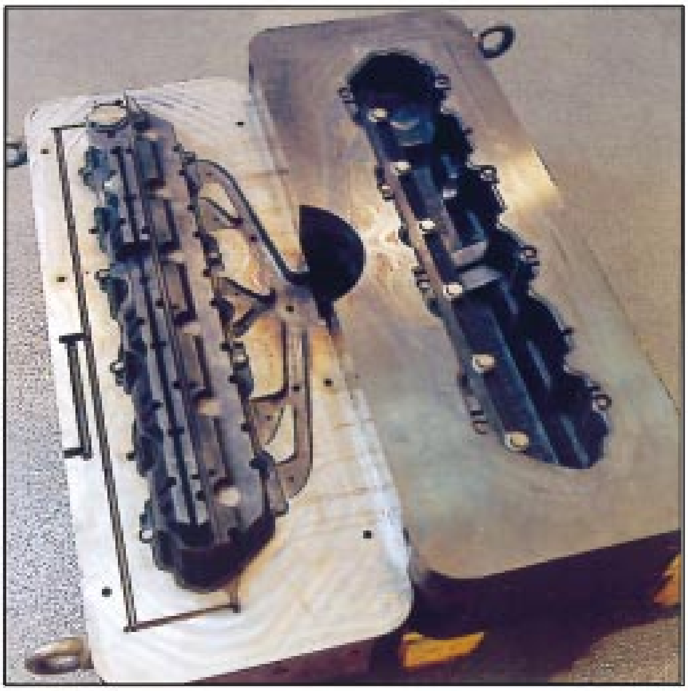
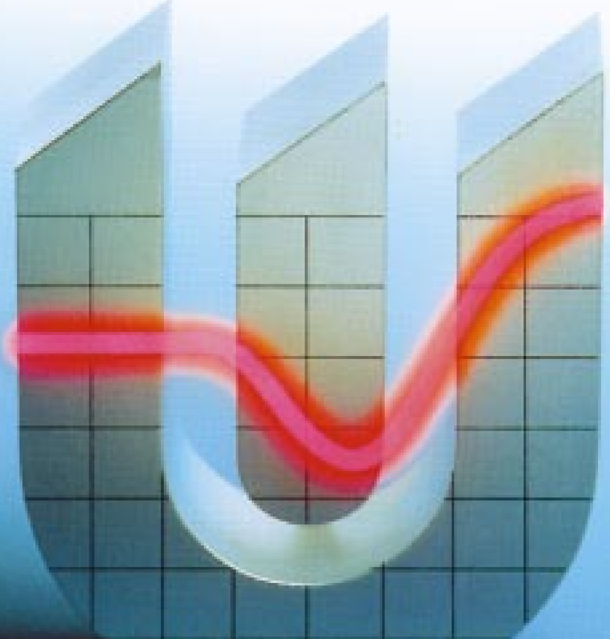


ORVAR® SUPREME

Premium hot work tool steel



UDDEHOLM

Great Tooling Starts Here!

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					
Color 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 or exceeds the North American Die Casting Association (NADCA) #207-97 for **premium** high quality H-13 die steel.

The charpy V-notch impact toughness is certified to meet a minimum average of 10 ft - lbs.

Applications

TOOLS FOR DIE CASTING

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

TOOLS FOR EXTRUSION

Part	Aluminum, 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.)	1870–1885°F (1020–1030°C)	1900–1920°F (1040–1050°C)	

TOOLS FOR HOT PRESSING

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

MOLDS FOR PLASTICS

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

OTHER APPLICATIONS

Application	Austenitizing temp.	HRC
Severe cold punching, scrap shears	1870–1885°F (1020–1030°C) Tempering 480°F (250°C)	50–52
Hot shearing	1870–1885°F (1020–1030°C) Tempering 1. 480°F (250°C) or 2. 1070–1110°F (575–600°C)	50–52 45–50
Shrink rings (e.g. for cemented carbide dies)	1870–1885°F (1020–1030°C) Tempering 1070–1110°F (575–600°C)	45–50
Wear-resisting parts	1870–1885°F (1020–1030°C) Tempering 1070°F (575°C) Nitriding	Core 50–52 Surface ~1000HV$_1$

Properties

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

PHYSICAL DATA

Data at room and elevated temperatures.

Temperature	68°F (20°C)	750°F (400°C)	1110°F (600°C)
Density lbs/in^3 kg/m^3	 0.281 7 800	 0.277 7 700	 0.274 7 600
Modulus of elasticity psi MPa	 30.5 x 10^6 210 000	 26.1 x 10^6 180 000	 20.3 x 10^6 140 000
Coefficient of thermal expansion per °F from 68°F °C from 20°C	 – –	 7.0 x 10^{-6} 12.6 x 10^{-6}	 7.3 x 10^{-6} 13.2 x 10^{-6}
Thermal conductivity Btu in/(ft^{2}h°F) W/m °C	 176 25	 204 29	 211 30

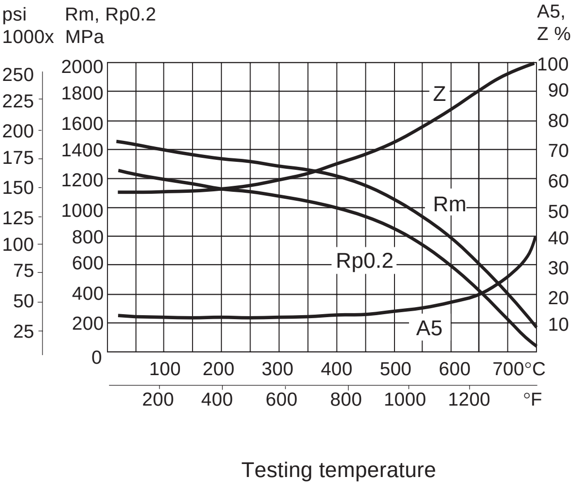
MECHANICAL PROPERTIES

Approximate tensile strength at room temperature.

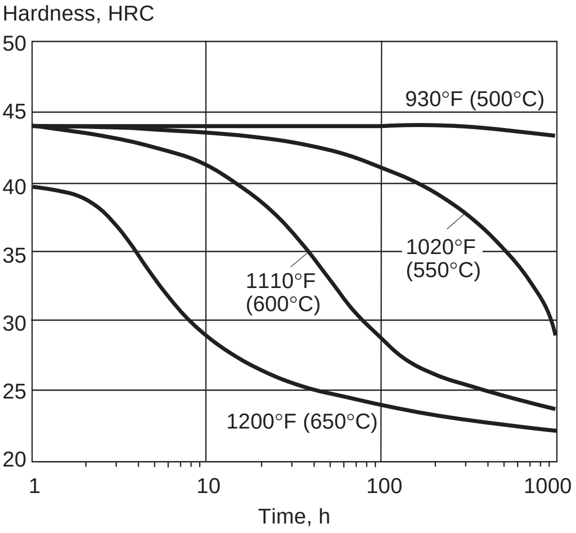
Hardness	52 HRC	45 HRC
Tensile strength Rm	263 000 psi 117 tsi 1820 MPa 185 kp/mm^2	206 000 psi 92 tsi 1420 MPa 145 kp/mm^2
Yield strength Rp0.2	220 000 psi 98 tsi 1520 MPa 155 kp/mm^2	185 000 psi 83 tsi 1280 MPa 130 kp/mm^2

Approximate strength at elevated temperatures

Longitudinal direction.

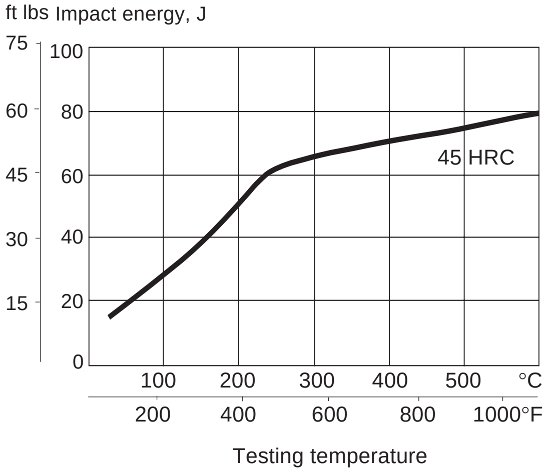


Effect of time at high temperatures on hardness



Effect of testing temperature on impact energy

Charpy V specimens, short transverse direction.



Heat treatment–general recommendations

SOFT ANNEALING

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

STRESS RELIEVING

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

HARDENING

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

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

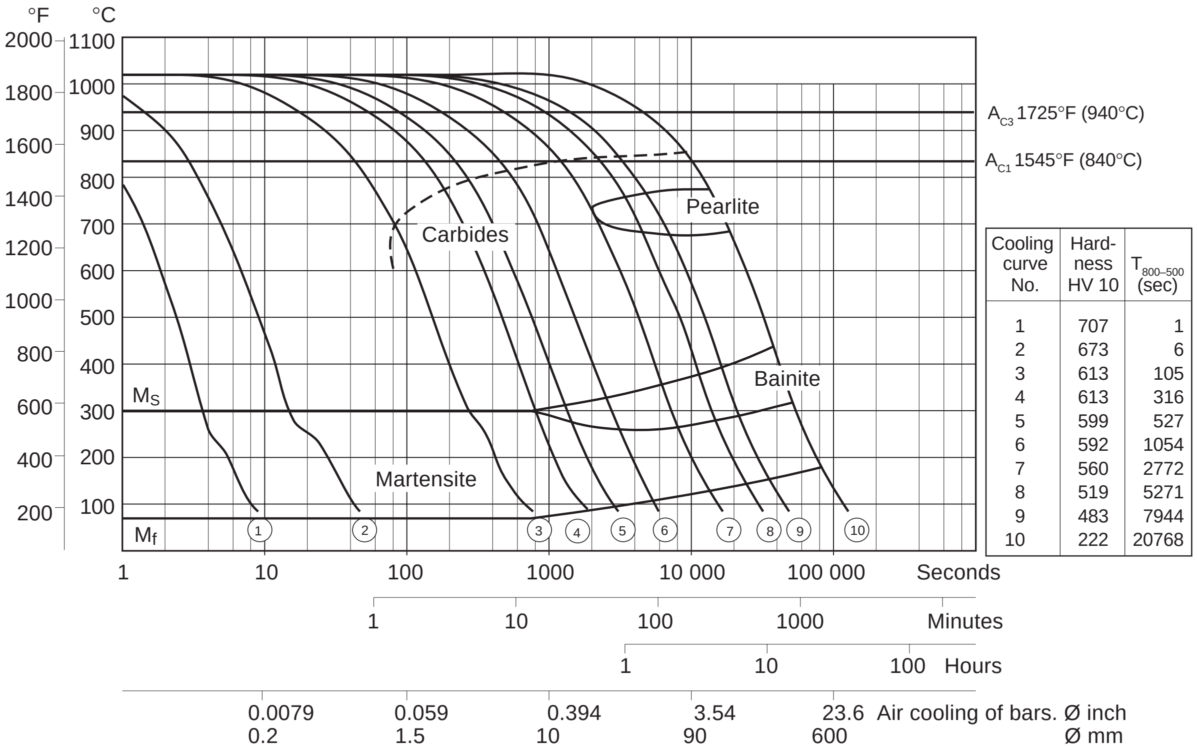
Temperature		Soaking* time minutes	Hardness before tempering
°F	°C		
1875	1025	30	53±2 HRC
1920	1050	15	54±2 HRC

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

Protect the part against decarburization and oxidation during hardening.

CCT graph

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



Cooling curve No.	Hard-ness HV 10	$T_{800-500}$ (sec)
1	707	1
2	673	6
3	613	105
4	613	316
5	599	527
6	592	1054
7	560	2772
8	519	5271
9	483	7944
10	222	20768

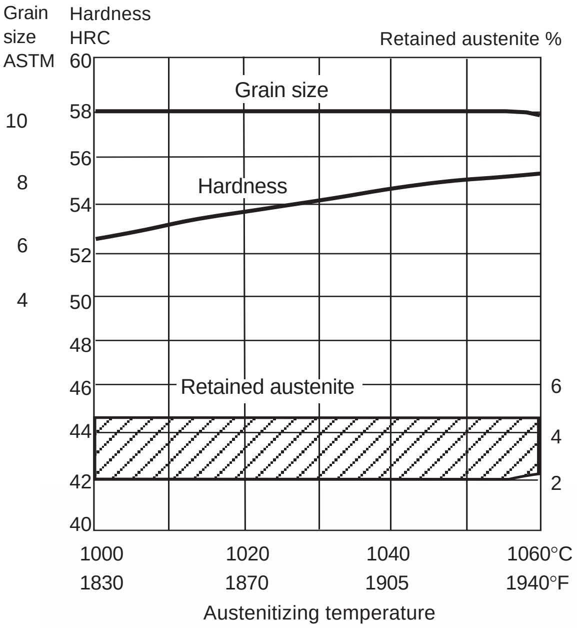
QUENCHING MEDIA

- 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 840–1020° F (450–550° C), then cool in air
- Martempering bath or fluidized bed at approx. 360–430° F (180–220° C) then cool in air
- Warm oil.

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

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.

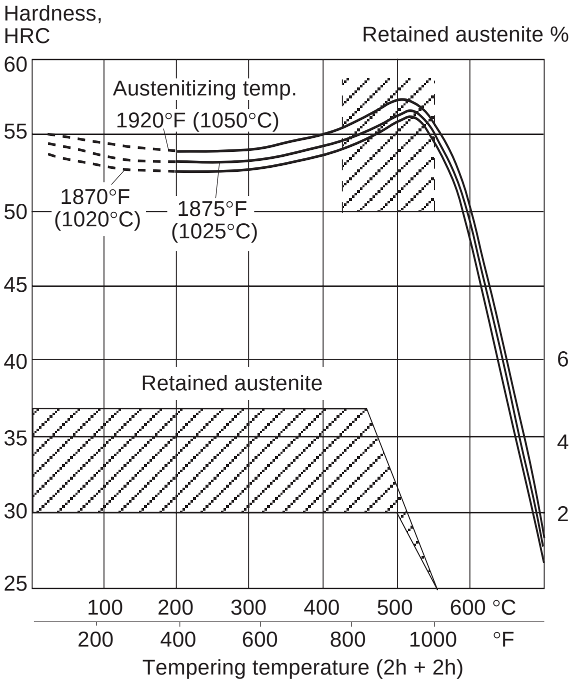
Hardness, grain size and retained austenite as functions of austenitizing temperature



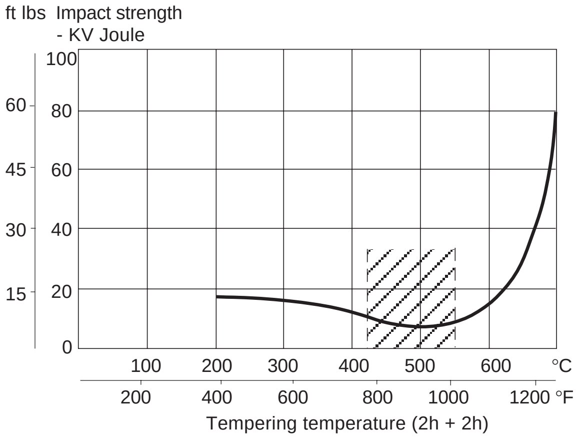
TEMPERING

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 480° F (250° C). Holding time at temperature minimum 2 hours. To avoid "temper brittleness", do not temper in the range 800–1020° F (425–550° C), see graph.

Tempering graph



Approximate impact strength at different tempering temperatures.
Charpy V specimens, short transverse direction.



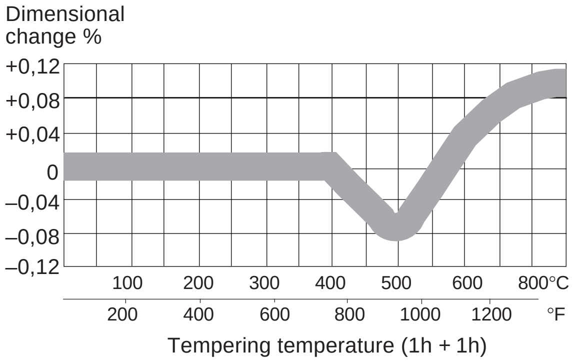
Tempering within the range 800–1020° F (425–550° C) is normally not recommended due to the reduction in toughness properties.

DIMENSIONAL CHANGES DURING HARDENING

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

		Width %	Length %	Thickness %
Oil hardened from	Min.	–0.08	–0.06	±0
1870°F (1020°C)	Max.	–0.15	–0.16	+0.30
Air hardened from	Min.	–0.02	–0.05	±0
1870°F (1020°C)	Max.	+0.03	+0.02	+0.05
Vac hardened from	Min.	+0.01	–0.02	+0.08
1870°F (1020°C)	Max.	+0.02	–0.04	+0.12

DIMENSIONAL CHANGES DURING TEMPERING



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 90° F (50° C) above the nitriding temperature.

Nitriding in ammonia gas at 950° F (510° C) or plasma nitriding in a 75% hydrogen/25% nitrogen mixture at 895° F (480° C) 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 inch	mm
Gas nitriding at 950°F (510°C)	10 h 30 h	0.0047 0.0079	0.12 0.20
Plasma nitriding at 895°F (480°C)	10 h 30 h	0.0047 0.0071	0.12 0.18
Nitrocarburizing – in gas at 1075°F (580°C)	2.5 h	0.0043	0.11
– in salt bath at 1075°F (580°C)	1 h	0.0024	0.06

Nitriding to case depths >0.012 inch (>0.3 mm) 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 Rough turning	 Fine turning	Turning with high speed steel Fine turning
Cutting speed (v_c) f.p.m. m/min	 500–665 150–200	 665–835 200–250	 100 30
Feed (f) i.p.r. mm/r	 0.012–0.024 0.3–0.6	 –0.012 –0.3	 –0.012 –0.3
Depth of cut (a_p) inch mm	 0.08–0.24 2–6	 –0.08 –2	 –0.08 –2
Carbide designation US ISO	 C5–C6 P20–P30 Coated carbide	 C7 P10 Coated carbide or cermet	 – –

MILLING

Face milling and square shoulder face milling

Cutting data parameters	Milling with carbide Rough milling	 Fine milling	Milling with high speed steel Fine milling
Cutting speed (v_c) f.p.m. m/min	 535–700 160–210	 700–930 210–280	 115 35
Feed (f_z) inch/tooth mm/tooth	 0.008–0.016 0.2–0.4	 0.004–0.008 0.1–0.2	 –0.004 –0.1
Depth of cut (a_p) inch mm	 0.08–0.20 2–5	 –0.08 –2	 –0.08 –2
Carbide designation US ISO	 C5–C6 P20–P40 Coated carbide	 C6–C7 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) f.p.m. m/min	 235 70	 435–600 130–180	 115[1] 35[1]
Feed (f_z) inch/tooth mm/tooth	 0.001–0.008[2] 0.03–0.20[2]	 0.003–0.008[2] 0.08–0.20[2]	 0.002–0.014[2] 0.05–0.35[2]
Carbide designation US ISO	 C3, C5 K10, P40	 C5, C6 P20, P30	 –

[1] *For coated HSS end mill v_c ~150 f.p.m. (45 m/min.).*
[2] *Depending on radial depth of cut and cutter diameter.*

DRILLING

High speed steel twist drill

Drill diameter inch	 mm	Cutting speed, v_c f.p.m.	 m/min	Feed, f i.p.r.	 mm/r
–3/16	– 5	56*	17*	0.003–0.008	0.08–0.20
3/16–3/8	5–10	56*	17*	0.008–0.012	0.20–0.30
3/8–5/8	10–15	56*	17*	0.012–0.014	0.30–0.35
5/8–3/4	15–20	56*	17*	0.014–0.016	0.35–0.40

*) *For coated HSS drill v_c ~80 f.p.m. (24 m/min.).*

Carbide drill

Cutting data parameters	Type of drill Indexable insert	 Solid carbide	 Brazed carbide[1]
Cutting speed (v_c) f.p.m. m/min	 600–735 180–220	 265 80	 200 60
Feed (f) i.p.r. mm/r	 0.001–0.004[2] 0.03–0.10[2]	 0.004–0.010[2] 0.10–0.25[2]	 0.006–0.010[2] 0.15–0.25[2]

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

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm brochure “Grinding of Tool Steel”.

Wheel recommendation

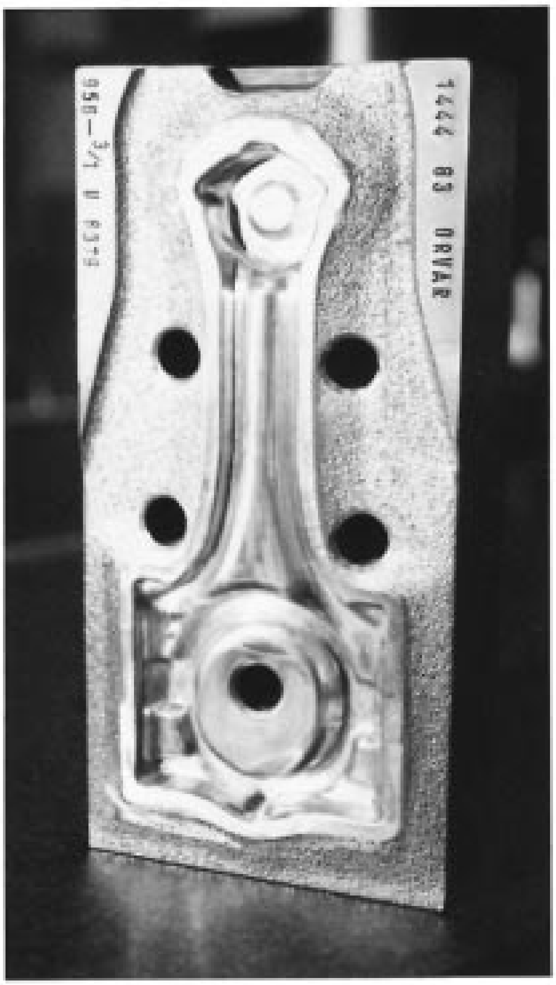
Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 GV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 JV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 JV

Welding

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

Welding method	TIG	MMA
Working temperature	620–710°F 325–375°C	620–710°F 325–375°C
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 50°F (25°C) below the original tempering temperature.	
Soft annealed	Soft-anneal the material at 1560°F condition (850°C) in protected atmosphere. Then cool in the furnace at 20°F (10°C) per hour to 1200°F (650°C) 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. 50° F (25° C) below the previous tempering temperature.

Hard-chromium plating

After plating, parts should be tempered at 360° F (180° C) 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 sulfur 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 aluminum 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.