Exotic Materials Tubing

June 2019

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Stainless Steel 316/316L

Stainless Steels 316/316L are austenitic grades and two of the most used alloys in a variety of industrial applications. The molybdenum addition gives this grade good resistance to general corrosion and provides increased strength at elevated temperatures. The austenitic structure also gives these grades excellent toughness, even at cryogenic temperatures. Grade 316L, the low carbon version of 316, minimizes harmful carbide precipitation due to welding.

It is common for 316 and 316L to be stocked in 'Dual Certified' form. These items have chemical and mechanical properties complying with both 316 and 316L specifications.

The corrosion resistance of stainless steel grades 316/316L is excellent in a wide range of atmospheric environments and many corrosive media. However, it is subjected to pitting and crevice corrosion in warm chloride environments, as well as to stress corrosion cracking.

Initially developed for use in paper mills, 316/316L stainless steel is typically used in the following applications:

- Food processing equipment
- Brewery equipment
- Chemical and petrochemical equipment
- Laboratory equipment
- Boat fittings
- Chemical transportation containers
- Heat exchangers
- Nuts and bolts
- Springs
- Medical implants
- General Service Process Equipment

Typical Composition	
Element	**Weight (%)**
Carbon	0.03/0.08 max
Manganese	2.00 max
Chromium	16.0 to 18.0
Nickel	10.0 to 14.0
Molybdenum	2.0 to 3.0

Typical Specifications	
Product	**Standard**
Bar	ASTM A479 ASTM A276 EN 10088-3
Forging	ASTM A182
Casting	ASTM A351
Tube	ASTM A269 ASTM A213
Other	NACE MR0175
	NACE MR0103
UNS No.	S31600/S31603

Tubing Specification: High Quality, Fully Annealed, Stainless Steel Tubing to ASTM A269 Grade 316/316L UNS S31600/S31603. Recommended Tube Hardness 80 HRB. Maximum Permissible Hardness 90 HRB.

Table 1	316/316L Stainless Steel															Imperial
Tube O.D. Size	Wall Thickness, inches															
	0.010	0.012	0.014	0.016	0.020	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.120	0.134	0.156	0.188
1/16	5600	6900	8200	9500	12100	16800										
1/8						8600	10900									
3/16						5500	7000	10300								
1/4						4000	5100	7500	10300							
5/16							4100	5900	8100							
3/8							3300	4800	6600							
1/2							2600	3700	5100	6700						
5/8								3000	4000	5200	6100					
3/4								2400	3300	4300	5000	5800				
7/8								2100	2800	3600	4200	4900				
1									2400	3200	3700	4200	4700			
1 1/4										2500	2900	3300	3700	4100	4900	
1 1/2											2400	2700	3000	3400	4000	4500
2												2000	2200	2500	2900	3200

Working pressure is measured in ‘psig’

Table 2	316/316L Stainless Steel									Metric
Tube O.D. Size	Wall Thickness, mm									
	0.8	1.0	1.2	1.5	1.8	2.0	2.2	2.5	2.8	3.0
3	720									
6	330	430	520	680						
8		310	380	490						
10		240	300	380	470					
12		200	240	310	380	430				
14		180	220	280	340	390	430			
15		170	200	260	320	360	400			
16			190	240	300	330	370	430		
18			170	210	260	290	330	380		
20			150	190	230	260	290	330	380	
22			140	170	210	230	260	300	340	
25					180	200	230	260	300	320

Working pressure is measured in ‘bar’

- Not recommended for gas service
- Recommended for all services - standard assembly
- Recommended for all services - Use pre-assembly tool
- Recommended for all services - Use ‘Hyferset’ pre-assembly tool
- No data/Not recommended/No solution

Alloy 400

Alloy 400, also known as Monel™, is a nickel-copper alloy, resistant to sea water and steam at high temperatures as well as to salt and caustic solutions. The alloy possesses excellent corrosion resistance in a wide variety of media and is also characterized by good weldability and moderate to high strength.

The alloy has been used in a variety of applications. It has excellent resistance to rapidly flowing brackish water or seawater. It is particularly resistant to hydrochloric and hydrofluoric acids when they are de-aerated. Indeed, it is one of few metallic materials which can be used in contact with fluorine, hydrofluoric acid, hydrogen fluoride and their derivatives.
The alloy is widely used in the chemical, oil and marine industries. Good mechanical properties from sub-zero temperatures up to 1020 °F.

Typical applications include:

- Valves, pumps, shafts, fittings, and fasteners, especially in marine environment
- Chemical and hydrocarbon processing equipment
- Crude oil distillation towers
- Gasoline and freshwater tanks
- Seawater Handling Equipment

Typical Composition Grade 2	
Element	**Weight (%)**
Nickel	63.0 min
Copper	28.0 to 34.0
Iron	2.5 max
Manganese	2.0 max
Carbon	0.3 max

Typical Specifications	
Product	**Standard**
Bar	ASTM B164
Forging	ASTM B564
Tube	ASTM B165
Other	NACE MR0175 NACE MR0103
UNS No.	N04400

Tubing Specification: High Quality, Fully Annealed, Alloy 400 Tubing to ASTM B165 Grade UNS N04400.
Recommended Tube Hardness 70 HRB. Maximum Permissible Hardness 75 HRB.

Table 3	Alloy 400							Imperial
Tube O.D. Size	Wall Thickness, inches							
	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.12
1/8	8000	10400						
1/4	3700	4800	7000	9800				
5/16		3700	5400	7500				
3/8		3100	4400	6100				
1/2		2400	3500	4700	6200			
3/4			2200	3000	4000	4600	5400	
1				2200	2900	3400	3900	4300

Working pressure is measured in 'psig'

Table 4	Alloy 400							Metric
Tube O.D. Size	Wall Thickness, mm							
	0.8	1	1.2	1.5	2	2.5	2.8	3
3	670	890						
6	310	400	490	640				
8		290	350	460				
10		230	280	360				
12		190	230	290	400			
18			160	200	270			
20			140	180	240	310	350	
25				140	190	240	280	300

Working pressure is measured in 'bar'

Not recommended for gas service

Recommended for all services - standard assembly

No data/Not recommended/No solution

Super Austenitic 6Mo

Super austenitic stainless steel 6Mo is a high performance alloy designed specifically for added corrosion resistance. It has the same structure as the common austenitic alloys, and greater levels of elements such as chromium, nickel, molybdenum, copper, and nitrogen, which gives it enhanced strength and corrosion resistance.

6Mo is especially suited for high-chloride environments such as brackish water, seawater, pulp mill bleach plants, and other high-chloride process streams. It is often used as a replacement in critical components where alloy 316/316L has failed by pitting, crevice attack, or chloride stress corrosion cracking. In many applications, the super austenitic stainless steels have been found to be a technically suitable and much more cost-effective alternative than nickel-base alloys.

Typical Composition	
Element	**Weight (%)**
Carbon	0.02 max
Manganese	1.00 max
Chromium	19.5 to 20.5
Nickel	17.5 to 18.5
Molybdenum	6.0 to 6.5
Nitrogen	0.18 to 0.22
Copper	0.5 to 1.0

Typical Specifications	
Product	**Standard**
Bar	ASTM A479 ASTM A276
Forging	ASTM A182 F44
Tube	ASTM A269
Other	NACE MR0175
	NACE MR0103
UNS No.	S31254

Refer to page 9 for product availability.

Typical applications of this alloy are:

- Seawater Handling Equipment
- Pulp Mill Bleach Systems
- Tall Oil Distillation Columns and Equipment
- Chemical Processing Equipment
- Food Processing Equipment
- Desalination Equipment
- Flue Gas Desulfurization Scrubbers
- Oil and Gas Production Equipment

Why selecting Steel 6Mo grade over Steel 316 grade?

- For all those applications which involve moderate to high chloride presence.
- For those applications in which 316 has failed or is likely to fail due to pitting, crevice or induced stress corrosion cracking.
- For those applications that require compliance to NACE standards and the existing 316 range can not meet such demand.
- For NACE equipment in processes over 60 °C, where 316 is not permitted.

Parker Hannifin carried out Stress Corrosion Cracking Testing as per ASTM G48 conducted by an independent party that determined the time to failure of 6Mo to be 3 times higher of that of 316. In service applications, those results translate into a life expectancy of 6Mo three times longer than that of 316 in the same given conditions, reducing leakage and downtime and increasing safety by over 60%.

Why selecting Steel 6Mo grade over Super duplex grades?

- Choose 6Mo for improved corrosion resistance and super duplex for increased strength. The higher strength of super duplex grades can make this material more susceptible to stress corrosion cracking under certain conditions.
- For those applications that are likely to suffer from pitting corrosion. The pitting resistance given by the PREN or Pitting Resistance Equivalent Number is higher for 6Mo than for its super duplex counterparts.

6Mo is one of our best-seller materials. It has been successfully used in a wide range of applications in the North Sea, Middle East, Mexico Gulf or Australia. Typical applications cover offshore platforms, heat exchangers or desalination plants.

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Tubing Specification: High Quality, Fully Annealed, Super Stainless Steel Tubing to ASTM A269/A213 Grade UNS S31254. Recommended Tube Hardness 80 HRB. Maximum Permissible Hardness 90 HRB.

Table 5	6Mo						Imperial
Tube O.D. Size	Wall Thickness, inches						
	0.02	0.028	0.035	0.049	0.065	0.083	0.095
1/16							
1/8	7100	10500					
3/16		6700	8600				
1/4		4900	6300				
5/16			4900	7100			
3/8			4000	5800	8000		
1/2			3200	4600	6200		
5/8				3600	4900		
3/4				3000	4000	5200	
7/8				2500	3400	4400	
1					2900	3800	4400

Working pressure is measured in 'psig'

Table 6	6Mo							Metric
Tube O.D. Size	Wall Thickness, mm							
	0.8	1	1.2	1.5	1.8	2	2.2	2.5
3	550							
6	410	520						
8		380	470					
10		300	370	470				
12		250	300	380	470			
14			270	340	420			
15			250	320	390			
16			230	300	360			
18			210	260	320	360		
20			180	230	290	320		
22				210	260	290	320	
25					220	250	280	320

Working pressure is measured in 'bar'

- Not recommended for gas service
- Recommended for all services - standard assembly
- Recommended for all services - Use pre-assembly tool
- Recommended for all services - Use 'Hyferset' pre-assembly tool
- No data/Not recommended/No solution

Alloy 825

Alloy 825 is a nickel-iron-chromium alloy with additions of molybdenum, copper, and titanium. The alloy is designed to provide exceptional resistance to many corrosive environments. Alloy 825 is resistant to corrosion in many acids and alkalis under both oxidising and reducing conditions, including sulphuric, sulphurous, phosphoric, nitric and organic acids, alkalis such as sodium or potassium hydroxide, and aqueous chloride solutions. High nickel content gives the alloy virtual immunity to stress corrosion cracking and good resistance to pitting and crevice.

Alloy 825 is a versatile general engineering alloy that exhibits good mechanical properties at both room and elevated temperatures (over 1000 °F).

Typical applications include:

- Chemical processing
- Pollution control
- Oil and gas recovery
- Acid production
- Nuclear fuel reprocessing

Typical Composition	
Element	**Weight (%)**
Carbon	0.05 max
Manganese	1.00 max
Chromium	19.5 to 23.5
Nickel	38.0 to 46.0
Molybdenum	2.5 to 3.5
Iron	22.0 min
Titanium	0.06 to 1.2
Aluminium	0.2 max
Copper	0.5 to 3.0

Typical Specifications	
Product	**Standard**
Bar	ASTM B425
Forging	ASTM B564
Tube	ASTM B423
Other	NACE MR0175 NACE MR0103
UNS No.	N08825

Tubing Specification: High Quality, Fully Annealed, Alloy 825 Tubing to ASTM B163 or B423 Grade UNS N08825. Recommended Tube Hardness 80 HRB. Maximum Permissible Hardness 90 HRB.

Table 7	Alloy 825			Imperial
Tube O.D. Size	Wall Thickness, inches			
	0.035	0.049	0.065	0.083
1/4	5400	8700	11100	
3/8	3500	5500	7600	
1/2	2700	4300	5900	

Working pressure is measured in 'psig'

Table 8	Alloy 825				Metric
Tube O.D. Size	Wall Thickness, mm				
	0.8	1	1.2	1.5	2
6	260	450	610	730	
10		260	350	440	
12		210	280	360	

Working pressure is measured in 'bar'

- Not recommended for gas service
- Recommended for all services - standard assembly
- Recommended for all services - Use pre-assembly tool
- No data/Not recommended/No solution

Alloy 625

This alloy has outstanding resistance to pitting and crevice corrosion as well as good resistance to intergranular attack. It also is almost totally resistant to chloride-induced stress corrosion cracking. With these properties the alloy has extremely high resistance to attack by a wide range of media and environments including nitric, phosphoric, sulphuric and hydrochloric acids, as well as alkalis and organic acids in both oxidising and reducing conditions. Alloy 625 has virtually no corrosive attack in marine and industrial atmospheres with extremely good resistance to seawater, even at elevated temperatures.

It is an excellent choice for applications that require high corrosion-fatigue strength or high tensile strength applications, creep and rupture strength and weldability.

Typical applications include:

- Sour Gas Service
- Engine exhaust systems
- Fuel and Hydraulic Lines
- Distillation columns and chemical transfer lines
- Nuclear water reactors

Alloy 625 is one of our best seller materials. It is one of the preferred alloy in a wide range of sour gas applications.

Typical Composition	
Element	**Weight (%)**
Carbon	0.1 max
Manganese	0.5 max
Chromium	20.0 to 23.0
Nickel	58.0 min
Molybdenum	8.0 to 10.0
Iron	5.0 max
Columbium + Tantalum	3.15 to 4.15
Titanium	0.4 max
Aluminium	0.4 max
Cobalt	1.0 max

Typical Specifications	
Product	**Standard**
Bar	ASTM B446
Forging	ASTM B564
Tube	ASTM B444
Other	NACE MR0175 NACE MR0103
UNS No.	N06625

Tubing Specification: High Quality, Fully Annealed, Alloy 625 Tubing to ASTM B444 Grade 2 UNS N06625. Recommended Tube Hardness 85 HRB. Maximum Permissible Hardness 93 HRB.

Table 9	Alloy 625		
Tube O.D. Size	Wall Thickness, inches		
	0.035	0.049	0.065
1/4	6800		
3/8	4400	6400	8700
1/2		5000	6800
3/4			4400

Working pressure is measured in 'psig'

Table 10	Alloy 625				Metric
Tube O.D. Size	Wall Thickness, mm				
	0.8	1	1.2	1.5	1.8
6	440	570			
10	260	330	400	510	630
12			330	420	

Working pressure is measured in 'bar'

- Recommended for all services - standard assembly
- Recommended for all services - Use pre-assembly tool
- Recommended for all services - Use 'Hyferset' pre-assembly tool
- No data/Not recommended/No solution

Alloy C276

Alloy C-276 is known for its excellent resistance to a wide variety of chemical process environments, including strong oxidizers such as ferric and cupric chlorides, hot contaminated media, chlorine, formic and acetic acids, acetic anhydride, and seawater and brine solutions. Alloy C-276 alloy has excellent resistance to pitting and to stress-corrosion cracking. It is also one of the few materials that withstands the corrosive effects of wet chlorine gas, hypochlorite, and chlorine dioxide. Alloy C-276 can resist the formation of grain boundary precipitates in the weld heat-affected zone, making it also a common candidate for most chemical and petrochemical processing applications in the as-welded condition.

This alloy might be used in any environment that requires resistance to heat and corrosion but where the mechanical properties of the metal must be retained.

Typical applications include:

- Chemical processing
- Air Pollution control
- Pulp and Paper Production
- Marine Engineering
- Waste Treatment

Refer to page 9 for product availability.

Typical Composition	
Element	**Weight (%)**
Carbon	0.01 max
Manganese	1.00 max
Chromium	14.5 to 16.5
Nickel	51.0 min
Molybdenum	15.0 to 17.0
Iron	4.0 to 7.0
Tungsten	3.0 to 4.5
Cobalt	2.5 max
Vanadium	0.35 max

Typical Specifications	
Product	**Standard**
Bar	ASTM B574
Forging	ASTM B564
Tube	ASTM B622
Other	NACE MR0175 NACE MR0103
UNS No.	N10276

Tubing Specification: High Quality, Fully Annealed, Alloy C276 Tubing to ASTM B622 Grade UNS N10276. Recommended Tube Hardness 85 HRB. Maximum Permissible Hardness 93 HRB.

Table 11	Alloy C276			Imperial
Tube O.D. Size	Wall Thickness, inches			
	0.028	0.035	0.049	0.065
1/4	5500			
3/8		4500	6500	8900
1/2		3500	5100	6900
5/8		2800		

Working pressure is measured in 'psig'

Table 12	Alloy C276			Metric
Tube O.D. Size	Wall Thickness, mm			
	0.8	1	1.2	1.5
6	450	580		
10		330	410	520
12		270	330	430
15		230		

Working pressure is measured in 'bar'

- Not recommended for gas service
- Recommended for all services - standard assembly
- Recommended for all services - Use pre-assembly tool
- No data/Not recommended/No solution

How to Order

The correct part number is easily derived from the following number sequence. The seven product characteristics required are coded as shown below.

TUBE	1/4	OD	X	035	-316L	-ST
↑	↑			↑	↑	↑
1. Seamless Tubing	2. OD			3. Wall Thickness	4. Material	5. Tube Type

1/8	= 1/8" Out Diameter	**028** = 0.028"	**316L** = 316/316L	**ST** = Straight tube(6m)
1/4	= 1/4"	**035** = 0.035"	**317L** = 317/317L	**CT** = Coil tube
3/8	= 3/8"	**049** = 0.049"	**400** = Alloy 400	
1/2	= 1/2"	**065** = 0.065"	**904L** = Alloy 904L	
3/4	= 3/4"	**1.0** = 1.0mm	**625** = Alloy 625	
1	= 1"	**1.5** = 1.5mm	**825** = Alloy 825	
6MM	=6mm	**2.0** = 2mm	**6MO** = 6 Mo	
8MM	= 8mm		**HC** = Alloy 276	
10MM	= 10mm		**SD** = Super Duplex	
12MM	= 12mm			
15MM	= 15mm			
18MM	= 18mm			
20MM	= 20mm			

Example 1 : Tubing 1/2" OD X Wall Thickness 0.065", Imaterial Alloy 825 Straight tube 6 meters

PN : **TUBE 1/2OD X 065-825-ST**

Example 2: Tubing 12MM OD X Wall thickness 1.5MM, material Alloy 625 Straight Tube 6 meters

PN : **TUBE 12MMOD X 1.5-625-ST**

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Parker Hannifin Korea
Instrumentation Group
23, Jangangongdan 1-gil, Jangan-myeon,
Hwaseong-si, Gyeonggi-do, 18579, Korea
Tel: (+82)31-359-0700 Fax: (+82)31-359-0780
www.parker.com

Authorized Distributor
MONILEK OILFIELD

E: sales@monilek.com
W: www.monilekgroup.com