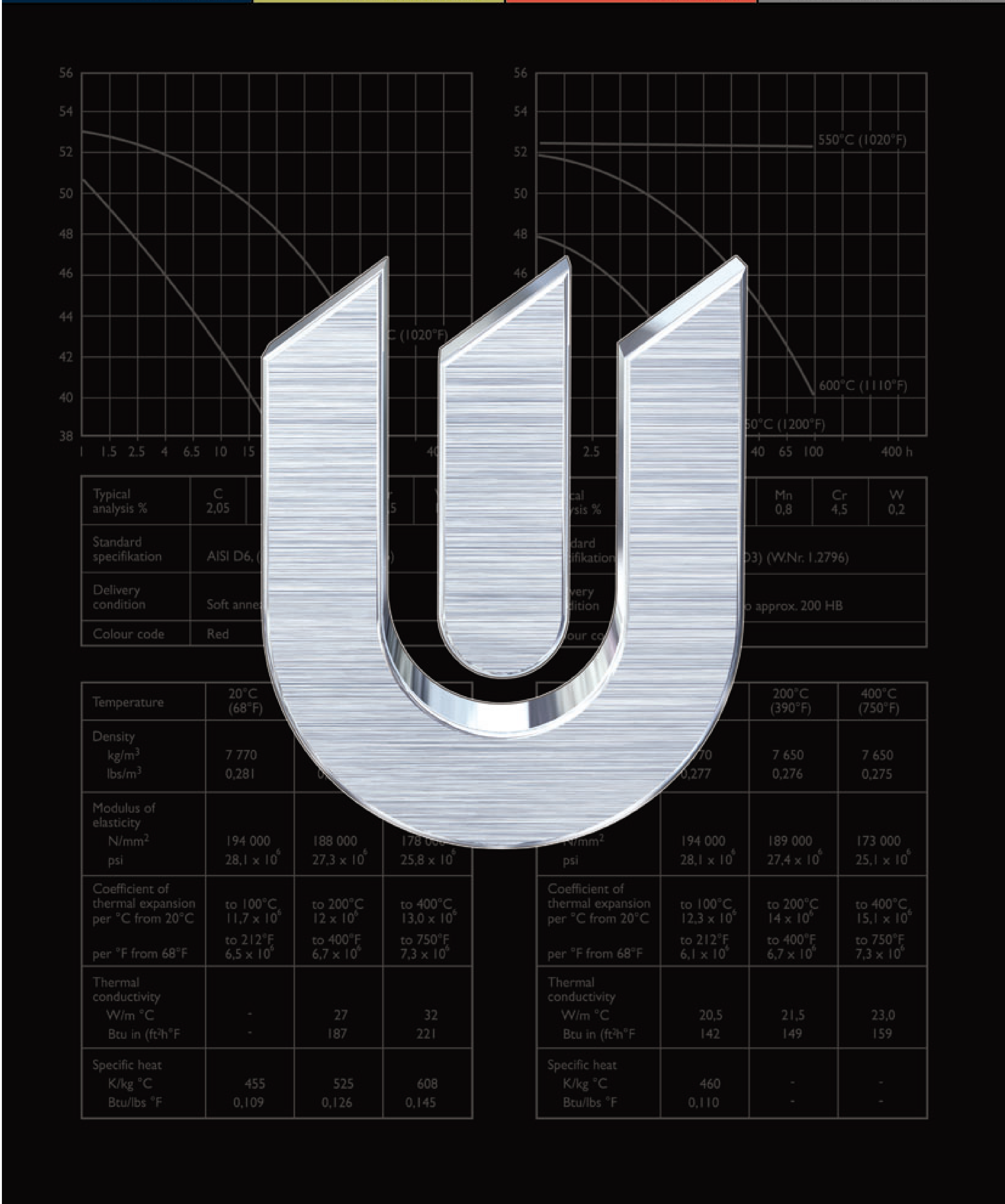
TOUGHTEC

A tool steel with an excellent combination of wear resistance and toughness

COLD WORK | **PLASTIC** MOULDING | **HOT** WORK | **HIGH** PERFORMANCE STEEL



Critical tool steel properties for

GOOD TOOL PERFORMANCE

- Correct hardness for the application
- High wear resistance
- Good toughness to prevent premature failure due to chipping/crack formation.

High wear resistance is often associated with low toughness and vice-versa. However, in many cases both high wear resistance and toughness are essential for optimal tooling performance.

Toughtec is a spray formed* tool steel offering a combination of excellent wear resistance and toughness.

TOOL MAKING

- Machinability
- Grindability
- Heat treatment
- Dimensional stability in heat treatment
- Surface treatment

Toughtec has a high wear resistance and this means that it is particularly important to use suitable cutting tools and cutting conditions. Similarly, suitable grinding wheels and grinding conditions should be used.

Due to the carefully balanced alloying Toughtec has a similar heat treatment procedure to the steel AISI D2. One big advantage with Toughtec is that the dimensional stability after hardening is better than for the conventional produced cold work steels. This also means that Toughtec is a tool steel which is very suitable for various surface coating techniques.

Applications

Toughtec is suitable for medium run to long run tooling of work materials where mixed (abrasive-adhesive) or abrasive wear and/or chipping/cracking and/or plastic deformation are dominating failure mechanisms.

Examples:

- Screws and barrels for plastic processing
- Cold and hot forming rolls
- Hot shearing knives
- Hot forging trimming dies
- Wear parts
- Engineering applications

** Toughtec is spray formed by Dan Spray A/S.*

General

Toughtec is a chromium-molybdenum-vanadium alloyed tool steel which is characterized by:

- Very high wear resistance
- Good compressive strength
- Very good toughness
- Good dimensional stability at heat treatment and in service
- Very good through-hardening properties
- Very good resistance to tempering back
- Good WEDM properties
- Good surface treatment properties.

Typical analysis %	C 1,6	Si 0,3	Mn 0,5	Cr 5,0	Mo 2,3	V 7,2
Standard specification	None					
Delivery condition	Soft annealed to approx. 215 HB					
Colour code	Green/brown					

Properties

PHYSICAL DATA

Hardened and tempered to 53 HRC

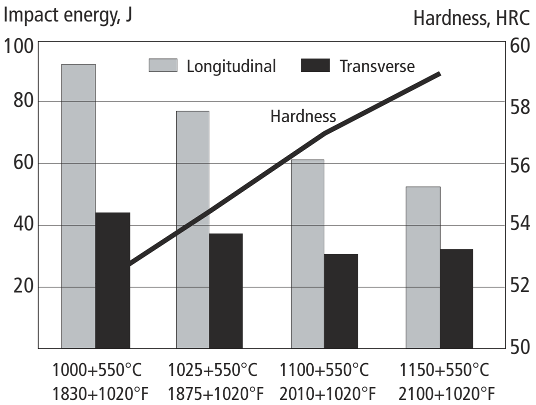
Temperature	20°C (70°F)	200°C (390°F)	400°C (750°F)
Density			
kg/m³	7 580	–	–
lbs/in³	0,273	–	–
Modulus of elasticity			
MPa	212 000	204 000	193 000
psi	$30,8 \times 10^6$	$29,5 \times 10^6$	$28,0 \times 10^6$
Specific heat			
J/kg °C	460	–	–
Btu /lb °F	0,11	–	–

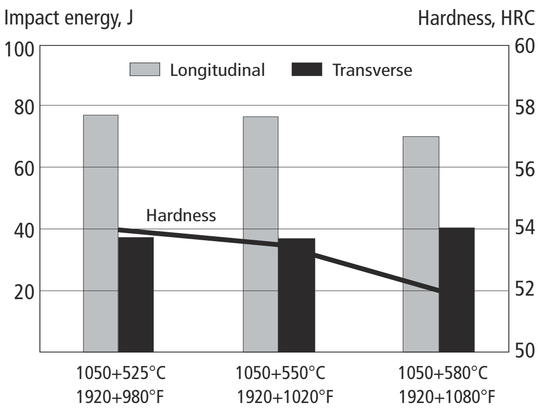
COMPRESSIVE STRENGTH

Hardness HRC	Compressive strength Rc0,2 (MPa)
50	1 650
52	1 750
54	1 850
56	1 950
58	2 050
60	2 150

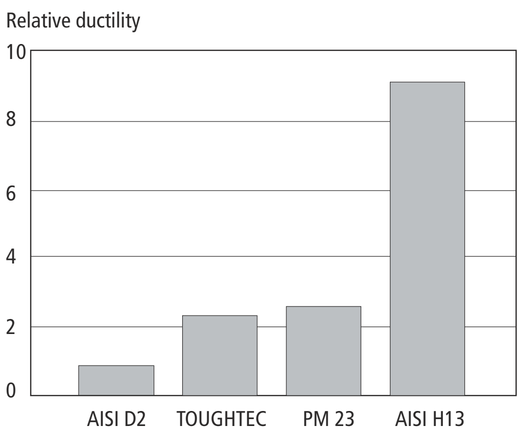
IMPACT STRENGTH

Approximate room temperature impact strength at different tempering temperatures.
Specimen size: 7 x 10 x 55 mm (0,27 x 0,4 x 2,2”) unnotched.
Hardened for 30 minutes, except at 1150°C (2100°F) where 10 minutes is used. Quenched in air. Tempered 2 x 2h.



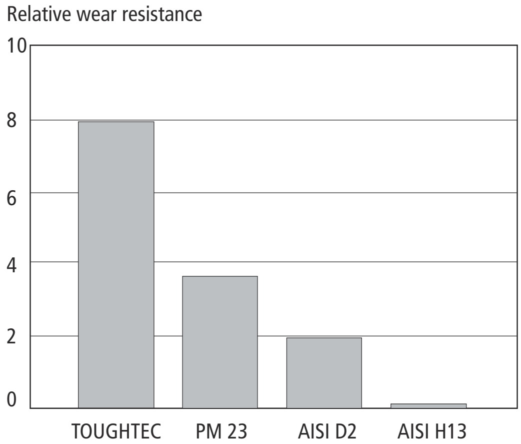


Relative chipping resistance for AISI D2, PM 23, Toughtec at 58 HR and AISI H13 at 52 HRC.
High value indicates good ductility. High temperature tempered condition.

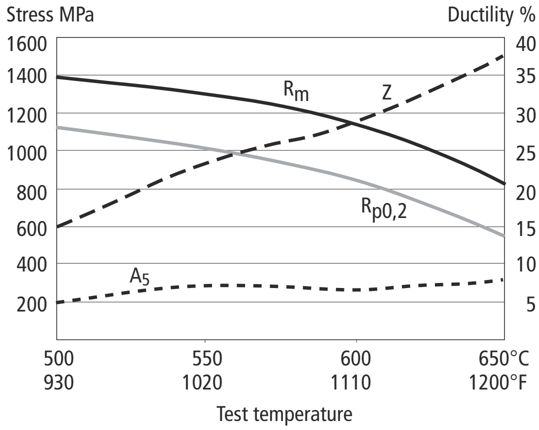


WEAR RESISTANCE

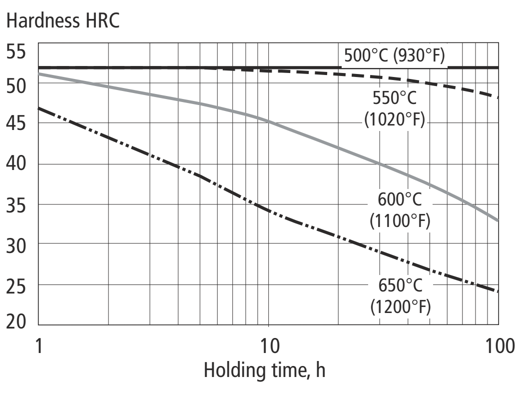
Relative abrasive wear resistance for AISI D2, PM 23, Toughtec at 58 HRC and AISI H13 at 52 HRC. High value indicates good wear resistance. High temperature tempered condition.



Hot strength
Hot strength in longitudinal direction.
The specimens have been heat treated to 52 HRC, 1050°C (1920°F) + 580°C (1080°F), 2 x 2h.



Effect of time at high temperature on hardness
The softening at high temperatures and different holding times are shown below.
The specimens have been heat treated to 52 HRC, 1050°C (1920°F) + 580°C (1080°F), 2 x 2h.



Heat treatment recommendations

SOFT ANNEALING

Protect the steel and heat through to 900°C (1650°F). Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F), then freely in air.

STRESS RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

HARDENING

Preheating in two stages: 600–650°C (1100–1200°F) and 900–950°C (1650–1740°F)
Austenitizing temperature: 1000–1150°C (1830–2100°F), normally 1050°C (1920°F).
Holding time: 30 min. for ≤1120°C (2050°F), 10 minutes for >1120°C (2050°F).

Protect the part against decarburization and oxidation during hardening.

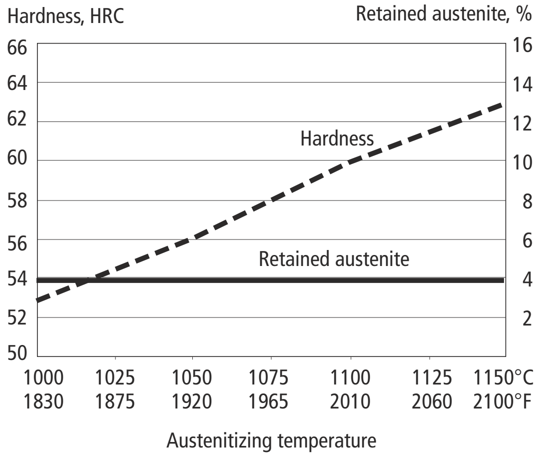
QUENCHING MEDIA

- High speed gas/circulating atmosphere
- Vacuum furnace (high speed gas with sufficient overpressure)
- Martempering bath or fluidized bed at 500–550°C (930–1020°F)
- Martempering bath or fluidized bed at approx. 200–350°C (390–660°F)

Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

Hardness and retained austenite as a function of austenitizing temperature.

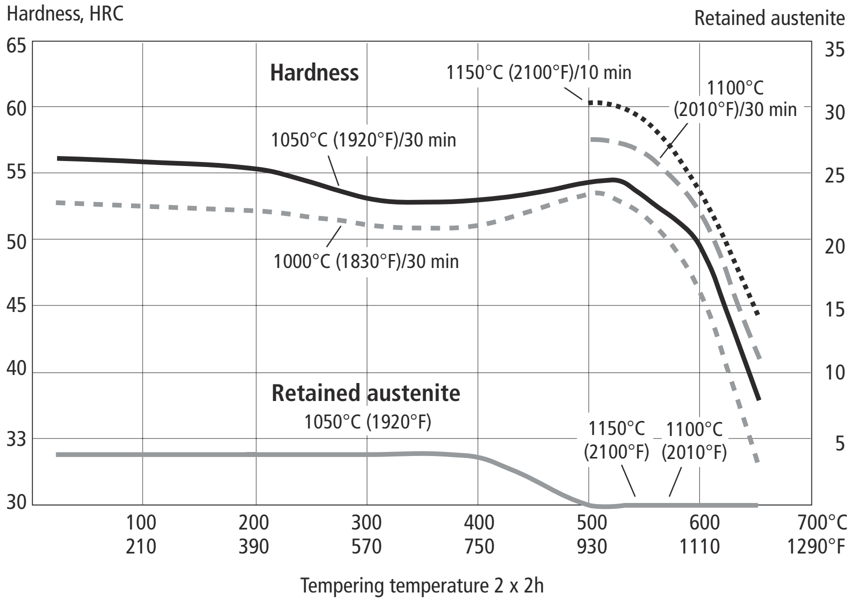
10 minutes holding time at 1150°C (2100°F), else 30 minutes.



TEMPERING

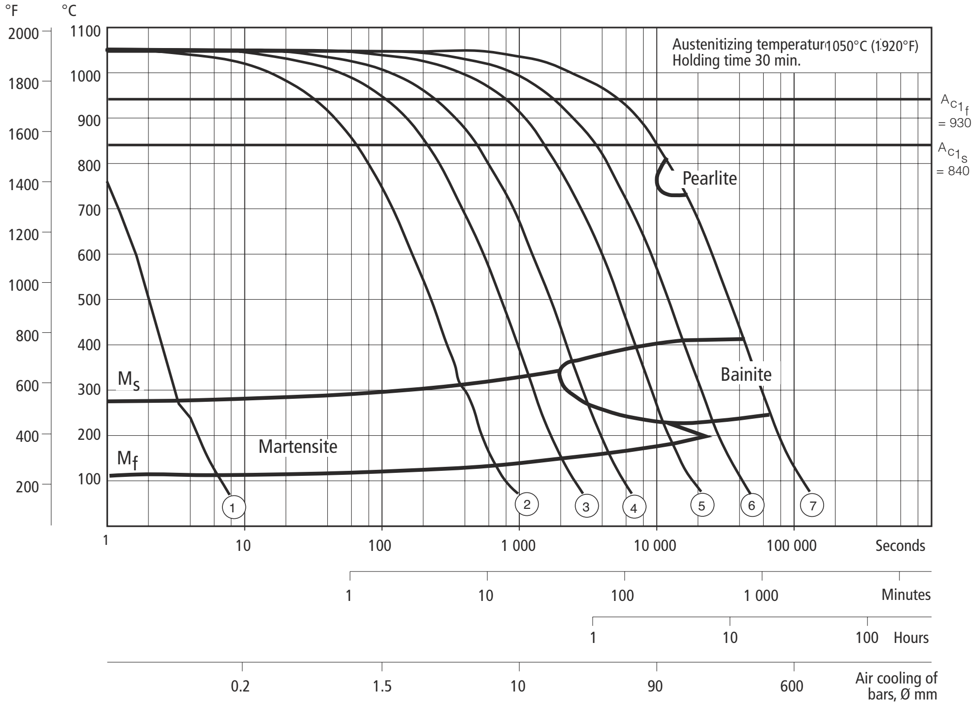
Choose the tempering temperature according to the hardness required by reference to the tempering graph below.
Temper at least twice with intermediate cooling to room temperature. The lowest tempering temperature which should be used is 525°C (980°F). The minimum holding time at temperature is 2 hours.

Tempering graph without sub-zero treatment after hardening



CCT-graph

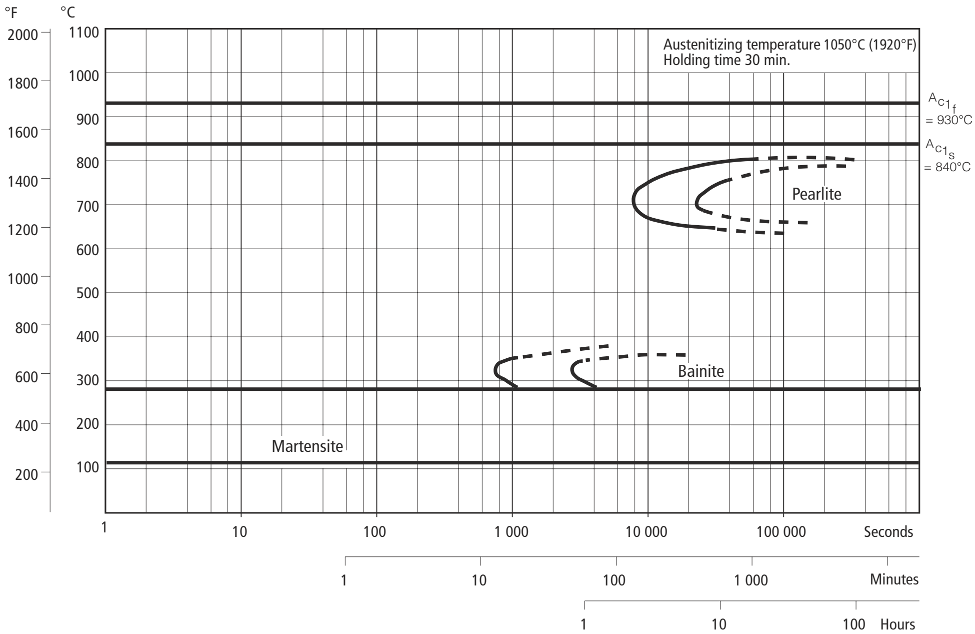
Austenitizing temperature 1050°C (1920°F). Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ (sec)
1	681	1
2	634	140
3	592	450
4	572	1030
5	536	3205
6	514	7370
7	483	20800

TTT-graph

Austenitizing temperature 1050°C (1920°F). Holding time 30 minutes.



Temp. °C	Time hours	Hardn. HV 10
800	23,0	488
750	23,0	193
700	7,0	266
650	23,4	433
425	15,5	707
375	14,9	681
350	1,5	743
325	15,1	585

SUB-ZERO TREATMENT

Pieces requiring maximum dimensional stability in service can be sub-zero treated as follows:

Immediately after quenching the piece should be sub-zero treated to –70 to –80°C (–95 to –110°F), soaking time 1–3 hours, followed by tempering. Sub-zero treatment will give a hardness increase of ~1 HRC. Avoid intricate shapes as there will be risk of cracking.
For the highest demands on dimensional stability, sub-zero cooling in liquid nitrogen is recommended after quenching and after each tempering.

DIMENSIONAL CHANGES

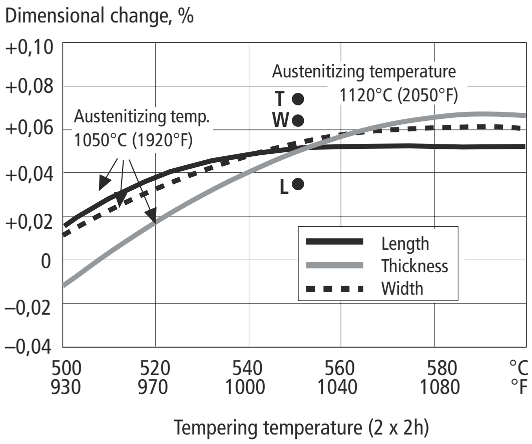
The dimensional changes have been measured after austenitizing and tempering.

Austenitizing: 1050°C (1920°F)/30 min or 1120°C (2050°F)/30 min, cooling in vacuum furnace at 1,1°C/s (1,8°F/s) between 800°C (1470°F) and 500°C (930°F)

Tempering: 2 x 2 h at various temperatures

Specimen size: 60 x 60 x 60 mm (2,4 x 2,4 x 2,4")

Dimensional changes during hardening and tempering in length, width and thickness direction



Surface treatments

Some tool steels are given a surface treatment in order to reduce friction and increase wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers produced via PVD or CVD.

The high hardness and toughness together with a good dimensional stability makes Toughtec ideal as a substrate steel for various surface coatings.

NITRIDING

Nitriding gives a hard surface layer that is resistant to wear and erosion.
Toughtec is normally high temperature tempered at around 525°C (980°F). This means that the nitriding temperature used should not exceed 500–525°C (930–980°F). Ion nitriding at a temperature below the tempering temperature used is preferred.
The surface hardness after nitriding is approximately 1150 $HV_{0,2kg}$. The thickness of the layer should be chosen to suit the application in question.

Process	Time	Depth mm	Depth inch
Gas nitriding at 510°C (950°F)	10 h	0,15	0,0059
Plasma nitriding at 480°C (895°F)	10 h 30 h	0,10 0,20	0,0039 0,0079

PVD

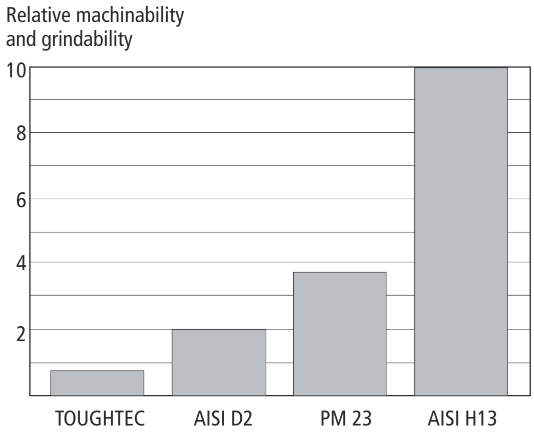
Physical vapour deposition, PVD, is a method of applying a wear resistant coating at temperatures between 200–500°C (390–930°F).

CVD

Chemical vapour deposition, CVD, is used for applying wear resistant surface coatings at a temperature approx. 1000°C (1830°F). It is recommended that the tools should be separately hardened and tempered in vacuum furnace after surface treatment.

Machinability

Relative machinability and grindability for Toughtec, AISI D2, PM 23 and AISI H13. High value indicates good machinability and grindability.



Machining recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions.

Condition: Soft annealed to approx. 215 HB

TURNING

Cutting data parameters	Turning with carbide	
	Rough turning	Fine turning
Cutting speed ,v_c m/min. f.p.m.	 70–100 230–330	 100–120 330–395
Feed, f mm/rev. i.p.r.	 0,2–0,4 0,008–0,016	 0,1–0,2 0,004–0,008
Depth of cut, a_p mm inch	 2–4 0,08–0,16	 1–2 0,04–0,08
Carbide designation ISO	 K15–K20*	 K15–K20*

** Use a wear resistant Al_2O_3-coated carbide*

DRILLING

High speed steel twist drill

Drill diameter mm	Drill diameter inch	Cutting speed v_c m/min.	Cutting speed v_c f.p.m.	Feed f mm/r	Feed f i.p.r.
– 5	–3/16	8–10*	26–33*	0,05–0,10	0,002–0,004
5–10	3/16–3/8	8–10*	26–33*	0,10–0,20	0,004–0,008
10–15	3/8–5/8	8–10*	26–33*	0,20–0,25	0,008–0,010
15–20	5/8–3/4	8–10*	26–33*	0,25–0,30	0,010–0,012

** For coated HSS drills v_c = 12–16 m/min (39–52 f.p.m.)*

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1)]
Cutting speed, v_c m/min f.p.m.	 80–100 260–330	 40–60 130–200	 30–40 100–130
Feed, f mm/r i.p.r.	 0,05–0,15[2)] 0,002–0,006[2)]	 0,10–0,25[2)] 0,004–0,010[2)]	 0,15–0,25[2)] 0,006–0,010[2)]

[1)] Drill with internal cooling channels and brazed tip.
[2)] Depending on drill diameter.

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed ,v_c m/min. f.p.m.	 40–100 130–330	 80–110 260–360
Feed, f_z mm/tooth inch/tooth	 0,2–0,4 0,008–0,016	 0,1–0,2 0,003–0,008
Depth of cut, a_p mm inch	 2–4 0,08–0,16	 –2 –0,08
Carbide designation ISO	 K20, P20*	 K15, P15*

** Use a wear resistant Al_2O_3-coated carbide*

End milling

Cutting data parameters	Type of mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed v_c m/min f.p.m.	 30–40 100–130	 70–100 230–330	 3–5[3)] 10–16[3)]
Feed f_z mm/tooth inch/tooth	 0,03–0,2[1)] 0,001–0,008[1)]	 0,08–0,2[1)] 0,003–0,008[1)]	 0,05–0,35[1)] 0,002–0,014[1)]
Carbide designation ISO	–	K15–K20[2)]	–

[1)] Depending on radial depth of cut and cutter diameter.
[2)] Use a wear resistant Al_2O_3-coated carbide
[3)] For coated HSS end mills 10–14 m/min (33–46 f.p.m.)

BAND SAWING

Sawing of Toughtec should be carried out in a rigid band saw. The tooth pitch should be coarse. The cutting speed should be low (approx. 20 m/min.) but the down feed high. Try to keep a feed rate of about 3–5 μm/tooth. Both bi-metal and carbide tipped band can be used.

GRINDING

General grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Type of grinding	Annealed condition	Hardened condition
Face grinding straight wheel	B151 R50 B3[1)] A 46 HV[2)]	B151 R50 B3[1)] A 46 GV[2)]
Face grinding segments	A 36 GV	A 46 GV
Cylindrical grinding	B151 R50 B3[1)] A 60 KV[2)]	B151 R50 B3[1)] A 60 KV[2)]
Internal grinding	B151 R75 B3[1)] A 60 JV	B151 R75 B3[1)] A 60 IV
Profile grinding	B126 R100 B6[1)] A 100 JV[2)]	B126 R100 B6[1)] A 100 IV[2)]

[1)] The first choice is a CBN-wheel for this operation
[2)] Preferable a wheel type containing sintered Al_2O_3 (seeded gel)

Electrical-discharge machining, EDM

If EDM is performed in the hardened and tempered condition, finish with "fine-sparking", i.e. low current, high frequency.

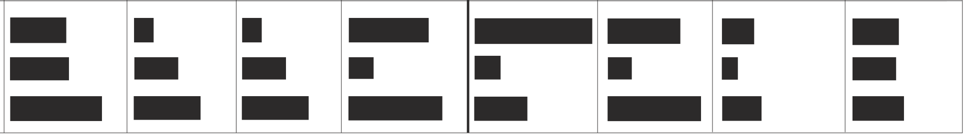
For optimal performance the EDM'd surface should be ground/polished and the tool retempered at approx. 25°C (50°F) lower than the original tempering temperature.

When EDM'ing larger sizes or complicated shapes *TOUGHTEC* should be tempered at high temperatures, ≥525°C (980°F).

Relative comparison of Uddeholm tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS

Uddeholm grade	Hardness/ Resistance to plastic deformation	Machin-ability	Grind-ability	Dimension stability	Resistance to: Abrasive wear	Resistance to: Adhesive wear	Fatigue cracking resistance: Ductility/ resistance to chipping	Fatigue cracking resistance: Toughness/ gross cracking
TOUGHTEC								
AISI D2								
PM 23								



Further information

Please, contact your local Uddeholm office of further information on the selection, heat treatment, application and availability of Uddeholm tool steels.