Industeel

ArcelorMittal

D2

D2: A cold work tool steel

D2 is a high chromium tool steel specifically designed to provide a high abrasive wear resistance and a high hardenability.
The grade is delivered in annealed condition to keep a good machinability. After machining it requires a hardening to achieve its service properties. The adjustment of hardness should be done to get the best compromise between touhness and wear resistance.

This grade can be used for cutting and deformation tools submitted to high abrasive wear. It can be used when 2% carbon steels (D3 type) shows an excessive sensivity to cracking or chipping.
Main applications are stamping tools, punches and dies, forming dies, shear blades and cutters, ceramic molds, ...

PROPERTIES

STANDARDS

- > **EURONORM** X153 CrMoV12
- > **Werkstoff Nb** W1.2379
- > **AISI** D2

CHEMICAL ANALYSIS -% WEIGHT

Typical values

C	S max	P max	Si	Mn	Cr	Mo	V
1.55	0.005	0.020	0.30	0.35	11.75	0.75	0.75

MECHANICAL PROPERTIES

D2 is delivered in annealed condition with hardness ≤ 250 HB

Hardness in annealed condition (HB)	Hardness in heat treated condition (HRC)	Young modulus (GPA)	Compression strength (MPA)	KV* J
250 max	56	205	2000	18
	60	205	2190	12

* unnotched specimen. Typical values.

PROPERTIES

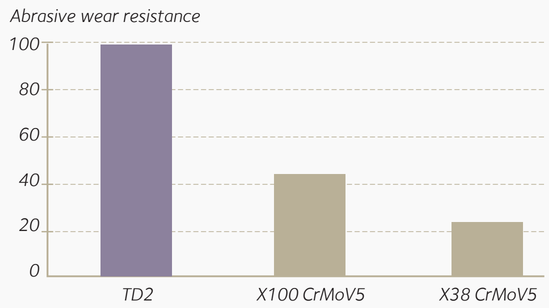
PHYSICAL PROPERTIES

Thermal conductivity 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
18	11.7	11.96	12.2	12.7

Specific heat (J.kg^{-1}°C^{-1})	Density 20°C
460	7.8

ABRASIVE WEAR RESISTANCE

D2 has a very good wear resistance based on high carbon and chromium contents.



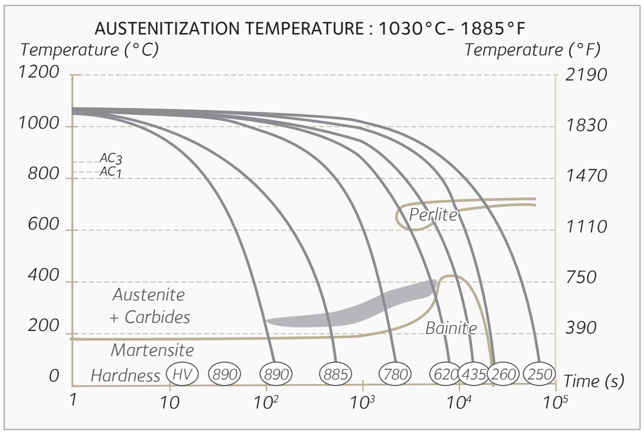
METALLURGIC PROPERTIES

D2 is delivered in annealed condition to make machining easier. Its structure is made of primary carbides inserted in a soft ferritic matrix in which there is also a distribution of secondary carbides of chromium and vanadium.

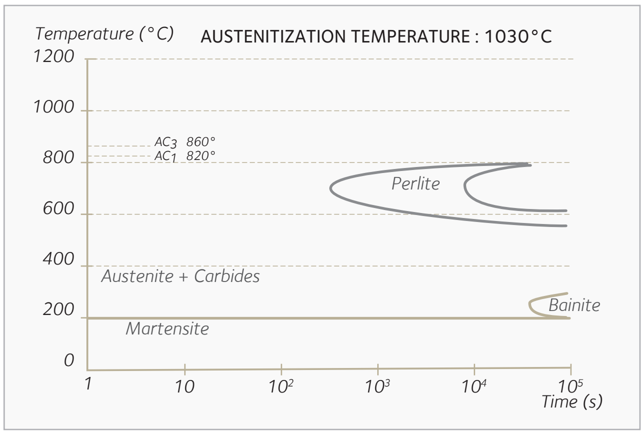
Metallurgical transformation points

AC_1		AC_3		Ms	
°C	°F	°C	°F	°C	°F
820	1508	860	1580	200	390

CCT Diagram



TTT Diagram



DELIVERY CONDITIONS

DIMENSIONAL PROGRAM

Thickness	Width
15 - 100 mm (.59" - 3.9")	1500 - 2000 mm (59" - 78.7")

For specific sizes, please consult

MACHINING

Milling with carbide tips

Cutting parameters	Roughing	Finishing
Cutting speed (Vc) m/min	100-130	120-150
Feed (Fz) - mm/tooth	0.15 - 0.4	0.1 - 0.23
Cutting depth (ap) / mm	2 - 5	≤ 2

Drilling with naked HSS drill

Cutting parameters	Ø ≤ 10	Ø 10-20
Cutting speed (Vc) m/min	10	10
Feed (Fz) - mm/rotation	0.08 - 0.3	0.3 - 0.4

HEAT TREATMENT

After machining, service properties of D2 should be restored by hardening. Generally, heat treatment consist in made of **a quenching operation and at least two temperings.** It is recommended to perform heat treatments in vacuum furnaces or under protective atmospheres to avoid decarburization or oxidation of surfaces.

Austenitization

> To minimize deformations and cracking risks, slow heating rates should be used with an homogenization at 750°C -1380°F (holding time ½ hour per 25 mm thickness). After homogenization, final heating shall be done also slowly.

> Austenitization temperature shall be high enough to ensure a complete dissolution of secondary carbides. On an other hand, a too high austenitization temperature will induce an important grain coarsening detrimental for toughness, it will also induce a high content of retained austenite. The best optimized temperature range is 1020 / 1050°C.

> Generally holding time at austenitization temperature shall be 1min/mm. The final holding time is left to the heat treating company, according to the size and shape of the piece, and according to furnace characteristics and to the constitution of the furnace load.

Quenching

> Quenching process shall be selected in order to:
1. Obtain the best microstructure (martensite),
2. Reduce cracking risks,
3. Ensure the smallest deformation possible.

> Cooling speed shall be sufficient to avoid formation of unacceptable components such as bainite or pearlite. Selection of quenching media shall take into account the size of the piece (see CCT diagram).

> On an other hand, a high cooling speed can cause strong distortions, because of important temperature gradients between mid-thickness and surface of the piece.

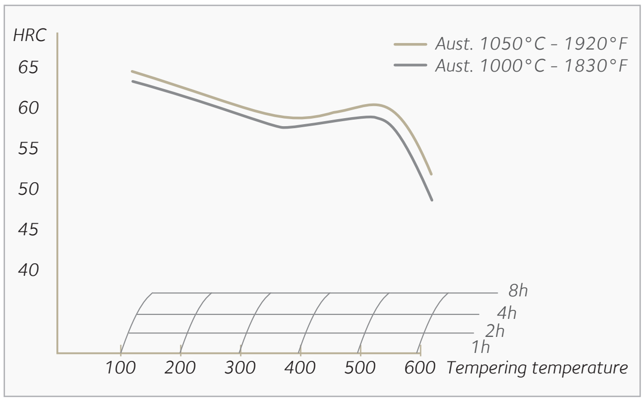
> High stress levels induced by fast cooling rates can also eventually generate cracking when pieces have complex shapes.

> When possible, cooling under over pressed gases (nitrogen) shall be preferred to more efficient media such as oil quenching. Oil quenching should be limited to high sections and simple shapes.

Tempering

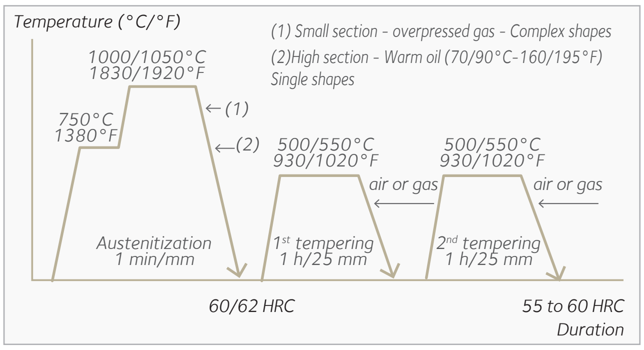
> Service hardness will be obtained by the adjustment of tempering temperature (see softening curve below).

It is highly recommended to perform several successive tempering, at least two, to reduce as much as possible the quantity of retained austenite. Destabilization of retained austenite will be more efficient when tempering is done at high temperature (500°C-930°F and over). It is not advised to perform tempering at low temperature (200°C-392°F), which may induce a weakening of the tools.

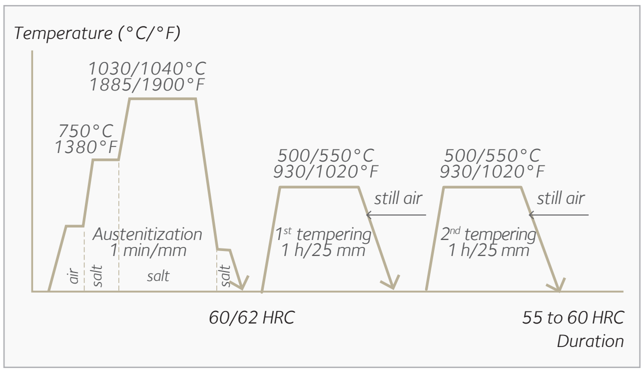


D2-Softening curve for a plate th 80 mm (3.1") oil quenched

Heat treatment chart



Vacuum furnaces or heat treatment under protective atmosphere



Salt bath heat treatment

Stress relieving

In case of complex shape or heavy machining, it may be necessary to perform a stress relieving before hardening to avoid distortion during heat treatment.
Stress relieving shall be conducted as follow:

- Heating 650/700°C (1200/1300°F) - vacuum furnace to avoid decarburization,
- Holding time ½ hour per 25 mm,
- Slow cooling in furnace.

Annealing

When necessary, it is possible to perform an annealing to soften (250 HB max) a piece which is already hardened.
Thermal cycle to apply is:

- Heating 860°C ±10°C (1580°F ±50°F),
- Holding ½ hour per 25 mm,
- Cooling 60°C/H max down to 780°C (1435°F),
- Cooling 20°C/H max within 780/700°C (1430/1290°F)
- Still air-cooling.

YOUR CONTACTS

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