Industeel

ArcelorMittal

Tenasteel®

Tenasteel®: a cold work tool steel, combining a high compression strength and a very good toughness.

Its other advantages are a particularly high resistance to thermal softening and a good machinability in the asdelivery condition. The steel is delivered in the soft annealed condition with a maximum hardness of 250 HB.
Tenasteel® is specially designed to replace D2/ X160 CrMoV12/W1.2379 type steels widely used by tool makers but suffering from an excessive brittleness. Thanks to its chemistry increasing resistance to softening during tempering, Tenasteel® is especially suited for all processes of surface treatment and coatings commonly used by end - users. Tenasteel® can replace D2 type steels in all applications.

PROPERTIES

STANDARDS

> EURONORM: X110 CrMoV8 family

> INDUSTEEL Tenasteel®

CHEMICAL ANALYSIS - % WEIGHT

Typical values

C	S max	Mn	Cr	Mo	V	Other element
1.00	0.005	0.35	7.50	2.60	0.30	Ti

MECHANICAL PROPERTIES

Typical values

Hardness in annealed condition (HB)	Hardness in heat treated condition (HRC)	Young modulus (GPA)	Compression strength MPa (ksi)	KCV*J (ft.lbs)
250 HB maxi	56	205	2210 (320)	40 (29.5)
	62	205	2550 (370)	25 (18.4)

** unnotched specimens*

PHYSICAL PROPERTIES

Thermal conductiv. W $m^{-1} K^{-1}$	Thermal expansion coefficient $10^{-6}°C^{-1}/10^{-6}°K^{-1}$			
20°C 68°F	20 - 100°C 68 - 212°F	20 - 200°C 68 - 392°F	20 - 300°C 68 - 572°F	20 - 400°C 68 - 752°F
21	10.2	11.3	11.9	12.8

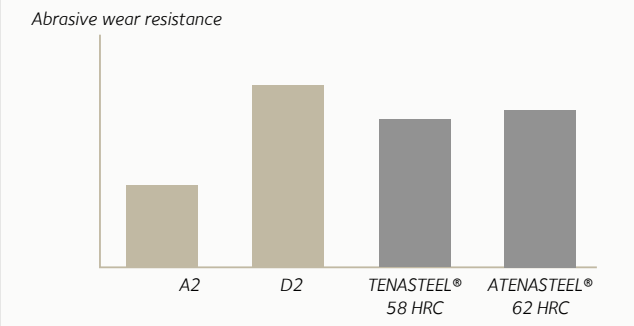
Specific heat 20°C ($J.kg^{-1}°C^{-1}$)	Density 20°C
460	7.75

TOUGHNESS / CHIPPING RESISTANCE

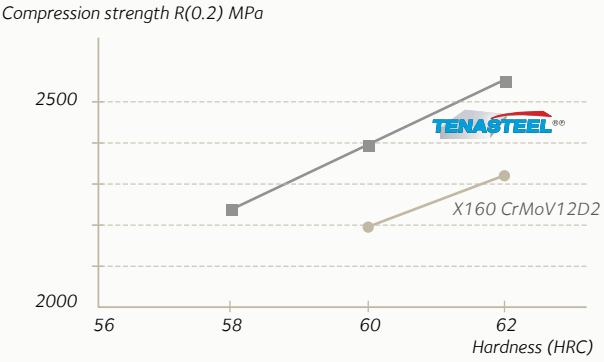
Wear Resistance

Abrasive wear resistance of Tenasteel® is similar to D2 type steel. The lower carbon and chromium contents of Tenasteel® are compensated by an increase of alloying elements forming finer and harder carbides than the coarse chromium carbides of D2.

Nota: wear resistance is important when tools are not coated. On coated tools it is more important to ensure toughness and/or compression strength of the substrat when wear resistance is ensured by coatings (PVD/CVD/...)



COMPRESSION STRENGTH



METALLURGICAL PROPERTIES

Cleanliness

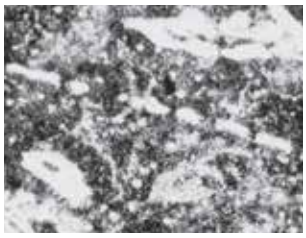
Following cleanliness values are guaranteed according to ASTM E45 A method

Type	A	B	C	D
Rating	≤ 1.5	≤ 1.5	≤ 1	≤ 1.5

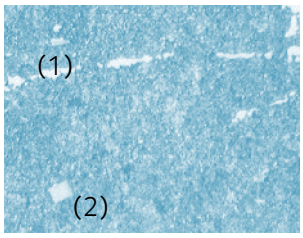
Microstructure

In the as - delivered condition, Tenasteel® 's microstructure is made of a ferritic matrix, in which are homogeneously distributed fine primary carbides formed during steel solidification, as well as secondary carbides formed during annealing.

Following micrographs show clearly the general refinement of Tenasteel® structure compared to a classical D2 type grade.



D2 - Large chromium carbides



Tenasteel®

This finer microstructure induces a significant improvement in terms of toughness and machinability. Thanks to carbides harder than those traditionally observed in a D2 type steel microstructure, abrasive wear resistance remains at a high level.

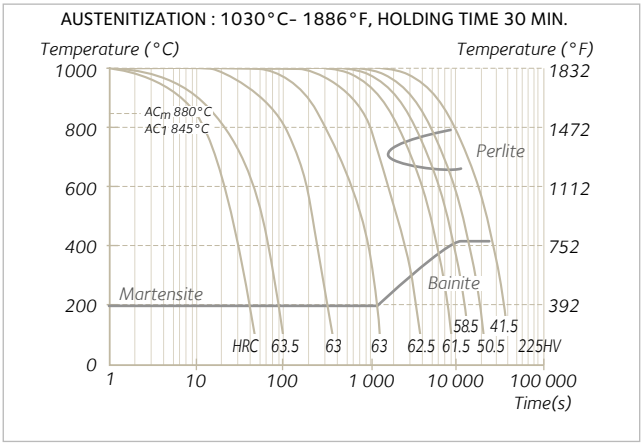
(1) Fine carbides of Chromium Molybdenium Vanadium
(2) Titanium precipitates

Transformation points

AC_1		AC_m		M_S	
°C	°F	°C	°F	°C	°F
845	1555	880	1676	200	392

Test conditions: heating 150°C/hour (302°F/hour) up to 1000°C (1832°F) then fast cooling

CCT Diagram



TTT Diagram

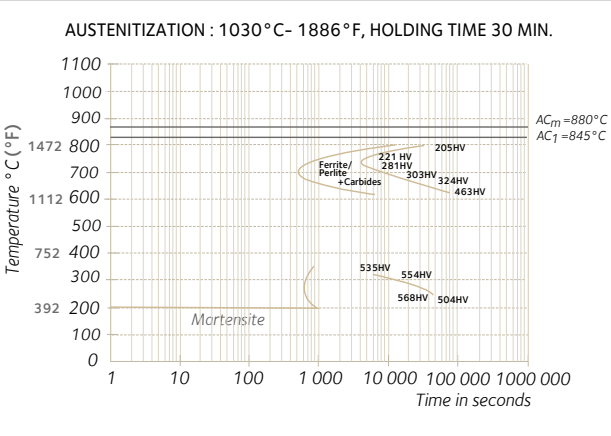


PLATE PROCESSING

HEAT TREATMENT

Tenasteel® is delivered in annealed condition (maximum softening) for easier machining. After machining, required mechanical properties are restored by a quenching and tempering heat treatment cycle.

Austenitization

Slow heating up to 750°C (1392°F) and homogenization. Then, slow heating up to 1030 / 1050°C (1886/1922°F), holding time 30 min per 25 mm of thickness.

Note: austenitization must be done under vacuum or under gas protection in order to avoid surface oxydation and decarburization.

Quenching

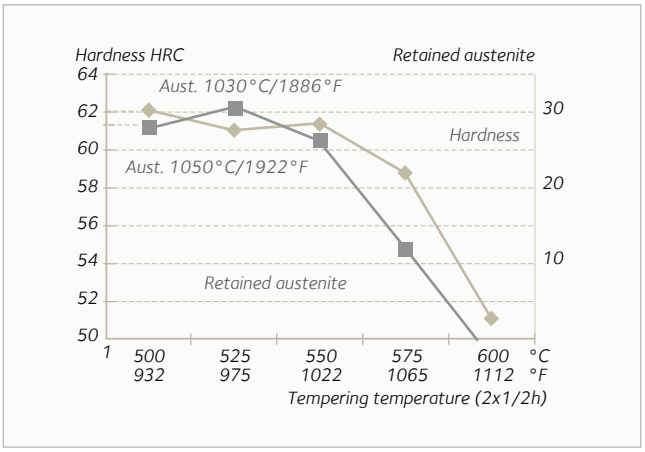
Cooling after austenitization shall be done preferably under overpressed gas. When it is not possible it can be done in salt bath or better in fluidized bed within temperature range 250 / 350°C (482 / 662°F) Oil quenching can be used only for very simple shapes when other processes do not provide a sufficient cooling speed (see TTT and CCT diagrams). Tempering shall be done immediately when temperature reaches 40 to 60°C (104/140°F) except in case of cryogenic treatment (see § "Cryogenic treatments").

Tempering

Depending on the final application, required hardness shall be obtained by the adjustment of tempering temperature with the help of following softening curves. After the first tempering, a second one shall be done identical or at a slightly lower temperature to obtain a fully tempered microstructure necessary to ensure a complete dimensional stability of the heat treated piece. As shown on the graph, an austenitization at 1050°C (1922°F) enables a hardness level higher than 58 HRC even with tempering temperature higher than 570°C (1058°F).

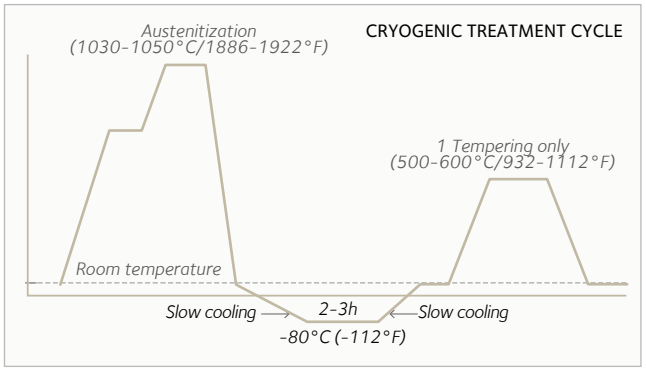
Tenasteel® allows the use of high tempering temperatures. After tempering at high temperature (ic.550°C), retained austenite content is very low, consequently heat treated piece will have a good dimensional stability in service.

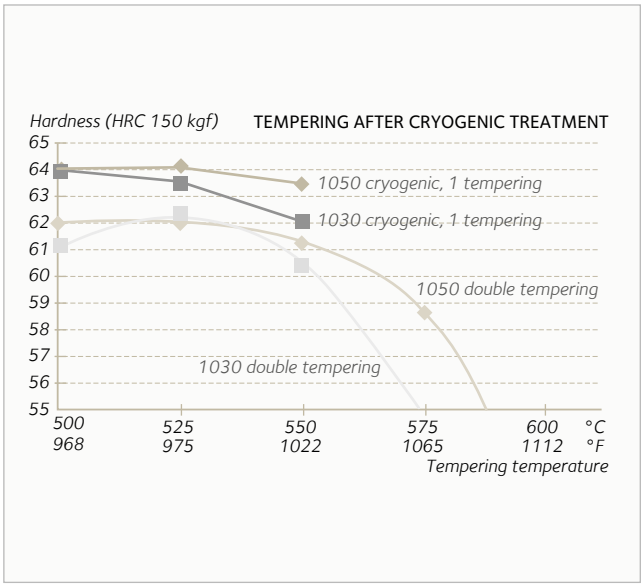
At the contrary, pieces tempered under 500°C (20% retained austenite) may suffer some defered dimensional change after heat treatment.



Cryogenic treatment

Cryogenic treatment allows an almost complete reduction of retained austenite in the steel after quenching. Consequently, defered deformations induced by austenite transformation are avoided. When it is necessary, cryogenic treatment can be done as follows:





SURFACE TREATMENTS

Surface treatment purpose is to increase surface hardness, wear resistance and to reduce friction coefficient between tool / piece, by enrichment of a surface layer with one or several alloying elements. The high hardness / toughness of Tenasteel® combined with a very high softening resistance make it specially suitable for a large range of surface treatments: Gaseous nitriding, classical or ionic within a range of temperature close to 500/525°C (930/975°F) giving a hard layer of about 1100HV on a depth of a few microns.

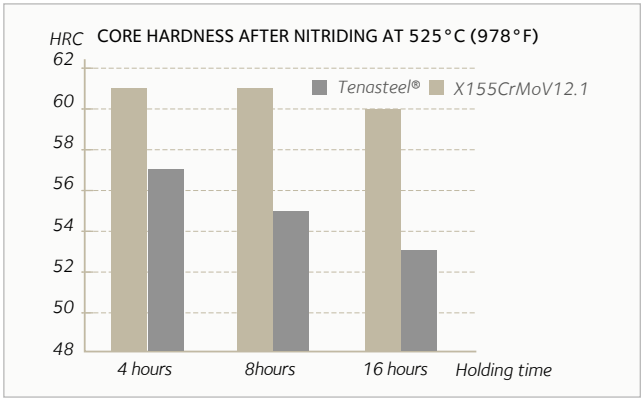


Diagram here above shows that core hardness of Tenasteel® is not affected by nitriding process when D2 shows a drop of 5/10 HRC under nitrided layer.

SURFACE COATINGS

Purpose of surface coating on tools is the same as surface treatments, increasing wear resistance and reduction of friction coefficient.
These processes are different: deposit of an exogen material on the surface without any reaction with the base material. This layer will constitute a second "skin" on the tool.

> PVD: physical vapor deposition – Deposit can be done at 200 to 500°C (392/932°F) and do not consequently affect the hardness of the base material. Hardness can reach 2000Hv on a few microns.

> CVD – Chemical vapor deposition – CVD coating is performed after pre - hardening and tool adjustment. Temperature necessary to activate the reaction is very high, 800 to 1000°C (1472/1832°F). It is necessary to perform a heat treatment after coating to restore the hardness of the base material. Hardness of the layer can reach 2500 HV and more, depending on the type of deposit.

MACHINING – IN ANNEALED CONDITIONS

Milling with carbide tips

Cutting parameters	Rough milling	Finishing
Cutting speed (Vc) m/min	130 - 190	170 - 210
Feed (Fz) - mm/tooth	0.15 - 0.4	0.1 - 0.2
Cutting depth (ap) / mm	2 - 5	≤ 2

Drilling with High speed tool

Cutting parameters	Ø ≤ 10	Ø 10 - 20
Cutting speed (Vc) m/min	15	15
Feed (Fz) - mm/rotation	0.05 to 0.2	0.2 to 0.3

Compared to D2, thinness of Tenasteel® carbides ensure an increased tool life of about 25% minimum for machining in annealed conditions, and 70% minimum for machining in heat treated conditions.

WIRE CUTTING / EDM

Tenasteel® is compatible with all type of EDM in annealed or heat treated conditions when classical simple precautions are respected (finishing passes, final polishing or immediat stress relieving at a temperature 20°C (68°F) lower than the last tempering temperature if EDM is done after hardening).

WELDING

Weld repairs on Tenasteel® tools are possible. It is necessary to follow strictly recommendations and to use welding rods mentioned in our processing guide.

DELIVERY CONDITIONS

Plates	2000 x 4000 mm 79" x 158"	th 15 to 75 mm th 0.60" to 3"
Bars	500 mm 20"	th 300 mm maxi th 12" maxi

APPLICATIONS

Tenasteel® can replace D2 type steels in all applications

> cutting tools,

> extrusion tools,

> forming tools,

> stamping tools,

> cutting blades...

YOUR CONTACTS

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