

QRO[®] 90 SUPREME

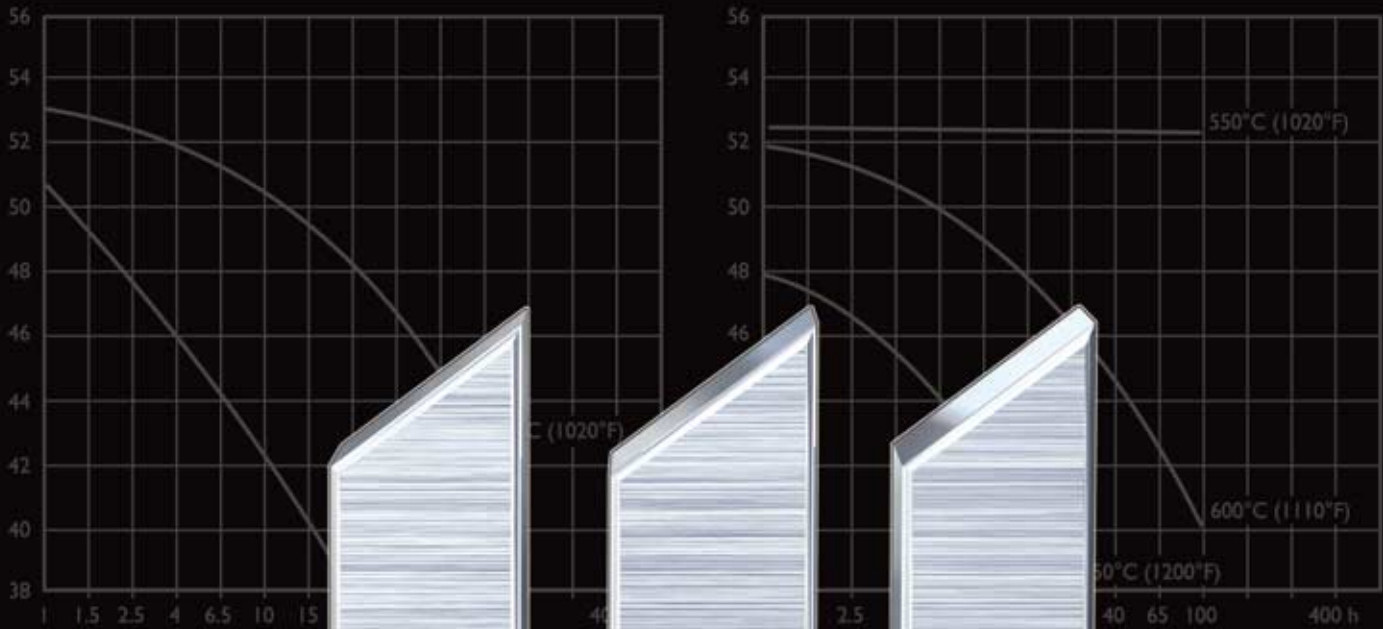
Hot work tool steel

COLD WORK

PLASTIC MOULDING

HOT WORK

HIGH PERFORMANCE STEEL



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

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m ³ lbs/m ³	7 770 0,281	7 770 0,277	7 650 0,275
Modulus of elasticity N/mm ² psi	194 000 28,1 × 10 ⁴	188 000 27,3 × 10 ⁴	173 000 25,1 × 10 ⁴
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

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 warranty for fitness for a particular purpose.

General

QRO 90 Supreme is a high-performance, chromium-molybdenum-vanadium alloyed hot-work tool steel which is characterized by:

- Excellent high temperature strength and hot hardness
- Very good temper resistance
- Unique resistance to thermal fatigue
- Excellent thermal conductivity
- Good toughness and ductility in longitudinal and transverse directions
- Uniform machinability
- Good heat treatment properties

Typical analysis %	C 0,38	Si 0,30	Mn 0,75	Cr 2,6	Mo 2,25	V 0,9
Standard specification	None. Product is covered by patent world wide					
Delivery condition	Soft annealed to approx. 180 HB					
Color code	Orange/light brown					

IMPROVED TOOLING PERFORMANCE

QRO 90 Supreme is a specially premium hot work steel developed by Uddeholm to provide better performance in high temperature tooling. The name "Supreme" implies that by special manufacturing techniques, including electro-slag remelting the steel attains high purity and good mechanical properties. This together with the optimum balance of alloying elements in QRO 90 Supreme gives a properties profile which is unique among hot work die steels. The combination of high temperature strength, temper resistance and thermal conductivity exhibited by QRO 90 Supreme is unparalleled.

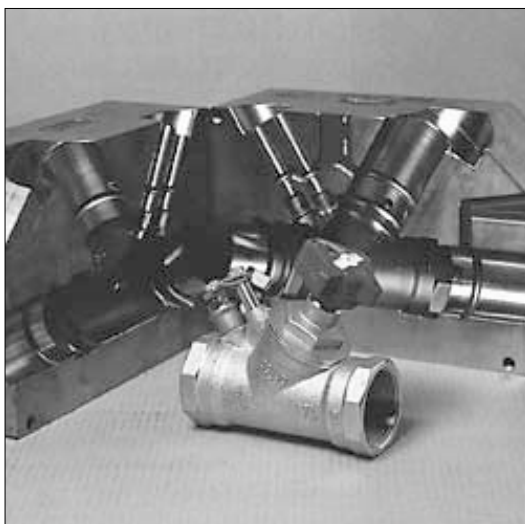


Photo: Bo Dahlgren

Thus QRO 90 Supreme has given improved service life in die casting and extrusion of nonferrous metals and forging and extrusion of steel.

Applications

DIE CASTING DIES AND ASSOCIATED TOOLING

QRO 90 Supreme will normally out-perform other standard hot work steels in both aluminum, brass and copper die casting. Its excellent high temperature strength ensures suppression of heat checking and prolonged die life.

Furthermore its high thermal conductivity gives the opportunity to reduce the cycle time and improve productivity.

QRO 90 Supreme can be used for parts where resistance against heat checking, erosion and bending is required. Typical applications are cores, core pins, inserts, small- to medium-sized dies, shot sleeves, moving parts for aluminum, brass and copper die casting.

EXTRUSION DIES AND EXTRUSION TOOLING

In aluminum extrusion QRO 90 Supreme is recommended for dies when the extruded tonnage is likely to exceed the die life for a standard tool steel e.g.:

- Dies for simple profiles to be produced in long series requiring more than one die
- Dies for complicated or thin walled profiles
- Hollow dies
- Dies for difficult-to-extrude alloys

For extrusion tooling components e.g. liners, dummy blocks, mandrels and stems QRO 90 Supreme gives an improved tool life compared to AISI H13 in aluminum and steel extrusion.

In brass and copper extrusion QRO 90 Supreme has given improved tool life for dummy blocks and die holders compared to AISI H13.

Similar improvements have also been made with liners in QRO 90 Supreme for brass extrusion.

FORGING DIES

QRO 90 Supreme has given many outstanding results for pressforging of steel, and brass, particularly in small- and medium-sized dies. The product is also eminently suitable for progressive forging, upset forging, extrusion forging, powder forging and all processes where heavy water cooling is used.

Properties

All specimens are taken from the centre of a 14" x 5" (356 x 127 mm) bar. Unless otherwise is indicated all specimens were hardened 30 minutes at 1885°F (1030°C), quenched in air and tempered 2 + 2h at 1190°F (645°C). The hardness were 45 ±1 HRC.

PHYSICAL DATA

Hardened and tempered to 45 HRC.
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 N/mm ²	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	- -	230 33	230 33

MECHANICAL PROPERTIES

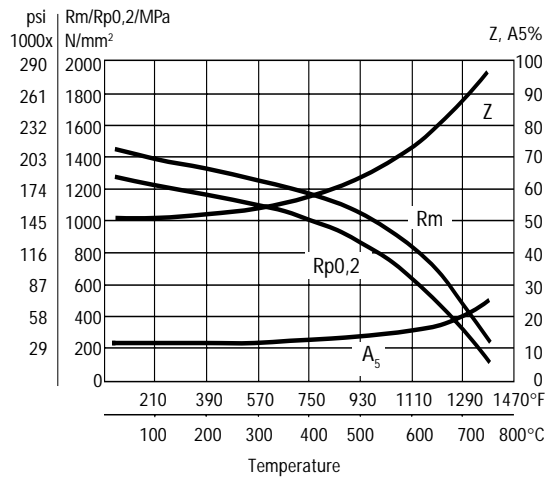
Approximate tensile strength at room temperature.

Hardness	48 HRC	45 HRC	40 HRC
Tensile strength Rm	1620 N/mm ² 165 kp/mm ² 105 tsi 235 000 psi	1470 N/mm ² 150 kp/mm ² 95 tsi 213 000 psi	1250 N/mm ² 128 kp/mm ² 81 tsi 181 000 psi
Yield strength Rp0,2	1400 N/mm ² 143 kp/mm ² 91 tsi 203 000 psi	1270 N/mm ² 130 kp/mm ² 82 tsi 184 000 psi	1100 N/mm ² 112 kp/mm ² 71 tsi 160 000 psi

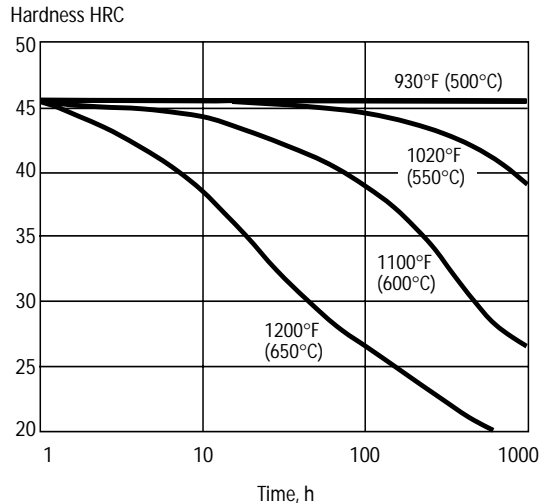


Approximate strength at elevated temperatures

Longitudinal direction

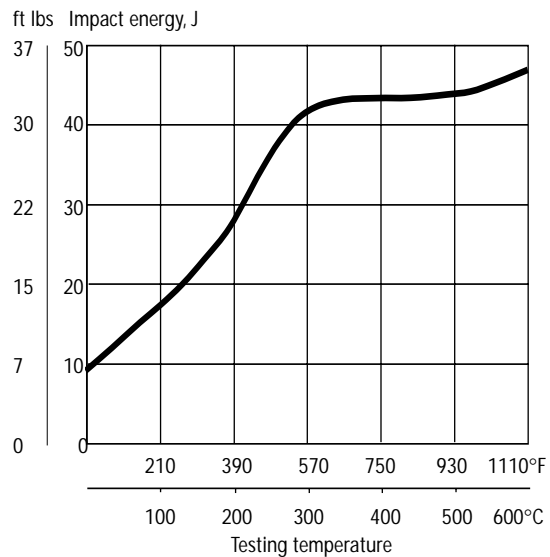


Effect of time at high temperatures on hardness



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 1500°F (820°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).

Temperature °F °C		Soaking* time minutes	Hardness before tempering
1870	1020	30	51±2 HRC
1920	1050	15	52±2 HRC

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

Protect the part against decarburization and oxidation during hardening.

QUENCHING MEDIA

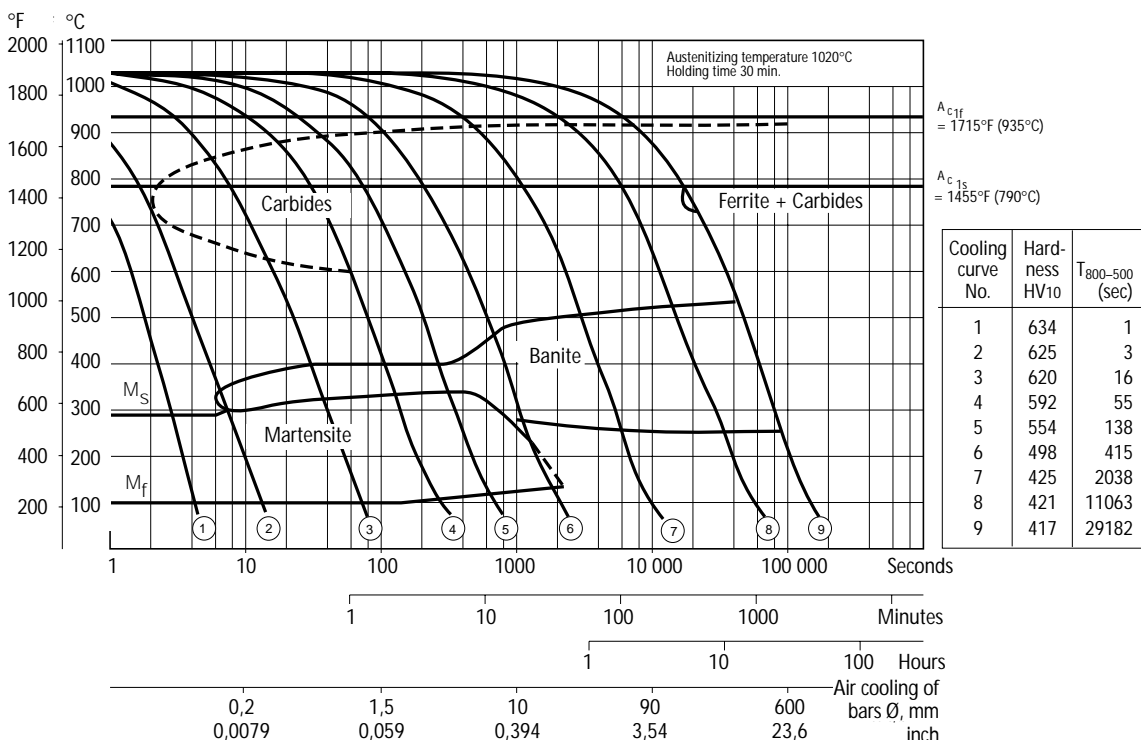
- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench is recommended
- Martempering bath or fluidized bed at 1020°F (550°C)
- Martempering bath or fluidized bed at approx. 360–430°F (180–220°C)
- Warm oil

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

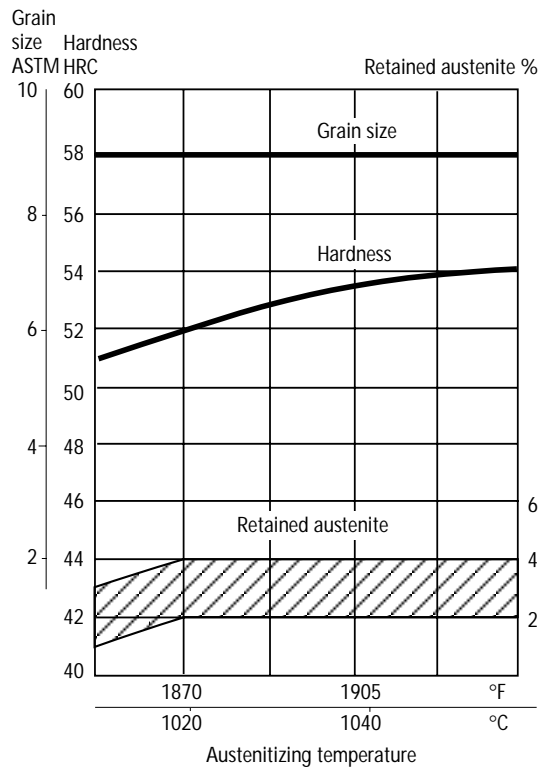
Note 2: In order to obtain the optimum properties for the tool, the cooling rate should be fast but not at a level that gives excessive distortion or cracks.

CCT graph

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



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

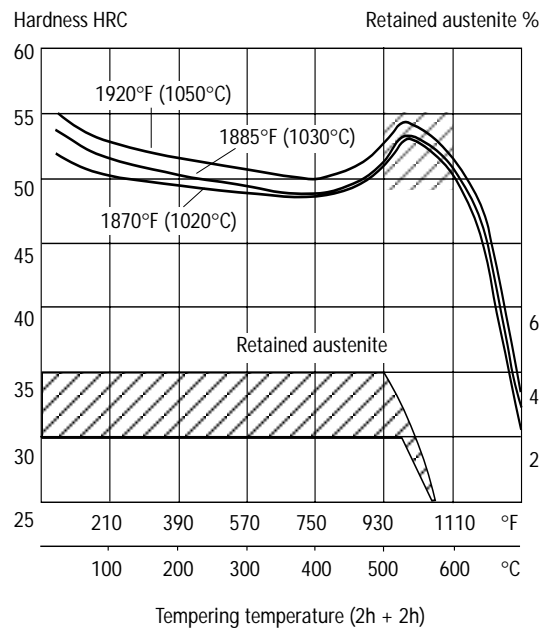


TEMPERING

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 1110°F (600°C). Holding time at temperature minimum 2 hours. To avoid “temper brittleness” do not temper in the range 500–600°C (930–1110°F).

Tempering graph

Air cooling of specimens 1" x 1" x 1 1/2" (25 x 25 x 40 mm). Larger sections, which contain bainite after hardening, are characterized by a lower initial hardness and displacement of the secondary-hardening peak to higher temperatures. During overtempering, however, the curves are more or less identical from about 45 HRC down, irrespective of section size.



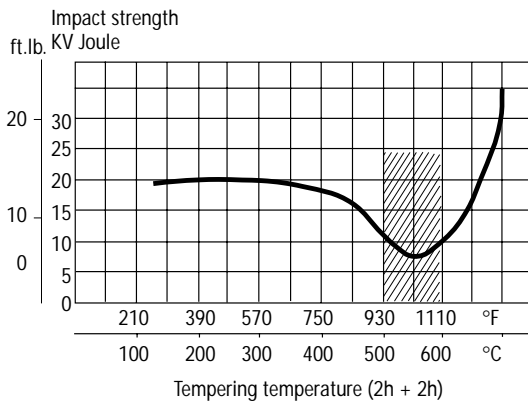
Core pins in QRO 90 HT (prehardened QRO 90 Supreme)



Shot sleeves in QRO 90 Supreme

Approximate impact strength at different tempering temperatures

Longitudinal specimens, heat treated after machining.



Tempering within the range 930–1110°F (500–600°C) is normally not recommended due to the reduction in toughness properties.

DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING

During hardening and tempering the die is exposed to thermal as well as transformation stresses. This will inevitably result in dimensional changes and in the work case distortion. It is therefore recommended to always leave a machining allowance after machining before the die is hardened and tempered. Normally the size in the largest direction will shrink and the size in the smallest direction might increase but this is also a matter of the die size, the die design as well as the cooling rate after hardening.

For QRO 90 Supreme it is recommended to leave a machining allowance of 0,3 per cent of the dimension in length, width and thickness.

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 50–90°F (25–50°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 1000 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.

QRO 90 Supreme can also be nitrocarburized in either gas or salt bath. The surface hardness after nitrocarburizing is 800–900 HV_{0,2}.

DEPTH OF NITRIDING

Process	Time	Depth	
		inch	mm
Gas nitriding at 950°F (510°C)	10 h	0,0063	0,16
	30 h	0,0106	0,27
Plasma nitriding at 895°F (480°C)	10h	0,0070	0,18
	30 h	0,0106	0,27
Nitrocarburizing – in gas at 1075°F (580°C)	2,5 h	0,0078	0,20
	1 h	0,0051	0,13

Nitriding to case depths >0,012 inch (0,3 mm) is not recommended for hot-work applications. It should be noted that QRO 90 Supreme exhibits better nitridability than AISI H13. For this reason, the nitriding times for QRO 90 Supreme should be shortened in relation to H13, otherwise there is considerable risk that the case depth will be too great.

QRO 90 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. More information can be found in the Uddeholm publication "Cutting data recommendations".

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS Fine turning
	Rough turning	Fine turning	
Cutting speed (v_c) f.p.m. m/min	656–820 200–250	820–984 250–300	82–98 25–30
Feed (f) i.p.r. mm/r	0,01–0,024 0,3–0,6	0,002–0,008 0,05–0,2	0,002–0,01 0,05–0,3
Depth of cut (a_p) inch mm	0,08–0,16 2–4	0,02–0,08 0,5–2	0,02–0,08 0,5–2
Carbide designation US ISO	C6–C5 P20–P30 Coated carbide	C7–C6 P10–P20 Coated carbide or cermet	– –

DRILLING

High speed steel twist drill

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

* For coated HSS drill $v_c = 92–98$ f.p.m. (28–30 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	722–787 220–240	427–525 130–160	262–361 80–110
Feed, f i.p.r. mm/r	0,002–0,01 ²⁾ 0,05–0,25 ²⁾	0,004–0,01 ²⁾ 0,1–0,25 ²⁾	0,006–0,01 ²⁾ 0,15–0,25 ²⁾

¹⁾ Drill with internal cooling channels and brazed carbide 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) f.p.m. m/min	590–853 180–260	853–984 260–300
Feed (f_z) inch/tooth mm/tooth	0,008–0,016 0,2–0,4	0,004–0,008 0,1–0,2
Depth of cut (a_p) inch mm	0,08–0,2 2–5	–0,08 –2
Carbide designation US ISO	C6–C5 P20–P40 Coated carbide	C7–C6 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) f.p.m. m/min	525–656 160–200	558–755 170–230	115–131 ¹⁾ 35–40 ¹⁾
Feed (f_z) inch/tooth mm/tooth	0,001–0,008 ²⁾ 0,03–0,2 ²⁾	0,003–0,008 ²⁾ 0,08–0,2 ²⁾	0,002–0,014 ²⁾ 0,05–0,35 ²⁾
Carbide designation US ISO	– –	C6–C5 P20–P30	– –

¹⁾ For coated HSS end mill $v_c = 180–197$ f.p.m. (55–60 m/min.)

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 publication "Grinding of Tool Steel".

Wheel recommendation

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24GV	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 JV

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.

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	620–710°F (325–375°C)	620–710°F (325–375°C)
Filler metals	QRO 90 TIG-WELD	QRO 90 WELD
Post welding cooling	35–70°F/h (20–40°C/h) for the first 2–3 hours and then freely in air.	
Hardness after welding	50–55 HRC	50–55 HRC
Heat treatment after welding		
Hardened condition	Temper at 20–40°F (10–20°C) below the original tempering temp.	
Soft annealed condition	Soft-anneal the material at 1500°F (820°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”.

Hard-chromium plating

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

Further information

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



Dummy blocks in QRO 90 Supreme