DIEVAR

Uddeholm Dievar

ASSAB

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 / HH	IMPAX SUPREME / 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)
RAMAX HH	RAMAX HH	(420 F)		
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

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Edition 20190801

DIEVAR - The New Generation

The new generation of Dievar provides outstanding performance. The unique problem-solving chemistry, combined with the latest re-melting technology and new process improvements over the whole manufacturing route has resulted in a new level of very high toughness and ductility. The new generation of Dievar gives you the best of both worlds in its class:

- The classic chemistry of Dievar to fight heat checking or thermal fatigue
- The new class-leading toughness to use in bigger die inserts

The steel is suitable in high demand hot work applications like die casting, forging and extrusion. The property profile makes it also suitable in other applications, e.g. plastics and High Performance Steel.

Dievar offers the potential for significant improvements in die life, thereby improving the tooling economy.

GENERAL

Dievar is a high performance chromium-molybdenum-vanadium alloyed hot work tool steel which offers very good resistance to heat checking, gross cracking, hot wear and plastic deformation. It is tested and approved according to the NADCA specification before delivery. Dievar is characterised by:

- Excellent ductility in all directions
- Excellent cleanliness
- A new level of toughness ≥ 25 J
- Very good temper resistance
- Very good high-temperature strength
- Excellent hardenability
- Suitable for nitriding
- Good dimensional stability throughout heat treatment and coating operations

Typical analysis %	C 0.35	Si 0.2	Mn 0.5	Cr 5.0	Mo 2.3	V 0.6
Standard specification	None					
Delivery condition	Soft annealed to approx. 160 HB.					

IMPROVED TOOLING PERFORMANCE

Dievar is a premium hot work tool steel, like all ASSAB grades, is exposed to a continuous improvement of the processes throughout the whole of production. Improved processes in the melting shop followed by the latest re-melting technology have given a further increased level of homogeneity and cleanliness. In addition to this, changes and improvements have been made in the heat-treatment and hot-working processes which resulted in a hot-work tool steel that is able to reach a new level of toughness.

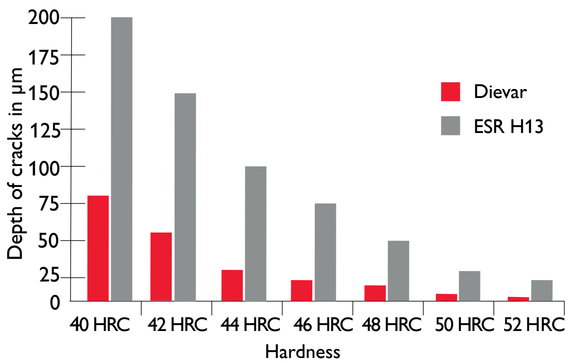
Today, Dievar is delivered with a tested toughness of ≥ 25 J according to the NADCA standard. This combination, with its unique chemical composition, gives the die steel ultimate resistance to heat checking, gross cracking, hot wear and plastic deformation. The unique properties profile for Dievar makes it the best choice for die casting, forging and extrusion.

HOT WORK APPLICATIONS

Heat checking is one of the most common failure mechanisms e.g. in die casting and noway also in forging applications. Dievar's superior properties yield the highest possible level of heat checking resistance. It is a known fact that a higher hardness level improves the heat-checking resistance. By taking advantage of Dievar's outstanding toughness and hardenability, the resistance to heat checking can be further improved by increasing the hardness level with up to 52 HRC (if gross cracking is not a factor). Regardless of the dominant failure mechanism (heat checking, gross cracking, hot wear or plastic deformation) Dievar offers the potential for significant improvements in die life, and resulting in better tooling economy.
Dievar is the material of choice for the high demand die casting-, forging and extrusion industries.

DIEVAR VS H13 - HEAT CHECKING RESISTANCE

20-700°C/air/800 cycles, thermal fatigue testing, depth of cracks



DIEVAR IN LARGER SIZES

Changes in the automotive industry have pushed demand for larger and more complex parts. Structural parts, battery boxes and electrical motor housings have implied demand for very large die inserts and in some cases, whole dies.
Dievar can be made into these blocks using standard upset forged ingots. For sizes outside the standard ingot range, contact your local sales team to see if your non-standard size can conform to Dievar - 25 Joules quality standards. In the below chart we can see 2 examples of non-standard sizes which exceeded 25 Joules.

Examples of sizes outside of the standard range

Size mm	Charpy-V, J	Grain size	Micro-structure
1300 x 600	28	7	B3
1550 x 550	26	7	B3

Acc. To the NADCA standard

TOOLS FOR DIE CASTING

Part	Aluminium, magnesium alloys HRC
Dies	44 – 50

TOOLS FOR EXTRUSION

Part	Copper, Copper alloys, HRC	Aluminium, Magnesium alloys HRC
Dies	-	46 – 52
Liners, dummy blocks, stems	46 – 52	44 - 52

TOOLS FOR HOT FORGING

Part	Steel, Aluminium, HRC
Inserts	44 – 52

PROPERTIES

The reported properties are representative of samples which have been taken from the centre of a 610 x 203 mm bar.
Unless otherwise is indicated all specimens have been hardened at 1025°C, quenched in oil and tempered twice at 615°C for two hours; yielding a working hardness of 44–46 HRC.

PHYSICAL PROPERTIES

DATA AT ROOM AND ELEVATED TEMPERATURES

Temperature	20 °C	200 °C	400 °C
Density, kg/m^3	7 800	7 700	7 600
Modulus of elasticity N/mm^2	210 000	180 000	145 000
Coefficient of thermal expansion /°C from 20°C	-	12.7 x 10^{-6}	13.3 x 10^{-6}
Thermal conductivity* W/m °C	-	31	32

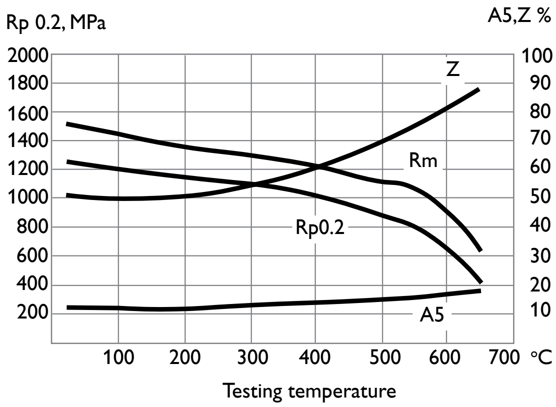
MECHANICAL DATA

TENSILE PROPERTIES AT ROOM TEMPERATURE, SHORT TRANSVERSE DIRECTION

Hardness	44 HRC	48 HRC	52 HRC
Tensile strength, R_m MPa	1 480	1 640	1 900
Yield point Rp0.2 MPa	1 210	1 380	1 560
Elongation, A_5, %	13	13	12.5
Reduction of area Z, %	55	55	52

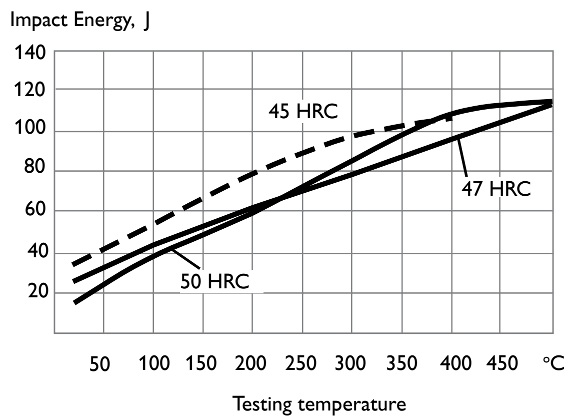
TENSILE PROPERTIES AT ELEVATED TEMPERATURE

SHORT TRANSVERSE DIRECTION



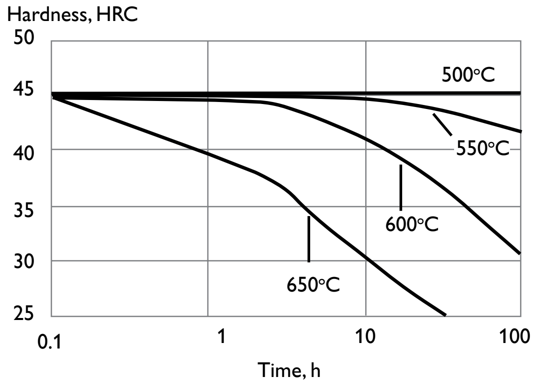
Minimum average unnotched impact ductility is 300 J in the short transverse direction at 44 – 46 HRC.

CHARPY V-NOTCH IMPACT TOUGHNESS AT ELEVATED TEMPERATURE
SHORT TRANSVERSE DIRECTION



TEMPER RESISTANCE

The specimens have been hardened and tempered to 45 HRC and then held at different temperatures from 1 to 100 hours.



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 850 °C. Then cool in furnace at 10 °C per hour to 600 °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

Preheating temperature: 600 – 900°C. Normally a minimum of two preheats, the first in the 600 – 650°C range, and the second in the 820 – 850°C range. When three preheats are used the second is carried out at 820°C and the third at 900°C.

Austenitising temperature: 1000 – 1025°C. General guideline for bigger dies with thickness >250 mm then max austenitising temperature 1010°C is recommended.

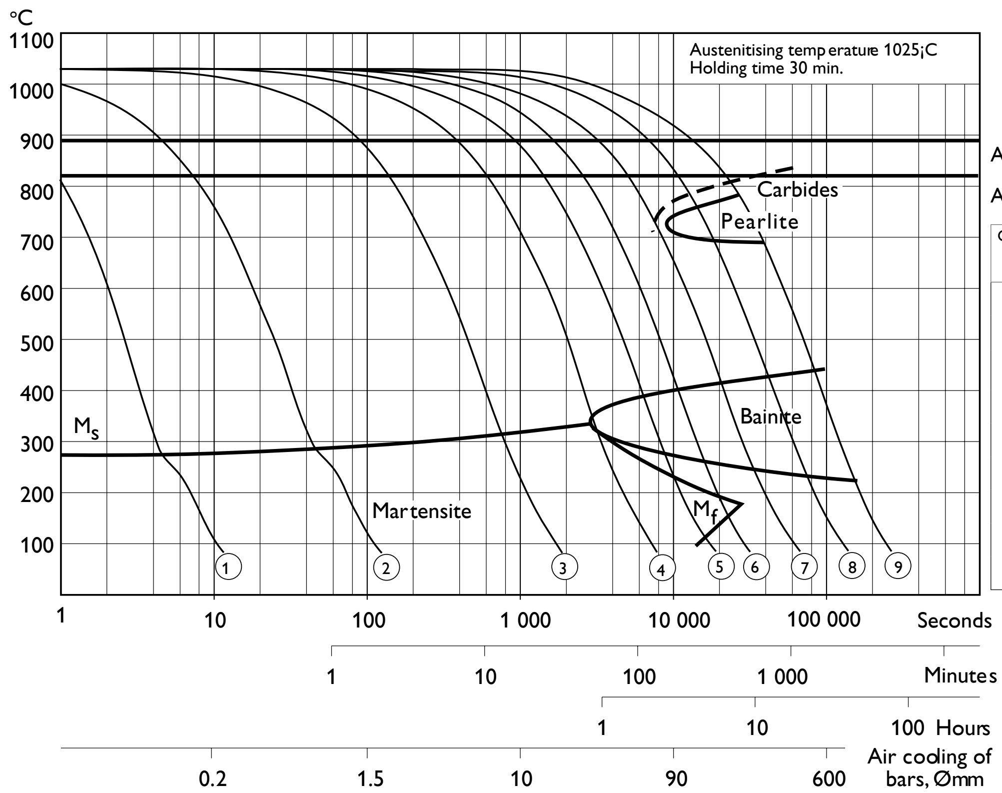
Temperature °C	Soaking time* minutes	Hardness before tempering HRC
1000	30	52±2
1025	30	55±2

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

Protect the tool against decarburisation and oxidation during austenitising.

CCT-GRAPH

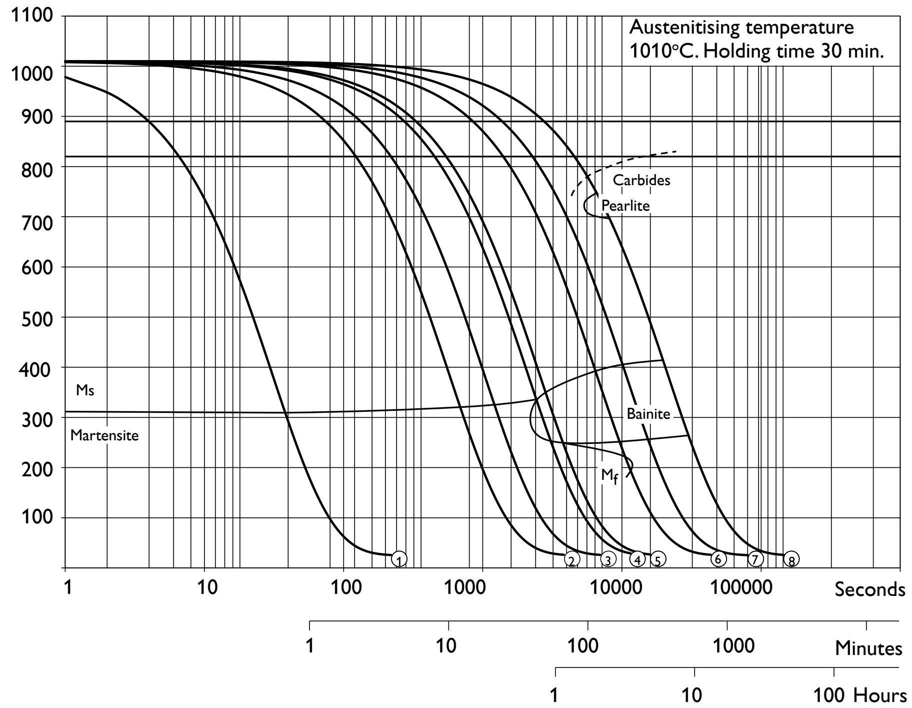
Austenitising temperature 1025 °C. Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ sec
1	681	1.5
2	627	15
3	620	280
4	592	1 248
5	566	3 205
6	488	5 200
7	468	10 400
8	464	20 800
9	405	41 600

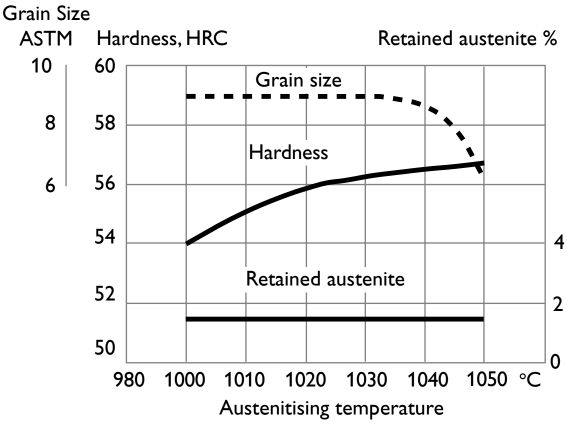
CCT-GRAPH

Austenitising temperature 1010 °C. Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ sec
1	690	15
2	657	280
3	627	500
4	606	760
5	599	1 030
6	592	1 248
7	519	3 205
8	514	5 200
9	483	10 400

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



QUENCHING

As a general rule, quench rates should be as rapid as possible. Accelerated quench rates are required to optimise tool properties specifically with regards to toughness and resistance to gross cracking. However, risk of excessive distortion and cracking must be considered.

QUENCHING MEDIA

The quenching media should be capable of creating a fully hardened micro-structure.
Different quench rates for Dievar are defined by the CCT graphs.

RECOMMENDED QUENCHING MEDIA

- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench at 425 – 450 °C is recommended where distortion control and quench cracking are a concern
- Martempering bath, salt bath or fluidised bed at 450 – 550 °C
- Martempering bath, salt bath or fluidised bed at 180 – 200 °C
- Warm oil, approx. 80 °C

Note: Temper the tool as soon as its temperature reaches 50 – 70 °C.

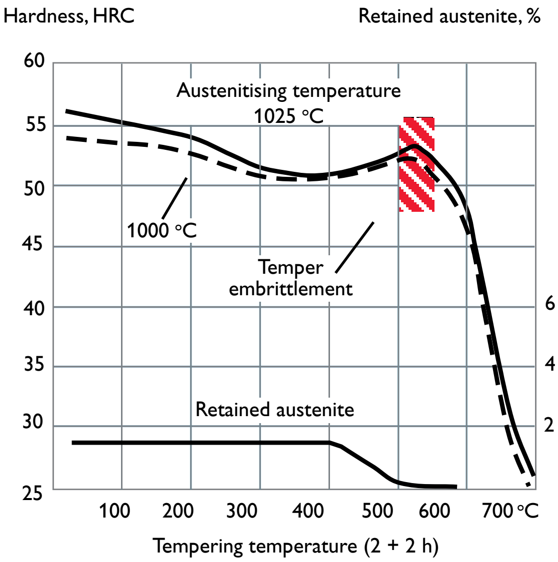
TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph below. Temper minimum three times for die casting dies and minimum twice for forging and extrusion tools with intermediate cooling to room temperature.

Holding time at temperature minimum 2 hours.

Tempering in the range of 500 – 550 °C for the intended final hardness will result in a lower toughness.

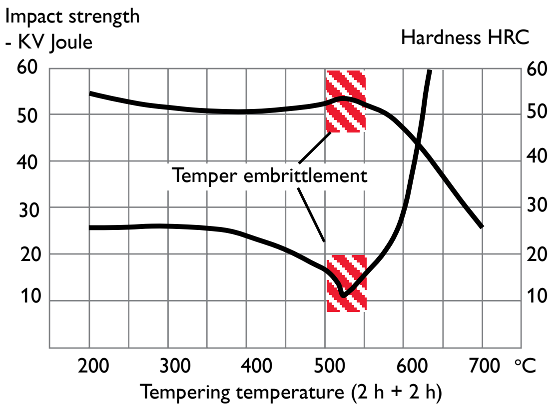
TEMPERING GRAPH



Above tempering curves are obtained after heat treatment of samples with a size of 15 x 15 x 40 mm, cooling in forced air. Lower hardness can be expected after heat treatment of tools and dies due to factors like actual tool size and heat treatment parameters.

EFFECT OF TEMPERING TEMPERATURE ON ROOM TEMPERATURE CHARPY V NOTCH IMPACT ENERGY

Short transverse direction.



DIMENSIONAL CHANGES DURING HARDENING AND TEMPERING

During hardening and tempering the tool is exposed to both thermal and transformation stresses. These stresses will result in distortion. Insufficient levels of machine stock may result in slower than recommended quench rates during heat treatment. In order to predict maximum levels of distortion with a proper quench, a stress relief is always recommended between rough and semi-finish machining, prior to hardening.

For a stress relieved Dievar tool a minimum machine stock of 0.3% is recommended to account for acceptable levels of distortion during a heat treatment with a rapid quench.

NITRIDING AND NITROCARBURISING

Nitriding and nitrocarburising result in a hard surface layer which has the potential to improve resistance to wear and soldering, as well as resistance to premature heat checking. Dievar can be nitrided and nitrocarburising via a plasma, gas, fluidised bed, or salt process. The temperature for the deposition process should be minimum 25 - 50 °C below the highest previous tempering temperature, depending upon the process time and temperature. Otherwise a permanent loss of core hardness, strength, and/or dimensional tolerances may be experienced.

During nitriding and nitrocarburising, a brittle compound layer, known as the white layer, may be generated. The white layer is very brittle and may result in cracking or spalling when exposed to heavy mechanical or thermal loads. As a general rule, the white layer formation must be avoided.

Nitriding in ammonia gas at 510 °C or plasma nitriding at 480 °C both result in a surface hardness of approx. 1100 $HV_{0.2}$. In general, plasma nitriding is the preferred method because of better control over nitrogen potential. However, careful gas nitriding can give same results.

The surface hardness after nitrocarburising in either gas or salt bath at 580 °C is approx. 1100 $HV_{0.2}$.

DEPTH OF NITRIDING

Process	Time	Hardness Depth*	$HV_{0.2}$
Gas nitriding at 510 °C	10 h	0.16 mm	1 100
	30 h	0.22 mm	1 100
Plasma nitriding at 480 °C	10 h	0.15 mm	1 100
Nitrocarburising - in gas at 580 °C	2 h	0.13 mm	1 100
- in salt bath at 580 °C	1 h	0.08 mm	1 100

* Depth of case = distance from surface where hardness is 50 $HV_{0.2}$ over base hardness

CUTTING DATA RECOMMENDATIONS

The cutting data below should be considered as guidelines only. These guidelines must be adapted to local machining conditions.

The recommendations, in following tables, are valid for Dievar in soft annealed condition approx. 160 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with High speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_C), m/min	150 – 200	200 – 250	15 - 20
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 Coated carbide or cermet	-

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_C) m/min	130 – 180	180 – 220
Feed (f_z) mm/tooth	0.2 – 0.4	0.1 – 0.2
Depth of cut (a_p) mm	2 – 4	< 2
Carbide designation ISO	P20 – P40 Coated carbide	P10 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	130 – 170	120 – 160	25 – 30 [1)]
Feed (f_z) mm/tooth	0.03 – 0.20 [2)]	0.08 – 0.20 [2)]	0.05 – 0.35 [2)]
Carbide designation ISO	–	P20 – P30	–

[1)] For coated HSS end mill, vc ~ 45 – 50 m/min
[2)] Depending on radial depth of cut and cutter diameter

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Cutting speed (v_C) m/min	Feed (f) mm/r
≤ 5	15 – 20 *	0.05 – 0.15
5 – 10	15 – 20 *	0.15 – 0.20
10 – 15	15 – 20 *	0.20 – 0.25
15 – 20	15 – 20 *	0.25 – 0.35

* For coated HSS drill v_c = 35 - 40 m/min.

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1)]
Cutting speed (v_C), m/min	180 – 220	120 – 150	60 – 90
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

E-mobility – picture showing e.g. battery box, electrical motor housing and structural parts on an EV car.

CUTTING DATA RECOMMENDATIONS

The cutting data below should be considered as guidelines only. These guidelines must be adapted to local machining conditions.

The recommendations, in following tables, are valid for Dievar hardened and tempered to 44 – 46 HRC.

TURNING

Cutting data parameters	Turning with carbide	
	Rough turning	Fine turning
Cutting speed (v_C), m/min	40 – 60	70 – 90
Feed (f) mm/rev	0.2 – 0.4	0.05 – 0.2
Depth of cut (a_p) mm	1 – 2	0.5 – 1
Carbide designation ISO	P20 - P30 Coated carbide	P10 Coated carbide or cermet

DRILLING

HIGH SPEED STEEL TWIST DRILL (TiCn COATED)

Drill diameter mm	Cutting speed (v_C) m/min	Feed (f) mm/r
≤ 5	13 – 20	0.05 – 0.10
5 – 10	13 – 20	0.10 – 0.15
10 – 15	13 – 20	0.15 – 0.20
15 – 20	13 – 20	0.20 – 0.30

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1)]
Cutting speed (v_C), m/min	60 – 80	60 – 80	40 – 50
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	50 – 90	90 – 130
Feed (f_z) mm/tooth	0.2 – 0.4	0.1 – 0.2
Depth of cut (a_p) mm	2 – 4	< 2
Carbide designation ISO	P20 - P40 Coated carbide	P10 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	60 – 80	70 – 90	5 – 10
Feed (f_z) mm/tooth	0.03 – 0.20 [1)]	0.08 – 0.20 [1)]	0.05 – 0.35 [1)]
Carbide designation ISO	–	P10 – P20	–

[1)] 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 LV	A 120 JV

WELDING

Welding of die components can be performed, with acceptable results, as long as the proper precautions are taken during the preparation of the joint, the filler material selection, the preheating of the die, the controlled cooling of the die and the post weld heat treatment processes. The following guidelines summarise the most important welding process parameters.

Welding method	TIG	MMA
Preheating temperature*	325 - 375 °C	325 - 375 °C
Filler metals	DIEVAR TIG Weld QRO 90 TIG Weld	QRO 90 Weld
Maximum interpass temperature	475 °C	475 °C
Post welding cooling	20 - 40 °C/h for the first 2 - 3 hours and then freely in air.	
Hardness after welding	48 - 53 HRC	48 - 53 HRC
Heat treatment after welding		
Hardened condition	Temper 10 – 20°C below condition the highest previous tempering temperature.	
Soft annealed condition	Soft-anneal the material at 850 °C in protected atmosphere. Then cool in the furnace at 10 °C per hour to 600 °C	

* Preheating temperature must be established throughout the die and must be maintained for the entire of the welding process to

Typical example of a die casting tool for structural parts.

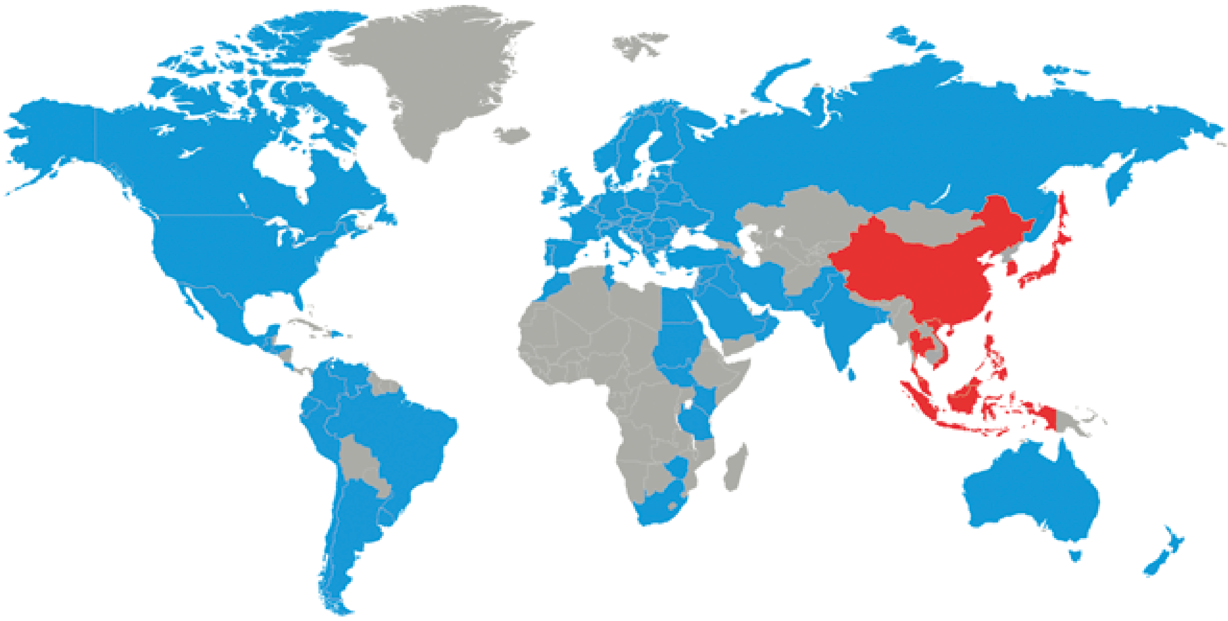
ELECTRICAL DISCHARGE MACHINING — EDM

Following the EDM process, the applicable die surfaces are covered with a resolidified layer (white layer) and a rehardened and untempered layer, both of which are very brittle and hence detrimental to die performance. If EDM is used the white layer must be completely removed mechanically by grinding or stoning.

After the finish machining the tool should also then be given an additional temper at approx. 25 °C below the highest previous tempering temperature.

FURTHER INFORMATION

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



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

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