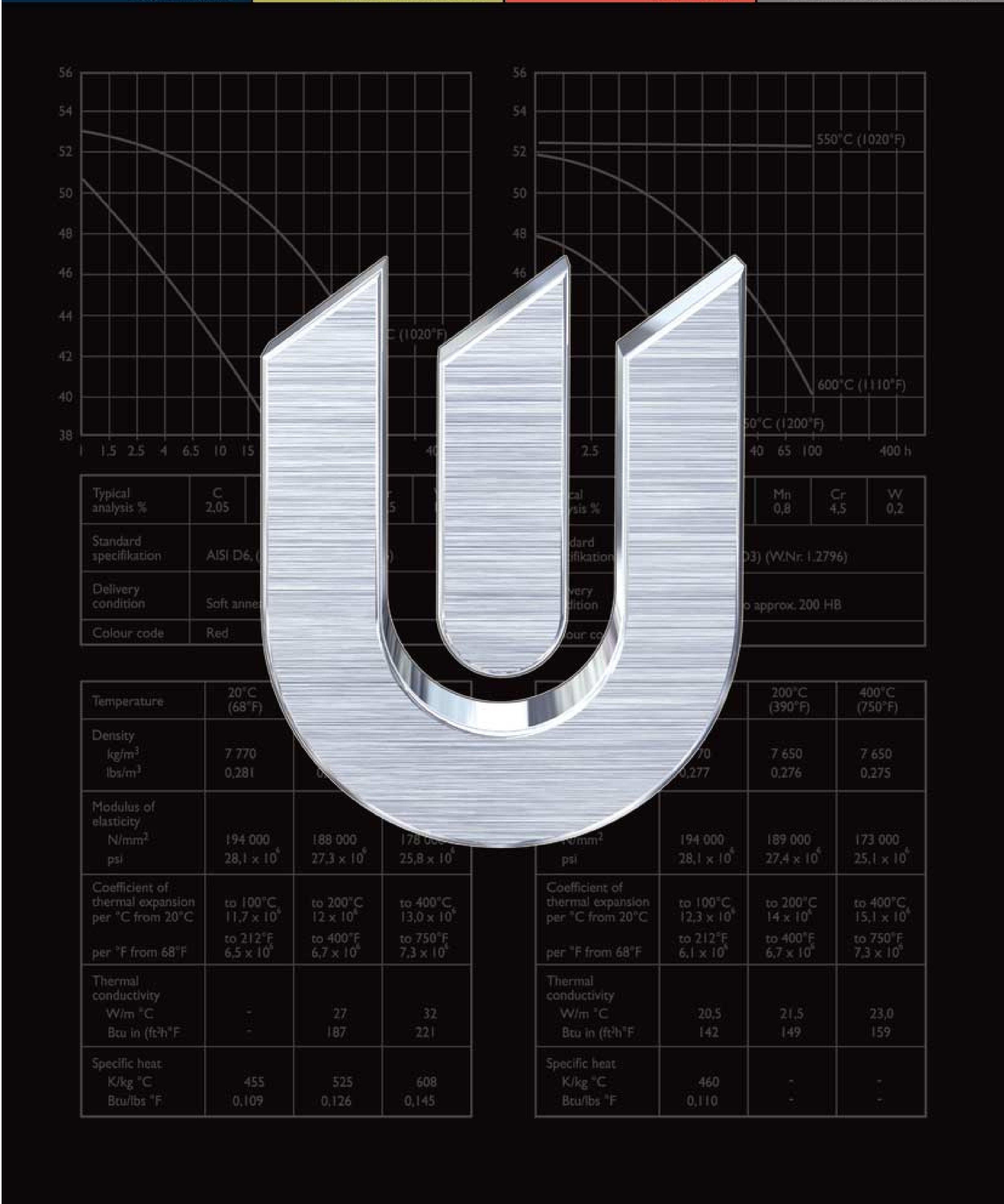
ARNE

Cold work tool steel

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



General

ARNE general purpose oil-hardening tool steel is a versatile manganese-chromium-tungsten steel suitable for a wide variety of cold-work applications. Its main characteristics include:

- Good machinability
- Good dimensional stability in hardening
- A good combination of high surface hardness and toughness after hardening and tempering.

These characteristics combine to give a steel suitable for the manufacture of tooling with good tool-life and production economy.

ARNE can be supplied in various finishes including hot-rolled, pre-machined, fine-machined and precision ground. It is also available in the form of hollow bar.

Typical analysis %	C 0,95	Mn 1,1	Cr 0,6	W 0,6	V 0,1
Standard specification	AISI O1, W.-Nr. 1.2510				
Delivery condition	Soft annealed approx. 190 HB				
Colour code	Yellow				

Applications

Tools for	Material thickness	HRC
Cutting Blanking, punching, piercing, cropping, shearing, trimming clipping	up to 3 mm (1/8") 3– 6 mm (1/8–1/4") 6–10 mm (1/4–13/32")	60–62 56–60 54–56
Short cold shears		54–60
Clipping and trimming tools for forgings	Hot Cold	58–60 56–58
Forming Bending, raising, drawing, rim rolling, spinning and flow forming		56–62
Small coining dies		56–60
Gauges, measuring tools Turning centres Guide bushes, ejector pins, high duty, small/medium drills and taps Small gear wheels, pistons, nozzles, cams		58–62

Properties

PHYSICAL DATA

Hardened and tempered to 62 HRC. Data at ambient temperature and elevated temperature.

Temperature	20°C (68°F)	200°C (375°F)	400°C (750°F)
Density			
kg/m³	7 800	7 750	7 700
lbs/in³	0,282	0,280	0,278
Modulus of elasticity			
N/mm²	190 000	185 000	170 000
kp/mm²	19 500	19 000	17 500
tsi	12 500	12 200	11 200
psi	28 x 10^6	27 x 10^6	25 x 10^6
Coefficient of thermal exp.			
per °C from 20°C	–	11,7 x 10^{-6}	11,4 x 10^{-6}
per °F from 68°F	–	6,5 x 10^{-6}	6,3 x 10^{-6}
Thermal conductivity			
W/m °C	32	33	34
Btu in/ft² h °F	222	229	236
Specific heat			
J/kg C	460	–	–
Btu/lb. °F	0,11	–	–

COMPRESSIVE STRENGTH

The figures are to be considered approximate.

Hardness	Rc0,2 N/mm²	Rc0,2 ksi
62 HRC	2200	319
60 HRC	2150	312
55 HRC	1800	261
50 HRC	1350	196

Clipping and edging tool in ARNE tool steel to clip and form edge of 0,914 mm (0,036") thick stainless steel container approx. 254 x 152 x 203 mm (10" x 6" x 8").

Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 780°C (1435°F). Then cool in the furnace at 15°C (27°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 temperature: 600–700°C (1110–1290°F)
Austenitizing temperature: 790–850°C (1450–1560°F)

Temperature °C	Temperature °F	Soaking* time minutes	Hardness before tempering
800	1470	30	approx. 65 HRC
825	1520	20	approx. 65 HRC
850	1560	15	approx. 63 HRC

** Soaking time = time at austenitizing temperature after the tool is fully heated through.*

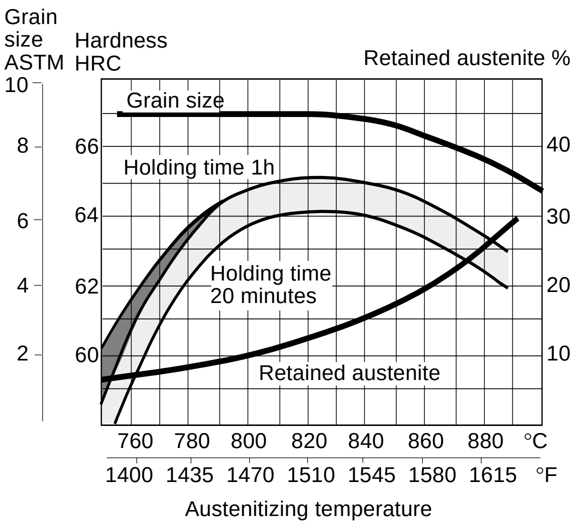
Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

- Oil
- Martempering bath. Temperature 180–225°C (360–435°F), then cooling in air.

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

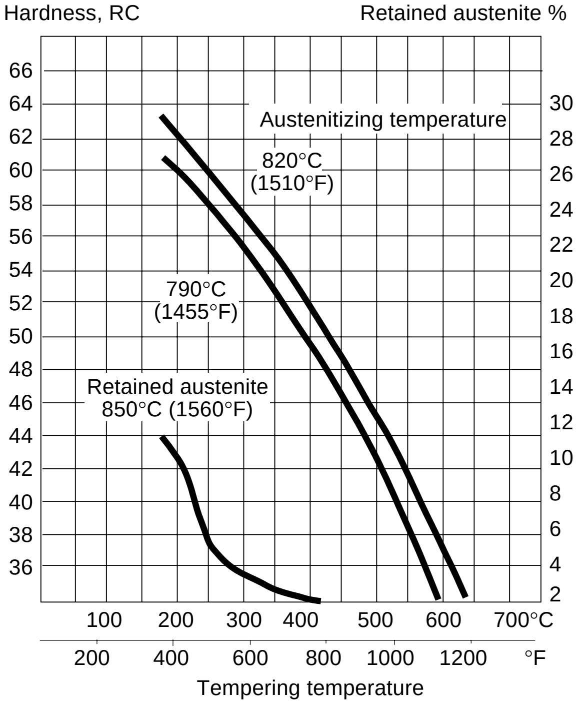
Hardness as a function of hardening temperature.



TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 180°C (360°F). Holding time at temperature minimum 2 hours.

Tempering graph



MARTEMPERING

Tools at austenitizing temperature are immersed in the martempering bath for the time indicated, then cooled in air to not lower than 100°C (210°F). Temper immediately as with oil-quenching.

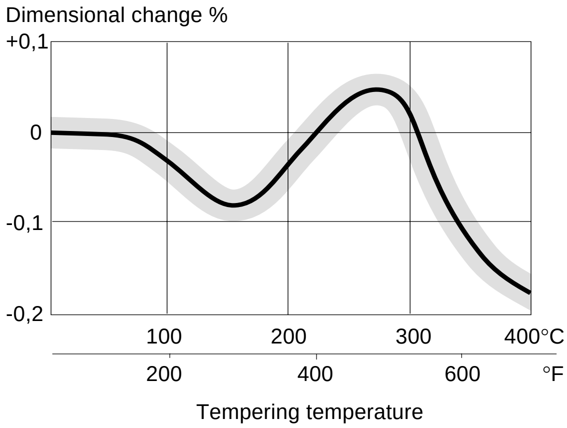
Austenitizing temperature °C	Austenitizing temperature °F	Temp. of martemp. bath °C	Temp. of martemp. bath °F	Holding time in martemp. bath, minutes	Surface hardness prior to tempering (obtained by martempering)
825	1520	225	435	max. 5	64±2 HRC
825	1520	200	390	max. 10	63±2 HRC
825	1520	180	355	max. 20	62±2 HRC
850	1560	225	435	max. 10	62±2 HRC

DIMENSIONAL CHANGES DURING HARDENING

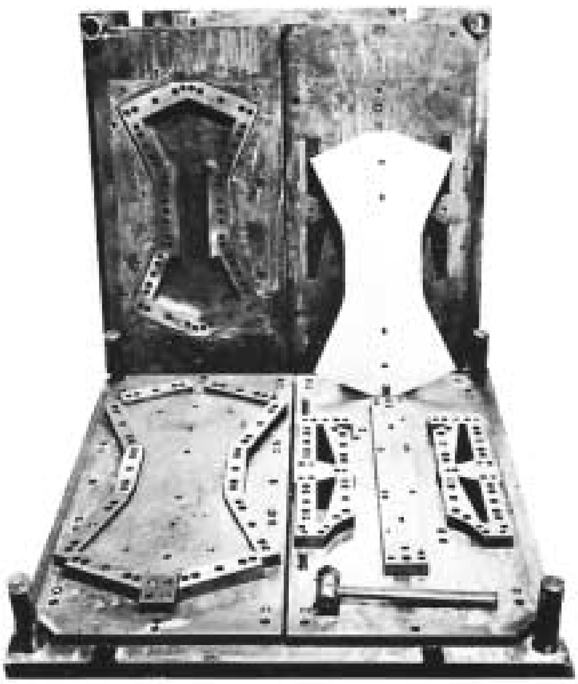
Sample plate, 100 x 100 x 25 mm, 4" x 4" x 1"

	Width %	Length %	Thickness %
Oil hardening from 830°C (1530°F) min.	+0,03	+0,04	–
max.	+0,10	+0,10	+0,02
Martempering from 830°C (1530°F) min.	+0,04	+0,06	–
max.	+0,12	+0,12	+0,02

DIMENSIONAL CHANGES DURING TEMPERING



Note: The dimensional changes on hardening and tempering should be added together. Recommended allowance 0,25%.



Blanking tool made from fine-machined ARNE tool steel.

SUB-ZERO TREATMENT AND AGING

Pieces requiring maximum dimensional stability should be sub-zero treated and / or artificially aged, as volume changes may occur in the course of time. This applies, for example, to measuring tools like gauges and certain structural components.

Sub-zero treatment

Immediately after quenching the piece should be sub-zero treated to between –70 and –80° C (–95 to –110° F), soaking time 3–4 hours, followed by tempering or aging. Sub-zero treatment will give a hardness increase of 1–3 HRC. Avoid intricate shapes as there will be risk of cracking.

Aging

Tempering after quenching is replaced by aging at 110–140° C (230–285° F). Holding time 25–100 hours.

Machining recommendations

The following tables give machining data for *ARNE* in soft annealed condition. Hardness 190 HB. The data are to be considered as guiding values, which must be adapted to existing local conditions.

TURNING

Cutting data parameters	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min f.p.m.	140–170 460–560	170–220 560–730	20 65
Feed (f) mm/r i.p.r.	0,3–0,6 0,012–0,023	–0,3 –0,01	–0,3 –0,01
Depth of cut (a_p) mm inch	2–6 0,08–0,24	–2 –0,08	–2 –0,08
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	—

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide		Milling with high speed steel
	Rough milling	Fine milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	160–200 530–660	200–240 660–790	25 80
Feed (f_z) mm/tooth in/tooth	0,2–0,4 0,008–0,016	0,10–0,20 0,004–0,008	0,1 0,004
Depth of cut (a_p) mm inch	2–5 0,08–0,2	–2 –0,08	–2 –0,08
Carbide designation ISO	P20–P40 Coated carbide	P10–P20 Coated carbide or cermet	—

End milling

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	50 165	120–170 400–560	25[1)] 80[1)]
Feed (f_z) mm/tooth in/tooth	0,03–0,2[2)] 0,001–0,008[2)]	0,08–0,2[2)] 0,003–0,008[2)]	0,05–0,35[2)] 0,002–0,014[2)]
Carbide designation ISO	K20, P40	P20–P30	—

[1)] *For coated end mills $v_c \approx$ 35 m/min. (115 f.p.m.)*
[2)] *Depending on radial depth of cut and cutter diameter.*

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	16*	50*	0,08–0,20	0,003–0,008
5–10	3/16–3/8	16*	50*	0,20–0,30	0,008–0,012
10–15	3/8 –5/8	16*	50*	0,30–0,35	0,012–0,014
15–20	5/8 –3/4	16*	50*	0,35–0,40	0,014–0,016

**) For coated HSS drills v_c ~22 m/min. (70 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.	120–160 400–530	60 200	55 180
Feed (f) mm/r i.p.r.	0,05–0,25[2)] 0,002–0,01[2)]	0,10–0,25[2)] 0,004–0,01[2)]	0,15–0,25[2)] 0,006–0,01[2)]

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

GRINDING

General grinding wheel recommendation for *ARNE* is given below. More information can be found in the Uddeholm publication “Grinding of Tool Steel”.

Type of grinding	Wheel recommendation	
	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 H V	A 46 G V
Face grinding segments	A 24 G V	A 36 G V
Cylindrical grinding	A 46 L V	A 60 J V
Internal grinding	A 46 J V	A 60 I V
Profile grinding	A 100 L V	A 120 J V

Welding

Good results when welding tool steel can be achieved if proper precautions are taken during welding (elevated working temperature, joint preparation, choice of consumables and welding procedure). If the tool is to be polished or photo-etched, it is necessary to work with an electrode type of matching composition.

Welding method	Working temperature	Consumables	Hardness after welding
MMA (SMAW)	200–250°C	AWS E312 ESAB OK 84.52 UTP 67S Castolin 2 Castolin N 102	300 HB 53–54 HRC 55–58 HRC 54–60 HRC 54–60 HRC
TIG	200–250°C	AWS ER312 UTPA 67S UTPA 73G2 Castotig 5	300 HB 55–58 HRC 53–56 HRC 60–64 HRC

Electrical-discharge machining

If spark-erosion, EDM, is performed in the hardened and tempered condition, the tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

Further information

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

Relative comparison of Uddeholm cold work tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS