CROMELSO®91

Special alloy steel (9Cr1Mo0.2V) with high temperature creep resistance

CromElso®91 is an alloyed martensitic CrMoVNb steel designed for high temperature creep resistance up to 600℃ (1100℉). CromElso®91 is manufactured via the electric furnace with dephosphorisation, ladle refining and vacuum degassing to provide a reproducible, clean and homogeneous steel.

The use of special steelmaking practice gives CromElso®91 improved heat affected zone impact toughness properties. Balanced low carbon gives enhanced weldability for pipe and pressure vessel fabrication, while it is at the same time high enough to contribute to the creep resistance. Other controlled ratios of compositional elements like nitrogen and aluminium also give rise to the better creep properties of the steel, which is basically obtained through its strong martensitic structure.

CromElso®91 is particularly suitable for supercritical steam piping for enhanced thermodynamical efficiency in energy generation processes.

This steel is available in plate form in thickness up to at least 90 mm. Very large thicknesses can be available for pressure vessel components typical of the nuclear energy industry.

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EQUIVALENT STANDARDS

EN10028-2…….. X10CrMoVNb9.1 (1.4903)
ASTM…….. A 387 gr. 91 class 2 (UNS S50460)
ASME II Part A…. SA 387 gr. 91 class 2 (UNS S50460)

CHEMICAL ANALYSIS AND MICROSTRUCTURE

Typical values on heat (Weight %)

C	S	P	Si	Mn	Cr	Mo	V	Nb	N	Al
0.10	0.002	0.018	0.3	0.4	9.00	1.00	0.2	0.08	0.055	0.012

The chemistry is specially balanced to combine good welding and fabrication properties as well as optimised mechanical properties and creep strength, e.g. through a sufficient N/Al ratio.

This fully martensitic steel possesses a microstructure composed of at least 98% of tempered martensite that contributes to the creep resistance.

MECHANICAL AND IMPACT PROPERTIES, HARDNESS

Transverse values at room temperature

According to applicable National Standard and customer specification.

Minimum guaranteed values for as-delivered plates are per the following table.

thickness (mm)	Rp0,2 (MPa)	Rm (MPa)	A (%)	Kv (J)		
< 60	445	580-760	18	27 at –20℃	34 at 0℃	40 at +20℃
60< t < 90	435	550-730				

Typical as-delivered Yield Strength is 560-600 MPa and Tensile Strength 690-720 MPa. The high-end targeting of plate mechanical properties contributes to creep resistance and gives reserve for the lowering of properties linked with further heat processing during fabrication.

Typical as-delivered transverse Charpy-V impact strength at -20℃ is about 100-150 J. The balanced low carbon martensite possesses sufficient toughness.

Studies have shown a correlation between hardness and creep resistance. CromElso®91 is guaranteed to possess an as-delivered hardness of minimum 210 HV30. As hardness is directly linked to tensile strength, this also explains why the latter is in the higher range of requested values.

High temperature tensile properties can be provided upon request. For information, notice that some of these are described in the material standards.

The internal soundness of the plates is guaranteed to ultrasonic levels determined by ASTM A 578 level B or EN 10160-S1E2. The surface state delivery condition is generally shotblasted to help better surface inspection. 9% Cr steels have generally a higher roughness aspect than other alloy steels.

HEAT TREATMENT

Normalising at 1050℃ and tempering above 750℃.

Tempering temperature to be confirmed with the mill, as a function of required mechanical properties and PWHT.

The total fabrication sequence of the final equipment may necessitate several cycles of heat treatments : the plate steel chemistry is specially designed to support more heat treatments cycles than what would be typically requested from seamless materials.

It is furthermore possible to adjust plate tempering parameters to minimize the equivalent time-temperature impact on the material while assuring the suitable level of properties of the welds.

For any special requirement, please consult.

FABRICATION AND WELDING CONDITIONS

Cutting of the material can be executed by shear cutting or plasma cutting, or any other suitable method. Care should be taken not to introduce hydrogen in the material, through the gases or the presence of humidity. Cutting with some heat source will harden the heat affected zone close to the cut face. Normal practice however does not embrittle the material, but further machining e.g. to bevel the edges before welding may prove to be more demanding on the beveling tools. It is not recommended to use oxycutting as the high chromium content of the steel gives it a certain resistance to the flame.

When no heat treatments are scheduled further in the processing of the CromElso®91 plates, then a regeneration heat treatment according to the parameters indicated in the materials certificate is recommended when cold deformation exceeds 5%. A short PWHT cycle may be applied when cold deformation is between 3 and 5%.

Welding consumables should be of chemically matching composition. The following table summarizes typical acceptable standards.

	Sheathed electrodes	MIG-MAG	Flux-cored	flux-wire combination SAW
AWS	**A5-5** E901x-B9 E901x-G	**A5-28**	**A5-29**	**A5-23** EB9
EN	**EN 1599** E CrMo 9 1 B 42 H5			**EN 12070** S CrMo 9 1 **+** **EN760** SA FB 2 55 DC

The following consumables have been considered by Industeel and are available from various suppliers. This list is not intended to be limitative.

	SMAW	CMAW	FCAW	SAW	
				Wire	Flux
ESAB	OK 76.98				
KOBELCO	CM-9Cb				
AIR LIQUIDE	Safer CDV95				
THYSSEN	Chromo 9V			MTS 3	Marathon 543
METRODE	Chromet 9-B9 Chromet 9MV Chromet 9MV-N	Cormet M91 MCW	Supercore F91	9CRMOV-N	

Preheating should be at least 200℃ whereas interpa ss temperature should remain below 325℃. Suggested heat input range is between 1.0 and 2.0 kJ/mm to limit the risks of cold and hot cracking. Care should be taken to avoid hydrogen pick-up in the weld zone. Care should also be exerted when considering temporary attachments.

PWHT should be sufficient to remove welding stress while at the same time avoiding a drop of mechanical properties below the minimum of the required standards.

Most user requirements demand relatively high values of the time-temperature parameter P=T(K)[20+log(t(hr))]/1000, due to the need for heat treatment in the weld metal. Extensive testing and research by Industeel show that CromElso®91 plate material can keep up to 21.5 or slightly higher in certain circumstances, thanks to the specially targeted metallurgy and optimized plate heat treatment cycles.

CREEP PROPERTIES

Creep resistance is generally considered as the main interesting engineering property of CromElso®91. These properties are conferred by the chemical analysis and the special ladle metallurgy treatment, leading to the synergistic effect of the high strength martensitic structure and the dislocation and grain boundary movements locking features at the microscale of the steel constitutive parts. This leads to the targeted high tensile strength as well as hardness, while maintaining acceptable levels of toughness.

A full research program is ongoing as to collate most relevant creep data on base materials and weldments. Some historical data of earlier generation materials is available as basic reference. Please contact Industeel for further information.

APPLICATIONS AND USES

CromElso®91 is suitable for superheated / supercritical steam piping of power and co-generation plants. As it is a plate material, it allows for fabricating larger pipes than the usual seamless materials.

It is also used for some pressure vessel applications as well as for certain valve systems in the oil & gas and other chemical and processing industry.

Furthermore, it is a candidate material for vessel fabrication in nuclear power plants as well as future radioactive waste disposal nuclear reactor designs or parts of nuclear fusion reactors. Its low molybdenum and nickel contents compared to standard austenitic stainless steels make it less prone to activation under irradiation.

CromElso®91 has already been used all over the World, from Europe, to North America, to Eastern Asia.

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 program on high temperature service grades CromElso® and Sirius®.

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.

All Industeel facilities are ISO 9001 certified.

Further information may be obtained from the following addresses.

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