Industeel

ArcelorMittal

SOLEIL™ C5

SOLEIL™ C5: A 13Cr 4Ni martensitic stainless steel

Soleil™ C5 is a 13% Cr-4% Ni-0.5% Mo martensitic stainless steel. Its nickel content, associated with low carbon ensures better weldability, ductility, impact and fatigue resistance than 13 Cr martensitic grades (410, 420).
The alloy has good corrosion resistance to fresh water and performs well in abrasive conditions. It combines high mechanical properties, excellent toughness and weldability.
It is commonly used in turbines and flow control systems in the hydropower industries.

PROPERTIES

STANDARDS

> EURONORM EN 1.4313 X3 Cr Ni Mo 13-4

> ASTM/ASME UNS 41500

CHEMICAL ANALYSIS - WEIGHT %

Typical values

C	Cr	Ni	Mo	Si	Others
.04	13	4	.5	.4	S = .001 - P = .020

PHYSICAL PROPERTIES

Density: 7.7 kg/dm³

Interval temperature °C	Thermal expansion ($\alpha x10^{-6} K^{-1}$)	T °C (°F)	Resistivity (µΩ.cm)	Thermal conductivity ($W.m^{-1}.K^{-1}$)	Specific heat ($J.kg^{-1}.K^{-1}$)	Young modulus E (GPa)	Shear modulus G (GPa)
0 - 100	11	20 (68)	80	26	460	206	80
0 - 200	11	200 (392)	-	27	500	195	76
0 - 400	12	400 (752)	-	28	540	180	70

MECHANICAL PROPERTIES

Tensile properties - Minimum guaranteed values

Temperature		Y.S. 0.2%		Y.S. 1%		UTS		El
°C	°F	MPa	ksi	MPa	ksi	MPa	ksi	%
20	68	560	81	580	84	750-950	109-138	18
100	212	500	72	520	75	700-920	102-133	18
300	572	420	61	440	64	650-900	94-130	18

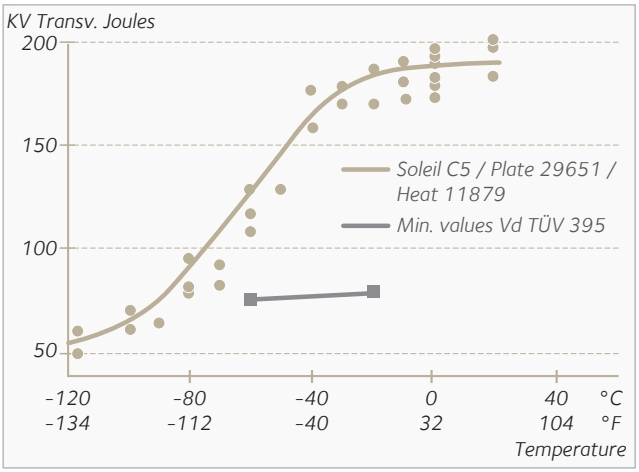
Results in the annealed condition (soft material). The grade may be hardened by heat treatment. Minimum 700 MPa (102 ksi) yield strength may be guaranteed.

Impact strength (KV minimum values)

	0%	32°F	20°C	68°F
Single	60 J	44 ft.lb	80 J	59 ft.lb
Average (5)	80 J	59 ft.lb	100 J	74 ft.lb

Typical Charpy V values in the Z direction at room temperature are 80-120 J (59-89 ft.lb). The Charpy-V transititon temperature is close to -50°C (-58°F). A value of 50 J mini in the Z direction may be guaranteed even for 100 mm thick plates.

Typical KV transition curve



Soleil™ C5 alloy presents improved toughness properties when compared to ferritic-martensitic grades (AISI 410- 420 / EN 1.4000-X6 Cr 13).

Fatigue properties (indicative results)

Rotating beam fatigue (longitudinal, smooth specimens) $R_{p0.2}$/YS = 640 MPa.

Fatigue limit 10^7 cycles.

Air	540 MPa
Synthetic sea water	380 MPa

Indicative results.

Hardness values - Typical values

Average (5)	HV_{10} = 240-320	HB = 220-320

Hardness varies with heat treatment

DELIVERY CONDITIONS

SIZE RANGE

	Hot rolled plates
Thickness	5 to 150 mm 3/16" to 6"
Width	Up to 3300 mm Up to 130"
Length	Up to 12000 mm Up to 472"

Formed pieces are available through Industeel France - Chateauneuf Euroform Plant

PLATE PROCESSING

STRUCTURE AND HEAT TREATMENT

The chemical composition of Soleil™ C5 is balanced to obtain a martensitic structure with less than 1 % ferrite after heat treatment. Due to its very low sulfur content, the alloy has a very high cleanliness, improving corrosion resistance and toughness properties. The alloy is generally air or water quenched after heat treatment at 950 - 1050°C (1742 - 1922°F). A tempering treatment is performed in the 600 - 700°C (1112 - 1292°F) range. The alloy is more stable than ferritic stainless steels without nickel additions. As a result the alloy Soleil™ C5 is less prone to embrittlement effects in the 550 - 300°C (932 - 572°F) temperature range. Embrittlement start after 1000 hours at 400°C (752°F) or 10 000 hours at 300°C (572°F). The steel is magnetic.

HOT FORMING

Hot forming should be carried out in the temperature range 1100 - 800°C (2012 - 1472°F) followed by air cooling and followed by heat treatment (see above).

COLD FORMING

When performed, a final stress relieving treatment may be requested. Typical temperature range is 580 - 620°C (1076 - 1148°F), for 2 hours.

PICKLING

If pickling is needed, use the following conditions:

(1)	- HNO_3 - Nitric acid 36° Bé - HF - Hydrofluoric 65° - Water	10 % 1 %
	Temperature : 20°C (68°F) - 1-3 hours. A slight increase of temperature reduces pickling times	
(2)	- H_2SO_4 - Sulfuric acid 65° - HNO_3 - Nitric acid 36°	10% 0.3%
	Temperature 60°C (140°F) - a few minutes	
(3)	Pickling pastes (follow suppliers' recommendations)	

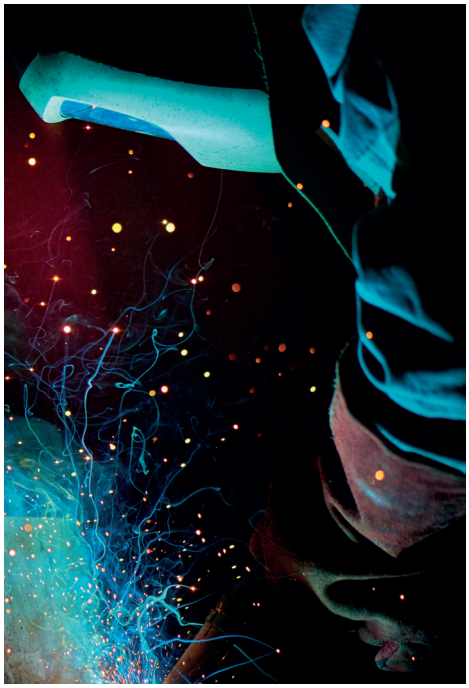
After processing or machining, the alloy should be decontaminated using the following bath:
For most application, Soleil™ C5 alloy is delivered in the blasted condition

WELDING

The nickel addition and the low carbon content improve the weldability of SOLEIL™ C5 compared to 410 type martensitic steels, but precautions must be taken to avoid cold cracking and to improve the toughness of welds:

- > Preheating at 150°C and interpass temperature limited to 200°C - 392°F (below the Ms temperature).
- > SMAW welding with basic type electrodes of similar composition; electrodes must be well dried over 250°C.
- > SAW welding with a high basicity flux dried before welding. Preliminary test is necessary to check mechanical properties in the weld deposit.
- > Post heating: 200°C/392°F - 2H and slow cooling under cover.
- > Stress relieving at 600-620°C (1112-1148°F).

SOLEIL™ C5 can be welded using 309L type fillers, but this will produce joints of lower strength. Consult for details. Final pickling and decontamination are recommended when corrosion resistance properties are required. If needed, consult.



APPLICATIONS

SOLEIL™ C5 grade is specially designed for applications requiring high strength, high toughness and medium corrosion resistance properties.
The chromium, nickel and molybdenum additions make the alloy resistant to corrosion in fresh water. Typical applications are hydroelectric turbines and systems (blades, runners, gates, rings, shield plates,...), hydropter wings to fight cavitation by high speed water.

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