Industeel

ArcelorMittal

UREA 316L mod

A 316L modified - low Si, high Mo stainless steel for Urea plants

The UREA 316L Modified grade has been specially developed for Urea plant applications. It is a 316L modified stainless steel with extra-low silicon content and substantial higher molybdenum contents.

The low carbon content, combined with a well balanced chemistry (low silicon and nickel content close to 14%) makes the alloy fully austenitic, free of intermetallic phase precipitations. The ferrite level is kept under 0.5% in the solution annealing and water quenched conditions.

The alloy is designed for improved corrosion resistance properties in Urea-carbonate environments.

Standards

EURONORM	1.4435 X2CrNiMo18.14.3
ASTM	316L Modified

Chemical analysis

Typical values (% weight)

C	Cr	Ni	Mo	Others
< .03	18	13.5	2.6	Si < 0.5, 1 ≤ Mn ≤ 2

Mechanical properties

Typical tensile properties after solution annealing heat treatment

C°	F°	Y.S. 0.2%		Y.S. 1%		UTS		El%
		MPa	*Ksi*	MPa	*Ksi*	MPa	*Ksi*	
20	*68*	250	*36*	280	*41*	530	*77*	55
100	*212*	190	*27*	210	*30*	490	*71*	55
200	*392*	160	*23*	180	*26*	460	*67*	55
300	*572*	135	*19*	155	*22*	420	*61*	55
400	*752*	125	*18*	140	*20*	390	*56*	55

Impact value:
KCV ≥ 120 J/cm² (room temperature)
Minimum yield strength : 190 Mpa (*27 ksi*) at room temperature (th<20 mm)
Minimum tensile strength: 490 MPa (*71 ksi*) at room temperature (th<20 mm)

Physical properties

Density = 7900 kg/m³

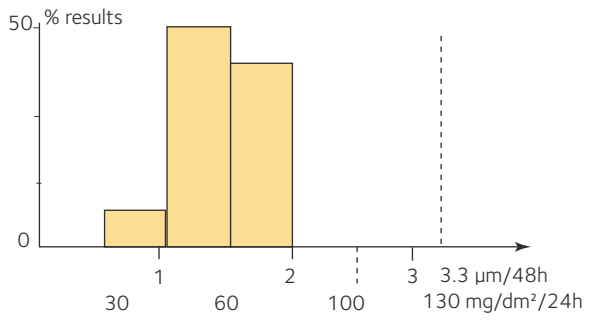
Interval temperature	Thermal expansion	°C	°F	Resistivity	Thermal conductivity	Specific heat	Young modulus E	Shear modulus G
°C	α x10⁻⁶K⁻¹			µΩ cm	W.m⁻¹.K⁻¹	J.kg⁻¹.K⁻¹	GPa	GPa
20-100	16	20	*68*	74	15	500	200	75
20-300	16.5	200	*392*	90	17	550	185	70
20-500	17.5	400	*752*	100	20	590	170	64

Structure

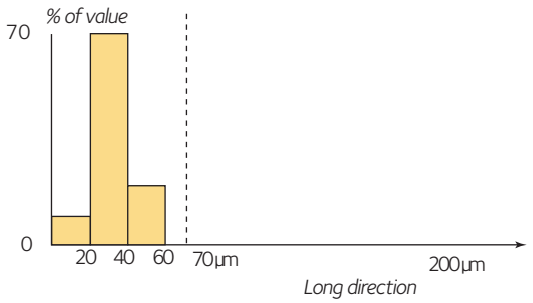
The UREA 316L Modified grade is a fully austenitic stainless steel which ferrite content is guaranteed less than 0.5% after solution annealing heat treatment - 1120°-1180°C (*2048-2156°F*) /water quenched. The carbon content is kept low while the steel making is optimised in order to improve the cleanliness properties of the steel.The alloy is designed for urea applications

Corrosion resistance

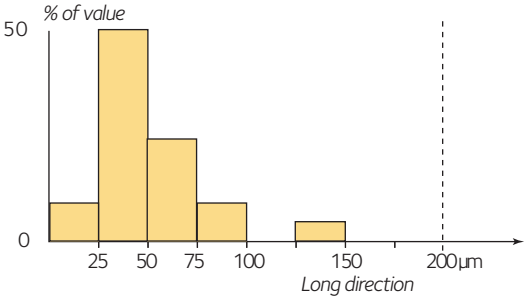
(low carbon and silicon contents). Typical maximum corrosion results required following different specifications after Huey tests (ASTM A262 C - five periods of 48 h.) are : maximum weight loss lower than 3,3 µm/48 h (130 mg/dm² per 24 h.), with a maximum depth for microcracks of 200 µm in the long direction and 70 µm in the transverse direction. The UREA 316L Modified grade behaves much better than those maximum values as indicated on the following graphs where 100 test results performed on a 2 years production period are reported :



Huey test A262C
General corrosion rate
after 5 periods of 48 h.



Huey test A262C
Selective corrosion test results
after 5 periods of 48 h.



Huey test A262C
Intergranular penetrations
after 5 periods of 48 h.

Processing

Hot forming

Hot forming should be carried out in a temperature range of 1200-950°C (*2732-1742°F*) after the piece has been uniformely heat treated. Final full annealing trem-perature is required to obtain the requested microstruc-ture. It will be performed at 1120°-1180°C (*2048-2156°F*) followed by water quenching.

Cold forming

Due to its fully austenitic microstructure, the alloy can be cold formed without any problem. The higher molybde-num content and cold hardening behaviour of the steel explains that it may require more powerfull equipments than 304 stainless steel.

Pickling

The UREA 316L Modified grade must be used in the as pickled and passivated conditions. Pickling treatment may be performed with a nitro-hydrofluoric acid bath (10-20 % HNO_3 - 1.5-5% HF) at room temperature (few hours) or 20 minutes approx. at 60°C (*140°F*). 10-20% H_2SO_4 - 1.5-5% HF pickling bath may also be used.

Machining

Operation	Tool	Lubrication	Conditions					
			Depth - mm	*Depth - in*	Feed - mm/t	*Feed - in/t*	Speed - m/min	*Speed - ft/min*
Turning	High speed steel	Cutting oil	6 3 1	*.23* *.11* *.04*	0.5 0.4 0.2	*.019* *.016* *.008*	11-16 18-23 25-30	*36.1-52.5* *59.1-75.5* *82-98.4*
	Carbide	Dry or cutting oil	6 3 1	*.23* *.11* *.04*	0.5 0.4 0.2	*.019* *.016* *.008*	70-80 85-95 100-110	*229.7-262.5* *278.9-312.7* *328.1-360.9*
			Depth of cut-m	*Depth of cut-in*	Feed - mm/t	*Feed - in/t*	Speed - m/min	*Speed - ft/min*
Parting off	High speed steel	Cutting oil	1.5 3 6	*.06* *.11* *.23*	0.03 0.04 0.05	*.0012* *.0016* *.0020*	17-22 18-23 19-24	*55.8-72.2* *59.1-75.5* *62.3-78.7*
			Drill Ø mm	*Drill Ø in*	Feed - mm/t	*Feed - in/t*	Speed - m/min	*Speed - ft/min*
Drilling	High speed steel	Cutting oil	1.5 3 6 12	*.06* *.11* *.23* *.48*	0.025 0.06 0.08 0.010	*.0010* *.0024* *.0031* *.0039*	10-14 11-15 11-15 11-15	*32.8-45.9* *36.1-49.2* *36.1-49.2* *36.1-49.2*
					Feed - mm/t	*Feed - in/t*	Speed - m/min	*Speed - ft/min*
Milling Profiling	High speed steel	Cutting oil			0.05-0.10	*.002-.0039*	10-20	*32.8-65.6*

Welding

The UREA 316L Modified grade can be welded with most of the welding processes: TIG, Plasma, MIG welding, as well as SMAW, SAW or FCAW processes. The alloy is sensitive to hot cracking phenomenon due to its fully austenitic microstructure. Weld should be performed in order to obtain extra-low ferrite contents, no carbide or nitrides precipitations, low silicon contents as well as no intermetallic phases precipitations. Higher manganese content products should be considered.

Typical chemistry of filler materials to be used is as follow

Cr	Ni	Mo	Mn	N
20%	16%	3%	6.5%	.2%

Use basic coated electrodes or fluxes in order to decrease the hot cracking susceptibility. The heat input should be limited to 1,5 kJ/mm and interpass temperature kept below 150°C (*302°F*).

Typical corrosion test results in Huey test solution - ASTM A262-C are as follow:
maxi weight loss 3.3µm/48h - 0,54 g/m² h with selective attack lower than 200 µm.

Applications

The UREA 316L Modified grade is designed for the fabrication of lining interiors in Urea units or complementary products (pipes, fittings...).

The alloy is not designed for nitric acid application.

Size range

	Hot rolled plates	Clad plates
Thickness	5 up to 150mm *3/16" to 6"*	6 up to 150mm *1/4" to 6"*
Width	Up to 3300mm *Up to 130"*	Up to 3300mm *Up to 130"*
Length	Up to 12000mm *Up to 39.3 ft*	Up to 14000mm *Up to 45.9 ft*

Other sizes are available on request, including 4100mm (*161,4"*) width plates

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