SOLEIL C5

A 13% Cr 4 Ni martensitic stainless steel with improved toughness

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 resistance and fatigue resistance properties when compared to 13 Cr ferritic-martensitic grades (AISI 410-420/EN 1.4000 X6 Cr 13).

The alloy has good corrosion resistance to fresh water and performs well in abrasive conditions.

The alloy is specially designed for all applications requiring high mechanical properties combined with high toughness and may be used in medium corrosive conditions. Typical applications are shafts or compressor impellers, particularly for hydraulic applications.

STANDARDS

EURONORM ..... 1.4313-X4 Cr Ni Mo 13-4
AISI 41500

CHEMICAL ANALYSIS

Typical values (Weight %)

C	Cr	Ni	Mo	Si	Others
0.04	13	4	0.5	0.4	S = 0.001 - P = 0.020
Note the extra low sulfur which increases the cleanliness of the steel					

MECHANICAL PROPERTIES

Tensile properties - Minimum guaranteed values

°C	Rp 0.2 MPa	Rp 1.0 MPa	Rm MPa	°F	YS 0.2% KSI	YS 1.0% KSI	UTS KSI	A/Elong
20	560	580	750-950	*68*	81	84	109-138	18
100	500	520	700-920	*212*	72	75	102-133	18
300	420	440	650-900	*572*	61	64	94-130	18

The results here presented are those in the annealed condition (soft material). The grade may be hardened by controlling the heat treatments. Minimum 700 MPa (102 KSI) yield strength may be guaranteed.

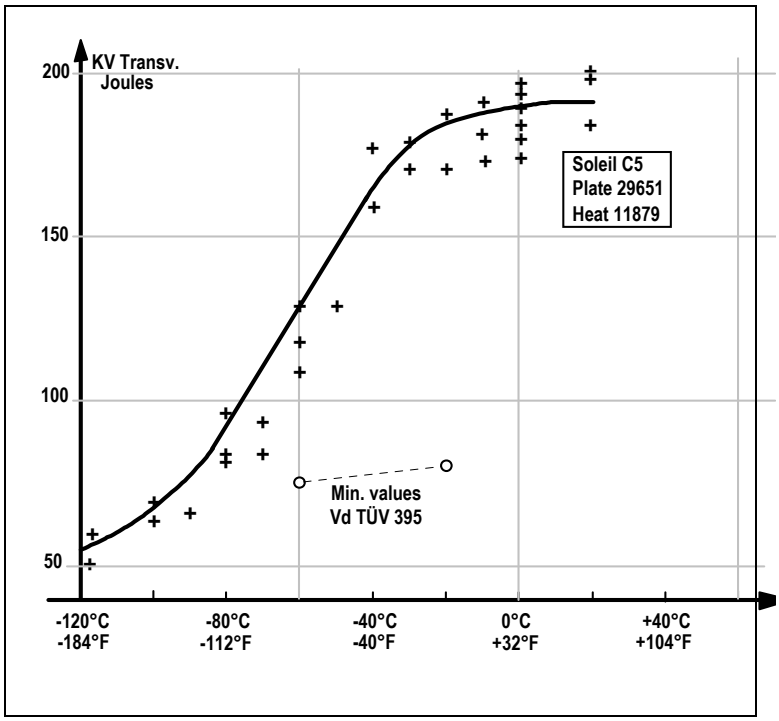
Impact strength (KV minimum values)

	0°C	+20°C	+32°F	+70°F
Single	60 J	80 J	44 ft.lb	59 ft.lb
Average (5)	80 J	100 J	59 ft.lb	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 transition 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-martensitif grades (AISI 410-420/ EN 1.4000-X6 Cr 13).

Fatigue properties (indicative results)

STANDARDS			TENSILE PROPERTIES		FATIGUE PROPERTIES	
Industeel	EN	AISI	Rp 0.2 Y.S. 0.2%	Rm/UTS	Wihout notch	Notched r = 0.25 mm
Soleil A2	1.4000 X6Cr 13	410	620 MPa	720 MPa	360 MPa	110 MPa
Soleil C5	1.4313X4CrNi13-4	41500	680 MPa	770 MPa	450 MPa	150 MPa

The improved fatigue properties of Soleil C5 grade are mainly due to the 4 % nickel additions.

Hardness values - Typical values

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

Hardness values are dependant upon heat treatment

PHYSICAL PROPERTIES

Density : 7700 kg/m3

Interval Temper °C	Thermal expansion ax10^{-6}K^{-1}	°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

STRUCTURE AND HEAT TREATMENT

Soleil C5 is a 13 Cr 4Ni stainless steel the chemical composition of which 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.

PROCESSING

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 10 %
- HF - Hydrofluoric 65° 1 %
- Water
Temperature : 20°C (68°F) - 1-3 hours
A slight increase of temperature reduces pickling times

(2) -H_2SO_4 - Sulfuric acid 65° 10 %
-HNO_3 - Nitric acid 36° 0.5 %
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 :

- $HN0_3$ 36°	20 to 25%
- Water remaining	≈ 75 %

room temperature, 30 minutes, water cleaning

For most applications, Soleil C5 alloy is delivered in the blasted condition.

WELDING

The nickel addition and the low carbon content greatly 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 (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/2H and slow cooling under cover.
- Stress relieving at 600°C – 620°C.

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.

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 Loire.

NOTE

This technical data and information represents our best knowledge at the time of printing. However, it may be subject to some slight variations due to our ongoing research programme on corrosion resistant grades.

We therefore 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 is only for the purpose of description, and may only be considered as guarantees when our company has given written formal approval.

Further information may be obtained from the following address.

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