Austenitic Stainless Steel

Aperam 316L Low Carbon with Molybdenum

Chemical Composition

Elements (%)	C	Si	Mn	Cr	Ni	Mo
316L	0.025	0.40	1.20	16.80	10.10	2.10

Typical values

Grade designation	European designation	American designation	IMDS Nr
316L	X5CrNiMo17-12-2/ 1.4401 [1]	UNS 31600/ Type 316 [2]	336840014
	X2CrNiMo17-12-2/ 1.4404 [1]	UNS 31603/ Type 316L [2]	

[1] According to EN 10088-2

[2] According to ASTM A 240

These grades comply with:

- Aperam Stainless Europe - Safety Information Sheet for Stainless Steel
- European Directive 2000/53/EC on end-of-life vehicles and later modifications
- PED (Pressure Equipment Directive) according to EN 10028-7 and AD2000 Merkblatt W2 and W10 (TÜVWB494)
- NFA 36 711 standard "Stainless steel intended for use in contact with foodstuffs, products and beverages for human and animal consumption (non packaging steel)"
- NSF/ANSI 51-2009 edition International Standard for "Food Equipment Materials" and of the FDA. (United States Food and Drug Administration) regarding materials used for food contact
- French Decree No. 92-631, dated 8 July 1992, and Regulation No. 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food (repealing Directives 80/590/EEC and 89/109/EEC)
- French regulatory paper dated 13 January 1976 relating to materials and articles made of stainless steel in contact with foodstuffs
- Italian Decree of 21 March 1973: a list of stainless steel types appropriate to "Regulations on the hygiene of packaging, receptacles and tools intended to come into contact with substances for food use or with substances for personal use"

Key Features

The principal features of our 316L grade are:

- Very good resistance to corrosion in acids and chloride-containing media, as well as to pitting, crevice, and intergranular corrosion -even after welding
- Excellent weldability and polishing
- High ductility
- Good drawability

Applications

- Food industry equipment: tanks, tubes, pumps
- Naval engineering
- Road transport: IMO tanks, swap bodies and trailers
- Building industry: architectural components, roofing, façades
- Water industry
- Chemical and pharmaceutical industries
- Oil & Gas industry
- Paper industry

Product Range

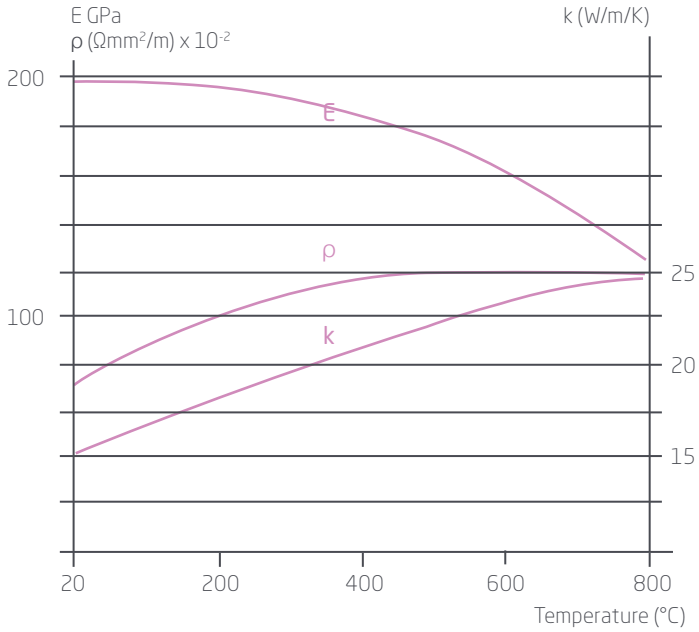
	Coils	Sheets / Blanks	Discs	Precision Strip	Precision Sheet	Tubes	Flat Bars
Thickness (mm)	0.30 up to 13	0.15 up to 13	0.38 up to 2.50	0.06 up to 2.5	0.20 up to 2.5	0.80 up to 2.5	2 up to 20
Width (mm)	up to 2,000	80 up to 2,000	Ø 15 up to 1,000	3 up to 700	40 up to 670	Ø 8 up to 80	10 up to 300
Finish	2R / 2B / 2D / 1D	2R / 2B / 2D / 1D	2R / 2B / 2D / 1D	2R / 2B / 2D / 2H / 2F	2R / 2B / 2D / 2H / 2F	2B / 2D / 1D	1D / Polished

Physical Properties

Cold rolled and annealed sheet

Density	d	kg/dm³	20°C	7.9
Melting temperature		°C	Liquidus	1,440
Specific heat	c	J/kg.K	20°C	500
Thermal conductivity	k	W/m.K	20°C	15
Mean thermal expansion coefficient	α	10^{-6}/K	20-100°C 20-300°C 20-500°C	16.0 17.0 18.0
Electric resistivity	ρ	Ω mm²/m	20°C	0.75
Magnetic resistivity	μ	at 0.8 kA/m DC or AC	20°C	1.005
Young's modulus	E	GPa	20°C	200

Poisson's coefficient: 0.30



Mechanical Properties

Test piece

Length = 50 mm (thickness < 3 mm)
Length = 5.65 √ S_o (thickness ≥ 3 mm)
Cold rolled

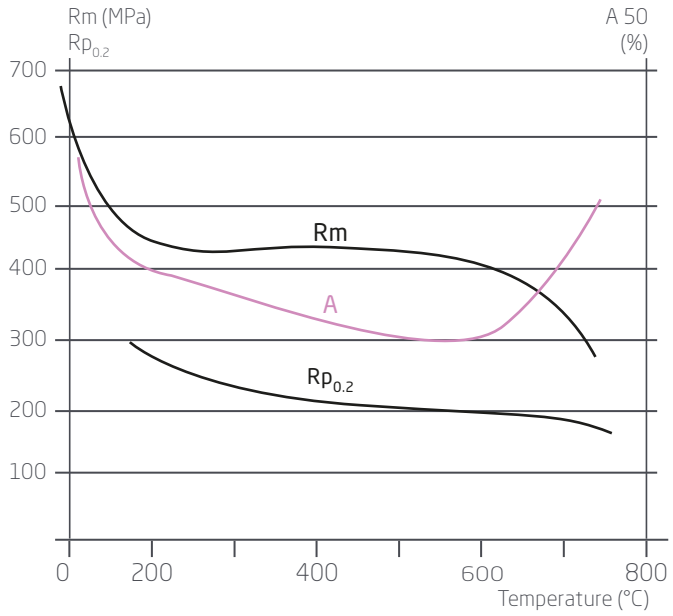
Grades	European designation	ASTM A240	Rm(1) (MPa)	$Rp_{0.2}$(2) (MPa)	A(3) %
316L	1.4401/4404	316/316L	620	300	52
DX2205	1.4462	2205	840	620	29
K44	1.4521	444	520	370	29

1 MPa = 1 N/mm² - Typical values
(1) Ultimate Tensile Strength (UTS) - (2) Yield Strength (YS) - (3) Elongation (A)

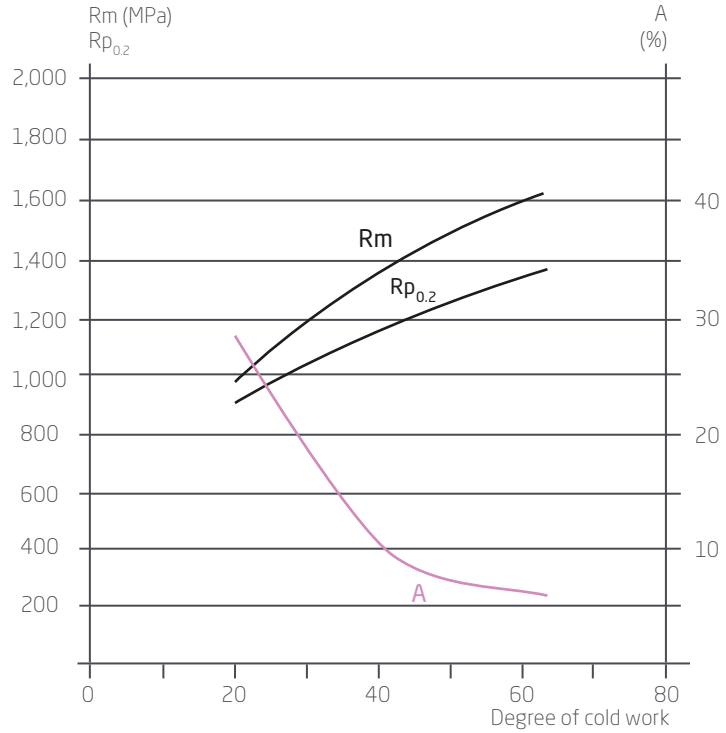
In the annealed condition

In accordance with ISO 6892-1, part 1
Test piece perpendicular to rolling direction

At high temperatures (Typical values)



Work-hardened by cold rolling (Typical values)

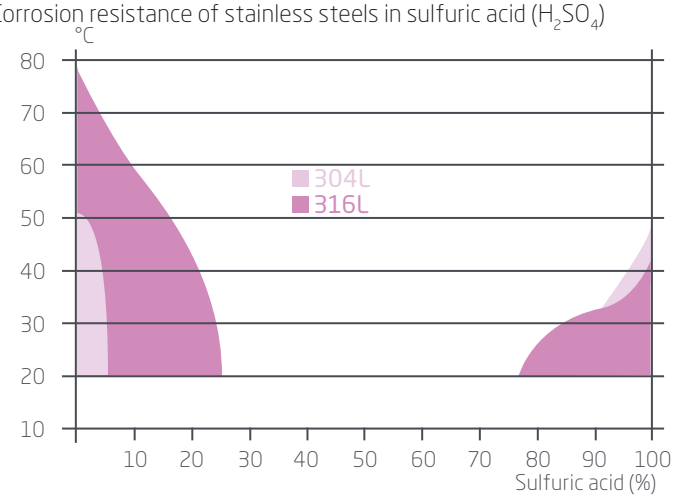


Corrosion Resistance

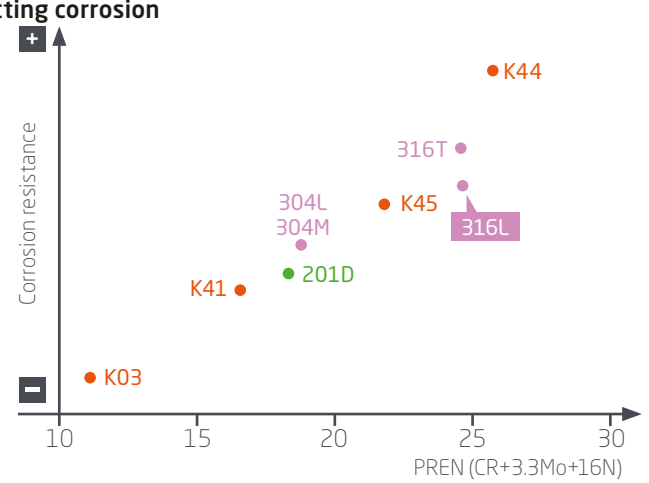
Offering excellent resistance in acid solutions and good resistance in chloride containing media, our 316L grade is well-suited for manufacturing parts that come into contact with seawater at low temperatures.

Generalized corrosion

Corrosion resistance of stainless steels in sulfuric acid (H_2SO_4)



Pitting corrosion



K44 and duplex DX2205 and DX2304 grades are alternatives to 316L. However, due to their higher corrosion resistance, the pitting potential of duplex in certain temperatures (23°C) and chloride concentrations (0.02M) cannot be determined. For more information, please see these grades specific technical data sheets.

Pitting potential

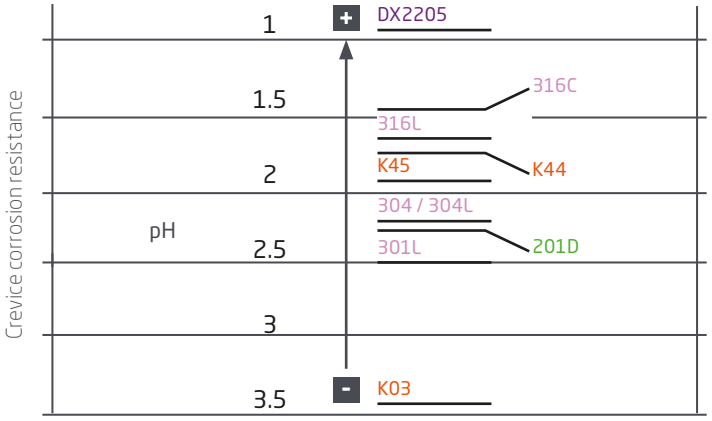
In variations following the temperature and the chloride concentration.

Grades	NaCl 0.02/23°C	NaCl 0.02/50°C	NaCl 0.05/23°C	NaCl 0.05/50°C
316L	630 mV	500 mV	455 mV	270 mV

Typical values

Crevice corrosion

Depassivation pH in a deaerated NaCl 2M environment at 23°C



Crevice corrosion occurs in two stages. During the first stage (initiation), chloride accumulates and acidification begins. This eventually causes depassivation within the crevice region. A depassivation pH is the critical condition for passivity breakdown.

The metal begins to dissolve during the second stage (propagation). This process can be slowed down using grades that contain molybdenum and nickel as both elements are known to decrease the speed of propagation.

Intergranular corrosion

This grade is recommended when there is a risk of intergranular corrosion so long as the following requirements of the standard intergranular corrosion tests are met: EN ISO 3651-2 (sensitizing treatments T1 and T2), ASTM A 262, ex DIN 50914.

Forming

In the annealed condition, our 316L grade can be readily cold formed using all standard processes (bending, contour forming, drawing, deep drawing, flow turning and stretching).

Deep drawing (Swift test)

The Swift test is used to determine the Limiting Drawing Ratio (LDR). LDR is defined by the maximum ratio between the blank diameter (variable) and the punch diameter (fixed) that the drawing operation can be successfully performed.

Stretching (Erichsen test)

The stretching behaviour is characterized by the dome height (h) of the Erichsen test, also known as Index 'EI'.

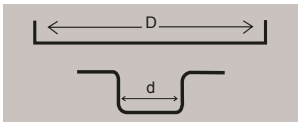
Bending

Our 316L has good bending capacity up to 180°, with very small bending radii for thicknesses below 0.8 mm. For thicker gauges, a bending radius of at least half the thickness of the sheet is recommended. When bending the material, the elastic springback must always be taken into consideration.

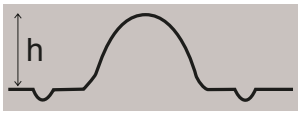
Grades	European designation	ASTM A240	LDR*	EI** (mm)
316L	1.4401/4404	316/316L	2.01	11.5
DX2205	1.4462	2205	1.9 - 1.95	9.5
K44	1.4521	444	2.10 - 2.15	8.6

* Limiting Drawing Ratio
** Erichsen Index - Lubricant = Mobilux EP00 - Typical values tests done on 0.8 mm thickness.

$$LDR = \frac{D_{max}}{d}$$



EI =



Welding

Welding process	No filler material	With filler metal			Shielding gas*
	Typical thicknesses	Thicknesses	Filler material		* Hydrogen and nitrogen forbidden in all cases
			Rod	Wire	
Resistance: spot, seam	≤ 2 mm				
TIG	< 1.5 mm	> 0.5 mm	ER 316 L(1)	ER 316 L(1)	Ar Ar + 5% H_2 Ar + He
PLASMA	< 1.5 mm	> 0.5 mm		ER 316 L(1)	Ar Ar + 5% H_2 Ar + He
MIG		> 0.8 mm		ER 316 L (Si) (1)	Ar + 2% CO_2 Ar + 2% O_2 Ar + 2% CO_2 + 1% H_2 Ar + 2% CO_2 + He
SAW		> 2 mm		ER 316 L(1)	
Electrode		Repairs	E 316 L(1)		
Laser	< 5 mm				He Under certain circumstances: Ar

(1) ER 308L (AWS A5.9) = G 19 9 L (NF EN ISO 14343)

In general, heat treatment is not required after welding. However, to fully restore the metal's corrosion resistance, the welds must be mechanically or chemically descaled and passivated. In case of applications at temperatures above 500°C, a specific filler material must be used to guarantee a ferrite level below 8% in the weld.

Heat Treatment and Finishing

Annealing

After cold forming (work hardening) and welding, using an annealing treatment for a couple of minutes at 1,050 ± 25°C, followed by air cooling or water quenching, will restore the microstructure (recrystallisation and dissolution of carbides) and eliminates internal stresses.
After annealing, pickling, followed by passivation, is necessary.

Pickling

- Nitric-Hydrofluoric acid mixture (10%HNO_3 + 2% HF) at ambient temperature or up to 60°C
- Sulfuric-nitric acid mixture (10% H_2SO_4 + 0.5% HNO_3) at 60°C
- Use descaling pastes for weld areas

Passivation

- 20-25% HNO_3 solution (36° Baumé) at 20°C
- Use passivating pastes for weld zones

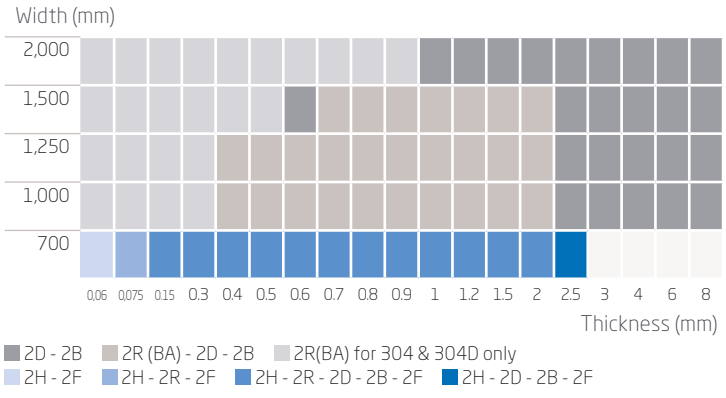
Polishing

316L's surface is suitable for all kinds of polishing (grit, scotch-brite, electro polishing).

Size range

Our size range is based on our production capabilities. Please contact us for the latest information per grades on offer.

Cold Rolled



Hot Rolled and HRC