UGINOX

F18MT

Niobium-titanium stabilized molybdenum containing 18 % chromium ferritic stainless steel

European designation[1]
X2CrMoTi18-2
1.4521

American designation[2]
AISI 444

(1) According to NF EN 10088-2
(2) According to ASTM A 240

This grade is in accordance with:
- UGINE & ALZ Material Safety Data Sheet n°1: stainless steels (European Directive 2001/58/EC).
- European Commission Directive 2000/53/EC for end-of-life vehicles, and to Annex II dated 27 June 2002.
- PED (Pressure Equipment Directive) according to EN 10028-7.
- NFA 36 711 Standard «Stainless steel intended for use in contact with foodstuffs, products and beverages for human and animal consumption» (non packaging steel).

Chemical composition
Mean values

Elements	C	Si	Mn	Cr	Mo	Ti + Nb
%	0.02	0.40	0.40	17.70	1.80	0.450

General characteristics

The principal features of **UGINOX F18MT** are:
- Very good resistance to pitting corrosion in chloride media, better than UGINOX 18-9L (304L) and UGINOX 18-11ML (316L) grades
- Insensitivity to stress corrosion cracking and intergranular corrosion
- Low toughness transition temperature, even in weld zones
- good drawability, very close to that of UGINOX F17T (430Ti)
- good weldability
- thermal conductivity higher than that of austenitic grades, with lower thermal expansion coefficient.

Typical applications

- Agrofood industry
- Hot water tanks
- Boilers
- Fume ducts
- Heat exchangers
- Tubes
- Solar panels

Product range

Forms: sheets, blanks, coils, foils, disks
Thicknesses: 0.30 to 4 mm
Width: according to thickness, consult us
Finish: cold rolled

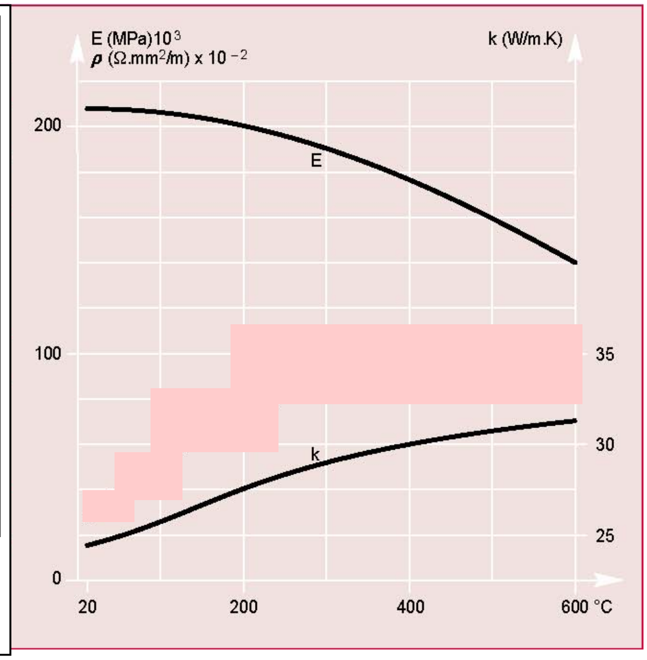
Physical properties

(cold rolled sheet - annealed)

Density	d	–	4 °C	7.7
Melting temperature		°C		1495
Specific heat	c	J/kg.K	20 °C	430
Thermal conductivity	k	W/m.K	20 °C	23
Mean coefficient of Thermal expansion	α	10^{-6}/K	20 - 200 °C 20 - 400 °C 20 - 600 °C 20 - 800 °C	10.8 11.6 12.0 12.5
Electric resistivity	ρ	$\Omega.mm^2/m$	20 °C	0.80
Magnetic permeability	µ	at 0,8 kA/m DC or AC	20 °C	800
Young's modulus	E	MPa.10^3	20 °C	220

Curie point: 650°C

Notice: The thermal conductivity is superior to austenitic stainless steel 304L-316L (k = 15W/m.°C) and the mean coefficient of thermal expansion is lower (α=19x10^{-6} - 20°C to 200°C.



Tensile properties

Delivery condition
According to NF EN 10002-1 (July 2001), specimen perpendicular to the rolling direction

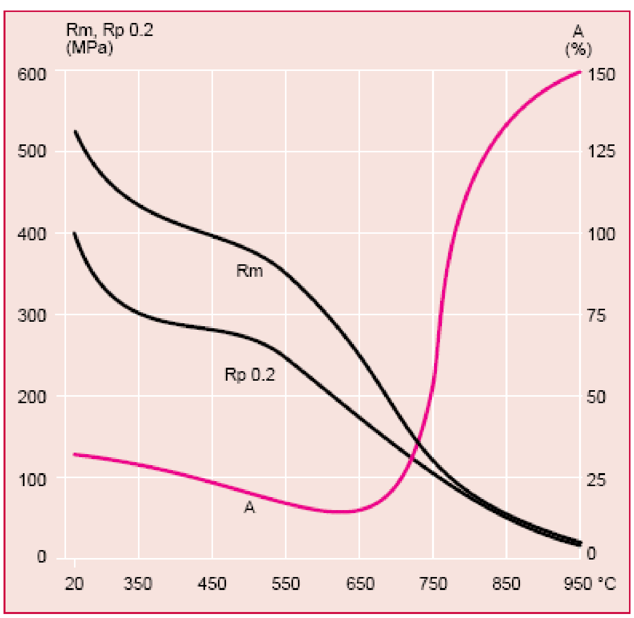
Specimen
Lo = 80 mm (thickness < 3 mm)
Lo = 5,65 √ So (thickness ≥ 3 mm)

1 MPa = 1 N/mm²

Condition	R_m (1) (MPa)	$Rp_{0,2}$ (2) (MPa)	A (3) (%)	HRB
Cold rolled;	540	380	27	82

* Mean values (1) Ultimate Tensile Strength (UTS) (2) Yield Strength (YS) (3) Elongation (A)

At high temperature



Typical values

Comparative tensile properties
(mean values at 20°C for annealed condition)

	Rm (1) (MPa)	$Rp_{0,2}$ (2) (MPa)	A (3) (%)	HRB
F17T / 430Ti	450	300	30	78
F17 / 430	500	340	26	80
F17M / 434	540	370	27	82
F18MT / 444	540	380	27	82
18-9E / 304	670	320	50	80
18.11ML / 316L	610	320	48	82

- The yield stress of ferritic steels is higher than for austenitic grades.
- Like all ferritic grade, UGINOX F18MT is prone to embrittlement after long exposure at temperature around 475°C. Consequently, prolonged holding in the range 400°C-500°C is not recommended for **UGINOX F18MT**. If such exposure has occurred, the embrittlement can be eliminated by heat treatment for about 5 minutes at ≥ 600°C.

Corrosion resistance

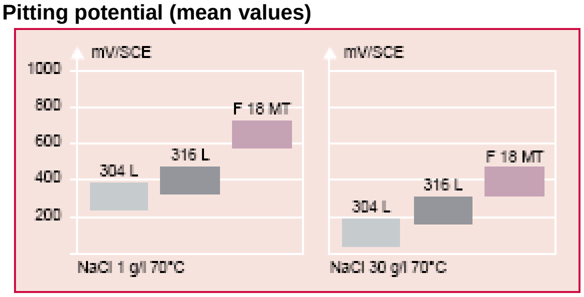
The chromium and molybdenum contents of this grade, together with well balanced stabilization by niobium and titanium, confers to **UGINOX F18MT** an excellent resistance to all types of corrosion.

Pitting corrosion

In the majority of cases, the important factor is the PREN (Pitting Resistance Equivalent Number), given by PREN = % Cr + 3,3 % Mo et 16 % N. For **UGINOX F18MT**, the PREN value is 25.
Due to its well adapted chromium and molybdenum contents, **UGINOX F18MT** shows excellent resistance to pitting corrosion better than type 304 L et 316 L austenitic grades.

Corrosion tests
In a typical electrochemical corrosion test, the metal sample is immersed in a standard solution and the corrosion current is measured as a function of the imposed increasing electric potential. The occurrence of pitting leads to a sudden increase in current, at a certain value of potential: **pitting potential .**
The higher this potential, the greater the pitting resistance of the material.

Pitting potential (mean values)

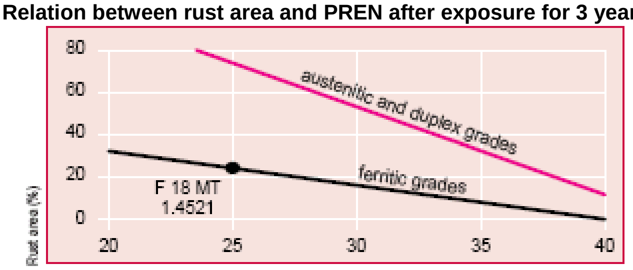


NB : After 2000 h salt spray exposure according to NFX 41002, **F 18 MT** with a 2B or 2R surface finish shows no trace of corrosion.

Atmospheric corrosion

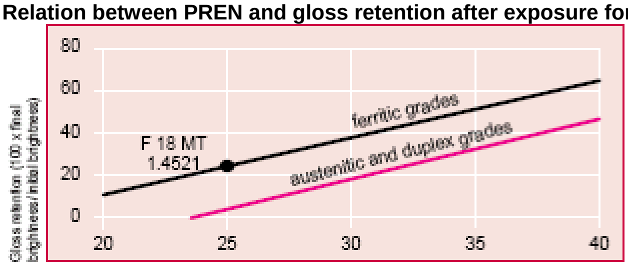
Recent studies in various countries have shown that ferritic stainless steels have greater resistance to atmospheric corrosion than austenitic or duplex grades of equivalent PREN, particularly with regard to rust area and glass retention criteria.

Relation between rust area and PREN after exposure for 3 years in a marine/industrial atmosphere



PREN = % Cr + 3.3 % Mo + 16 % N
for austenistic steel.
PREN = % Cr + 3.3 % Mo
for ferritic steel.

Relation between PREN and gloss retention after exposure for 3 years in a marine/industrial atmosphere

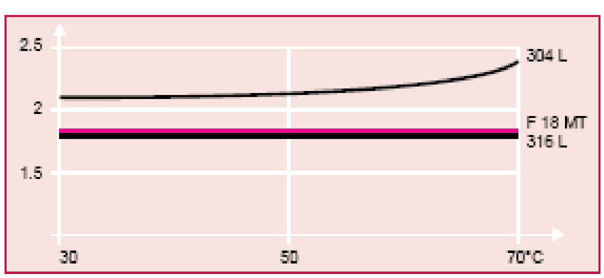


PREN = % Cr + 3.3 % Mo + 16 % N
for austenistic steel.
PREN = % Cr + 3.3 % Mo
for ferritic steel.

Source :
Atmospheric Corrosion Resistance
of High Cr ferritic Stainless Steels
for Architectural Exterior Applications
Y. Yazawa, T. Ujiro, K. Yamato, H. Kaito.
"Stainless steels 96", Dusseldorf 1996.

Crevice corrosion

Due to the presence of molybdenum, **UGINOX F18MT** has good resistance to the initiation of crevice corrosion, similar to that of the 316 L austenitic grade.
This resistance is measured in terms of the depassivation pH, which for UGINOX F18MT is of the order of 1.8, and is little sensitive to temperature.



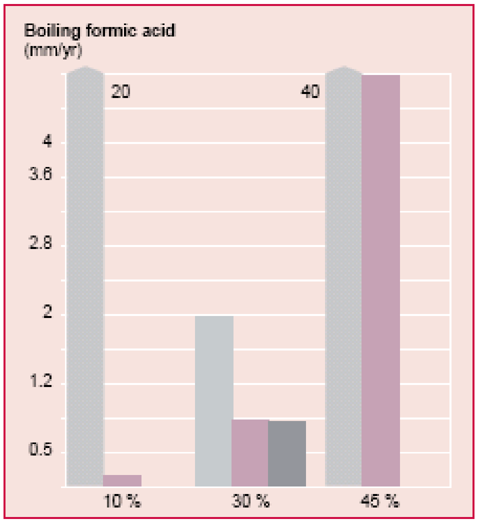
Intergranular corrosion

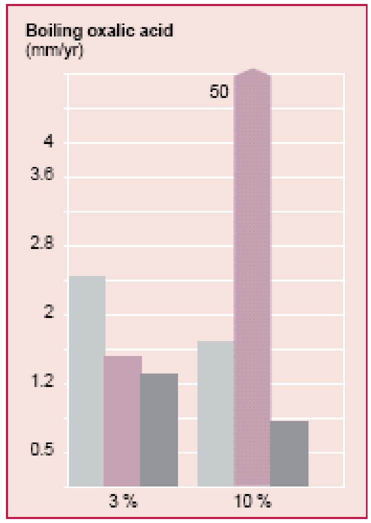
UGINOX F18MT has good resistance to intergranular corrosion (Strauss test), due to effective stabilization of carbon and nitrogen with titanium and niobium. Because of the high chromium content and the presence of molybdenum, precipitates of Laves phase can appear on heating in the range 600 to 900°C. These precipitates can alter the intergranular corrosion resistance in highly oxidizing media (e.g. Huey test), but do not modify the behaviour in the more usual Strauss test. For applications in such severe conditions, heat treatment in the above range should therefore be avoided.

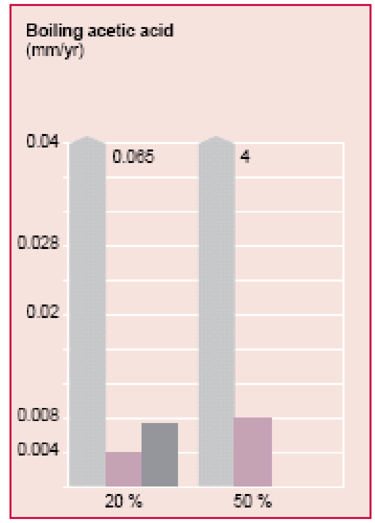
Acid corrosion

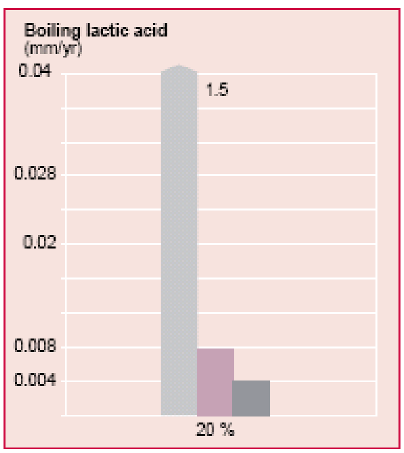
304
316
F18MT

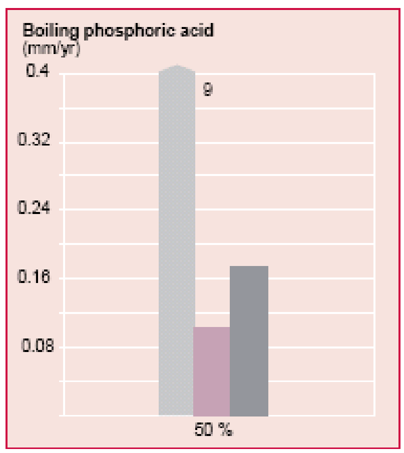
Although the corrosion rate is generally higher for ferritic steels than for austenitic grades with a similar molybdenum content, **UGINOX F18MT** is perfectly suitable for use in numerous organic and mineral acids, as show below.
Furthermore, it is highly resistant to fume condensates and has been certified by the French building industry (CSTB) for use with high yield domestic heating oils.

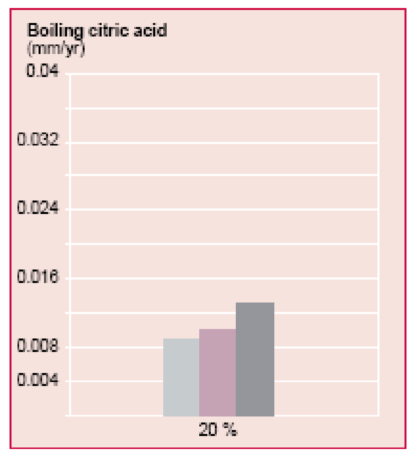


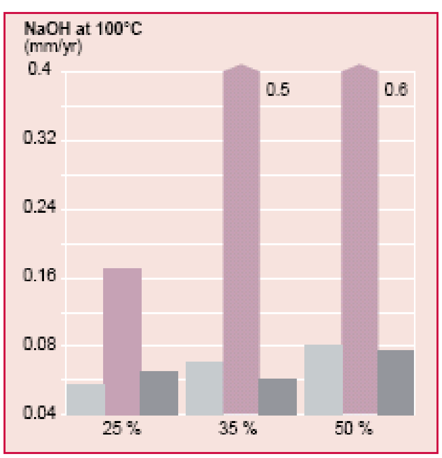


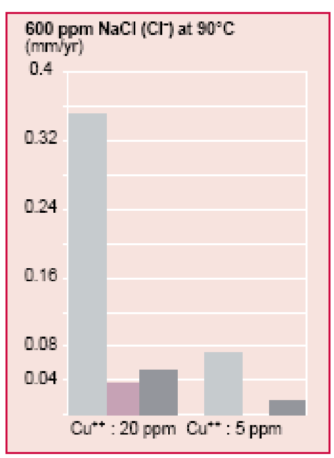


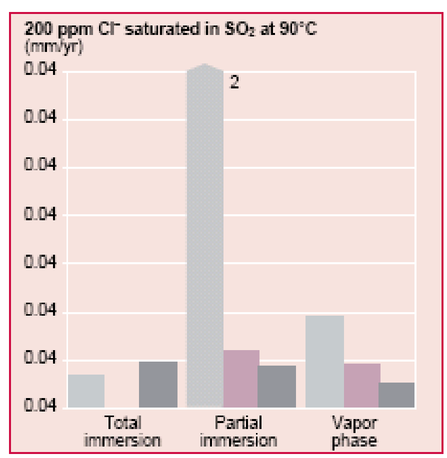












Stress corrosion cracking

Like all ferritic grades, **UGINOX F18MT** is insensitive to stress corrosion.
For example, in hot seawater, loaded to 95 %of the yield stress, no failure is observed after 3000 hours.

Time to crack initiation (hours)

	304	316	**UGINOX F18MT**
Boiling 42 % Mg Cl_2	< 2	< 16	> 1 700*
42 % $CaCl_2$ et 100°C	< 25	< 75	> 1 700*

* no crack initiation

Welding

UGINOX F18MT can be resistance welded by spot or seam techniques. Good results are obtained without the need for post treatment provided that forging of the weld is sufficient.

Welding process	No filler metal	With filler metal			Shielding gas*
	Typical thicknesses	Thickness	Filler metal		*Hydrogen and nitrogen forbidden in all cases
			Rod	Wire	
Resistance Spot Seam	 ≤ 2 mm ≤ 2 mm				
TIG	< 1.5 mm	> 0.5 mm	ER 316 L (Si)	ER 316 L (Si)	Argon Argon + Helium
PLASMA	< 1.5 mm	> 0.5 mm		ER 316 L (Si)	Argon Argon + Helium
MIG		> 0.8 mm		ER 316 L (Si)	Argon + 2% CO_2 Argon + 2% O_2 Argon + 2% CO_2 + Helium
S.A.W		> 2 mm		ER 316 L	
Electrode		Repairs	E 316 L		
Laser	< 5 mm				Helium Argon in certain conditions

The addition of hydrogen or nitrogen to the argon must be avoided since these gases decrease the ductility of the welds. For the same reason, nitrogen shielding must not be employed, while additions of CO2 must be limited to 3 %.

In order to restrict grain growth in the HAZ, the use of high welding powers must be avoided. For example, in automatic TIG welding, the power should not exceed 2.5 kJ/cm for a sheet thickness of 1.5 mm. Pulsed MIG/MAG welding has a lower power input than conventional MIG welding and enables better control of both bead geometry and grain size.

Post-weld heat treatment is generally not necessary.
The welds must be mechanically or chemically descaled, then passivated.
Oxyacetylene torch welding is to be proscribed.

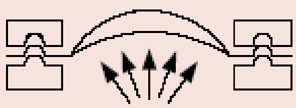
Forming

UGINOX F18MT can be cold formed using all the common processes (folding, contour forming, bending, deep drawing, etc.).

Bending
180° bending can be performed up to 0.8 mm, but above 0.8 mm thick radius of at least ½ the thickness should be allowed.

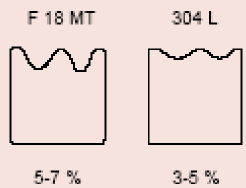
Grade	Erichsen test (deflection in mm)	Swift test (% earing)	Cup drawing LDR
UGINOX F 17 T / 430 Ti	9.6	5-7 %	2.15-2.20
UGINOX F 18 MT / 444	8.6	5-7 %	2.10-2.15
UGINOX 18-10 L / 304 L	11.5	3-5 %	2.00-2.05

Expansion

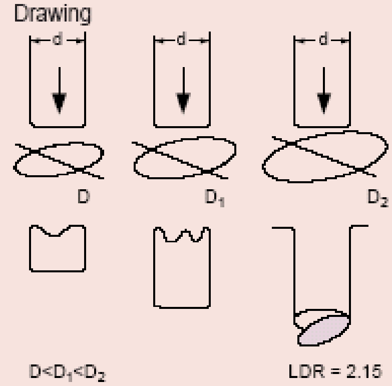


* Thickness 0.8 mm

Drawing



Drawing



$$LDR = \frac{\text{critical blank diameter D}}{\text{punch diameter d}}$$

Polishability

Stabilized ferritic stainless steels in general, and **UGINOX F18MT** in particular, can be readily polished with abrasive belts to 3 to 6 finishes. However, because of the presence of the stabilizing elements (Ti, Nb), they do not give a good mirror finish.
Polishing with abrasives containing iron salts is to be proscribed. If the steel has nevertheless been contaminated with iron or iron salts, a final decontamination treatment must be performed.

Heat treatment and finishing

Before any heat treatment, the metal must be carefully degreased.
Annealing
After cold work, annealing is performed by treating for a few minutes at 925°C followed by air cooling. For treatments longer than 5 minutes, it is essential never to exceed 1000°C.

Pickling
Nitric-hydrofluoric acid mixture
(20% HNO_3 + 1% HF)
Descaling pastes for weld zones.
Passivation
20-25 % HNO_3 solution at 20 °C
Passivating pastes for weld zones.

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