QRO 90 SUPREME

UDDEHOLM QRO 90 SUPREME

ASSAB	UDDEHOLM a voestalpine company	REFERENCE STANDARD		
		AISI	WNr.	JIS
ASSAB DF-3	ARNE	O1	1.2510	SKS 3
ASSAB XW-10	RIGOR	A2	1.2363	SKD 12
ASSAB XW-42	SVERKER 21	D2	1.2379	(SKD 11)
CALMAX / CARMO	CALMAX / CARMO		1.2358	
VIKING	VIKING / CHIPPER		(1.2631)	
CALDIE	CALDIE			
ASSAB 88	SLEIPNER			
ASSAB PM 23 SUPERCLEAN	VANADIS 23 SUPERCLEAN	(M3:2)	1.3395	(SKH 53)
ASSAB PM 30 SUPERCLEAN	VANADIS 30 SUPERCLEAN	(M3:2 + Co)	1.3294	SKH 40
ASSAB PM 60 SUPERCLEAN	VANADIS 60 SUPERCLEAN		(1.3292)	
VANADIS 4 EXTRA SUPERCLEAN	VANADIS 4 EXTRA SUPERCLEAN			
VANADIS 8 SUPERCLEAN	VANADIS 8 SUPERCLEAN			
VANCRON SUPERCLEAN	VANCRON SUPERCLEAN			
ELMAX SUPERCLEAN	ELMAX SUPERCLEAN			
VANAX SUPERCLEAN	VANAX SUPERCLEAN			
ASSAB 518		P20	1.2311	
ASSAB 618 T		(P20)	(1.2738)	
ASSAB 618 / 618 HH		(P20)	1.2738	
ASSAB 718 SUPREME / 718 HH	IMPAX SUPREME / IMPAX HH	(P20)	1.2738	
NIMAX / NIMAX ESR	NIMAX / NIMAX ESR			
VIDAR 1 ESR	VIDAR 1 ESR	H11	1.2343	SKD 6
UNIMAX	UNIMAX			
CORRAX	CORRAX			
ASSAB 2083		420	1.2083	SUS 420J2
STAVAX ESR	STAVAX ESR	(420)	(1.2083)	(SUS 420J2)
MIRRAX ESR	MIRRAX ESR	(420)		
MIRRAX 40	MIRRAX 40	(420)		
TYRAX ESR	TYRAX ESR			
POLMAX	POLMAX	(420)	(1.2083)	(SUS 420J2)
ROYALLOY	ROYALLOY	(420 F)		
COOLMOULD	COOLMOULD			
ASSAB 2714			1.2714	SKT 4
ASSAB 2344		H13	1.2344	SKD 61
ASSAB 8407 2M	ORVAR 2M	H13	1.2344	SKD 61
ASSAB 8407 SUPREME	ORVAR SUPREME	H13 Premium	1.2344	SKD 61
DIEVAR	DIEVAR			
QRO 90 SUPREME	QRO 90 SUPREME			
FORMVAR	FORMVAR			

( ) - modified grade

Edition 20210913

GENERAL

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

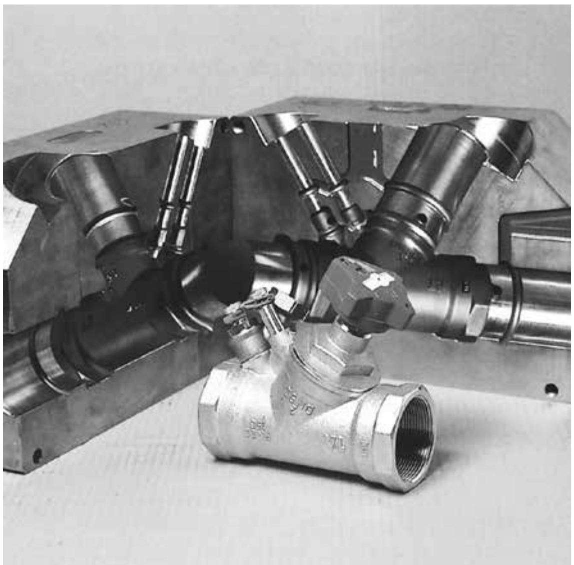
- Excellent high temperature strength and hot hardness
- Very good temper resistance
- Unique resistance to thermal fatigue
- Excellent thermal conductivity
- Good toughness and ductility in longitudinal and transverse directions
- Uniform machinability
- Good heat treatment properties

Typical analysis %	C 0.38	Si 0.30	Mn 0.75	Cr 2.6	Mo 2.25	V 0.9
Standard specification	None					
Delivery condition	Soft annealed to approx. 180 HB.					
Colour code	Orange/light brown					

IMPROVED TOOLING PERFORMANCE

QRO 90 Supreme is a specially premium hot work steel developed by ASSAB 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 steel.



The combination of high temperature strength, temper resistance and thermal conductivity, exhibited by QRO 90 Supreme is unparalleled. 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 steel in both aluminium, 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 aluminium, brass and copper die casting.

EXTRUSION DIES AND EXTRUSION TOOLING

In aluminium 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 aluminium 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 press forging 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 356 x 127 mm bar. Unless otherwise is indicated all specimens were hardened 30 minutes at 1030°C, quenched in air and tem-pered 2 + 2h at 645°C. The hardness were 45 ±1 HRC.

PHYSICAL DATA

Hardened and tempered to 45 HRC.
Data at room and elevated temperatures.

Temperature	20 °C	400 °C	600 °C
Density, kg/m³	7 800	7 700	7 600
Modulus of elasticity N/mm²	210 000	180 000	140 000
Coefficient of thermal expansion /°C from 20°C	-	12.6×10^{-6}	13.2×10^{-6}
Thermal conductivity* W/m °C	-	33	33

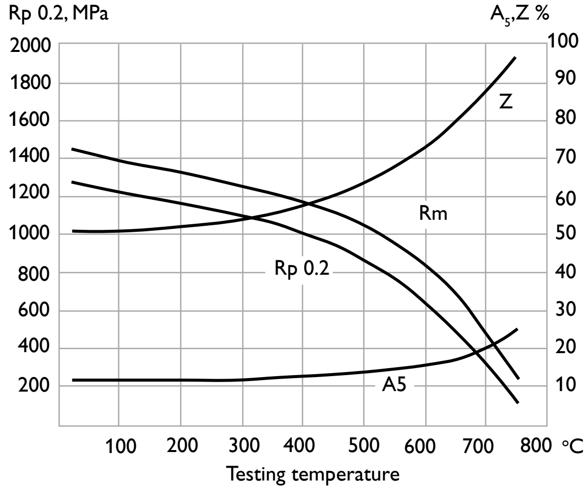
MECHANICAL PROPERTIES

Approximate tensile strength at room temperature.

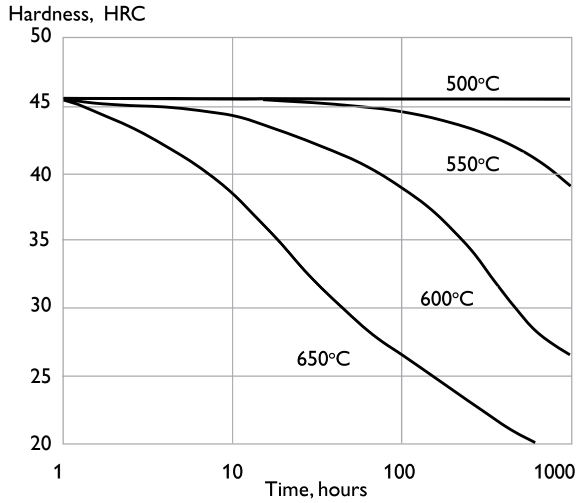
Temperature	48 HRC	45 HRC	40 HRC
Tensile strength, R_m MPa	1 620	1 470	1 250
Yield point Rp0.2 MPa	1 400	1 270	1 100

TENSILE PROPERTIES AT ELEVATED TEMPERATURE

LONGITUDINAL DIRECTION.

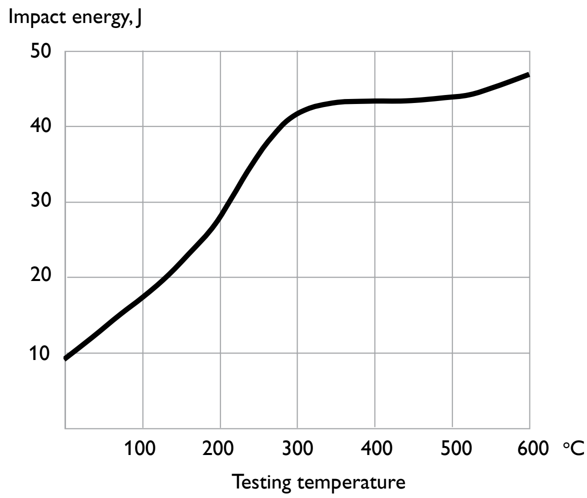


EFFECT OF TIME AT HIGH TEMPERATURES ON HARDNESS



EFFECT OF TESTING TEMPERATURE ON IMPACT ENERGY

CHARPY V SPECIMENS, SHORT TRANSVERSE DIRECTION



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 820 °C. Then cool in furnace at 10 °C per hour to 650 °C, then freely in air.

STRESS RELIEVING

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

HARDENING

Pre-heating temperature: 600–850°C normally in two pre-heating steps.
Austenitising temperature: 1020–1050°C.

Temperature °C	Soaking time* minutes	Hardness before tempering HRC
1 020	30	51±2
1 050	15	52±2

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

Protect the part against decarburisation and oxidation during hardening.

QUENCHING MEDIA

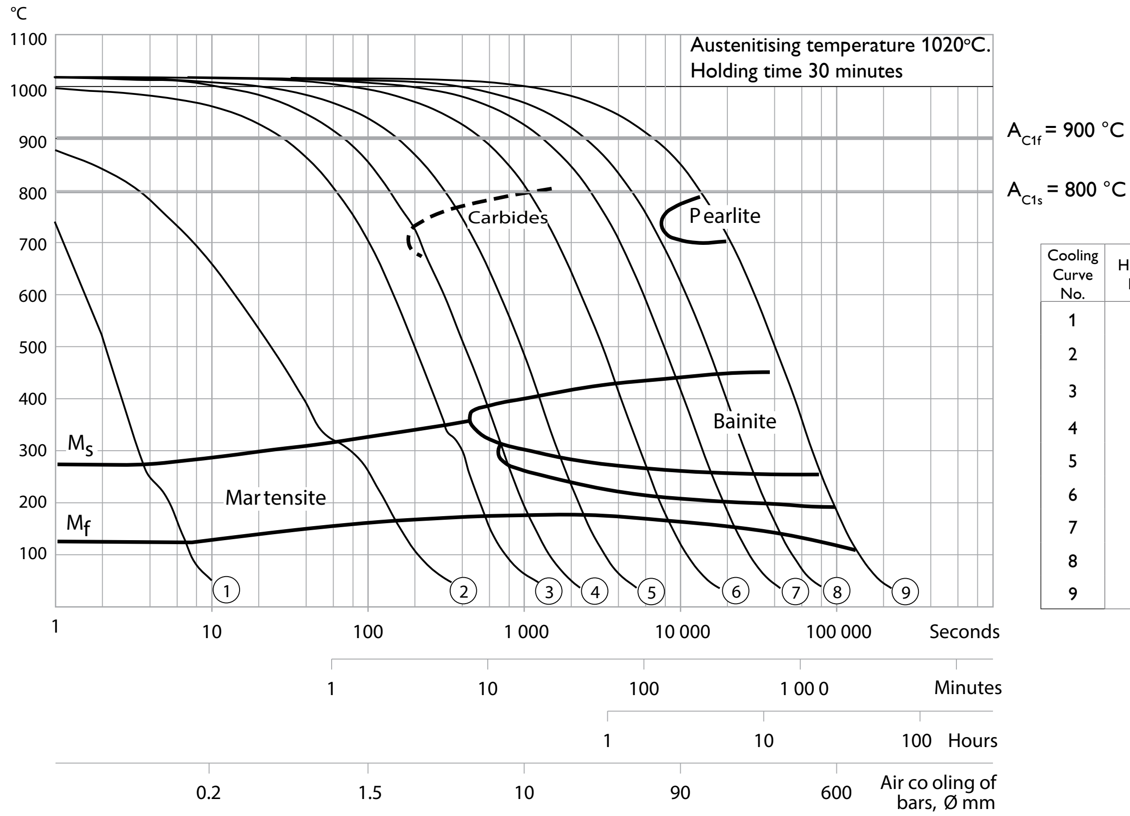
- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench is recommended
- Martempering bath or fluidized bed at 550°C
- Martempering bath or fluidized bed at 180–220°C
- Warm oil

Note 1: Temper the tool as soon as its temperature reaches 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.

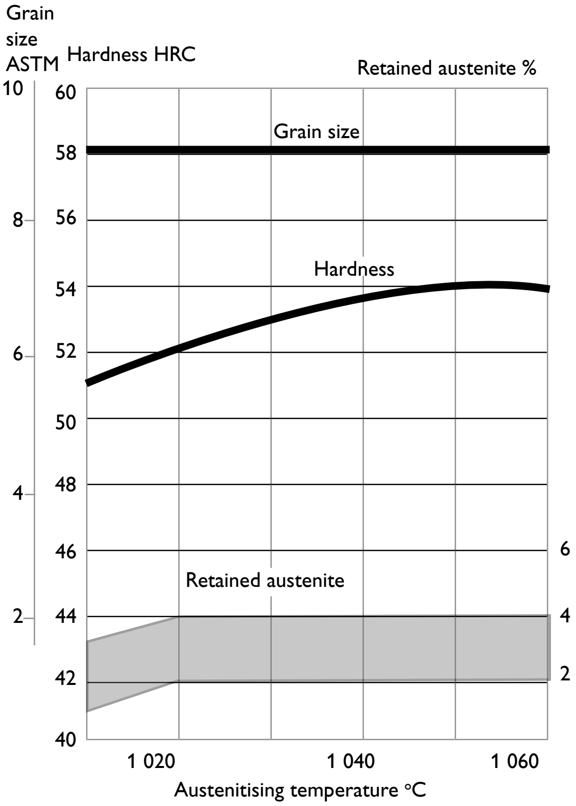
CCT-GRAPH

Austenitising temperature 1020 °C. Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ sec
1	642	1
2	606	28
3	606	140
4	585	280
5	542	630
6	450	2 3 25
7	450	5 215
8	429	11 063
9	429	32 840

HARDNESS, GRAIN SIZE AND RETAINED AUSTENITE AS FUNCTIONS OF AUSTENITISING TEMPERATURE



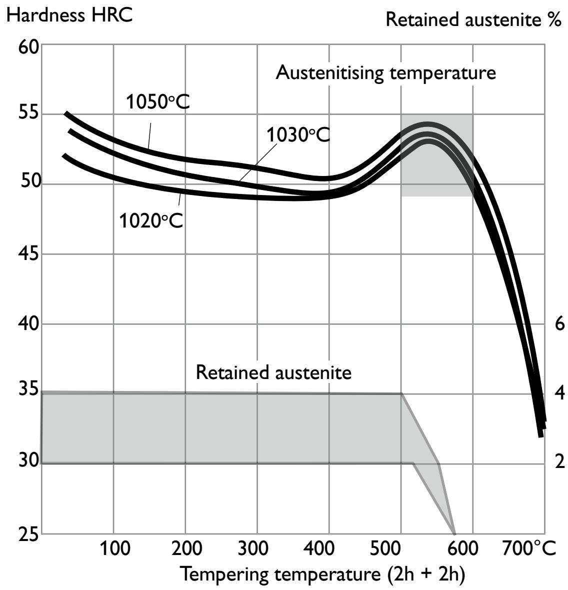
TEMPERING

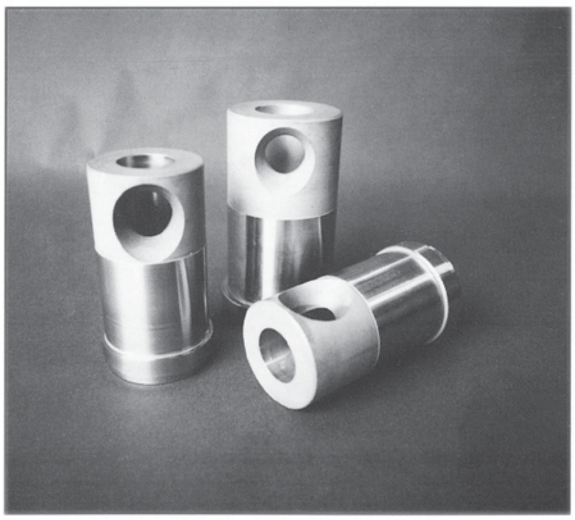
Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper minimum twice with intermediate cooling to room temperature. Lowest tempering temperature 600°C. Holding time at temperature minimum 2 hours. To avoid "temper brittleness" do not temper in the range 500–600°C.

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

TEMPERING GRAPH

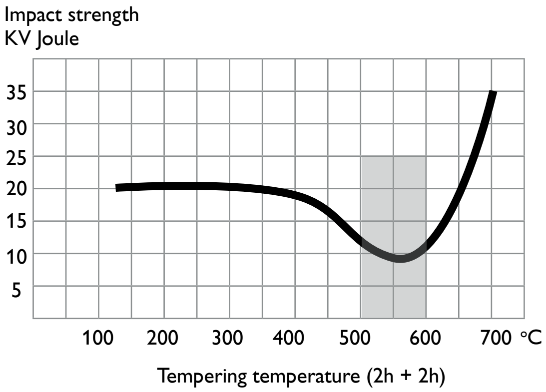
Air cooling of specimens 25 x 25 x 40 mm. Larger sections, which contain bainite after hardening, are characterised by a lower initial hardness and displacement of the secondary hardening peak to higher temperatures.
During overtempering, however, the curves are more or less identical from about 45 HRC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





Shot sleeves in QRO 90 Supreme.

APPROXIMATE IMPACT STRENGTH AT DIFFERENT TEMPERING TEMPERATURES



Tempering within the range 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 can give same results.

NITRIDING AND NITROCARBURISING

Nitriding and nitrocarburising 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 minimum 25–50°C above the nitriding temperature.

Nitriding in ammonia gas at 510°C or plasma nitriding in a 75% hydrogen/25% nitrogen mixture at 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.

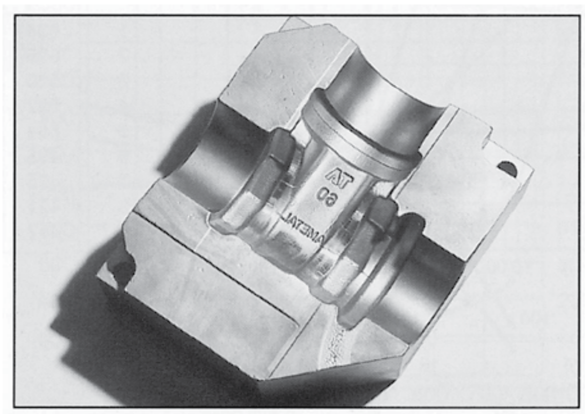
QRO 90 Supreme can also be nitrocarburised in either gas or salt bath. The surface hardness after nitrocarburizing is 800–900 $HV_{0.2}$.

DEPTH OF NITRIDING

Process	Time	Depth*
Gas nitriding at 510 °C	10 h 30 h	0.16 mm 0.27 mm
Plasma nitriding at 480 °C	10 h	0.18 mm
Nitrocarburising - in gas at 580 °C	2.5 h	0.20 mm
- in salt bath at 580 °C	1 h	0.13 mm

Nitriding to case depths >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.



Mould inserts

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	200 – 250	250 – 300	25 - 30
Feed (f) mm/rev	0.2 – 0.4	0.05 – 0.2	0.05 -0.3
Depth of cut (a_p) mm	2 – 4	0.5 – 2	0.5 - 2
Carbide designation ISO	P20 - P30 Coated carbide	P10 - P20 Coated carbide or cermet	-

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Cutting speed (v_C) m/min	Feed (f) mm/r
≤ 5	16 – 18 *	0.05 – 0.15
5 – 10	16 – 18 *	0.15 – 0.20
10 – 15	16 – 18 *	0.20 – 0.25
15 – 20	16 – 18 *	0.25 – 0.30

* For coated HSS drill v_c = 28 - 30 m/min.

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1)]
Cutting speed (v_C), m/min	220 – 240	130 – 160	80 – 110
Feed (f) mm/r	0.05 – 0.25 [2)]	0.10 – 0.25 [3)]	0.15 – 0.25 [4)]

[1)] Drill with replaceable or brazed carbide tip
[2)] Feed rate for drill diameter 20 – 40 mm
[3)] Feed rate for drill diameter 5 – 20 mm
[4)] Feed rate for drill diameter 10 – 20 mm

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_C) m/min	180 – 260	260 – 300
Feed (f_z) mm/tooth	0.2 – 0.4	0.1 – 0.2
Depth of cut (a_p) mm	2 – 5	< 2
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	160 – 200	170 – 230	35 – 40 [1)]
Feed (f_z) mm/tooth	0.03 – 0.20 [2)]	0.08 – 0.20 [2)]	0.05 – 0.35 [2)]
Carbide designation ISO	–	P10 – P20	–

[1)] For coated HSS end mill Vc = 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 publication ”Grinding of tool steel”.

Type of grinding	Soft annealed	Hardened
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 KV	A 120 JV

ELECTRICAL DISCHARGE MACHINING — EDM

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 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*	325 - 375 °C	325 - 375 °C
Filler metals	QRO 90 TIG Weld	QRO 90 Weld
Post welding cooling	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 10 – 20°C below the original tempering temperature	
Soft annealed condition	Soft-anneal the material at 820 °C in protected atmosphere. Then cool in the furnace at 10 °C per hour to 650 °C	

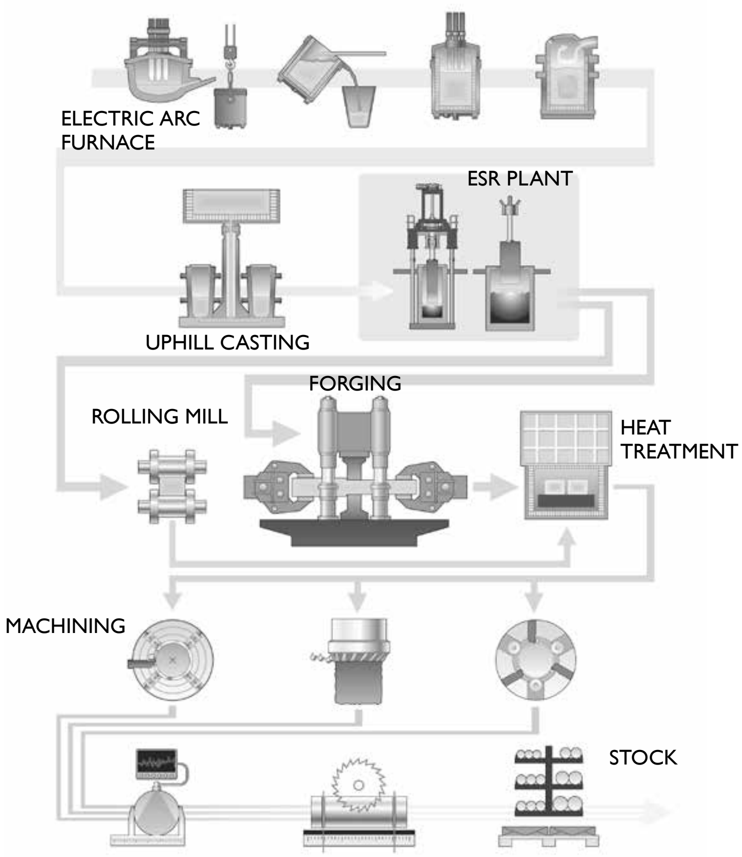
Dummy blocks in QRO 90 Supreme.

HARD CHROMIUM PLATING

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

FURTHER INFORMATION

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



THE ESR TOOL STEEL PROCESS

The starting material for our tool steel is carefully selected from high quality recyclable steel. Together with ferroalloys and slag formers, the recyclable steel is melted in an electric arc furnace. The molten steel is then tapped into a ladle.

The de-slagging unit removes oxygen-rich slag and after the de-oxidation, alloying and heating of the steel bath are carried out in the ladle furnace. Vacuum degassing removes elements such as hydrogen, nitrogen and sulphur.

ESR PLANT

In uphill casting the prepared moulds are filled with a controlled flow of molten steel from the ladle. From this, the steel can go directly to our rolling mill or to the forging press, but also to our ESR furnace where our most sophisticated steel grades are melted once again in an electro slag remelting process. This is done by melting a consumable electrode immersed in an overheated slag bath. Controlled solidification in the steel bath results in an ingot of high homogeneity, thereby removing macro segregation. Melting under a protective atmosphere gives an even better steel cleanliness.

HOT WORKING

From the ESR plant, the steel goes to the rolling mill or to our forging press to be formed into round or flat bars.

Prior to delivery all of the different bar materials are subjected to a heat treatment operation, either as soft annealing or hardening and tempering. These operations provide the steel with the right balance between hardness and toughness.

MACHINING

Before the material is finished and put into stock, we also rough machine the bar profiles to required size and exact tolerances. In the lathe machining of large dimensions, the steel bar rotates against a stationary cutting tool. In peeling of smaller dimensions, the cutting tools revolve around the bar.

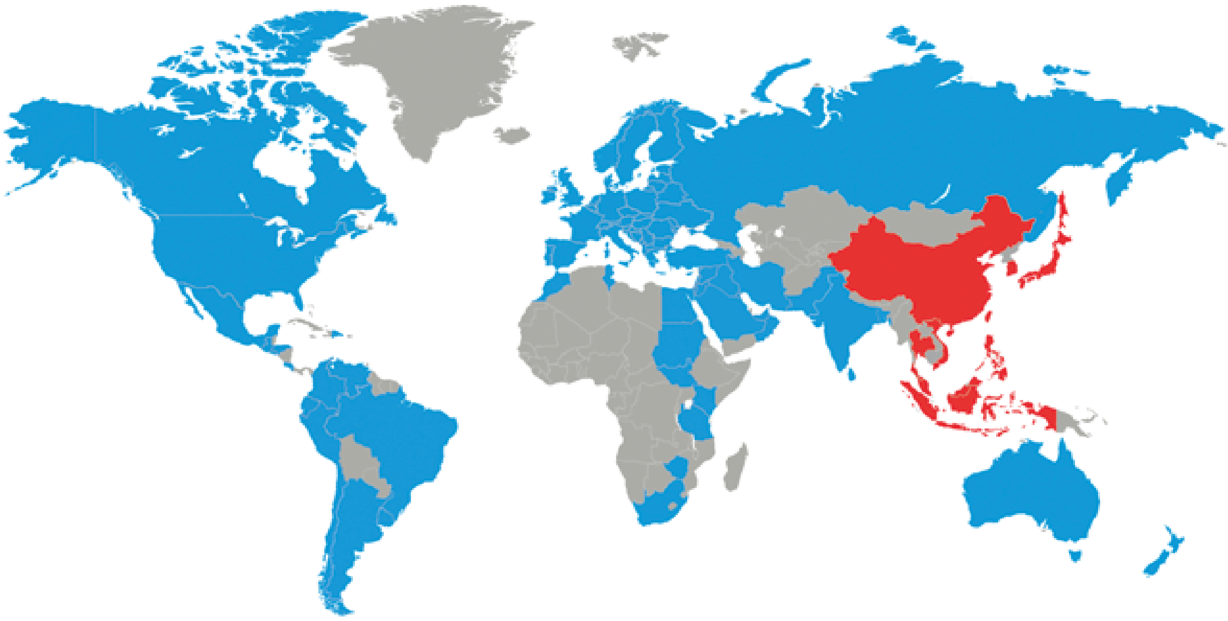
To safeguard our quality and guarantee the integrity of the tool steel we perform both surface - and ultrasonic inspections on all bars. We then remove the bar ends and any defects found during the inspection.

ASSAB

SUPERIOR TOOLING SOLUTIONS

A ONE-STOP SHOP

ASSAB is unmatched as a one-stop product and service provider that offers superior tooling solutions. In addition to the supply of tool steel and other special steel, our range of comprehensive value-added services, such as machining, heat treatment and coating services, span the entire supply chain to ensure convenience, accountability and optimal usage of steel for customers. We are committed to achieving solutions for our customers, with a constant eye on time-to-market and total tooling economy.



Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. ASSAB not only supplies steel products with superior quality, we offer state-of-the-art machining, heat treatment and surface treatment services to enhance steel properties to meet your requirement in the shortest lead time. Using a holistic approach as a one-stop solution provider, we are more than just another tool steel supplier.

ASSAB and Uddeholm are present on every continent. This ensures you that high quality tool steel and local support are available wherever you are. Together we secure our position as the world's leading supplier of tooling materials.

For more information, please visit
www.assab.com