ASSAB DF-3

ASSAB

ASSAB	UDDEHOLM	REFERENCE STANDARD		
		AISI	DIN	JIS
DF-2	ARNE	O1	1.2510	SKS 3
DF-3		O1	1.2510	SKS 3
XW-5	SVERKER 3	D6 (D3)	(1.2436)	(SKD 2)
XW-10	RIGOR	A2	1.2363	SKD 12
XW-41	SVERKER 21	D2	1.2379	SKD 11
XW-42		D2	1.2379	SKD 11
CARMO	CARMO			
CALMAX	CALMAX			
CALDIE	CALDIE			
ASSAB 88	SLEIPNER			
ASP 23		(M3:2)	1.3344	SKH 53
ASP 30		(M3:2 + Co)	1.3244	SKH 40
ASP 60			1.3241	
VANADIS 4 EXTRA	VANADIS 4 EXTRA			
VANADIS 6	VANADIS 6			
VANADIS 10	VANADIS 10			
VACRON 40	VANCRON 40			
618		P20 Mod.	1.2738	
618 HH		P20 Mod.	1.2738	
618 T		P20 Mod.	1.2738 Mod.	
718 SUPREME	IMPAX SUPREME	P20 Mod.	1.2738	
718 HH	IMPAX HH	P20 Mod.	1.2738	
NIMAX	NIMAX			
UNIMAX	UNIMAX			
CORRAX	CORRAX			
STAVAX ESR	STAVAX ESR	420 Mod.	1.2083 ESR	SUS 420J2
MIRRAX ESR	MIRRAX ESR	420 Mod.		
POLMAX	POLMAX			
ELMAX	ELMAX			
RAMAX LH	RAMAX LH	420 F Mod.		
RAMAX HH	RAMAX HH	420 F Mod.		
ROYALLOY				
PRODAX				
ASSAB PT18				
ASSAB MMXL				
ASSAB MM40				
ALVAR 14	ALVAR 14		1.2714	SKT 4
8407 2M	ORVAR 2M	H13	1.2344	SKD 61
8407 SUPREME	ORVAR SUPREME	H13 Premium	1.2344 ESR	SKD 61
DIEVAR	DIEVAR			
HOTVAR	HOTVAR			
QRO 90 SUPREME	QRO 90 SUPREME			
705		4340	1.6582	SNCM8
709		4140	1.7225	SCM4
760		1050	1.1730	S50C

Edition 090619

General

DF-3 is a general purpose oil-hardening tool steel suitable for a wide variety of cold work applications.

Its main characteristics include:

- Good machinability
- Good dimensional stability during hardening
- A good combination of high surface hardness and toughness after hardening and tempering

These characteristics combine to give a steel suitable for the manufacture of tooling with good tool life and production economy.

DF-3 can be supplied in various surface executions including hot rolled, pre-machined, fine machined and precision ground. It is also available in the form of hollow bar.

Typical analysis %	C 0.95	Mn 1.1	Cr 0.6	W 0.6	V 0.1
Standard spec.	AISI O1, WNr. 1.2510, SKS 3				
Delivery condition	Soft annealed to max. 230 HB				
Colour code	Yellow				

Applications

BLANKING, CUTTING, FORMING AND OTHER APPLICATIONS

Application	Work material thickness	Hardness HRC
Tools for: Blanking, punching, piercing, cropping, shearing, trimming, clipping	< 3 mm 3 - 6 mm 6 - 10 mm	60 - 62 56 - 60 54 - 56
Short cold shears		54 - 60
Clipping and trimming tools for forgings	Hot Cold	58 - 60 56 - 58
Tools for: Bending, raising, drawing, rim-rolling, spinning and flow-forming		56 - 62
Small coining dies		56 - 60
Gauges, measuring tools Turning centres Guide bushes, ejector pins, small to medium-sized drills and taps Small gear wheels, pistons, nozzles, cams		58 - 62

Properties

PHYSICAL PROPERTIES

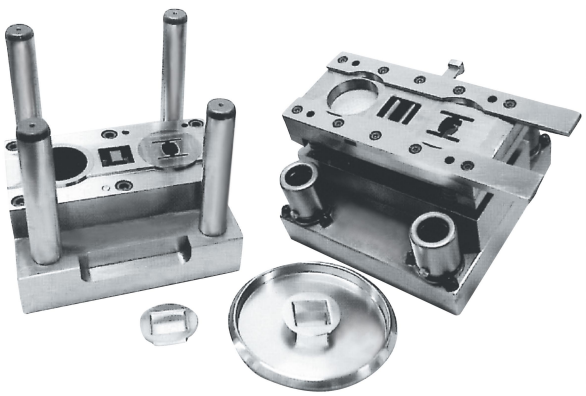
Hardened and tempered to 62 HRC.

Temperature	20°C	200°C	400°C
Density kg/m³	7 850	7 750	7 700
Modulus of elasticity MPa	190 000	185 000	170 000
Coefficient of thermal expansion per °C from 20°C	–	12.6 x 10^{-6}	13.1 x 10^{-6}
Thermal conductivity W/m °C	32	33	34
Specific heat J/kg °C	460	–	–

COMPRESSIVE STRENGTH

Approximate compressive strength at room temperature.

Hardness	50 HRC	55 HRC	60 HRC	62 HRC
Compressive strength, R_{mc}	1700 MPa	2200 MPa	2700 MPa	3000 MPa
Compressive yield strength, $R_c0.2$	1350 MPa	1800 MPa	2150 MPa	2200 MPa



Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 780°C. Cool in the furnace at 15°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

Preheating temperature: 600 - 700°C

Austenitising temperature: 790 - 850°C

Temperature °C	Soaking time minutes	Hardness before tempering
800	30	65±2 HRC
825	20	65±2 HRC
850	15	65±2 HRC

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

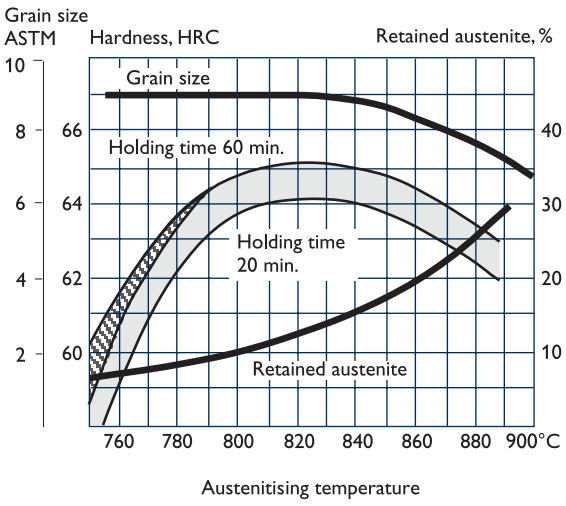
Protect the part against decarburisation and oxidation during hardening.

QUENCHING MEDIA

- Warm oil, approx. 80°C
- Martempering bath or fluidised bed at 180 - 225°C, then cooling in air

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

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

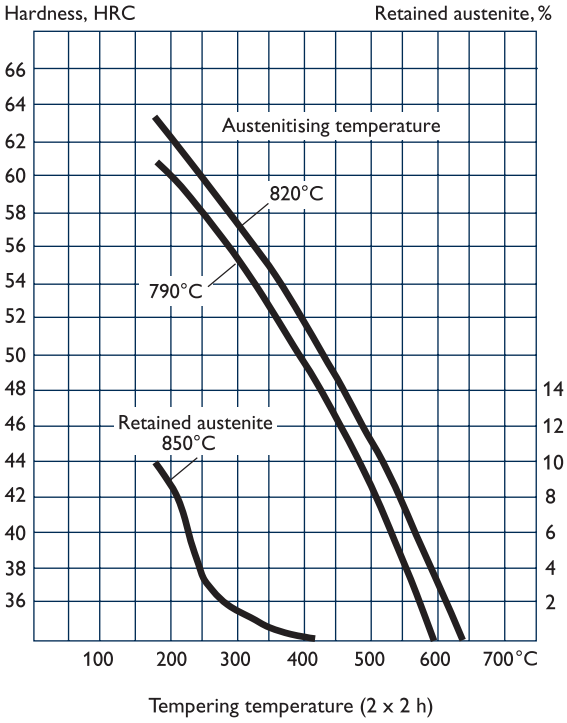


TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph.

Temper at least twice with intermediate cooling to room temperature. The lowest tempering temperature which should be used is 180°C. The minimum holding time at temperature is 2 hours.

Tempering graph



MARTEMPERING

Tools at austenitising temperature are immersed in the martempering bath for the time indicated, then cooled in air to not lower than 100°C. Temper immediately as with oil quenching.

Austenitising temperature °C	Temperature[1] °C	Holding time[2] minutes	Surface hardness[3]
825	225	max. 5	64±2 HRC
825	200	max. 10	63±2 HRC
825	180	max. 20	62±2 HRC
850	225	max. 10	62±2 HRC

[1] *Temperature of martempering bath*

[2] *Holding time in martempering bath*

[3] *Obtained by martempering but prior to tempering*

MACHINING ALLOWANCE TO COMPENSATE FOR DIMENSIONAL CHANGES

The dimensional changes during hardening and tempering vary depending on temperature, type of equipment and cooling media used during heat treatment.

The size and geometric shape of the tool are also of essential importance. During toolmaking, provide adequate machining allowance to compensate for distortion. Use 0.25% as a guideline for DF-3. Any distortion arising from hardening and tempering can then be adjusted during finish machining.

SUB-ZERO TREATMENT AND AGEING

Pieces requiring maximum dimensional stability should be sub-zero treated and/or artificially aged, as volume changes may occur in the course of time. This applies to, for examples, measuring tools like gauges and certain structural components.

Sub-zero treatment

Immediately after quenching the piece should be sub-zero treated to between -70 and -80°C, soaking time 3 - 4 hours, followed by tempering or ageing. Sub-zero treatment will give a hardness increase of 1 - 3 HRC. Avoid intricate shapes as there will be risk of cracking.

Ageing

Tempering after quenching is replaced by ageing at 110 - 140°C. Holding time 25 - 100 hours.

Sub-zero treatment chamber.

Welding

There is a general tendency for tool steel to crack after welding. When welding is required, take proper precautions with regards to joint preparation, filler material selection, preheating, welding procedure and postweld heat treatment to ensure good welding results. If the tool is to be polished or photo-etched, it is necessary to work with an electrode type of matching composition.

Welding method	TIG	MMA
Preheating temp.[1]	200 - 250°C	200 - 250°C
Filler material	AWS ER 312 (buffering layers) UTP A73G2 UTP A67S CastoTIG 5[3]	AWS E 312 (buffering layers) ESAB OK 84.52 UTP 67S Castolin 2 Castolin N 102
Maximum interpass temp.[2]	400°C	400°C
Postweld cooling	20 - 40°C/h for the first 2 hours, then freely in air < 70°C	
Hardness after welding	AWS ER 312 (buffering layers) 300 HB UTP A73G2 53 - 56 HRC UTP A67S 55 - 58 HRC CastoTIG 5 60 - 64 HRC	AWS E 312 (buffering layers) 300 HB ESAB OK 84.52 53 - 54 HRC UTP 67S 55 - 58 HRC Castolin 2 / Castolin N 102 54 - 60 HRC
Heat treatment after welding		
Hardened condition	Temper 10 - 20°C below the original tempering temperature.	
Soft annealed condition	Soft anneal according to the "Heat treatment" recommendation.	

[1] *Preheating temperature must be established throughout the tool and must be maintained for the entire welding process, to prevent weld cracking. For hardened and tempered tool, the actual preheat temperature used is typically lower than the original tempering temperature to prevent a drop in hardness.*

[2] *The temperature of the tool in the weld area immediately before the second and subsequent pass of a multiple pass weld. When exceeded, there is a risk of distortion of the tool or soft zones around the weld.*

[3] *Should not be used for more than 4 layers because of the increased risk of cracking.*

Machining recommendations

The cutting data below are to be considered as guiding values and as starting points for developing your own best practice.

Condition: Soft annealed condition ~190 HB

TURNING

Cutting data parameters	Turning with carbide		Turning with HSS†
	Rough turning	Fine turning	Fine turning
Cutting speed (v_c) m/min	160 - 210	210 - 260	20 - 25
Feed (f) mm/r	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 - 3
Carbide designation ISO	P20 - P30 Coated carbide	P10 Coated carbide or cermet	–

† *High speed steel*

DRILLING

High speed steel twist drill

Drill diameter mm	Cutting speed (v_c) m/min	Feed (f) mm/r
≤ 5	15 - 17*	0.08 - 0.20
5 - 10	15 - 17*	0.20 - 0.30
10 - 15	15 - 17*	0.30 - 0.35
15 - 20	15 - 17*	0.35 - 0.40

* *For coated HSS drill, v_c = 26 - 28 m/min*

Carbide drill

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Brazed carbide[1]
Cutting speed (v_c) m/min	200 - 220	110 - 140	70 - 90
Feed (f) mm/r	0.05 - 0.25[2]	0.10 - 0.25[2]	0.15 - 0.25[2]

[1] *Drill with internal cooling channel 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) m/min	170 - 250	250 - 290
Feed (f_z) mm/tooth	0.2 - 0.4	0.10 - 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 end mill		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min	150 - 190	160 - 220	25 - 30[1]
Feed (f_z) mm/tooth	0.03 - 0.2[2]	0.08 - 0.2[2]	0.05 - 0.35[2]
Carbide designation ISO	K20, P40 Coated carbide	P20 - P30 Coated carbide	–

[1] *For coated end mill, v_c = 45 - 50 m/min*
[2] *Depending on radial depth of cut and cutter diameter*

GRINDING

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 JV

Electrical discharge machining

If EDM is performed in the hardened and tempered condition, the EDM'd surface is covered with a resolidified layer (white layer) and a rehardened and untempered layer, both of which are very brittle and hence detrimental to the tool performance.

When a profile is produced by EDM, it is recommended to finish with "fine-sparking", i.e., low current, high frequency. For optimal performance, the EDM'd surface should be ground/polished to remove the white layer completely. The tool should then be retempered at approx. 25°C below the highest previous tempering temperature.

Further information

For further information, i.e., steel selection, heat treatment, application and availability, please contact our ASSAB office* nearest to you.

*See back cover page.

Relative comparison of ASSAB cold work tool steels

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS

ASSAB grade	Hardness/ Resistance to plastic deformation	Machinability	Grindability	Dimension stability	Resistance to		Fatigue cracking resistance	
					Abrasive wear	Adhesive wear	Ductility/ resistance to chipping	Toughness/ gross cracking
DF-3								
CALMAX								
CALDIE (ESR)								
XW-10								
ASSAB 88								
XW-42								
XW-5								
VANADIS 4 EXTRA								
VANADIS 10								
VANCRON 40								
ASP 23								
ASP 30								
ASP 60								
AISI M2								

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* *Sales office with warehouse and/or value added services*

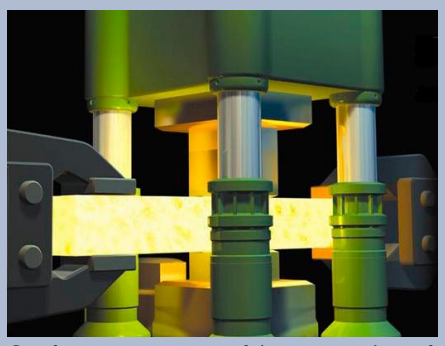
† *Sales office only*

ASSAB TOOL STEELS have been in Asia since 1945. Our customers associate ASSAB brand with tooling materials that are high in quality and consistency.

The ASSAB sales companies and distributors offer you well assorted stocks in a number of places covering the Asia Pacific region. To further shorten the lead time, ASSAB will mill, grind, drill and even wire-cut the tool steel to meet your requirements. ASSAB also provides state-of-the-art vacuum heat treatment services to enhance the steel properties.

Our engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treament for each application. We always carry out material examinations at our local mini laboratories and at the central laboratory in Sweden.

Our steel mill in Sweden, Uddeholm Tooling, is one of the few steelworks in the world that is dedicated to the manufacture of tool steels only. Uddeholm Tooling is certified to ISO 9001 and ISO 14001.



Our forging press is one of the most modern of its kind in the world.

Besides tool steels, the ASSAB services for tool makers include:

- Welding electrodes for repair welding of tools
- High strength aluminium for tooling purposes
- Copper alloys (e.g., beryllium copper) for inserts in moulds
- Alloy machinery steels
- Cold rolled strip steels for saws, compressor valves, coater blades, etc.
- High Performance Steels (HPS)
- Granshot