

**STAINLESS
STEEL
TUBULAR
PRODUCTS**

aalco

The information contained herein is based on our present knowledge and experience and is given in good faith. However, no liability will be accepted by the Company in respect of any action taken by any third party in reliance thereon.

As the products detailed herein may be used for a wide variety of purposes and as the Company has no control over their use, the Company specifically excludes all conditions or warranties expressed or implied by statute or otherwise as to dimensions, properties and/or their fitness for any particular purpose. Any advice given by the Company to any third party is given for that party's assistance only and without any liability on the part of the Company.

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Weights

All weights shown in this publication are for guidance only. They are calculated using nominal dimensions and scientifically recognised densities. Please note that in practice, the actual weight can vary significantly from the theoretical weight due to variations in manufacturing tolerances and compositions.

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Stainless Steel Tubular Products

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Aalco is the UK's largest independent multi-metals stockholder. Customers from every sector of the UK manufacturing and engineering industries, whether small local businesses or large multinational corporations, benefit from a cost-effective single source for all their metals requirements.

Aalco – delivering customer service and investing in capability:

- ◊ An inventory that includes aluminium, stainless steel, copper, brass, bronze and nickel alloys in all semi-finished forms
- ◊ Comprehensive processing services providing items cut and/or finished to customer requirements
- ◊ Eighteen locations bringing local service to every corner of the UK
- ◊ Ongoing investment in technology and logistics to ensure on-time delivery

No order is too large or too small and Aalco offers a responsive and competitive service for supplying anything from single item orders to major JIT contracts, tailoring this service to individual needs.

Whatever your requirement, in whatever quantity, your local Aalco service centre is ready and willing to satisfy your needs. For a quotation, for further information, more extensive technical information, advice on product selection or to place an order, please contact your local Aalco service centre or refer to the web site www.aalco.co.uk.

Service

The most comprehensive stock range; the highest investment in processing equipment; local service centres nationwide; helpful, friendly, knowledgeable staff and the industry's biggest fleet of delivery vehicles – it all adds up to unbeatable service.

Aalco has maintained market leadership over many years through an absolute dedication to customer service – a service level that is continuously monitored and improved through key performance indicators.

That's why, for reliable, on-time delivery of exactly what you want, when and where you need it, whether it's a small one-off item or a complex JIT contract, Aalco is the essential first choice.

People

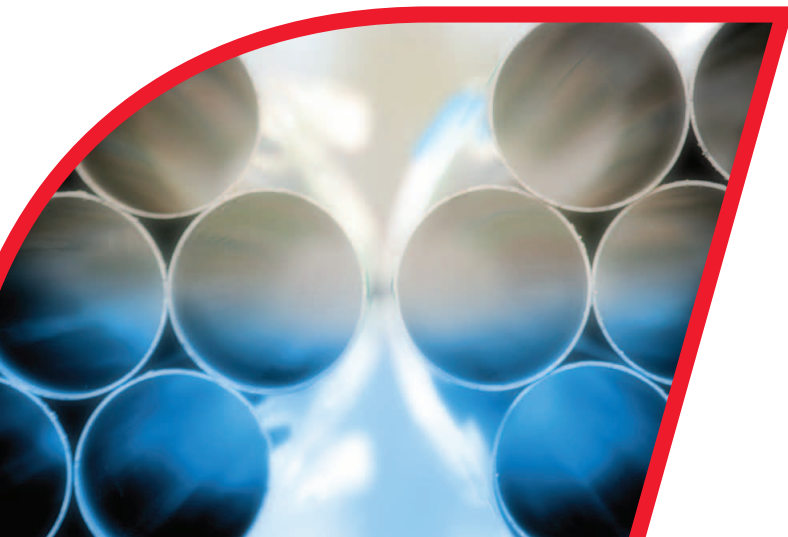
Exceptional customer service starts with people. Aalco develops and retains high quality personnel using a variety of 'in house' courses which cover both skills training, product knowledge and teamwork.

Every Aalco service centre has a dedicated team of people working together to provide an unbeatable service to customers in their region. Customers can expect to receive a quick and informed response to any enquiries for material or for information.

Quality

Aalco takes great care when selecting manufacturing sources for its products and every mill we use is measured against a series of predetermined quality control requirements. All products supplied by Aalco conform to the relevant BS or international standards. Certification can be supplied on request.

Aalco service centres operate a quality manual designed to ISO9001/2008 requirements. Many vendor approvals and bespoke quality control systems are operated through individual Aalco service centres.





Tube

Seamless to ASTM A269, imperial sizes from 1/8" O/D x 24swg to 4" O/D x 1/4" wall in grade 316L

Seamless to ASTM A269, grades 304L & 316L, in metric sizes 6mm O/D x 0.5mm wall to 38mm O/D x 4mm wall

Decorative – Round, Square, Rectangular

Structural – Square and Rectangular up to 250mm

Hygienic (see below)

Welded Metric Nominal Internal Diameter (see below)

Pipe

Seamless and Welded to ASTM A312 from 1/8" to 24" in grades 304L & 316L

Flanges

ASTM A182 / ANSI B16.5

BS 10 Table E, Grade 316L

BS 4504 / EN 1092 Raised Face, 16 Bar

Backing Flanges in Aluminium and Coated Mild Steel

Fittings

Butt Weld Fittings, Seamless and Welded, to ASTM A403 in grades 304L & 316L including elbows, tees & reducers

BSP Screwed Fittings, grade 316 from 1/8" to 3"

Hygienic fittings (see below)

Welded Metric Nominal Internal Diameter (see below)

Hygienic Tube and Fittings

Grades 304L & 316L 3/4" O/D to 4" O/D:

Tube – As Welded & Descaled, Annealed & Polished or Bright Annealed

Bends, Fitted Bends, Tees, Reducers, Clamps & Tube Hangers

Unions – RJT, IDF & DIN

Metric – Welded Nominal Internal Diameter (ND)

From 18mm O/D x 1.5mm wall to 910mm O/D x 5mm wall

Grades 1.4432 (316L High Molybdenum) & 1.4307 (304L)

Tube, Elbows, Tees, Reducers, Collars, End Caps, Tube Clamps & Clips

Backing Flanges in Aluminium & Coated Mild Steel

Further information is provided by these publications, available either from your local Service Centre or at www.aalco.co.uk



Product Guide

Technical information on applications, uses and specifications for stainless

steel, aluminium, copper, brass and bronze.



Stocklist

A guide to the Aalco standard stock range in stainless steel, aluminium, copper, brass and bronze.



Metric

A guide to the range of light-walled nominal diameter metric stainless steel tubular products used

in water treatment, pulp & paper and other industries.



Handrail

A guide to all of the stainless steel handrail/balustrade systems comprising

tube and slotted tube plus associated fittings.

ASTM Pipe

Introduction

The term pipe covers a specific range of sizes laid down by ANSI specifications. Any sizes not covered by these specifications are tube. Stainless Steel Pipe dimensions determined by ASME B36.19 covering the outside diameter and the Schedule wall thickness. Note that stainless wall thicknesses to ANSI B36.19 all have an 'S' suffix. Sizes without an 'S' suffix are to ANSI B36.10 which is intended for carbon steel pipes.



Seamless and Welded

ASTM A312: Seamless and straight-seam welded austenitic pipe intended for high temperature and general corrosive service. Filler metal not permitted during welding.

ASTM A358: Electric fusion welded austenitic pipe for corrosive and/or high temperature service. Typically only pipe up to 8 inch is produced to this specification. Addition of filler metal is permitted during welding.

ASTM A790: Seamless and straight-seam welded ferritic/austenitic (duplex) pipe intended for general corrosive service, with a particular emphasis on resistance to stress corrosion cracking.

ASTM A409: Straight-seam or spiral-seam electric fusion welded large diameter austenitic light-wall pipe in sizes 14" to 30" with walls Sch 5S and Sch 10S for corrosive and/or high temperature service.

ASTM A376: Seamless austenitic pipe for high temperature applications.

ASTM A813: Single-seam, single- or double- welded austenitic pipe for high temperature and general corrosive applications.

ASTM A814: Cold-worked welded austenitic pipe for high temperature and general corrosive service.

Note: Welded pipes manufactured to ASTM A312, A790 and A813 must be produced by an automatic process with NO addition of filler metal during the welding operation.

Welded pipe specifications

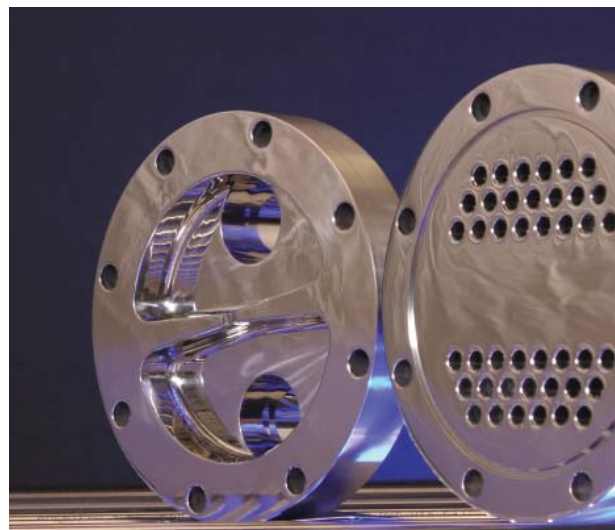
Usually it will be to ASTM A312. If it is to ASTM A358 then there are various Classes available as shown below. The Class Number dictates how the pipe is welded and what non-destructive tests:

- ◊ **Class 1:** Pipe shall be double welded by processes employing filler metal in all passes and shall be completely radiographed.
- ◊ **Class 2:** Pipe shall be double welded by processes employing filler metal in all passes. No-radiography is required.
- ◊ **Class 3:** Pipe shall be welded in one pass by processes employing filler metal and shall be completely radiographed.
- ◊ **Class 4:** Same as Class 3 except that the welding process exposed to the inside pipe surface may be made without the addition of filler metal.
- ◊ **Class 5:** Pipe shall be double welded by processes employing filler metal in all passes and shall be spot radiographed.

Markings on pipe

The full identification of the pipe should be continuously marked down its whole length, including:

- ◊ Nominal Pipe Size (Nominal Bore)
- ◊ Schedule (Wall Thickness)
- ◊ Specification
- ◊ Grade
- ◊ Method of Manufacture (Seamless or Welded)
- ◊ Heat Number
- ◊ Manufacturer's Name or Symbol



Dimensions and weights per metre - stainless steel pipe

Nominal Pipe Size	OD		Schedule 5S ¹			Schedule 10S ¹			Schedule 40S			Schedule 80S		
	in	mm	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m
1/8	0.405	10.3	-	-	-	0.049	1.24	0.28	0.068	1.73	0.37	0.095	2.41	0.47
1/4	0.540	13.7	-	-	-	0.065	1.65	0.49	0.088	2.24	0.63	0.119	3.02	0.80
3/8	0.675	17.1	-	-	-	0.065	1.65	0.63	0.091	2.31	0.84	0.126	3.20	1.10
1/2	0.840	21.3	0.065	1.65	0.80	0.083	2.11	1.00	0.109	2.77	1.27	0.147	3.73	1.62
3/4	1.050	26.7	0.065	1.65	1.03	0.083	2.11	1.28	0.113	2.87	1.69	0.154	3.91	2.20
1	1.315	33.4	0.065	1.65	1.30	0.109	2.77	2.09	0.133	3.38	2.50	0.179	4.55	3.24
1 1/4	1.660	42.2	0.065	1.65	1.65	0.109	2.77	2.70	0.140	3.56	3.39	0.191	4.85	4.47
1 1/2	1.900	48.3	0.065	1.65	1.91	0.109	2.77	3.11	0.145	3.68	4.05	0.200	5.08	5.41
2	2.375	60.3	0.065	1.65	2.40	0.109	2.77	3.93	0.154	3.91	5.44	0.218	5.54	7.48
2 1/2	2.875	73.0	0.083	2.11	3.69	0.120	3.05	5.26	0.203	5.16	8.63	0.276	7.01	11.41
3	3.500	88.9	0.083	2.11	4.51	0.120	3.05	6.45	0.216	5.49	11.29	0.300	7.62	15.27
3 1/2	4.000	101.6	0.083	2.11	5.18	0.120	3.05	7.40	0.226	5.74	13.57	0.318	8.08	18.63
4	4.500	114.3	0.083	2.11	5.84	0.120	3.05	8.36	0.237	6.02	16.07	0.337	8.56	22.32
5	5.563	141.3	0.109	2.77	9.47	0.134	3.40	11.57	0.258	6.55	21.77	0.375	9.53	30.97
6	6.625	168.3	0.109	2.77	11.32	0.134	3.40	13.84	0.280	7.11	28.26	0.432	10.97	42.56
8	8.625	219.1	0.109	2.77	14.79	0.148	3.76	19.96	0.322	8.18	42.55	0.500	12.70	64.64
10	10.750	273.1	0.134	3.40	22.63	0.165	4.19	27.78	0.365	9.27	60.31	0.500 ²	12.70 ²	96.01 ²
12	12.750	323.9	0.156	3.96	31.25	0.180	4.57	36.00	0.375 ²	9.53 ²	73.88 ²	0.500 ²	12.70 ²	132.08 ²
14	14.000	355.6	0.156	3.96	34.36	0.188 ²	4.78 ²	41.30 ²	-	-	-	-	-	-
16	16.000	406.4	0.165	4.19	41.56	0.188 ²	4.78 ²	47.29 ²	-	-	-	-	-	-
18	18.000	457	0.165	4.19	46.81	0.188 ²	4.78 ²	53.26 ²	-	-	-	-	-	-
20	20.000	508	0.188	4.78	59.25	0.218 ²	5.54 ²	68.61 ²	-	-	-	-	-	-
22	22.000	559	0.188	4.78	65.24	0.218 ²	5.54 ²	75.53 ²	-	-	-	-	-	-
24	24.000	610	0.218	5.54	82.47	0.250	6.35	94.45	-	-	-	-	-	-
30	30.000	762	0.250	6.35	118.31	0.312	7.92	147.36	-	-	-	-	-	-

Notes

- 1 Schedules 5S and 10S wall thicknesses do not permit threading in accordance with ANSI/ASME B1.20.1.
- 2 These dimensions and weights do not conform to ANSI/ASME B36.10M.
 - The suffix 'S' after the schedule number indicates that the pipe dimensions and weight are in compliance with this stainless steel pipe specification, ANSI/ASME B36.19M-1985, and not the more general ANSI/ASME B36.10M-1995 specification.
 - Although this specification is applicable to stainless steel, quoted weights are for carbon steel pipe and should be multiplied by 1.014 for austenitic and duplex steels, or by 0.985 for ferritic and martensitic steels.

ASTM Pipe

Pipe Sizes - ANSI/ASME B36.10M

Dimensions and weights per metre - steel pipe

Nominal Pipe Size	OD		Schedule 10			Schedule 20			Schedule 30			Schedule 40		
	in	mm	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m
1/8	0.405	10.3	-	-	-	-	-	-	0.057	1.45	0.32	0.068	1.73	0.37
1/4	0.540	13.7	-	-	-	-	-	-	0.073	1.85	0.54	0.088	2.24	0.63
3/8	0.675	17.1	-	-	-	-	-	-	0.073	1.85	0.70	0.091	2.31	0.84
1/2	0.840	21.3	-	-	-	-	-	-	0.095	2.41	1.12	0.109	2.77	1.27
3/4	1.050	26.7	-	-	-	-	-	-	0.095	2.41	1.44	0.113	2.87	1.69
1	1.315	33.4	-	-	-	-	-	-	0.114	2.90	2.18	0.133	3.38	2.50
1 1/4	1.660	42.2	-	-	-	-	-	-	0.117	2.97	2.87	0.140	3.56	3.39
1 1/2	1.900	48.3	-	-	-	-	-	-	0.125	3.18	3.53	0.145	3.68	4.05
2	2.375	60.3	-	-	-	-	-	-	0.125	3.18	4.48	0.154	3.91	5.44
2 1/2	2.875	73.0	-	-	-	-	-	-	0.188	4.78	8.04	0.203	5.16	8.63
3	3.500	88.9	-	-	-	-	-	-	0.188	4.78	9.92	0.216	5.49	11.29
3 1/2	4.000	101.6	-	-	-	-	-	-	0.188	4.78	11.41	0.226	5.74	13.57
4	4.500	114.3	-	-	-	-	-	-	0.188	4.78	12.91	0.237	6.02	16.07
5	5.563	141.3	-	-	-	-	-	-	-	-	-	0.258	6.55	21.77
6	6.625	168.3	-	-	-	-	-	-	-	-	-	0.280	7.11	28.26
8	8.625	219.1	-	-	-	0.250	6.35	33.31	0.277	7.04	36.81	0.322	8.18	42.55
10	10.750	273.0	-	-	-	0.250	6.35	41.77	0.307	7.80	51.03	0.365	9.27	60.31
12	12.750	323.8	-	-	-	0.250	6.35	49.73	0.330	8.38	65.20	0.406	10.31	79.73
14	14.000	355.6	0.250	6.35	54.69	0.312	7.92	67.90	0.375	9.53	81.33	0.438	11.13	94.55
16	16.000	406.4	0.250	6.35	62.64	0.312	7.92	77.83	0.375	9.53	93.27	0.500	12.70	123.30
18	18.000	457	0.250	6.35	70.57	0.312	7.92	87.71	0.438	11.13	122.38	0.562	14.27	155.80
20	20.000	508	0.250	6.35	78.55	0.375	9.53	117.15	0.500	12.70	155.12	0.594	15.09	183.42
22	22.000	559	0.250	6.35	86.54	0.375	9.53	129.13	0.500	12.70	171.09	-	-	-
24	24.000	610	0.250	6.35	94.53	0.375	9.53	141.12	0.562	14.27	209.64	0.688	17.48	255.41
26	26.000	660	0.312	7.92	127.36	0.500	12.70	202.72	-	-	-	-	-	-
28	28.000	711	0.312	7.92	137.32	0.500	12.70	218.69	0.625	15.88	271.21	-	-	-
30	30.000	762	0.312	7.92	147.28	0.500	12.70	234.67	0.625	15.88	292.18	-	-	-
32	32.000	813	0.312	7.92	157.24	0.500	12.70	250.64	0.625	15.88	312.15	0.688	17.48	342.91
34	34.000	864	0.312	7.92	167.20	0.500	12.70	266.61	0.625	15.88	332.12	0.688	17.48	364.90
36	36.000	914	0.312	7.92	176.96	0.500	12.70	282.27	0.625	15.88	351.70	0.750	19.05	420.42
38	38.000	965	-	-	-	-	-	-	-	-	-	-	-	-
40	40.000	1016	-	-	-	-	-	-	-	-	-	-	-	-
42	42.000	1067	-	-	-	-	-	-	-	-	-	-	-	-
44	44.000	1118	-	-	-	-	-	-	-	-	-	-	-	-
46	46.000	1168	-	-	-	-	-	-	-	-	-	-	-	-
48	48.000	1219	-	-	-	-	-	-	-	-	-	-	-	-

Notes

- This specification is applicable to all steel pipe including stainless steel. Quoted weights are for carbon steel pipe and should be multiplied by 1.014 for austenitic and duplex steels, or by 0.985 for ferritic and martensitic steels.

Dimensions and weights per metre - steel pipe

Nominal Pipe Size	OD		Schedule (STD)			Schedule 60			Extra Strong (XS)			Schedule 80		
	in	mm	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m
1/8	0.405	10.3	0.068	1.73	0.37	-	-	-	0.095	2.41	0.47	0.095	2.41	0.47
1/4	0.540	13.7	0.088	2.24	0.63	-	-	-	0.119	3.02	0.80	0.119	3.02	0.80
3/8	0.675	17.1	0.091	2.31	0.84	-	-	-	0.126	3.20	1.10	0.126	3.20	1.10
1/2	0.840	21.3	0.109	2.77	1.27	-	-	-	0.147	3.73	1.62	0.147	3.73	1.62
3/4	1.050	26.7	0.113	2.87	1.69	-	-	-	0.154	3.91	2.20	0.154	3.91	2.20
1	1.315	33.4	0.133	3.38	2.50	-	-	-	0.179	4.55	3.24	0.179	4.55	3.24
1 1/4	1.660	42.2	0.140	3.56	3.39	-	-	-	0.191	4.85	4.47	0.191	4.85	4.47
1 1/2	1.900	48.3	0.145	3.68	4.05	-	-	-	0.200	5.08	5.41	0.200	5.08	5.41
2	2.375	60.3	0.154	3.91	5.44	-	-	-	0.218	5.54	7.48	0.218	5.54	7.48
2 1/2	2.875	73.0	0.203	5.16	8.63	-	-	-	0.276	7.01	11.41	0.276	7.01	11.41
3	3.500	88.9	0.216	5.49	11.29	-	-	-	0.300	7.62	15.27	0.300	7.62	15.27
3 1/2	4.000	101.6	0.226	5.74	13.57	-	-	-	0.318	8.08	18.63	0.318	8.08	18.63
4	4.500	114.3	0.237	6.02	16.07	-	-	-	0.337	8.56	22.32	0.337	8.56	22.32
5	5.563	141.3	0.258	6.55	21.77	-	-	-	0.375	9.53	30.97	0.375	9.53	30.97
6	6.625	168.3	0.280	7.11	28.26	-	-	-	0.432	10.97	42.56	0.432	10.97	42.56
8	8.625	219.1	0.322	8.18	42.55	0.406	10.31	53.08	0.500	12.70	64.64	0.500	12.70	64.64
10	10.750	273.0	0.365	9.27	60.31	0.500	12.70	81.55	0.500	12.70	81.55	0.594	15.09	96.01
12	12.750	323.8	0.375	9.53	73.88	0.562	14.27	108.96	0.500	12.70	97.46	0.688	17.48	132.08
14	14.000	355.6	0.375	9.53	81.33	0.594	15.09	126.71	0.500	12.70	107.39	0.750	19.05	158.10
16	16.000	406.4	0.375	9.53	93.27	0.656	16.66	160.12	0.500	12.70	123.30	0.844	21.44	203.53
18	18.000	457	0.375	9.53	105.16	0.750	19.05	205.74	0.500	12.70	139.15	0.938	23.83	254.55
20	20.000	508	0.375	9.53	117.15	0.812	20.62	247.83	0.500	12.70	155.12	1.031	26.19	311.17
22	22.000	559	0.375	9.53	129.13	0.875	22.23	294.25	0.500	12.70	171.09	1.125	28.58	373.83
24	24.000	610	0.375	9.53	141.12	0.969	24.61	355.26	0.500	12.70	187.06	1.219	30.96	442.08
26	26.000	660	0.375	9.53	152.87	-	-	-	0.500	12.70	202.72	-	-	-
28	28.000	711	0.375	9.53	164.85	-	-	-	0.500	12.70	218.69	-	-	-
30	30.000	762	0.375	9.53	176.84	-	-	-	0.500	12.70	234.67	-	-	-
32	32.000	813	0.375	9.53	188.82	-	-	-	0.500	12.70	250.64	-	-	-
34	34.000	864	0.375	9.53	200.31	-	-	-	0.500	12.70	266.61	-	-	-
36	36.000	914	0.375	9.53	212.56	-	-	-	0.500	12.70	282.27	-	-	-
38	38.000	965	0.375	9.53	224.54	-	-	-	0.500	12.70	298.24	-	-	-
40	40.000	1016	0.375	9.53	236.53	-	-	-	0.500	12.70	314.22	-	-	-
42	42.000	1067	0.375	9.53	248.52	-	-	-	0.500	12.70	330.19	-	-	-
44	44.000	1118	0.375	9.53	260.50	-	-	-	0.500	12.70	346.16	-	-	-
46	46.000	1168	0.375	9.53	272.25	-	-	-	0.500	12.70	351.82	-	-	-
48	48.000	1219	0.375	9.53	284.24	-	-	-	0.500	12.70	377.79	-	-	-

Notes
 - This specification is applicable to all steel pipe including stainless steel. Quoted weights are for carbon steel pipe and should be multiplied by 1.014 for austenitic and duplex steels, or by 0.985 for ferritic and martensitic steels.

ASTM Pipe

Pipe Sizes - ANSI/ASME B36.10M

Dimensions and weights per metre - steel pipe

Nominal Pipe Size	OD		Schedule 100			Schedule 120			Schedule 140			Schedule 160		
	in	mm	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m	in	mm	kg/m
1/2	0.840	21.3	-	-	-	-	-	-	-	-	-	0.188	4.78	1.95
3/4	1.050	26.7	-	-	-	-	-	-	-	-	-	0.219	5.56	2.90
1	1.315	33.4	-	-	-	-	-	-	-	-	-	0.250	6.35	4.24
1 1/4	1.660	42.2	-	-	-	-	-	-	-	-	-	0.250	6.35	5.61
1 1/2	1.900	48.3	-	-	-	-	-	-	-	-	-	0.281	7.14	7.25
2	2.375	60.3	-	-	-	-	-	-	-	-	-	0.344	8.74	11.11
2 1/2	2.875	73.0	-	-	-	-	-	-	-	-	-	0.375	9.53	14.92
3	3.500	88.9	-	-	-	-	-	-	-	-	-	0.438	11.13	21.35
3 1/2	4.000	101.6	-	-	-	-	-	-	-	-	-	-	-	-
4	4.500	114.3	-	-	-	0.438	11.13	28.32	-	-	-	0.531	13.49	33.54
5	5.563	141.3	-	-	-	0.500	12.70	40.28	-	-	-	0.625	15.88	49.11
6	6.625	168.3	-	-	-	0.562	14.27	54.20	-	-	-	0.719	18.26	67.56
8	8.625	219.1	0.594	15.09	75.92	0.719	18.26	90.44	0.812	20.62	100.92	0.906	23.01	111.27
10	10.750	273.0	0.719	18.26	114.75	0.844	21.44	133.06	1.000	25.40	155.15	1.125	28.58	172.33
12	12.750	323.8	0.844	21.44	159.91	1.000	25.40	186.97	1.125	28.58	208.14	1.312	33.32	238.76
14	14.000	355.6	0.938	23.83	194.96	1.094	27.79	224.65	1.250	31.75	253.56	1.406	35.71	281.70
16	16.000	406.4	1.031	26.19	245.56	1.219	30.96	286.64	1.438	36.53	333.19	1.594	40.49	365.35
18	18.000	457	1.156	29.36	309.62	1.375	34.93	363.56	1.562	39.67	408.26	1.781	45.24	459.37
20	20.000	508	1.281	32.54	381.53	1.500	38.10	441.49	1.750	44.45	508.11	1.969	50.01	564.81
22	22.000	559	1.375	34.93	451.42	1.625	41.28	527.02	1.875	47.63	600.63	2.125	53.98	672.26
24	24.000	610	1.531	38.89	547.71	1.812	46.02	640.03	2.062	52.37	720.15	2.344	59.54	808.22

Nominal Pipe Size	OD		Double Extra Strong (XXS)		
	in	mm	in	mm	kg/m
1/2	0.840	21.3	0.294	7.47	2.55
3/4	1.050	26.7	0.308	7.82	3.64
1	1.315	33.4	0.358	9.09	5.45
1 1/4	1.660	42.2	0.382	9.70	7.77
1 1/2	1.900	48.3	0.400	10.15	9.56
2	2.375	60.3	0.436	11.07	13.44
2 1/2	2.875	73.0	0.552	14.02	20.39
3	3.500	88.9	0.600	15.24	27.68

Nominal Pipe Size	OD		Double Extra Strong (XXS) continued		
	in	mm	in	mm	kg/m
continued					
3 1/2	4.000	101.6	-	-	-
4	4.500	114.3	0.674	17.12	41.03
5	5.563	141.3	0.750	19.05	57.43
6	6.625	168.3	0.864	21.95	79.22
8	8.625	219.1	0.875	22.23	107.92
10	10.750	273.0	1.000	25.40	155.15
12	12.750	323.8	1.000	25.40	186.97

Notes

- This specification is applicable to all steel pipe including stainless steel. Quoted weights are for carbon steel pipe and should be multiplied by 1.014 for austenitic and duplex steels, or by 0.985 for ferritic and martensitic steels.

Chemical Compositions - ASTM A240/A240M

Grade	UNS	Composition Percentage, Max or Range																		
		Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Titanium	Niobium	Tantalum	Nitrogen	Vanadium	Copper	Cerium	Boron	Aluminium	Tungsten	Selenium
		C	Mn	P	S	Si	Ni	Cr	Mo	Ti	Nb	Ta	N	Va	Cu	Ce	Bo	Al	W	Se
201	S20100	0.15	5.50-7.50	0.060	0.030	1.00	3.5-5.5	16.00-18.00	-	-	-	-	0.25	-	-	-	-	-	-	-
202	S20200	0.15	7.50-10.0	0.060	0.030	1.00	4.00-6.00	17.00-19.00	-	-	-	-	0.25	-	-	-	-	-	-	-
301	S30100	0.15	2.00	0.045	0.030	1.00	6.00-8.00	16.00-18.00	-	-	-	-	0.10	-	-	-	-	-	-	-
302	S30200	0.15	2.00	0.045	0.030	0.75	8.00-10.00	17.00-19.00	-	-	-	-	0.10	-	-	-	-	-	-	-
304	S30400	0.07	2.00	0.045	0.030	0.75	8.00-10.50	17.50-19.50	-	-	-	-	0.10	-	-	-	-	-	-	-
304L	S30403	0.030	2.00	0.045	0.030	0.75	8.00-12.00	17.50-19.50	-	-	-	-	0.10	-	-	-	-	-	-	-
304H	S30409	0.04-0.10	2.00	0.045	0.030	0.75	8.00-10.50	18.00-20.00	-	-	-	-	-	-	-	-	-	-	-	-
309S	S30908	0.08	2.00	0.045	0.030	0.75	12.00-15.00	22.00-24.00	-	-	-	-	-	-	-	-	-	-	-	-
310S	S31008	0.08	2.00	0.045	0.030	1.50	19.00-22.00	24.00-26.00	-	-	-	-	-	-	-	-	-	-	-	-
310H	S31009	0.04-0.10	2.00	0.045	0.030	0.75	19.00-22.00	24.00-26.00	-	-	-	-	-	-	-	-	-	-	-	-
316	S31600	0.08	2.00	0.045	0.030	0.75	10.00-14.00	16.00-18.00	2.00-3.00	-	-	-	0.10	-	-	-	-	-	-	-
316L	S31603	0.03	2.00	0.045	0.030	0.75	10.00-14.00	16.00-18.00	2.00-3.00	-	-	-	0.10	-	-	-	-	-	-	-
316H	S31609	0.04-0.10	2.00	0.045	0.030	0.75	10.00-14.00	16.00-18.00	2.00-3.00	-	-	-	-	-	-	-	-	-	-	-
317	S31700	0.08	2.00	0.045	0.030	0.75	11.00-15.00	18.00-20.00	3.00-4.00	-	-	-	0.10	-	-	-	-	-	-	-
317L	S31703	0.03	2.00	0.045	0.030	0.75	11.00-15.00	18.00-20.00	3.00-4.00	-	-	-	0.10	-	-	-	-	-	-	-
321	S32100	0.08	2.00	0.045	0.030	0.75	9.00-12.00	17.00-19.00	-	5x(C+N) min, 0.70 max	-	-	0.10	-	-	-	-	-	-	-
347	S34700	0.08	2.00	0.045	0.030	0.75	9.00-13.00	17.00-19.00	-	-	10xC min, 1.00 max	-	-	-	-	-	-	-	-	-
409	S40910	0.03	1.00	0.040	0.020	1.00	0.50	10.50-11.70	-	6xC min, 0.5 max	0.17	-	0.03	-	-	-	-	-	-	-
410	S41000	0.08-0.15	1.00	0.040	0.030	1.00	0.75	11.5-13.5	-	-	-	-	-	-	-	-	-	-	-	-
430	S43000	0.12	1.00	0.040	0.030	1.00	0.75	16.00-18.00	-	-	-	-	-	-	-	-	-	-	-	-
439	S43035	0.03	1.00	0.040	0.030	1.00	0.050	17.00-19.00	-	0.20 + 4(C+N) min, 1.10 max	-	-	0.03	-	-	-	-	0.15	-	-

ASTM Pipe

Dimensional Tolerances - ASTM A530/A530M

Standard cross-section and weight tolerances (ASTM A530/A530M)

NPS	Outside Diameter (OD) ¹				Wall Thickness (t) ²		Weight ³	
	Under		Over		Under	Over	Under	Over
	in	mm	in	mm	%	%	%	%
1/8 to 1 1/2	0.031	0.8	0.015	0.4	12.5	20	3.5	10
>1 1/2 to 4	0.031	0.8	0.031	0.8	12.5	20	3.5	10
>4 to 8	0.031	0.8	0.062	1.6	12.5	22.5	3.5	10
>8 to 12	0.031	0.8	0.093	2.4	12.5	22.5	3.5	10
>12 to 18	0.031	0.8	0.093	2.4	12.5	22.5	5	10
>18 to 26	0.031	0.8	0.125	3.2	12.5	22.5	5	10
>26 to 34	0.031	0.8	0.156	4.0	12.5	22.5	5	10
>34 to 48	0.031	0.8	0.187	4.8	12.5	22.5	5	10

Notes

1 Includes ovality tolerance except for thin wall pipe (i.e. $t > 3\%$ OD).

2 Min wall thickness = Nominal wall thickness (t) x 0.875. Not applicable if filler metal added.

3 Refer to pages 1-2 to 1-5 for standard pipe weights. For non standard pipes $W(\text{lb/ft}) = 10.68(\text{OD}-t)t$, or $W(\text{kg/m}) = 0.02466(\text{OD}-t)t$

◊ **Standard Cut Lengths.** Pipe ordering alternatives are:

- **Random.** Standard lengths are in the range 15 to 24 feet. Shorter lengths as agreed with the purchaser.
- **Specified Lengths.** Cut lengths as specified, with end finish also specified.

◊ **Length tolerances.** No pipe shall be shorter than specified. No pipe shall be more than 1/4 in (6mm) longer than specified. Tighter tolerances may be specified, e.g. for bevelled pipe.

◊ **Straightness.** All finished pipe shall be reasonably straight. For metal-arc welded pipe maximum deviation from straight = 1/8 in (3.2mm) in 10 ft (3 m).

Seamless and welded austenitic stainless steel pipes

This specification covers austenitic steel pipe intended for high temperature and general corrosive service. H grades in the chemical composition table are specifically for high temperature service.

Manufacture

- Manufacture.** In order to comply with this specification welded pipe must be manufactured by an automatic welding process using no filler metal, or it must be a seamless pipe. If a welded pipe has a nominal pipe size greater than 14 then it may be constructed from two longitudinal sections, and hence have two longitudinal welds. The pipe may be either hot finished or cold finished.

Finish and repair

- Finish.** The surface of the pipe must be clean and free of scale and contaminating iron particles. It can be bright annealed but may be pickled, blasted or can be passivated.
- Repair by welding.** Permitted on $\leq 20\%$ of the weld seam length of welded pipe if $\geq \text{NPS } 6$ and having a wall thickness ≥ 0.200 in (mm). Tungsten-arc welding process is used for repairs, with filler metal to a grade as specified in A 312 (not repeated here). Weld repairs must be identified on the pipe and in test certificate.

Tensile requirements

Grade	UNS	Tensile Strength min		Yield Strength min		Elongation in 2 in (50mm) or 4D min	
		ksi	MPa	ksi	MPa	Longit %	Trans %
All	All	75	515	30	205	35	25
All = All grades listed in the chemical composition table except those listed below							
TP304L	S30403	70	485	25	170	35	25
TP304N	S30451	80	550	35	240	35	25
	S31272	65	450	29	200	35	25
TP316L	S31603	70	485	25	170	35	25
TP316N	S31651	80	550	35	240	35	25
TP321	S32100	75(70 ¹)	515(485 ¹)	30(25 ¹)	205(170 ¹)	35	25
TP321H	S32109	75(70 ¹)	515(485 ¹)	30(25 ¹)	205(170 ¹)	35	25

Notes

1 Values for wall thickness $> \frac{3}{8}$ in (9.5mm)

ASTM Pipe

Pipe Specifications - ASTM A358/A358M

Electric-fusion-welded austenitic chromium-nickel alloy steel pipe for high-temperature service

This specification covers electric-fusion-welded austenitic chromium-nickel alloy steel pipe suitable for high temperature and general corrosive service.

Tolerances

- ◊ **Tolerances.** ASTM A530 requirements, apply unless otherwise stated below.
- ◊ **Outside Diameter.** $\pm 0.5\%$ of specified OD.
- ◊ **Wall Thickness.** Minimum wall thickness shall be ≤ 0.01 in (0.3mm) under nominal thickness.
- ◊ **Out-of-Roundness.** Major and minor outside diameters to differ by less than 1%.
- ◊ **Alignment.** The gap between the pipe and a 10 ft (3 m) straight edge shall $\leq \frac{1}{8}$ in (3mm)

Finish and repair

- ◊ **Appearance.** Finished pipe will have a workmanlike finish.
- ◊ **Plate Defect Repair by Grinding.** Defects may be repaired by machining or grinding, provided the wall thickness is not reduced below the minimum.
- ◊ **Plate Defect Repair by Welding.** Defects which give unsatisfactory wall thicknesses can be repaired by welding if the purchaser agrees. Repair welds must be suitably NDT examined or lengths pressure tested if repair depth is $> \frac{1}{4}$ wall thickness.
- ◊ **Finish.** Pipe will be free of scale and contaminating iron particles. Bright annealed pipe need not be pickled, or blasted. The purchaser may request a passivating treatment.

General Information

General Data

Calculation of tube weights

Form	Dimensions	Weight for Alloys of Density
	mm	p Kg/dm ³
Pipe/Tube (Round)	Outside diameter = D Inside diameter = d Wall thickness = t	0.0031416 (D-t)tp, or 0.0031416 (d+t)tp Kg/m
Square/Rectangular Tube	Sides = a ₁ , a ₂ , Wall thickness = t	0.001 (2a ₁ + 2a ₂ -4t)tp Kg/m

Elements and symbols

Aluminium – Al	Cobalt – Co	Lithium – Li	Oxygen – O	Tin – Sn
Arsenic – As	Columbium – Cb *	Manganese – Mn	Phosphorus – P	Titanium – Ti
Boron – B	Copper – Cu	Molybdenum – Mo	Selenium – Se	Zinc – Zn
Cadmium – Cd	Hydrogen – H	Nickel – Ni	Silicon – Si	Zirconium – Zr
Carbon – C	Iron – Fe	Niobium – Nb	Sulphur – S	
Chromium – Cr	Lead – Pb	Nitrogen – N	Tellurium – Te	* The American designation for Niobium

Densities

Material	Density Kg/dm ³
Aluminium	2.70
Stainless Steel – Ferritic/Martensitic	7.75
– Austenitic	7.75
Copper	8.90
Brass	8.47
Bronze	8.89
INCOLOY Alloy 800	7.95
INCOLOY Alloy 800H	7.95
INCOLOY Alloy 825	8.14
INCOLOY Alloy 903	8.14
INCOLOY Alloy DS	7.92
INCONEL Alloy 600	8.42
INCONEL Alloy 601	8.06

Densities

Material	Density Kg/dm ³
INCONEL Alloy 617	8.36
INCONEL Alloy 625	8.44
INCONEL Alloy 690	8.19
INCONEL Alloy 718	8.19
INCONEL Alloy X-750	8.25
MONEL Alloy 400	8.83
MONEL Alloy K-500	8.46
Nickel 200	8.89
Nickel 201	8.89
UNS 31803	7.80
17-4 PH	7.75

Comparitive densities

Material	Density Kg/dm ³
Stainless Steel	1.000
Stainless Steel – Ferritic/Martensitic	0.977
Mild and Carbon Steel	0.994
Low Alloy Steel	0.987
Aluminium	0.341
Copper	1.134
Brass	1.066
Aluminium Bronze	0.970
Titanium	0.571
Lead	1.440

Abbreviations for Standards Organisations

Abbreviations for standards organisations and documents, referred to in this manual, are expanded below:

AFNOR	French Standards Association	EN	European Norm (Standard) issued by European Committee for Standardisation (CEN)
AISI	American Iron and Steel Institute	ISO	International Organisation for Standardisation
ANSI	American National Standards Institute, Inc.	JIS	Japanese Industrial Standards issued by Japanese Standards Authority (JSA)
API	American Petroleum Institute	MSS	Manufacturers Standardisation Society of the Valve and Fittings Industry, Inc.
ASME	The American Society of Mechanical Engineers	SIS	Swedish Standards
ASTM	American Society for Testing and Materials	SMS	Swedish Mechanical Standards
BS	British Standards issued by British Standards Institution (BSI)	UNI	Italian Standards
DIN	German Standards		

Conversion factors

Description	From Unit	To Units	Multiply by
Angstrom units to microns	Å	μ	0.001
Atmospheres (standard) to pounds per square inch	A	lb/in ² (psi)	14.70
Atmospheres (standard) to Pascal	A	Pa	101325
Bar to kilograms force per square centimetre	bar	kgf/cm ²	1.0197
Bar to pounds force per square inch	bar	lbf/in ² (psi)	14.5038
Centigrade to Fahrenheit	°C	°F	multiply by 1.8 and add 32
Centimetres to feet	cm	ft	0.03280840
Centimetres to inches	cm	in	0.393701
Cubic centimetres to cubic feet	cm ³	ft ³	0.0000353147
Cubic centimetres to cubic inches	cm ³	in ³	0.06102376
Fahrenheit to Centigrade	°F	°C	subtract 32 and multiply 0.5555
Feet per second to miles per hour	ft/s	mph	0.681818
Feet to centimetres	ft	cm	30.48
Feet to metres	ft	m	0.3048
Feet to millimetres	ft	mm	304.8
Cubic feet to cubic metres	ft ³	m ³	0.02831685
Cubic feet to gallons	ft ³	gal	6.2288
Foot pounds to kilogram metres	ftlb	kgm	0.1382
Gallons (UK) to litres	gal	l	4.546092
Gallons (US) to litres	gal	l	3.785412
Grams per cubic centimetres to pounds per cubic inch (density)	gm/cm ³	lb/in ³	0.0361275
Grams to ounces	gm	oz	0.035274
Grams to pounds	gm	lb	0.00220462
Inches to centimetres	in	cm	2.540
Inches to metres	in	m	0.0254
Inches to millimetres	in	mm	25.4
Cubic inches to cubic centimetres	in ³	cm ³	16.38706
Cubic inches to litres	in ³	l	0.01639
Kilogram metres to foot pounds	kgm	ftlb	7.233
Kilograms force to bar	kgf	B	0.9807
Kilograms force to Newtons	kgf	N	9.806650
Kilograms per metre to pounds per foot (assuming constant cross sectional area)	kg/m	lb/ft	0.671970
Kilograms per square centimetre to pounds per square inch	kg/cm ²	lb/in ² (psi)	14.223
Kilograms per square metre to pounds per square foot	kg/cm ²	lb/ft ²	0.2048
Kilograms per square metre to Newtons per square metre	kg/m ²	N/m ²	9.806650
Kilograms per square millimetre to pounds per square inch	kg/mm ²	lb/in ² (psi)	1422.34
Kilograms per square millimetre to tons per square inch	kg/mm ²	ton/in ²	0.63497
Kilogram to pounds	kg	lb	2.205
Kilograms to tons (long)	kg	ton	0.0009842
Kilometres to miles	km	mile	0.62137
Litres of water at 62°F to pounds	l	lb	2.205
Litres to cubic inches	l	in ³	61.03
Litres to gallons (UK)	l	gal	0.2199692
Litres to gallons (US)	l	gal	0.2641720
Metres to inches	m	in	39.37008
Metres to microns	m	μ	1 million
Metres to miles	m	miles	0.000621371
Metres to feet	m	ft	3.28084
Metres to yards	m	yd	1.093613
Cubic metre to cubic inch	m ³	in ³	61023.76
Cubic metre to cubic feet	m ³	ft ³	35.31466
Cubic metre to gallon (UK)	m ³	gallon	219.9692
Cubic metre to gallon (US)	m ³	gallon	264.1720
Cubic metre to litre	m ³	l	1000.0
Cubic metre to cubic yard	m ³	yd ³	1.307951
Metric tons (or tonnes, 1000kg) to long tons	tonne	ton	0.9842
Microns to Angstrom units	μ	Å	1000
Microns to metres	μ	m	0.000001

General Information

General Data

Conversion factors continued

Description	From Unit	To Units	Multiply by
Microns to millimetres	μ	mm	0.001
Microns to thousands of an inch	μ	thou	0.03937008
Miles per hour to feet per second	mph	ft/s	1.46666
Miles to kilometres	m	km	1.60934
Millimetres to feet	mm	ft	0.003280840
Millimetres to inches	mm	in	0.03937008
Millimetres to microns	mm	μ	1000
Millimetres to thousands of an inch	mm	thou	39.37008
Newtons per square metre (Pascal) to kilograms per square metre	N/m ² (Pa)	kg/m ²	0.1019716
Newtons per square millimetre to pounds per square inch	N/mm ²	lb/in ² (psi)	145.0377
Newtons per square millimetre to tons per square inch	N/mm ²	tons/in ²	0.06475
Newtons to kilograms force	N	kgf	0.1019716
Newtons to pound force	N	lbf	0.2248089
Ounces to grams	oz	gm	28.3495
Pints imperial to litres	pt	l	0.5679
Pounds force to Newtons	lbf	N	4.448222
Pounds per cubic inch to grams per cubic centimetre density	lb/in ³	gm/cm ³	27.67990
Pounds per foot to kilograms per metre (assuming constant cross sectional area)	lb/ft	kg/m	1.4882
Pounds per square foot to kilograms per square metre	lb/ft ²	kg/m ²	4.882429
Pounds per square inch to atmospheres	lb/in ² (psi)	A	0.06803
Pounds per square inch to bars	lb/in ² (psi)	bar	0.06894757
Pounds per square inch to kilograms per square centimetre	lb/in ² (psi)	kg/cm ²	0.07030697
Pounds per square inch to kilograms per square millimetre	lb/in ² (psi)	kg/mm ²	0.0007030697
Pounds per square inch to Newtons per square millimetre	lb/in ² (psi)	N/mm ²	0.006894757
Pounds to grams	lb	gm	453.60
Pounds to kilograms	lb	kg	0.453593
Square centimetres to square inches	cm ²	in ²	0.1550003
Square feet to square metres	ft ²	m ²	0.09290304
Square inches to square centimetres	in ²	cm ²	6.4516
Square inches to square millimetres	in ²	mm ²	645.16
Square kilometres to square miles	km ²	miles ²	0.386103
Square metres to square feet	m ²	ft ²	10.763910
Square metres to square yards	m ²	yd ²	1.195990
Square miles to square kilometres	miles ²	km ²	2.590
Square millimetres to square inches	mm ²	in ²	0.001550003
Square yards to square metres	yd ²	m ²	0.8361274
Tons per square inch to kilograms per square millimetre	ton/in ²	kg/mm ²	1.575
Tons per square inch to Newtons per square millimetre	ton/in ²	N/mm ²	15.4443
Tons (long) to kilograms	ton	kg	1016.047
Tons (long) to metric tons (or tonne, 1000kg)	ton	tonne	1.016047
Yards to metres	yd	m	0.9144
Cubic yards to cubic metres	yd ³	m ³	0.7645549

General Information

Standard and Birmingham Wire Gauges

Conversion of SWG and BWG number to wall thickness

Standard Wire Gauge (formerly Imperial Wire Gauge) SWG		
SWG	Wall Thickness	
	in	mm
0 SWG	0.324	8.23
1 SWG	0.300	7.62
2 SWG	0.276	7.01
3 SWG	0.252	6.40
4 SWG	0.232	5.89
5 SWG	0.212	5.38
6 SWG	0.192	4.88
7 SWG	0.176	4.47
8 SWG	0.160	4.06
9 SWG	0.144	3.66
10 SWG	0.128	3.25
11 SWG	0.116	2.95
12 SWG	0.104	2.64
13 SWG	0.092	2.34
14 SWG	0.080	2.03
15 SWG	0.072	1.83
16 SWG	0.064	1.63
17 SWG	0.056	1.42
18 SWG	0.048	1.22
19 SWG	0.040	1.02
20 SWG	0.036	0.91
21 SWG	0.032	0.81
22 SWG	0.028	0.71
23 SWG	0.024	0.61
24 SWG	0.0220	0.56
25 SWG	0.0200	0.51
26 SWG	0.0180	0.46
27 SWG	0.0164	0.42
28 SWG	0.0148	0.38
29 SWG	0.0136	0.35
30 SWG	0.0124	0.31
31 SWG	0.0116	0.29
32 SWG	0.0108	0.27
33 SWG	0.0100	0.25
34 SWG	0.0092	0.23
35 SWG	0.0084	0.21
36 SWG	0.0076	0.19
37 SWG	0.0068	0.17
38 SWG	0.0060	0.15
39 SWG	0.0052	0.13
40 SWG	0.0048	0.12

Birmingham Wire Gauge BWG		
BWG	Wall Thickness	
	in	mm
0 BWG	0.340	8.64
1 BWG	0.300	7.62
2 BWG	0.284	7.21
3 BWG	0.259	6.58
4 BWG	0.238	6.05
5 BWG	0.220	5.59
6 BWG	0.203	5.16
7 BWG	0.180	4.57
8 BWG	0.165	4.19
9 BWG	0.148	3.76
10 BWG	0.134	3.40
11 BWG	0.120	3.05
12 BWG	0.109	2.77
13 BWG	0.095	2.41
14 BWG	0.083	2.11
15 BWG	0.072	1.83
16 BWG	0.065	1.65
17 BWG	0.058	1.47
18 BWG	0.049	1.24
19 BWG	0.042	1.07
20 BWG	0.035	0.89
21 BWG	0.032	0.81
22 BWG	0.028	0.71
23 BWG	0.025	0.64
24 BWG	0.022	0.56
25 BWG	0.020	0.51
26 BWG	0.018	0.46
27 BWG	0.016	0.41
28 BWG	0.014	0.36
29 BWG	0.013	0.33
30 BWG	0.012	0.30
31 BWG	0.010	0.25
32 BWG	0.009	0.23
33 BWG	0.008	0.20
34 BWG	0.007	0.18
35 BWG	0.005	0.13
36 BWG	0.004	0.10

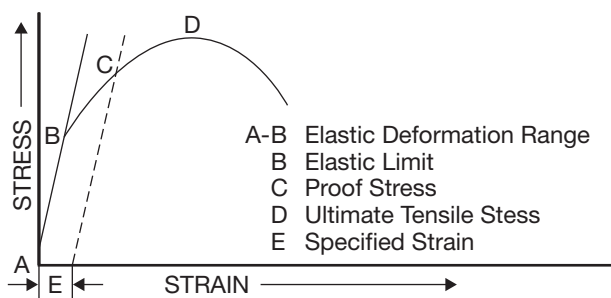
General Information

Testing Stainless Steel Products

There are two main categories of tests: destructive tests in which the parent material or representative samples of the product are tested, and nondestructive tests performed on the finished product.

Tensile test

This is probably the most revealing of the mechanical tests that can be performed upon a specimen of pipe or tubular product material. A longitudinal specimen¹ of known cross sectional area is taken from the material and gripped at each end, and then pulled apart until fracture occurs. By recording the gradually increasing load applied and the extension during loading a Stress-Strain Graph can be plotted (see diagram).



Notes

- Stress = Force per unit area,
Example units: Pounds per square inch (psi or lbf/in²),
Newtons per square metre (N/m²), Pascal (Pa).
1 ksi = 1x10³ psi, 1 Pa = 1 N/m²; 1 MPa = 1x10⁶ Pa.
- Strain = Increase in length per unit length

Initially the graph is a straight line, and the material can be expected to return to its original dimensions when the load is removed.

The graph deviates from the straight line at point B, when it enters the plastic region. The deformation is permanent after this load has been applied.

The test piece continues to stretch and also weakens so that the elongation increases even though the load is decreased. Eventually the test piece fractures.

From this graph the following values can be computed.

- ◊ **Tensile Strength (D).** The maximum tensile stress that the material is capable of sustaining.
- ◊ **Yield Strength or Proof Stress (C).** The load at which the sample is permanently elongated by a specific percentage of the original length. The percentage elongation (corresponding to the distance E on the graph) is commonly set at 0.2%. The dotted line to C on the graph is drawn parallel to line A-B.)
- ◊ **Elongation.** This is a measure of the extension of the test piece at the point of fracture. The fractured test piece is carefully fitted together and the distance between gauge marks on the test piece is measured and compared with original gauge length. The increase in length is expressed as a percentage of the original length.
- ◊ **Elastic Limit or Yield Point (B).** The stress at which the test piece is permanently deformed.
- ◊ **Modulus of Elasticity.** In the tensile test, the ratio between Stress and Strain within the elastic deformation range (A-B) is known as Young's Modulus of Elasticity.
- ◊ **Reduction of Area.** This is the reduction in cross-sectional area of the test piece after tensile fracture expressed as a percentage of the original cross-sectional area.

Notes

¹ The longitudinal specimen may be a full size tubular section with metal plugs fitted in the ends to allow gripping by the test machine, or for larger tube sizes a strip may be cut from the tube. Transverse tension tests may also be performed using a ring expansion method or for larger tube sizes (e.g. greater than 8 in NPS) a transverse strip may be cut/flattened.

General Information

Testing Stainless Steel Products

Hardness tests

- **Brinell Hardness Test.** A standard size hardened steel ball is indented into the surface of material by an applied standard load. The diameter of the impression is measured accurately by microscope and converted to a hardness value using tables.
- **Vickers Diamond Hardness Test.** This determines hardness by measuring the impression left in material by a diamond pyramid under a standard load. The impression is accurately measured, and its area calculated. The Vickers Hardness Number is calculated by dividing the load (kg) by the area of impression (mm²).
- **Rockwell Hardness Test.** This determines hardness by measuring the depth to which a diamond cone or hardened steel ball, under specific load, penetrates the material. Two loads are used, a minor load (10 kgf) and then a major load (100 or 150 kgf), the difference in indentation being used by the machine to determine the Rockwell number. The number increases with increasing hardness and is displayed or printed by the machine. Two scales are most frequently used, a B scale with a 100 kgf load and 1.588mm steel ball, and a C scale with a 150 kgf load and diamond cone.
A Rockwell superficial hardness machine is used for testing very thin wall thicknesses, the minor load used being 3 kgf and the major load being 15, 30 or 45 kgf. The superficial hardness scales used are then 15T, 30T or 45T with a 1.588mm steel ball, or 15N, 30N or 45N with a diamond cone.

Impact tests

In this type of test, a sample is subjected to sudden force to measure its toughness or resistance to shock.

- **Charpy Impact Test.** In this test a specimen is supported at both ends and subjected to a blow by a Pendulum immediately behind a prepared notch, either 'U' or 'V' shape in cross section. The energy absorbed in fracturing the specimen is measured by the height to which the pendulum rises after breaking the test piece. These tests can be carried out at various temperatures to determine the performance of material at either elevated or cryogenic temperatures.
At higher temperature specimens fracture by a ductile mechanism, absorbing much energy. At low temperatures they fracture in a brittle manner absorbing less energy. Within the transition range a mixture of ductile and brittle fracture is observed. Minimum test results for absorbed energy, fracture appearance, lateral expansion or a combination of these, may be specified.

Manipulating tests

These tests prove the ductility of certain tubular products and confirm the soundness of welds.

- **Bend Tests.** A bend test involves bending a sufficient length of full size pipe through 90° or 180° degrees around a mandrel having 12 or 8 times the nominal pipe diameter. This checks the ductility and weld soundness of pipe (2 in and under) used for coiling. Transverse guided bend tests may also be specified to check the ductility of fusion welds. These involve bending the root or face of the weld in a specimen against a plunger.
- **Flange Test.** This tests the ability of boiler tubes to withstand bending into a tube sheet. It involves the tube having a flange turned over a right angles to the tube body.
- **Flattening Test.** This is usually applied to tube and involves flattening a sample of tube between two parallel faces without the tube showing flaws or cracks.
The length of the test piece and degree to which it is to be flattened (i.e. the distance between the parallel faces) are specified.
- **Flare or Drift Test.** This is an alternative to the flange test for certain types of pressure tube. A cone is forced into the end of the tube. The end of the tube is expanded by a specified increase in diameter without splits or cracks. The included angle of drift is also specified.

General Information

Testing Stainless Steel Products

Corrosion testing

Various corrosion tests are available using different corrosive environments to indicate the performance of material under heavy duty applications.

- ◊ **Weld Decay Test.** This test detects intercrystalline corrosion and involves the use of boiling copper sulphate/sulphuric acid solution. Test samples are first sensitised and then immersed in the solution for 72 hours. After the immersion the samples are bent through 90 degrees and are considered satisfactory if no cracks are present.
- ◊ **Strauss Test.** This test detects intercrystalline corrosion and involves the use of boiling copper sulphate/sulphuric acid solution which must contain solid electrolytic copper. The test samples are immersed in the solution for 15 hours. After immersion the samples are bent through 90 degrees and are considered resistant to intercrystalline corrosion if they bend without cracking.
- ◊ **Huey Test.** This test detects the susceptibility of a material to intergranular attack and involves the use of boiling nitric acid. The test samples are immersed in the solution at a concentration of 65% by weight for five 48 hour periods. The effect of the acid on the material is measured by the loss in weight after each period and the corrosion rate assessed as a thickness loss in a given time.
- ◊ **Potentiostat Test** This is a method of determining the corrosion properties of stainless steel by producing polarisation curves which relate electrode potentials and a current flow. The shapes of the curves, which are very sensitive to microstructure and composition, provide a critical method of assessing the corrosion properties of stainless steel.

Non-destructive tests

Non-destructive tests do not damage the material or product being tested. Frequently they are built into production processes, as is the case with pipe tested using eddy current equipment.

- ◊ **Ultrasonic Testing.** This test involves ultrasonic sound waves being aimed, via a coupling medium, at the material to be tested. A proportion are bounced back at the interface but the remainder enter the material and bounce from the internal surface, to the external surface, where a transducer converts them into electrical energy. This is then monitored on a cathode ray tube where results are compared with those from a calibration standard. Any deviations from the standard are visible, thus indicating cracks or internal defects.
- ◊ **Eddy-Current Testing.** This involves inducing eddy currents into the material by exciting a coil which surmounts two narrow search coils surrounding the material. Any discontinuities in material are found by comparing the electrical conditions that exist in the two search coils. The fault signals are amplified and can be shown on a cathode ray tube or as an audible signal.
- ◊ **Hydrostatic Testing.** This is used to test the manufactured items under a pressure equivalent to or greater than pressure to be encountered in service. It involves filling the tube with water, which cannot be compressed, and increasing the pressure inside the tube to that specified.
- ◊ **Magnetic Particle Testing.** This method of testing is used when trying to detect discontinuities in material of ferromagnetic structure. The method is based on the principle that an imperfection will cause a distortion in the magnetic field pattern of a magnetised component. The imperfection can be revealed by applying magnetic particles to the component during or after magnetisation.
- ◊ **Radiographic (X-Ray) Testing.** This is usually used to determine whether a weld is sound. It involves subjecting a weld or weld area to an X-Ray source with an X-Ray sensitive film plate on the under side of the weld. The results are shown on the developed film (a photomicrograph) and interpreted according to specification.
- ◊ **Dye-Penetrant Test.** This is used to detect cracks and involves spraying a dye on the area to be tested. After allowing time for penetration the surplus dye is removed and the area is then sprayed with a white developer. Any faults are revealed as coloured lines or spots caused by the developer absorbing the dye seeping from the cracks. If more sensitive results are required, a fluorescent dye is used and the same process is followed. When viewed under ultraviolet light any defects show as a highly fluorescent line or spot.

Pressure ratings for pipes, tubes and fittings

Wall thickness calculations for straight pipe under internal pressure

The following equations and tables are based on those provided in the Process Piping Specification, ASME B31.3a-2008, ASME Code for Pressure Piping (see Notes for references to source paragraphs and tables in this specification).

Firstly, any one of the following four equations may be used to calculate the ‘pressure design wall thickness’ (t) of a straight pipe subject to internal pressure.

The equations assume $t < D/6$ (for pipe with $t > D/6$ or $P/SE > 0.385$ additional factors need to be considered).

The four alternative equations are:

$$t = \frac{PD}{2(SE + PY)} \quad t = \frac{PD}{2SE} \quad t = \frac{D}{2} \left(1 - \sqrt{\frac{SE - P}{SE + P}} \right) \quad t = \frac{P(d + 2c)}{2[SE - P(1 - Y)]}$$

where:

t = Pressure design thickness

d = Inside diameter of pipe. For pressure design calculation, the inside diameter of the pipe is the maximum value allowable under the purchase specification.

P = Internal design pressure.

D = Outside diameter pipe as listed in tables of standards or specifications or as measured.

E = Quality factor. See the table “Basic quality factors ‘E’ for longitudinal weld joints in stainless steel pipes, tubes and fittings” on page 8-10.

S = Stress value for material from the table “Basic allowable stresses ‘S’ in tension for stainless steels” on page 8-10.

Y = Coefficient from table “Values of coefficient ‘Y’ for $t < D/6$ ” on page 8-9.

Secondly, the minimum required wall thickness t_m of straight sections of pipe is determined in accordance with the following equation.

$$t_m = t + c$$

where:

t_m = Minimum required thickness, including mechanical, corrosion and erosion allowances.

c = The sum of the mechanical allowances (thread or groove depth) plus corrosion and erosion allowances.
For threaded components, the nominal thread depth (dimension h of ASME B1.20.1, or equivalent) shall apply.
For machined surfaces or grooves where the tolerance is not specified, the tolerance shall be assumed to be 0.5 mm (0.02 in) in addition to the specified depth of the cut.

The actual minimum thickness for the pipe selected, considering manufacturer’s tolerance, shall not be less than t_m .

Units of measure for calculations

It is important to use compatible units for pressure calculations. ASTM and ASME/ANSI specifications are based upon imperial sizes.

Pipe bends

The equations above may also be used for pipe bends provided the requirement for minimum wall thickness (t_m) is met.

Further information

Refer to ASME B31.3a-2008 paragraph 304 for further details relating to pressure rating and wall thickness calculations applicable to elbows, branch connections, closures, flanges, reducers and other components.

General Information

Pressure Ratings

Values of coefficient 'Y' for t<D/6

Materials	Temperature, °F (°C)					
	≤900 (≤482)	950 (510)	1000 (538)	1050 (566)	1100 (593)	≥1150 (≥621)
	Y					
Ferritic Steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic Steels	0.4	0.4	0.4	0.4	0.5	0.7
Cast Iron	0.0	-	-	-	-	-

Notes

- The above table and the equations are based on paragraph 304.1 of ASME B31.3a-2008
- The value for Y may be interpolated for intermediate temperatures. For t > D/6:

$$Y = \frac{d + 2c}{D + d + 2c}$$

Basic quality factors 'E' for longitudinal weld joints in stainless steel pipes, tubes and fittings

Spec No.	Class (or Type)	Description	E	Notes
A182	-	Forgings and Fittings	1.00	-
A268	-	Seamless Tube	1.00	-
	-	Electric Fusion Welded Tube, Double Butt Seam	0.85	-
	-	Electric Fusion Welded Tube, Single Butt Seam	0.80	-
A269	-	Seamless Tube	1.00	-
	-	Electric Fusion Welded Tube, Double Butt Seam	0.85	-
	-	Electric Fusion Welded Tube, Single Butt Seam	0.80	-
A312	-	Seamless Pipe	1.00	-
	-	Electric Fusion Welded Pipe, Double Butt Seam	0.85	-
	-	Electric Fusion Welded Pipe, Single Butt Seam	0.80	-
A358	1, 3, 4	Electric Fusion Welded Pipe, 100% radiographed	1.00	-
	5	Electric Fusion Welded Pipe, Spot radiographed	0.90	-
	2	Electric Fusion Welded Pipe, Double Butt Seam	0.85	-
A376	-	Seamless Pipe	1.00	-
A403	-	Seamless Fittings	1.00	-
	-	Welded Fitting, 100% radiographed	1.00	1
	-	Welded Fitting, Double Butt Seam	0.85	-
	-	Welded Fitting, Single Butt Seam	0.80	-
A409	-	Electric Fusion Welded Pipe, Double Butt Seam	0.85	-
	-	Electric Fusion Welded Pipe, Single Butt Seam	0.80	-
A430	-	Seamless Pipe	1.00	-
A789	-	Seamless	1.00	-
	-	Electric Fusion Welded Pipe, 100% radiographed	1.00	-
	-	Electric Fusion Welded Tube, Double Butt Seam	0.85	-
	-	Electric Fusion Welded Tube, Single Butt Seam	0.80	-
A790	-	Seamless	1.00	-
	-	Electric Fusion Welded Pipe, 100% radiographed	1.00	-
	-	Electric Fusion Welded Pipe, Double Butt Seam	0.85	-
		Electric Fusion Welded Pipe, Single Butt Seam	0.80	-

Notes

- This table is based on Table A-1B of ASME B31.3a-2008
- 1 An E factor of 1.00 may be applied only if all welds, including welds in the base material, have passed 100% radiographic examination. Substitution of ultrasonic examination for radiography is not permitted for the purpose of obtaining an E of 1.00.

Basic allowable stresses 'S' in tension for stainless steels

ASTM Spec No.	Grade	Min Temp °F (for °C see Notes)	Metal Temperature, °F (°C)										Notes
			Min Temp to 100 (37.8)	300 (149)	500 (260)	700 (371)	850 (454)	1000 (538)	1150 (621)	1300 (704)	1400 (760)	1500 (816)	
			Basic Allowable Stress, S ksi										
A312	TP321	-325	16.7	16.7	16.1	14.6	14.0	13.5	5.0	1.7	0.8	0.3	1, 2
A376	TP321	-325	16.7	16.7	16.1	14.6	14.0	13.5	5.0	1.7	0.8	0.3	1, 2
A269	TP304L	-425	16.7	16.7	14.8	13.5	12.8	7.8	4.0	2.1	1.1	0.9	2, 3
A312	TP304L	-425	16.7	16.7	14.8	13.5	12.8	7.8	4.0	2.1	1.1	0.9	-
A358	304L	-425	16.7	16.7	14.8	13.5	12.8	7.8	4.0	2.1	1.1	0.9	2
A269	TP316L	-325	16.7	16.7	14.4	12.9	12.1	11.2	8.8	3.5	1.8	1.0	2, 3
A312	TP316L	-325	16.7	16.7	14.4	12.9	12.1	11.2	8.8	3.5	1.8	1.0	-
A358	316L	-325	16.7	16.7	14.4	12.9	12.1	11.2	8.8	3.5	1.8	1.0	2
A312	TP321	-325	16.7	16.7	16.1	14.6	14.0	13.5	6.9	3.2	1.9	1.1	1, 2, 4
A376	TP321	-325	16.7	16.7	16.1	14.6	14.0	13.5	6.9	3.2	1.9	1.1	1, 2, 4
A312	TP321H	-325	16.7	16.7	16.1	14.6	14.0	13.5	6.9	3.2	1.9	1.1	1, 2
A376	TP321H	-325	16.7	16.7	16.1	14.6	14.0	13.5	6.9	3.2	1.9	1.1	-
A268	TP409	-20	20.0	-	-	-	-	-	-	-	-	-	6
A268	TP430Ti	-20	20.0	-	-	-	-	-	-	-	-	-	6, 7
A376	16-8-2H	-325	20.0	-	-	-	-	-	-	-	-	-	5, 6, 8
A268	TP405	-20	20.0	17.7	17.2	16.2	10.4	4.0	-	-	-	-	6
A268	TP410	-20	20.0	17.7	17.2	16.2	10.4	6.4	1.8	-	-	-	6
A268	TP430	-20	20.0	19.6	19.0	17.6	10.4	6.5	2.4	-	-	-	6, 7
A312	TP317L	-325	20.0	20.0	17.7	16.2	15.2	-	-	-	-	-	-
A312	TP310	-325	20.0	20.0	20.0	18.3	14.6	11.0	3.6	0.8	0.4	0.2	4, 6, 10
A358	310S	-325	20.0	20.0	20.0	18.3	14.6	11.0	3.6	0.8	0.4	0.2	2, 4, 5, 6
A409	TP310	-325	20.0	20.0	20.0	18.3	14.6	11.0	3.6	0.8	0.4	0.2	2, 4, 5, 6, 10
A312	TP321	-325	20.0	20.0	19.3	17.5	16.7	16.2	5.0	1.7	0.8	0.3	1
A358	321	-325	20.0	20.0	19.3	17.5	16.7	16.2	5.0	1.7	0.8	0.3	1, 2
A376	TP321	-325	20.0	20.0	19.3	17.5	16.7	16.2	5.0	1.7	0.8	0.3	1, 2
A409	TP321	-325	20.0	20.0	19.3	17.5	16.7	16.2	5.0	1.7	0.8	0.3	1, 2
A312	TP309	-325	20.0	20.0	20.0	18.3	14.6	10.5	5.0	2.3	1.3	0.7	4, 6, 10
A358	309S	-325	20.0	20.0	20.0	18.3	14.6	10.5	5.0	2.3	1.3	0.7	4, 5, 6, 2
A409	TP309	-325	20.0	20.0	20.0	18.3	14.6	10.5	5.0	2.3	1.3	0.7	2, 4, 5, 6, 10
A312	TP347	-425	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	-
A358	347	-425	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	1, 2
A376	TP347	-425	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	1, 2
A409	TP347	-425	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	1, 2
A312	TP348	-325	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	-
A358	348	-325	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	1, 2
A376	TP348	-325	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	1, 2
A409	TP348	-325	20.0	20.0	19.9	18.6	18.2	18.0	6.1	2.2	1.2	0.8	1, 2
A312	TP310	-325	20.0	20.0	20.0	18.3	14.6	11.0	7.3	3.5	1.6	0.8	4, 6, 10, 11
A358	310S	-325	20.0	20.0	20.0	18.3	14.6	11.0	7.3	3.5	1.6	0.8	2, 4, 5, 6, 11
A430	FP321	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	1, 2
A312	TP321	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	1, 4
A358	321	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	1, 2, 4
A376	TP321	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	1, 2, 4
A409	TP321	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	1, 2, 4
A430	FP321H	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	1, 2
A376	TP321H	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	1, 2
A312	TP321H	-325	20.0	20.0	19.3	17.5	16.7	16.2	6.9	3.2	1.9	1.1	-
A430	FP316	-425	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 5, 8
A430	FP316H	-325	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 5, 8
A269	TP316	-425	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 3, 4, 5, 8
A312	TP316	-425	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	4, 8
A358	316	-425	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 4, 5, 8
A376	TP316	-425	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 4, 5, 8
A409	TP316	-425	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 4, 5, 8
A312	TP317	-325	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	4, 8
A409	TP317	-325	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 4, 5, 8

General Information

Pressure Ratings

ASTM Spec No.	Grade	Min Temp °F (for °C see Notes)	Metal Temperature, °F (°C)										Notes
			Min Temp to 100 (37.8)	300 (149)	500 (260)	700 (371)	850 (454)	1000 (538)	1150 (621)	1300 (704)	1400 (760)	1500 (816)	
			Basic Allowable Stress, S ksi										
A376	TP316H	-325	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	2, 5, 8
A312	TP316H	-325	20.0	20.0	17.9	16.3	15.7	15.3	9.8	4.1	2.3	1.3	8
A430	FP347	-425	20.0	20.0	18.6	18.2	18.2	18.0	10.5	4.4	2.5	1.3	1, 2
A430	FP347H	-325	20.0	20.0	18.6	18.2	18.2	18.0	10.5	4.4	2.5	1.3	1, 2
A376	TP347H	-325	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	1, 2
A312	TP347	-425	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	4
A358	347	-425	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	1, 2, 4
A376	TP347	-425	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	1, 2, 4
A409	TP347	-425	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	1, 2, 4
A312	TP348	-325	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	4
A358	348	-325	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	1, 2, 4
A376	TP348	-325	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	1, 2, 4
A409	TP348	-325	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	1, 2, 4
A312	TP347H	-325	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	-
A312	TP348H	-325	20.0	20.0	19.9	18.6	18.2	18.0	10.5	4.4	2.5	1.3	-
A430	FP304	-425	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	2, 5, 8
A430	FP304H	-325	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	2, 5, 8
A269	TP304	-425	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	2, 3, 4, 5, 8
A312	TP304	-425	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	4, 8
A358	304	-425	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	2, 4, 5
A376	TP304	-425	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	2, 4, 5, 8
A376	TP304H	-325	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	2, 5, 8
A409	TP304	-425	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	2, 4, 5, 8
A312	TP304H	-325	20.0	20.0	17.5	16.0	14.9	13.8	7.7	3.7	2.3	1.4	8
A268	TP443	-20	23.3	21.4	19.4	17.5	15.1	4.5	-	-	-	-	6
A268	TP446	-20	23.3	21.4	19.4	17.5	15.1	4.5	-	-	-	-	6
A789	S32304	-60	29.0	26.3	24.9	-	-	-	-	-	-	-	9
A790	S32304	-60	29.0	26.3	24.9	-	-	-	-	-	-	-	9
A789	S31803	-60	30.0	28.9	27.2	-	-	-	-	-	-	-	9
A790	S31803	-60	30.0	28.9	27.2	-	-	-	-	-	-	-	9
A789	S32900	-20	30.0	-	-	-	-	-	-	-	-	-	9
A790	S32900	-20	30.0	-	-	-	-	-	-	-	-	-	9
A789	S32750	-20	38.7	33.1	31.4	-	-	-	-	-	-	-	9
A790	S32750	-20	38.7	33.1	31.4	-	-	-	-	-	-	-	9

Notes

- This table is based on Table A-1A of ASME B31.3a-2008.
- For specified minimum tensile and yield strengths refer to the individual ASTM specifications in Sections 1, 2, 3 and 5.
- Minimum temperatures in °C: -20°F = -29°C, -60°F = -51°C, -325°F = -199°C, -425°F = -254°C
- 1 For temperatures above 538°C (1000°F), these stress values may be used only if the material has been heat treated at a temperature of 1093°C (2000°F) minimum.
- 2 When the material has not been solution heat treated, the minimum temperature shall be -29°C (-20°F) unless the material is impact tested.
- 3 Must be verified by tensile test.
- 4 For temperatures above 538°C (1000°F), these stress values apply only when the carbon content is 0.04% or higher.
- 5 For temperatures above 538°C (1000°F), these stress values may be used only if the material has been heat treated by heating to a minimum temperature of 1038°C (1900°F) and quenching in water or rapidly cooling by other means.
- 6 This steel is intended for use at high temperatures; it may have low ductility and/or low impact properties at room temperature after being used at higher temperatures.
- 7 If the chemical composition of this Grade is such as to render it hardenable, qualification under P-No. 6 is required.
- 8 Increasingly tends to precipitate intergranular carbides as the carbon content increases above 0.03%.
- 9 This steel may develop embrittlement after service at approximately 316°C (600°F) and higher temperature.
- 10 This material when used below -29°C (-20°F) shall be impact tested if the carbon content is above 0.10%.
- 11 The stress values above 538°C (1000°F) shall be used only when the micrograin size, is No. 6 or less (coarser grain). Otherwise, the lower stress values listed for the same material, specification, and grade shall be used.



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