



CromElso™ 22 SA-387 grade 22

CromElso™ 22: Special low alloy (2¼Cr1Mo) steel for high temperature hydrogen service

CromElso™ 22 is a low alloyed Cr-Mo steel designed for pressure equipment such as hydrotreating reactors operating at elevated hydrogen pressure and temperature. **CromElso™ 22** is manufactured via the electric arc furnace with dephosphorisation, ladle refining and vacuum degassing to provide reproducible, clean and homogeneous steel. The use of special steelmaking practice with extralow phosphorus levels gives **CromElso™ 22** improved resistance to temper embrittlement, as well as providing excellent low temperature impact toughness properties. **CromElso™ 22** is particularly suitable for pressure equipment in high temperature hydrogen service (e.g. hydrotreating reactors, exchangers). This steel is available in plate form in thickness up to 250 mm, and can also be provided in single- or multi-piece heads and cores.

PROPERTIES

STANDARDS

- > EN 10028-2 10CrMo9-10 (W 1.7380)
- > ASTM A387 grade 22
- > ASME SA-387 grade 22

CHEMICAL ANALYSIS - WEIGHT %

C	Mn	Si	P	S	Cr	Mo
≤ 0.15	< 0.6	0.15-0.40	≤ 0.007	≤ 0.004	2.0-2.5	0.9-1.10

Typical values on heat. With the following additional requirements: (P+S) ≤ 0.012% ; J factor* ≤ 100

* $J = (Si+Mn).(P+Sn) \times 10^4$ (elements in wt.%)

DELIVERY CONDITION

Normalising and Tempering or Normalising, accelerated cooling and tempering depending on thickness and required impact properties.

MECHANICAL PROPERTIES

Guaranteed transverse tensile values at room temperature after PWHT according to applicable Standard. These values are guaranteed for a total Larsen-Miller parameter (LMP)* = 20850 (including tempering and PWHT)

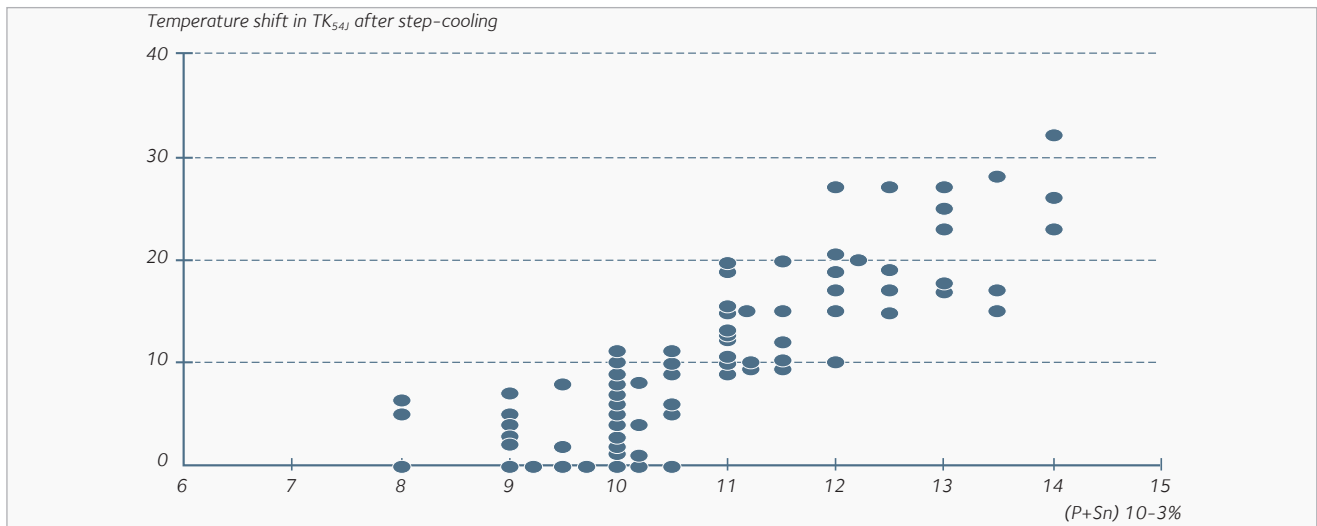
	YS (MPa [ksi])	TS (MPa [ksi])		Elongation%
	Min	Min	Max	Min
EN 10028-2	250 [36]	460 [66]	610 [88]	17
ASTM A387 grade 22 class 2	310 [45]	515 [75]	690 [100]	18

High temperature tensile properties can be provided upon demand. Plate soundness guaranteed to ultrasonic levels determined by ASTM A 578 level B or EN 10160-S1E2.

* LMP = T (20 + log t) with T as the temperature in K and t as the duration in hours.

Impact properties

The impact properties of CromElso™ 22 depend upon temperature and duration of heat treatment (tempering and PWHT) as well as plate thickness. For typical heat treatment conditions, a 54J transition temperature (TK_{54J}) of -29°C (°F) can be guaranteed. The effect of temper embrittlement can be measured using the step-cooling test. For Industeel production, the following guarantee is given. $TK_{54J} + 3\Delta TK_{54J} \leq 10^\circ\text{C}$ where ΔTK_{54J} is the temperature shift upon step-cooling, according to the procedure given in API 934. As can be seen in the following figure, this shift in step-cooling depends principally on the impurity content (P+Sn)%. For (P+Sn) contents below 0.012%, the risk of temper embrittlement is considerably reduced.



CREEP PROPERTIES

CromElso™ 22 complies with the creep properties given in table C.1. of EN 10028-2. Further data are available on request.

DISBONDING

Hydrogen Induced Disbonding Resistance is often required for hot hydrogen service. Disbonding resistance depends on the overlay conditions, and PWHT, however it has been shown that a limitation of C content in the parent material is effective to reduce the sensitivity. In order to help its customer to define testing conditions representative of service Conditions, Industeel has developed numerical simulation tools, which allow the determination of hydrogen profiles through the wall of reactors or in laboratory test specimens. A laboratory test condition representative of actual service conditions gives the same level of hydrogen at the interface.

PLATE PROCESSING

FORMING

Cold forming (+ stress relief for high strains) or hot forming can be applied:

- > cold forming (< 500°C/930°F): to be followed by PWHT
- > warm forming (500°C/930°F to tempering temperature)
- > hot forming (900-1100°C/1650-2010°F): to be followed by complete heat treatment

Please consult for full heat treatment details.

HEAT TREATMENT

Austenitizing at 910°C - 970°C (1670°F - 1780°F), water quenching.

Tempering temperature (>675°C/1250°F) is adjusted depending on the required PWHT. PWHT in the range 660-690°C (1220-1275°F). For other requirements, please consult.

WELDING

Filler materials

Consumables used for the welding of CromElso™ 22 shall correspond to the following standards:

	SMAW	GMAW	FCAW	SAW
				Wire + Flux
AWS	A5-5 E 9015-B3	A5-28 ER80S-B3	A5-29 E80T5-B3	A5-23 EB3R
EN	EN1599 E CrMo 2 B 4 2 H5	EN12070 G CrMo2	EN 12071 T CrMo2	EN 1 2070 S CrMo 2 EN 760 SA FB 1 65 DC/AC

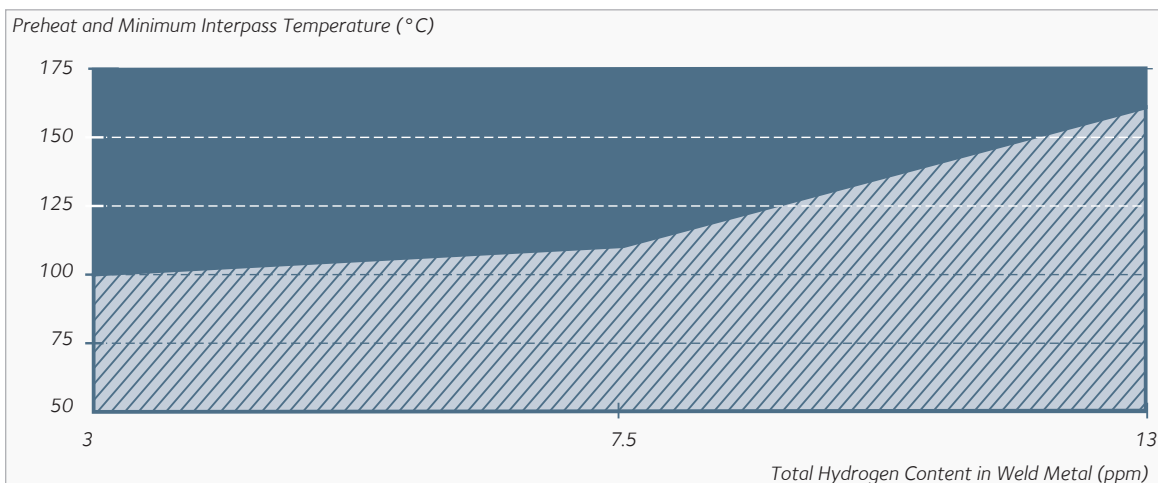
A non-exclusive list of suitable filler materials is given hereafter:

	SMAW	GMAW	FCAW	SAW	
				Wire	Flux
KOBELCO	CMA 106	MGS-2CM	DWA-91B3	US 521 S	PF 200
METRODE	CHROMET 2	2 CrMo	CORMET 2 FCW	SA 2 CrMo	LA 491
ALW	ALCROMO E225	Carbofil CrMo2	Fluxofil 37	S1 CrMo2	OP121TTW
T-PUT	Phoenix SH Chromo 2K S	Union I CrMo 910	Union MV CrMo 910	Union S1 CrMo2	UV420TTR UV420TTRW

The above list of filler materials has been determined according to suppliers' data, please confirm this choice with your supplier.

Welding conditions

The determination of the preheat and minimum interpass temperature conditions can be done using the implant test of standard ISO 17642-3. Test results show that a minimum of 125°C is necessary for the Heat Affected Zone of the Base Material.



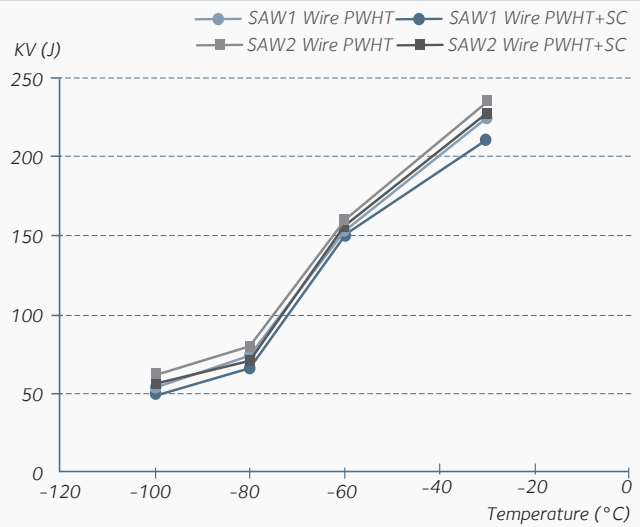
However, the risk of cold cracking is known to be greater in the weld metal than in the HAZ. Therefore, preheating and interpass temperatures of 200°C are recommended for thickness higher than 30 mm*. After welding a Dehydrogenation Heat Treatment ≥ 300°C is recommended.

* Document CEN (European Committee for Standardization): «Welding Guidelines: part 6: avoidance of hydrogen cracking for low alloy creep resisting steels» (CEN-TC121-WG4-SG1-N34)

PLATE PROCESSING

HAZ properties

CromElso™ 22 is designed for hot hydrogen service and therefore meets the HAZ hardness requirements of API 934. Extra-low levels of impurity elements (P,S,O) help ensure excellent toughness properties in the HAZ, even after step-cooling.



APPLICATIONS

CromElso™ 22 is suitable for pressure equipment such as reactors or exchangers operating under hot hydrogen service (within the limits of API RP 941):

- > hydrodesulfuration (HDS) unit
- > hydrotreatment (HDT) unit
- > hydrocracking (HDC) unit

YOUR CONTACTS

Valéry Ngomo

Tel. +33 4 77 75 21 04

valery.ngomo@arcelormittal.com

Patrick Toussaint

Tel. +32 71 44 16 27

patrick.toussaint@arcelormittal.com

<http://industeel.arcelormittal.com>

Industeel France

Châteauneuf Plant - BP 368

F - 42803 Rive de Gier Cedex

Industeel Belgium

266, rue de Châtelet

B - 6030 Marchienne-au-Pont

Technical data and information are to the best of our knowledge at the time of printing. However, they may be subject to some slight variations due to our ongoing research programme on steels. Therefore, we 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 are only for the purpose of description, and considered as guarantees when written formal approval has been delivered by our company. Further information may be obtained from the address opposite.