3000	3000	3000	3000
		0.562	80.73			1450	1690	2870	3000	3000	3000	3000	3000	3000
		0.594	85.13		60	1530	1790	3000	3000	3000	3000	3000	3000	3000
		0.625	89.36			1610	1880	3000	3000	3000	3000	3000	3000	3000
		0.688	97.91			1770	2060	3000	3000	3000	3000	3000	3000	3000
		0.750	106.23		80	1930	2250	3000	3000	3000	3000	3000	3000	3000
		0.812	114.48			2090	2440	3000	3000	3000	3000	3000	3000	3000
		0.875	122.77			2250	2630	3000	3000	3000	3000	3000	3000	3000
		0.938	130.98		100	2410	2800	3000	3000	3000	3000	3000	3000	3000
		1.000	138.97			2570	2800	3000	3000	3000	3000	3000	3000	3000
		1.094	150.93		120	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.125	154.84			2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.250	170.37		140	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.406	189.29		160	2800	2800	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
		0.219	36.95			490	570	980	1080	1210	1320	1400	1520	1640
		0.250	42.09		10	560	660	1120	1230	1390	1500	1600	1730	1870
		0.281	47.22			630	740	1260	1390	1560	1690	1800	1950	2100
		0.312	52.32		20	700	820	1390	1540	1730	1880	2000	2160	2330
		0.344	57.57			770	900	1540	1700	1900	2070	2200	2390	2570
		0.375	62.64	STD	30	840	980	1680	1850	2080	2260	2400	2600	2800
		0.406	67.68			910	1070	1820	2000	2250	2440	2600	2820	3000
		0.438	72.86			990	1150	1960	2160	2430	2630	2800	3000	3000
		0.469	77.87			1060	1230	2100	2310	2600	2820	3000	3000	3000
		0.500	82.85	XS	40	1130	1310	2240	2470	2770	3000	3000	3000	3000
16	16.00 (Seamless and Electric Resistance Weld)	0.562	92.75			1260	1480	2510	2770	3000	3000	3000	3000	3000
		0.625	102.72			1410	1640	2800	3000	3000	3000	3000	3000	3000
		0.656	107.60		60	1480	1720	2930	3000	3000	3000	3000	3000	3000
		0.688	112.62			1550	1810	3000	3000	3000	3000	3000	3000	3000
		0.750	122.27			1690	1970	3000	3000	3000	3000	3000	3000	3000
		0.812	131.84			1830	2130	3000	3000	3000	3000	3000	3000	3000
		0.844	136.74		80	1900	2220	3000	3000	3000	3000	3000	3000	3000
		0.875	141.48			1970	2300	3000	3000	3000	3000	3000	3000	3000
		1.000	160.35			2250	2630	3000	3000	3000	3000	3000	3000	3000
		1.031	164.98		100	2320	2710	3000	3000	3000	3000	3000	3000	3000
		1.125	178.89			2530	2800	3000	3000	3000	3000	3000	3000	3000
		1.188	188.11			2670	2800	3000	3000	3000	3000	3000	3000	3000
		1.219	192.61		120	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.250	197.10			2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.438	223.85		140	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.594	245.48		160	2800	2800	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness, Inches	Weight Lb/Ft Plain End	Class	Sched. No.	Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches					Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
18	18.000 (Seamless and Electric Resistance Weld)	0.250	47.44		10	500	580	990	1100	1230	1340	1420	1540	1660
		0.281	53.23			560	660	1120	1230	1390	1500	1600	1730	1870
		0.312	58.99		20	620	730	1240	1370	1540	1670	1770	1920	2070
		0.344	64.93			690	800	1370	1510	1700	1840	1960	2120	2280
		0.375	70.65	STD		750	880	1490	1640	1850	2000	2130	2310	2490
		0.406	76.36			810	950	1610	1780	2000	2170	2310	2500	2700
		0.438	82.23		30	880	1020	1740	1920	2160	2340	2490	2700	2910
		0.469	87.89			940	1090	1860	2060	2310	2510	2670	2890	3000
		0.500	93.54	XS		1000	1170	1990	2190	2470	2670	2840	3000	3000
		0.562	104.76		40	1120	1310	2230	2460	2770	3000	3000	3000	3000
		0.625	116.09			1250	1460	2490	2740	3000	3000	3000	3000	3000
		0.688	127.32			1380	1610	2740	3000	3000	3000	3000	3000	3000
		0.750	138.30		60	1500	1750	2980	3000	3000	3000	3000	3000	3000
		0.812	149.20			1620	1890	3000	3000	3000	3000	3000	3000	3000
		0.875	160.18			1750	2040	3000	3000	3000	3000	3000	3000	3000
		0.938	171.08		80	1880	2190	3000	3000	3000	3000	3000	3000	3000
		1.000	181.73			2000	2330	3000	3000	3000	3000	3000	3000	3000
		1.125	202.94			2250	2630	3000	3000	3000	3000	3000	3000	3000
		1.156	208.15		100	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.188	213.51			2380	2770	3000	3000	3000	3000	3000	3000	3000
		1.250	223.82			2500	2800	3000	3000	3000	3000	3000	3000	3000
		1.375	244.37		120	2800	2800	3000	3000	3000	3000	3000	3000	3000
		1.562	274.48		140	2800	2800	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
20	20.000 (Seamless and Electric Resistance Weld)	0.250	52.78	STD	10	450	530	950	1040	1170	1270	1350	1470	1580
		0.281	59.23			510	590	1060	1170	1320	1430	1520	1650	1780
		0.312	65.66			560	660	1180	1300	1470	1590	1690	1830	1970
		0.344	72.28			620	720	1300	1440	1620	1750	1860	2020	2180
		0.375	78.67		20	680	790	1420	1570	1760	1910	2030	2200	2370
		0.406	85.04			730	850	1540	1700	1910	2070	2200	2390	2570
		0.438	91.59			790	820	1660	1830	2060	2230	2370	2570	2770
		0.469	97.92			840	980	1780	1960	2200	2390	2540	2760	2970
		0.500	104.23	XS	30	900	1050	1890	2090	2350	2550	2710	2940	3000
		0.562	116.78			1010	1180	2130	2350	2640	2860	3000	3000	3000
		0.594	123.23		40	1170	1250	2250	2480	2790	3000	3000	3000	3000
		0.625	129.45			1180	1310	2370	2610	2940	3000	3000	3000	3000
		0.688	142.03			1240	1440	2610	2870	3000	3000	3000	3000	3000
		0.750	154.34			1350	1580	2840	3000	3000	3000	3000	3000	3000
		0.812	166.56		60	1460	1710	3000	3000	3000	3000	3000	3000	3000
		0.875	178.89			1580	1840	3000	3000	3000	3000	3000	3000	3000
		1.000	203.11			1800	2100	3000	3000	3000	3000	3000	3000	3000
		1.031	209.06		80	1860	2170	3000	3000	3000	3000	3000	3000	3000
		1.125	227.00			2030	2360	3000	3000	3000	3000	3000	3000	3000
		1.188	238.91			2140	2490	3000	3000	3000	3000	3000	3000	3000
		1.250	250.55			2250	2630	3000	3000	3000	3000	3000	3000	3000
		1.281	256.34		100	2800	2800	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness, Inches	Weight Lb/Ft Plain End			Mill Hydrostatic Test Pressure* — psi								
NPS	OD Inches			Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70
22	22.000 (Seamless and Electric Resistance Weld)	0.250	58.13			410	480	860	950	1070	1160	1230	1340	1440
		0.281	65.24			460	540	970	1070	1200	1300	1380	1500	1620
		0.312	72.34			510	600	1070	1180	1330	1440	1540	1670	1790
		0.344	79.64			560	660	1180	1310	1470	1590	1690	1840	1980
		0.375	86.69	STD	20	610	720	1290	1420	1610	1740	1850	2000	2160
		0.406	93.72			660	780	1400	1540	1730	1880	2000	2170	2340
		0.438	100.96			720	840	1510	1660	1870	2030	2160	2340	2520
		0.469	107.95			770	900	1620	1780	2000	2170	2310	2510	2700
		0.500	114.92	XS	30	820	950	1720	1900	2140	2320	2460	2670	2880
		0.562	128.79			920	1070	1940	2130	2400	2600	2770	3000	3000
		0.625	142.81			1020	1190	2150	2370	2670	2890	3000	3000	3000
		0.688	156.74			1130	1310	2370	2610	2940	3000	3000	3000	3000
		0.750	170.37			1230	1430	2580	2850	3000	3000	3000	3000	3000
		0.812	183.92			1330	1550	2800	3000	3000	3000	3000	3000	3000
		0.875	197.60		60	1430	1670	3000	3000	3000	3000	3000	3000	3000
		1.000	224.49			1640	1910	3000	3000	3000	3000	3000	3000	3000
		1.250	277.27			2050	2390	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
$2\frac{3}{8}$" to $3\frac{1}{2}$" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to $5\frac{9}{16}$" Incl.	A-B	60% or 2800 psi – whichever is the lesser
$6\frac{5}{8}$" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
$2\frac{3}{8}$" to $8\frac{5}{8}$" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
$10\frac{3}{4}$" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.250	63.47		10	380	440	790	870	980	1060	1130	1220	1320	1510
		0.281	71.25			420	490	890	980	1100	1190	1270	1380	1480	1700
		0.312	79.01			470	550	990	1090	1220	1320	1410	1530	1650	1880
		0.344	86.99			520	600	1090	1200	1350	1460	1550	1680	1810	2080
		0.375	94.71	STD	20	560	660	1180	1300	1470	1590	1690	1840	1980	2260
		0.406	102.40			610	710	1280	1410	1590	1720	1830	1990	2140	2450
		0.438	110.32			660	770	1380	1520	1710	1860	1980	2150	2310	2640
		0.469	117.98			700	820	1480	1630	1840	1990	2120	2300	2470	2830
		0.500	125.61	XS		750	880	1580	1740	1960	2120	2260	2450	2640	3000
		0.562	140.81		30	840	980	1770	1960	2200	2390	2540	2750	2960	3000
		0.625	156.17			940	1090	1970	2180	2450	2650	2820	3000	3000	3000
24	24.00 (Seamless and Electric Resistance Weld)	0.688	171.45		40	1030	1200	2170	2390	2690	2920	3000	3000	3000	3000
		0.750	186.41			1130	1310	2370	2610	2940	3000	3000	3000	3000	3000
		0.812	201.28			1220	1420	2560	2830	3000	3000	3000	3000	3000	3000
		0.875	216.31			1310	1530	2760	3000	3000	3000	3000	3000	3000	3000
		0.938	231.25			1410	1640	2960	3000	3000	3000	3000	3000	3000	3000
		0.969	238.57		60	1450	1700	3000	3000	3000	3000	3000	3000	3000	3000
		1.000	245.87			1500	1750	3000	3000	3000	3000	3000	3000	3000	3000
		1.125	275.10			1690	1970	3000	3000	3000	3000	3000	3000	3000	3000
		1.219	296.86		80	1830	2130	3000	3000	3000	3000	3000	3000	3000	3000
		1.250	304.00			1880	2190	3000	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.250	68.82			350	400	730	800	900	980	1040	1130	1220	1390
		0.281	77.26			390	450	820	900	1020	1100	1170	1270	1370	1570
		0.312	85.68		10	430	500	910	1000	1130	1220	1300	1410	1520	1740
		0.344	94.35			480	560	1000	1110	1240	1350	1430	1560	1670	1920
		0.375	102.72	STD		520	610	1090	1200	1360	1470	1560	1700	1830	2090
		0.406	111.08			560	660	1180	1300	1470	1590	1690	1840	1980	2260
		0.438	119.69			610	710	1280	1410	1580	1720	1830	1980	2130	2440
		0.469	128.00			650	760	1370	1510	1690	1840	1950	2120	2280	2610
		0.500	136.30	XS	20	690	810	1460	1610	1810	1960	2080	2260	2430	2790
		0.562	152.83			780	910	1640	1810	2030	2200	2340	2540	2740	3000
26	26.000	0.625	169.54		30	870	1010	1820	2010	2260	2450	2600	2830	3000	3000
		0.688	186.16			950	1110	2010	2210	2490	2700	2870	3000	3000	3000
		0.750	202.44			1040	1210	2190	2410	2710	2940	3000	3000	3000	3000
		0.812	218.64			1120	1310	2370	2610	2930	3000	3000	3000	3000	3000
		0.875	235.01			1210	1410	2550	2810	3000	3000	3000	3000	3000	3000
		0.938	251.30			1300	1520	2730	3000	3000	3000	3000	3000	3000	3000
		1.000	267.25			1380	1620	2910	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.250	74.16			320	380	680	750	840	910	970	1050	1130	1290
		0.281	83.26			360	420	760	840	940	1020	1090	1180	1270	1450
		0.312	92.35		10	400	470	840	930	1050	1140	1210	1310	1410	1610
		0.344	101.70			440	520	930	1030	1150	1250	1330	1440	1550	1780
		0.375	110.74	STD		480	560	1010	1120	1260	1360	1450	1570	1690	1940
		0.406	119.74			520	610	1100	1210	1360	1480	1570	1700	1830	2100
		0.438	129.05			560	660	1190	1310	1470	1590	1700	1840	1980	2270
		0.469	138.03			600	700	1270	1400	1570	1710	1820	1970	2120	2430
28	28.000														
		0.500	146.99	XS	20	640	750	1350	1490	1680	1820	1940	2100	2260	2590
		0.562	164.84			720	840	1520	1680	1890	2040	2170	2360	2540	2910
		0.625	182.90		30	800	940	1690	1860	2100	2270	2420	2620	2820	3000
		0.688	200.87			880	1030	1860	2050	2310	2500	2660	2890	3000	3000
		0.750	218.48			960	1130	2030	2240	2520	2730	2900	3000	3000	3000
		0.812	236.00			1040	1220	2200	2420	2720	2950	3000	3000	3000	3000
		0.875	253.72			1130	1310	2370	2610	2940	3000	3000	3000	3000	3000
		0.938	271.36			1210	1410	2540	2800	3000	3000	3000	3000	3000	3000
		1.000	288.63			1290	1500	2710	2980	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.250	79.51			300	350	630	700	780	850	900	980	1050	1210
		0.281	89.27			340	390	710	780	880	950	1010	1100	1190	1360
		0.312	99.02		10	370	440	790	870	980	1060	1130	1220	1320	1510
		0.344	109.06			410	480	870	960	1080	1170	1240	1350	1450	1660
		0.375	118.76	STD		450	530	950	1040	1170	1270	1350	1470	1580	1810
		0.406	128.44			490	570	1030	1130	1270	1380	1470	1590	1710	1960
		0.438	138.42			530	610	1110	1220	1370	1490	1580	1720	1850	2120
		0.469	148.06			560	660	1180	1310	1470	1590	1690	1840	1980	2270
		0.500	157.68	XS	20	600	700	1260	1390	1570	1700	1810	1960	2110	2420
		0.562	176.86			670	790	1420	1560	1760	1910	2030	2200	2370	2710
30	30.000	0.625	196.26		30	750	880	1580	1740	1960	2120	2260	2450	2640	3000
		0.688	215.58			830	960	1740	1920	2150	2340	2490	2700	2900	3000
		0.750	234.51			900	1050	1890	2090	2350	2550	2710	2940	3000	3000
		0.812	253.36			970	1140	2050	2260	2540	2760	2930	3000	3000	3000
		0.875	272.43			1050	1230	2210	2440	2740	2970	3000	3000	3000	3000
		0.938	291.41			1130	1310	2370	2610	2940	3000	3000	3000	3000	3000
		1.000	310.01			1200	1400	2530	2780	3000	3000	3000	3000	3000	3000
		1.125	347.26			1350	1580	2840	3000	3000	3000	3000	3000	3000	3000
		1.250	384.17			1500	1750	3000	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall	Weight			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Thickness, Inches	Lb/Ft Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.250	84.85			280	330	590	650	730	800	850	920	990	1130
		0.281	95.28			320	370	670	730	830	890	950	1030	1110	1270
		0.312	105.69		10	350	410	740	810	920	990	1060	1150	1230	1410
		0.344	116.41			390	450	810	900	1010	1100	1160	1260	1360	1560
		0.375	126.78	STD		420	490	890	980	1100	1190	1270	1380	1480	1700
		0.406	137.12			460	530	960	1060	1190	1290	1370	1490	1610	1840
		0.438	147.78			490	570	1040	1140	1290	1390	1480	1610	1730	1980
		0.469	158.08			530	620	1110	1220	1380	1490	1590	1720	1850	2120
		0.500	168.37	XS	20	560	660	1180	1310	1470	1590	1690	1840	1980	2260
		0.562	188.87			630	740	1330	1470	1650	1790	1900	2060	2220	2540
32	32.00	0.625	209.62		30	700	820	1480	1630	1840	1990	2120	2300	2470	2830
		0.688	230.29		40	770	900	1630	1800	2020	2190	2330	2530	2720	3000
		0.750	250.55			840	980	1780	1960	2200	2390	2540	2750	2970	3000
		0.812	270.72			910	1070	1920	2120	2380	2590	2750	2980	3000	3000
		0.875	291.14			980	1150	2070	2280	2570	2790	2960	3000	3000	3000
		0.938	311.47			1060	1230	2220	2450	2750	2990	3000	3000	3000	3000
		1.000	331.39			1130	1310	2370	2610	2940	3000	3000	3000	3000	3000
		1.125	371.31			1270	1480	2660	2940	3000	3000	3000	3000	3000	3000
		1.250	410.90			1410	1640	2960	3000	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.250	95.54			250	290	530	580	650	710	750	820	880	1010
		0.281	107.30			280	330	590	650	730	800	850	920	990	1130
		0.312	119.03		10	310	360	660	720	810	880	940	1020	1100	1260
		0.344	131.12			340	400	720	800	900	970	1040	1120	1210	1380
		0.375	142.81	STD		380	440	790	870	980	1060	1130	1220	1320	1510
		0.406	154.48			410	470	850	940	1060	1150	1220	1330	1430	1630
		0.438	166.51			440	510	920	1020	1140	1240	1320	1430	1540	1760
		0.469	178.14			470	550	990	1090	1220	1330	1410	1530	1650	1890
		0.500	189.75	XS	20	500	580	1050	1160	1310	1420	1510	1630	1760	2010
		0.562	212.90			560	660	1180	1300	1470	1590	1690	1830	1980	2260
36	36.000	0.625	236.35		30	630	730	1320	1450	1630	1770	1880	2040	2200	2520
		0.688	259.71			690	800	1450	1600	1800	1950	2070	2250	2420	2770
		0.750	282.62		40	750	880	1580	1740	1960	2120	2260	2450	2640	3000
		0.812	305.44			810	950	1710	1880	2120	2300	2440	2650	2850	3000
		0.875	328.55			880	1020	1840	2030	2280	2480	2630	2860	3000	3000
		0.938	351.57			940	1090	1970	2180	2450	2650	2820	3000	3000	3000
		1.000	374.15			1000	1170	2110	2320	2610	2830	3000	3000	3000	3000
		1.125	419.42			1130	1310	2370	2610	2940	3000	3000	3000	3000	3000
		1.250	464.35			1250	1460	2630	2900	3000	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.344	153.18			290	340	620	680	770	830	890	960	1040	1190
		0.375	166.86	STD		320	380	680	750	840	910	970	1050	1130	1290
		0.406	180.52			350	410	730	810	910	980	1050	1140	1220	1400
		0.438	194.60			380	440	790	870	980	1060	1130	1230	1320	1510
		0.469	208.22			400	470	850	930	1050	1140	1210	1310	1410	1620
		0.500	221.82	XS		430	500	900	990	1120	1210	1290	1400	1510	1730
		0.562	248.95			480	560	1010	1120	1260	1360	1450	1570	1690	1940
		0.625	276.44			540	630	1130	1240	1400	1510	1610	1750	1880	2160
42	42.000	0.688	303.84			590	690	1240	1370	1540	1670	1780	1930	2070	2370
		0.750	330.72			640	750	1350	1490	1680	1820	1940	2100	2260	2590
		0.812	357.52			700	810	1470	1610	1820	1970	2090	2270	2450	2800
		0.875	384.67			750	880	1580	1740	1960	2120	2260	2450	2640	3000
		0.938	411.74			800	940	1690	1870	2100	2280	2420	2630	2830	3000
		1.000	438.29			860	1000	1800	1990	2240	2430	2580	2800	3000	3000
		1.125	491.57			960	1130	2030	2240	2520	2730	2900	3000	3000	3000
		1.250	544.52			1070	1250	2260	2490	2800	3000	3000	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Size		Nom. Wall Thickness,	Weight Lb/Ft			Mill Hydrostatic Test Pressure* — psi									
NPS	OD Inches	Inches	Plain End	Class	Sched. No.	Grade A	Grade B	Grade X-42	Grade X-46	Grade X-52	Grade X-56	Grade X-60	Grade X-65	Grade X-70	Grade X-80
		0.344	175.25			260	300	540	600	670	730	780	840	910	1040
		0.375	190.92	STD		280	330	590	650	730	800	850	920	990	1130
		0.406	206.56			300	360	640	710	790	860	920	990	1070	1230
		0.438	222.70			330	380	690	760	860	930	990	1070	1150	1320
		0.469	238.30			350	410	740	820	920	1000	1060	1150	1240	1420
		0.500	253.89	XS		380	440	790	870	980	1060	1130	1220	1320	1510
		0.562	285.00			420	490	890	980	1100	1190	1270	1380	1480	1700
		0.625	316.52			470	550	990	1090	1220	1330	1410	1530	1650	1890
48	48.000	0.688	347.97			520	600	1090	1200	1350	1460	1550	1680	1810	2080
		0.750	378.83			560	660	1180	1310	1470	1590	1690	1840	1980	2260
		0.812	409.61			610	710	1280	1410	1590	1720	1830	1990	2140	2450
		0.875	440.80			660	770	1380	1520	1710	1860	1980	2140	2310	2640
		0.938	471.90			700	820	1480	1630	1840	1990	2120	2300	2470	2830
		1.000	502.43			750	880	1580	1740	1960	2120	2260	2450	2640	3000
		1.125	563.73			840	980	1780	1960	2200	2388	2540	2750	2970	3000
		1.250	624.70			940	1090	1970	2180	2450	2650	2820	3000	3000	3000

* The mill hydrostatic test pressures indicated were calculated on the basis of a fiber stress equal to a percentage of the specified minimum yield strength for the various sizes and grades, as follows:

OD SIZES	GRADE	PERCENT OF SPECIFIED MINIMUM YIELD
2⅜" to 3½" Incl.	A-B	60% or 2500 psi – whichever is the lesser
4" to 5⁹⁄₁₆" Incl.	A-B	60% or 2800 psi – whichever is the lesser
6⅝" to 44" Incl.	A-B	75% or 2800 psi – whichever is the lesser
2⅜" to 8⅝" Incl.	**All X-Grades	75% or 3000 psi – whichever is the lesser
10¾" to 18" Incl.	All X-Grades	85% or 3000 psi – whichever is the lesser
20" to 48" Incl.	All X-Grades	90% or 3000 psi – whichever is the lesser

* Pressure values at yield and ultimate are calculated on the basis of minimum yield strength, minimum ultimate strength and nominal dimensions specified by API.

**Due to columnar effects in lengths over 45 feet, it may become necessary in some cases to use standard test pressures.

Pressure Determinations and Wall Thickness

Pressure Determinations

Barlow's Formula is commonly used to determine **1. Internal Pressure at Minimum Yield, 2. Ultimate Bursting Pressure, 3. Maximum Allowable Operating Pressure** and, **4. Mill Hydrostatic Test Pressure**

This formula is expressed as $P = \frac{2St}{D}$

where:

P = pressure, psig

t = nominal wall thickness, inch

D = outside diameter, inch

S = allowable stress, psi, which depends on the pressure being determined

To illustrate, assume a piping system 8⅝" OD x 0.375" wall specified to ASTM A53 Grade B which has a specified yield strength (SMYS) of 35,000 psi and a specified minimum tensile strength (SMTS) of 60,000 psi.

For 1. Internal Pressure at Minimum Yield,

S = SMYS (35,000 psi) and

$$P = \frac{2St}{D} = \frac{(2)\ (35{,}000)\ (0.375)}{8.625}$$

= 3043 or 3040 psig (rounded to nearest 10 psig)

For 2. Ultimate Bursting Pressure,

S = SMTS (60,000 psi) and

$$P = \frac{2St}{D} = \frac{(2)\ (60{,}000)\ (0.375)}{8.625}$$

= 5217 or 5220 psig (rounded to nearest 10 psig)

For 3. Maximum Allowable Operating Pressure (MAOP),

S = SMYS (35,000 psi) reduced by a design factor, for example 0.72 and

$$P = \frac{2St}{D} = \frac{(2)\ (35{,}000 \times 0.72)\ (0.375)}{8.625}$$

= 2191 or 2190 psig (rounded to nearest 10 psig)

For 4. Mill Hydrostatic Test Pressure,

S = SMYS (35,000 psi) reduced by a factor depending on OD and grade (0.60 for 8⅝" OD grade B) and

$$P = \frac{2St}{D} = \frac{(2)\ (35{,}000 \times 0.60)\ (0.375)}{8.625}$$

= 1826 or 1830 psig (rounded to nearest 10 psig)

Some safety codes and regulatory agencies also assign a longitudinal joint factor to account for weld efficiency. The more common are 0.85 for ERW pipe and 0.60 for CW pipe. Seamless pipe enjoys a joint factor of 1.00. This means that some some designers consider ERW pipe 85 percent as efficient as seamless pipe and CW pipe only 60 percent as efficient for the same application, ERW pipe would require a heavier wall than seamless pipe, and CW pipe, in turn, would require a heavier wall than ERW pipe.

Distributors who stock pipe in a combination of seamless, ERW and CW must exercise extreme care to see that pipe with joint efficiency factors of 0.85 or 0.60 is not used on jobs which require pipe with a joint factor of 1.00.

Wall Thickness

Barlow's Formula is also useful in determining the wall thickness required for a piping system. To illustrate, assume a piping system has been designed with the following criteria:

1. A working pressure of 2000 psig (P)
2. The pipe to be used is 8 ⅝" OD (D) specified to ASTM A53 grade B (SMYS = 35,000 psi)

Rearranging **Barlow's Formula** to solve for wall thickness gives:

$$t = \frac{PD}{2S} = \frac{(2000)\ (8.625)}{(2)\ (35{,}000)} = 0.246\text{" wall}$$

Wall thickness does not affect the outside diameter—only the inside diameter is affected. For example, the outside diameter of a one-inch extra-strong piece of pipe compared with a one-inch standard weight piece of pipe is identical; however, the inside diameter of the extra strong is smaller than the inside diameter of the standard weight because the wall thickness is greater in the extra-strong pipe.

The American National Standards Institute (ANSI) assigns "schedule numbers" to classify wall thicknesses for different pressure uses. ANSI schedule numbers cover all pipe sizes from NPS ⅛" through NPS 36".

In pipe sizes NPS ⅛"-10", ANSI Schedule 40 thicknesses are identical to standard weight pipe; Schedule 80 (NPS ⅛" through 8") is identical to extra-strong pipe; and, Schedule 160 falls between extra-strong and double extra-strong pipe.

Calculations

Price/Ton to Price/Foot Conversion

1. (Price/ton ÷ 2,000) x wt./ft. of pipe
2. (Wt./ft. x price/ton) ÷ 2,000

Calculating Theoretical I.D.

Wall thickness x 2, subtract from O.D.

Carbon Equivalent

For pipe grades up to Grade X70 inclusive, the carbon equivalent, CE, calculated using product analysis and the following equation shall not exceed 0.43%:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + CU}{15}$$

Formula For Calculating Weight Per Foot On Stainless And Carbon Steel Tubing And Pipe

In determining the Average Wall Weight of a tube, the following formula was used:

$$W = 10.69\ (D - t)t$$

In determining the Minimum Wall Weight of a tube, the following formula was used:

$$W = 10.69\left(D - \frac{t}{0.875}\right)\frac{t}{0.875}$$

Where W = Weight in pounds per foot (carried to four digits)

D = Outside diameter in inches (to three decimal places)

t = Wall thickness in decimals (to three decimal places)

The computed weight is for either Hot Finished or Cold Drawn round tubes.*

All weights are carried to four digits only, the fifth digit being carried forward if five or over, or dropped if under five.

Outside diameters and wall thickness are carried to three decimal places, the fourth decimal being carried forward if five or over, or dropped if under five.

*To determine Average or Minimum Wall Weight of square or rectangular tubing, substitute 13.60 for 10.68 in the above formula.

Conversion Constants

To Change	To	Multiply By
Inches	Feet	0.0833
Inches	Millimeters	25.4
Feet	Inches	12
Feet	Yards	0.3333
Yards	Feet	3
Meters	Inches	39.37
Meters	Feet	3.281
Inches	Meters	0.0254
Feet	Meters	0.3048
Gallons	Cubic inches	231
Gallons	Cubic feet	0.1337
Gallons	Pounds of water	8.33
Pounds of water	Gallons	0.12004
Pounds	Ounces	16
Inches of water	Pounds per square foot	0.0361
Inches of water	Ounces per square inch	0.578
Inches of water	Pounds per square inch	5.2
Ounces per square inch	Inches of water	1.733
Pounds per square inch	Inches of water	27.72
Pounds per square inch	Feet of water	2.310
Feet of water	Pounds per square inch	0.434
Feet of water	Pounds per square foot	62.5
Long tons	Pounds	2240
Short tons	Pounds	2000
Long tons	Short tons	0.892857
Short tons	Metric tons	1.102
Metric tons	Short tons	0.907
Kilograms	Pounds	2.2046
U.S. gallon	Imperial gallon	0.833
Imperial gallon	U.S. gallon	1.2009

Decimal Equivalents

1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

Gauge Wall Thickness

BWG	Inches
20	.035
18	.049
16	.065
14	.083
12	.109
11	.120
10	.134
9	.148
8	.165
7	.180
6	.203
5	.220
4	.238
3	.259

Pipe Size Metric Conversion Table

Diameter

Nominal Size		Outside Diameter		Nominal Size		Outside Diameter	
Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches
6	1/8	10.3	0.405	350	14	355.6	14.000
8	1/4	13.7	0.540	400	16	406.4	16.000
10	3/8	17.1	0.675	450	18	457.2	18.000
15	1/2	21.3	0.840	500	20	508.0	20.000
20	3/4	26.7	1.050	550	22	558.8	22.000
25	1	33.4	1.315	600	24	609.6	24.000
32	1 1/4	42.2	1.660	650	26	660.4	26.000
40	1 1/2	48.3	1.900	700	28	711.2	28.000
50	2	60.3	2.375	750	30	762.0	30.000
65	2 1/2	73.0	2.875	800	32	812.8	32.000
80	3	88.9	3.500	850	34	863.6	34.000
90	3 1/2	101.6	4.000	900	36	914.4	36.000
100	4	114.3	4.500	950	38	965.2	38.000
125	5	141.3	5.563	1000	40	1016.0	40.000
150	6	168.3	6.625	1050	42	1066.8	42.000
200	8	219.1	8.625	1100	44	1117.6	44.000
250	10	273.0	10.750				
300	12	323.8	12.750				

Wall Thickness

Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches
1.73	.068	5.16	.203	8.74	.344	21.95	.864
2.24	.088	5.49	.216	9.27	.365	22.23	.875
2.31	.091	5.54	.218	9.53	.375	23.01	.906
2.41	.095	5.56	.219	10.31	.406	23.83	.938
2.77	.109	5.74	.226	10.97	.432	24.61	.969
2.79	.110	6.02	.237	11.07	.436	25.40	1.000
2.87	.113	6.35	.250	11.13	.438	26.19	1.031
2.90	.114	6.55	.258	11.91	.469	27.79	1.094
3.02	.119	7.01	.276	12.70	.500	28.58	1.125
3.07	.121	7.04	.277	14.02	.552	29.36	1.156
3.20	.126	7.09	.279	14.27	.562	30.96	1.219
3.38	.133	7.11	.280	15.09	.594	32.54	1.281
3.56	.140	7.14	.281	15.88	.625	33.32	1.312
3.68	.145	7.62	.300	16.66	.656	35.71	1.406
3.91	.154	7.80	.307	17.12	.674	38.10	1.500
3.96	.156	7.92	.312	17.48	.688	44.45	1.750
4.55	.179	8.08	.318	18.26	.719	50.80	2.000
4.78	.188	8.18	.322	19.05	.750		
4.85	.191	8.38	.330	20.62	.812		
5.08	.200	8.56	.337	21.44	.844		

Grades

CSA Grade 290 = API 5L x 42	CSA Grade 386 = API 5L x 56	CSA Grade 448 = API 5L x 65
CSA Grade 359 = API 5L x 52	CSA Grade 414 = API 5L x 60	CSA Grade 483 = API 5L x 70

Top Figure = Wall Thickness in Inches Bottom Figure = Weight Per Ft. in Pounds

Pipe Size	OD Inches	5		10				20			30		40	STD.		60	80	XH	100	120	140	160	XXH
1/8	.405	.035 .14		.049 .19									.068 .24	.068 .24			.095 .31	.095 .31					
1/4	.540	.049 .26		.065 .33									.088 .43	.088 .43			.119 .54	.119 .54					
3/8	.675	.049 .33		.065 .42									.091 .57	.091 .57			.126 .74	.126 .74					
1/2	.840	.065 .54		.083 .67									.109 .85	.109 .85			.147 1.09	.147 1.09				.187 1.31	.294 1.72
3/4	1.050	.065 .68		.083 .86									.113 1.13	.113 1.13			.154 1.48	.154 1.48				.218 1.94	.308 2.44
1	1.315	.065 .87		.109 1.41									.133 1.68	.133 1.68			.179 2.17	.179 2.17				.250 2.85	.358 3.66
1 1/4	1.660	.065 1.11		.109 1.81									.140 2.27	.140 2.27			.191 3.00	.191 3.00				.250 3.77	.382 5.22
1 1/2	1.900	.065 1.28		.109 2.09									.145 2.72	.145 2.72			.200 3.63	.200 3.63				.281 4.86	.400 6.41
2	2.375	.065 1.61		.109 2.64									.154 3.66	.154 3.66			.218 5.03	.218 5.03				.344 7.45	.436 9.04
2 1/2	2.875	.083 2.48		.120 3.53									.203 5.80	.203 5.80			.276 7.67	.276 7.67				.375 10.02	.552 13.71
3	3.500	.083 3.03		.120 4.34	.156 5.58	.188 6.66							.216 7.58	.216 7.58			.300 10.26	.300 10.26				.438 14.31	.600 18.60
3 1/2	4.00	.083 3.48		.120 4.98									.226 9.12	.226 9.12			.318 12.52	.318 12.52					.636 22.87
4	4.50	.083 3.92		.120 5.62	.156 7.24	.188 8.67							.237 10.80	.237 10.80		.281 12.67	.337 15.00	.337 15.00		.438 19.02		.531 22.53	.674 27.57
4 1/2	5.00													.247 12.55				.355 17.63					.710 32.56
5	5.563	.109 6.36		.134 7.78									.258 14.63	.258 14.63	.281 15.87		.375 20.80	.375 20.80		.500 27.06		.625 32.99	.750 38.59
6	6.625	.109 7.59		.134 9.30	.156 10.79	.188 12.94	.219 15.00		.250 17.04				.280 18.99	.280 18.99			.432 28.60	.432 28.60		.562 36.43		.718 45.39	.864 53.21
7	7.625													.301 23.57				.500 38.08					.875 63.14
8	8.625	.109 9.92		.148 13.41	.156 14.12	.188 16.96	.219 19.68	.250 22.38			.277 24.72		.322 28.58	.322 28.58	.344 30.45	.406 35.67	.500 43.43	.500 43.43	.594 50.91	.719 60.77	.812 67.82	.906 74.76	.875 72.49
9	9.625													.342 33.94				.500 48.77					
10	10.75	.134 15.21		.165 18.67	.188 21.23	.203 22.89	.219 24.65	.250 28.06	.279 31.23		.307 34.27	.344 38.27	.365 40.52	.365 40.52		.500 54.79	.594 64.39	.500 54.79	.718 77.10	.844 89.28	1.000 104.23	1.125 115.75	
11	11.75													.375 45.60				.500 60.13					
12	12.75	.165 22.20		.180 24.19	.188 25.25	.203 27.23	.219 29.34	.250 33.41	.281 37.46	.312 41.48	.330 43.81		.406 53.57	.375 49.61		.562 73.22	.688 88.71	.500 65.48	.844 107.30	1.000 125.61	1.125 139.81	1.312 160.42	
14	14.00		.219 32.26	.250 36.75				.312 45.65			.375 54.62		.438 63.50	.375 54.62		.593 84.99	.750 106.23	.500 72.16	.938 130.98	1.094 150.81	1.250 170.37	1.406 189.29	
16	16.00		.219 36.95	.250 42.09				.312 52.32	.344 57.57		.375 62.64		.500 82.85	.375 62.64		.656 107.60	.844 136.59	.500 82.85	1.031 164.98	1.219 192.47	1.438 223.71	1.594 245.34	
18	18.00			.250 47.44				.312 58.99			.437 82.23		.562 104.76	.375 70.65		.750 138.30	.938 171.08	.500 93.54	1.156 208.15	1.375 244.37	1.562 274.48	1.781 308.79	
20	20.00			.250 52.78		.312 65.66		.375 78.67			.500 104.23		.594 123.02	.375 78.67		.812 166.56	1.031 209.06	.500 104.23	1.281 256.15	1.500 296.65	1.750 341.41	1.969 379.36	
22	22.00			.250 58.13				.375 86.69			.500 114.92			.375 86.69		.875 197.60	1.125 251.05	.500 114.92	1.375 303.16	1.625 353.94	1.875 403.38	2.125 451.49	
24	24.00			.250 63.47	.312 79.01	.344 86.99		.375 94.71			.562 140.81		.688 171.45	.375 94.71		.969 238.33	1.219 296.63	.500 125.61	1.531 367.74	1.812 429.79	2.062 483.57	2.344 542.44	
26	26.00			.312 85.68				.500 136.30						.375 102.72				.500 136.30					
28	28.00			.312 92.35				.500 146.99			.625 182.90			.375 110.74				.500 146.99					
30	30.00		.250 79.51	.312 99.02				.500 157.68			.625 196.26			.375 118.76				.500 157.68					
32	32.00			.312 105.69				.500 168.37			.625 209.62		.688 230.29	.375 126.78				.500 168.37					
34	34.00			.344 123.77				.500 179.06			.625 222.99		.688 245.0	.375 134.79				.500 179.06					
36	36.00		.250 95.54	.312 119.03				.500 189.75			.625 236.5		.750 282.62	.375 142.81				.500 189.75					
42	42.00													.375 166.86				.500 221.82					
48	48.00													.375 190.92				.500 253.89					

*OTHER SIZES MAY BE AVAILABLE, PLEASE CALL WITH YOUR INQUIRIES. INFORMATION ALSO APPLIES TO SEAMLESS FOR STANDARD AND EXTRA HEAVY WALLS.

THIS CHART GIVES GENERAL INFORMATION ONLY AND IS NOT INTENDED FOR DESIGN.

THE FORMULA USED TO CALCULATE THE WEIGHT PER FOOT OF STEEL PIPE:

W = (D-T) x T x 10.69
D = OUTSIDE DIAMETER TO THREE DECIMAL PLACES
T = WALL THICKNESS TO THREE DECIMAL PLACES
W = WEIGHT PER FOOT

Pre-Packaged Lifts

DOMESTIC

STANDARD PIPE (Sch.40) Black or Galvanized
Plain End or Threaded & Coupled, 21 Foot Length

Size	Length of pipe	Pcs per Lift	Footage per Lift
1/8”	* 21’	30	630
1/4”	* 21’	24	504
3/8”	* 21’	18	378
1/2”	21’	132	2772
3/4”	21’	98	2058
1”	21’	65	1365
1-1/4”	21’	48	1008
1-1/2”	21’	39	819
2”	21’	28	588
2-1/2”	21’	18	378
3”	21’	14	294
3-1/2”	21’	11	231
4”	21’	10	210

EXTRA STRONG PIPE (Sch.80)
Black Plain End, 21 Foot Lengths

Size	Length of pipe	Pcs per Lift	Footage per Lift
1/8”	* 21’	30	630
1/4”	* 21’	24	504
3/8”	* 21’	18	378
1/2”	21’	96	2016
3/4”	21’	70	1470
1”	21’	50	1050
1-1/4”	21’	36	756
1-1/2”	21’	30	630
2”	21’	21	441
2-1/2”	21’	14	294
3”	21’	10	210
3-1/2”	21’	8	168
4”	21’	7	147

STANDARD PIPE (Sch.40)
10 Foot Length (Thread x Thread)

Size	Length of pipe	Pcs per Lift	Footage per Lift
1/2”	10’	130	1300
3/4”	10’	100	1000
1”	10’	65	650
1-1/4”	10’	50	500
1-1/2”	10’	45	450
2”	10’	30	300
2-1/2”	10’	20	200
3”	10’	10	100
4”	10’	10	100

STANDARD PIPE, API COUPLINGS (Sch.40)
Black Threaded & Coupled, 25 Foot Length

Size	Length of pipe	Pcs per Lift	Footage per Lift
1”	25’	60	1500
2”	25’	26	650
3”	25’	12	300
4”	25’	9	225

*Bundle Increments

IMPORT

STANDARD PIPE (Sch.40) Black or Galvanized
Plain End or Threaded & Coupled, 21 Foot Length

Size	Length of pipe	Pcs per Lift	Footage per Lift
1/2”	21’	120	2520
3/4”	21’	84	1764
1”	21’	60	1260
1-1/4”	21’	42	882
1-1/2”	21’	36	756
2”	21’	26	546
2-12”	21’	18	378
3”	21’	14	294
4”	21’	10	210

EXTRA STRONG PIPE (Sch.80)
Black Plain End, 21 Foot Length

Size	Length of pipe	Pcs per Lift	Footage per Lift
1/2”	21’	120	2520
3/4”	21’	84	1764
1”	21’	60	1260
1-1/4”	21’	42	882
1-1/2”	21’	36	756
2”	21’	26	546

THREADED & COUPLED, API COUPLINGS (Sch.40)
Black, 25 Foot Length

Size	Length of pipe	Pcs per Lift	Footage per Lift
1”	25’	60	1500
2”	25’	26	650
3”	25’	13	325
4”	25’	9	225

Weight and Load Chart

Normal Size	Wall	Schedule	Pipe Weight per Foot	Footage per Truckload Bare		Footage per Truckload Fusion Bond Coated	
				Pyramid	Strip	Pyramid	Strip
2"	0.154	40/STD	3.66	12,307	12,307	12,054	12,054
2"	0.218	80/XH	5.03	8,952	8,952	8,817	8,817
2"	0.343	160	7.45	6,040	6,040	5,978	5,978
2½"	0.203	40/STD	5.80	7,761	7,761	7,638	7,638
2½"	0.276	80/XH	7.67	5,868	5,868	5,798	5,798
2½"	0.375	160	10.02	4,490	4,490	4,449	4,449
3"	0.156		5.58	8,069	8,069	7,909	7,909
3"	0.188		6.66	6,761	6,761	6,648	6,648
3"	0.216	40/STD	7.58	5,934	5,934	5,847	5,847
3"	0.300	80/XH	10.26	4,385	4,385	4,337	4,337
3"	0.438	160	14.34	3,139	3,139	3,114	3,114
3½"	0.226	40/STD	9.12	4,935	4,935	4,867	4,867
3½"	0.318	80/XH	12.52	3,595	3,595	3,559	3,559
4"	0.156		7.24	6,212	6,212	6,090	6,090
4"	0.188		8.67	5,193	5,193	5,107	5,107
4"	0.237	40/STD	10.80	4,166	4,166	4,111	4,111
4"	0.337	80/XH	15.00	3,001	3,001	2,972	2,972
4"	0.438	120	19.02	2,366	2,366	2,348	2,348
4½"	0.247	STD	12.55	3,586	3,586	3,545	3,545
4½"	0.355	XH	17.63	2,553	2,553	2,532	2,532
5"	0.258	40/STD	14.63	3,076	3,076	3,037	3,037
5"	0.375	80/XH	20.80	2,164	2,164	2,145	2,145
6"	0.156		10.79	3,780	4,171	3,780	4,090
6"	0.188		12.94	3,479	3,479	3,422	3,422
6"	0.219		15.00	3,001	3,001	2,958	2,958
6"	0.250		17.04	2,641	2,641	2,609	2,609
6"	0.280	40/STD	18.99	2,369	2,369	2,343	2,343
6"	0.432	80/XH	28.60	1,573	1,573	1,562	1,562
6"	0.562	120	36.43	1,235	1,235	1,228	1,228
8"	0.156		14.12	2,268	3,186	2,268	3,125
8"	0.188		16.96	2,268	2,654	2,268	2,611
8"	0.219		19.68	2,268	2,287	2,255	2,255
8"	0.250	20	22.38	2,011	2,011	1,986	1,986
8"	0.277	30	24.72	1,820	1,820	1,800	1,800
8"	0.322	40/STD	28.58	1,575	1,575	1,559	1,559
8"	0.500	80/XH	43.43	1,036	1,036	1,030	1,030
8"	0.594	100	51.00	882	882	878	878
10"	0.188		21.23	1,470	2,120	1,470	2,086
10"	0.219		24.65	1,470	1,825	1,470	1,800
10"	0.250	20	28.06	1,470	1,604	1,470	1,584
10"	0.279		31.23	1,441	1,441	1,425	1,425
10"	0.307	30	34.27	1,313	1,313	1,300	1,300
10"	0.365	40/STD	40.56	1,111	1,111	1,101	1,101
10"	0.500	60/XH	54.79	821	821	816	816
10"	0.594	80	64.49	698	698	694	694

Above calculations are based upon the following:
1. Loading 45,000#/s maximum/truck.
2. Trailer width of 96" (some trailers are 102").
3. The maximum load height is 13'6".
4. The pipe and coating weights are theoretical. Please verify for each industry requirement.

Normal Size	Wall	Schedule	Pipe Weight per Foot	Footage per Truckload Bare		Footage per Truckload Fusion Bond Coated	
				Pyramid	Strip	Pyramid	Strip
12"	0.188		25.25	1,134	1,782	1,134	1,754
12"	0.219		29.34	1,134	1,534	1,134	1,513
12"	0.250	20	33.41	1,134	1,347	1,134	1,331
12"	0.281		37.46	1,134	1,201	1,134	1,188
12"	0.312		41.48	1,085	1,085	1,074	1,074
12"	0.330	30	43.81	1,027	1,027	1,018	1,018
12"	0.375	STD	49.61	907	907	900	900
12"	0.406	40	53.57	840	840	834	834
12"	0.500	XH	65.48	687	687	683	683
12"	0.562	60	73.22	615	615	611	611
12"	0.688	80	88.71	507	507	505	505
14"	0.188	10	27.76	840	1,512	840	1,512
14"	0.219		32.26	840	1,395	840	1,376
14"	0.250	10	36.75	840	1,225	840	1,210
14"	0.312	20	45.65	840	986	840	976
14"	0.375	30/STD	54.62	824	824	817	817
14"	0.438	40	63.50	709	709	704	704
14"	0.500	XH	72.16	624	624	620	620
14"	0.594	60	85.13	529	529	526	526
16"	0.219		36.95	840	1,218	840	1,201
16"	0.250	10	42.09	840	1,069	840	1,056
16"	0.281		47.22	840	953	840	943
16"	0.312	20	52.32	840	860	840	852
16"	0.375	30/STD	62.64	718	718	713	713
16"	0.500	40/XH	82.85	543	543	540	540
16"	0.656	60	107.60	418	418	416	416
18"	0.250	10	47.44	588	840	588	937
18"	0.312	20	58.99	588	763	588	755
18"	0.375	STD	70.65	588	637	588	632
18"	0.500	XH	93.54	481	481	478	478
18"	0.562	40	104.76	430	430	427	427
18"	0.750	60	138.30	325	325	324	324
20"	0.250	10	52.78	588	840	588	842
20"	0.312		65.66	588	685	588	679
20"	0.375	20/STD	78.67	572	572	567	567
20"	0.500	30/XH	104.23	432	432	429	429
20"	0.594	40	123.23	365	365	363	363
20"	0.750		154.34	292	292	290	290
22"	0.250	10	58.13	378	672	378	672
22"	0.375	20/STD	86.69	378	519	378	515
22"	0.500	30/XH	114.92	378	392	378	389
22"	0.688	40	156.74	287	287	286	286
22"	0.750		170.37	264	264	263	263
24"	0.250	10	63.47	378	504	378	504
24"	0.312		79.04	378	504	378	504
24"	0.375	20/STD	94.71	378	475	378	475
24"	0.500	XH	125.61	358	358	378	358
24"	0.562	30	140.81	320	320	320	320
24"	0.688	40	171.45	262	262	262	262
24"	0.750		186.41	241	241	241	241

Normal Size	Wall	Schedule	Pipe Weight per Foot	Footage per Truckload Bare		Footage per Truckload Fusion Bond Coated	
				Pyramid	Strip	Pyramid	Strip
26"	0.375		102.72	200'	360'	200'	360'
26"	0.500		136.30	200'	320'	200'	320'
26"	0.625		169.54	200'	240'	200'	240'
26"	0.750		202.25	200'	200'	200'	200'
26"	1.000		267.25	200'	160'	200'	160'
28"	0.375		110.74	200'	360'	200'	360'
28"	0.500		147.00	200'	280'	200'	280'
28"	0.625		182.70	200'	240'	200'	240'
28"	0.750		218.48	200'	200'	200'	200'
28"	1.000		288.63	160'	160'	160'	160'
30"	0.250		79.51	200'	360'	200'	360'
30"	0.312		99.02	200'	360'	200'	360'
30"	0.375		118.77	200'	360'	200'	360'
30"	0.406		128.43	200'	360'	200'	360'
30"	0.429		135.61	200'	320'	200'	320'
30"	0.500		157.68	200'	280'	200'	280'
30"	0.625		196.33	200'	200'	200'	200'
30"	0.688		215.58	200'	200'	200'	200'
30"	0.750		234.51	200'	200'	200'	200'
30"	0.877		274.00	160'	160'	160'	160'
30"	1.500		456.99	80'	80'	80'	80'
32"	0.375		126.78	200'	240'	200'	240'
32"	0.500		168.37	200'	240'	200'	240'
34"	0.375		79.06	120'	160'	120'	160'
34"	0.500		134.80	120'	160'	120'	160'
36"	0.375		142.81	120'	160'	120'	160'
36"	0.500		189.57	120'	160'	120'	160'
36"	0.529		200.59	120'	160'	120'	160'
36"	0.625		236.35	120'	160'	120'	160'
36"	0.750		282.62	120'	160'	120'	160'
36"	1.000		374.15	120'	120'	120'	120'
36"	1.500		553.21	80'	80'	80'	80'
40"	0.375		158.85	120'	160'	120'	160'
40"	0.500		211.13	120'	160'	120'	160'
42"	0.375		166.86	120'	160'	120'	160'
42"	0.486		215.68	120'	160'	120'	160'
42"	0.500		221.82	120'	160'	120'	160'
42"	0.625		276.44	120'	160'	120'	160'
42"	0.750		330.71	120'	120'	120'	120'
42"	0.888		390.26	80'	80'	80'	80'
42"	1.000		438.29	80'	80'	80'	80'
42"	1.500		649.42	40'	40'	40'	40'
48"	0.375		190.89	120'	160'	120'	160'
48"	0.500		253.89	120'	160'	120'	160'
48"	0.688		347.97	120'	120'	120'	120'
48"	0.750		378.83	120'	120'	120'	120'
48"	1.000		502.43	80'	80'	80'	80'
48"	1.500		745.63	40'	40'	40'	40'

Types of Coating

Extruded Polyethylene Coating

X-tru coat corrosion protection pipe coating is a tough, resilient plastic, of a high-density polyethylene or polypropylene, tightly bonded to the pipe by a flexible bituminous mastic effectively eliminating moisture and oxygen, migration and permeation, respectively.

Cathodic disbondment is minimized resulting in reduced cathodic protection costs. It stays just as strong, just as flexible, impermeable and unaffected by contaminants throughout its entire range. Polypropylene is available for high temperature applications. The approximate maximum operating temperature for polyethylene is 165°F*, and 190°F* for polypropylene.

Fusion Bonded Epoxy

FBE coatings are made with thermosetting epoxy based powders. Properly applied to the preheated pipe, the powder melts, flows, and bonds to form a continuous corrosion-resistant coating to the steel substrate. Because the coating is a thermosetting epoxy, its inherent durability and flexibility give it excellent resistance to damage and ultra-violet ray deterioration under normal transportation or storage conditions. Fusion bonded epoxy is an economical, efficient and effective method of extending the life of steel line pipe. The approximate maximum operating temperature is 200°F*.

Pipe Clad 2040

Pipe Clad 2040 is a super durable protective coating that is applied over a Fusion Bonded Epoxy (FBE) corrosion coating. It is used in applications where coating flexibility is not a major design consideration. Pipe Clad 2040 is formulated to have proper reactivity for optimum cure on both large and small diameter pipe. The Pipe Clad 2040 powder undergoes a chemical reaction when heated during the controlled application process. The resulting thermoset polymer structure provides optimum corrosion protection, and protection against mechanical damage during pipe storage, transportation, construction, and underground pipeline service conditions.

Pipe Clad 2040's durability and high degree of scrape and mar resistance allows consideration for use in specialty applications, such as horizontal directional bores and impingement concrete applications (e.g., road crossings, road bores and river crossings). It also improves resistance to loss of adhesion in wet, elevated temperature environments. Under dry conditions, Pipe Clad 2040 withstands operating temperatures up to 250°F*.

Powercrete

Powercrete is an epoxy based polymer concrete. Its main purpose is to protect the fusion bonded epoxy coating on steel pipe under severe handing conditions. The highly abrasion resistant Powercrete provides a smooth surface that allows the pipeline to be pulled under the crossing in a "slick bore" operation with much less drag resistance than conventional concrete. It can also be used as a rockshield.

Pritec

Pritec® is a dual side extrusion application, butyl/polyethylene coating that combines a special butyl rubber adhesive with a tough, impervious, high-density polyethylene. Applied in overlapping films, they create a protective barrier that is not only superior in its impact, abrasion, ductility and bonding properties, but one that shrugs off almost every environmental contaminant and actually has the ability to "heal" small cuts and gouges in its surfaces. The approximate maximum operating temperature is 180°F*.

Synergy

The Synergy Pipeline Coating System is composed of three specially engineered, co-dependent layers: a high tack adhesive primer, a crosslinked elastomer inner layer, and a polyolefin outer layer. The layers are thermally fused into a composite coating that provides proven performance-superior resistance to soil stress, cathodic disbondment, and mechanical damage, along with excellent bendability. The Synergy system is white in color and 50 Mils in thickness. The approximate maximum operating temperature is 180°F*.

TGF III or TF III

EP-10 Epoxy-Enamel TGF-3: The EP-10 Coating System consists of an epoxy primer combined with $^{3}/_{32}$" of a High Operating Temperature Coal Tar Enamel together with an innerlayer of fiberglass, an outerlayer of coal tar saturated fiberglass outerwrap and an outerlayer of kraft paper. The EP-10 gives the superior bonding of an epoxy, the water resistance of coal tar enamel, and the operational temperature capability of far more costly hybrid systems. The EP-10 can withstand operating temperatures of up to 230°F*.

Three Layer Coatings

This three-layer system combines the best features of fusion bonded epoxy and stabilized polyethylene or polypropylene.

- A fusion bonded epoxy primer bonds the steel to the adhesive layer.
- The copolymer adhesive tightly bonds to the outer polyethylene/polypropylene coating.
- The fully stabilized coating, with all the outstanding mechanical properties of either polyethylene or polypropylene, yields optimal corrosion protection.
- This superior 3-layer system is so tough, it exceeds the specified DIN-values—maintaining the integrity of the pipe during handling, storage, and pipeline construction.

***Approximate maximum operating temperature may vary depending on application.**

Types of Coating (cont.)

Three Layer Coatings (cont.)

• Three-layer polyethylene/polypropylene systems provide particularly high resistance against diffusion and disbonding, even under extreme conditions of corrosion, elevated temperatures up to 230ºF (dependent on system) and cathodic protection.

YG III

The YGIII system is a highly effective anti-corrosion system for in-ground pipelines. Its primary components are a primer, anti-corrosion innerwrap and multiple layers of outerwrap. The complete YGIII system provides maximum mechanical protection during transportation, handling and installation. The approximate maximum operating temperature is 150°F.

Concrete Coating

Plant-applied concrete coating. With this coating you may specify slogging, crack inducers, buckle arresters and sacrificial anodes.

• Densities lesser or greater than the normal range of 140 to 190 pounds/cubic floor (PCF) bases on available aggregates.
• Thicknesses from 1 to 9 inches.
• Reinforcement-welded steel cages-welded wire mesh-galvanized wire-fabricated and placed to specification.
• Concrete core compressive strengths from 3,000 to 6,000 psi.
• Application over polyethylene, fusion bonded epoxy, or polyurethane insulated pipe.

Spray Foam Insulation

Hot and cold service pipelines require special engineering and economic considerations. Today, use of plant-applied polyurethane foam insulation is the most widely accepted, and most economical technique for controlling heat transfer in above or below ground pipelines.

Coating Weights

Theoretical Coating Weights/100 L.F.								
Nominal Pipe Size	Actual O.D.	Fusion Bonded 15 Mils	Pritec 50 Mils	X-Tru Std.	Multi-Layer 60 Mils	Synergy	TGF	PowerCrete 30 mils
2	2.375	7.7	16	13		17.00	57.00	25.00
2½	2.875	9.3	19	16		22.60	69.00	30.00
3	3.5	11.3	24	22		28.00	84.00	37.00
4	4.5	14.5	30	28	44.5	35.00	108.00	47.00
6	6.625	21.4	44	45	65.5	51.00	157.00	69.00
8	8.625	27.8	58	59	85.3	67.00	204.00	90.00
10	10.75	34.7	72	73	106.3	84.00	254.00	113.00
12	12.75	41.1	85	87	126	100.00	300.00	134.00
14	14	45.1	93	96	138.4	110.00	329.00	147.00
16	16	51.6	106	110	158.2	125.00	377.00	168.00
18	18	58	120	144	177.9	141.00	424.00	188.00
20	20	64.5	133	160	197.7	157.00	469.00	209.00
24	24	77.4	160		237.3	188.00	563.00	251.00
26	26	83.8	173		257	210.00	611.00	272.00
30	30	96.7	199		296.6	235.00	704.00	314.00
36	36	116.1	239		355.2	282.00	847.00	377.00
42	42	135.4	278		415.2	330.00	986.00	440.00

Weights & Conversions

Square Footage Conversion					
Size	SqFt/LFt	Size	SqFt/LFt	Size	SqFt/LFt
2"	0.622	12"	3.338	26"	6.807
2½"	0.753	14"	3.665	28"	7.330
3"	0.916	16"	4.189	30"	7.854
4"	1.178	18"	4.712	36"	9.425
6"	1.734	20"	5.236	40"	10.472
8"	2.258	22"	5.760	42"	10.996
10"	2.814	24"	6.283	48"	12.566

Concrete Coating Weights & Formulas

Concrete Coating Thickness	Weight Of Concrete Coating Per Linear Foot Of Pipe*																		
	O.D. Pipe Size																		
	4½"	6⅝"	8⅝"	10¾"	12¾"	14"	16"	18"	20"	22"	24"	26"	30"	32"	34"	36"	38"	40"	42"
1"	17	24	30	37															
1¼"	22	31	39	47															
1½"	28	38	47	57															
2"	40	54	66	80	92	100	112	125	137	150	162	175	200	212	225	237	250	262	275
2¼"					105	114	128	142	156	170	184	198	226	240	254	268	283	297	311
2½"					119	129	144	160	175	191	207	222	253	269	285	300	316	331	347
2¾"					133	144	161	178	195	212	229	247	281	298	315	332	350	367	384
3"					147	159	178	197	215	234	253	271	309	328	346	365	384	402	421
3¼"					162	175	195	215	236	256	276	297	337	357	378	398	418	438	459
3½"					177	191	213	235	257	278	300	322	366	388	409	431	453	475	497
3¾"					193	208	231	254	278	301	325	348	395	418	442	465	488	512	535
4"					209	225	250	275	299	324	349	375	424	449	474	499	524	549	574

*Above weights are based on the industry standard of 145#/cu.ft.

Calculation of Concrete Pipe Coating

Procedure:

1. Read the volume displaced and weight of your pipe and the mud density. Calculate Upward Buoyancy = Volume Displaced x Mud Density and Net Buoyancy = Upward Buoyancy — Weight Pipe
2. Read the weight of concrete in your mud. Calculate:

$$\text{Weight Concrete/Ft. Pipe} = \frac{\text{Net Buoyancy}}{(\text{Wt. Concrete in Mud}) \times 143}$$

Select Concrete Coating Thickness.

$$\text{Yards Concrete} = \frac{(\text{Weight Concrete/Ft. Pipe}) \times \text{Length Pipe (Ft.)}}{3861}$$

(Note: All calculations based on 143#/cu. ft. or 3861#/cu. yd. concrete)

Example:

36" O.D. Pipe

0.375" Wall

2000' crossing with 1.25 specific gravity mud

Volume Displaced = 7.069 Cubic Feet

Weight = 142.68

1.25 Sp. Gr. Mud Density = 78

Upward Buoyancy = 7.069 x 78 = 551.4

Net Buoyancy = 551.4 - 142.73 = 408.7

Concrete Weight in 1.25 Specific Gravity Mud = 65

Weight Concrete/Ft. Pipe = 408.7 x 143/65 = 899

Select 6¾" Coating Thickness

Weight of 6¾" Coating = 900#/Ft.

Yards Concrete = 900 x 2000/3861 = 466 Cubic Yards

Galvanizing

Hot-Dipped Galvanized Pipe

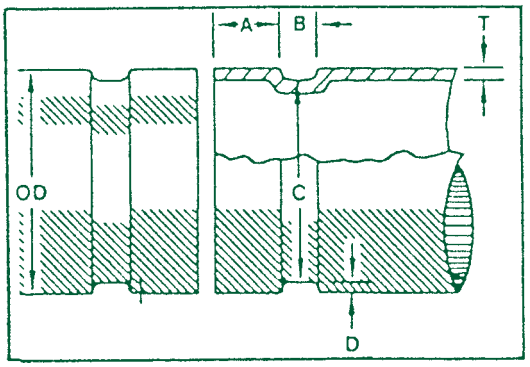
The average weight of zinc coating shall be not less than 1.8 oz. per sq. ft. of surface (inside and outside) as detailed in ASTM specification A53.

When galvanized pipe is bent, roll grooved or otherwise fabricated to a degree which causes zinc coating to stretch or compress beyond the limit of elasticity, some flaking of the coating may occur.

Grooving

Roll Grooved Pipe

Roll grooving removes no metal, cold forming a groove by the action of an upper male roll being forced into the pipe as it is rotated by a lower female drive roll. Roll groove configuration has rounded edges which reduce the available pipe end movement (expansion, contraction and deflection) to one-half of the amount shown for a standard cut groove. **Note: It is common practice to leave the bevels on when roll grooving.**



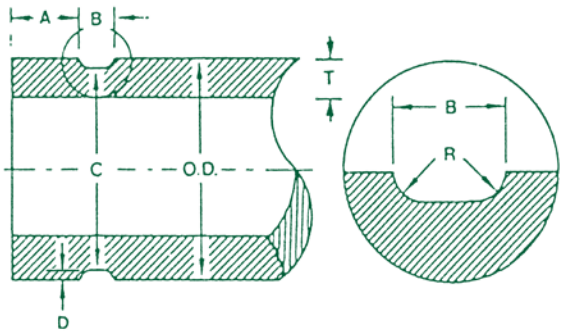
Standard Roll Groove Specifications For Steel Pipe

Nominal Pipe Size Inches	Pipe Outside Diameter O.D.			Gasket Seat A ±0.03	Groove Width B ±0.03	Groove Diameter C		Groove Depth D (ref.)	Min. Allow. Wall Thick. T Max.	Allow. Flare Dia.
	Basic	Tolerance				Basic	Tolerance			
2	2.375	+0.024	-0.024	0.625	0.344	2.250	-0.015	0.063	0.065	2.48
2½	2.875	+0.029	-0.029	0.625	0.344	2.720	-0.018	0.078	0.083	2.98
3	3.500	+0.035	-0.031	0.625	0.344	3.344	-0.018	0.078	0.083	3.60
3½	4.000	+0.040	-0.031	0.625	0.344	3.834	-0.020	0.083	0.083	4.10
4	4.500	+0.045	-0.031	0.625	0.344	4.334	-0.020	0.083	0.083	4.60
5	5.563	+0.056	-0.031	0.625	0.344	5.395	-0.022	0.084	0.109	5.66
6	6.625	+0.063	-0.031	0.625	0.344	6.455	-0.022	0.085	0.109	6.73
8	8.625	+0.063	-0.031	0.750	0.469	8.441	-0.025	0.092	0.109	8.80
10	10.750	+0.063	-0.031	0.750	0.469	10.562	-0.027	0.094	0.134	10.92
12	12.750	+0.063	-0.031	0.750	0.469	12.531	-0.030	0.109	0.156	12.92
14 O.D.	14.000	+0.063	-0.031	0.938	0.469	13.781	-0.030	0.109	0.156	14.10
16 O.D.	16.000	+0.063	-0.031	0.938	0.469	15.781	-0.030	0.109	0.165	16.10
18 O.D.	18.000	+0.063	-0.031	1.000	0.469	17.781	-0.030	0.109	0.165	18.16
20 O.D.	20.000	+0.063	-0.031	1.000	0.469	19.781	-0.030	0.109	0.188	20.16
24 O.D.	24.000	+0.063	-0.031	1.000	0.500	23.656	-0.030	0.172	0.218	24.20

Grooving (cont.)

Cut Grooved Pipe

Cut grooving standard steel pipe removes less metal, to less depth, than threading, maintaining the designed integrity of the pipe.



Standard Cut Groove Specifications For Steel Pipe

Nominal Pipe Size Inches	Pipe Outside Diameter O.D.			Gasket Seat A ±0.03	Groove Width B ±0.03	Groove Diameter C		Groove Depth D (ref.)	Min. Allow. Wall Thick. T
	Basic	Tolerance				Basic	Tolerance		
2	2.375	+0.024	-0.024	0.625	0.313	2.250	-0.015	0.063	0.154
2 1/2	2.875	+0.029	-0.029	0.625	0.313	2.720	-0.018	0.078	0.188
3	3.500	+0.035	-0.031	0.625	0.313	3.344	-0.018	0.078	0.188
3 1/2	4.000	+0.040	-0.031	0.625	0.313	3.834	-0.020	0.083	0.188
4	4.500	+0.045	-0.031	0.625	0.375	4.334	-0.020	0.083	0.203
5	5.563	+0.056	-0.031	0.625	0.375	5.395	-0.022	0.084	0.203
6	6.625	+0.063	-0.031	0.625	0.375	6.455	-0.022	0.085	0.219
8	8.625	+0.063	-0.031	0.750	0.438	8.441	-0.025	0.092	0.238
10	10.750	+0.063	-0.031	0.750	0.500	10.562	-0.027	0.094	0.250
12	12.750	+0.063	-0.031	0.750	0.500	12.531	-0.030	0.109	0.279
14 O.D.	14.000	+0.063	-0.031	0.938	0.500	13.781	-0.030	0.109	0.281
16 O.D.	16.000	+0.063	-0.031	0.938	0.500	15.781	-0.030	0.109	0.312
18 O.D.	18.000	+0.063	-0.031	1.000	0.500	17.781	-0.030	0.109	0.312
20 O.D.	20.000	+0.063	-0.031	1.000	0.500	19.781	-0.030	0.109	0.312
24 O.D.	24.000	+0.063	-0.031	1.000	0.563	23.656	-0.030	0.172	0.375

Threading

Threads:

Pipe threads for general purpose applications are covered by an American National Standard ***Pipe Threads, General Purpose (INCH) ANSI/ASME B1.20.0***. Threads for Line Pipe are covered by an American Petroleum Institute Standard ***API Specification 5B***. The thread form, number of threads per inch and other thread dimension details are shown in the drawings and tables which follow. Dimensions for grooving pipe ends to be used with Victaulic Couplings are also included.

Couplings

Pipe Couplings for general purpose applications are covered by ASTM Standard A865-86 ***Threaded Couplings, Steel, Black or Zinc Coated (Galvanized), Welded or Seamless, for use in Steel Pipe Joints***. The normal practice is to utilize non-recessed straight tapped (NPSC threads) couplings with standard weight pipe for trade sizes 1/8" through 2" and taper tapped (NPT Thread) Non-Recessed Couplings with standard weight pipe for trade sizes 2 1/2" through 6". The specifications for the coupling threads are covered in the American National Standard ***Pipe Threads General Purpose (INCH) ANSI/ASME B1.20.1***.

Taper Tapped Couplings (non-recessed) may be specified for pipe trade sizes 2" and under. It is normal practice to utilize Taper Tapped (NPT threads) Recessed Couplings for Extra-Strong and Double-Extra-Strong pipe in all trade sizes, and for standard pipe in trade sizes 8" and larger. The Taper Tapped (NPT) Recessed Couplings are the same as those for Line Pipe and are covered by the American Petroleum Institute Standard ***API Specifications 5L***.

Line Pipe Couplings are approximately 30 percent longer than merchant couplings and with the exception of the 1 1/4", 2", 2 1/2" and 4" trade sizes, have the same outside diameters. Line Pipe Couplings are recessed for two purposes. The recess helps to center the pipe in the coupling and guides it into the threads. The recess also covers the incomplete threads on the pipe created by the taper of the threads and thereby minimizes corrosion at that point. The specifications for Line Pipe Couplings are covered in the American Petroleum Institute specification ***API Specification 5L***.

Table 2 Coupling Thread Dimension—Straight-Tapped (NPSC) for Standard Weight Pipe

NPS	Threads/in.	Outside diameter, in. *W*	Coupling min length, in. *NL*	Pitch diameter, in.	
				min	max
1/8	27	0.563	3/4	0.370	0.377
1/4	18	0.719	1 1/8	0.486	0.497
3/8	18	0.875	1 1/8	0.622	0.632
1/2	14	1.063	1 1/2	0.772	0.785
3/4	14	1.313	1 9/16	0.982	0.996
1	11 1/2	1.576	1 5/16	1.231	1.247
1 1/4	11 1/2	1.900	2	1.575	1.592
1 1/2	11 1/2	2.200	2	1.814	1.831
2	11 1/2	2.750	2 1/16	2.288	2.304
Outside diameter tolerances:			For sizes 1 1/2 and under	+0.015	-0.031 in.
			2 in. and over	±1%	

Threading (cont.)

Table 3 Coupling Thread Dimensions—Taper-Tapped (NPT) Non-Recessed for Standard Weight Pipe

NPS	Threads/in.	Outside diameter, in. *W*	Coupling min length, in. *NL*	Pitch diameter, in. (E_1) Handtight engagement
1/8	27	0.563	3/4	0.3736
1/4	18	0.719	1 1/8	0.4916
3/8	18	0.875	1 1/8	0.6270
1/2	14	1.063	1 1/2	0.7784
3/4	14	1.313	1 9/16	0.9889
1	11 1/2	1.576	1 15/16	1.2386
1 1/4	11 1/2	1.900	2	1.5834
1 1/2	11 1/2	2.200	2	1.8223
2	11 1/2	2.750	2 1/16	2.2963
2 1/2	8	3.250	3 1/16	2.7622
3	8	4.000	3 3/16	3.3885
3 1/2	8	4.625	3 5/16	3.8888
4	8	5.000	3 7/16	4.3871
5	8	6.296	3 11/16	5.4493
6	8	7.390	3 15/16	6.5060
Outside diameter tolerances:		For sizes 1 1/2 and under	+0.015	-0.031 in.
		2 in. and over	±1%	

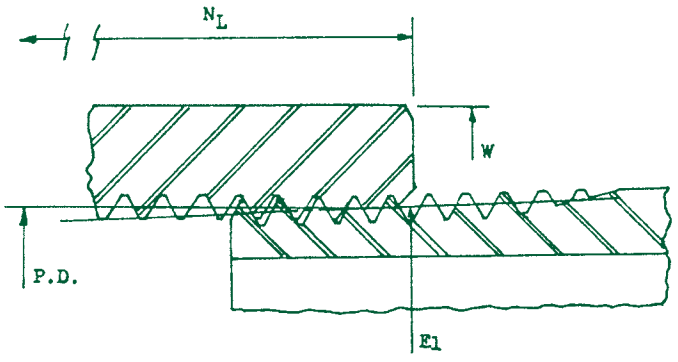


FIG. 1 Straight-Tapped Coupling and Pipe
(See Table 2 for Coupling Dimensions)

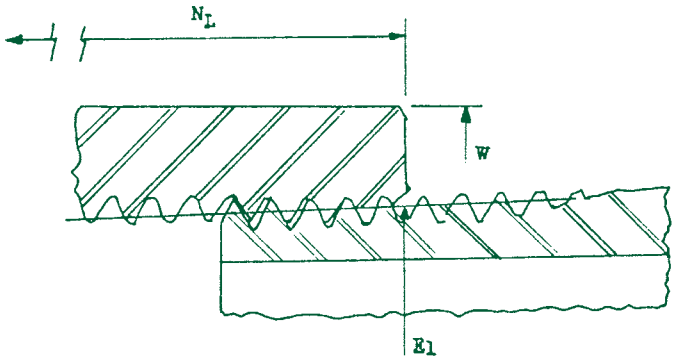


FIG. 2 Nonrecessed Taper-Tapped Coupling and Pipe
(See Table 3 for Coupling Dimensions)

Threading (cont.)

Table 4 Coupling Thread Dimensions—Taper-Tapped (NPT) Recessed for Extra-Strong and Double-Extra-Strong Pipe (Dimensions conform to Line Pipe Couplings in accordance with API 5L)[A]

NPS	Threads/in.	Outside diameter, in. *W*	Coupling min length, in. *NL*	Pitch diameter, in. (E_1) Handtight engagement
1/8	27	0.563	1 1/16	0.3736
1/4	18	0.719	1 5/8	0.4916
3/8	18	0.875	1 5/8	0.6270
1/2	14	1.063	2 1/8	0.7784
3/4	14	1.313	2 1/8	0.9889
1	11 1/2	1.576	2 5/8	1.2386
1 1/4	11 1/2	1.900	2 3/4	1.5834
1 1/2	11 1/2	2.200	2 3/4	1.8223
2	11 1/2	2.750	2 7/8	2.2963
2 1/2	8	3.250	4 1/8	2.7622
3	8	4.000	4 1/4	3.3885
3 1/2	8	4.625	4 3/8	3.8888
4	8	5.000	4 1/2	4.3871
5	8	6.296	4 5/8	5.4493
6	8	7.390	4 7/8	6.5060
8	8	9.625	5 1/4	8.5000
10	8	11.750	5 3/4	10.6209
12	8	14.000	6 1/8	12.6178
14	8	15.000	6 3/8	13.8726
16	8	17.000	6 3/4	15.8758
18	8	19.000	7 1/8	17.8750
20	8	21.000	7 5/8	19.8703
Outside diameter tolerances:		For sizes 1 1/2 and under	+0.015	-0.031 in.
		2 in. and over	±1%	
Stand off tolerances:		±1 thread		

The Zap-Lok Connection®

The Zap-Lok joint is a widely used mechanical interference joint for pipeline use. The joint has pressure, mechanical and fatigue strength suitable for the same service as welded butt joints.

Typical applications include gathering and distribution systems, transmission lines and specialized pipe installations. Thousands of miles of pipe have been joined, using the Zap-Lok process under a wide range of operating conditions. Zap-Lok pipe joining machines have performed on virtually every type of terrain, under severe weather conditions and in hostile environments. They have been used to install portions of offshore pipeline systems and in joining both internally and externally coated pipe.

The basic concept of the Zap-Lok process is relatively simple. A bell, or expanded area, is formed on one end of a joint of pipe, and a groove is formed on the opposite end. Both end-forming operations are accomplished with a hydraulic joining unit and a hydraulic groover, respectively, operated by hydraulic power units. These end preparations are automatically controlled to specifications required for the Zap-Lok joint. The belled end of one length of pipe and grooved end of another are forced together with a thin coating of Zapoxy serving as a lubricant. The resulting joint is a mechanical connection, with an Zapoxy “O” ring seal. The Zap-Lok joint is made cold and formed from the pipe itself. A Zap-Lok joint cross section is shown in Figure1.
The Zap-Lok process produces strong, permanent joints which can be used in the same pressure service as welded lines. This allows the pipeline system design to be based on 100% joint strength. Extensive independent evaluations under varied laboratory test conditions and in-service performance records have proven the Zap-Lok joint to be strong, reliable and leakproof.

Pipe ends can be belled and grooved at the pipe mill or at the pipe yard, and then joined by a hydraulic Zap-Lok unit in the field.

The Zap-Lok method of joining pipe complies with Section 192.273 of the United States Department of Transportation Pipeline Safety Standards, the requirements of ASME codes B31.4 and B31.8.

The Zap-Lok method is recognized by several state regulatory and pipeline controlling bodies in the United States and Canada and thousands of miles of Zap-Lok pipelines have been installed in North America to the requirements of these regulators.

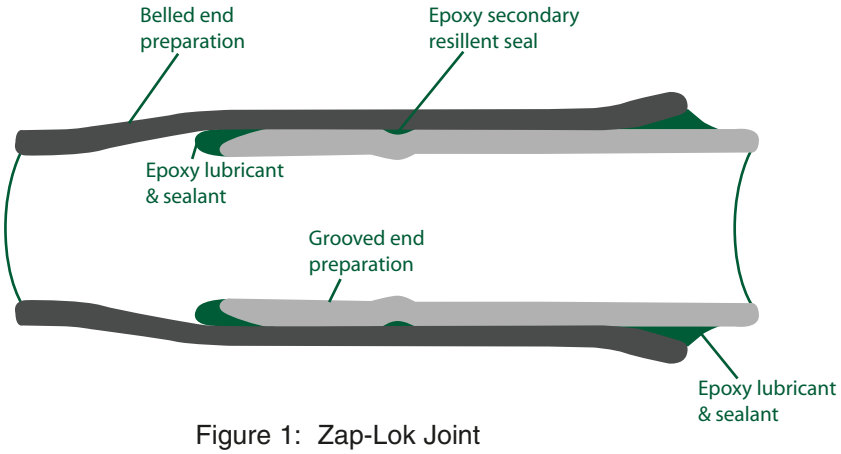


Figure 1: Zap-Lok Joint

Glossary of Terms

ALLOY STEEL - Steel is commercially classified as alloy when the maximum of the range given for the content of alloying elements exceeds one or more of the following: manganese, 1.65%; silicon, 0.60%; copper, 0.60%; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, boron, chromium up to 3.99%, cobalt, columbium, molybendum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying element added to obtain a desired alloying effect.

ALLOYING ELEMENTS - Chemical elements added for improving the properties of the finished products. Chief alloying elements in medium alloy steels are: nickel, chromium, manganese, molybdenum, vanadium, silicon, copper.

ANNEALING - A process involving heating of steel to above the critical temperature. Usually applied to induce softening. The term also refers to treatments intended to alter mechanical or physical properties, produce a definite microstructure, or remove gases. Desired properties of the steel are developed by controlling the cooling rate.

API - American Petroleum Institute.

ANSI - American National Standards Institute. Formerly the ASA American Standards Association.

ASME - American Society of Mechanical Engineers.

ASTM - American Society for Testing Materials.

AWWA - American Water Works Association.

BEND TEST - Various tests used to determine the ductility of sheet, plate or tubulars that are subjected to bending. These tests may include determination of the minimum radius or diameter required to make a satisfactory bend and the number of repeated bends that the material can withstand without failure when it is bent through a given angle and over a definite radius.

BEVEL - The angle formed between the prepared edge of the end of the pipe and a plane perpendicular to the surface of the member. The standard bevel for line pipe is 30 degrees to facilitate welding.

BLACK - Term associated with pipe surface whereby material ordered in this manner is protected with a varnish-type oil on the O.D. for temporary corrosion protection during transit and in storage.

BLACK BARE - Term associated with pipe surface whereby the pipe will not be coated with mill spray oil and grease spots and cutting oil will be removed by washing.

BOP OR BOF - Basic oxygen process or basic oxygen furnace.

BURST TEST - A destructive hydraulic test employed to determine actual yield strength and ultimate strength of both seamless and welded pipe.

CARBON STEEL - Steel which owes its properties chiefly to various percentages of carbon without substantial amounts of other alloying elements; also known as steel when no minimum content of elements other than carbon is specified or required to obtain a desired alloying effect; when the specified minimum for copper does not exceed 0.40%; or the maximum content for the following does not exceed the percentage noted: manganese, 1.65; silicon, 0.60; and copper, 060.

CHARPY TEST - A method for measuring the amount of energy absorbed by a notched specimen during fracture as a result of an impact load.

CHECK ANALYSIS - A chemical analysis of the metal after it has been rolled or forged into semifinished or finished forms.

COLUMBIUM - An alloying element added to high-strength low alloy steels. Retards grain growth and recrystalization during controlled rolling; increases strength.

CONDUIT - Pipe serving as a duct for electrical wiring.

COUPLING - Threaded sleeve used to connect two lengths of pipe.

CONTINUOUS WELD - In common usage, a phrase for continuous butt weld. Furnace-welded pipe produced in continuous lengths from coiled skelp and subsequently cut into individual lengths, having its longitudinal butt joint forge welded by the chemical pressure developed in rolling the hot-formed skelp through a series of round pass welding rolls.

CRACK, HOOK - Metal separations resulting from imperfections at the edge of the plate or skelp, parallel to the surface, which turn towards the I.D. or O.D. surfaces when the edges are upset during welding.

DOUBLE EXTRA STRONG - Standard pipe weight designation (XXS). Sometimes described as XXH (double extra heavy).

DOUBLE JOINTED - Two standard length pipe joints welded together to form a single joint or double length.

DRL - Double Random Length (35' minimum average or as defined in specifications).

DROP WEIGHT TEAR TEST - An impact test used to determine the nil ductility transition temperature of ferritic steel.

DUCTILITY - The property that permits permanent deformation before fracture by stress in tension.

EDDY-CURRENT TESTING - A nondestructive testing method in which Eddy-Current flow is induced in the test object. Changes in the flow caused by variations in the specimen are reflected into a nearby coil or coils for subsequent analysis by suitable instrumentation and techniques.

ELONGATION - In tensile testing, the increase in the gage length, measured after fracture of the specimen within the gage length, usually expressed as a percentage of the original gage length.

ERW - Electric Resistance Weld. See high frequency welding.

EXPANDERS - Mechanical device used to expand pipe to obtain increased transverse yield strength and the desired O.D. size.

EXTRA STRONG - Standard pipe weight designation (XS). Sometimes described as XH (extra heavy).

FLATTENING TEST - A quality test for tubing in flattened between parallel plates that are closed to a specified height.

FRACTURE TEST - Breaking a piece of metal for the purpose of examining the fractured surface to determine the structure or carbon content of the metal, or to detect the presence of internal defects.

Glossary of Terms (cont.)

FULL BODY NORMALIZING - Uniformly heating the pipe to a temperature slightly above the point at which grain structure is effected (known as the critical temperature), followed by cooling in still air. This produces uniform grain structure and hardness throughout the pipe.

GALVANIZING - Covering of iron or steel surfaces with a protective layer of zinc (weight defined in specifications).

GRADE - The term grade designates divisions within different types based on carbon content or mechanical properties; for example: "This is a high tensile (grade) structural steel".

HARDNESS - Defined in terms (usually stated as a Rockwell number, Brinell number or Vicker number) of the method of measurement. (1) Usually the resistance to indentation. (2) Stiffness or temper of wrought products. (3) Machinability characteristics.

HEAT - (1) A form of energy which raises the temperature of bodies into which it is absorbed. (2) An individual bath of metal as it is melted in a furnace.

HEAT TREATMENT - A combination of heating and cooling operations applied to a metal or alloy in the solid state to obtain desired conditions or properties.

HIC TEST - A test ofr Hydrogen Induced Cracking, a form of corrosion in pipelines characterized by stepwise cracking along the rolling direction of the steel. The cracks are the adverse effect of the absorption of hydrogen generated by the corrosion of steel in wet hydrogen sulfide (H2S). The standard method for HIC tests is described in the National Association of Corrosion Engineers Standard Test Method 0284 (NACE TM0284).

HIGH FREQUENCY WELDING - A technique employed in the manufacture of electric resistance weld pipe. Typical radio frequency power for welding is supplied at 450,000 cycles/sec.

HIGH STRENGTH STEEL - Low alloy steels forming a specific class in which enhanced mechanical properties and, in most cases, good resistance to atmospheric corrosion are obtained by the incorporation of moderate proportions of one or more alloying elements other than carbon. The preferred terminology is now "high strength, low-alloy steels".

HYDROSTATIC TEST - Normal mill test as required by specifications. The pipe ends are sealed and high pressure water is introduced to predetermined pressures as required by specifications.

I.D. - Inside Diameter.

IMPACT TEST - A test to determine the energy absorbed in fracturing a test bar at high velocity. The test may be in tension or in bending, or it may properly be a notch test if a notch is present, creating multiaxial stresses.

LADLE - A large vessel into which molten metal or molten slag is received and handled. Molten metal may transported short distances by carrying it in a ladle.

LADLE ANALYSIS - The term applied to the chemical analysis representative of a heat or blow of steel and is the analysis reported to the purchaser. It is determined by analyzing, (for such elements as have been specified) a test ingot sample obtained from the first part or middle part of the heat or blow during the pouring of the steel from a ladle.

LAND - Face at pipe and between the bevel and the interior surface.

LIFTS - Term associated with separated segments of pipe (banded or unbanded for ease of handling).

MAGNAFLUX TEST - An inspection given to important or highly stressed parts or pipe for critical applications. It consists in suitably magnetizing the material and applying a prepared magnetic powder which adheres to it along lines of flux leakage. It shows the existence of surfaces and subsurface non-uniformities and electromagnetic current.

MAGNETIC PARTICLE INSPECTION - A nondestructive testing method for detecting cracks and other discontinuities at or near the surface in ferromagnetic materials utilizing iron powder and electromagnetic current.

MECHANICAL PROPERTIES - Those properties of a material that reveal the elastic and inelastic reaction when force is applied, or that involve the relationship between stress and strain; for example, the modulus of elasticity, tensile strength and fatigue limit. These properties have often been designated as "physical properties", but the term "mechanical properties" is much to be preferred.

METALLURGY - The science which deals with the extraction of metals from their ores and the adaptation and application of these metals to the uses for which they are intended.

MILL FINISH - A surface finish produced on sheet and plate, characteristic of the ground finish on the rolls used to fabrication.

MOLYBDENUM - A special alloying element commonly used to increase hardenability of steel. Molybdenum is sometimes added to stainless steel to enhance its corrosion resistance to certain chemicals. Molybdenum is commonly called "moly".

N.D.E. - Nondestructive examination is the utilization of nondestructive testing methods primarily, eddy current, liquid penetrant, magnetic particle, radiography, and ultrasonics.

NOMINAL - Name given to standard pipe size designation through 12" nominal or 12$^{3}/_{4}$" O.D. Wall thicknesses: are also expressed as nominal. Example: 4$^{1}/_{2}$" has a nominal .237 wall. Maximum wall is .272, minimum wall is .208.

NORMALIZE - The normalizing process which is commonly applied to steel articles of heavy section consists of: heating to a temperature about 100 degrees F. above the critical range and cooling in still air.

NPS - Nominal Pipe Size

O.D. - Outside Diameter.

PE - Plain End.

PICKLING - Pipe immersed into acid bath for removal of scale, oil, dirt, etc.

PILING - A form of rolled structural shape of two types; sheet piling, and bearing piling. The three forms of sheet pile—straight, arch type and zee—are used for such types of construction as docks, breakwaters, coffer dams, etc. Bearing piles—which range from 14 in. to 8 in. in depth, are heavy, wide flange sections for foundation work, etc.

Glossary of Terms (cont.)

PLATE - Carbon steel plate comprise that group of flat rolled finished steel products within the following size limitation:

.0180 in. or thicker, over 48 in. wide
.0230 in. or thicker, over 6 in. wide
7.53 lb./ sq. ft. or heavier, over 48 in. wide
9.62 lb./ sq. ft. or heavier, over 6 in. wide

PREHEATING - (1) A general term used to describe heating applied as a preliminary to some further thermal or mechanical treatment. (2) A term applied specifically to tool steel to describe a process in which the steel is heated slowly and uniformly to a temperature below the hardening temperature and is then transferred to a furnace in which the temperature is substantially above the preheating temperature.

PSI - Pounds per square inch gage.

PSL - Product Specification Level

QUENCHING - A process of rapid cooling from an elevated temperature by contact with liquids, gases or solids.

RANDOM LENGTHS - Lengths can be specified, but, if random lengths are permitted, cutters have a spread from 2 to 5 feet, depending on ordered length and size.

SCALE - An oxide of iron which forms on the surface of hot steel. Sometimes it forms in large sheets which fall off when the steel is rolled.

SCARFING - Cutting surface areas of metal objects, ordinarily by using a gas touch. The operation permits surface defects to be cut from ingots, billets, or the edges of plate that is to be beveled for butt welding.

SCHEDULE NUMBERS - ANSI numbers assigned to pipe depending upon wall thickness (Becoming obsolete).

SEAM ANNEALED - Heating a weld seam to a temperature slightly below the point at which grain structure is effected (known as the critical temperature), followed by cooling in still air. This reduces weld hardness without changing the grain structure.

SKELP - A plate of steel or wrought iron from which pipe or tubing is made by rolling the skelp into shape longitudinally and welding or riveting the edges together.

SLAB - A semifinished block of steel cut from a rolled ingot, with its width at least twice its thickness. It differs from a bloom which is square or nearly so. Slabs are the product of a slabbing mill, or a blooming mill.

SMLS - Seamless.

SRL - Single Random Lengths-(16-22 ft. for standard weight ASTM pipe or as defined in specifications).

STENCIL - Paint spray identification placed on pipe. Specification, size, wall, grade, test pressure, method of manufacture and normal mill characters and mill identification are usually included; however, detail varies by specification. “Made in USA” is included.

STRESS RELIEVING - A process of reducing residual stresses in a metal object by heating the object to a suitable temperature and holding for a sufficient time, and cooling slowly. This treatment may be applied to relative stresses induced by casting, quenching, normalizing, machining, cold working or welding.

STRETCH REDUCTION - Property of absorbing considerable energy before fracture; usually represented by the area under a stress-strain curve, and therefore involving both ductility and strength.

TBE - Threaded Both Ends.

T&C - Threaded and Coupled.

TENSILE STRENGTH - The value obtained by dividing the maximum load observed during tensile straining until breakage occurs by the specimen cross-sectional area before straining. Also called “ultimate strength”.

TOUGHNESS - Property of absorbing considerable energy before fracture; usually represented by the area under a stress-strain curve, and therefore involving both ductility and strength.

TURN - A work shift in the mill of usually 8 hours duration.

ULTRASONIC - A nondestructive testing method of detecting, locating, and measuring both surface and subsurface defects in metals with the use of high frequency sound.

VICTAULIC - Registered trademark of Victaulic Corp. of American.

VIC-VICTAULIC Groove.

WALL-HEAVY - Wall thickness more than the specified minimum wall thickness called for by the pipe standard designated in the purchase order specifications.

WALL-THIN - Wall thickness less than the specified minimum wall thickness called for by the pipe standard designated in the purchase order specifications.

YIELD STRENGTH - The stress at which a material exhibits a specified deviation from proportionality of stress and strain. An offset of 0.2% is used for many metals including steel. API 5L and API 5LX state that the yield strength shall be the tensile stress required to produce a total elongation of 0.5% of the gauge length as determined by an extensometer or by multiplying dividers. Usually expressed in pounds per square inch.

SALES LOCATIONS

Main Office
1660 Lincoln, Suite 1950
Denver, CO 80264

California
2430-A N. Glassel St.
Orange, CA 92865

Missouri
225 S. Meramec, Ste. 1028T
Clayton, MO 63105

Texas
2002 Timberloch Pl., Ste. 200
The Woodlands, TX 77380

Washington
1780 Down River Dr.
Woodland, WA 98674

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