



ASSAB 88

Uddeholm Sleipner

|  |  <small>a voestalpine company</small> | REFERENCE STANDARD | | |
|---|---|--------------------|----------|-------------|
| | | AISI | Wnr. | JIS |
| ASSAB DF-3 | ARNE | O1 | 1.2510 | SKS 3 |
| ASSAB XW-5 | SVERKER 3 | D6 (D3) | (1.2436) | (SKD 2) |
| ASSAB XW-10 | RIGOR | A2 | 1.2363 | SKD 12 |
| ASSAB XW-42 | SVERKER 21 | D2 | 1.2379 | SKD 11 |
| CARMO | CARMO | | 1.2358 | |
| CALMAX | CALMAX | | 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 6 SUPERCLEAN | VANADIS 6 SUPERCLEAN | | | |
| VANADIS 8 SUPERCLEAN | VANADIS 8 SUPERCLEAN | | | |
| VANADIS 10 SUPERCLEAN | VANADIS 10 SUPERCLEAN | | | |
| VANCRON 40 SUPERCLEAN | VANCRON 40 SUPERCLEAN | | | |
| ELMAX SUPERCLEAN | ELMAX SUPERCLEAN | | | |
| ASSAB 518 | | P20 | 1.2311 | |
| ASSAB 618 | | (P20) | 1.2738 | |
| ASSAB 618 HH | | (P20) | 1.2738 | |
| ASSAB 618 T | | (P20) | (1.2738) | |
| ASSAB 718 SUPREME | IMPAX SUPREME | (P20) | 1.2738 | |
| ASSAB 718 HH | IMPAX HH | (P20) | 1.2738 | |
| NIMAX | NIMAX | | | |
| NIMAX ESR | 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) | | |
| POLMAX | POLMAX | (420) | (1.2083) | (SUS 420J2) |
| RAMAX HH | RAMAX HH | (420 F) | | |
| ROYALLOY | ROYALLOY | (420 F) | | |
| COOLMOULD | COOLMOULD | | | |
| ALVAR 14 | ALVAR 14 | | 1.2714 | SKT 4 |
| 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 | | | |
| HOTVAR | HOTVAR | | | |
| QRO 90 SUPREME | QRO 90 SUPREME | | | |
| FORMVAR | FORMVAR | | | |

() - modified grade

ASSAB is a trademark of voestalpine High Performance Metals Pacific Pte Ltd. The information contained herein is based on our present state of knowledge and is intended to provide general notes on our products and their uses. It should therefore not be construed as a warranty of specific properties of the products described or a warranty for fitness for a particular purpose. Each user of ASSAB products is responsible for making its own determination as to the suitability of ASSAB products and services.

Edition 20180208

20180208

ASSAB 88

THE CHANGING TOOLING ENVIRONMENT

The tooling environment is changing to adapt to the changing market environment. Lead time is one aspect of this change and they are getting shorter and shorter. This ultimately means that more emphasis has to be placed on tool reliability in service and on time to manufacture the tooling.

The production materials used nowadays are placing more demands on the tools and the tool steel used to manufacture them. For example, advanced high strength steel materials now being used for automotive parts place extra demands on resistance to chipping and cracking, compressive strength and wear resistance.

THE MODERN GENERAL COLD WORK TOOL STEEL

The classical 12 % Cr-steel such as AISI D2 or W.-Nr. 1.2379 are still the backbone of cold work tooling but their limitations are becoming more and more apparent in the changing production environment.

ASSAB 88 is a 8 % Cr-steel from ASSAB. Its property profile has been carefully balanced and the result is a very versatile tool steel which overcomes the limitations of the 12% Cr-steel.

A VERSATILE TOOL STEEL

The property profile of ASSAB 88 is more versatile and superior to that of 12 % Cr-steel. The machinability, grindability and hardenability are much better and it is easier to make small repair welds. This means that ASSAB 88 is the right choice for faster toolmaking. The significantly better chipping resistance also result in better tool performance and easier maintenance.

GENERAL

ASSAB 88 is a chromium-molybdenum-vanadium alloyed tool steel which is characterised by:

- Good wear resistance
- Good chipping resistance
- High compressive strength
- High hardness (>60 HRC) after high temperature tempering
- Good through-hardening properties
- Good stability in hardening
- Good resistance to tempering back
- Good WEDM properties
- Good machinability and grindability
- Good surface treatment properties

| | | | | | | |
|------------------------|---------------------------------|-----------|-----------|-----------|-----------|----------|
| Typical analysis % | C 0.9 | Si 0.9 | Mn 0.5 | Cr 7.8 | Mo 2.5 | V 0.5 |
| Standard specification | None | | | | | |
| Delivery condition | Soft annealed to approx. 235 HB | | | | | |
| Colour code | Blue / Brown | | | | | |

APPLICATIONS

ASSAB 88 is a general purpose steel for cold work tooling. It has a mixed abrasive wear profile and a good resistance to chipping. Furthermore, a high hardness (>60 HRC) can be obtained after high temperature tempering. This means that surface treatment such as nitriding or PVD can be made on a high strength substrate. It also means that complicated shapes with hardness levels >60 HRC can be wire EDM'd from blocks with relatively thick cross-sections with a much reduced risk of cracking.

ASSAB 88 is recommended for medium run tooling applications where a resistance to mixed or abrasive wear and a good resistance to chipping are required.

TYPICAL APPLICATIONS

- Blanking and fine blanking
- Shearing
- Forming
- Coining
- Cold forging
- Cold extrusion
- Thread rolling
- Drawing and deep drawing
- Powder pressing

PROPERTIES

PHYSICAL DATA

Hardened and tempered to 62 HRC. Data at room and elevated temperatures.

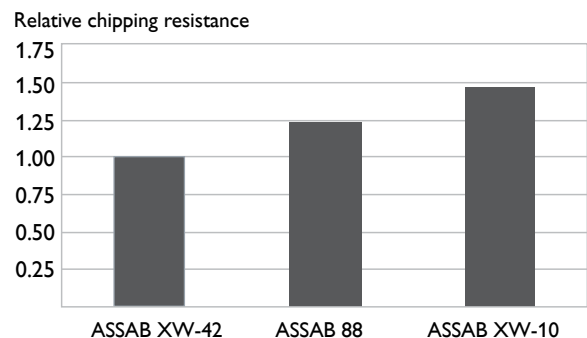
| Temperature | 20 °C | 200 °C | 400 °C |
|---|---------|-------------------------|-------------------------|
| Density kg/m ³ | 7 730 | 7 680 | 7 620 |
| Modulus of elasticity MPa | 205 000 | 190 000 | 180 000 |
| Coefficient of thermal expansion | | | |
| - after low temperature tempering (60HRC) per °C from 20 °C | - | 12.7 × 10 ⁻⁶ | - |
| - after high temperature tempering per °C from 20 °C | - | 11.6 × 10 ⁻⁶ | 12.4 × 10 ⁻⁶ |
| Thermal conductivity W/m °C | - | 20 | 25 |
| Specific heat J/kg °C | 460 | - | - |

COMPRESSIVE STRENGTH

The figures should be considered as approximate.

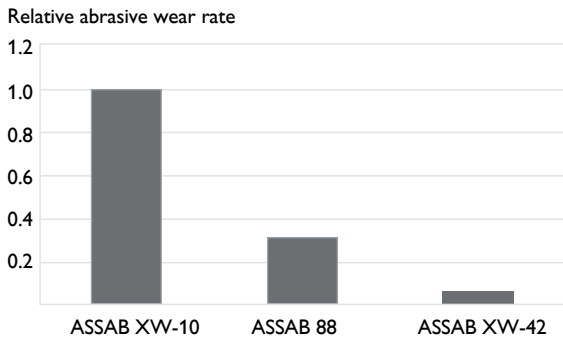
| Hardness HRC | Compressive yield strength R _{c0.2} (MPa) |
|-----------------|---|
| 50 | 1 700 |
| 55 | 2 050 |
| 60 | 2 350 |
| 62 | 2 500 |
| 64 | 2 650 |

Relative chipping resistance for ASSAB XW-42, ASSAB 88 and ASSAB XW-10 at the same hardness level.



ABRASIVE WEAR RESISTANCE

Relative abrasive wear resistance for ASSAB XW-42, ASSAB 88 and ASSAB XW-10 at the same hardness level (low value means better wear resistance).



HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 850 °C. Then cool in the 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 and held for 2 hours. Cool slowly to 500 °C, then freely in air.

HARDENING

Preheating temperature: 600 – 650 °C and 850 – 900 °C.

Austenitising temperature: 950 – 1080 °C, but usually 1030 – 1050 °C.

Holding time: 30 minutes

Note: Holding time = time at hardening temperature after the tool is fully heated through. A holding time of less than recommended time will result in loss of hardness.

Protect the part against decarburisation and oxidation during hardening.

QUENCHING MEDIA

- Vacuum (high speed gas with sufficient overpressure minimum 2 bar)
- Martempering bath or fluidised bed at approx. 200 – 550 °C
- Forced air/gas

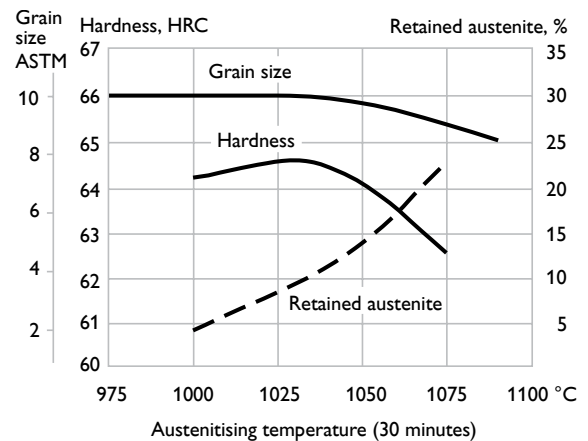
Note: Temper the tool as soon as its temperature reaches 50 – 70 °C.

In order to obtain the optimum properties for the tool, the cooling rate should be as fast as possible with regards to acceptable distortion.

A slow quench rate will result in loss of hardness compared with the given tempering curves.

Martempering should be followed by forced air cooling if wall thickness is exceeding 50 mm.

HARDNESS, RETAINED AUSTENITE AND GRAIN SIZE AS FUNCTION OF AUSTENISING TEMPERATURE

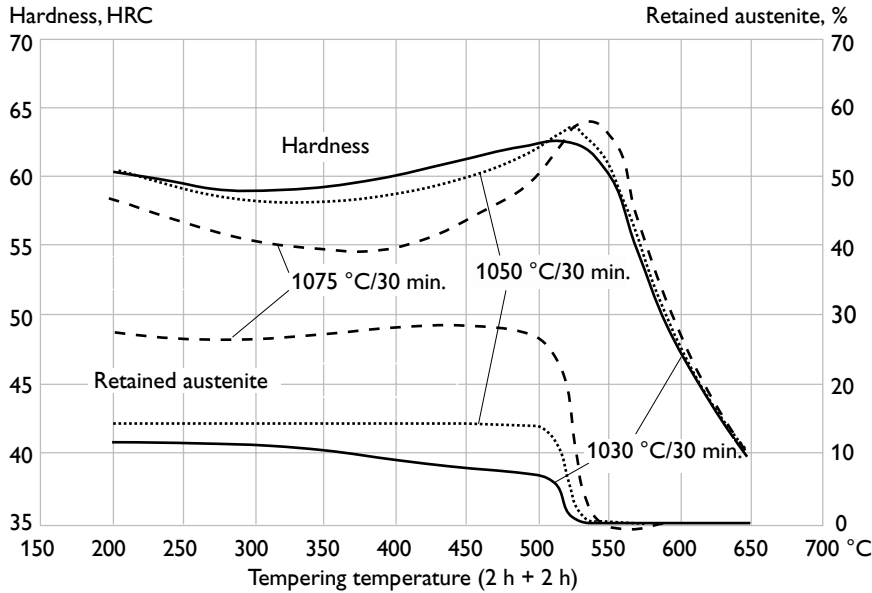


TEMPERING

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. For highest dimensional stability and ductility, a minimum temperature of 540 °C and three tempers is strongly recommended.

Tempering at a lower temperature than 540 °C may increase the hardness and compressive strength to some extent but also impair cracking resistance and dimensional stability. However, if lowering the tempering temperature, do not temper below 520 °C.

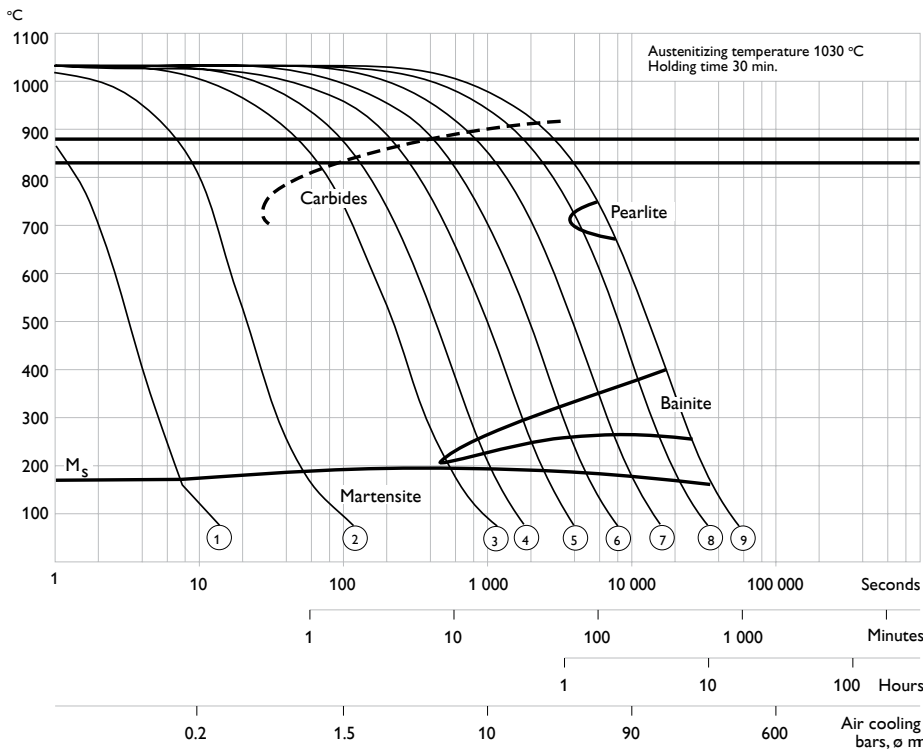
When tempering twice the minimum holding time at temperature is 2 hours. When tempering three times the minimum holding time is 1 hour.



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.

CCT GRAPH

Austenitising temperature 1030 °C. Holding time 30 minutes.



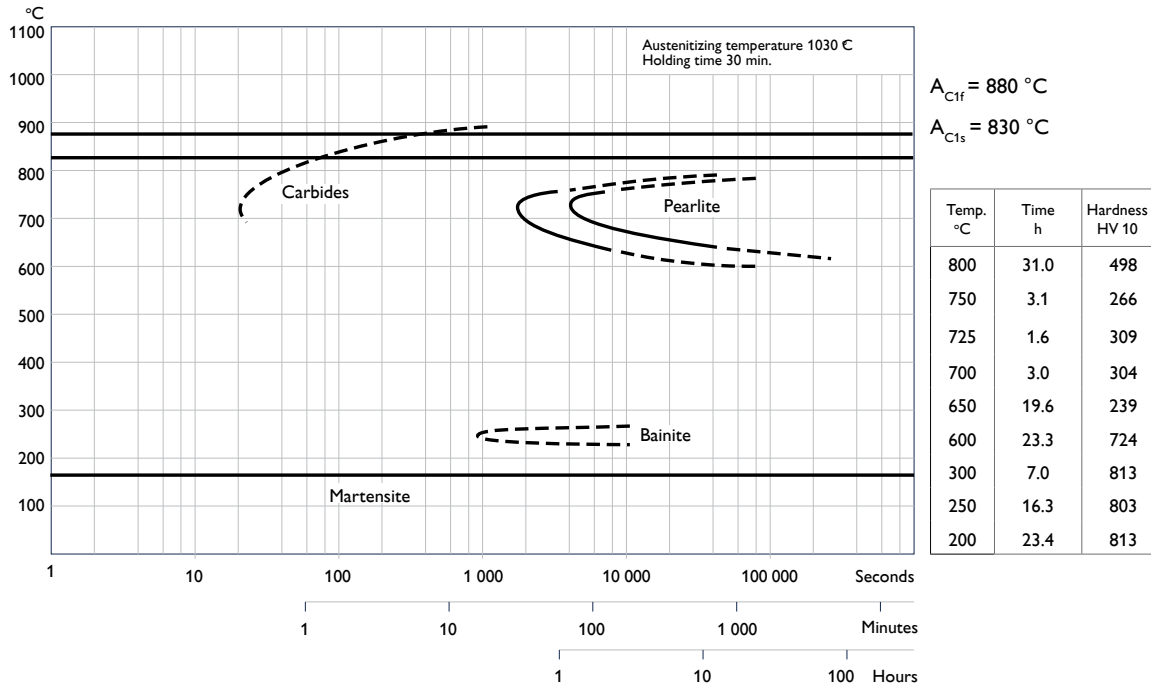
$A_{C1f} = 880 \text{ }^\circ\text{C}$

$A_{C1s} = 830 \text{ }^\circ\text{C}$

| Cooling Curve No. | Hardness HV 10 | $T_{800-500}$ sec |
|-------------------|----------------|-------------------|
| 1 | 824 | 2 |
| 2 | 824 | 11 |
| 3 | 813 | 140 |
| 4 | 813 | 280 |
| 5 | 813 | 630 |
| 6 | 813 | 1 241 |
| 7 | 724 | 2 482 |
| 8 | 649 | 5 215 |
| 9 | 572 | 8 360 |

TTT GRAPH

Austenitising temperature 1030 °C. Holding time 30 minutes.



DIMENSIONAL CHANGES

The dimensional changes have been measured after austenitising and tempering.

Austenitising: 1030 °C/30 min, cooling in vacuum furnace at 0.75 °C/s between 800 °C and 500 °C

Tempering: 2 x 2 h at various temperatures

Specimen size: 100 x 100 x 100 mm

SUB-ZERO TREATMENT

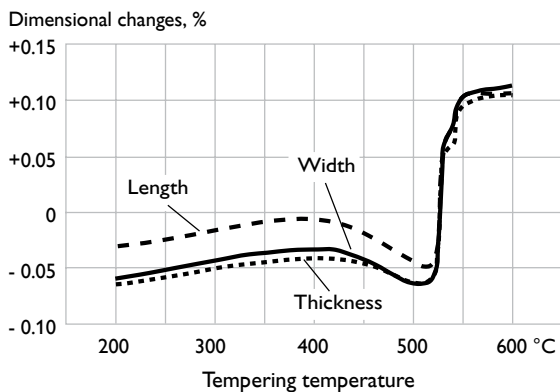
Pieces requiring maximum dimensional stability in service should be sub-zero treated.

Sub-zero treatment reduces the amount of retained austenite and changes the hardness as shown in the diagram below.

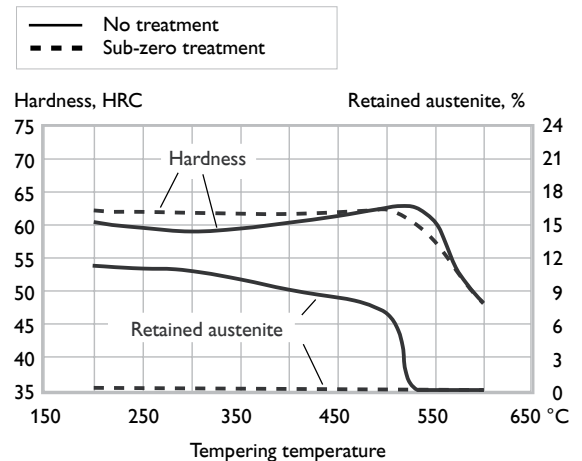
Austenitising: 1030 °C /30 min

Tempering: 2 x 2 h at various temperatures

DIMENSIONAL CHANGES AS FUNCTION OF TEMPERING TEMPERATURE



HARDNESS AND RETAINED AUSTENITE AS FUNCTION OF TEMPERING TEMPERATURE AND SUB-ZERO TREATMENT



SURFACE TREATMENT

Some cold work tool steel are given a surface treatment in order to reduce friction and increase wear resistance. The most commonly used treatments are nitriding and surface coating with wear resistant layers produced via PVD or CVD.

The high hardness and good resistance to chipping together with a good dimensional stability make ASSAB 88 suitable as a substrate steel for various surface coatings.

NITRIDING AND NITROCARBURISING

Nitriding and nitrocarburising result in a hard surface layer which is very resistant to wear and galling. The surface hardness after nitriding is approximately 1100 HV_{0.2kg}. The thickness of the layer should be chosen to suit the application in question.

PVD

Physical vapour deposition, PVD, is a method of applying a wear-resistant coating at temperatures between 200–500 °C.

CVD

Chemical vapour deposition, CVD, is used for applying wear-resistant surface coatings at a temperature of around 1000 °C. It is recommended that the tools are separately hardened and tempered in a vacuum furnace after surface treatment.

MACHINING RECOMMENDATIONS

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions.

Condition: Soft annealed condition ~235 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 | 100 – 150 | 150 – 200 | 17 – 22 |
| 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 – 3 |
| Carbide designation ISO | K20, P20 Coated carbide | K10, P15 Coated carbide | – |

MILLING

FACE AND SQUARE SHOULDER MILLING

| Cutting data parameters | Milling with carbide | |
|-------------------------------|-------------------------|--------------------------|
| | Rough milling | Fine milling |
| Cutting speed (v_c) m/min | 110 – 180 | 180 – 220 |
| 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 | K20, P20 Coated carbide | P10 – P20 Coated carbide |

END MILLING

| Cutting data parameters | Type of milling | | |
|--------------------------------|--------------------------|--------------------------|--------------------------|
| | Solid carbide | Carbide indexable insert | High speed steel |
| Cutting speed (v_c), m/min | 80 – 120 | 100 – 140 | 13 – 18 ¹ |
| Feed (f_z) mm/tooth | 0.03 – 0.20 ² | 0.08 – 0.20 ² | 0.05 – 0.35 ² |
| Carbide designation ISO | – | P15 – P40 | – |

¹ For coated High Speed Steel end mill, $v_c \sim 30 - 35$ 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 | 13 – 18* | 0.05 – 0.10 |
| 5 – 10 | 13 – 18* | 0.10 – 0.20 |
| 10 – 15 | 13 – 18* | 0.20 – 0.25 |
| 15 – 20 | 13 – 18* | 0.25 – 0.30 |

* For coated high speed steel drill, $v_c \sim 25 - 35$ m/min

CARBIDE DRILL

| Cutting data parameters | Type of drill | | |
|-----------------------------------|--------------------------|--------------------------|-----------------------------|
| | Indexable insert | Solid carbide | Carbide tip ¹ |
| Cutting speed (v_c), m/min | 140 – 160 | 80 – 100 | 45 – 55 |
| Feed (f) mm/r | 0.05 – 0.15 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

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 JV |
| Profile grinding | A 100 KV | A 120 JV |

WELDING

Good results when welding tool steel can be achieved if proper precautions are taken during the welding operation.

- The joints should be prepared properly.
- Repair welds should be made at elevated temperature. Make the two first layers with the same electrode diameter and/or current.
- Always keep the arc length as short as possible. The electrode should be angled at 90° to the joint sides to minimise undercut. In addition, the electrode should be held at an angle of 75 – 80° to the direction of forward travel.
- For large repairs, weld the initial layers with a soft filler material (buffering layer).

FILLER MATERIAL

TIG WELDING CONSUMABLES

| Filler Material | Hardness after welding |
|--------------------|-------------------------------|
| Type AWS ER312 | 300 HB (for buffering layers) |
| UTP A67S | 55 – 58 HRC |
| UTP A696 | 60 – 64 HRC |
| Casto Tig 45303W * | 60 – 64 HRC |
| Caldie Tig-Weld | 58 – 62 HRC |

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

MMA (SMAW) WELDING CONSUMABLES

| Filler Material | Hardness after welding |
|-----------------------|-------------------------------|
| Type AWS ER312 | 300 HB (for buffering layers) |
| Castolin EutecTrode 2 | 54 – 60 HRC |
| UTP 67S | 55 – 58 HRC |
| UTP 69 | 60 – 64 HRC |
| Castolin EutecTrode 6 | 60 – 64 HRC |
| Caldie Weld | 58 – 62 HRC |

PREHEATING TEMPERATURE

The temperature of the tool during the entire welding process should be maintained at an even level.

| | Soft annealed | Hardened |
|----------------------------|---------------|-------------|
| Hardness | 230 HB | 60 – 62 HRC |
| Preheating temperature | 250 °C | 250 °C |
| Max. interpass-temperature | 400 °C | 400 °C |

HEAT TREATMENT AFTER WELDING

| | Soft annealed | Hardened |
|----------------|---|---|
| Hardness | 230 HB | 60 – 62 HRC |
| Cooling rate | 20 – 40 °C/h for the first 2 hours then freely in air | |
| Heat treatment | Soft anneal Harden Temper | Temper 10 – 20 °C below the latest tempering temperature |

FLAME HARDENING

Use oxy-acetylene equipment with a capacity of 800 – 1250 l/h. Oxygen pressure 2.5 bar, acetylene pressure 1.5 bar. Adjust to give neutral flame.

Temperature: 980 – 1020 °C. Cool freely in air.

The hardness at the surface will be 58 – 62 HRC and 41 HRC at a depth of 3 – 3.5 mm.

ELECTRICAL DISCHARGE MACHINING — EDM

If EDM is performed in the hardened and tempered condition, finish with a fine-sparking, i.e. low current, high frequency.

For optimal performance the EDM'd surface should be ground/polished to completely remove the EDM layer and the tool re-tempered at approx. 25 °C below the original tempering temperature.

When EDM'ing larger sizes or complicated shapes ASSAB 88 should be tempered at high temperature, above 500 °C, during the heat treatment to lower the residual stress level and thereby reducing the risk of potential cracking in connection with the EDM.

Further information

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

RELATIVE COMPARISON OF THE RESISTANCE TO FAILURE MECHANISMS

| ASSAB grade | Hardness/ Resistance to plastic deformation | Machinability | Grindability | Dimension stability | Resistance to | | Fatigue cracking resistance | |
|------------------|--|---------------|--------------|------------------------|------------------|------------------------------|---|---------------------------------|
| | | | | | Abrasive wear | Adhesive wear/ Galling | Ductility/ resistance to chipping | Toughness/ gross cracking |
| ASSAB DF-3 | █ | █ | █ | █ | █ | █ | █ | █ |
| Calmax | █ | █ | █ | █ | █ | █ | █ | █ |
| Caldie (ESR) | █ | █ | █ | █ | █ | █ | █ | █ |
| ASSAB 88 | █ | █ | █ | █ | █ | █ | █ | █ |
| ASSAB XW-42 | █ | █ | █ | █ | █ | █ | █ | █ |
| ASSAB XW-10 | █ | █ | █ | █ | █ | █ | █ | █ |
| ASSAB XW-5 | █ | █ | █ | █ | █ | █ | █ | █ |
| Vanadis 4 Extra* | █ | █ | █ | █ | █ | █ | █ | █ |
| Vanadis 8* | █ | █ | █ | █ | █ | █ | █ | █ |
| Vancron 40* | █ | █ | █ | █ | █ | █ | █ | █ |
| ASSAB PM 23* | █ | █ | █ | █ | █ | █ | █ | █ |
| ASSAB PM 30* | █ | █ | █ | █ | █ | █ | █ | █ |
| ASSAB PM 60* | █ | █ | █ | █ | █ | █ | █ | █ |

The longer the bar, the better the resistance.

* ASSAB SuperClean PM tool steel.

ASSAB

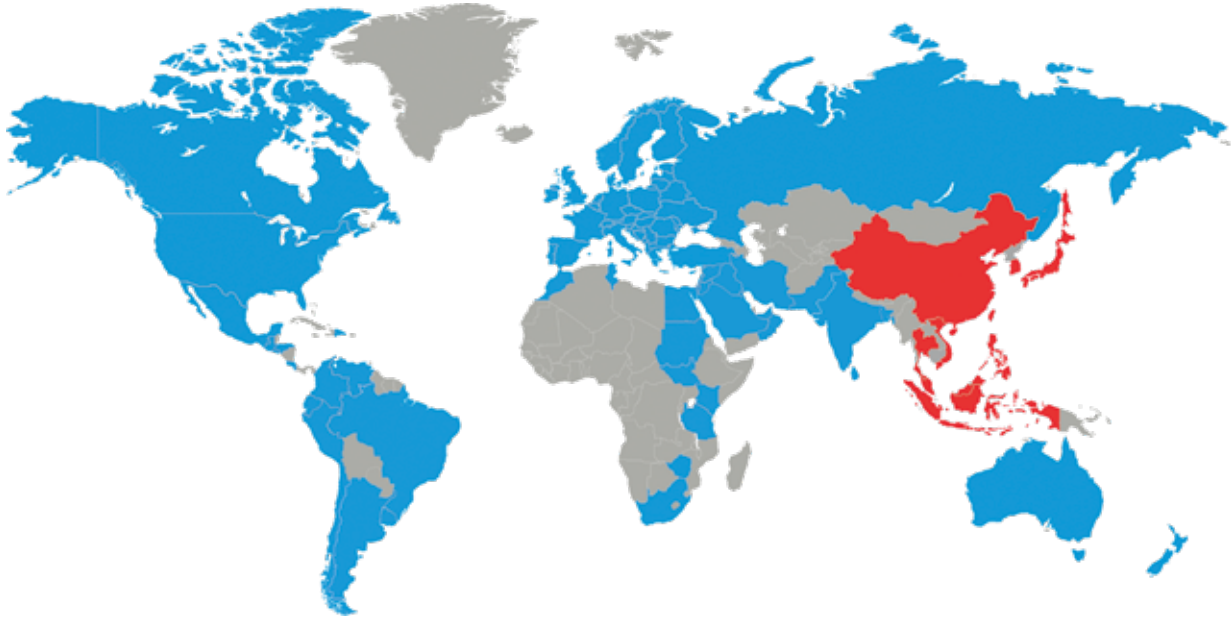
SUPERIOR TOOLING SOLUTIONS

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