UGINOX

F 12 N

11 % chromium ferritic stainless steel for welded structures

European designation (1)
X2CrNi12
1.4003

American designation (2)
AISI 410 S

(1) According to NF EN 10088-2
(2) Approximate correspondence

Chemical composition
according to NF EN 10088-2

Element	C	Si	Mn	Cr	Ni
Weight %	≤ 0.03	≤ 1.0	≤ 1.5	10.5-12.5	0.3-1.0

General characteristics

The principal features of **UGINOX F 12 N** are :
- good mechanical strength (Rp 0.2 ≥ 320 MPa)
- excellent weld properties, particularly high toughness
- good corrosion resistance in natural atmospheres and in contact with moderately aggressive media
- good resistance to abrasion-corrosion
- good weldability
- good formability.

Typical applications

- Transport equipment : railroad carriages and wagons, containers, coaches, etc.
- Industrial equipment : hoppers, conveyors, storage tanks, etc.
- Building equipment and municipal furnishings.

In general, all the applications of conventional structural steels, with the advantage of improved resistance to service in corrosive environments.

Product range

- Forms : sheets, blanks, coils, oscillated-coils, strips, circles.
- Thicknesses : 0.5 to 6.5 mm.
- Width : according to thickness, maximum 1500 mm.
- Finish : cold rolled or hot rolled, depending on the thickness.

Tensile properties

1 MPa = 1 N/mm²

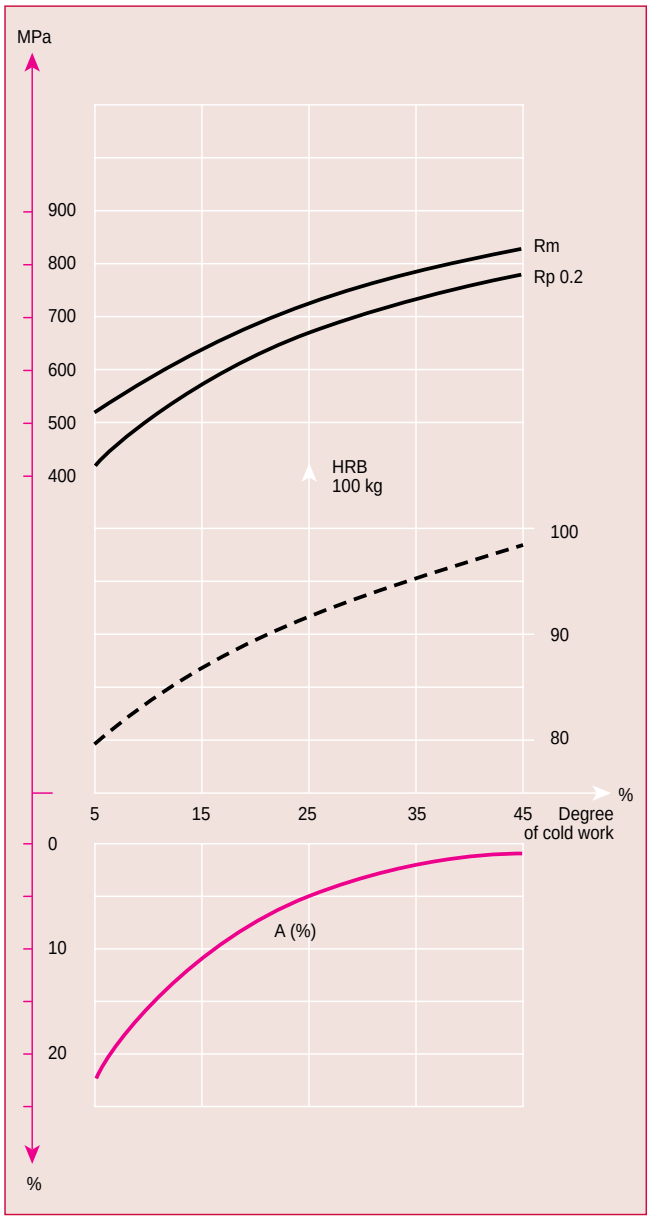
Annealed condition
According to NF EN 10002-1 (Oct. 1990), specimen perpendicular to the rolling direction.

Specimen
Lo = 80 mm (thickness < 3 mm)
Lo = 5.65 $\sqrt{So}$ (thickness ≥ 3 mm).

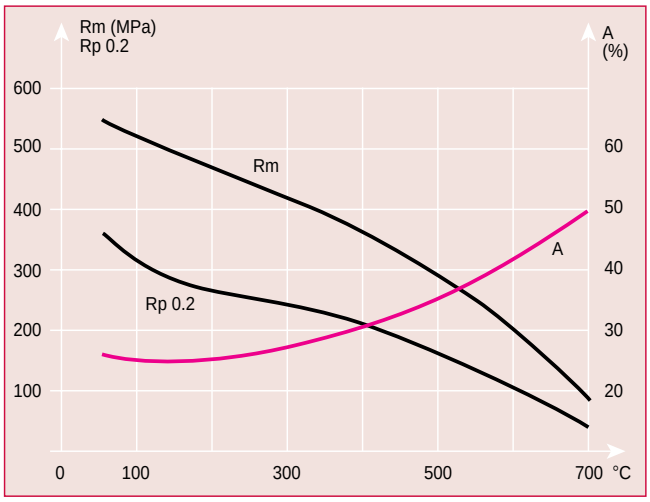
Condition	Rm(1) (MPa)	Rp 0.2(2) (MPa)	A(3) (%
Cold rolled	450-600 (510)	≥ 320 (340)	≥ 20 (29)
Hot rolled	450-600 (520)	≥ 340 (360)	≥ 20 (27)

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

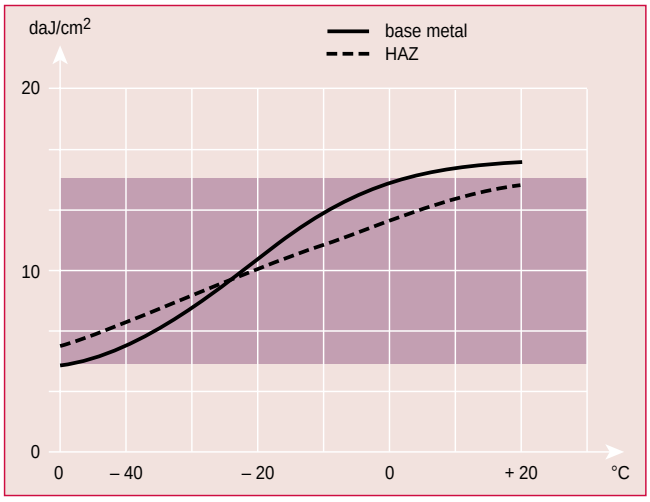
Effect of cold work



At high temperature



Impact strength (1/2 KCV)



UGINOX F 12 N has been specially designed for high integrity welded structures.
The microstructure obtained in the heat affected zones (HAZ) is essentially martensitic, with a low carbon content and a fine grain size, leading to excellent low temperature toughness properties.

Fatigue properties

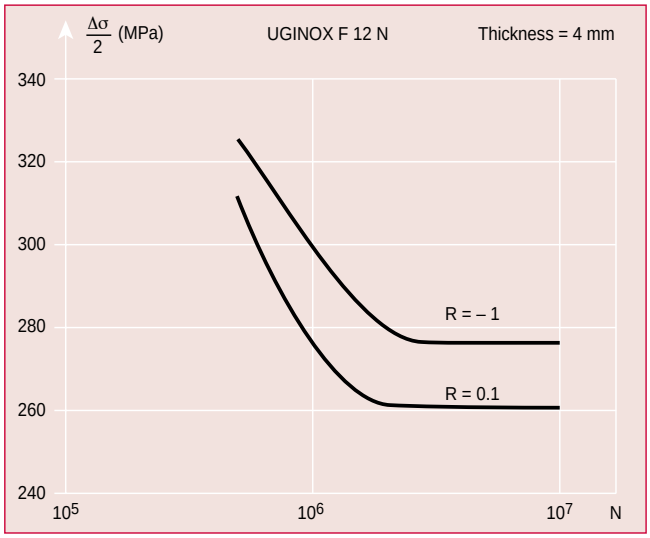
UGINOX F 12 N shows excellent fatigue behavior, characterized by :
- a 10^7 cycle endurance ratio ($0.5\Delta\sigma/UTS$) ≥ 0.5,
- weld structures of strength at least equivalent to that obtained with standard E 355 steel.

UGINOX F 12 N is therefore particularly suited for the production of welded structures subjected to mechanical loading during service.

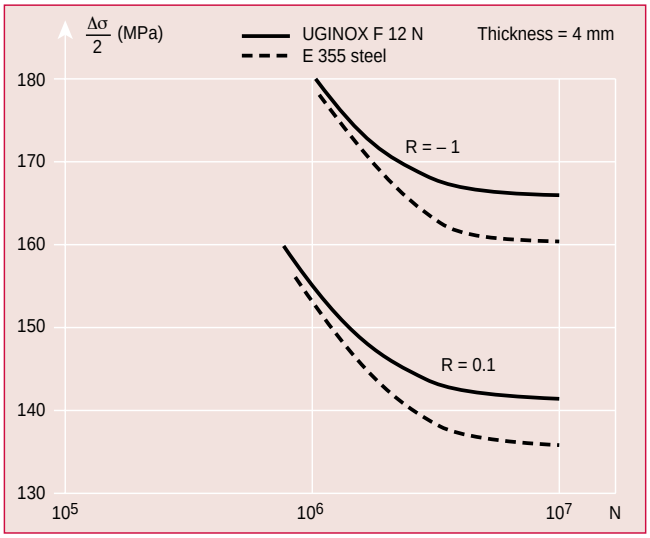
Bending test results

Endurance ratio $r = \frac{0.5\Delta\sigma}{UTS}$ Endurance limit $0.5\Delta\sigma = \frac{\sigma_{max} - \sigma_{min}}{2}$ Load ratio $R = \frac{\sigma_{min}}{\sigma_{max}}$	R = –1		R = 0.1	
	$\Delta\sigma/2$ (MPa)	r	$\Delta\sigma/2$ (MPa)	r
UGINOX F 12 N base metal	280	0.53	260	0.50
UGINOX F 12 N weld assembly	165	–	140	–
E 355 steel weld assembly	160	–	135	–

Base metal



MIG butt welded joint



Heat treatment and finishing

Heat treatment
- After cold working, annealing for a few minutes at 750 °C enables the structure to be restored.
- UGINOX F 12 N transforms to martensite when cooled rapidly from temperatures above 780 °C.

Polishing, brushing, buffing, satin finishing
No particular difficulty.

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.

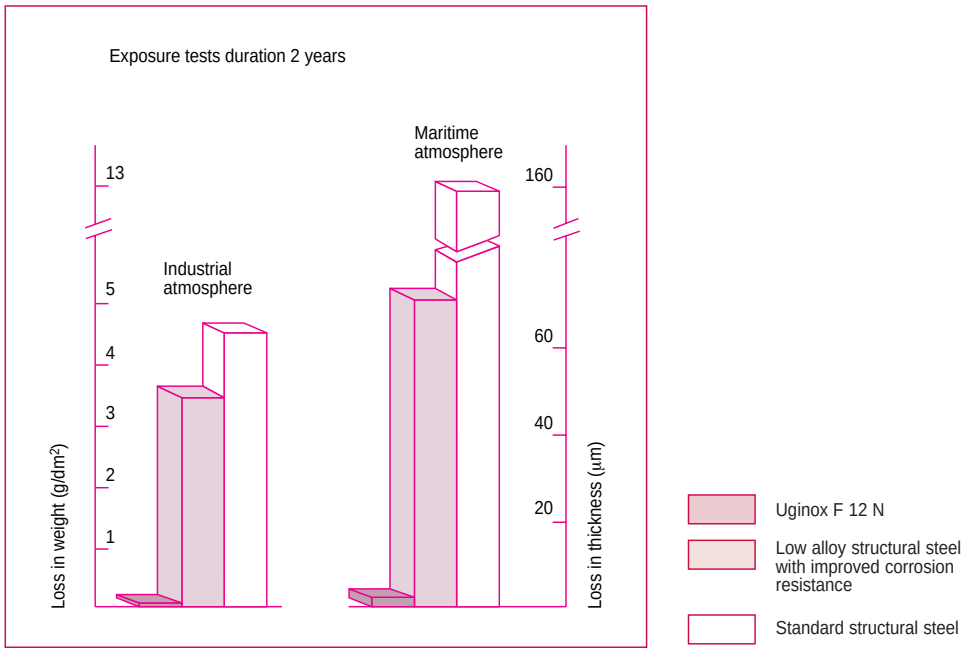
Corrosion resistance

In normal circumstances, the rate of corrosion of **UGINOX F 12 N** in natural atmospheres is less than 1 µm per year, i.e. about a hundred times lower than for standard structural steels. This excellent behavior enables **UGINOX F 12 N** to be used in numerous applications without a paint coating, while ensuring the integrity of the equipment concerned.

Nevertheless, weathering of the metal surface can lead to the formation of a brown tarnish, so that a paint coating is preferable in applications where appearance is important.

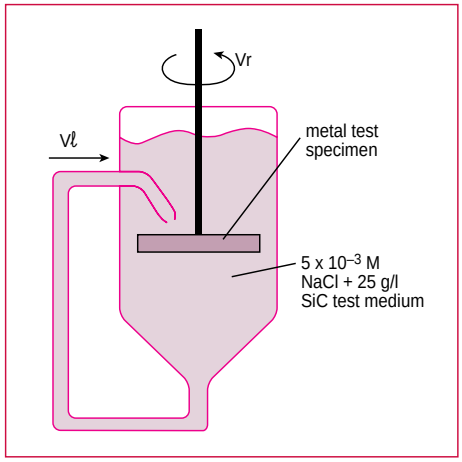
When painted, the time to reach a standard degree of damage in the salt spray test (AFNOR NFX 41 002) is five times greater than for a painted conventional structural steel.

The use of either bare or painted **UGINOX F 12 N** in place of a standard structural steel increases the life of the equipment concerned, while at the same time reducing maintenance costs, thus leading to an excellent cost / performance ratio.



Resistance to abrasion-corrosion

Because of its combination of good corrosion resistance and high mechanical strength, **UGINOX F 12 N** performs extremely well in situations where corrosive attack can be associated with abrasive loading. Such conditions are frequently encountered in numerous industrial sectors, for example in the storage and handling of solid or powdery materials in moist environments, handling of liquids containing solid particles in suspension, etc. Such situations have been simulated experimentally (see diagram) in laboratory tests which clearly show the superiority of **UGINOX F 12 N**.



	Weight loss (g)	
	Vr = 150 rpm Vℓ = 3 m/s	Vr = 1 000 rpm Vℓ = 6 m/s
UGINOX F 12 N	15	20
E 355 steel	95	130

Forming

UGINOX F 12 N can be readily cold formed by all standard processes (bending, contour forming, drawing, etc.).

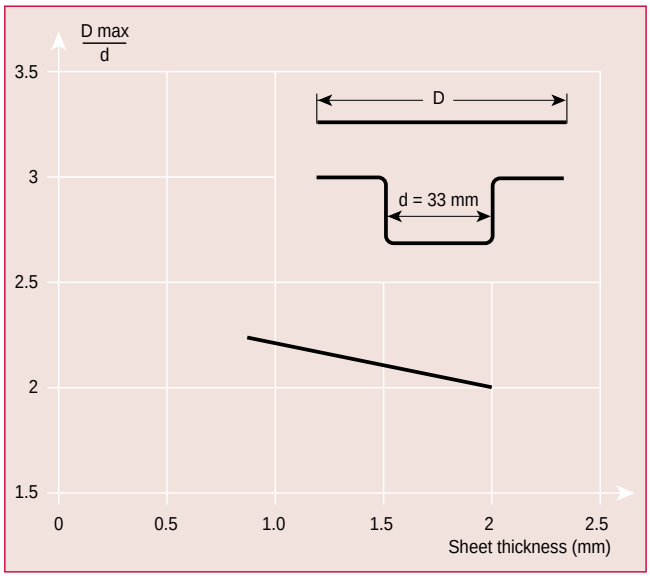
Bending
The high ductility of **UGINOX F 12 N** allows it to bent through 180° with a relatively small bend radius.

Drawing
UGINOX F 12 N has good drawing characteristics and can be used to produce a wide range of drawn components.

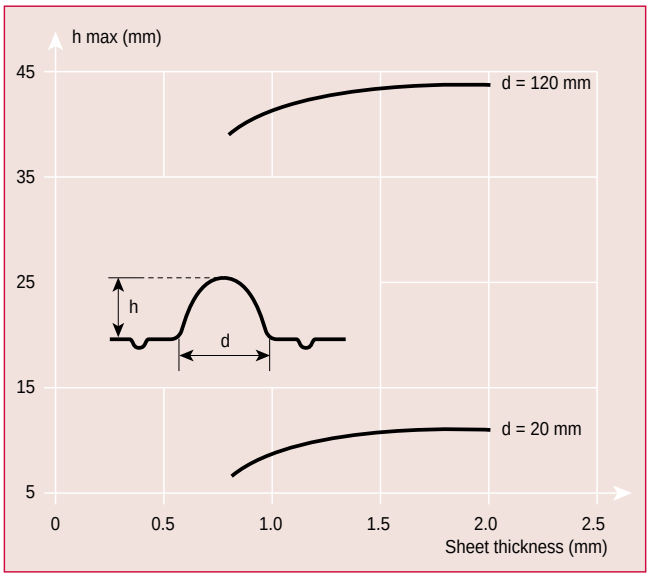
Thickness t (mm)	minimum bend radius in mm (transverse direction)	
	90°	180°
< 4.5	0.5 t	1 t
4.5-6.5	1 t	1.5 t

Standard test procedure NFA 03157 and NFA 03158 (June, 1978).

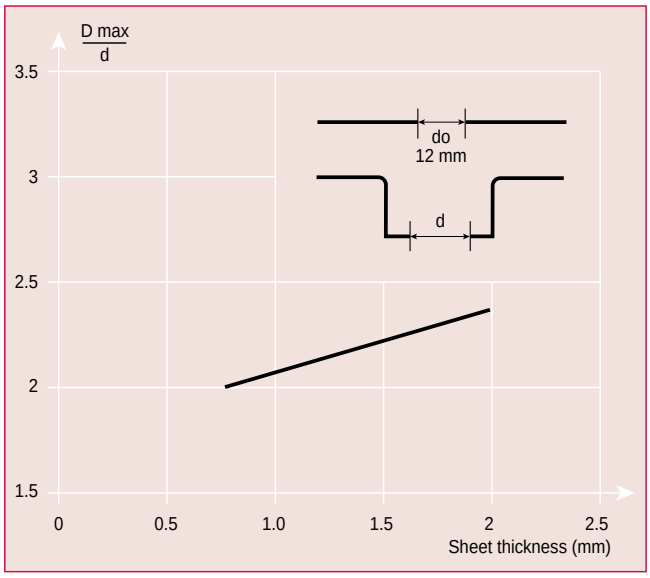
Swift test (drawing)



Erichsen test (expansion)



KWI test (expansion of a hole)



Welding

UGINOX F12 N 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 Typical thicknesses	With filler metal Thickness	Filler metal Rod	Filler metal Wire	Shielding gas*
Resistance - spot - seam	≤ 2 mm ≤ 2 mm				*Hydrogen and nitrogen forbidden in all cases
TIG	< 1.5 mm	> 0.5 mm	ER 308 L (Si)	WNr 1.4370 ER 308 L (Si)	Argon Argon + helium
PLASMA	< 1.5 mm	> 0.5 mm		WNr 1.4370 ER 308 L (Si)	Argon Argon + helium
MIG		> 0.8 mm		WNr 1.4370 ER 308 L (Si)	Argon + 2 % CO_2 Argon + 2 % O_2 Argon + 2 % CO_2 + helium
S.A.W.		> 2 mm		ER 308 L	
Electrode		Repairs	E 308 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 CO_2 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.

Except in particular cases, no pre- or post-weld heat treatment is necessary.

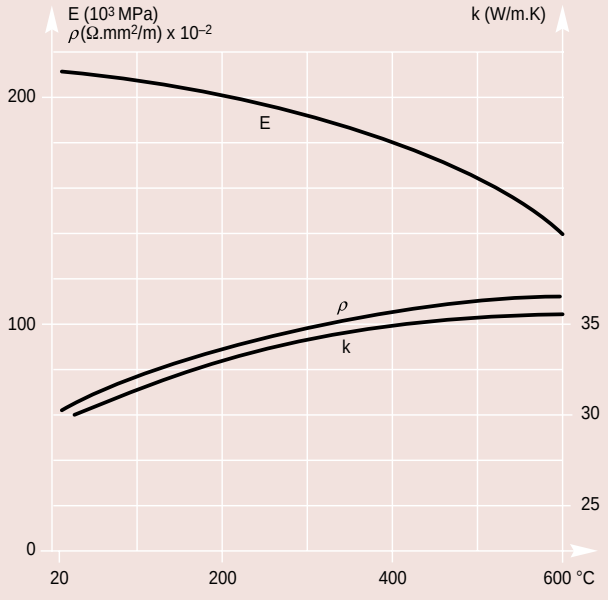
If it is wished to restore the full corrosion resistance of the weld metal, the welds must be mechanically or chemically descaled, then passivated. However, depending on the application, this operation may not be essential.

Physical properties

(cold rolled sheet)

Density	d	–	4 °C	7.7
Melting temperature (solidus)		°C		1460
Specific heat	c	J/kg. K	20 °C	460
Thermal conductivity	k	W/ m. K	20 °C	30
Mean coefficient of thermal expansion	α	$10^{-6}.K^{-1}$	20 - 100 °C 20 - 200 °C 20 - 400 °C	10.5 11.0 12.0
Electrical resistivity	ρ	$\Omega.mm^2/m$	20 °C	0.60
Magnetic permeability	μ			850
Young's modulus	E	MPa x 10^3	20 °C	215

Poisson's ratio : 0.28



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