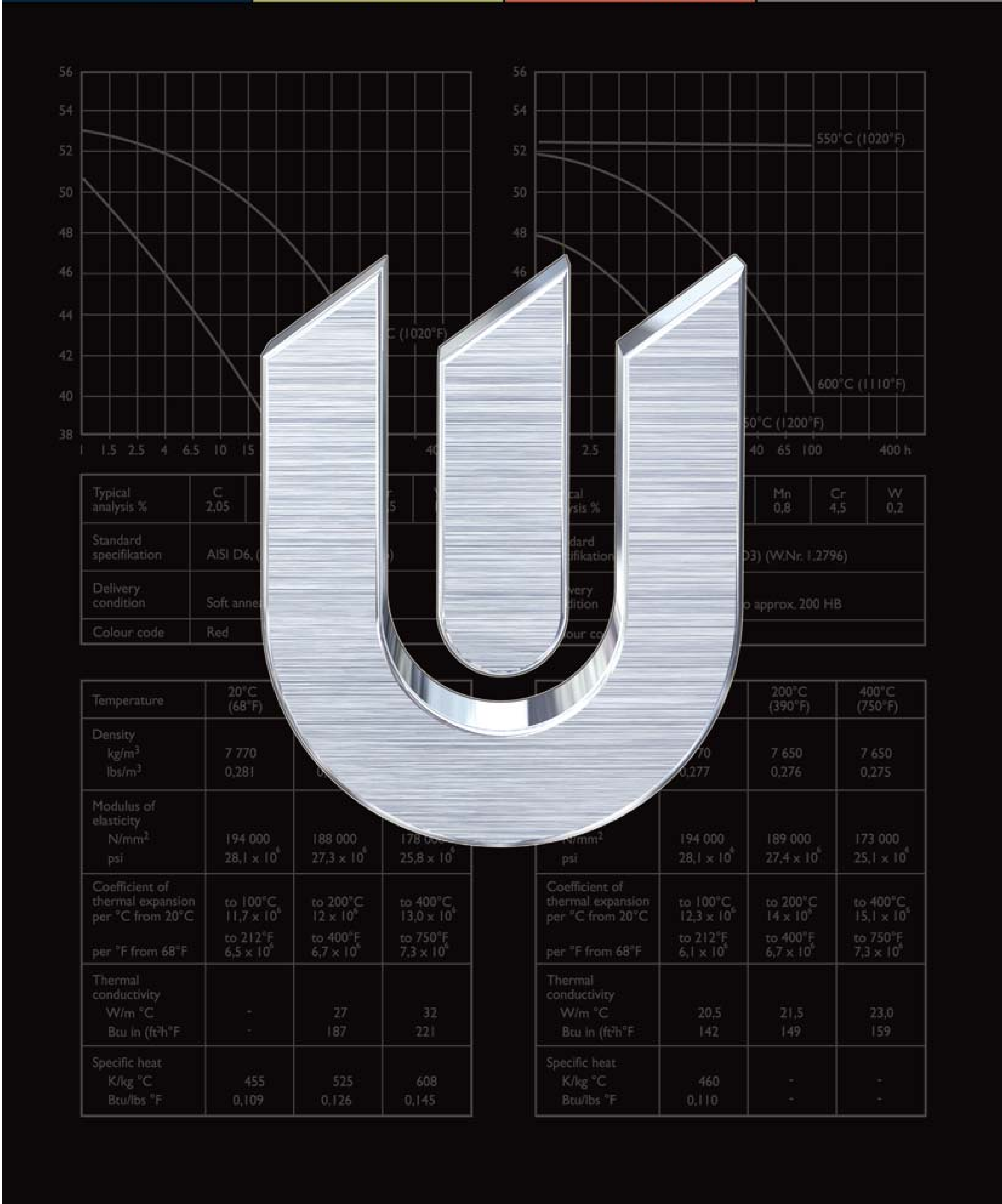
WEARTEC™SF

Cold work tool steel

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 cracking
- Good ductility to prevent chipping

High wear resistance is often associated with low toughness and ductility and vice-versa. However, in many cases high wear resistance and resistance to chipping or cracking are essential for optimal tool performance.

Weartec SF is a spray formed* cold work tool steel offering a combination of extremely high wear resistance and good resistance to chipping and cracking.

TOOLMAKING

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

Weartec SF has an extremely 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 Weartec SF has a similar heat treatment procedure to the steel AISI D2. One big advantage with Weartec SF is that the dimensional stability after hardening is better than for conventionally produced high alloyed cold work tool steels.

Applications

Weartec SF is suitable for medium and long run tooling where the work materials used are likely to result in abrasive wear and/or plastic deformation of the tool.

Examples:

- Cold rolls requiring very high wear resistance
- Forming rolls requiring a very high wear resistance
- Knives
- Dies for tile and brick pressing
- Granulator screws

** Weartec SF is spray formed by Dan Spray A/S.*

General

Weartec SF is a chromium-molybdenum-vanadium alloyed cold work tool steel which is characterized by:

- Excellent abrasive wear resistance
- High compressive strength
- 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 2,8	Si 0,8	Mn 0,7	Cr 7,0	Mo 2,3	V 8,9
Standard specification	None					
Delivery condition	Soft annealed to approx. 270 HB					
Colour code	Yellow/orange					

Properties

PHYSICAL DATA

Hardened and tempered to 62 HRC

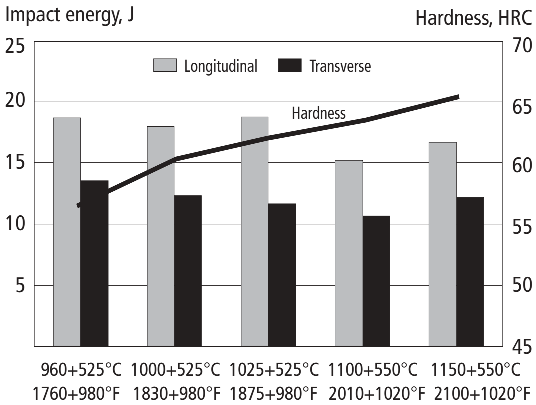
Temperature	20°C (70°F)	200°C (390°F)	400°C (750°F)
Density kg/m^3 lbs/in^3	7 340 0,264	– –	– –
Modulus of elasticity MPa psi	212 000 30,8 x 10^6	199 000 28,8 x 10^6	191 000 27,7 x 10^6
Coefficient of thermal expansion per °C form 20°C °F from 68°F	– –	10,8 x 10^{-6} 6,0 x 10^{-6}	11,6 x 10^{-6} 6,4 x 10^{-6}
Thermal conductivity W/m°C Btu in (ft^{2}h°F)	– –	17 118	20 132
Specific heat J/kg °C Btu /lb °F	460 0,11	– –	– –

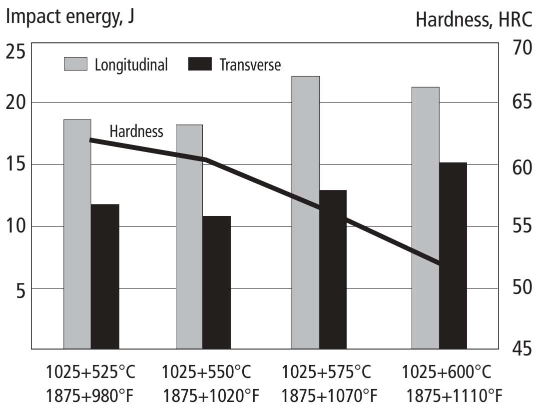
COMPRESSIVE STRENGTH

Hardness HRC	Compressive strength Rc0,2 (MPa)
50	1 550
55	2 050
60	2 450
62	2 600
64	2 800

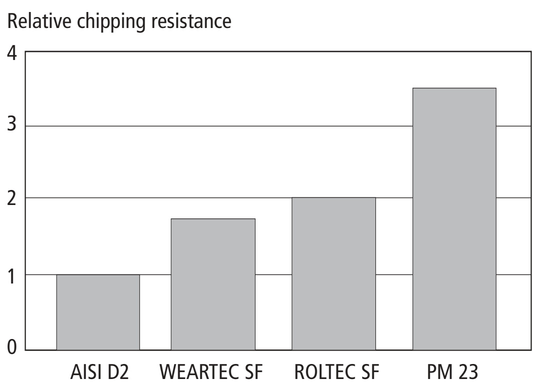
IMPACT STRENGTH

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 are used. Quenched in air. Tempered 2 x 2h.



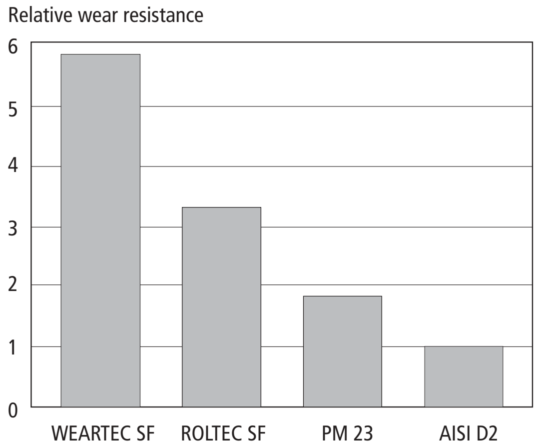


Relative chipping resistance for AISI D2, Weartec SF, Roltec SF and PM 23 at 60 HRC. High value indicates good ductility. High temperature tempered condition.



WEAR RESISTANCE

Relative abrasive wear resistance for Weartec SF, Roltec SF, PM 23 and AISI D2 at 60 HRC. A high value indicates good wear resistance. High temperature tempered condition.



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: 950–1150°C (1740–2100°F), normally 1020°C (1870°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.

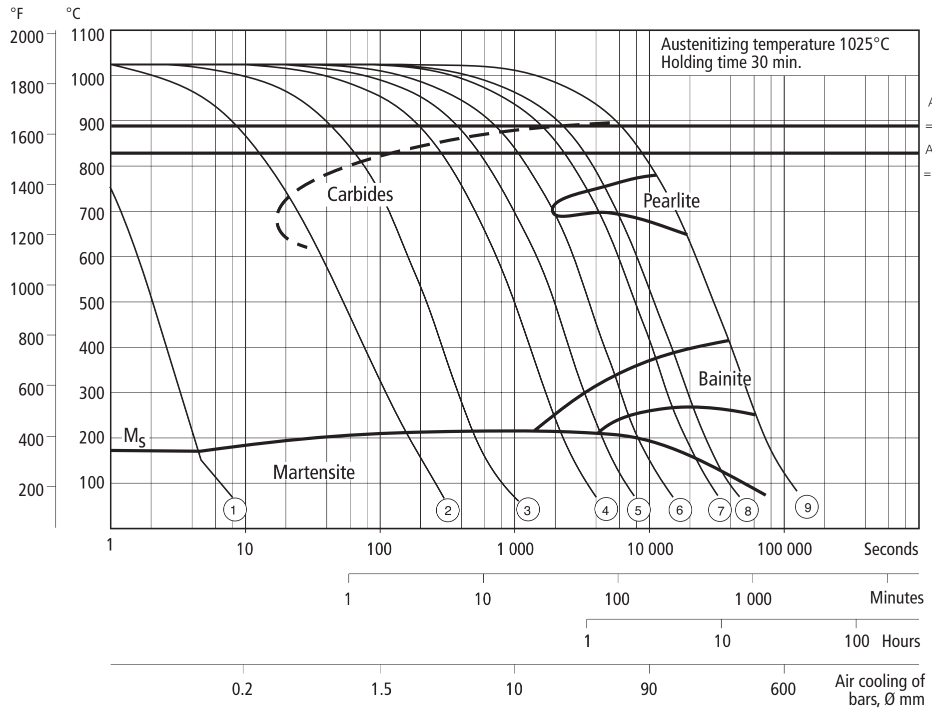
QUENCHING MEDIA

- 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).

CCT-graph

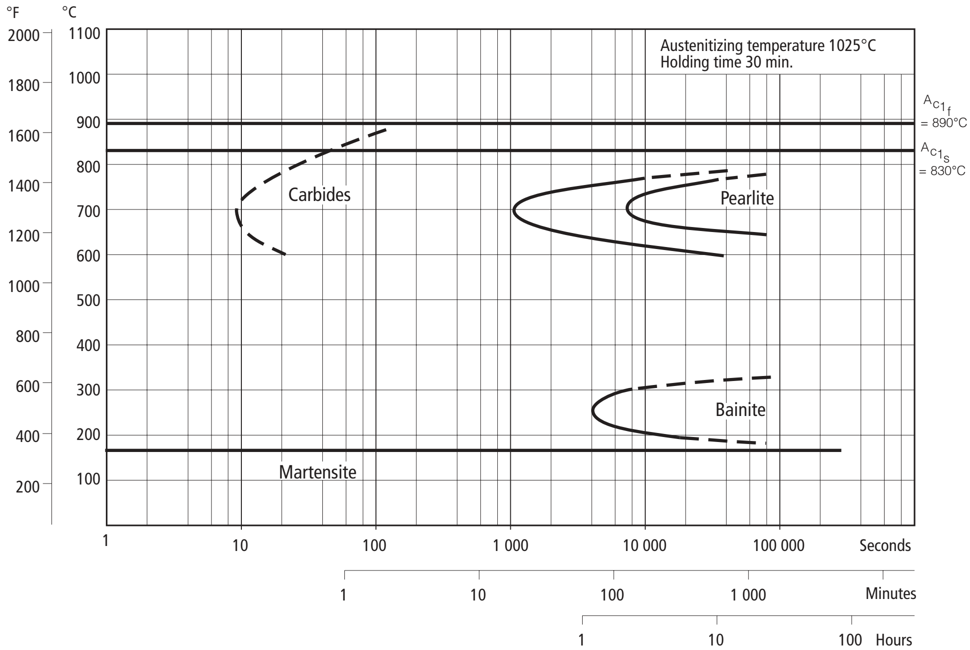
Austenitizing temperature 1025°C (1875°F). Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ (sec)
1	933	1
2	907	37
3	882	140
4	882	630
5	824	1241
6	734	2325
7	613	5215
8	620	7320
9	336	19400

TTT-graph

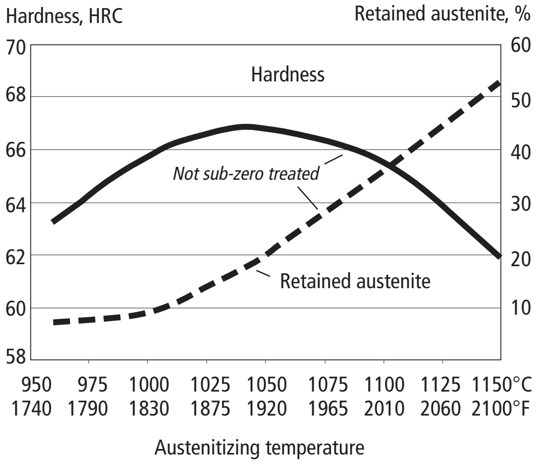
Austenitizing temperature 1025°C (1875°F). Holding time 30 minutes.



Temp. °C	Time hours	Hardn. HV 10
775	8,1	279
750	4,3	302
700	66,0	309
650	39,0	383
600	22,9	627
400	18,7	894
350	18,9	882
300	63,0	642
250	6,6	792
200	22,7	813

Hardness and retained austenite as a function of austenitizing temperature.

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

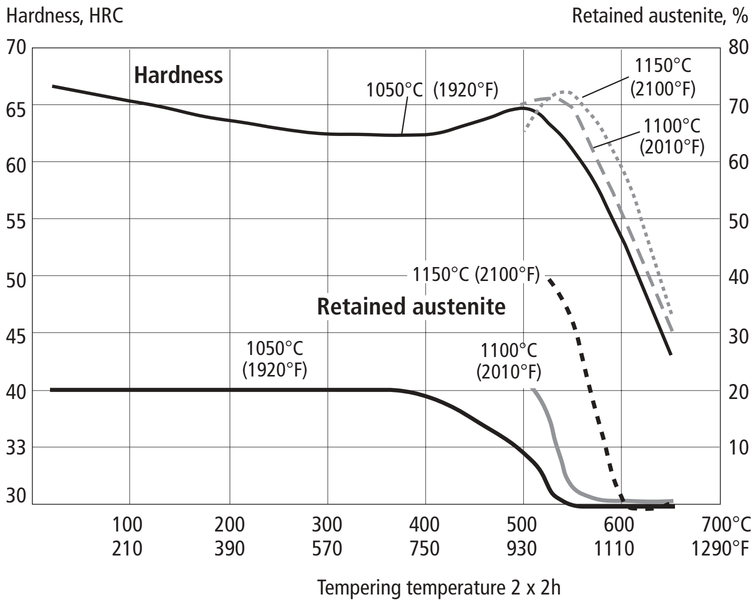


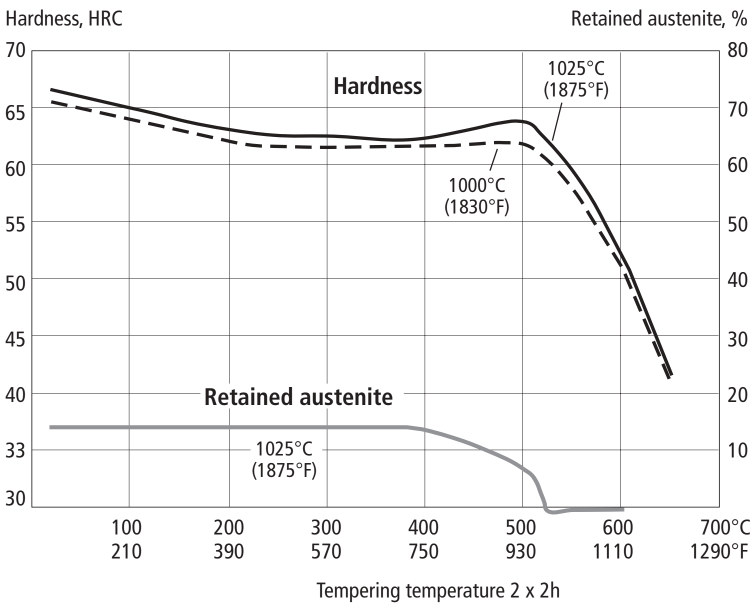
TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graphs below.

Temper at least twice with intermediate cooling to room temperature. The lowest tempering temperature which should be used without deep cooling is 525°C (980°F) and with sub-zero treatment 500°C (930°F). The minimum holding time at temperature is 2 hours. For a hardening temperature of ≥1100°C (2010°F) Weartec SF should be sub-zero cooled and/or high temperature tempered three times in order to reduce the amount of retained austenite.

Tempering graphs without sub-zero treatment after hardening





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

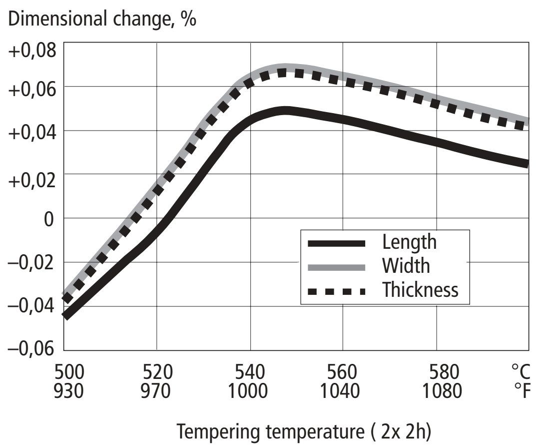
The dimensional changes have been measured after austenitizing and tempering.

Austenitizing: 1025°C (1875°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: 100 x 100 x 100 mm (3,9 x 3,9 x 3,9”)

Dimensional changes in length, width and thickness after hardening and tempering



Surface treatments

Some cold work 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 Weartec SF ideal as a substrate steel for various surface coatings.

NITRIDING

Nitriding gives a hard surface layer that is resistant to wear and erosion.
Weartec SF is normally high temperature tempered at 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

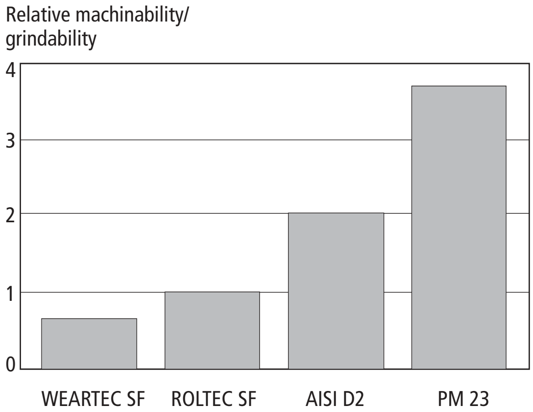
Physical vapour deposition, PVD, is a method of applying a wear resistant coating at temperatures between 200–500°C (390–930°F).

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 Weartec SF, Roltec SF, AISI D2 and PM 23. A high value indicates good machinability and grindability.



Machining recommendations

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

Condition: Soft annealed to approx. 270 HB

TURNING

Cutting data parameters	Turning with carbide	
	Rough turning	Fine turning
Cutting speed ,v_c m/min. f.p.m.	80–100 260–330	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	K20*, P20	K15, P15

** 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	6–8	20–26	0,05–0,10	0,002–0,004
5–10	3/16–3/8	6–8	20–26	0,10–0,20	0,004–0,008
10–15	3/8–5/8	6–8	20–26	0,20–0,25	0,008–0,010
15–20	5/8–3/4	6–8	20–26	0,25–0,30	0,010–0,012

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1)]
Cutting speed, v_c m/min f.p.m.	70–90 230–300	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.	40–60 130–200	60–80 200–260
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[3)]
Cutting speed v_c m/min f.p.m.	20–30 65–100	30–50 100–165	10–14 30–45
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[2)]	–

1) Depending on radial depth of cut and cutter diameter.
2) Use a wear resistant Al_2O_3-coated carbide
3) With coated HSS

BAND SAWING

For sawing of Weartec SF a carbide tipped band is recommended. The tooth pitch should be coarse but at least three teeth must be engaged in the workpiece at the same time.

	Carbide tipped band
Cutting speed m/min. f.p.m.	 40–50 130–165
Down feed mm/min. inch/mm	 10–15 0,4–0,6

GRINDING

General grinding wheel recommendations are 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 JV[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 Weartec SF should be tempered at high temperatures, ≥525°C (980°F).

Further information

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

Relative comparison of Uddeholm cold work tool steels

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS