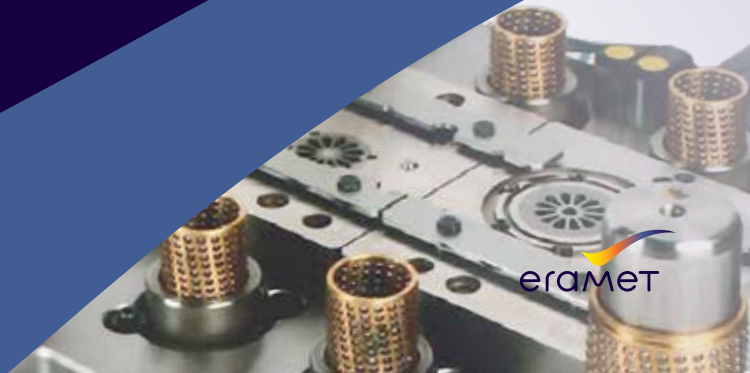


ERASTEEL

Conventional and Powder Metallurgy
High Speed Steels for

TOOLING APPLICATIONS

USER GUIDE



eramET

Dear reader,

This guide will hopefully give you all the information to show you that powder metallurgy and conventional High Speed steels (HSS) are a very good alternative for tooling applications.

If you are looking for superior cleanliness, toughness and wear resistance, then the large number of conventional HSS and Powder Metallurgy HSS grades produced and distributed by Erasteel will give you a great opportunity to optimize the manufacturing and performance of your tools.

Thanks to its unique properties, ASP® Powder Metallurgy HSS is the best alternative to conventional tool steels when early failures as wear or cracks are impacting your tool performance and total cost of ownership.

Conventional HSS leads you to upgrade or leverage the performance of your tools if you are a tool steel user looking for better hardness or wear resistance.

Over and above that, this guide aims at giving you valuable insight into areas of heat treatment, grinding, coating and other aspects relevant for anyone dealing with cold work, hot work and plastic injection tool manufacturing.

Whatever your requirements are, chances are there is an Erasteel solution that will match your needs.

Should you need more information than what is included in this manual, please feel free to contact us at:
Erasteel-CustomerSupport@eramet.com

Wishing you a good reading experience,

Your dedicated Erasteel team



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BLANKING

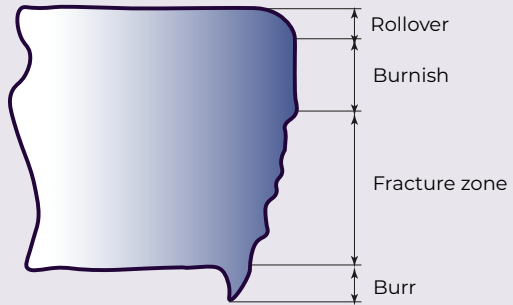
WHAT IS BLANKING?

Blanking is a metal production process, during which a metal workpiece is removed from the primary metal strip or sheet when it is punched. The material that is removed is the new metal workpiece or blank.



A die cut edge normally has four areas:

- roll-over
- burnish
- fracture
- burr



The cut surface of a cut band created with a conventional metal punching process is **partially angled** and has a **rough appearance** in the fracture zone of the cut.

WHICH SPECIFIC TECHNICAL REQUIREMENTS?

During the punching/blanking operation, the working parts (punches and dies) behavior depends on the worked material (tensile strength for both, or thicknesses), the geometry of the part and the tool steel ability to cope with the stresses that arise on the cutting edges.

Blanking of a thin and soft strip steel will be very different compared with blanking of a thick and hardened sheet metal.

In the first case abrasive wear will be the dominating failure mechanism, whereas chipping, cracking and plastic deformation can arise quickly in the second case.

To make the right material choice for the tool, a good understanding of the required mechanical properties is necessary.

WHY WOULD ASP® BE YOUR SOLUTION?

When abrasive wear resistance is required, even D2 or M2 will not be sufficient and only the high carbides ratio of ASP® can provide the suitable tool life and performance during production.

When the main failure mechanism is chipping (complicated geometry, heavy thickness, hardened worked material), then the extremely fine and homogeneous ASP® microstructure is the obvious choice. ASP®2012 and ASP®2005 impact strength and crack resistance are at least 10 times better compared to conventional tool steels as D2.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2005	E M35
ASP®2009	
ASP®20011	
ASP®2012	
ASP®2023	
ASP®2030	
ASP®2053	
ASP®2060	



Blanking and forming parts done with tools in ASP®



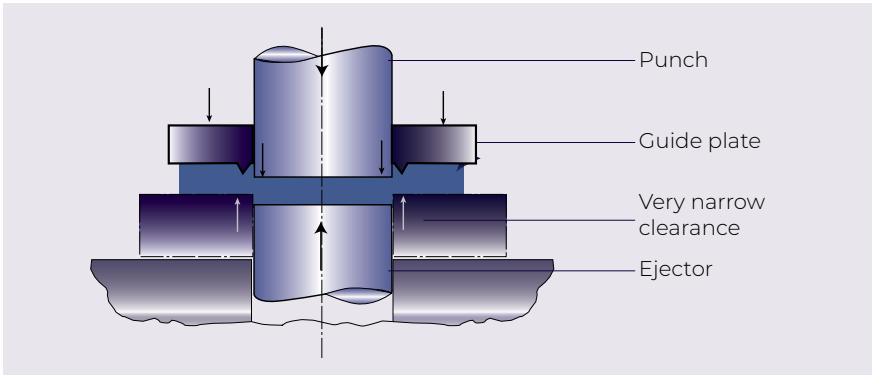
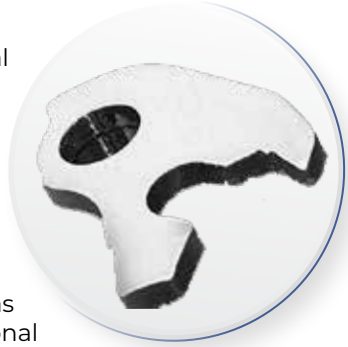
FINE BLANKING & FORMING

WHAT IS FINE BLANKING?

Fine blanking is a high precision metal forming process used in the automotive, heavy duty, electronics, medical, lawn and garden, and general industries.

In fine blanking, the strip is held securely by the blank holder (guide-plate with V ring) which forces the metal sheet to stay completely flat while the part is being cut.

The end result is that the produced part has right angles and very tight dimensional tolerances, excellent flatness, and with very little variation from part-to-part throughout long production runs. Fine blanking eliminates machining and reduces secondary operations.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

Fine blanking is characterized by the small blanking clearances and sharp edges creating near net shape parts.

In fine blanking, the produced parts generally have complex shapes which induce stress factors on active parts. Therefore, punches and dies have to withstand very high stresses leading to a higher risk of chipping and total breakage.

WHY WOULD ASP® BE YOUR SOLUTION?

Thanks to the powder metallurgy elaboration and the high level of cleanliness, ASP®2012 is a very good alternative to the conventional tool steels used in fine blanking when there is a large thickness to cut. It's a very good compromise between compressive strength, chipping / cracking resistance and wear resistance.

The hardness shall always be as high as possible without getting any problems with chipping or cracking. Thus the max. hardness has to be reduced with respect to geometry of blanked part, type, thickness and hardness of the work material.

As for normal blanking the hardness has to be reduced for increased thickness of work material.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2005	
ASP®2012	
ASP®2023	
ASP®2052	
ASP®2053	
ASP®2055	



Fine blanking parts done with tools in ASP®

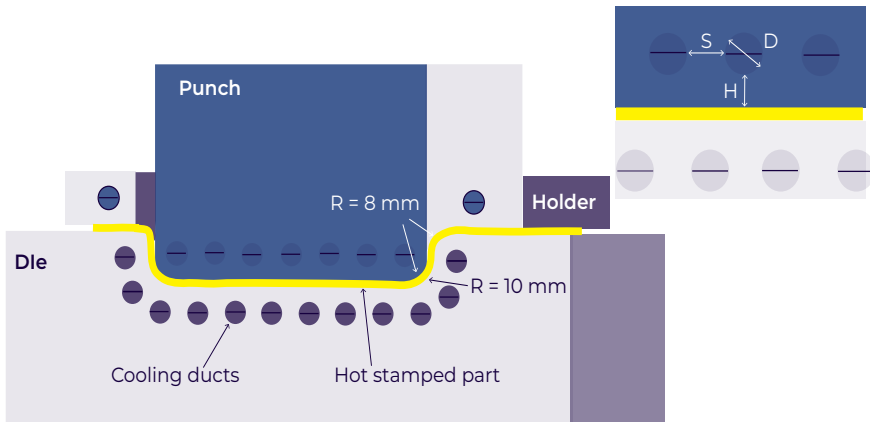


PRESS HARDENING

WHAT IS PRESS HARDENING?

Press hardening is a manufacturing process that is used to produce super high strength car body parts such as bumper beams, door reinforcements, A and B-pillar reinforcements, roof and dash panel cross members.

The blanks are first heated in a furnace up to its austenitising temperature, then transferred into a cooled forming tool. The blank is formed, and then the formed part is quenched by heat transfer through its contact with the cooled forming dies to produce a martensitic structure that provides the press-hardened parts with an extremely high tensile strength of up to 2,000 MPa.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

The forming phase means high compressive stresses on the surface of the tool, especially in areas of strong plastic deformation (with thickness reductions on the part).

Also, the hardening step implies a fast cooling rate (from 800°C to 200°C in few seconds) that creates thermal contractions and stresses at each press cycle, in addition to mechanical stresses.

Cracks often start at the surface and then propagate towards the underlying cooling channels.

In addition, press hardened boron steels coated with aluminum-silicon (AlSi) used to prevent decarburization and scale formation is very abrasive to tool surfaces.

Furthermore, no lubricants can be used because of the ultrahigh temperatures. As a result, managing friction is critical to avoid excessive die wear from the abrasion.

WHY WOULD ASP® BE YOUR SOLUTION?

In order to increase the performance of the tool, the solution is to use tool steels with better wear resistance, which mean higher hardness together with higher carbide content and better surface finish.

Due to its powder metallurgy and its analysis, ASP®2012 has a very fine microstructure with evenly distributed carbides.

Contrary to most of tool steels, ASP®2012 only contains very hard and fine MC carbides to optimise toughness and wear resistance.

Compared with other tool steels used in press hardening, ASP®2012 has a higher Carbon content allowing to reach a higher hardness.

Thanks to the powder metallurgy elaboration and the high level of cleanliness, ASP®2012 is a very good alternative to the conventional tool steels used in press hardening. It's a very good compromise between compressive strength, chipping / cracking resistance and wear resistance.

RECOMMENDED ERASTEEL GRADES

ASP® powder metallurgy HSS

ASP®2012



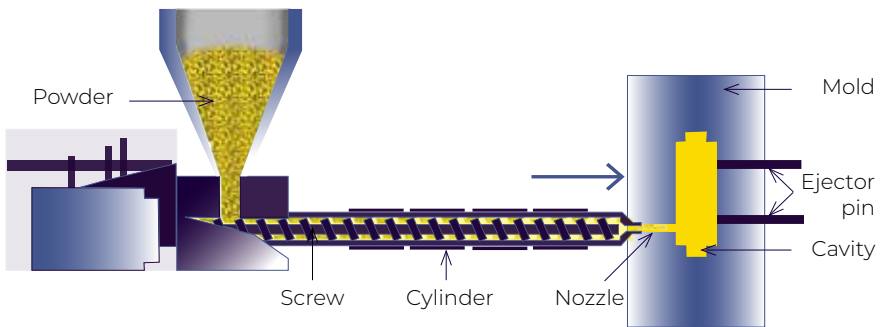
Typical
press hardened parts



MOULDING

WHAT IS PLASTIC INJECTION?

Injection moulding is a production process used to manufacture thin walled plastic parts for various applications such as household appliances, consumer electronics, power tools, optical, medical parts, technical pieces in automotive industry, packaging and food industry.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

Tools steels which are used as mould materials have to reach a sufficient level of :

- strength and hardness : due to high injection and closing pressure,
- toughness : cavities with complicated shapes, small radius, thin walls, sharp corners,
- wear resistance : in case of long series and abrasive plastics with high filler contents,
- cleanliness : to ensure a very good polishability when high surface finish is needed on the plastic part.

In the automotive industry, under the hood plastic parts are produced in fiber-reinforced thermoplastics, such as PA46, PA410, PPA, PPS, PEEK, with glass fibers content up to 60%.

As glass fiber reinforced plastics are very aggressive, the molds need much more wear resistance than that of the commonly used tool steel H13 can offer. When high abrasion resistance and important plastic deformation are needed the H13 is not the best choice. With such a solution, the mould will keep a low performance.

WHY WOULD ASP® BE YOUR SOLUTION?

ASP®2012 chemical composition provides a very good balance between the carbon content and the alloying elements such as W and V, which result in a much more wear resistance compared to H11 / H13.

ASP®2012 can increase the performance of the moulds, thanks to its outstanding toughness, even at high hardness levels such as 60/62 HRC. ASP®2012 wear resistance is also much higher compared to H13.

Compared to the other PM tool steels of the market, ASP®2012 gives a better compromise between compressive strength, toughness and wear resistance. ASP®2012 also has very good machinability, similar to H13, and can reach a very high surface finish and can be repaired by welding.

The Erasteel powder metallurgy tool steels are particularly suitable for technical plastic parts produced in large series with Glass fiber Reinforced Plastics. Our ASP® grades are specially recommended for small moulds, inserts and cores when the main failure mechanism is abrasion.

Furthermore, ASP®2005 and ASP®2053 can also be used for screws and injection points to improve wear resistance when long and abrasive fibers lead to heavy abrasion.

RECOMMENDED ERASTEEL GRADES

ASP®2005

ASP®2009

ASP®2011

ASP®2012

ASP®2023

ASP®2053

ASP®APZ10

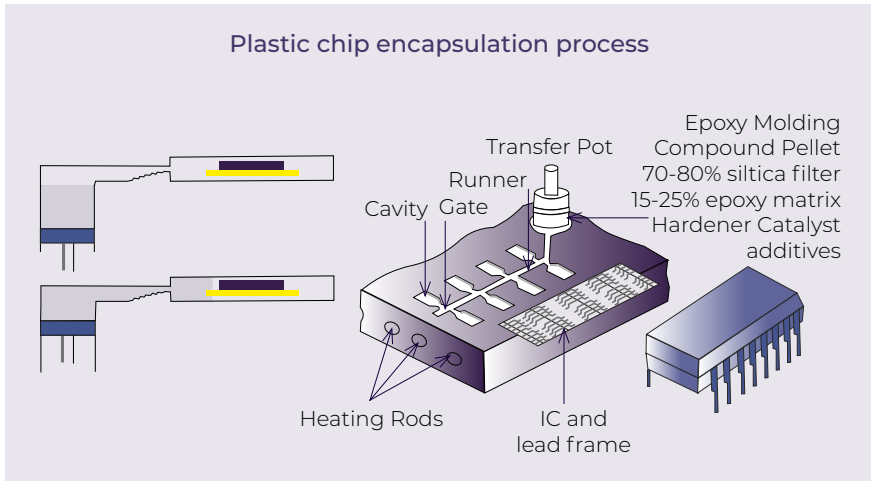
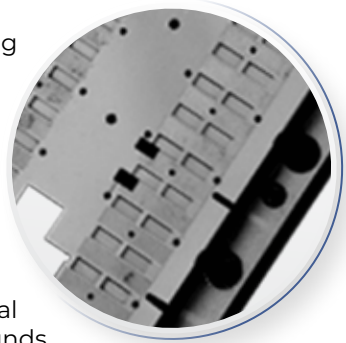


MOULDING

WHAT ARE IC MOLDS?

Plastic Chip Encapsulation is a molding process where chips are being encapsulated with Epoxy Molding Compound (EMC) to prevent physical damage or corrosion. This process contains the interconnection between microchips and other electronics (so-called wire bonding).

In basic terms, mold compounds are composite materials comprising organic resins, such as epoxy resin. Given the natural adhesive properties of epoxy resins, compounds also require a mold release agent to enable the extraction of the component from the mold. Temperature of the process between 240°C to 300°C maximum.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

Transfer molding is perhaps the most widely used molding process in the semiconductor industry, the molds have to produce huge quantities of parts at a high level of quality for that they have to reach a sufficient level of:

- Strength and Hardness: Due to high injection and closing pressure
- Wear resistance: for long series of parts production

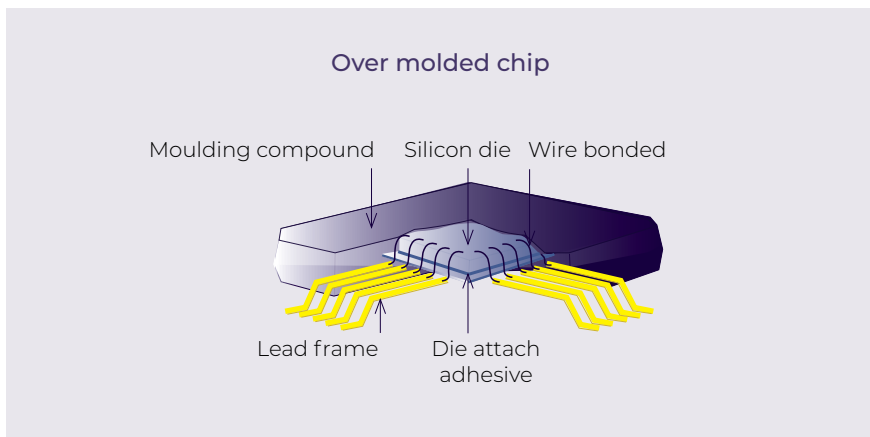
- Thermal stability: multicavity molds imply a high level of precision.
- Cleanliness: to ensure a very good fatigue resistance and facilitate the EDM (Electrical discharge machining) process.

WHY WOULD ASP® BE YOUR SOLUTION?

The powder metallurgy is largely used for the transfer molds and especially the ASP® which are the reference providing:

- Strong wear resistance
- High level of toughness
- A very good dimensional stability during production
- An improved quality during EDM process (Electrical Discharge Machining)

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2005	E M2
ASP®2012	
ASP®2023	
ASP®2030	
ASP®APZ10	



ASP® is a registered trademark of Erasteel.

POWDER COMPACTION

WHAT IS POWDER COMPACTION?

The raw material of a sintered component is always a metal powder that is loaded by gravity into the tool cavity.

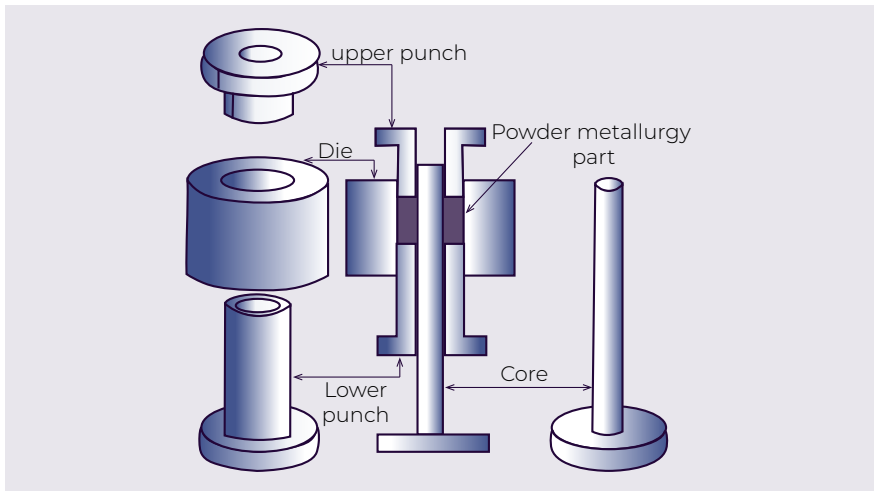
Powder compaction enables production of high precision parts, from a few grams to several kilos, with very good mechanical properties. Powder compaction is suitable for medium and long series.

The powder mixture is loaded by gravity into the tool cavity of a powder compaction tool. This tool consists in a die (external geometry of the part) and upper and lower punches.

The powder is compacted within the die with punches to form the compact under a pressure of 200 to 1500 MPa. Generally, compaction pressure is applied through punches from both ends of the toolset in order to reduce the level of density gradient within the compact.

This first operation will give the geometric shape of the part but without the required mechanical characteristics, that will be achieved during the sintering step in a furnace at high temperature (usually between 750°C and 1300°C) to bond the powdered metal particles together.

This cycle offers a readily automated and high production process rate.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

When a tool is defined with sharp edges or with complex geometry the toughness is a key factor to consider. The wear resistance combined with a good toughness is a plus when large production volumes are planned. High pressure processes and abrasive powders are also key factors to take into account when selecting the grade. Galling and adhesive wear can be solved also by the selection of the right grade.

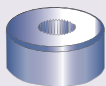
WHY WOULD ASP® BE YOUR SOLUTION?

ASP® has a higher cleanliness compared to conventional grades, greatly improving mechanical properties.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2005	
ASP®2012	
ASP®2023	
ASP®2030	
ASP®2052	
ASP®2053	
ASP®2055	
ASP®2060	
ASP®APZ10	



Tools set made in ASP®



Die



Upper punch



Lower outer punch



Lower inner punch



Tube



Crown



Core

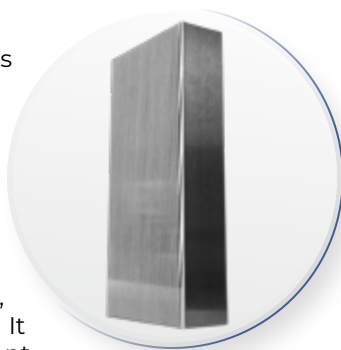
THREAD ROLLING

WHAT IS THREAD ROLLING?

Thread rolling is a cold forming process which involves deforming a metal part by rolling it through shaped hardened part dies (round or flat tools). As the dies and work piece rotate and advance relative towards one another, metal flows radially to achieve the desired thread form.

In contrast with other widely used threading processes such as thread cutting, thread rolling is not a subtractive process. It means the full metal quantity is kept constant.

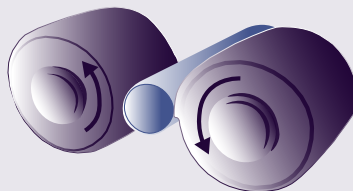
Thread rolling machines can be a flat-die, planetary, or cylindrical-die type.



Main applications



Flat thread rolling dies



Rolling dies

WHICH SPECIFIC TECHNICAL REQUIREMENTS?

Thread rolling uses hardened steel dies to displace and mold ductile metals. The dies apply pressure, compressing the minor diameter (thread roots), and forcing that material up to form the major diameter (thread crests).

Dies used for rolling must be hard and precise. Any distortion or plastic deformation of the die will result in poor dimensional accuracy of the threads.

Poor finish is resulting of worn-out dies.

Hardness and toughness must be high enough to enable the dies to withstand the extreme pressure against the workpiece's surface.

The main cause for removing thread rolling dies from service is chipping of the crest of the die thread.

Good wear resistance is also necessary in long series of production.

WHY WOULD ASP® BE YOUR SOLUTION?

The materials most commonly used to make thread rolling dies are D2 and high speed steels as E M2 or E M42.

Compared to these conventional tool steels, ASP® can reach higher hardness and compressive strength, together with much better toughness. This property will give a good resistance to chipping and cracking failures that often occur on the sharp angles of the thread die.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2005	E M2
ASP®2030	E M42
ASP®2042	
ASP®2053	

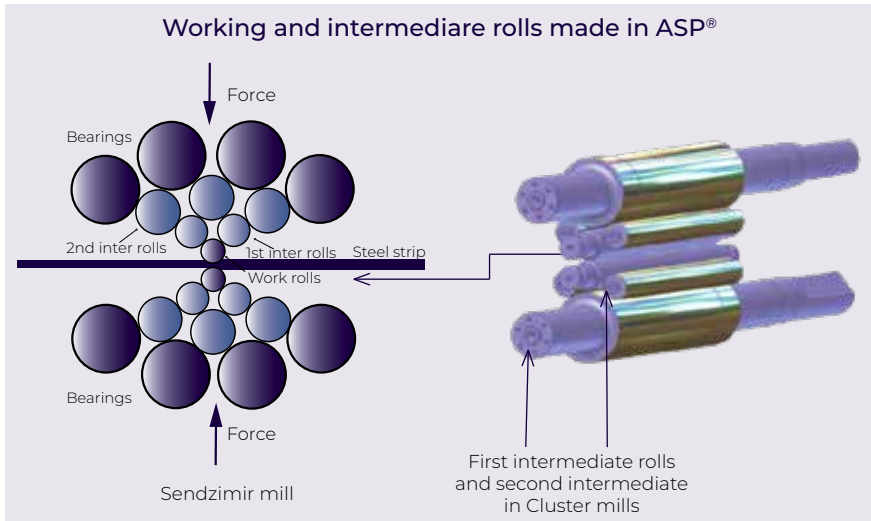


ROLLS FOR ROLLING MILLS

WHAT ARE ROLLING ROLLS?

The rolling process is the shaping of metals by passing between rotating rolls rotating in opposite direction. The main purpose of rolling is to decrease the thickness of the metal.

The deformation takes place when a compressive force is applied by a set of rolls on ingots or various other metal form products. This deformation decreases the cross-section area of the metal and converts it into the required shape. High production rate, grain structure, and surface-finish are obtained, which makes it a most suitable metal forming process for large length cross-section workpieces like plates and sheets.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

Rolls are required to carry out the heavy work of reduction during hot and cold rolling.

During rolling the roll is under high load and the contact area between the roll and material being rolled suffers wear.

As a result of the friction between the rolls and the metal surface, the metal is subjected to high compressive stresses.

Roll design is required to cope with the following requirements into considerations:

- maximum strength for taking care of the separating forces, torque and high pressure between the rolls.
- maximum wear resistance in the contact area between the roll and the material being rolled. There are a large number of parameters which influence roll wear.
- maximum fatigue strength to avoid fire cracks initiation sites and crack propagation. It is important since many failures in rolls occur due to fatigue. The combination of high hardness and a small increase in the stress contributes in initiating a crack which propagates under repeated load.

WHY WOULD ASP® BE YOUR SOLUTION?


High hardness is required to get the good level of compressive strength on the rolls. This hardness can be achieved with ASP® while maintaining a good impact resistance to avoid any chipping and cracking.


Regarding wear resistance, the influence of hardness of the material of the roll on the wear resistance is only marginal. The high contents of C and alloying elements in the ASP® analysis and the microstructures are more important parameters.

The good level of fatigue strength requires a fine, homogeneous and very clean microstructures that ASP® can provide.

The small carbide size and uniform carbide distribution lead to reduced regrinding depth when maintenance becomes necessary and easier to achieve a good surface finish during grinding.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2005	
ASP®2023	
ASP®2030	
ASP®2053	
ASP®2060	



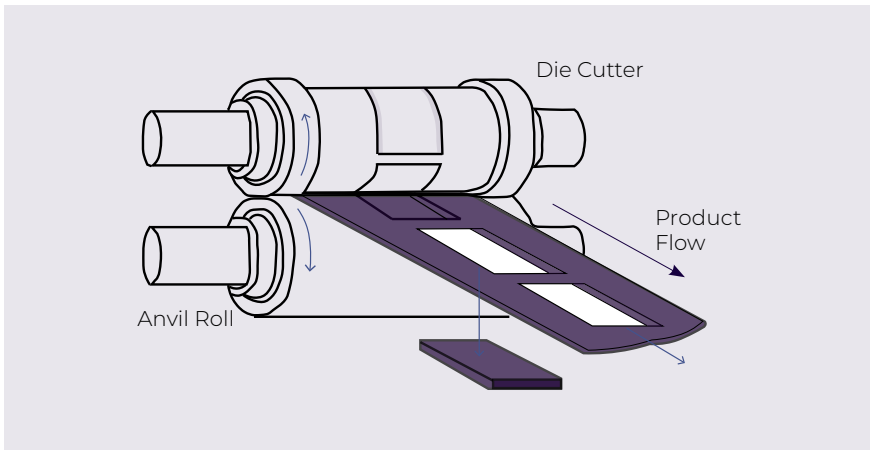


Precision strip

ROTARY DIE CUTTER

WHAT IS A ROTARY DIE CUTTER?

Rotary die cutting is used to process at high speed and in high precision wide range of materials, including thin metal, plastic, paper, foam, fabric, and laminates. The rotary press die cutting station, contains a cutting die cylinder and a hardened anvil cylinder rotating in opposite directions. The rotary cutting die serves as the machine tool which executes the actual cutting operation, while the anvil cylinder serves as a surface against which the cutting die performs it. The cutting die's edge compresses the raw material sheets against the anvil cylinder until the edge pierces through the material. This action produces the desired cuts, slits, or perforations.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

The cutting lines are engraved directly into the solid body of the cylinder. Depending on the final product, the cutting edges can be finished with a manual grinding/polishing operation to reach the high required accuracy and efficiency. Conventional D2 or 8% chromium tool steel gives coarse carbide network as banded structure that makes this operation very difficult.

The force required to cut a material by the pressing action of the die is considerably greater than the force required for a cutting process using a blade.

The conventional die cutter is made of tool steel, but it has a disadvantage in product-life cycle due to early chipping, cracks and abrasion of the cutting edges.

WHY WOULD ASP® BE YOUR SOLUTION?

ASP® provides a fine microstructure with evenly distributed carbides giving outstanding toughness, high hardness, high compressive strength and high wear resistance to extend die cutter life.

Moreover, due to uniform carbide distribution, ASP® is easier to achieve the high quality surface finish after grinding / polishing of the hardened edges.

Rotary die cutters needs very good dimensional and geometrical precision. Thanks to its very fine microstructure, ASP® meets all the dimensional stability requirements after heat treatment.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2011	E M2
ASP®2015	
ASP®2030	
ASP®2052	
ASP®2053	
ASP®2060	



Products made by Rotary die cutting



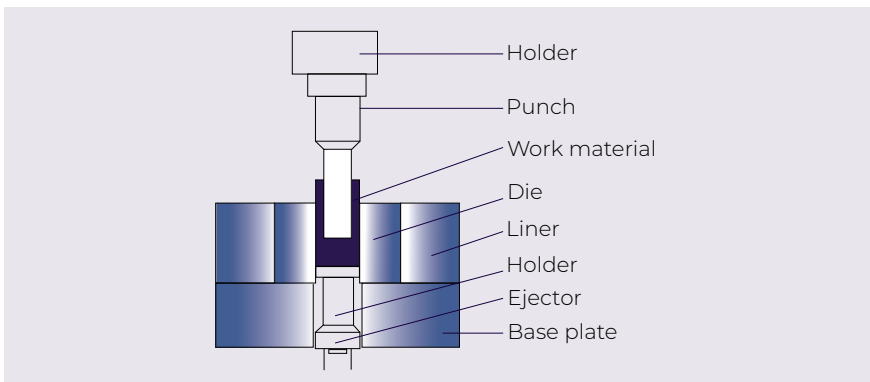
COLD FORGING

WHAT IS COLD FORGING?

Cold forging is an efficient and economical metal manufacturing process for the production of high volumes of parts at low cost in which bar material is inserted into a die and squeezed into a second closed die.

Unlike warm or hot forging, cold forging shapes and deforms bar material at room temperature using localized, compressive force. Depending on the requirements of the parts design, the workpiece may pass through multiple dies or be struck several times in succession to achieve the proper shape.

The process produces greater dimensional accuracy than hot forming, and does not produce scale. However, the plastic flow characteristics of the workpiece are not as good, so that higher forging pressures are required.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

Cold forging is one of the most demanding metal forming applications due to extreme stresses emerging on the tools as a consequence of very high forging loads.

In order to withstand high speeds and enormous stresses, the tool steels used in cold processing metal require high performance in edge retention, fatigue resistance, wear resistance and impact resistance.

Most critical failure mechanisms are cracking, abrasive wear, galling and plastic deformation.

Wear is caused by the combination of high contact stress and the relative Sliding stress between the workpiece and tool surface.

In case of fatigue, the micro cracks initiate where the tool is highly stressed up to the yield limit and propagates in a time/cycle dependent manner until the final fracture of the tool. The transition radius, the thin walls and the sharp angles are location with higher stress and thus they are preferential sites of crack initiation by local plastic deformation..

WHY WOULD ASP® BE YOUR SOLUTION?

It is obvious that the ASP® PM process provides a much more homogeneous structure and a much finer dispersion of the carbides.

Since the coarse carbides in the conventional steel can act as crack initiation sites under cyclic loading, this fine dispersion of carbides in PM becomes especially important for cold working tools, where it improves the resistance against fracture and thereby fatigue cracking.

Cold work die punches in ASP® cold work steels can reach a longer life due to the delayed crack initiation and the subsequent improved fatigue resistance.

With ASP®, it's easier to achieve a good surface finish during grinding due to uniform carbide distribution. ASP® is also a better substrate for surface coatings.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M42
ASP®2005	C8
ASP®2012	
ASP®2023	
ASP®2030	
ASP®2042	
ASP®2048	
ASP®2052	
ASP®2053	



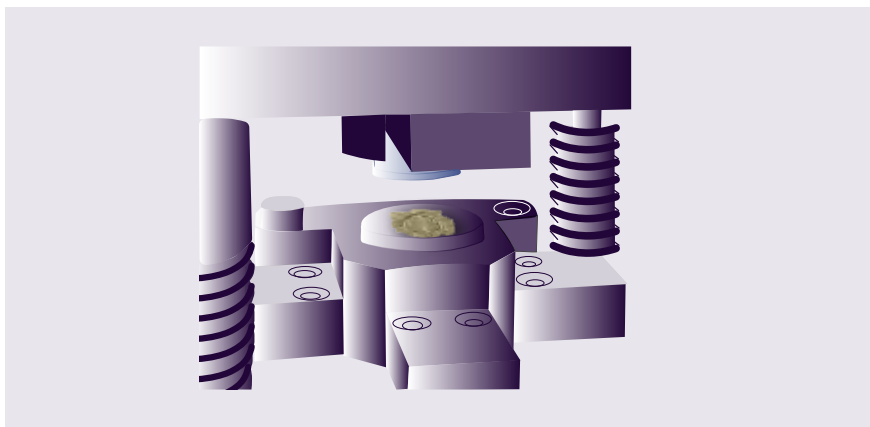
COINING

WHAT IS COINING?

Circulation coins are mass-produced from base metals such as copper, nickel and alloys. They are used for everyday cash transactions. After the mint's fitters and machinists install the dies in the coin presses, blanks are fed through the press where they are struck simultaneously on both sides by the dies. Dies can strike coins with up to 200 tonnes of pressure, at a rate of up to 650 pieces per minute. Under the pressure of striking, metal particles spread and stretch.



Uncirculated coins are mass-produced like circulation coins, but at a slower rate, and have not been distributed or used as currency. The press for uncirculated coins has an automatic feed and can make up to 80 coins per minute or 20,000 coins per day.



WHICH SPECIFIC TECHNICAL REQUIREMENTS?

Following the design (reliefs, curvature, rim width and height and PVD coating) the key factors for the tools can be different.

- Cleanliness is a key factor to obtain a high level of polishability which is necessary to produce for instance commemorative coins.
- Wear resistance is essential to protect the reliefs against erosion when doing long series


- Chipping and Cracking resistance are fundamental to preserve the quality of the curvature and the rims.
- Fatigue resistance is also an important point for the long series.

WHY WOULD ASP® BE YOUR SOLUTION?

The ASP®2012 is an excellent grade for the forming Die providing:

- High level of cleanliness (fatigue resistance improved)
- Probably the best in class regarding the toughness among the PM available on the market
- Excellent compressive strength (up to 63 HRC)
- Good abrasive wear resistance
- Very good resistance to tempering and very good dimensional stability
- Outstanding EDM machinability
- Can be PVD coated
- Very good polishability

ASP®2005 and ASP®2053 are dedicated to the blanking operation.

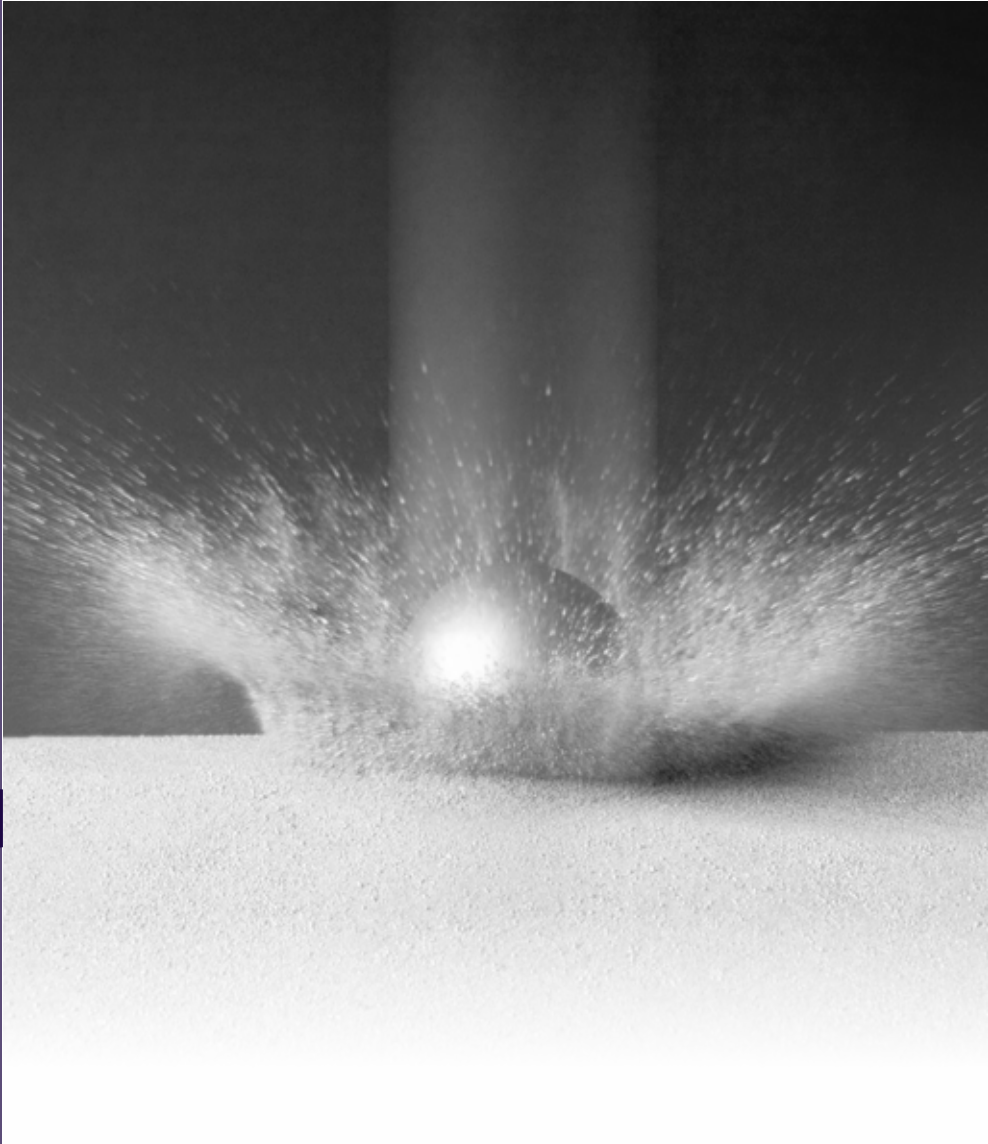
RECOMMENDED ERASTEEL GRADES	
	ASP® powder metallurgy HSS
	ASP®2005
	ASP®2012
	ASP®2053

Circular coins can be made of several parts cut





OUR GRADES PORTFOLIO



The following datasheets are for information only and do not create any binding contractual obligations.
Minimum hardness reachable depending on austenization temperature.

RECOMMENDED GRADES

Erasteel grades	Tooling				
	Blanking	Fine Blanking & Forming	Press Hardening	Moulding Plastic injection	Moulding IC Molds
ASP®2004	◆	◆			
ASP®2005	◆	◆		◆	◆
ASP®2009	◆			◆	
ASP®2011	◆			◆	
ASP®2012	◆	◆	◆	◆	◆
ASP®2015					
ASP®2023	◆	◆		◆	◆
ASP®2030	◆				◆
ASP®2042					
ASP®2048	◆				
ASP®2052		◆			
ASP®2053	◆	◆		◆	
ASP® 2055		◆			
ASP®2060	◆				
ASP®APZ10				◆	◆
E M2	◆	◆			◆
E M35	◆				
C8					
E M42					

This ranking is provided for information purposes.
Please contact our sales and technical network to select the most accurate grades fitting your application needs

ASP®, is a registered trademark of Erasteel.

BY APPLICATIONS

Erasteel grades	Tooling					
	Powder Compaction	Thread Rolling	Rolls for rolling mills	Rotary Die Cutter	Cold Forging	Coining
ASP®2004	◆		◆		◆	
ASP®2005	◆	◆	◆		◆	◆
ASP®2009						
ASP®2011				◆		
ASP®2012	◆				◆	◆
ASP®2015				◆		
ASP®2023	◆		◆		◆	
ASP®2030	◆	◆	◆	◆	◆	
ASP®2042		◆			◆	
ASP®2048					◆	
ASP®2052	◆			◆	◆	
ASP®2053	◆	◆	◆	◆	◆	◆
ASP® 2055	◆					
ASP®2060	◆		◆	◆		
ASP®APZ10	◆					
E M2	◆	◆	◆	◆		
E M35						
C8					◆	
E M42		◆			◆	

ASP®, AND

	ERASTEEL	Analysis %					
	Grades	C	Cr	Mo	W	Co	V
ASP®, non Cobalt-grades	ASP®2004*	1.4	4.2	5.0	5.8	-	4.1
	ASP®2005	1.5	4.0	2.5	2.5	-	4.0
	ASP®2009	1.8	5.3	1.3	-	-	9.1
	ASP®2011	2.45	5.3	1.3	-	-	9.5
	ASP®2012	0.60	4.0	2.0	2.1	-	1.5
	ASP®2023	1.28	4.1	5.0	6.4	-	3.1
	ASP®2053	2.48	4.2	3.1	4.2	-	8.0
ASP®, Cobalt-grades	ASP®2015	1.55	4.0	-	12.0	5.0	5.0
	ASP®2030*	1.28	4.2	5.0	6.4	8.5	3.1
	ASP®2042	1.08	3.8	9.4	1.5	8.0	1.2
	ASP®2048*	1.50	3.8	5.3	9.8	8.5	3.1
	ASP®2052*	1.67	4.8	2.0	10.5	8.0	4.9
	ASP®2055	1.69	4.0	4.6	6.3	9.0	3.2
	ASP®2060	2.30	4.2	7.0	6.5	10.5	6.5
Martensitic Stainless Steel	ASP®APZ10	1.25	19.0	2.1	-	-	0.8
HSS, non Cobalt- grades	E M2	0.90	4.2	5.0	6.4	-	1.8
HSS, Cobalt-grades	E M35	0.93	4.2	5.0	6.4	4.8	1.8
	C8	1.05	4.0	6.0	5.0	7.8	1.6
	E M42	1.08	3.8	9.4	1.5	8.0	1.2

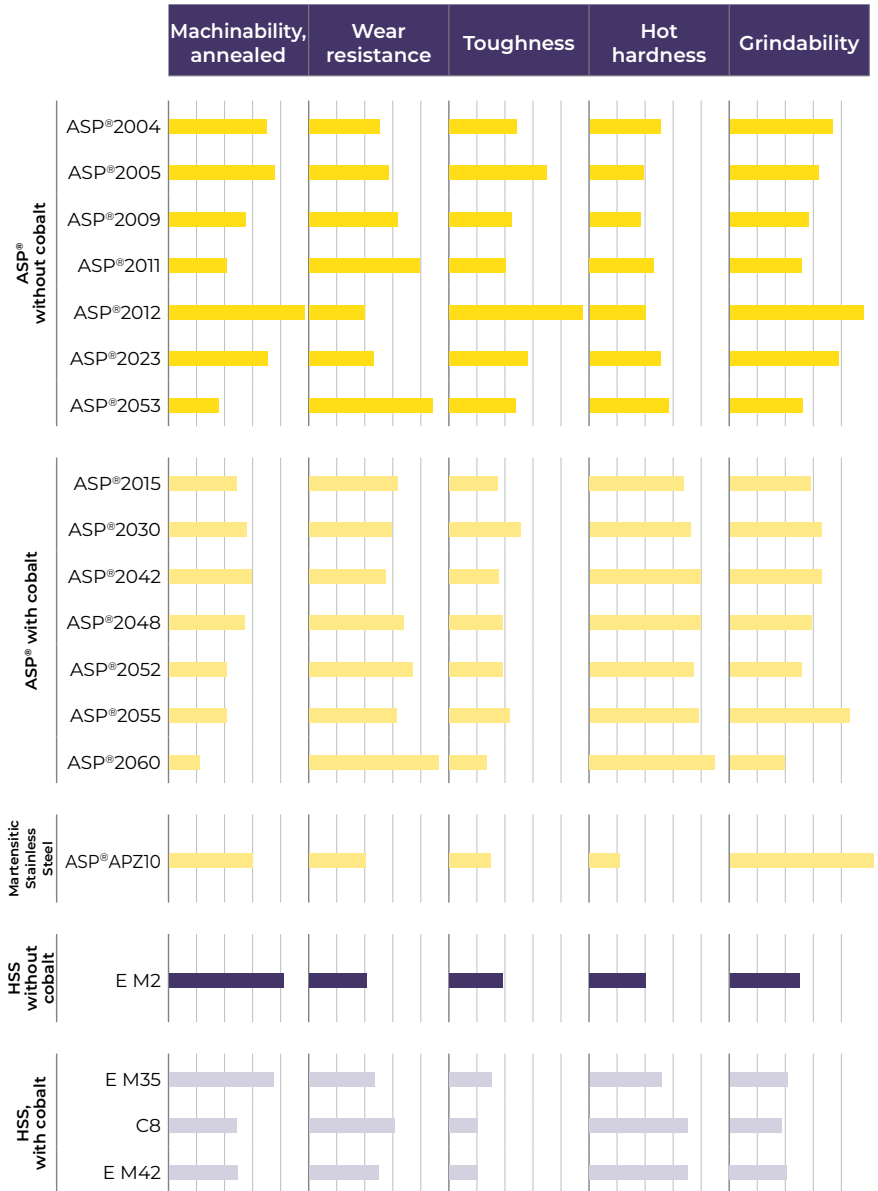
* also available with sulfur
ASP® is a registered trademark of Erasteel

HIGH SPEED STEEL GUIDE

	ERASTEEL	Characteristics and Applications
	Grades	
ASP®, non Cobalt-grades	ASP®2004*	Good wear resistance and hardness
	ASP®2005	Good wear resistance and toughness
	ASP®2009	Wear resistance and toughness for plastics extrusion
	ASP®2011	V-alloyed with high abrasion resistance
	ASP®2012	Very high toughness for hot and cold work
	ASP®2023	Non-Co-grade with overall good properties
	ASP®2053	V-alloyed grade for abrasive wear resistance
ASP®, Cobalt-grades	ASP®2015	High W-alloyed grade for high performance tools
	ASP®2030*	Co-grade with good combination of hardness and toughness
	ASP®2042	For flat red rolling dies application
	ASP®2048*	High alloyed for high performance tools
	ASP®2052	High Co-grade for high performance blanking Good wear resistance
	ASP®2055	2.1% Nb. High alloyed Co-grade with good grindability
	ASP®2060	For both hot hardness and wear resistance
Metastable Stainless Steel	ASP®APZ10	Good corrosion and wear resistance
HSS, non Cobalt-grades	E M2	Grade for general applications
HSS, Cobalt-grades	E M35	Grade for general applications
	C8	8% Co-grade with improved hot hardness
	E M42	Co-grade for flat thread rolling dies, strimming dies application

* also available with sulfur

COMPARATIVE PROPERTIES

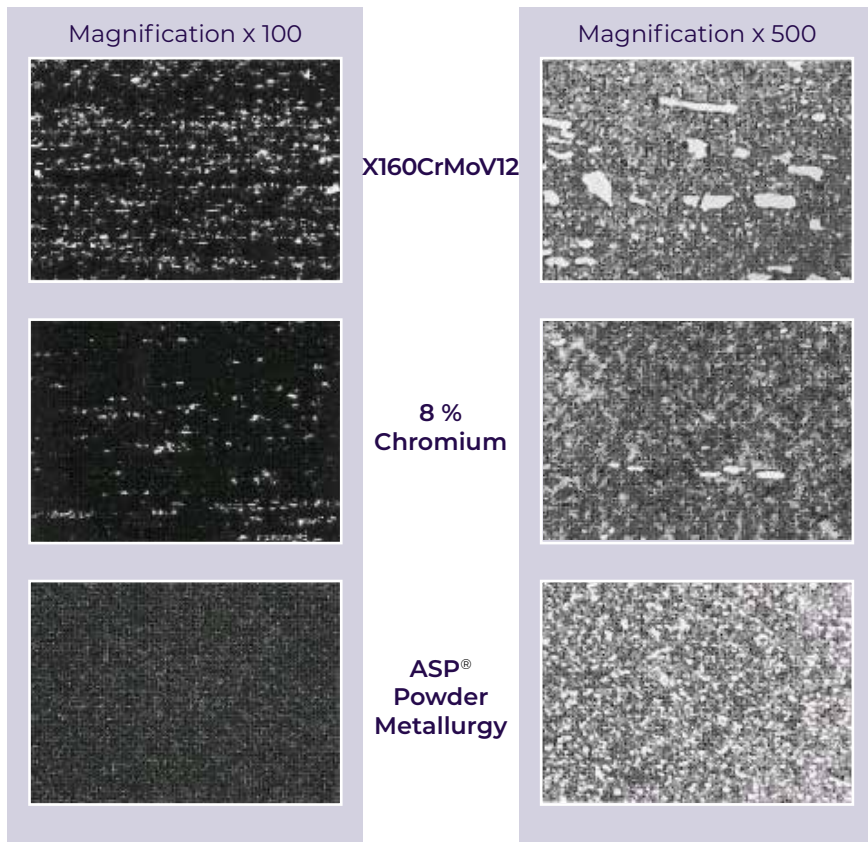


INTERNATIONAL STANDARDS

Erasteel	EN 100027-1	EN 100027-2 (W.Nr.)	ASTM (AISI)	JIS
ASP®2004	HS 6-5-4	1.3361	M4	SKH54
ASP®2005	HS 3-3-4	1.3377	-	-
ASP®2009	-	-	-	-
ASP®2011	-	-	A11	-
ASP®2012	HS 2-2-2	1.3397	-	-
ASP®2015	HS 12-0-5-5	1.3251	T15	SKH10
ASP®2023	HS 6-5-3	1.3395	M3:2	SKH53
ASP®2030	HS 6-5-3-8	1.3294	-	-
ASP®2042	HS 2-9-1-8	≈ 1.3247	M42	SKH59
ASP®2048	-	-	M48	-
ASP®2052	HS 10-2-5-8	-	-	-
ASP®2053	HS 4-3-8	1.3352	-	-
ASP®2055	-	-	-	-
ASP®2060	HS 7-7-7-11	1.3292	-	-
ASP®APZ10	-	-	-	-
E M2	HS 6-5-2	1.3343	M2	SKH51
E M35	HS 6-5-2-5	1.3243	M35	SKH55
C8	HS 5-6-2-8	1.3209	-	-
E M42	HS 2-9-1-8	1.3247	M42	SKH59

GRADES MAPPING

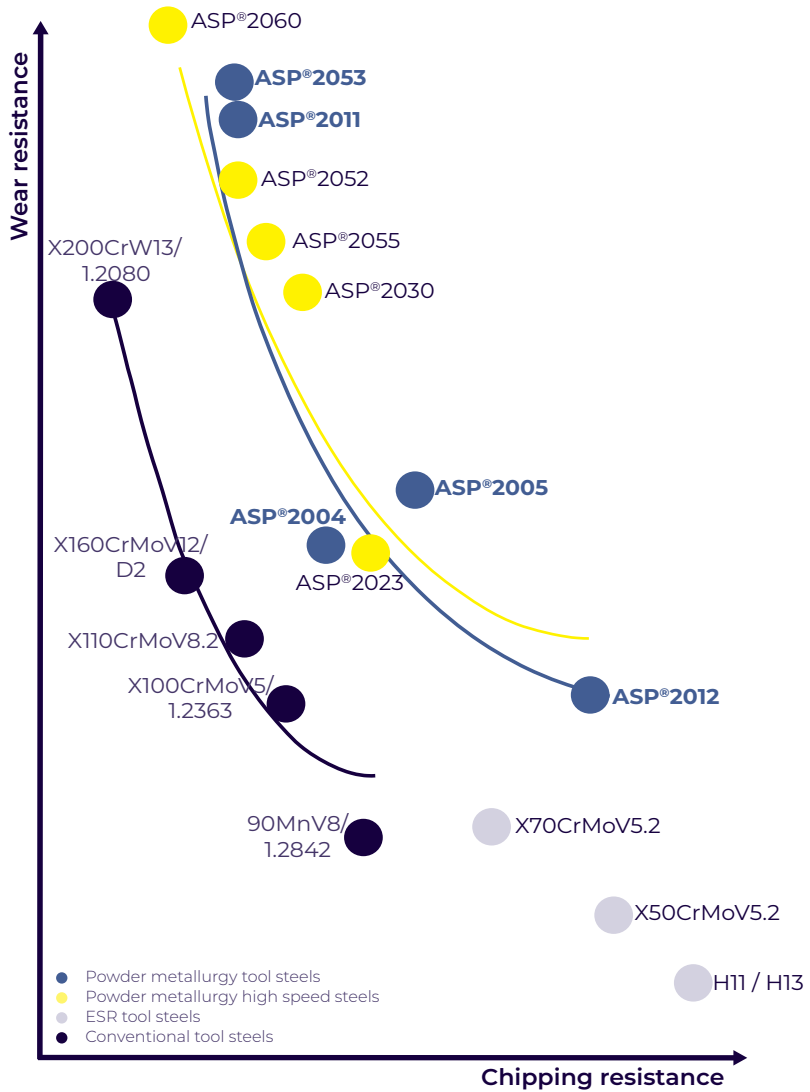
MICROSTRUCTURE COMPARISON BETWEEN CONVENTIONAL TOOLSTEEL AND ASP®



ASP® exhibits a fine and homogeneous microstructure with evenly distributed carbides particles.

- In the HSS material it's the carbide size and the presence of carbide stringers that sets the properties of the steel.
- Smaller carbides size and uniformity distributed increase significantly the performances.
- The average carbide size in the ASP® grades is $3\mu\text{m}$.

MAPPING OF ERASTEEL PM COLD WORK TOOL STEELS



ASP® is a registered trademarks of Erasteel



ASP® GRADES DATA SHEETS



The following datasheets are for information only and do not create any binding contractual obligations.
Minimum hardness reachable depending on austenization temperature.

ASP®2004 POWDER METALLURGY HSS

ASTM: AISI M4 / EN 10027-1: HS 6-5-4 / EN 10027-2: 1.3361 / JIS SKH54

DESCRIPTION

ASP®2004 is the reference non-Cobalt grade suitable for most cutting tool applications.

DELIVERY HARDNESS

- Typical soft annealed hardness is 265 HB.
- Cold drawn material is typically 10-40 HB harder..

FORM SUPPLIED

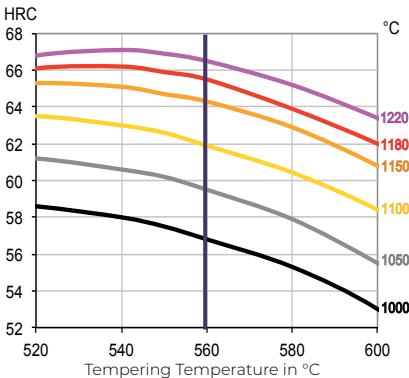
- Round bars
- Flat & square bars
- Forged blanks
- Coils

Available surface conditions: drawn, ground, peeled, rough machined, hot worked, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



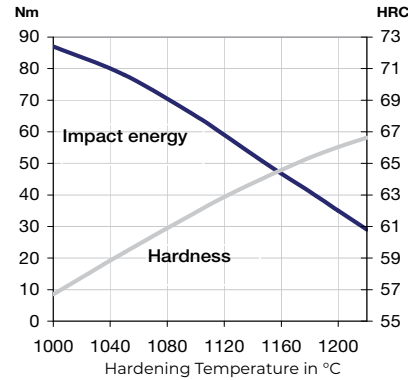
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

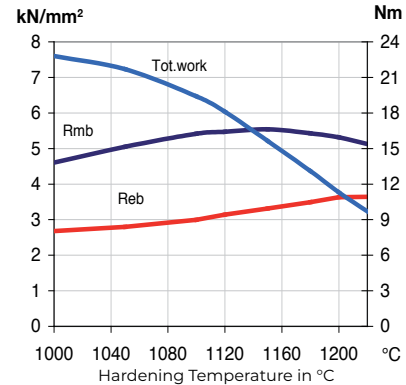
C	Cr	Mo	W	Co	V
1.4	4.2	5.0	5.8	-	4.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP[®]2005 POWDER METALLURGY TOOLSTEEL

EN: HS 3-3-4 / EN: 1.3377

DESCRIPTION

ASP[®]2005 is the best choice for high toughness, hardness and wear resistance.

DELIVERY HARDNESS

- Typical soft annealed hardness is 250 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

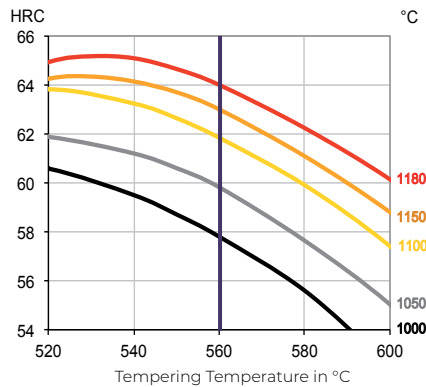
- Round bars
- Flat & square bars

Available surface conditions: drawn, ground, peeled, rough machined, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



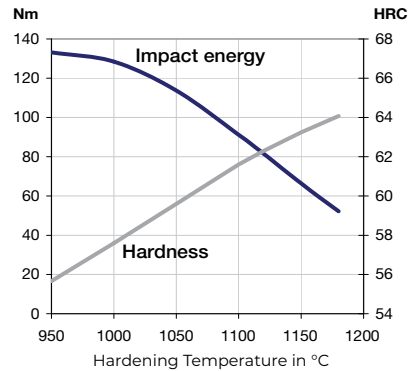
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

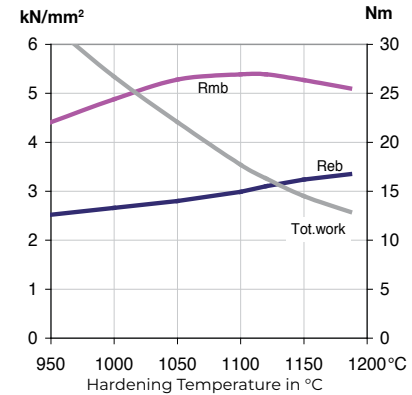
C	Cr	Mo	W	Co	V
1.50	4.0	2.5	2.5	-	4.0

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61.
All test carried out on samples tempered 3x1 hour at 560°C

ASP®2009 POWDER METALLURGY HSS

Not yet standardised

DESCRIPTION

ASP®2009 is a high alloyed PM grade for applications where high wear resistance and toughness are needed.

DELIVERY HARDNESS

- Typical soft annealed hardness is 250 HB.

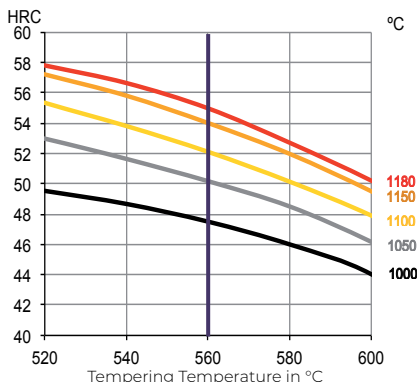
FORM SUPPLIED

- Round bars
 - Flat & square bars
 - Forged blanks
 - Coils
- Available surface conditions: drawn, ground, rough machined, hot worked, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



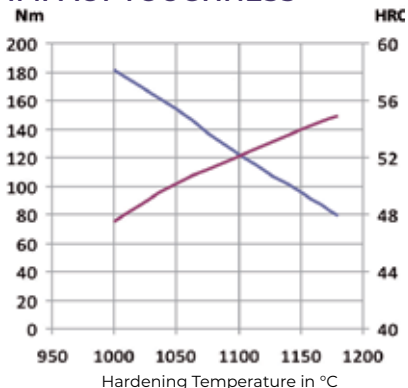
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.8	5.3	1.3	-	-	9.1

PROPERTIES

IMPACT TOUGHNESS



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP[®]2011 POWDER METALLURGY HSS

ASTM: AISI A71 / AMS6559

DESCRIPTION

ASP[®]2011 is a high Carbon and high Vanadium alloyed grade with excellent wear resistance for knives.

DELIVERY HARDNESS

- Typical soft annealed hardness is 280 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

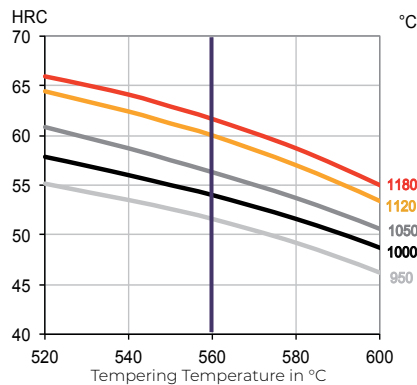
- Coils
- Flat & square bars
- Sheets
- Coarse round bars
- Discs
- Pieces cut from sheets

Available surface conditions: peeled, cold rolled, hot rolled, rough machined.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



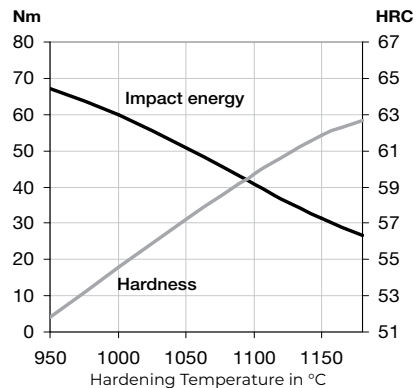
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

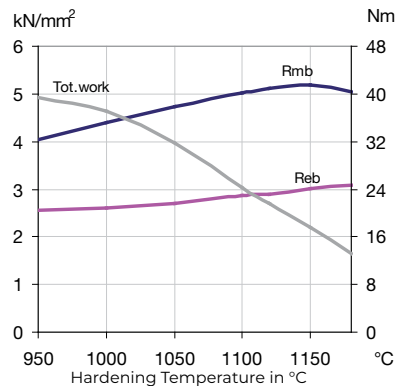
C	Cr	Mo	W	Co	V
2.45	5.3	1.3	-	-	9.5

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP®2012 ADVANTAGES VERSUS

VARIOUS AND NEW FIELD OF APPLICATIONS

MOULDS FOR PLASTIC INJECTION:

PM steels have been used for many years in the plastics processing industry.

Thanks to ASP®2012 outstanding properties, our technical offer also extends to the moulds themselves, especially in case of large series using reinforced plastics materials with high glass fibre content. Today, fiber-reinforced thermoplastics, as PA46, PA410, PPA, PPS, PEEK replace most of metal parts under the roof. Glass fibers content can reach 60%. They are very aggressive and the molds need improvements and more wear resistant tool steels than H11 and H13 which are today the big runners in this application. In order to outperform H13 performances, ASP®2012 was developed as a unique PM tool steel regarding the chemical analysis and its subsequent properties.

ASP®2012 analysis shows a very good balance between the carbon content and the alloying elements such as W and V, which result in a good toughness and a much more wear resistance compared to H11 / H13. This is a competitive advantage when the plastic moulds are suffering from heavy abrasive wear due to the aggressive glass fibers.

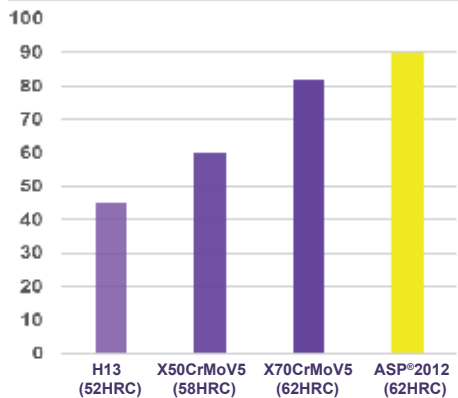
Furthermore, due to high injection pressures, the compressive stresses at the joint planes are high, so that plastic deformation is often a problem with H13.

To reach 61/63 HRC, ASP®2012 is a big advantage to cope with the needed compressive strength on the area of the mould clamp.

Mould makers will also appreciate ASP®2012 due to :

- Machinability: as good as H13 type
- EDM: very good
- Polishability: excellent thanks to a high level of cleanliness, above ESR tool steels
- Weldability: good with TIG and laser process for small repairs

Relative abrasive wear resistance comparison



CONVENTIONAL TOOL STEELS

PRESS HARDENING TOOLS:

Press hardening is a process used to form ultra-high-strength steel (UHSS) into finished part shapes. The steel is heated to 900 °C, is formed, and then the formed part is quenched in the same forming die.

The forming phase means high compressive stresses on the surface of the tool, especially in areas of strong plastic deformation.

As press hardened steels are coated with aluminum-silicon (AlSi), they are very abrasive to tool surfaces and the contact pressure lead to abrasion.

The usual hardness requirement with current hot work tool steels is in the range 52/56 HRC.

The hardening step implies a fast cooling rate that creates thermal stresses at each press cycle in the tool, in addition to mechanical stresses.

Very often cracks start and propagation occurs from the surface to the cooling channels.

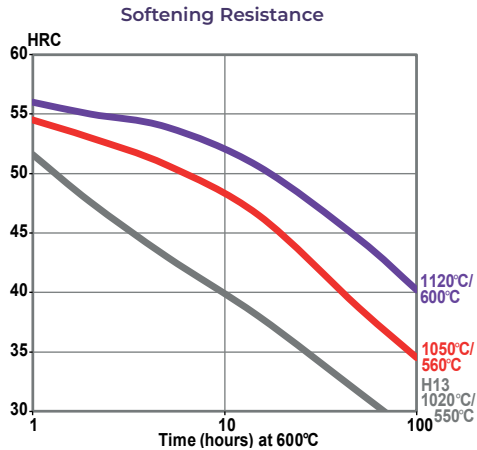
In order to increase the performance of the tool, use a PM tool steel with better toughness and wear resistance which means:

- A finer microstructure
- A higher hardness
- A higher carbide content.

The ability of ASP®2012 to keep its initial properties after a period at high temperature is good, as shown on the graph at the right.

Compared to conventional and PM tool steels, ASP®2012 reaches the better compromise between:

- A compressive strength, toughness and wear resistance.
- A very good machinability
- A very high surface finish
- Can be weld repair



ASP®2012 POWDER METALLURGY TOOLSTEEL

EN: HS 2-2-2 / EN: 1.3397

DESCRIPTION

ASP®2012 is a powder metallurgical tool Steel with a unique analysis that offers outstanding ductility level together with excellent compressive strength and a good wear resistance up to 62/63 HRC.

DELIVERY HARDNESS

- Typical soft annealed hardness is 230 HB.

FORM SUPPLIED

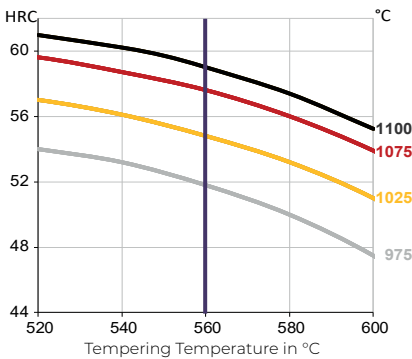
- Round bars
- Flat & square bars

Available surface conditions: drawn, ground, peeled, rough machined, hot worked, hot rolled.

HEAT TREATMENT

- Please refer to page 72 for specific heat treatment recommendation.

GUIDELINES FOR HARDENING



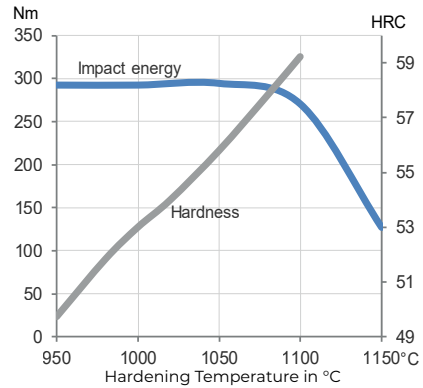
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

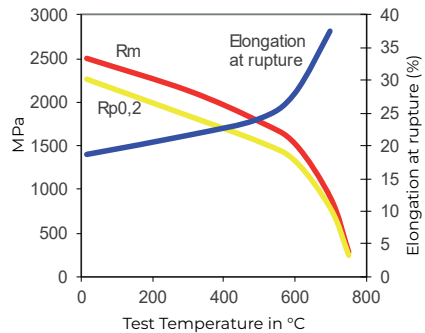
C	Si	Mn	Cr	Mo	W	V
0.60	1.0	0.3	4.0	2.0	2.1	1.5

PROPERTIES

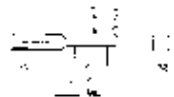
TRANSVERSE IMPACT TOUGHNESS



TENSILE STRENGTH



Size of blank Ø15mm.
Test piece dimensions are given below.
Hardness 58 HRC



For more information on mechanical tests and how to read the graphs see page 60-61.
All test carried out on samples tempered 3x1 hour at 560°C

ASP®2015 POWDER METALLURGY HSS

ASTM: AISI T15 / EN: HS 12-0-5-5 / EN: 1.3202 / JIS SKH10

DESCRIPTION

ASP®2015 is a high tungsten alloyed grade for high performance cutting tools.

DELIVERY HARDNESS

- Typical soft annealed hardness is 280 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

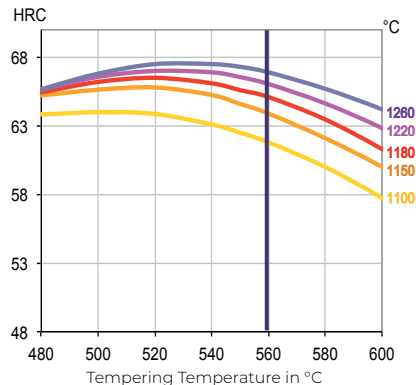
- Round bars
- Flat & square bars
- Forged blanks
- Coils

Available surface conditions: drawn, peeled, centerless ground, rough machined, hot worked, cold rolled, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



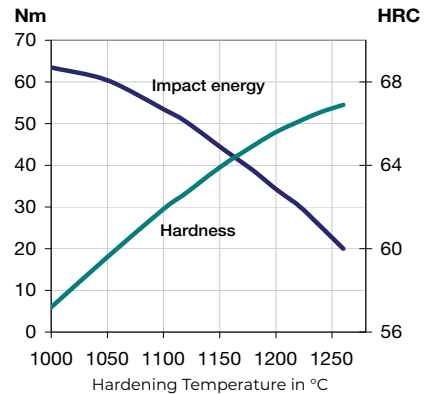
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.6	4.0	-	12	5.0	5.0

PROPERTIES

IMPACT TOUGHNESS



For more information on mechanical tests and how to read the graphs see page 60-61.

All test carried out on samples tempered 3x1 hour at 560°C

ASP®2023 POWDER METALLURGY HSS

ASTM: AISI M3:2 / EN: HS 6-5-3 / EN: 1.3395 / JIS SKH53

DESCRIPTION

ASP®2023 is a high tungsten alloyed grade for high performance cutting tools.

DELIVERY HARDNESS

- Typical soft annealed hardness is 280 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

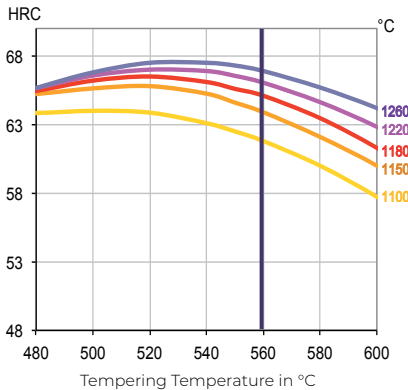
- Round bars
- Flat & square bars
- Forged blanks
- Coils

Available surface conditions: drawn, peeled, centerless ground, rough machined, hot worked, cold rolled, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



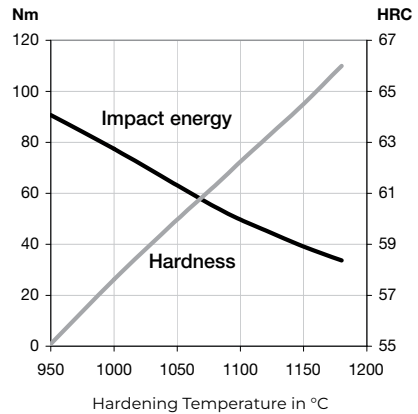
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

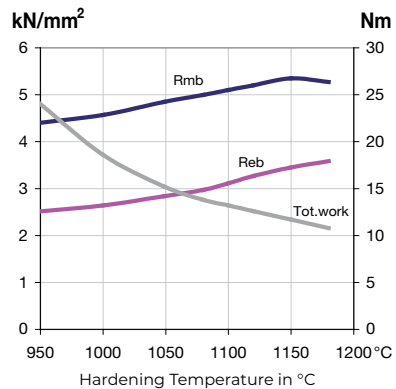
C	Cr	Mo	W	Co	V
1.28	4.1	5.0	6.4	-	3.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP®2030 POWDER METALLURGY HSS

ASTM: A11 / EN: HS 6-5-3 -8 / EN: 1.3294

DESCRIPTION

ASP®2030 is an excellent Cobalt alloyed grade suitable for most cutting tool applications when hot hardness is required.

DELIVERY HARDNESS

- Typical soft annealed hardness is 290 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

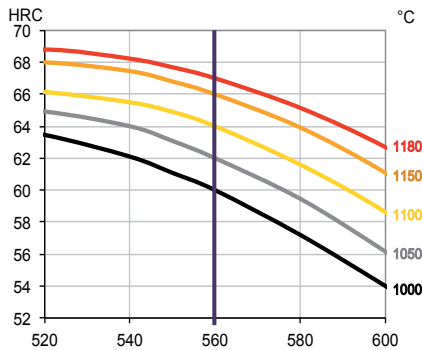
- Coils
- Flat & square bars
- Sheets
- Round bars
- Forged blanks

Available surface conditions: drawn, ground, hot worked, peeled, rough machined.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



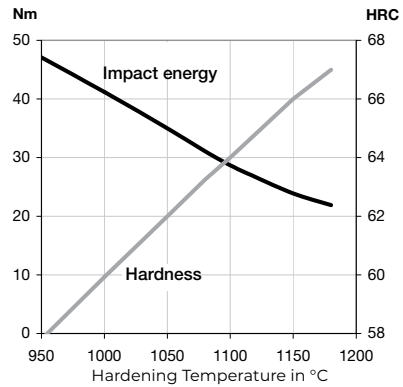
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

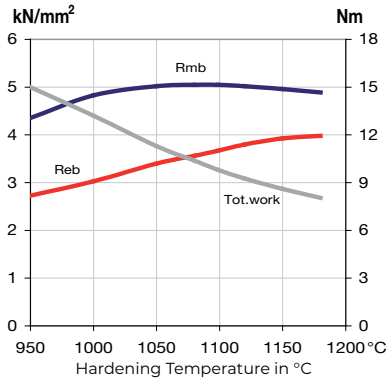
C	Cr	Mo	W	Co	V
1.28	4.2	5.0	6.4	8.5	3.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP® 2042 POWDER METALLURGY HSS

ASTM A151 M42 / EN: HS 2-9-1-8 / EN: ~1.3247 / JIS SKH59

DESCRIPTION

ASP®2042 is the reference grade for high performance bi-metal band saws. Available as laser or EB weldable version.

DELIVERY HARDNESS

- Typical soft annealed hardness is 280 HB.
- Cold drawn material is typically 10-40 HB harder.

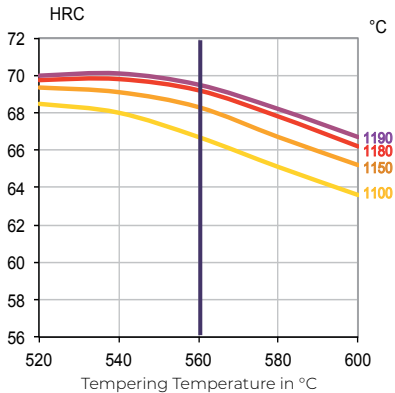
FORM SUPPLIED

- Round bars
- Flat bars
- Bimetal edge wire

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



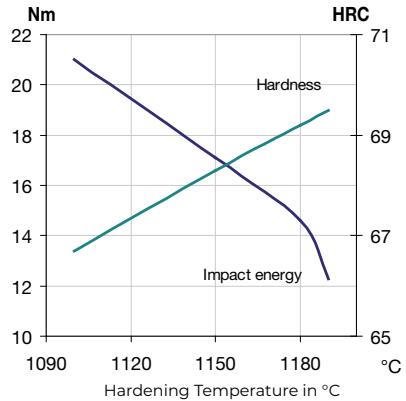
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

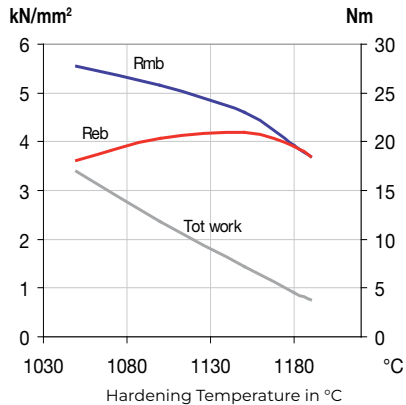
C	Cr	Mo	W	Co	V
1.08	3.8	9.4	1.5	8.0	1.2

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP®2048 POWDER METALLURGY HSS

ASTM: AISI M48

DESCRIPTION

ASP®2048 is a highly alloyed grade for high performance cutting tools.

DELIVERY HARDNESS

- Typical soft annealed hardness is 300 HB.

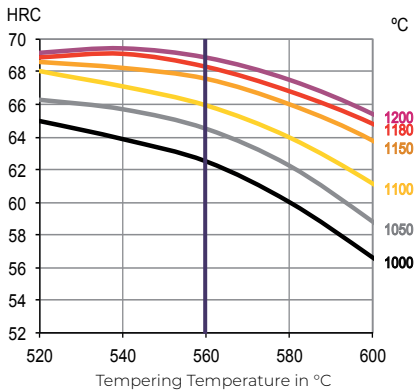
FORM SUPPLIED

- Coils
 - Round bars
 - Flat & square bars
- Available surface conditions: drawn, ground hot worked, peeled, rough machined, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



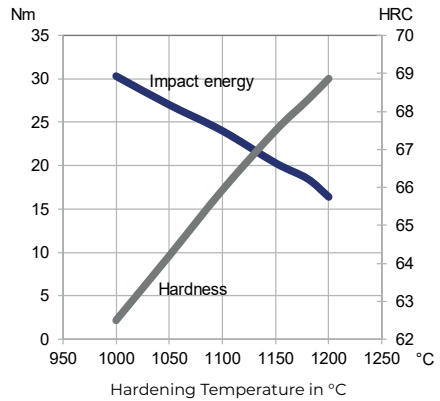
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

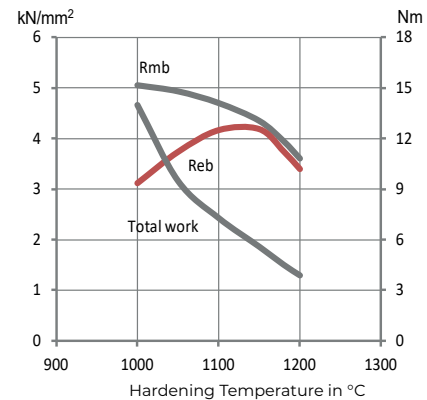
C	Cr	Mo	W	Co	V
1,5	3,8	5,3	9,8	8,5	3,1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP®2052 POWDER METALLURGY HSS

EN: HS 10-2-5-8 / EN: 1.3253

DESCRIPTION

ASP®2052 is a Tungsten alloyed grade for high performance cutting tools with a need of high hardness and good toughness.

DELIVERY HARDNESS

- Typical soft annealed hardness is 300 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

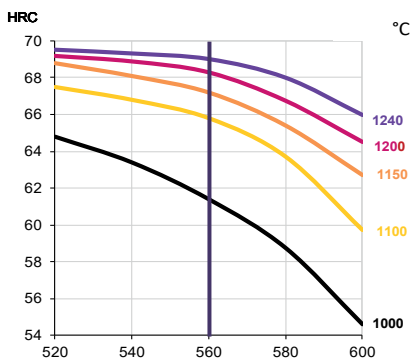
- Coils
- Round bars

Available surface conditions: drawn, ground, peeled, rough machined, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



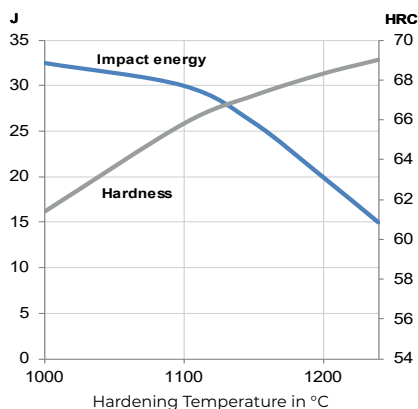
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

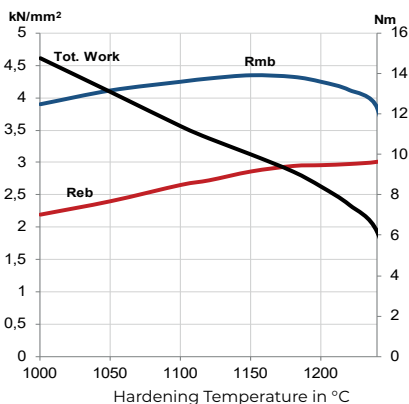
C	Cr	Mo	W	Co	V
1.67	4.8	2.0	10.05	8.0	4.9

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP[®]2053 POWDER METALLURGY TOOLSTEEL

EN: HS 4-3-8 / EN: 1.3252 / AMS6556

DESCRIPTION

ASP[®]2053 is a high Vanadium grade with excellent wear resistance perfect when cutting in very abrasive materials.

DELIVERY HARDNESS

- Typical soft annealed hardness is 300 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

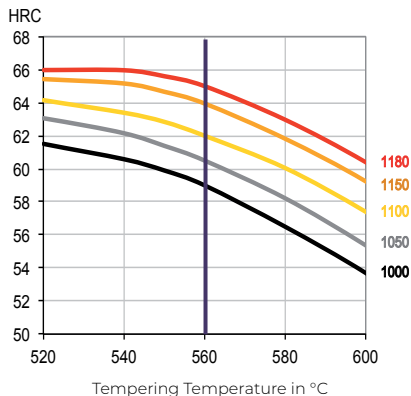
- Round bars
- Flat & square bars
- Coils
- Forged blanks
- Discs
- Sheets

Available surface conditions: drawn, ground, peeled, rough machined, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



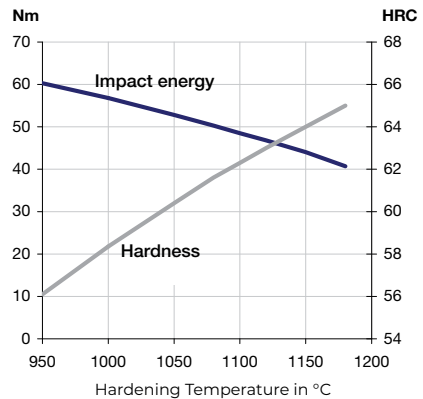
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

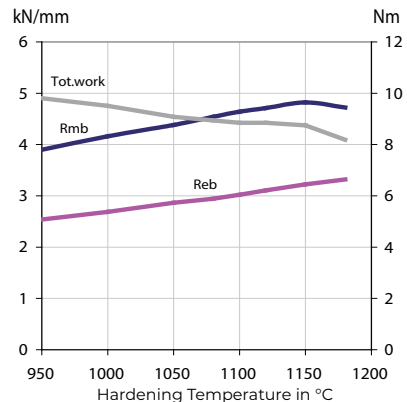
C	Cr	Mo	W	Co	V
2.48	4.2	3.1	4.2	-	8.0

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61.

All test carried out on samples tempered 3x1 hour at 560°C

ASP®2055 POWDER METALLURGY HSS

Not yet standardised

DESCRIPTION

ASP®2055 is a Niobium alloyed grade with a refined microstructure giving an excellent combination of strength, toughness and grindability.

DELIVERY HARDNESS

- Typical soft annealed hardness is 320 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

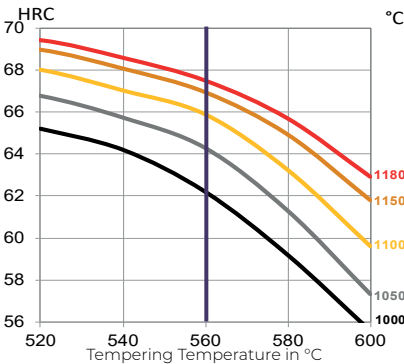
- Round bars
- Drawn & Ground bars

Available surface conditions: drawn, ground, and peeled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



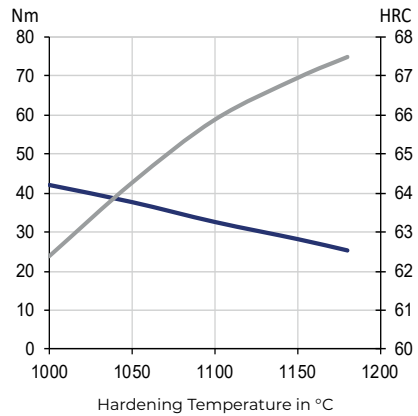
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

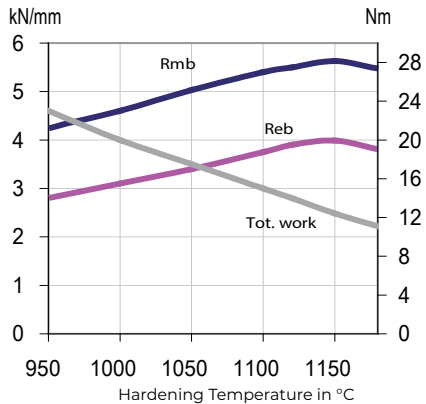
C	Cr	Mo	W	Co	V	Nb
1.69	4.0	4.6	6.3	9.0	3.2	2.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 3x1 hour at 560°C

ASP[®]2060 POWDER METALLURGY HSS

EN: HS 7-7-7-11 / EN: 1.3292 / AMS6560

DESCRIPTION

ASP[®]2060 is a very highly alloyed grade for high demanding cutting tools requiring high hardness, high hot hardness and wear resistance.

DELIVERY HARDNESS

- Typical soft annealed hardness is 345 HB.

FORM SUPPLIED

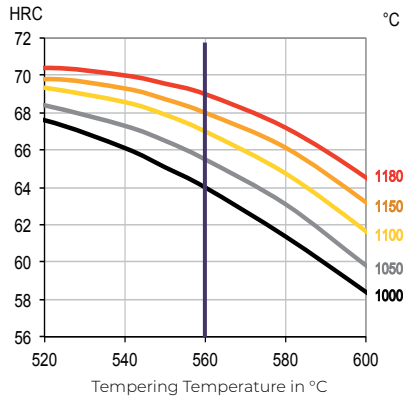
- Round bars
- Flat & square bars
- Forged bars
- Tool bit sections

Available surface conditions: drawn, ground, peeled, rough machined, hot worked.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



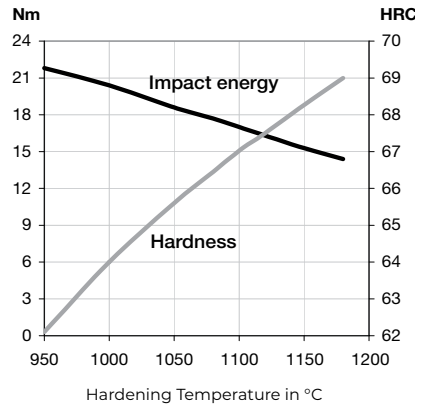
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

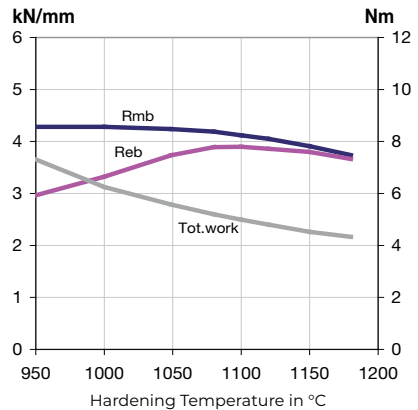
C	Cr	Mo	W	Co	V
2.30	4.2	7.0	6.5	10.5	6.5

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61.

All test carried out on samples tempered 3x1 hour at 560°C

ASP® APZ10 POWDER METALLURGY HSS

Not yet standardized

DESCRIPTION

ASP® APZ10 is a martensitic chromium PM grade designed for applications where high wear resistance and high corrosion resistance are needed.

DELIVERY HARDNESS

- Typical soft annealed hardness is 280 HB.

FORM SUPPLIED

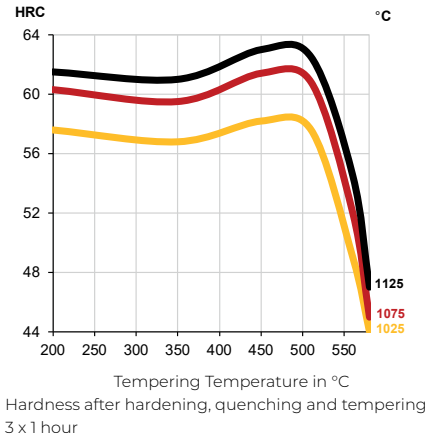
- Round bars
- Flat & square bars

Available surface conditions: peeled, rough machined, hot rolled.

HEAT TREATMENT

- Please refer to page 71 for specific heat treatment recommendation.

GUIDELINES FOR HARDENING

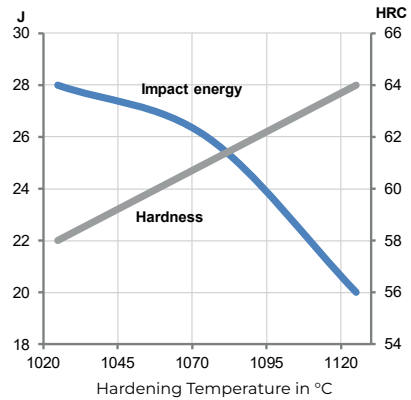


CHEMICAL COMPOSITION

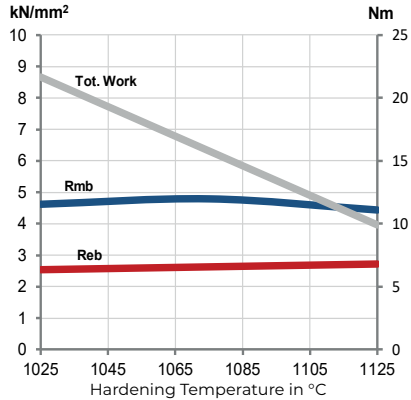
C	Cr	Mo	V	N
1.25	19.0	2.1	0.8	0.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 2x2 hour at 525°C

CONVENTIONAL GRADES DATA SHEETS



The following datasheets are for information only and do not create any binding contractual obligations.
Minimum hardness reachable depending on austenization temperature.

E M2 HIGH SPEED STEEL

ASTM: AISI M2 / EN: HS 6-5-2 / 1.3343 / JIS SKH51

DESCRIPTION

E M2 is a medium-alloyed high speed steel which has a good machinability and a good performance, and is used in a wide variety of applications.

DELIVERY HARDNESS

- Typical soft annealed hardness is 250 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

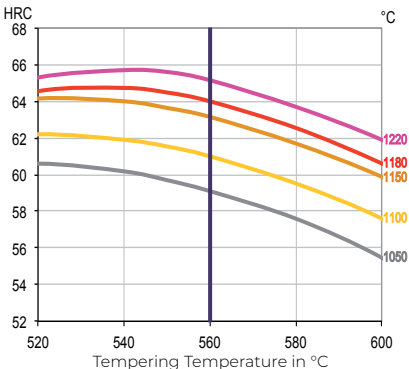
- Drawn wire
- Wire rod
- Round bars
- Flat bars
- Square bars
- Strips
- Sheets
- Discs
- Bi-metal edges

Available surface conditions: drawn, ground, peeled, turned, cold rolled, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C two times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



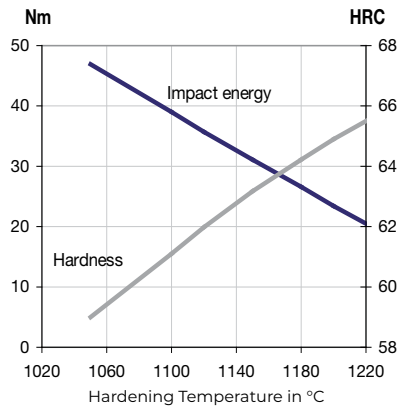
Hardness after hardening, quenching and tempering 2 x 1 hour

CHEMICAL COMPOSITION

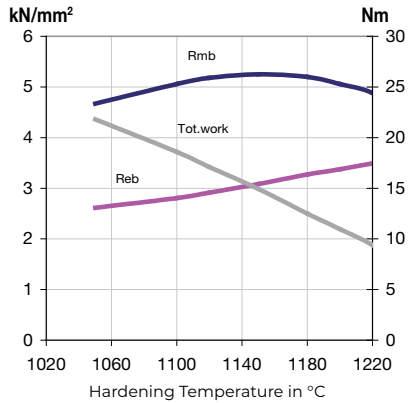
C	Cr	Mo	W	Co	V
0.90	4.2	5.0	6.4	-	1.8

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 2x1 hour at 560°C

E M35 HIGH SPEED STEEL

ASTM: AISI M35 / EN: HS 6-5-2-5 / 1.3243 / JIS SKH55

DESCRIPTION

E M35 contains cobalt for increased hot hardness. The composition of EM35 offers a good combination of toughness and hardness. EM35 has a good machinability.

DELIVERY HARDNESS

- Typical soft annealed hardness is 260 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

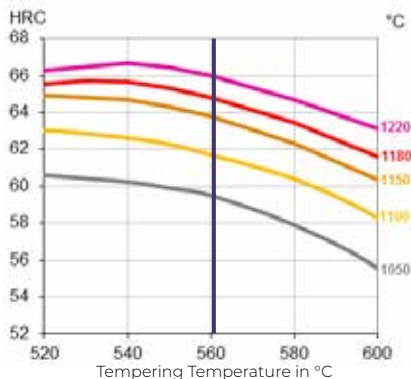
- Wire rod
- Drawn wire
- Round bars
- Flat bars
- Square bars
- Strips
- Sheets
- Discs

Available surface conditions: drawn, ground, peeled, turned, rolled, cold rolled, hot rolled.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C two times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



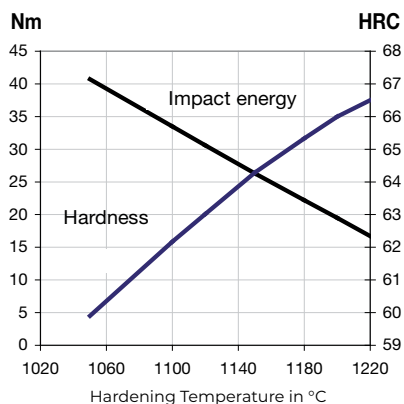
Hardness after hardening, quenching and tempering 2 x 1 hour

CHEMICAL COMPOSITION

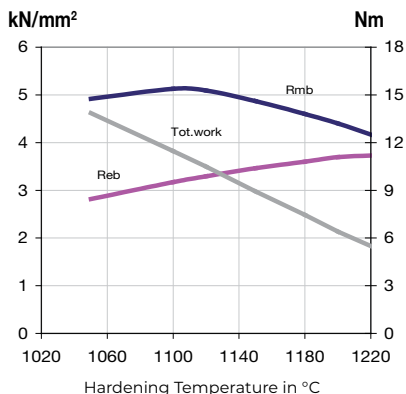
C	Cr	Mo	W	Co	V
0.93	4.2	5.0	6.4	4.8	1.8

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61. All test carried out on samples tempered 2x1 hour at 560°C

C8 HIGH SPEED STEEL

DESCRIPTION

C8 is a conventionally manufactured cobalt-alloyed high speed steel, characterised by a high hot hardness, and a very high hardness.

DELIVERY HARDNESS

- Typical soft annealed hardness is 270 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

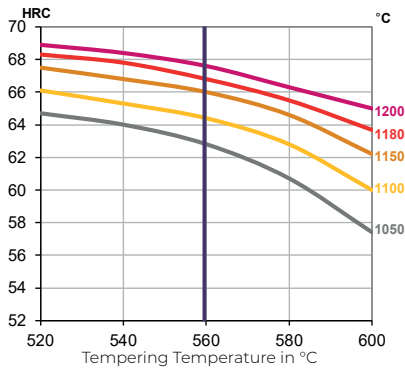
- Round bars
- Flat bars
- Flat bars
- Square bars

Available surface conditions: drawn, ground, peeled, hot rolled, turned.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



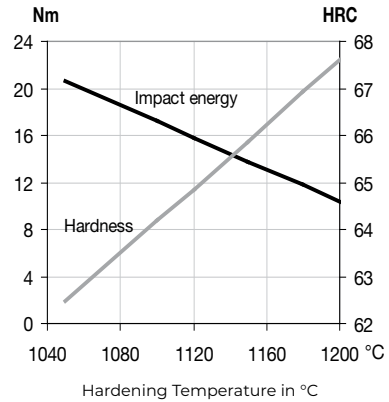
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

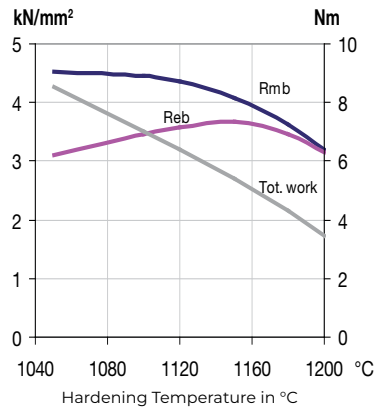
C	Cr	Mo	W	Co	V
1.05	4.0	6.0	5.0	7.8	1.6

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61.

All test carried out on samples tempered 3x1 hour at 560°C

E M42 HIGH SPEED STEEL

ASTM: AISI M42 / EN: HS 2-9-1-8 / 1.3247 / JIS SKH59

DESCRIPTION

E M42 is a cobalt alloyed high speed steel to be used when the demand for hot hardness is of great importance. E M42 has a good machinability and a good wear resistance.

DELIVERY HARDNESS

- Typical soft annealed hardness is 270 HB.
- Cold drawn material is typically 10-40 HB harder.

FORM SUPPLIED

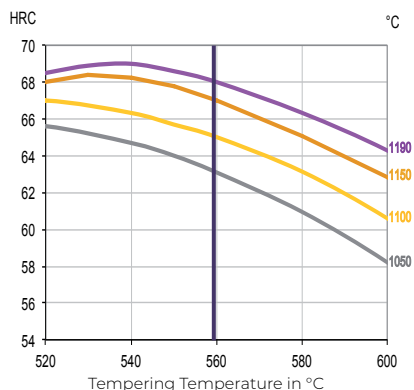
- Wire rod
- Square bars
- Drawn wire
- Discs
- Round bars
- Bi-metal edge
- Flat bars

Available surface conditions: drawn, ground, peeled, rolled, cold rolled, hot rolled, turned.

HEAT TREATMENT

- Please refer to page 70 for general heat treatment recommendation.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature <25°C between temperings.

GUIDELINES FOR HARDENING



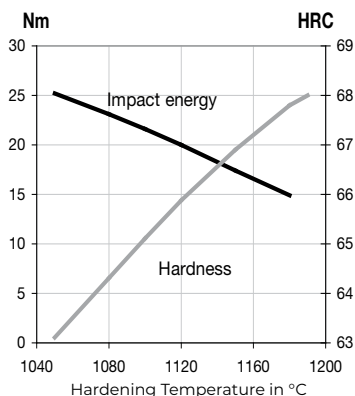
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

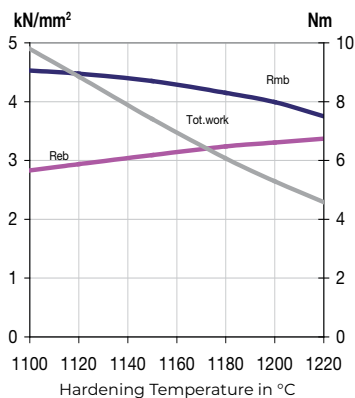
C	Cr	Mo	W	Co	V
1.08	3.8	9.4	1.5	8.0	1.2

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see page 60-61.

All test carried out on samples tempered 3x1 hour at 560°C

MECHANICAL PROPERTIES

Following is the explanation of how to interpret the mechanical properties listed in the datasheets.

IMPACT TOUGHNESS

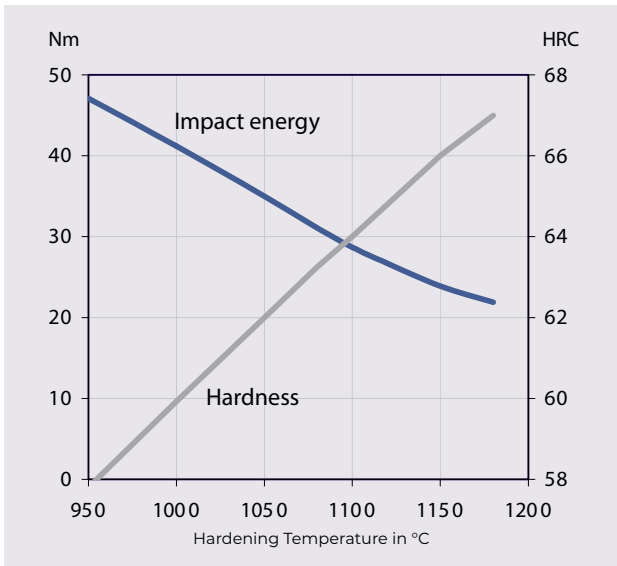
Impact toughness indicates how much energy a material can absorb before rupturing. For a material to be tough a material needs to have both high strength and high ductility.

For our datasheets:

- Impact toughness is measured using a pendulum impact tester.
- Samples are longitudinal and unnotched with a finished dimension of 7 x 10 x 55 mm.
- The hammer strikes the 10 mm tall face and goes through the 7 mm thickness of the sample.

The datasheet displays how the impact toughness evolves with different hardening temperatures.

- On the X-axis the hardening temperature is shown, on the left Y-axis the impact toughness can be read from the blue curve in joules
- On the right Y-axis the corresponding hardness from heat treatment can be read from the grey curve in HRC.



ASP®2030

INTERPRETATION

4-POINT BEND STRENGTH

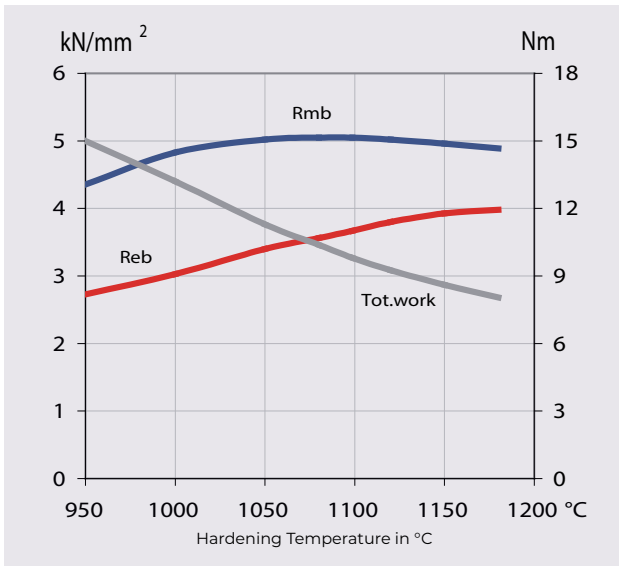
Strength indicates how much load a material can withstand without failure or plastic deformation.

For our datasheets:

- Strength is measured in bending using a 4-point bend test. This is the best way to measure strength on brittle materials such as HSS due to difficulty to perform tensile strength tests.
- Samples are longitudinal with a finished dimension of $\varnothing 4.7$ mm x 65 mm.

The datasheet displays how the ultimate bend strength (Rmb), bend yield strength (Reb), and total work (Tot. work) evolves with different hardening temperatures.

- On the X-axis the hardening temperature is shown
- On the left Y-axis the ultimate bend strength and bend yield strength can be read from the blue and red curves in kN/mm^2
- On the right Y-axis the total work can be read from the grey curve in Nm. condition will be reached where no more carbides are being dissolved into the matrix.



ASP®2030



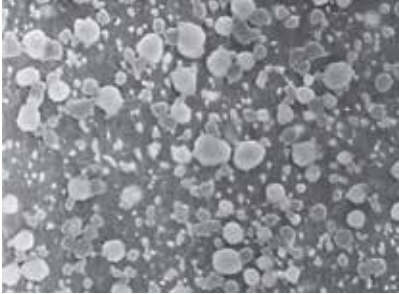
HEAT TREATMENT GUIDE



The following datasheets are for information only and do not create any binding contractual obligations.
Minimum hardness reachable depending on austenization temperature.

HEAT TREATMENT

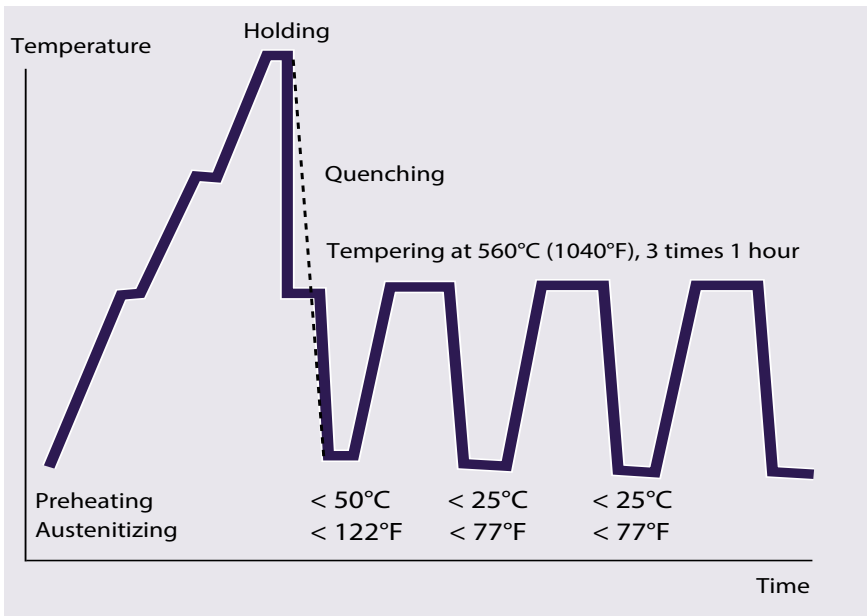
Material from Erasteel is supplied in a soft-annealed condition. The structure consists of a ferritic matrix containing primary carbides and smaller carbides which are formed during soft-annealing.



Soft-annealed structure

THE THREE STAGES

Heat treatment is carried out in three stages – austenitizing, quenching and tempering – giving ASP® the range of properties required for cutting tools.



AUSTENITIZING

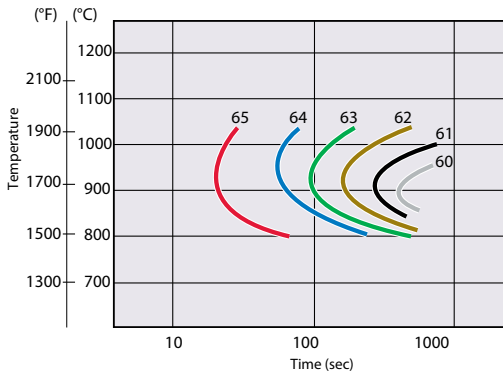
In the austenitizing process, the steel is heated up to a temperature corresponding to the wanted hardness (see below table or datasheets). The maximum recommended austenitizing temperature set by Erasteel should not be exceeded. The ferritic matrix is transformed into austenite and part of the carbides are dissolved. Given enough time an *equilibrium condition* will be reached where no more carbides are being dissolved into the matrix.

HRC	Austenitizing temperature (°C)					Tempering 3 x 560°C				
	ASP®									
	2004	2011	2015	2023	2030	2042	2052	2053	2055	2060
50										
52										
54		1000								
55		1020								
56		1050								
57		1060								
58		1080	1000	1000	960			990		
59	1040	1100	1040	1030	980		950	1020		
60	1060	1120	1060	1050	1000		1020	1040		
61	1080	1150	1100	1080	1020		1040	1070		
62	1100	1180	1120	1100	1050		1070	1100		950
63	1120		1150	1120	1075		1100	1130		980
64	1150		1180	1140	1100		1140	1150	1050	1000
65	1170		1220	1160	1130	1000	1170	1180	1100	1030
66	1200		1240	1180	1150	1050	1200		1150	1070
67			1260		1180	1100	1240		1180	1100
68						1150				1150
69						1180				1180

HRC	Austenitizing temperature (°F)					Tempering 3 x 1040°C				
	ASP®									
	2004	2011	2015	2023	2030	2042	2052	2053	2055	2060
50										
52										
54		1830								
55		1870								
56		1920								
57		1940								
58		1980	1830	1830	1760			1810		
59	1910	2010	1910	1890	1800		1800	1870		
60	1940	2050	1940	1920	1830		1870	1910		
61	1980	2100	2010	1980	1870		1910	1960		
62	2010	2160	2050	2010	1920		1960	2010		1740
63	2050		2100	2050	1970		2010	2070		1800
64	2100		2160	2090	2010		2090	2100	1920	1830
65	2140		2230	2120	2070	1830	2140	2160	2010	1890
66	2190		2270	2160	2100	1920	2190		2100	1960
67					2160	2010	2270		2160	2010
68						2100				2100
69						2160				2160

QUENCHING

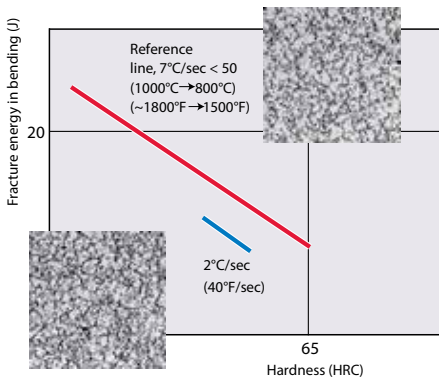
The cooling rate is a very important factor in the heat treatment process. If the cooling rate is too low, due to low pressure or an overloaded furnace, a phenomenon called Pro-Eutectoid Carbide Precipitation – PEC – will take place in the material. The influence of PEC is reduced hardness and reduced toughness. A minimum cooling rate between 1000°C and 800°C of 7°C/sec (~ 1800 - 1500°F of 45°F/sec) is necessary to avoid loss of hardness.



Hardness as function of temperature and quenching time.

Austenitizing temperature:
1180°C (2160°F).

Tempering:
3 x 1h at 560°C (1040°F).

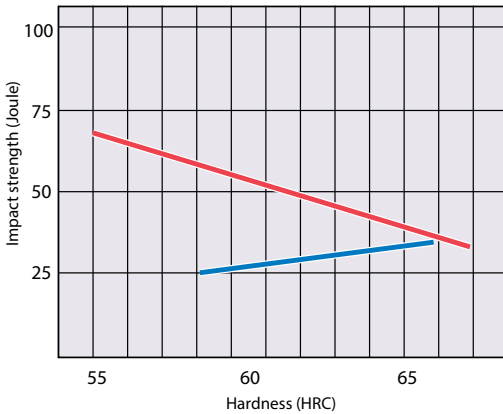


The effect of PEC on the toughness.

ASP® 2023 tempered 560°C (1040°F), 3 x 1h. (Structures after hardening, before tempering).

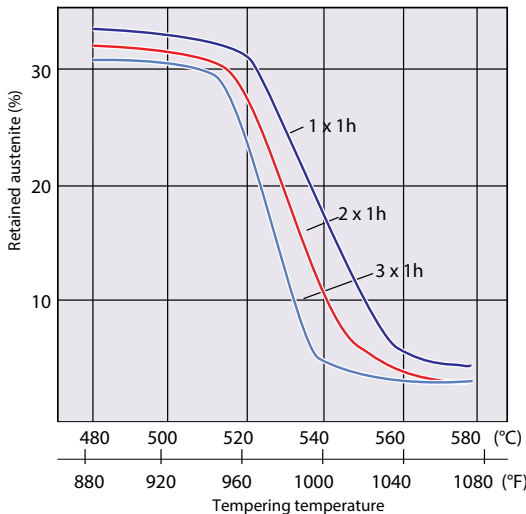
TEMPERING

Tempering is made in order to transform the retained austenite into martensite and fully temper all the martensite. For highly alloyed ASP® grades, three temperings at 560°C (1040°F) for 1 h is recommended to achieve the best combination of hardness and toughness. The best properties are obtained when the austenitization temperature is varied and the tempering is carried out at 560°C (1040°F).



Unnotched impact toughness for ASP®2023.

- Austenitizing temperature varied and tempering at 560°C (1040°F).
- Austenitizing temperature 1150°C (2100°F). Tempering varied.

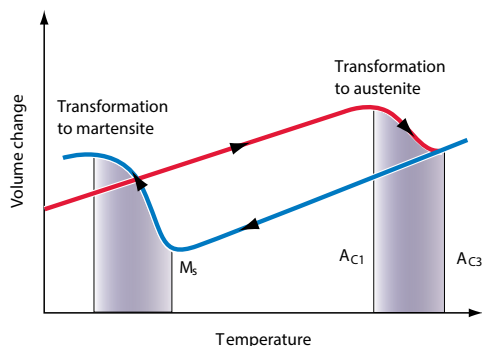


Retained austenite content in ASP®2023 as a function of tempering temperature and number of temperings. ASP®2023 austenitized at 1180°C prior to tempering.

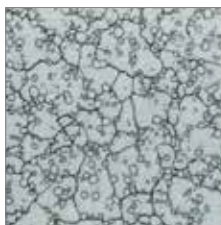
PHASE TRANSFORMATION AND VOLUME CHANGE

When ferrite transforms into austenite during heat treatment, the volume decreases due to a denser lattice. When the austenite transforms into martensite during the quenching, the volume increases again to a level above the ferrite volume. At the following tempering, the volume again decreases, but not fully to ferrite level, leaving the final hardened and tempered material with a slightly increased volume.

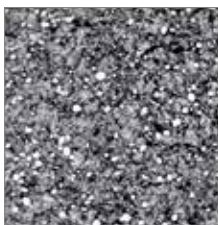
Temperature gradients are impossible to avoid and there is always a difference between surface and core. However, the general rule is to keep the gradient as symmetrical as possible.



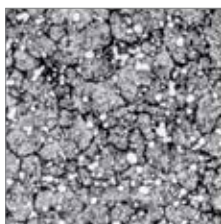
Volume change during hardening.



Structure only austenitized.



Structure after proper tempering.



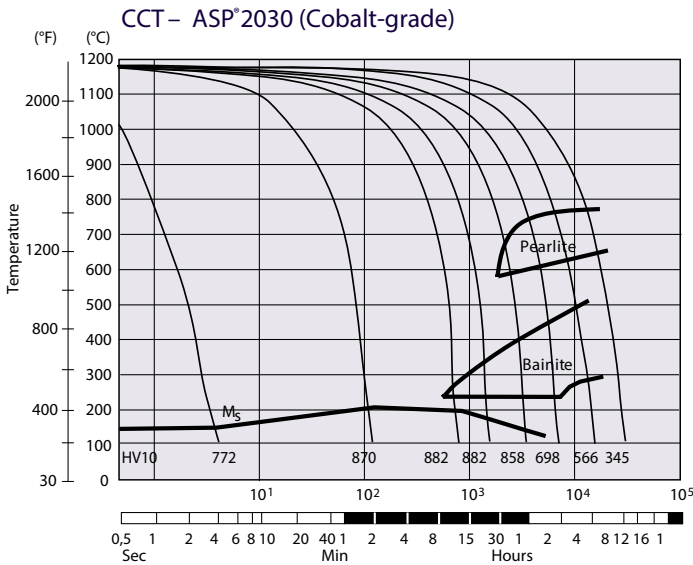
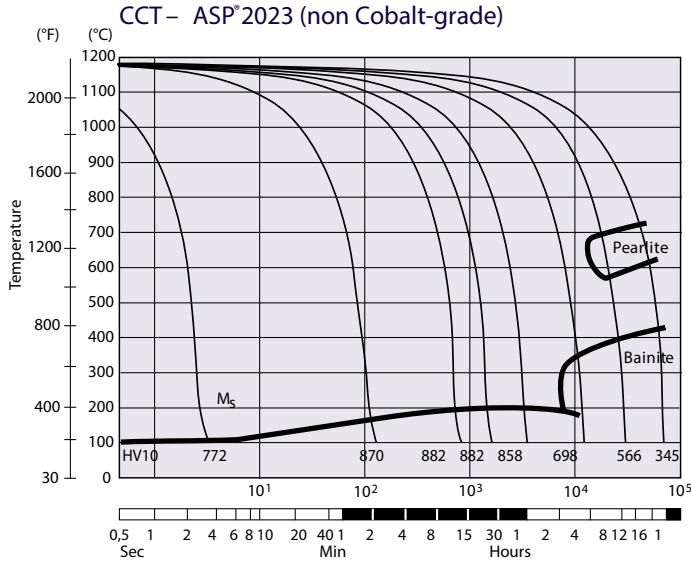
Structure after overtempering.



Structure after insufficient tempering.

CCT PHASE DIAGRAMS

EXAMPLES OF CONTINUOUS COOLING TRANSFORMATION CURVES



HEAT TREATMENT GUIDELINE

The following recommendations are valid for most of our ASP® and HSS grades, however there are some exceptions. Please refer to the datasheet of each grade and the specific heat treatment guidelines to find these exceptions.

SOFT ANNEALING

Soft annealing is done in a protective atmosphere at 850-900°C for 3 hours, followed by a slow cooling at 10°C/h down to 700°C, then air cooling.

A full soft annealing is done to reset the material and make it easier to machine. If for example a hardening procedure has not been done correctly it is always recommended to fully soft anneal the material before trying to harden it again.

STRESS-RELIEVING

Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.

A stress-relieving does not fully soft anneal the material, but it helps to remove any built-up stress in the material that could otherwise distort the material during machining or hardening.

HARDENING

Hardening is done in a protective atmosphere with pre-heating in 2 steps at 450-500°C and 850-900°C. Austenitising is done at a temperature suitable for the chosen working hardness after tempering (see heat treatment graph for each individual grade). It is important not to choose a temperature above the highest one recommended in the datasheet for the grade. Cooling down to 40-50°C.

TEMPERING

Tempering recommendation vary by grade (refer to the individual grades datasheets). Most grades benefit from three tempering cycles at 560°C with a holding time of 1 hour each. Cooling to room temperature <25°C between temperings.

SPECIFIC HEAT TREATMENT GUIDELINE

ASP®APZ10

SOFT ANNEALING

Soft annealing is done in a protective atmosphere at 870-900°C for 3 hours, followed by a slow cooling at 10°C/h down to 700°C, then air cooling.

Heat treatment of ASP®APZ10 can be done in two different ways depending on what properties are most important for the application at hand.

In applications where a high corrosion resistance is important and where temperatures does not exceed 150°C the following heat treatment is recommended:

- Austenitization: 1075°C.
- Cooling:
oil or gas pressure depending on the section and shape of the parts.
- Cryogenic treatment:
2 hours at -80°C.
- Tempering:
2 hours at 180-210°C.

In applications where a high wear resistance is required, or in which temperatures are likely to exceed 150°C in service or during surface coating operations, the following heat treatment is recommended:

- Austenitization: 1125°C.
- Cooling:
oil or gas pressure depending on the section and shape of the parts.
- Cryogenic treatment:
2 hours at -80°C.
- Tempering:
2 hours at 500-525°C two times.
Cooling to room temperature <25°C between temperings.

Keep in mind that this heat treatment provides a lower corrosion resistance compared to the first one.

SPECIFIC HEAT TREATMENT GUIDELINE

ASP®2012

SOFT ANNEALING

Soft annealing is done in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.

STRESS-RELIEVING

Stress-relieving is done at 600-700°C for approximately 2 hours, slow cooling down to 500°C.

HARDENING & TEMPERING

ASP®2012 offers a variety of heat treatment possibilities depending on the application and the targeted hardness (55 to 63 HRC). The hardening temperatures range from 1025 and 1150°C, whereas the tempering one is 525 to 560°C.

HARDENING

Hardening is done in a protective atmosphere with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for the chosen working hardness level (max 1150°C). Fast quenching down to 40-50°C.

It is important to respect the maximum hardening temperature at 1150°C as any higher hardening temperature will result in a rapid decrease in toughness.

In case of big dimensions (cross section > 150mm), a third preheating step is recommended.

TEMPERING

In order to better stabilize the tools, we recommend to perform 3 tempers at the chosen tempering temperature. Cooling to room temperature (<25°C) between temperings.

TOOL SURFACES



EDM AND WIRE CUTTING

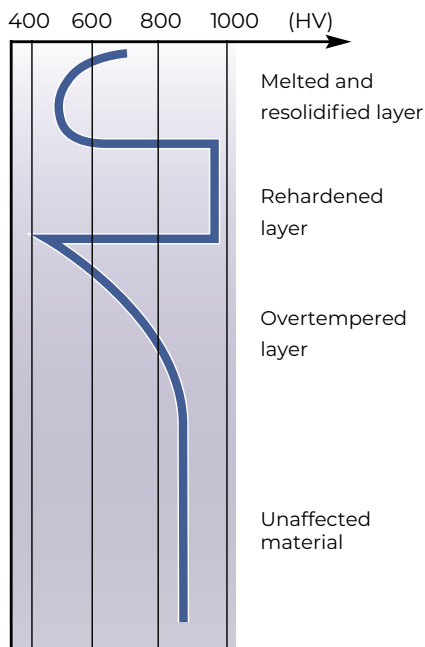
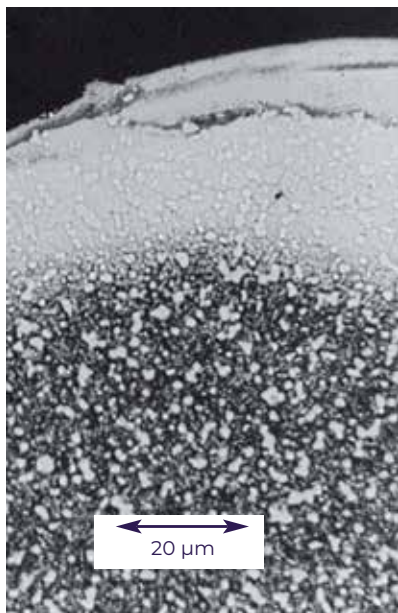
In Electric Discharge Machining (EDM), the temperature at the surface layer can be very high.

In this example, the temperature has been high enough to melt the outermost area of the surface, further down in the material to form a rehardening zone and finally cause an overtempered zone.

This heat affected zone, which in total stretches some hundred μm down in the material, has a severe influence on the mechanical properties. Indeed, the resolidification cracks in the melted zone provides excellent fracture initiation points, the rehardening zone contains very brittle untempered martensite and the overtempered zone gives a softening of the tool.

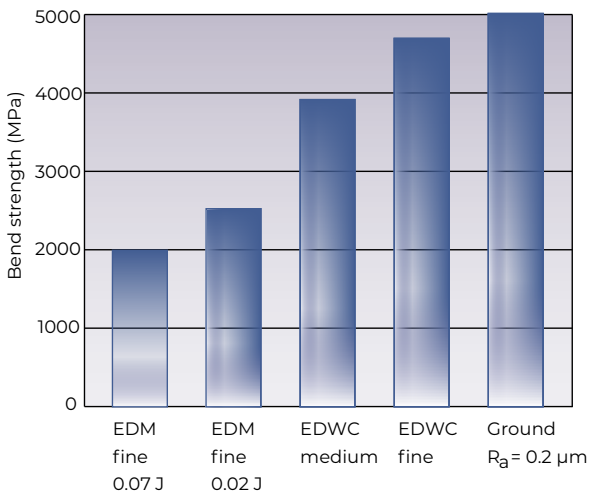
Clearly, it is very important to remove the entire heat affected zone before the tool can be used.

It is recommended to do a stress relieving process after EDM.

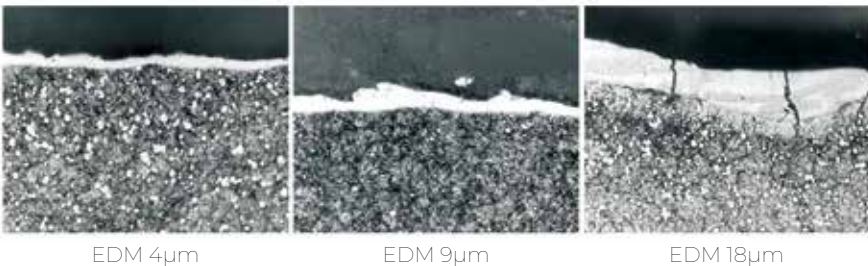


Depending on the type of EDM machining and strength of the discharge energy, the final surface quality and hence the final mechanical properties of the ASP® steel will vary.

From the figure below, we may conclude that die sinker EDM has more severe influence on surface quality than wire cutting EDM (EDWC) and that increased discharge energy decreases the surface quality and hence the bend strength.



An uppermost melted and resolidified layer, often referred to as the “white layer”, is always found after EDM-machining. The thickness of the layer can vary owing to, for instance, the discharge energy. For HSS, this uppermost layer should be removed as it contains very brittle non-tempered martensite which will lower the properties and the performance of the tool.



GRINDING

Grinding is typically carried out after heat treatment as it allows for material removal even when tools are extremely hard. Material removal rates are slow during grinding so most of the material should have been removed during soft machining. If done right, grinding will leave the tool with good surface finish, good tolerances and sharp cutting edges.

HOW DOES IT WORK?

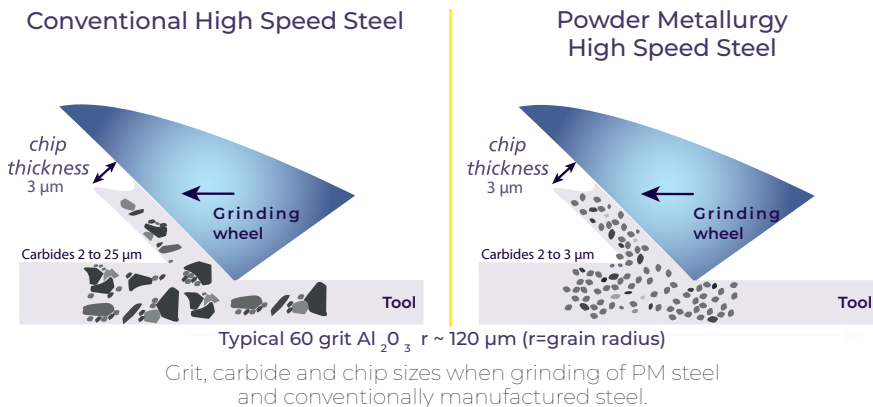
Grinding is a process of abrasive cutting where the grit of the grinding wheel acts as a cutting tool and the bond material serves as a tool holder. Similar to turning and milling, grinding is a process of chip formation. However, the chips produced are extremely small and the cutting edges are numerous, irregularly shaped and with negative cutting angles.

There are three primary interactions happening between the work piece and the grinding grit: Cutting, Ploughing and Rubbing. A sharp wheel will operate with a higher degree of cutting, being more efficient and generating less heat. Over time as the grinding continues the sharp grit will be dulled, increasing the ploughing and rubbing. This will in turn increase heat generation and power consumption.

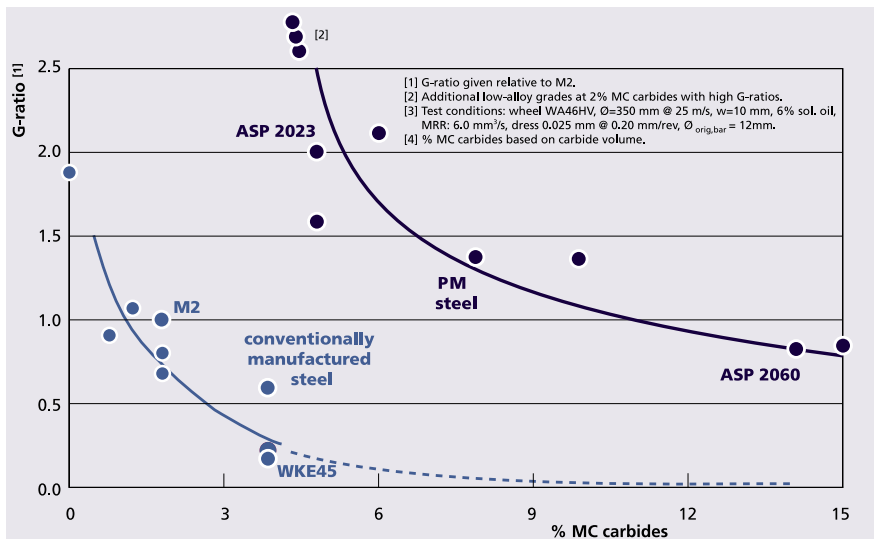
DIFFERENCE BETWEEN HSS GRADES

The rate at which a grinding wheel wears depends on the type of wheel selected and the grinding conditions, but it is also greatly affected by the steel grade. Just as HSS has a high wear resistance it is also difficult to grind due to its hardness and large volume of hard carbides. A newly dressed grinding wheel will perform similarly in a low alloyed steel as in a highly alloyed steel. However, as grinding progresses the dulling of the wheel is quicker in the highly alloyed steel causing power consumption and heat generation to increase more quickly.

When producing HSS by the conventional method of ingot casting large carbides and carbide clusters will be formed leading to even faster dulling of grinding wheels. This is avoided in all ASP® grades and BlueTap®Co as it is produced by powder metallurgy (PM). The PM process produces small fine carbides evenly dispersed in the material which leads to grinding wheels remaining sharp longer and wearing down slower. This difference is pronounced when grinding with conventional abrasives such as Aluminium oxide and Silicon carbide.



The grindability of a material will always decrease with higher alloying content, but the difference between conventionally manufactured HSS and ASP[®] means that a better grindability can be maintained compared to conventional counterparts. For example, ASP[®]2023 is a popular upgrade for E M2 and it has a higher carbide content giving it a higher performance. In spite of this, ASP[®]2023 is easier to grind than E M2 due to the difference in carbide size.



G-ratio versus percentage of hard MC (vanadium) carbides. For a given carbide content, PM steel is always easier to grind than conventionally manufactured steel.

G-ratio is the relative wear of the grinding wheel compared to material removed. It is calculated by dividing the amount of HSS removed by the wear of the grinding wheel.

GRINDING

PRODUCTIVITY AND COST SAVINGS IN GRINDING

For small diameter tools, typically taps, drills and small end mills, the cost of grinding is a significant portion of the total tool cost, often much larger than the material itself. Consequently, any improvement in grindability that reduces cycle time or reduces wheel wear will reduce the total cost of the tool. This means that for small diameter tools there is a possibility to reduce tool cost and increase

tool performance at the same time by upgrading from a conventional HSS to an ASP G-ratio is the relative wear of the grinding wheel compared to material removed. It is calculated by dividing the amount of HSS removed by the wear of the grinding wheel. grade or BlueTap®Co, if the cost reduction on grinding is large enough.

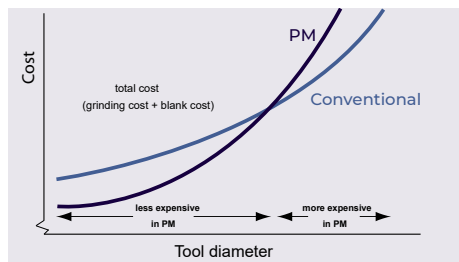
In order to reap the rewards of switching from a conventional grade to ASP® it is important to be aware of the potential benefits and consciously make changes to your grinding process. These changes could be things like increasing in-feed to increase output of parts or decrease wheel dressing frequency to save downtime and wheel wear.

It should also be noted that when switching to an easier-to-grind grade if you fail to upgrade the grinding conditions, such as speeds and feed rates, it might cause the grinding wheel to not self-sharpen and increase the risk of wheel clogging. To avoid this there is a need to grind more aggressively by increasing the table speed and/or the depth of cut. Changing to a softer grinding wheel can also help, but this will not increase productivity.

THERMAL DAMAGE OF TOOLS DURING GRINDING

As already mentioned, a dull grinding wheel will produce heat that will be transferred into the workpiece. Depending on the temperature that the tool reaches during grinding this can cause detrimental damage to the tool. These damages can be invisible to the naked eye and hard to detect before the end user reports poor tool performance.

This type of damage is usually loosely referred to as “grinding burn”, but in reality, different defects are introduced in the tool depending on the temperatures that the tool is subjected to during grinding.



Overall tool cost vs. diameter. At smaller diameters, producing a tool in PM is less expensive due to its better grindability.

Oxidation burn

Oxidation burn can start from 200°C and upwards and is a cosmetic defect caused by the oxidation of the workpiece leaving a discoloration on the surface. Unlike popular belief oxidation burn does not necessarily indicate if other more severe thermal damage has occurred. You can have severe thermal damage without clearly visible oxidation burn, and you can have a tool without any critical defects even if it shows oxidation burn. Oxidation burn can however affect the adhesion to coatings.

Thermal softening

Thermal softening starts to come into effect when the material is heated above the temperature used for tempering the steel. It will reduce the hardness of the surface of the tool and will adversely affect the strength and performance of the tool.

Residual tensile stress

During gentle grinding, the plastic deformation of the workpiece leaves the surface in a state of compressive stress. This can be beneficial for performance, especially in terms of fatigue life. However, when grinding conditions are harsher and higher temperatures are reached (above 650°C) there is a risk of introducing tensile stresses.

Residual tensile stresses are caused by restricted thermal expansion of the surface during grinding. After cooling, the surface is in a state of tension. In moderate cases, residual tensile stress negatively affects tool life. In extreme cases it results in cracking of the tool after grinding.

Rehardening burn

Rehardening burn occurs when temperatures of the workpiece exceeds the austenising temperature, causing a change in the phase of the material. As the material cools, a thin brittle zone of not tempered martensite is formed at the tool's surface. This zone is very susceptible to cracks and often leads to the tool failing from fractures.

Optimizing a grinding operation is always an exercise in avoiding thermal damage while keeping a high productivity. Avoiding thermal damage is easy but doing so while maintaining productivity, is difficult. The main objective is to avoid generation of heat and to effectively cool the work piece to avoid the heat being transferred into the tool.

SURFACE TREATMENT

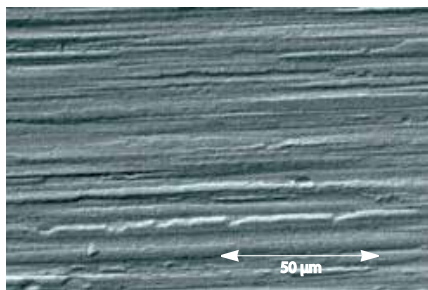
Correctly prepared surfaces are essential to maximize the potential of your tool. With the advances in powder metallurgical HSS manufacturing and the latest generation of ASP®, the microstructure and cleanliness of our products are finer than ever. This allows for high performance tools, but to achieve the high potential of the material, surfaces need to be correctly prepared.

Many high-performance tools can benefit from a surface coating such as Physical Vapor Deposition (PVD). Understanding what coating to apply and how to prepare surfaces before applying the coating is of high importance.

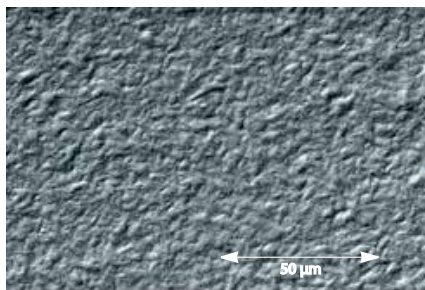
SURFACE ROUGHNESS

It is important to produce a fine and even surface with a low roughness. However, sometimes too much focus is put on metrics like the Ra value. Ra is a measurement of the average roughness of a surface by measuring the mean height between peaks and valleys of a surface. This does not consider the directionality of a surface or the largest defect size.

Ground surface ($R_a = 0.12 \mu\text{m}$),
5000 MPa bending strength



Homogeneous surface ($R_a = 0.18 \mu\text{m}$),
6000 MPa bending strength



Different surface homogeneity but similar Ra values of two otherwise identical ASP® 2023 tool materials. In this particular example the lower Ra value of the material to the left could lead one to believe wrongly that this material should be less influenced by the surface, and hence have a higher strength, than the material to the right. Evidently, Ra values alone should be used with caution when judging the surface finish.

Even if the ground surface in the picture above has a lower Ra value than the homogeneous surface finish it gives the material 1000 MPa lower bending strength due to some of the deep grooves lying in the direction of testing.

STRUCTURAL ALTERATIONS

High temperatures during machining of the tool or other processes will alter the structure of the material at the surface of the tool. This can lead to lower resistance to fractures or softer surfaces. These damages can be invisible to the eye and very hard to detect. Read more about these sorts of damages in the grinding chapter (page 74).

WORKING SURFACE

The adequate surface finishing to obtain for the tools is highly depending on the application, the working conditions and the worked material.

A wrong surface finishing will lead to lower performances, this is the reason why a good understanding of the failure mode is important.

The benefits are multiples:

- Increased performances of the Tools
- Decrease of tooling maintenance costs
- Better PVD coating adhesion
- Decreased friction
- Improved productivity

Our Customers Technical Support service will be happy to provide you assistance, just contact us.

EXAMPLE OF FAILURE due to a bad surface finish: powder compaction

- Punches fail prematurely due to build up of material. This causes heavy adhesive wear and galling
- Rough surface finishing after EDM was the reason for the material build up
- Better surface finishing would have improved a lot performances

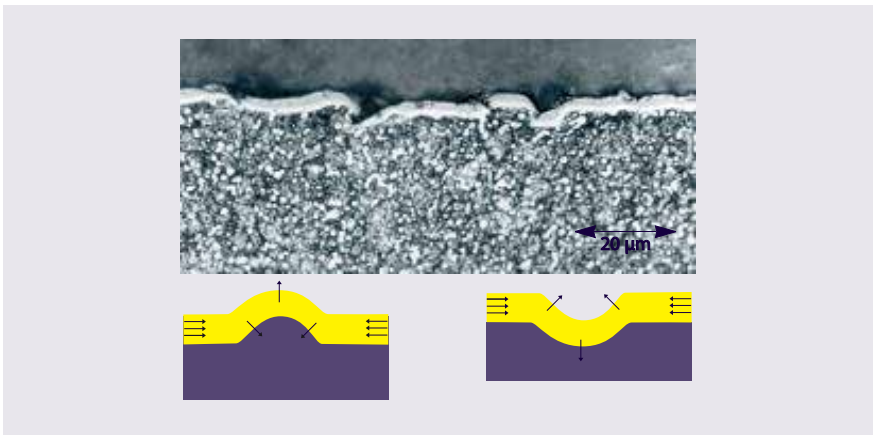


COATINGS AND SURFACES

SURFACE COATINGS

PVD coatings are often applied to a variety of HSS and ASP® tools in order to increase their performance. The coating is a thin hard layer of a ceramic material that protects the underlying substrate from heat, wear and chemical attack. The coating is also typically low friction towards the work material, decreasing the heat generated between the workpiece and the tool.







In order to produce a well performing tool, the correct combination of substrate (HSS or ASP®) and coatings need to be picked. A smooth tool surface without sharp geometries is also beneficial, otherwise the high internal compressive stresses in the coating might cause it to delaminate from the tool.



To put a coating on top of a rough tool surface is not a good idea. First of all, the roughness is not improved by the coating, as the coating is as thin as a few µm. Secondly, the coating may fall off at the peaks and in the valleys of the rough surface, owing to high compressive stresses in the coating. These unprotected areas will show accelerated wear and in addition provide starting points for fracture initiation. Thus, the combination of high performance tool materials, such as ASP® grades, and modern high performance PVD coatings requires also high quality surface preparation.

COATINGS - PVD

Following is a list of popular PVD coatings applied at maximum 500°C for tooling applications made in HSS or ASP®.

Coating material	Colour	Hardness GPa	Max. working temperature, °C	Areas of usage
TiN	 Gold	30	600	<ul style="list-style-type: none"> • Conventional, general purpose coating. • Reduces friction. • Good abrasion wear resistance. • Injection moulding of plastic material.
TiCN	 Grey-Violet	35	400	<ul style="list-style-type: none"> • Multi-purpose coating, especially for roughing end mills and forming tools. • High abrasion-wear resistance. • Available as mono or multilayer. • Recommended for construction steels ($R_m < 1000$ MPa).
TiAlN, TiAlCN or AlTiN	 Variants of grey	30-40	900 - 1000	<ul style="list-style-type: none"> • High performance coating for a widerange of cutting parameters. • 2x to 6x longer tool life than with conventional coatings. • Reduced heating of the tool. • Multilayered, nanostructured or alloyed versions offer even better performance. • Suitable for dry machining.
AlCrN	 Light grey	40	1100	Suitable for machining a wide range of materials. Suitable for high cutting speeds and dry machining.
AlTiN / TiSiXN	 Bronze / Copper	40	1100	For very hard and abrasive work piece materials like titanium, nickel alloys, stainless steel and hardened steel.
DLC (ta - C)	 Black to rainbow	50 - 60	500	<ul style="list-style-type: none"> • For aluminum alloys and other non-iron alloys like copper, silver or gold, GRP, CFRP and organic materials.

Read more in Erasteel's Surface Brochure.

FAILURE MECHANISMS

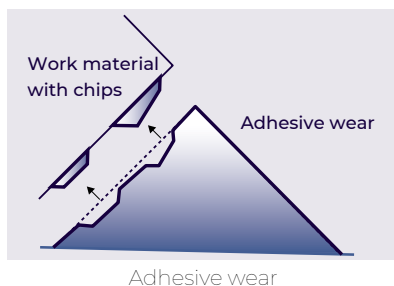
If you can identify the predominant failure mechanism in the tool, you know what to improve in order to make a longer lasting tool. Many of these improvements are connected to selecting the correct steel grade, correct heat treatment and surface treatment for the tool and application.

The following are some examples of typical failure mechanism that can be seen on tools and how to improve it.

GALLING AND ADHESIVE WEAR

Explanation: Both galling and adhesive wear are created by compressive stresses and sliding contact resulting in heavy friction and locally high temperature which can lead to micro-welds spots that destroy the surface quality of the tool. Then, due to the working stresses, parts of stick material are pulled out of the tool surface by the work material.

Improvements: The critical parameters are roughness, friction coefficient, toughness/ductility and hardness. Powder Metallurgy tool steels offer the optimal solution, together with surface coating in order to optimize the sliding properties.

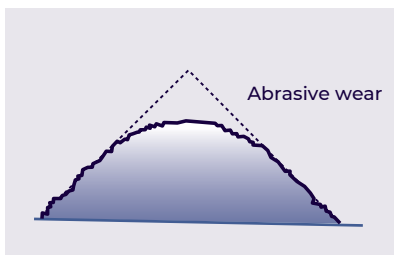


Adhesive wear

ABRASIVE WEAR

Explanation: Abrasive wear is often a slow, but unavoidable wear mechanism caused by hard non-metallic inclusions or other hard particles in contact with the tool surface.

Improvements: The critical tool steel properties are hardness, high volume of carbides and high hardness of the carbides. ASP® metallurgy enable to produce steels with much higher carbon and alloying element (carbides formers) that conventional tool steels. Consequently, ASP® can reach a very good abrasive wear resistance.

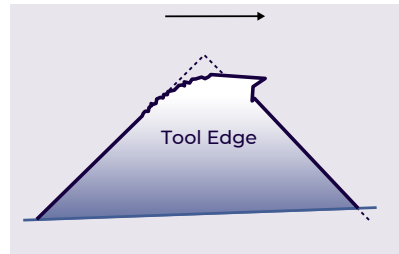


Abrasive wear

PLASTIC DEFORMATION

Explanation: The permanent deformation occurs when the compression stress exceed the compressive yield strength of the tool steel. Hardness is the critical parameter. This can more easily occur when the tool is subjected to high temperatures.

Improvements: ASP® are able to reach a higher hardness and compressive strength compared to D2 and 8% chromium conventional tool steel, which are limited to 62/64HRC. Most of ASP® exhibit a potential hardness above 65HRC, up to 70HRC.



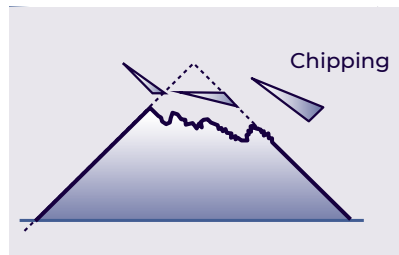
Plastic deformation

CHIPPING AND TOTAL BREAKAGE

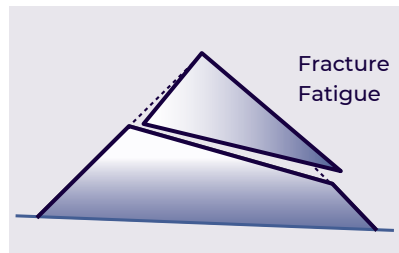
Explanation: The stresses in tools are mainly compressive but tensile stress components are also present. In most cases, stresses are cyclic and can cause fatigue fracture. Moreover, when punching or blanking of ultra advanced high strength sheet metals (UHSS), stresses and shock waves increase a lot on the cutting edges of the tools, leading to early chipping and cracks.

Improvements: Both cracks initiation and cracks growth are negated by high ductility/toughness, which is limited by the coarse structure of the conventional tools steels.

With the powder metallurgy process, the enhanced ASP® microstructure results in an improved combination of toughness, strength and hardness in comparison to conventional tool steels.



Chipping



Fracture

COMPANY PROFILE

Erasteel is a major player in the HSS market with high-end conventional and powder metallurgy High Speed Steels. With its ASP® range, Erasteel is the world leading producer of PM HSS for high performance tooling and components.

Erasteel also produces HIP powder, such as stainless powder, tool steel powder and High Speed Steel powder under the brandname Pearl®.

Erasteel is fully involved in reducing its overall environmental impact; indeed, its recycling rate to produce high speed steel is already 90% of input material. These good results are nevertheless still challenged with the objective to increase it to near 100% within 3 years by developing specific processes in order to recycle new sources of end of life material. For the most common grades, the decrease of CO₂ emission thanks to this recycling rate is 85% compared to a 100% production from metallic ores. This calculation includes the energy to melt and refine the scraps .

Our plants* are ISO 9001 and ISO 14001 certified and all emissions in air or water are carefully treated, cleaned and controlled.



ASP® and Pearl® are registered trademarks of Erasteel.
*Except Commentry

PRODUCTS

Erasteel products are available in a wide range of shapes and chemical compositions, perfectly adapted to a wide variety of tooling and other applications. The different geometries and product forms are available in various finishes: hot-rolled, cold-rolled, drawn, peeled, ground, etc.

Available standard dimensions (mm):

Grade	Min. Ø Max.	Min. width	Min. thickness	Max. Width**	Max. thickness**
HSS	0.60 - 205 mm	9.8*mm	9.8 mm	305 mm	100 mm
ASP®	0.60 - 410 mm	9.8*mm	9.8 mm	600 mm	400 mm

*Small flats & squares in HSS and ASP® can be provided on request.

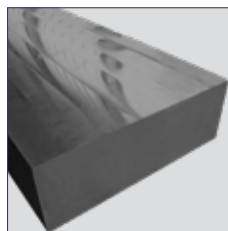
** Wider and thicker flats & squares in ASP® (defined as megablock) can be realized on request



Round bars



Flat & square bars



Megablock bars



Sheets (hot rolled)



Profiled bars



LINEA™ prehardened HSS blanks



Profiled edges



Strips (cold rolled)



Pear® Powders

COMPANY PROFILE

MARKET SEGMENT

The grades of Erasteel are used in a wide range of applications.



Cutting Tools



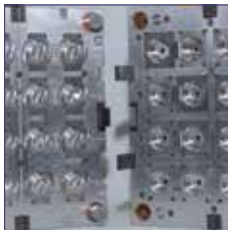
Cold Work & Hot Work



Saws



Knives



Plastic Forming Tools



Components

INNOVATION & EXPERTISE

Erasteel has achieved a high standard of quality and experience in the processing of Powder Metallurgy Steels and High Speed Steels. A policy of continuous investments has enabled Erasteel to use the latest technologies to improve both quality and productivity and develop new products in line with customers' needs.

Customer-oriented research and development

- A solution-oriented spirit to meet and support customers' needs and developments
- A long experience of technical service and examinations of powder metallurgy components and tools in ASP®
- Customer partnerships in product development analysis and improvement of tools and parts

50 years of expertise in Powder Metallurgy

- A unique knowledge of gas-atomized metal powders
- A focus on powder cleanliness, processing, consolidation and properties
- A dedicated research laboratory in Söderfors, Sweden, with highly skilled teams, cooperating with a network of universities, laboratories and industry organizations

A wide range of competencies and resources

- Alloy development in ASP® as well as Fe- base alloys
- Powder characterization: size, morphology, tap density, flowability, FEG-SEM micrography and chemical analysis
- Evaluation of physical, mechanical (such as impact toughness and fatigue testing) and corrosion properties, as well as cleanliness (e.g. high frequency ultrasonic)

ORIGINAL SWEDISH STEEL



ERASTEEL



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PROCESS TECHNOLOGY

HIGH SPEED STEEL CONVENTIONAL METALLURGY

Erasteel is a renowned producer of High Speed Steels and has a unique knowledge in this area, in terms of:

- Process: metallurgy, forging, rolling, drawing, heat treatment, etc.
- Steel grades: mechanical and physical properties, applications, etc.



Bottom
pouring



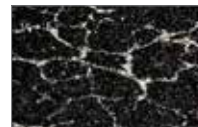
Ø30 mm/1,181 inch



Ø50 mm/1,969 inch



Ø125 mm/4,921 inch



Ingot

Carbide
network

PROCESS

POWDER METALLURGY



Easteel is the world leading producer of gas-atomized PM steels. With more than 50 years of experience in powder metallurgy, Easteel produces PM high speed steels with a high cleanliness level known under the trademark ASP®.

The molten steel is refined in a heated tundish to remove inclusions and homogenize the composition.

During gas atomization the molten steel is disintegrated by powerful jets of nitrogen gas into small droplets, which solidify at a very high speed. The powder is collected in a steel capsule which is then evacuated and welded. The capsule with powder is Hot Isostatically Pressed (HIP) to a 100% dense material.

Bars, wire rods, strips and sheets are obtained from forging, hot and cold rolling and wire drawing of the HIP'd capsule.

With the most advanced technology in powder metallurgy and a strong focus on Research & Development, Erasteel has built a high standard of quality and experience. Our researchers constantly innovate in direct liaison with engineers and technicians in the field, pushing back the limits of technology. Together with our technical experts, they provide the finest possible products and services to our customers, for their constant satisfaction.

Erasteel's PM HSS, ASP® are high quality products with the following key benefits:

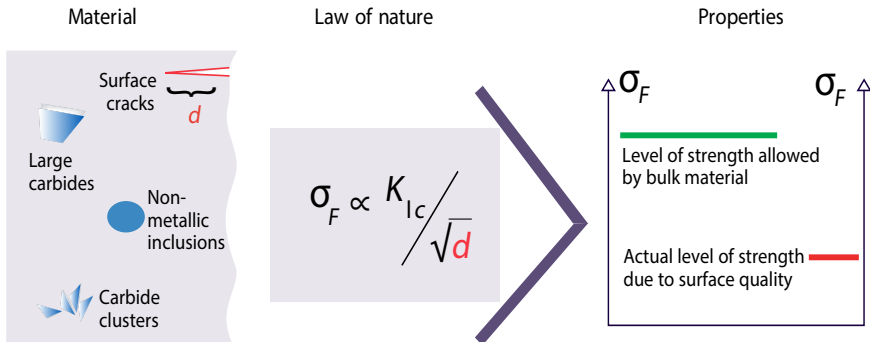
- Isotropic properties: a homogeneous and fine microstructure with an even distribution of carbide particles in the matrix phase, in contrast to ingot cast material where carbide stringers are formed during manufacturing
- A high level of cleanliness
- Higher hardness and wear resistance, due to a higher content of carbide-forming elements
- Higher toughness: the material is free from carbide segregation
- Very good polishability
- The main benefits of the fine PM micro-structure are the increased impact resistance and the polish-ability



Thanks to these properties, Erasteel's ASP® grades are widely used in many high performance applications such as tooling for metal, plastics, wood and paper processing as well as mechanical components.

CLEANLINESS OF ASP®

The strength of a tool or a cutting edge is always limited by the largest defect present in that tool or cutting edge. One of the main benefits of using ASP® and why we set out to develop this technology was in order to remove carbide clusters and large carbides. After successfully doing so through powder metallurgy and effectively making a stronger steel the next defect to tackle was non-metallic inclusions (NMI).



σ_F = the strength - K_{Ic} = fracture toughness -
 d = the size of the imperfection initiating the fracture.

NON-METALLIC INCLUSIONS (NMI): ADVANTAGE OF THE ASP® PROCESS

Excellent chipping resistance



PM with a poor cleanliness
 The inclusions causes crack initiation and failure



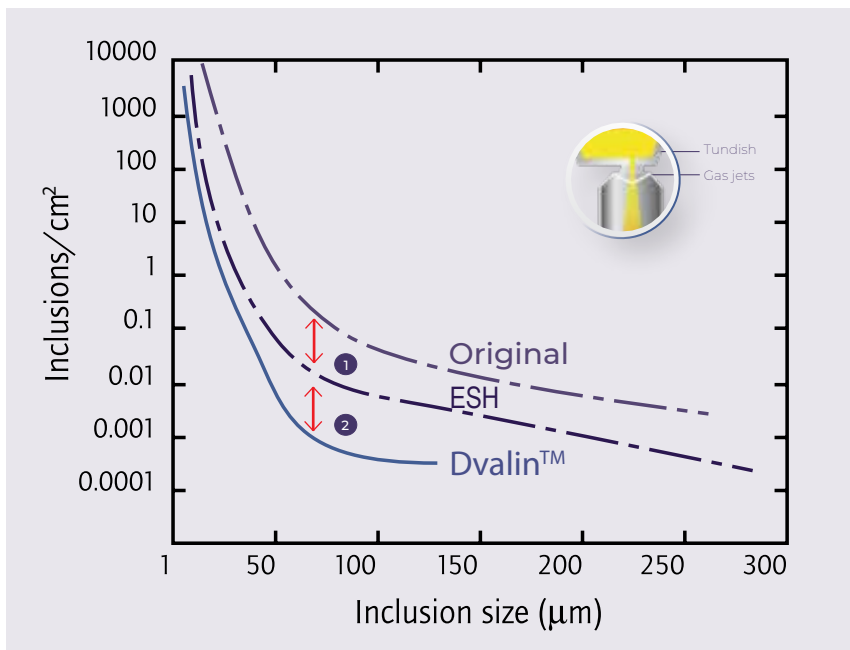
With ASP®
 Excellent chipping resistance thanks to high cleanliness

NMI's are defects left in the material from steel making and can originate from the steel itself as products of chemical reactions and are often referred to as endogenous. They can also be outside contaminations and are then referred to as exogenous.

The process to manufacture ASP® has gone through several major improvements over the years to bring the best quality possible to our customers. All of these improvements have been aimed at reducing the number and size of NMIs.

Compared to the original ASP® process from 1969 we have removed more than 99% of our inclusions and we continue to work on improving those numbers.

PM processes improvements



Number of large non-metallic inclusions:

- 1 ESH process = 90% Reduction
- 2 Dvalin™ process = Additional 90% reduction



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ASP® is a registered trademark of Erasteel

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