

UR™ 316L

UR™ 316L: A 2%Mo containing 18Cr – 10Ni austenitic stainless steel

UR™ 316L is one of the basic grade of the stainless steels range. The addition of molybdenum improves its resistance to pitting and crevice corrosion, compared to 304L.

UR™ 316L is an austenitic microstructure grade, free of chromium carbide precipitations in grain boundaries and some residual ferrite after solution annealing (1050 – 1150°C – 1922 – 2102°F) and water quenching.

The UR™ 316L steel resists to wet atmosphere solutions containing small chloride or fluoride additions at room temperature. The alloy may be used in diluted sulphuric acids at low temperature ($\leq 330^{\circ}\text{C}$ – 626°F) as well as in sour organic solutions.

PROPERTIES

STANDARDS

- > EURONORM: 1.4404 X2CrNiMo 17.12.2
- > ASTM: A240TP 316L – UNS S31603

CHEMICAL ANALYSIS – WEIGHT %

Typical values

C	Cr	Ni	Mn	Mo	N
0.02	17	10.5	< 2	> 2.0	0.04

PHYSICAL PROPERTIES

Density: 7950 kg/m³

Interval temperature (°C)	Thermal expansion $\alpha \times 10^{-6} \text{ K}^{-1}$	T °C (°F)	Resistivity ($\mu\Omega \cdot \text{cm}$)	Thermal conductivity ($\text{W m}^{-1} \text{ K}^{-1}$)	Specific heat ($\text{J kg}^{-1} \text{ K}^{-1}$)	Young modulus E (GPa)	Shear modulus G (GPa)
20 – 100	16	20 (68)	75	15	500	200	77
20 – 200	16.5	100 (212)	80	16	500	194	74
20 – 300	17	200 (392)	85	17.5	520	186	70.5
20 – 400	17.5	300 (572)	92	19	530	172	66.5
20 – 500	18	400 (752)	95	20.5	540	172	62.5
		500 (932)	100	22	540	165	59.5

MECHANICAL PROPERTIES

Tensile properties after solution annealing heat treatment

°C	°F	Minimum guaranteed values*						Typical values (10 mm plates)						
		YS 0.2%		YS 1%		UTS		YS 0.2%		YS 1%		UTS		Elongation
		MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	%
20	68	220	32	260	38	520/ 670	76/98	310	44	350	51	580	85	45
100	212	166	24	199	29	430	63	280	40	330	48	490	72	43
200	392	137	20	167	24	390	57	200	28	230	33	450	66	35
300	572	118	17	145	21	380	56	175	25	200	30	440	64	35
400	752	108	16	135	20	380	56	150	22	180	29	430	63	30
500	932	100	15	128	19	360	52	135	19	165	24	410	60	30

*Following EN10088 hot rolled plates - The EN guaranteed values are valid for a thickness from 5 to 75 mm

Impact values

Temperature °C (°F)	- 196 (- 320)	+ 20 (+ 68)
KCV (J/cm ²) minimum	100	120

Industeel produces special 316LN grades with high impact properties at - 269 °C (- 452 °F).

IN SERVICE CONDITIONS

CORROSION RESISTANCE

Standardized corrosion tests

TEST	OTHER NAME	CORROSION	RESULTS
ASTM A262 A		Intergranular	Step or dual structure
ASTM A262 B	STREICHER	Intergranular	≤ 1 mm/year (not sensitized)
ASTM A262 E DIN 50914 RCCM	STRAUSS	Intergranular	No cracking after bending
ASTM G48A		Pitting	Not recommended (typical CPT 5 °C)
ASTM G48B	ASTM G78	Crevice	Not recommended (typical CCT 5 °C)

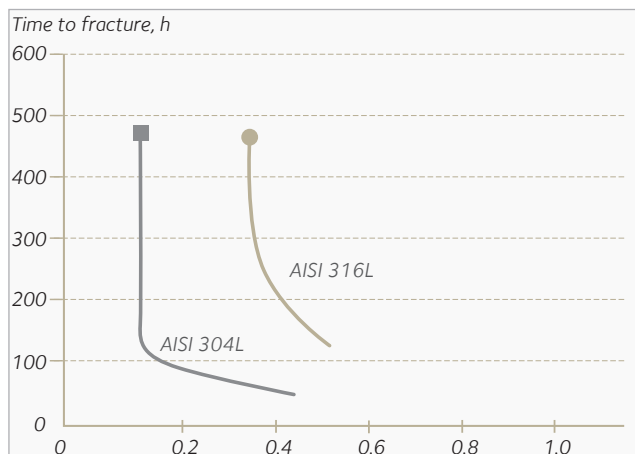


Figure 1: Results of SCC test with constant load in 40% CaCl₂ at 100 °C (210 °F) with aerated test solution

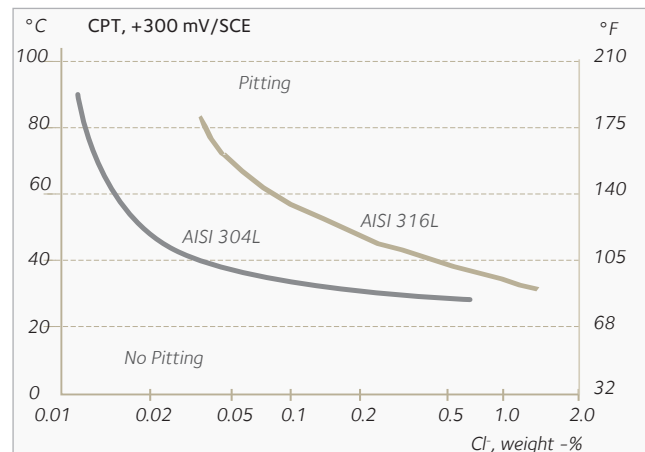


Figure 2: Critical pitting temperatures (CPT) for AISI 304 and AISI 316 at varying concentrations of sodium chloride (potentiostatic determination at +300 mV/SCE) pH ~ 6.0

IN SERVICE CONDITIONS

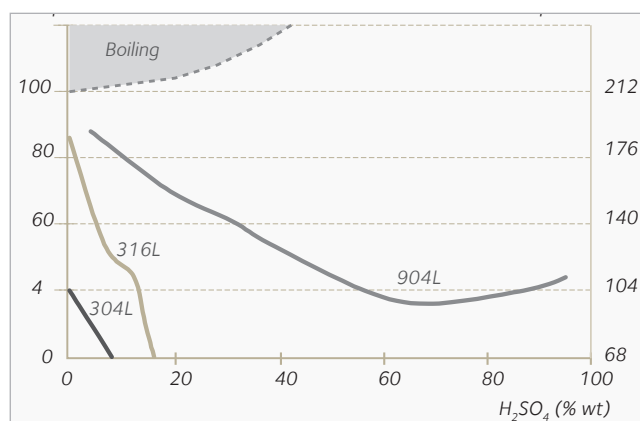


Figure 3: Isocorrosion diagram 0.1 mm/year for austenitic stainless steels in natural aerated sulphuric acid of chemical purity. Broken line curve represents the boiler point.

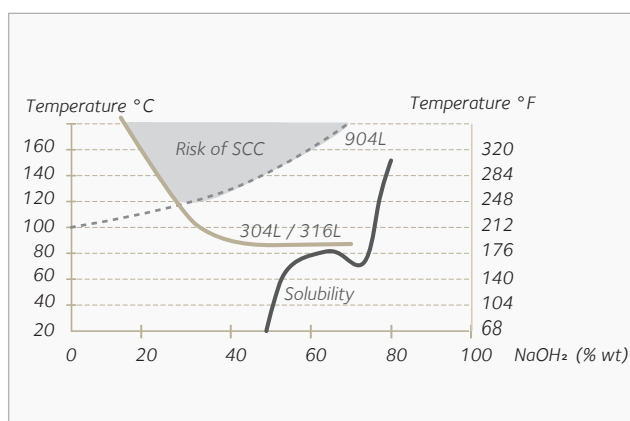


Figure 4: Isocorrosion diagram 0.1 mm/year, in sodium hydroxide

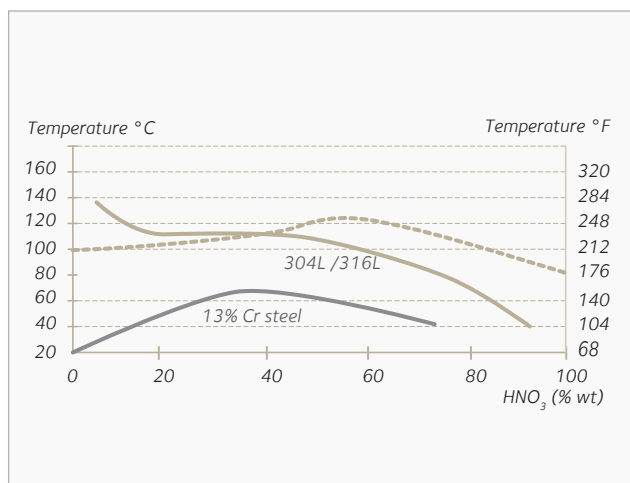
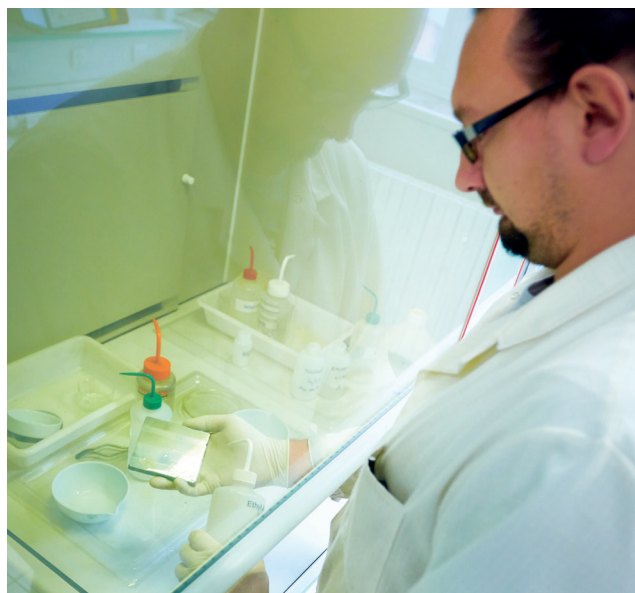


Figure 5: Isocorrosion diagram 0.1 mm/year, in nitric acid. Broken line represents the boiling point

DELIVERY CONDITIONS

SIZE RANGE

	Hot rolled plate	Clad plate
Thickness	5 to 150 mm 3/16" to 6"	Consult Industeel
Width	Up to 3800 mm* Up to 150"	
Length	Up to 16000 mm Up to 52"	

Cut to length plates available from ArcelorMittal Stainless Europe

Indicative dimensional programme - *Width related to thickness, please consult for specific request.

HOT FORMING

Hot forming should be carried out in a temperature range of 1150 - 800 °C (2102 - 1472 °F). If the final forming temperature falls below 950 °C (1742 °F), an annealing solution (1050 - 1150 °C, 1922 - 2102 °F) is necessary. The cleanliness of the surface is very important (avoid oil contamination). A neutral or slightly oxidising atmosphere is required. Due to the low thermal conductivity, the holding time of temperature may be longer than for a carbon steel (~50%). Cool rapidly after forming.

COLD FORMING

The alloy can be cold formed without any problem. The cold hardening of the steel explains why it may require more powerful equipments than for a structural steel. Molybdenum bearing implies also some more powerful equipments than Cr - Ni austenitic stainless steels.

PICKLING

A nitric hydrofluoric acid bath (10 - 20% HNO₃ - 1,5 - 5% HF) at 20 - 60 °C (68 - 142 °F) is used for the pickling treatment. A 10 - 20% H₂SO₄ - 1,5 - 5% HF pickling bath may also be used. Decontamination treatments may be performed with a 10 - 20% weight nitric acid solution. Rinse after pickling.

CUTTING

- > Thermal cutting (plasma, thermal sawing...).
- After cutting pickling or grinding are necessary to

eliminate the oxide formed layer

- > Mechanical cutting (shearing, stamping, cold sawing...)

WELDING

The alloy can be easily welded without hot cracking phenomenon, using an adequate filler metal (from 5 to 15% δ ferrite). The alloy is not sensitive to cold cracking phenomenon. All welding processes can be used including filler processes.

Filler material

- > Electrode: E316L - 15 or E316L - 16 (ASME Sect II - Part C SFA5 - 4)

- > Wire: ER 316L (ASME Sect II - Part C SFA 5 - 9)

A post - weld heat treatment is not necessary. Preheating and post heating are not necessary.

200 °C (392 °F) is the maximum interpass temperature. Post - weld pickling and passivation treatment are necessary.

MACHINING

Due to its cold work hardening, the alloy is less machinable than structural steel or than a 13% Cr martensitic stainless steel. Industeel has developed a 316L grade with improved machinability FASTINOX 17 - 12 - 2.

Operation	Tool	Lubrication	CONDITIONS		
			Depth of cut mm (inch)	Feed SPEED mm/t (inch/t)	SPEED m/min (feet/min)
Turning	High speed steel	Cutting oil	6 (0.23)	0.5 (0.019)	11 - 16 (36.7 - 52.5)
			3 (0.11)	0.4 (0.016)	18 - 23 (59.1 - 75.5)
			1 (0.04)	0.2 (0.008)	25 - 30 (82 - 98.4)
	Carbide	Dry or cutting oil	6 (0.23)	0.5 (0.019)	70 - 80 (229.7 - 262.5)
			3 (0.11)	0.4 (0.016)	85 - 95 (278.9 - 312.7)
			1 (0.04)	0.2 (0.008)	100 - 110 (328.1 - 360.9)
			Blade width mm (inch)	Feed mm/t (inch/t)	SPEED m/min (feet/min)
Cutting	High speed steel	Cutting oil	1.5 (0.06)	0.03 - 0.05 (0.0012 - 0.0020)	16 - 21 (52.5 - 68.9)
			3 (0.11)	0.04 - 0.06 (0.0016 - 0.0024)	17 - 22 (55.8 - 72.2)
			6 (0.23)	0.05 - 0.07 (0.0020 - 0.0027)	18 - 23 (59 - 75.45)
			Drill Ø mm (inch)	Feed mm/t (inch/t)	SPEED m/min (feet/min)
Drilling	High speed steel	Cutting oil	1.5 (0.06)	0.02 - 0.03 (0.0008 - 0.0012)	10 - 14 (32.8 - 45.9)
			3 (0.11)	0.05 - 0.06 (0.0020 - 0.0024)	12 - 16 (39.3 - 52.5)
			6 (0.23)	0.08 - 0.09 (0.0031 - 0.0035)	12 - 16 (39.3 - 52.5)
			12 (0.48)	0.09 - 0.10 (0.0035 - 0.0039)	12 - 16 (39.3 - 52.5)
				Feed mm/t (inch/t)	SPEED m/min (feet/min)
Milling profiling	High speed steel	Cutting oil		0.05 - 0.10 (0.002 - 0.004)	10 - 20 (32.8 - 65.6)

APPLICATIONS

- > Wet corrosion resistance properties in medium severe conditions
- > Chemical industry (industrial phosphoric acid; Concentration < 30% P₂O₅ without abrasion;
θ < 60°C - 140°F)
- > Food and beverage processing industry
- > Water treatment
- > Rail and road containers and tanks
- > Building decoration



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Technical data and information are to the best of our knowledge at the time of printing. However, they may be subject to some slight variations due to our ongoing research programme on steels. Therefore, we suggest that information be verified at time of enquiry or order. Furthermore, in service, real conditions are specific for each application. The data presented here are only for the purpose of description, and considered as guarantees when written formal approval has been delivered by our company. Further information may be obtained from the address opposite.