

ORVAR SUPREME

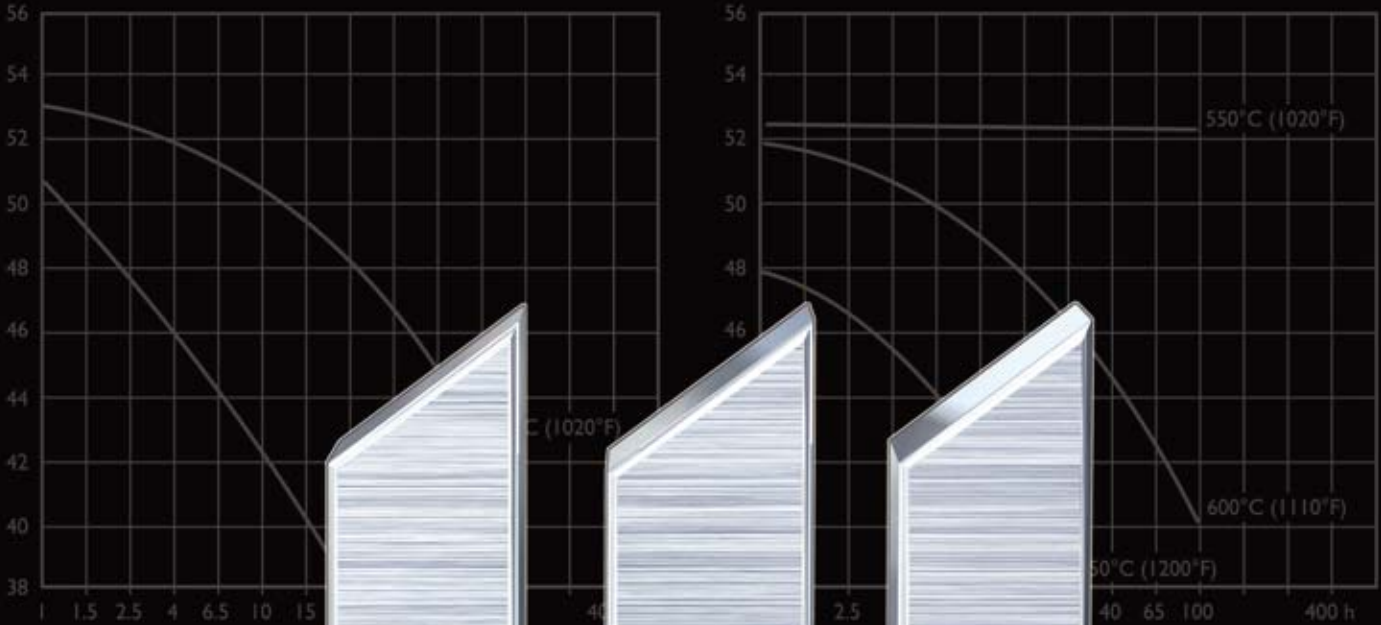
Hot work tool steel

COLD WORK

PLASTIC MOULDING

HOT WORK

HIGH PERFORMANCE STEEL



Typical analysis %	C 2,05	Mn 0,8	Cr 4,5	W 0,2
Standard specification	AISI D6, ()	D3) (WNr. 1.2796)		
Delivery condition	Soft annealed	to approx. 200 HB		
Colour code	Red	our co		



Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m ³ lbs/m ³	7 770 0,281	7 700 0,277	7 650 0,275
Modulus of elasticity N/mm ² psi	194 000 28,1 × 10 ⁶	188 000 27,3 × 10 ⁶	178 000 25,8 × 10 ⁶
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	to 100°C 11,7 × 10 ⁻⁶ to 212°F 6,5 × 10 ⁻⁶	to 200°C 12 × 10 ⁻⁶ to 400°F 6,7 × 10 ⁻⁶	to 400°C 13,0 × 10 ⁻⁶ to 750°F 7,3 × 10 ⁻⁶
Thermal conductivity W/m °C Btu in (ft ² h°F)	-	27 187	32 221
Specific heat K/kg °C Btu/lbs °F	455 0,109	525 0,126	608 0,145
		20,5 142	21,5 149
		460 0,110	- -

This information is based on our present state of knowledge and is intended to provide general notes on our products and their uses. It should not therefore be construed as a warranty of specific properties of the products described or a warranty for fitness for a particular purpose.

General

ORVAR SUPREME is a chromium-molybdenum-vanadium-alloyed steel which is characterized by:

- High level of resistance to thermal shock and thermal fatigue
- Good high-temperature strength
- Excellent toughness and ductility **in all directions**
- Good machinability and polishability
- Excellent through-hardening properties
- Good dimensional stability during hardening.

Typical analysis %	C 0,39	Si 1,0	Mn 0,4	Cr 5,2	Mo 1,4	V 0,9
Standard specification	Premium AISI H13, W.-Nr. 1.2344					
Delivery condition	Soft annealed to approx. 180 HB					
Colour code	Orange					

IMPROVED TOOLING PERFORMANCE

The name "SUPREME" implies that by special processing techniques and close control, the steel attains high purity and a very fine structure. Further, ORVAR SUPREME shows significant improvements in isotropic properties compared to conventionally produced AISI H 13 grades.

These improved isotropic properties are particularly valuable for tooling subjected to high mechanical and thermal fatigue stresses, e.g. die casting dies, forging tools and extrusion tooling. In practical terms, tools may be used at somewhat higher working hardnesses (+1 to 2 HRC) without loss of toughness. Since increased hardness slows down the formation of heatchecking cracks, improved tool performance can be expected.

ORVAR SUPREME meets the North American Die Casting Association (NADCA) #207-97 for premium high quality H-13 die steel.

Applications

TOOLS FOR DIE CASTING

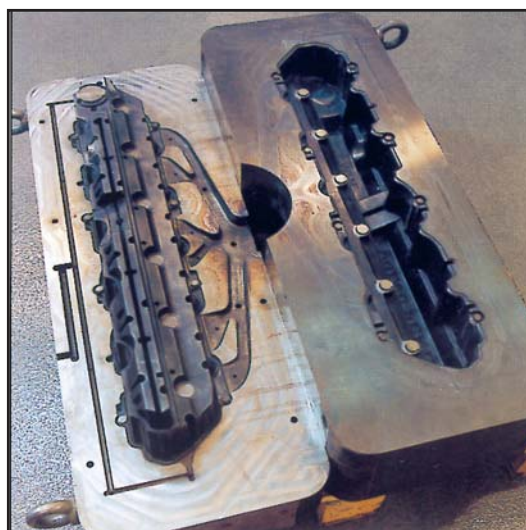
Part	Tin, lead zinc alloys HRC	Aluminium, magnesium alloys, HRC	Copper alloys HRC
Dies	46–50	42–48	(QRO 90 S)
Fixed inserts	46–52	44–48	(QRO 90 S)
cores	48–52	46–48	(QRO 90 S)
Sprue parts	35–42	42–48	(QRO 90 S)
Nozzles	46–50	46–50	46–50
Ejector pins (nitrided)	42–46	42–48	(QRO 90 S)
Plunger, shot-sleeve (normally nitrided)			
Austenitizing temperature	1020–1030°C (1870–1885°F)		1040–1050°C (1900–1920°F)

TOOLS FOR EXTRUSION

Part	Aluminium, magnesium alloys, HRC	Copper alloys HRC	Stainless steel HRC
Dies	44–50	43–47	45–50
Backers, die-holders, liners, dummy blocks, stems	41–50	40–48	40–48
Austenitizing temperature (approx.)	1020–1030°C (1870–1885°F)		1040–1050°C (1900–1920°F)

TOOLS FOR HOT PRESSING

Material	Aust. temp. (approx.)	HRC
Aluminium, magnesium	1020–1030°C (1870–1885°F)	44–52
Copper alloys	1040–1050°C (1900–1920°F)	44–52
Steel	1040–1050°C (1900–1920°F)	40–50



MOULDS FOR PLASTICS

Part	Austenitizing temp.	HRC
Injection moulds	1020–1030°C (1870–1885°F)	50–52
Compression/ transfer moulds	Tempering 250°C (480°F)	

OTHER APPLICATIONS

Application	Austenitizing temp.	HRC
Severe cold punching, scrap shears	1020–1030°C (1870–1885°F) Tempering 250°C (480°F)	50–52
Hot shearing	1020–1030°C (1870–1885°F) Tempering 1. 250°C (480°F) or 2. 575–600°C (1070–1110°F)	50–52 45–50
Shrink rings (e.g. for cemented carbide dies)	1020–1030°C (1870–1885°F) Tempering 575–600°C (1070–1110°F)	45–50
Wear-resisting parts	1020–1030°C (1870–1885°F) Tempering 575°C (1070°F) Nitriding	Core 50–52 Surface ~1000HV ₁

Properties

All specimens are taken from the centre of a 407 x 127 mm (16" x 5") bar. Unless otherwise is indicated all specimens were hardened 30 minutes at 1025°C (1875°F), quenched in air and tempered 2 + 2 h at 610°C (1130°F). The hardness were 45 ± 1 HRC.

PHYSICAL DATA

Data at room and elevated temperatures.

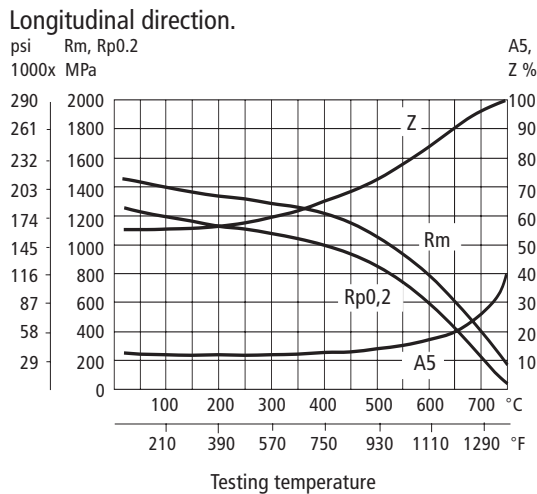
Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Density kg/m ³ lbs/in ³	7800 0,281	7700 0,277	7600 0,274
Modulus of elasticity MPa psi	210 000 30,5 x 10 ⁶	180 000 26,1 x 10 ⁶	140 000 20,3 x 10 ⁶
Coefficient of thermal expansion per °C from 20°C °F from 68°F	–	12,6 x 10 ⁻⁶ 7,0 x 10 ⁻⁶	13,2 x 10 ⁻⁶ 7,3 x 10 ⁻⁶
Thermal conductivity W/m °C Btu in/(ft ² h°F)	25 176	29 204	30 211

MECHANICAL PROPERTIES

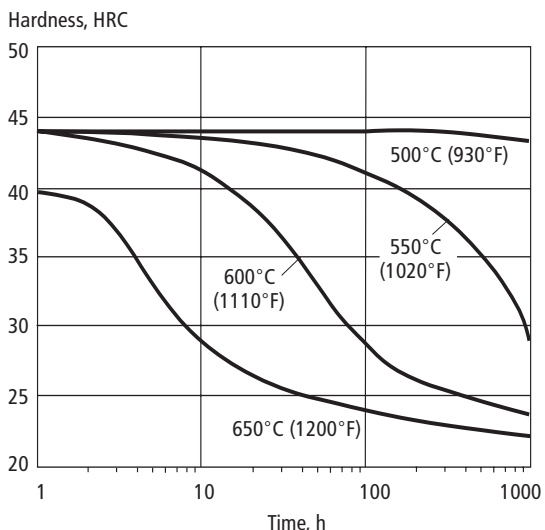
Approximate tensile strength at room temperature.

Hardness	52 HRC	45 HRC
Tensile strength R _m	1820 MPa 185 kp/mm ² 117 tsi 263 000 psi	1420 MPa 145 kp/mm ² 92 tsi 206 000 psi
Yield strength R _{p0,2}	1520 MPa 155 kp/mm ² 98 tsi 220 000 psi	1280 MPa 130 kp/mm ² 83 tsi 185 000 psi

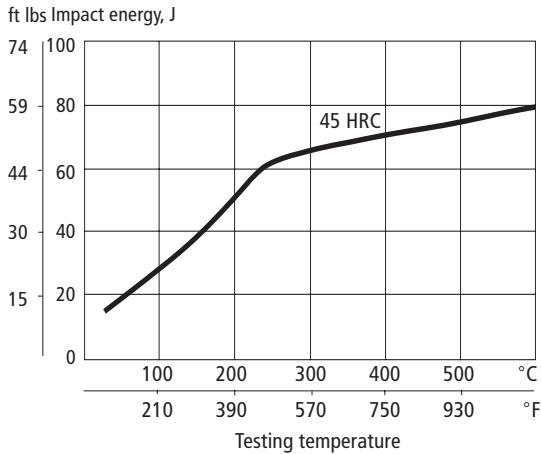
Approximate strength at elevated temperatures



Effect of time at high temperatures on hardness



Effect of testing temperature on impact energy
Charpy V specimens, short transverse direction.



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

Pre-heating temperature: 600–850°C (1110–1560°F), normally in two pre-heating steps.

Austenitizing temperature: 1020–1050°C (1870–1920°F), normally 1020–1030°C (1870–1885°F).

Temperature		Soaking* time minutes	Hardness before tempering
°C	°F		
1025	1875	30	53±2 HRC
1050	1920	15	54±2 HRC

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

Protect the part against decarburization and oxidation during hardening.

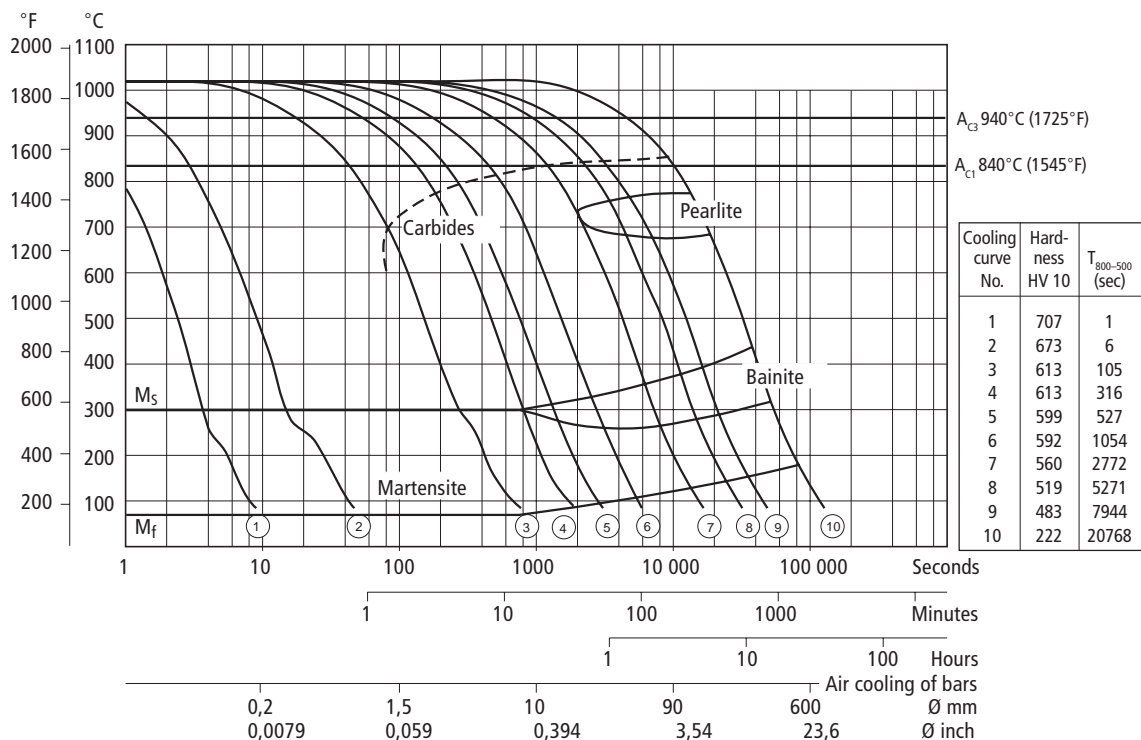
Heat treatment—general recommendations

SOFT ANNEALING

Protect the steel and heat through to 850°C (1560°F). Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F), then freely in air.

CCT graph

Austenitizing temperature 1020°C (1870°F). Holding time 30 minutes.



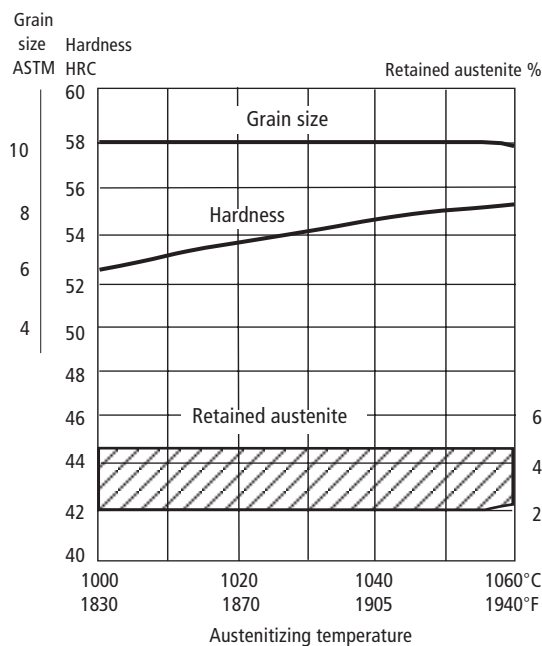
QUENCHING MEDIA

- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench is recommended where distortion control and quench cracking are a concern
- Martempering bath or fluidized bed at 450–550°C (840–1020°F), then cool in air
- Martempering bath or fluidized bed at approx. 180–220°C (360–430°F) then cool in air
- Warm oil.

Note 1: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

Note 2: In order to obtain the optimum properties for the tool, the cooling rate should be fast, but not at a level that gives excessive distortion or cracks.

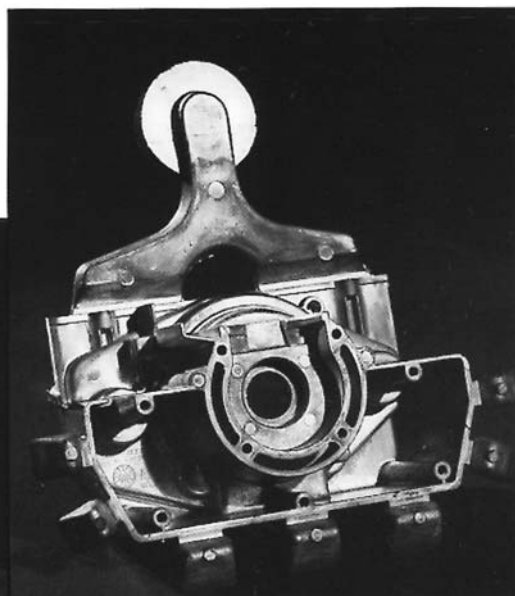
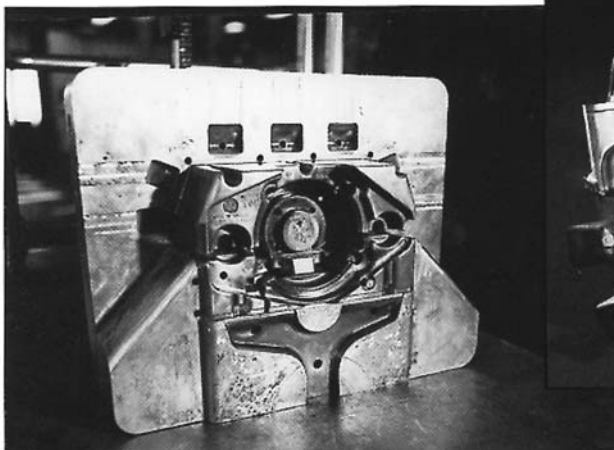
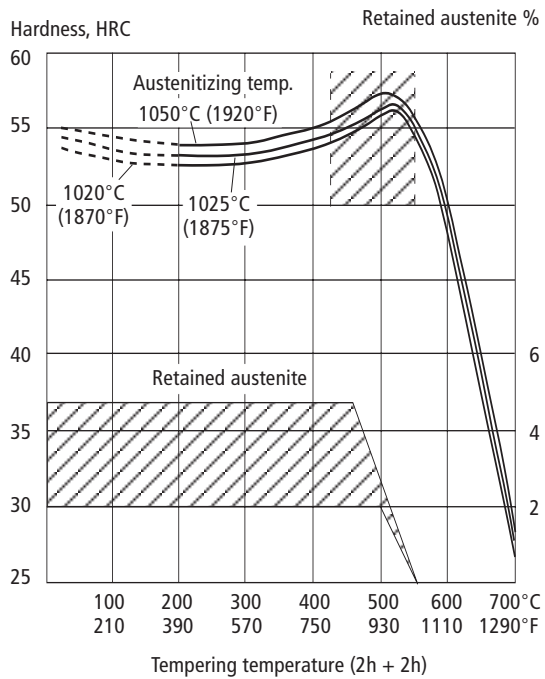
Hardness, grain size and retained austenite as functions of austenitizing temperature



TEMPERING

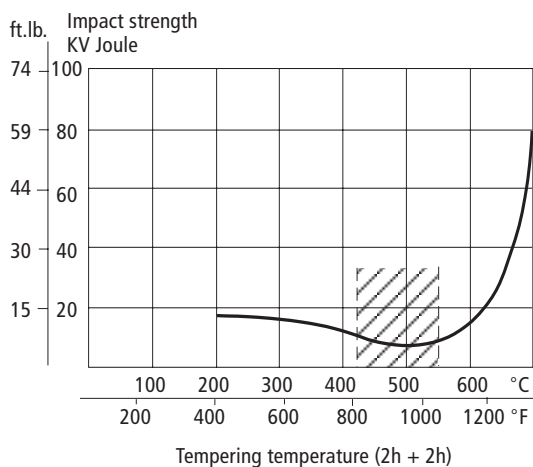
Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper minimum twice with intermediate cooling to room temperature. Lowest tempering temperature 250°C (480°F). Holding time at temperature minimum 2 hours. To avoid "temper brittleness", do not temper in the range 425–550°C (800–1020°F), see graph.

Tempering graph



Approximate impact strength at different tempering temperatures.

Charpy V specimens, short transverse direction.



Tempering within the range 425–550 °C (800–1020 °F) is normally not recommended due to the reduction in toughness properties.

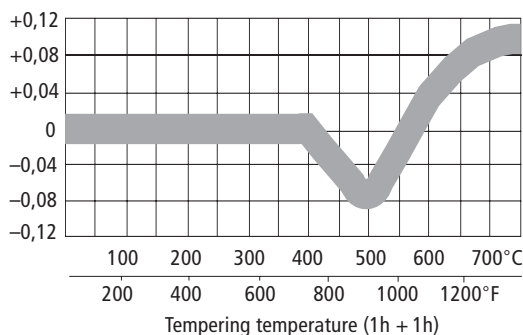
DIMENSIONAL CHANGES DURING HARDENING

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

		Width %	Length %	Thickness %
Oil hardened from 1020 °C (1870 °F)	Min.	-0,08	-0,06	±0
	Max.	-0,15	-0,16	+0,30
Air hardened from 1020 °C (1870 °F)	Min.	-0,02	-0,05	±0
	Max.	+0,03	+0,02	+0,05
Vac hardened from 1020 °C (1870 °F)	Min.	+0,01	-0,02	+0,08
	Max.	+0,02	-0,04	+0,12

DIMENSIONAL CHANGES DURING TEMPERING

Dimensional change %



Note: The dimensional changes in hardening and tempering should be added.

NITRIDING AND NITROCARBURIZING

Nitriding and nitrocarburizing result in a hard surface layer which is very resistant to wear and erosion. The nitrided layer is, however, brittle and may crack or spall when exposed to mechanical or thermal shock, the risk increasing with layer thickness. Before nitriding, the tool should be hardened and tempered at a temperature at least 50 °C (90 °F) above the nitriding temperature.

Nitriding in ammonia gas at 510 °C (950 °F) or plasma nitriding in a 75% hydrogen/25% nitrogen mixture at 480 °C (895 °F) both result in a surface hardness of about 1100 HV_{0,2}. In general, plasma nitriding is the preferred method because of better control over nitrogen potential; in particular, formation of the so-called white layer, which is not recommended for hot-work service, can readily be avoided. However, careful gas nitriding can give perfectly acceptable results.

ORVAR SUPREME can also be nitrocarburized in either gas or salt bath. The surface hardness after nitrocarburizing is 900–1000 HV_{0,2}.

DEPTH OF NITRIDING

Process	Time	Depth	
		mm	inch
Gas nitriding at 510 °C (950 °F)	10 h	0,12	0,0047
	30 h	0,20	0,0079
Plasma nitriding at 480 °C (895 °F)	10 h	0,12	0,0047
	30 h	0,18	0,0071
Nitrocarburizing – in gas at 580 °C (1075 °F)	2,5 h	0,11	0,0043

Nitriding to case depths >0,3 mm (>0,012 inch) is not recommended for hot-work applications. ORVAR SUPREME can be nitrided in the soft-annealed condition. The hardness and depth of case will, however, be reduced somewhat in this case.



Machining recommendations

The cutting data below 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.	200–250 660–820	250–300 820–985	25–30 82–100
Feed (f) mm/r i.p.r.	0,2–0,4 0,008–0,016	0,05–0,2 0,002–0,008	0,05–0,3 0,002–0,012
Depth of cut (a_p) mm inch	2–4 0,08–0,16	0,5–2 0,02–0,08	0,5–2 0,02–0,08
Carbide designation ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	–

DRILLING

High speed steel twist drill

Drill diameter		Cutting speed, v_c		Feed, f	
mm	inch	m/min	f.p.m.	mm/r	i.p.r.
– 5	–3/16	16–18*	52–59*	0,05–0,15	0,002–0,006
5–10	3/16–3/8	16–18*	52–59*	0,15–0,20	0,006–0,008
10–15	3/8–5/8	16–18*	52–59*	0,20–0,25	0,008–0,010
15–20	5/8–3/4	16–18*	52–59*	0,25–0,35	0,010–0,014

* For coated HSS drill v_c 28–30 m/min. (92–98 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.	220–240 720–785	130–160 425–525	80–110 260–360
Feed (f) mm/r i.p.r.	0,03–0,10 ²⁾ 0,001–0,004 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 carbide tip.

²⁾ Depending on drill diameter.

MILLING

Face milling and square shoulder face milling

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	180–260 590–850	260–300 850–985
Feed (f_z) mm/tooth inch/tooth	0,2–0,4 0,008–0,016	0,1–0,2 0,004–0,008
Depth of cut (a_p) mm inch	2–5 0,08–0,20	–2 –0,08
Carbide designation ISO	P20–P40 Coated carbide	P10–P20 Coated carbide or cermet

End milling

Cutting data parameters	Type of end mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	160–200 525–660	170–230 560–755	35–40 ¹⁾ 115–130 ¹⁾
Feed (f_z) mm/tooth inch/tooth	0,03–0,20 ²⁾ 0,001–0,008 ²⁾	0,08–0,20 ²⁾ 0,003–0,008 ²⁾	0,05–0,35 ²⁾ 0,002–0,014 ²⁾
Carbide designation ISO	–	P20, P30	–

¹⁾ For coated HSS end mill v_c 55–60 m/min. (180–195 f.p.m.).

²⁾ Depending on radial depth of cut and cutter diameter.

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm brochure "Grinding of Tool Steel" and can also be obtained from the grinding wheel manufacturer.

Wheel recommendation

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 KV

Welding

Welding of tool steel can be performed with good results if proper precautions are taken regarding elevated temperature, joint preparation, choice of consumables and welding procedure.

Welding method	TIG	MMA
Working temperature	325–375°C 620–710°F	325–375°C 620–710°F
Filler metal	QRO 90 TIG-WELD	QRO 90 WELD
Hardness after welding	50–55 HRC	50–55 HRC
Heat treatment after welding		
Hardened condition	Temper at 20°C (40°F) below the original tempering temperature.	
Soft annealed condition	Soft-anneal the material at 850°C (1560°F) in protected atmosphere. Then cool in the furnace at 10°C (20°F) per hour to 650°C (1200°F) then freely in air.	

More detailed information can be found in the Uddeholm brochure "Welding of Tool Steel".



Electrical-discharge machining

If spark-erosion is performed in the hardened and tempered condition, the white re-cast layer should be removed mechanically e.g. by grinding or stoning. The tool should then be given an additional temper at approx. 25°C (50°F) below the previous tempering temperature.

Hard-chromium plating

After plating, parts should be tempered at 180°C (360°F) for 4 hours within 4 hours of plating to avoid the risk of hydrogen embrittlement.

Photo-etching

ORVAR SUPREME is particularly suitable for texturing by the photo-etching method. Its high level of homogeneity and low sulphur content ensures accurate and consistent pattern reproduction.

Polishing

ORVAR SUPREME exhibits good polishability in the hardened and tempered condition. Polishing after grinding can be effected using aluminium oxide or diamond paste.

Typical procedure:

1. Rough grinding to 180–320 grain size using a wheel or stone.
2. Fine grinding with abrasive paper or powder down to 400–800 grain size.
3. Polish with diamond paste grade 15 (15µm grain size) using a polishing tool of soft wood or fibre.
4. Polish with diamond paste 3 (3µm grain size) using a polishing tool of soft wood or fibre.
5. When demands on surface finish are high, grade 1 (1µm grain size) diamond paste can be used for final polishing with a fibre polishing pad.

Further information

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