Conventional and Powder Metallurgy
High-Speed Steels for

CUTTING TOOL APPLICATIONS

USER GUIDE

ERASTEEL

Dear reader,

This guide will hopefully give you all the information to convince you that High-Speed Steel (HSS) is the best solution for your cutting tool needs.

If you are looking for superior cleanliness, toughness and wear resistance, then the large number of conventional High-Speed Steel and Powder Metallurgy High-Speed Steel 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 High-Speed Steel is the best alternative to cemented carbides when brittleness or grindability are impacting your tool performance and Total Cost of Ownership.

Conventional High-Speed Steel enables 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 soft machining, heat treatment, grinding, coating and other aspects relevant for anyone dealing with cutting tool manufacturing.

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

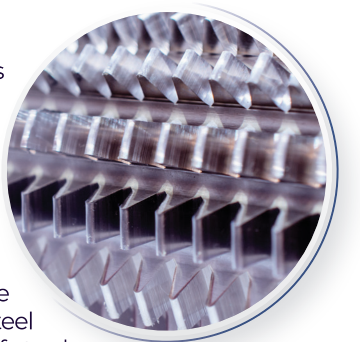
Should you need more information than what is included in this manual, please feel free to contact us.

Wishing you a good reading experience,

Your dedicated Erasteel team

SUMMARY

GEAR CUTTING



What is gear cutting?

Gears are essential mechanical components used in gear boxes and transmission systems to allow the transmission of torque. Many gears are produced by hobbing, shaper cutting or emerging technologies such as skiving.

Which specific technical requirements?

Gear cutting tools have developed to one of the most demanding end usages for High-Speed Steel and are constantly pushing the limits of tool materials in terms of cutting speeds, feeds and dry cutting. Gear cutting tools also have complex geometries and are often re-ground. Because of this the material delivered requires high hot hardness in order to survive the high cutting speeds and sufficient toughness to avoid chipping of teeth. At the same time the material has to feature a good soft machinability and grindability for tool manufacturing and re-grinding operations.

Why would ASP® be your solution?

The powder metallurgical process route used to produce our ASP® products is perfectly in line with the needs of gear cutting tool manufacturers. ASP® grades meant for gear cutting feature high hot hardness and high wear resistance, but they are also easier to grind and tougher due to the fine microstructure of the ASP® materials.

Our new developments, such as ASP®2078 feature even higher performance and improvements to machinability and finer surface finishes.

ASP®2190 is another new development which features previously unreachable hot hardness levels giving excellent resistance to crater wear and other thermally induced damages.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	
ASP®2023	
ASP®2030	
ASP®2048	
ASP®2052	
ASP®2060	
ASP®2078	
ASP®2190	

Sulphurized ASP® grades are also available

BROACHES

What is broaching?

Broaching can be both internal or external. Internal broaches generally create complex shapes of holes in the centre of tools such as non-circular holes, internal splines, keyways and flat surfaces. External broaches can be used to produce splines, slots or other surface contours that need high accuracy.

Which specific technical requirements?

Depending on the material to be cut, the complexity of the shape and the amount of parts being produced the requirements on a broach can be somewhat different. Common for all broaches are that the thermal stability of the material needs to be sufficient and that the tool material maintains the same properties over the whole tool. As the broaches can be relatively long tools, they can be prone to distortions during heat treatment and even during use and this can hurt the accuracy of the result.

Why would ASP® be your solution?

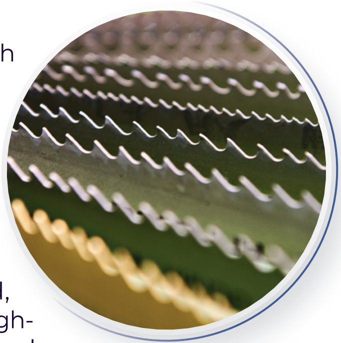
Due to the high technical requirements of these tools, a large portion of today's broach manufacturers have moved away from conventional High-Speed Steel to ASP® in order to increase performance and make manufacturing of the tools easier. ASP® offers excellent toughness, reliability and high grindability. Typical grades on the market today are ASP®2004, ASP®2030 and ASP®2015. Erasteel also offers the innovative grade ASP®2055 with improved performance and grindability better suiting broach makers' requirements.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2015	E M35
ASP®2023	E M42
ASP®2030	
ASP®2055	
ASP®2060	

ASP® is a registered trademark of Erasteel

SAWS

What is sawing?



Sawing can perform precise cuts through many materials and is usually an initial step in parts production. Saws are tools with a single row of teeth in a line and can be of many different types, they can be used in specific machines such as band saw machines or used in handheld tools such as hand hack saws, jig-saws, sabre saws, etc.

Saws are usually provided as either solid, where the entire saw blade is made of High-Speed Steel, or Bi-metal where a small edge wire of High-Speed Steel has been welded to a more flexible backing material.

Which specific technical requirements?

Like most cutting tools, saws require sufficient toughness in order to avoid chipping, high wear resistance and hot hardness to last longer without wearing down. The specific requirements also depend on the specific saw application. Hand hack saws and other reciprocating saws need to have a high toughness as they move back and forth through the material, while band saws only move in the optimal direction, decreasing the need of toughness.

For processing from edge wire to Bi-metal saws the tool material also needs to have excellent weldability, low outgassing and good drawability.

Why would ASP® be your solution?

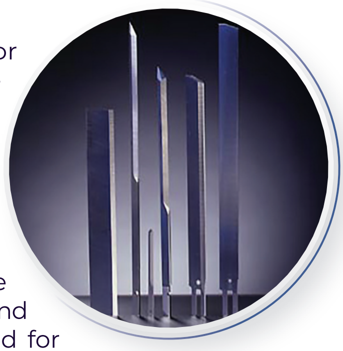
Erasteel offers many different grades in conventional ingot cast grades, but also the popular ASP®2042 and ASP®2051 powder metallurgical grades. The wide selection of grades offered by Erasteel is a great way to ensure the best option for each specific situation. Erasteel is unique in the ability to produce powder metallurgical High-Speed Steel able to be welded by both laser and electron beam welding.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2042	E M2
ASP®2051	ABC III
	E MAT II
	E M35
	E M42

ASP® is a registered trademark of Erasteel

KNIVES

What are knives?



Knives are made in a wide variety of shapes for many different applications. They are mainly used when you want to cut, slot, granulate or chip materials such as wood, textiles, paper, plastics, rubber and metals.

Which specific technical requirements?

The technical requirements on a knife are based on what type of material is going to be processed. Many materials such as wood and paper can be quite abrasive giving the need for high hardness and abrasive wear resistance. These sorts of materials are usually sensitive to any cooling media so good hot hardness can also be a requirement.

To make clean precise cuts with minimal cutting forces, a well-defined sharp edge needs to be formed and retained. Because of this, a fine microstructure and good toughness is required.

Why would ASP® be your solution?

Erasteel offers many conventionally manufactured grades in High-Speed Steel that are well suited for knife manufacturing such as E M2. For advanced high-performance knives where grindability, edge retention, edge sharpness and wear resistance are needed, the powder metallurgically manufactured ASP® grades are excellent upgrades. Grades such as ASP®2011 and ASP®2053 feature high wear resistance.

When corrosion resistance is needed, the stainless tool steels ASP®APZ10 and ASP®420H can be used for excellent performance in harsh environments not suitable for regular High-Speed Steel.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2011	E M35
ASP®2023	
ASP®2053	
ASP®APZ10	
ASP®420H	

ASP® is a registered trademark of Erasteel

MILLING CUTTERS

What is milling?

Milling covers many different machining operations and different types of tools and applications. It is one of the best ways of making intricate custom parts with high precision. Milling uses round cutting tools with varying number of cutting edges to remove material by feeding the milling cutter into the work piece while the cutter is rotating.

Which specific technical requirements?

End mills and other milling cutters require high hardness, high wear resistance and hot hardness to enable high cutting performance. Depending on the milling operation, work material and machine tool toughness can also play a large role.

Why would ASP® be your solution?

ASP® opens up new possibilities for end mills and milling cutters in general as the powder metallurgical steel offers a unique combination of hardness and wear resistance together with toughness.

Tools made from ASP® can be used in difficult machining operations where other materials would suffer from chipping or fast wear, especially when machining tough aerospace grade materials with low machinability. Difficult machining conditions with machine tools suffering from vibrations can be realized with ASP® milling tools without chipping due to the excellent toughness and resistance to impact.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2030	E M35
ASP®2052	C8
ASP®2055	E M42
ASP®2060	

ASP® is a registered trademark of Erasteel

DRILLS

What is drilling?

Drilling is a well-known machining operation in which the tool, often a multi cutting edge tool, is fed into the work piece while rotating in order to make a hole. As the cutting action happens along the entire cutting edge of a drill, the cutting speeds will vary from the rotational speed of the tool at the edge to zero at the center. This makes it impossible to have optimized cutting parameters along all points of contact and the center of the drill will push the metal instead of cutting it.

Which specific technical requirements?

The technical requirements of drills are very dependent on the market. The Do-It-Yourself segment catering to drills usually uses conventionally manufactured High-Speed Steel with standard performance requirement. However, there are also many applications that require high performance drills in manufacturing.

These drills require good wear resistance and toughness as the machining conditions alter along the cutting edge of the drill, causing unfavourable conditions close to the center of the drill.

Why would ASP® be your solution?

Erasteel offers all the common grades for drill manufacturers such as E M2, E M35 and E M42. For drills that require higher performance the properties of powder metallurgically manufactured ASP® are more suitable. ASP® can be used to increase tool life, allowing for machining in otherwise too unstable conditions or to machine difficult materials. ASP® can outperform solid carbide drills in some conditions and offers a better resistance to chipping.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
ASP®2004	E M2
ASP®2015	E M35
ASP®2023	E M42
ASP®2030	
ASP®2052	
ASP®2060	

TAPS

What is Tapping?

Tapping, thread cutting or thread forming operations are common machining operations, which produce internal threads in drilled holes, mostly to allow the usage of fasteners. Dies are tools used to cut or form outer threads on round shaped products.

Which specific technical requirements?

Tapping is often one of the last machining operations on a part and if the tap breaks in a hole, a high value part might have to be scrapped. Due to this, taps need to be reliable and have a predictable tool life.

Another concern for tap manufacturers is grindability as grinding operations make up a large part of the cost involved in producing taps.

Why would ASP® be your solution?

The powder metallurgical route used to produce ASP® and BlueTap® has brought many improvements to both tap manufacturers and end users. The fine microstructure and cleanliness of Powder Metallurgy High-Speed Steel do not only improve the reliability and performance of the tap, but also make it easier to grind, significantly decreasing tap manufacturers Total Cost of Ownership.

BlueTap® has been specifically designed to bring the benefits of the powder metallurgical route to tap manufacturers and end users.

Erasteel also supplies high performance conventional grades for tapping like Grindamax™V3. This grade has a unique formulation that allows it to be easy to grind and that still provides excellent wear resistance.

RECOMMENDED ERASTEEL GRADES	
ASP® powder metallurgy HSS	HSS conventional metallurgy
BlueTap®Co	E M2
BlueTap®Max	E M35
ASP®2015	Grindamax™V3
ASP®2023	
ASP®2030	
ASP®2052	
ASP®2055	
ASP®2060	

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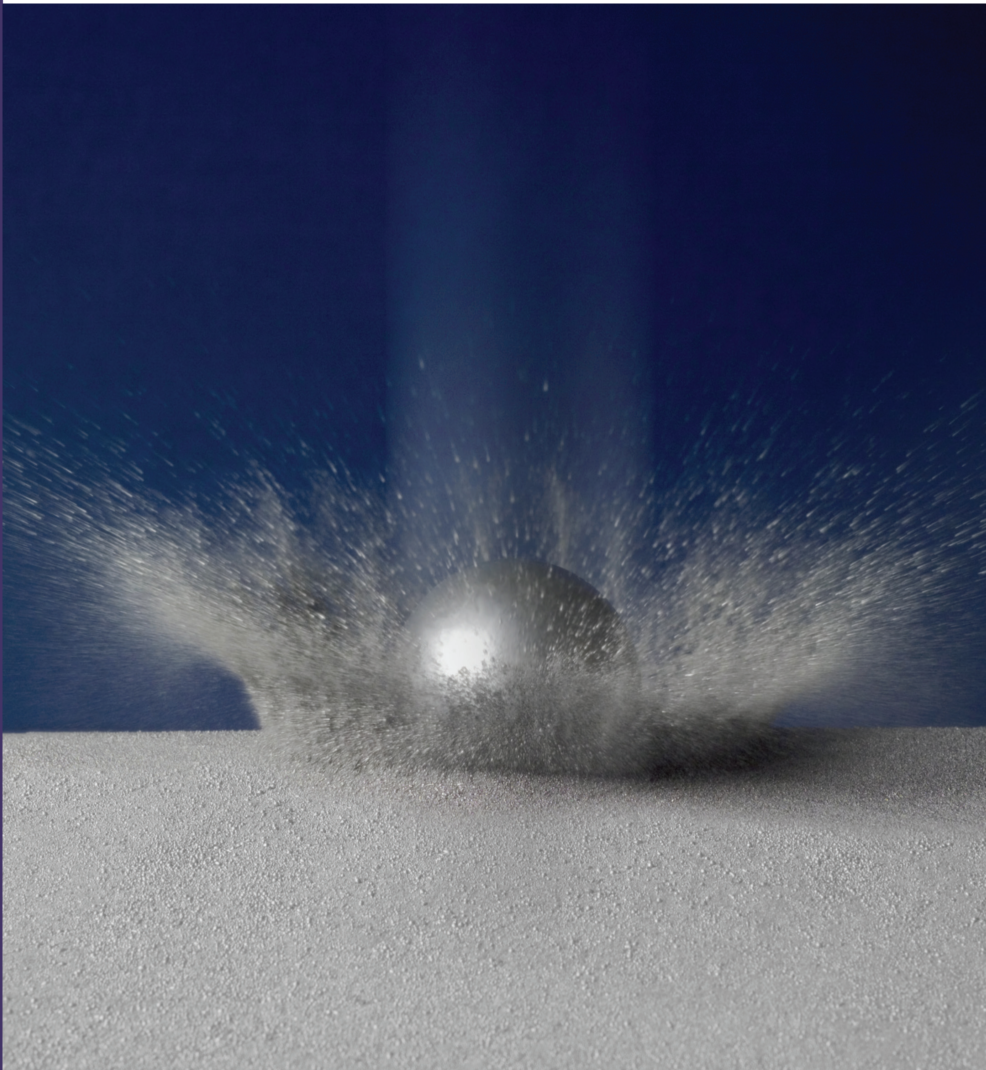
OUR GRADES PORTFOLIO



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	Cutting tools				
	Gear Cutting	Broaches	Saws	Knives	Milling Cutters
ASP®2004	◆	◆		◆	◆
ASP®2011				◆	
ASP®2015		◆			
ASP®2023	◆	◆		◆	
ASP®2030	◆	◆			◆
ASP®2042			◆		
ASP®2048	◆				
ASP®2051			◆		
ASP®2052	◆				◆
ASP®2053				◆	
ASP®2055		◆			◆
ASP®2060	◆	◆			◆
ASP®2078	◆				
ASP®2190	◆				
ASP®APZ10				◆	
ASP®420H				◆	
BlueTap®Co					
BlueTap®Max					
E M2		◆	◆	◆	◆
ABC III			◆		
Grindamax™V3					
E M35		◆	◆	◆	◆
C8					◆
E MAT II			◆		
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.

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BY APPLICATIONS

Erasteel grades	Cutting tools				
	Drills	Taps	Reamers	Deburring Tools	Tool Bits
ASP®2004	◆				
ASP®2011					
ASP®2015	◆	◆			
ASP®2023	◆	◆	◆		
ASP®2030	◆	◆	◆		◆
ASP®2042					
ASP®2048					
ASP®2051					◆
ASP®2052	◆	◆			
ASP®2053					
ASP® 2055		◆			
ASP®2060	◆	◆			◆
ASP®2078					
ASP®2190					
ASP®APZ10					
ASP®420H					
BlueTap®Co		◆			
BlueTap®Max		◆			
E M2	◆	◆		◆	
ABC III					
Grindamax™V3		◆	◆		
E M35	◆	◆	◆	◆	
C8					
E MAT II					
E M42	◆		◆		◆

ASP®, BlueTap® AND CONVENTIONAL

	ERASTEEL grades	ANALYSIS %					
		C	Cr	Mo	W	Co	V
ASP® non Cobalt-grades	ASP®2004*	1.40	4.2	5.0	5.8	-	4.1
	ASP®2011	2.45	5.3	1.3	-	-	9.5
	ASP®2023	1.28	4.0	5.0	6.4	-	3.1
	ASP®2053	2.48	4.2	3.1	4.2	-	8.0
ASP® Cobalt-grades	ASP®2015	1.60	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®2051	1.27	4.0	3.6	9.5	10.0	3.2
	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
	ASP®2078**	2.30	4.2	7.0	6.5	10.5	6.5
	ASP®2190	0.78	4.2	2.9	2.9	29.0	1.1
Mar-tensitic Stainless Steel	ASP®APZ10	1.25	19.0	2.1	-	-	0.8
	ASP®420H	2.30	14.0	1.0	-	-	9.0
BlueTap® grades	BlueTap®Co	0.93	4.2	5.0	6.4	4.8	1.8
	BlueTap®Max	1.08	3.8	9.3	1.5	7.8	1.1
HSS non Cobalt-grades	E M2	0.90	4.2	5.0	6.4	-	1.8
	ABC III	0.99	4.1	2.7	2.8	-	2.4
	Grindamax™V3	1.20	3.9	5.2	7.2	-	2.7
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 MAT II	0.72	4.0	5.0	1.0	8.0	1.0
	E M42	1.08	3.8	9.4	1.5	8.0	1.2

* also available with sulfur, ** ASP®2078 with 0.23% S

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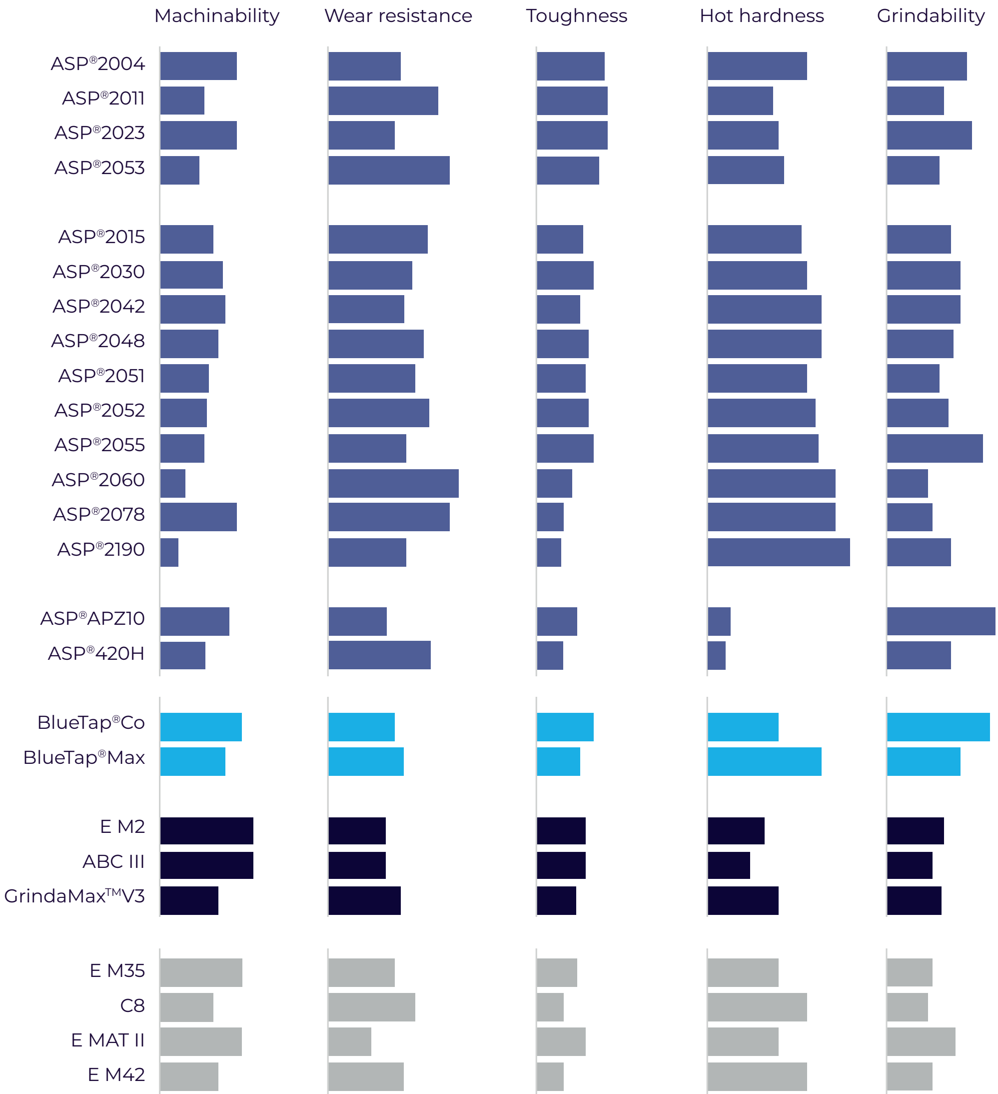
HIGH-SPEED STEELS GUIDE

	ERASTEEL grades	Characteristics and applications
ASP® non Cobalt-grades	ASP®2004*	Good wear resistance and hardness
	ASP®2011	V-alloyed with high abrasion resistance
	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 cutting tools
	ASP®2030*	Co-grade with good combination of hardness and toughness
	ASP®2042	For bi-metal saws with high attainable hardness and good weldability
	ASP®2048*	High alloyed for high performance cutting tools
	ASP®2051	For bi-metal saws, with excellent wear resistance and toughness
	ASP®2052*	High W- and Co-alloyed grade for high performance cutting tools Good wear resistance
	ASP®2055	2.1% Nb. High alloyed Co-grade with good grindability
	ASP®2060	For both hot hardness and wear resistance
	ASP®2078**	High performance grade with improved machinability
	ASP®2190	High performance high Co-grade for PVD coated gear cutting tools
Mar-tensitic Stainless Steel	ASP®APZ10	Good corrosion and wear resistance
	ASP®420H	Good corrosion and high wear resistance
BlueTap® grades	BlueTap®Co	For tap manufacturing: excellent grindability, and a good combination of hardness, wear resistance and toughness
	BlueTap®Max	Unrivalled tap performance to TCO ratio
HSS non Cobalt-grades	E M2	Grade for general applications
	ABC III	Grade for metal saws and wear parts
	Grindamax™V3	Grade with excellent grindability, ideal for taps
HSS Cobalt-grades	E M35	Grade for taps and general applications
	C8	8% Co-grade with improved hot hardness for end millls
	E MAT II	Grade for bi-metal saws with good toughness
	E M42	Co-grade for cutting tools and bi-metal bandsaws

* also available with sulfur, ** ASP®2078 with 0,23% S

COMPARATIVE PROPERTIES



INTERNATIONAL STANDARDS

ERASTEEL grades	EN 10027-1	EN 10027-2 (W.Nr.)	ASTM (AISI)	JIS
ASP®2004	HS 6-5-4	1.3361	M4	SKH54
ASP®2011	-	-	A11	-
ASP®2015	HS 12-0-5-5	1.3251	T15	SKH10
ASP®2023	HS 6-5-3C	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®2051	HS 10-4-3-10	1.3207	M51	SKH57
ASP®2052	HS 11-2-5-8	1.3253	-	-
ASP®2053	HS 4-3-8	1.3352	-	-
ASP®2055	-	-	-	-
ASP®2060	HS 7-7-7-11	1.3292	-	-
ASP®2078	HS 7-7-7-11S	1.3292	-	-
ASP®2190	-	-	-	-
ASP®APZ10	-	-	-	-
ASP®420H	-	-	-	-
BlueTap®Co	HS 6-5-2-5	1.3243	M35	SKH55
BlueTap®Max	-	-	-	-
E M2	HS 6-5-2C	1.3343	M2	SKH51
ABC III	HS 3-3-2	1.3333	-	-
Grindamax™V3	HS 7-5-3	1.3347	-	-
E M35	HS 6-5-2-5	1.3243	M35	SKH55
C8	HS 5-6-2-8	1.3209	-	-
E MAT II	HS 1-5-1-8	1.3270	-	-
E M42	HS 2-9-1-8	1.3247	M42	SKH59

ASP® and BlueTap® are registered trademarks of Erasteel

ASP® GRADES

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

ASP® GRADES DATA // ASP®2004

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

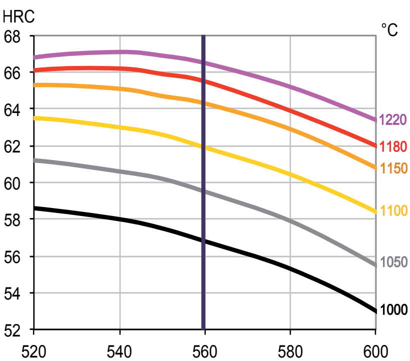
- Round bars
- Flat & square bars
- Forged blanks
- Coils

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



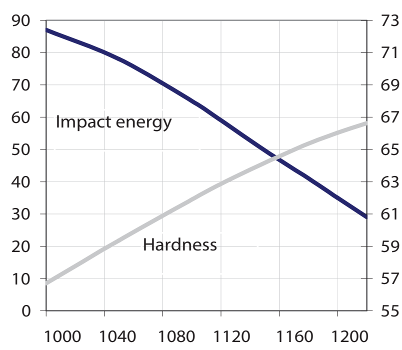
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

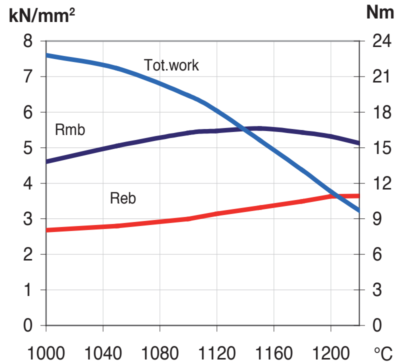
C	Cr	Mo	W	Co	V
1.40	4.2	5.0	5.8	-	4.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2011 POWDER METALLURGY HSS

ASTM: AISI A11

DESCRIPTION

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

DELIVERY HARDNESS

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

FORM SUPPLIED

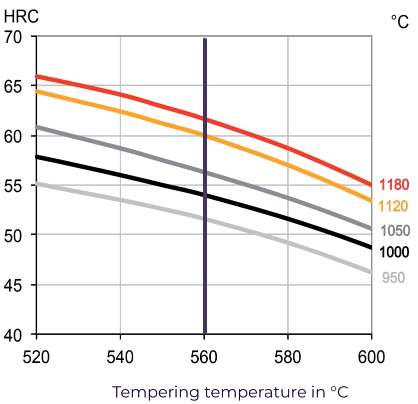
- Coils
- Coarse round bars
- Flat & square bars

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



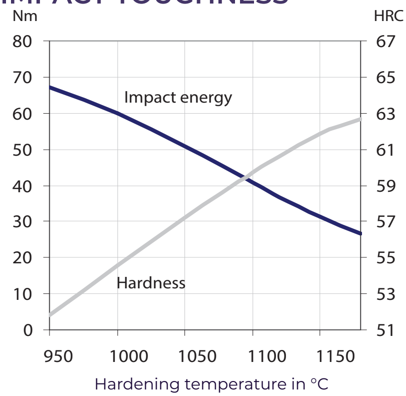
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

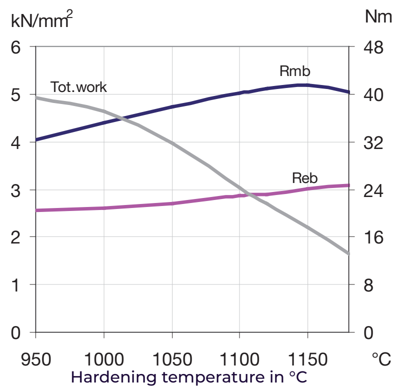
C	Cr	Mo	W	Co	V
2.45	5.3	1.3	-	-	9.5

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2015 POWDER METALLURGY HSS

ASTM: AISI T15 / EN 10027-1: HS 12-0-5-5 / EN 10027-2: 1.3251 / 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

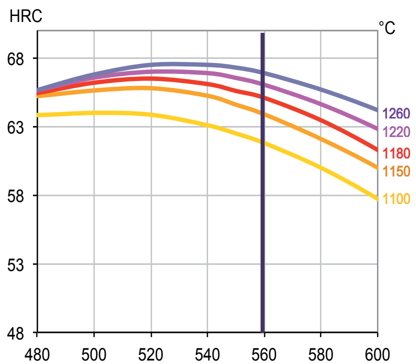
- Round bars
- Flat & square bars
- Forged blanks
- Coils

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

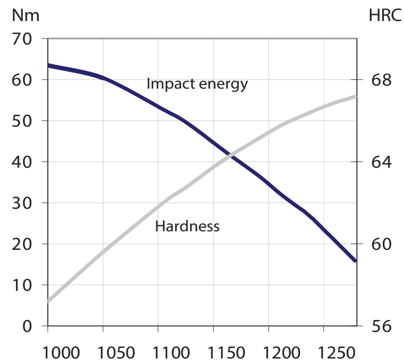
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.60	4.0	-	12.0	5.0	5.0

PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2023 POWDER METALLURGY HSS

ASTM: AISI M3:2 / EN 10027-1: HS 6-5-3C / EN 10027-2: 1.3395 / JIS SKH53

DESCRIPTION

ASP®2023 is an excellent non-Cobalt grade suitable for most cutting tool application.

DELIVERY HARDNESS

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

FORM SUPPLIED

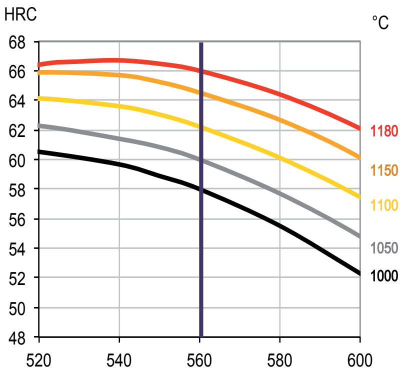
- Round bars
- Flat & square bars
- Strips
- Coils

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

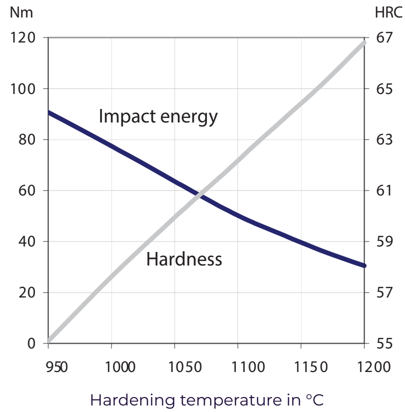
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

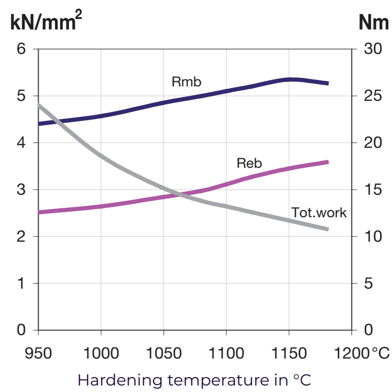
C	Cr	Mo	W	Co	V
1.28	4.0	5.0	6.4	-	3.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP® GRADES DATA // ASP®2030

ASP®2030 POWDER METALLURGY HSS

EN 10027-1: HS 6-5-3-8 / EN 10027-2: 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

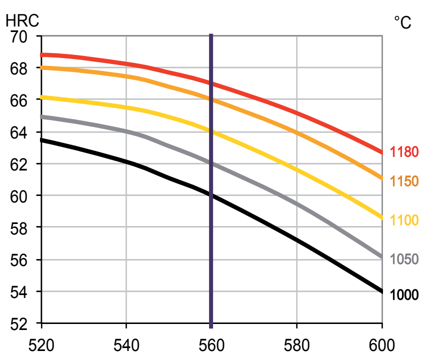
- Coils
- Round bars
- Forged blanks
- Flat & square bars

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

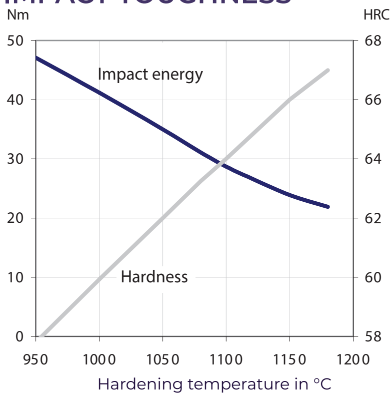
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

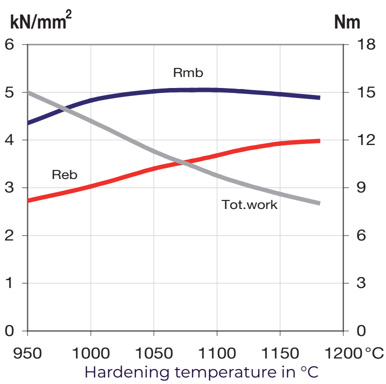
C	Cr	Mo	W	Co	V
1.28	4.2	5.0	6.4	8.5	3.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2042 POWDER METALLURGY HSS

ASTM AISI M42 / EN 10027-1: HS 2-9-1-8 / EN 10027-2: 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

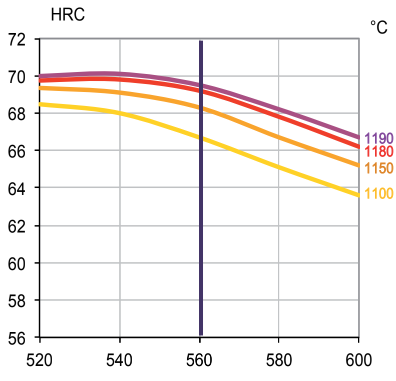
FORM SUPPLIED

- Round bars
- Flat bars
- Bi-metal edge wire

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

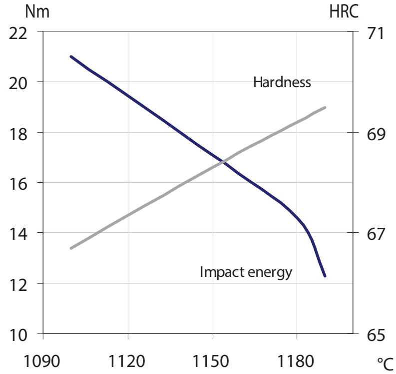
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

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

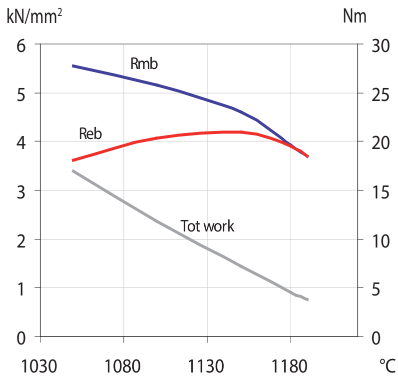
PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

4-POINT BEND STRENGTH



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53. All tests carried out on samples tempered 3 x 1 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

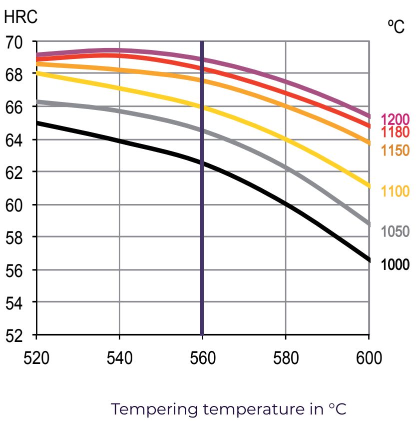
- Coils
- Round bars
- Flat & square bars

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



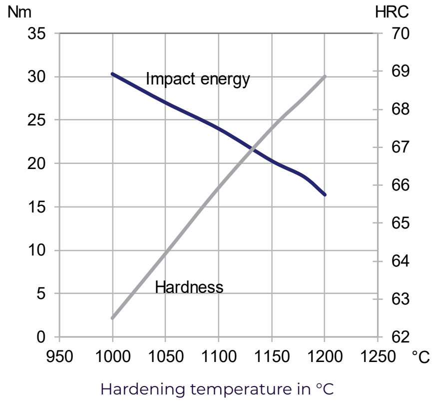
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

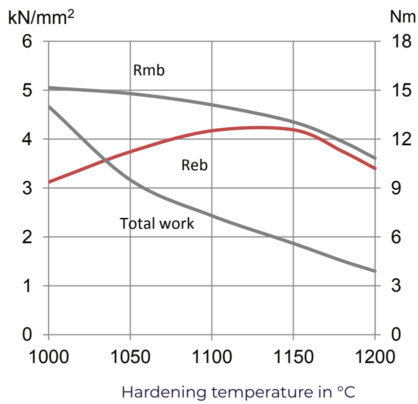
C	Cr	Mo	W	Co	V
1.50	3.8	5.3	9.8	8.5	3.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2051 POWDER METALLURGY HSS

ASTM: AISI M51 / EN 10027-1: HS 10-4-3-10 / EN 10027-2: 1.3207 / JIS SKH57

DESCRIPTION

ASP®2051 has a composition equivalent to M51, but with upgraded toughness for bi-metal band saws.

DELIVERY HARDNESS

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

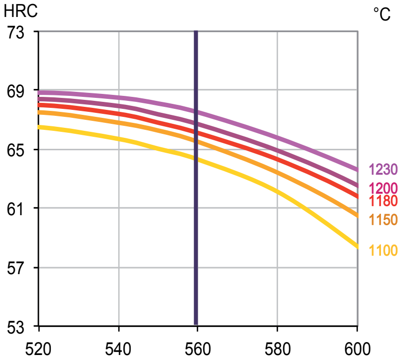
FORM SUPPLIED

- Bi-metal edge
  Available surface conditions: cold rolled.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



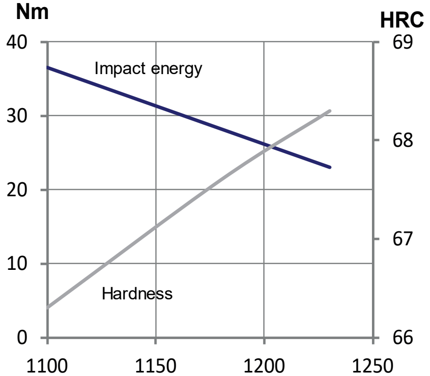
Tempering temperature in °C
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.27	4.0	3.6	9.5	10.0	3.2

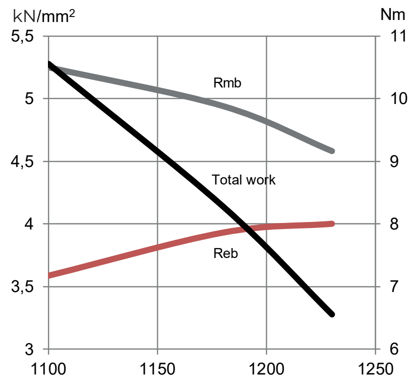
PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

4-POINT BEND STRENGTH



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2052 POWDER METALLURGY HSS

EN 10027-1: HS 11-2-5-8 / EN 10027-2: 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

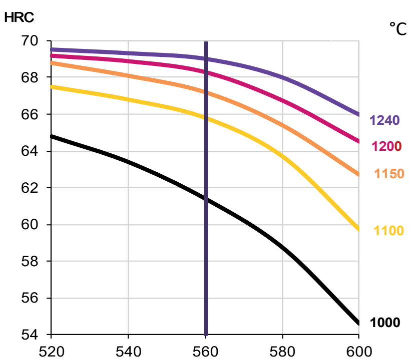
- Coils
- Round bars

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

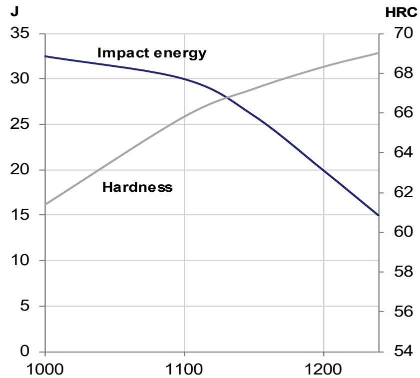
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.67	4.8	2.0	10.5	8.0	4.9

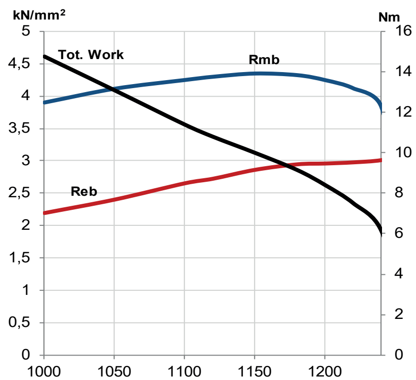
PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

4-POINT BEND STRENGTH



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2053 POWDER METALLURGY HSS

EN 10027-1: HS 4-3-8 / EN 10027-2: 1.3352

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

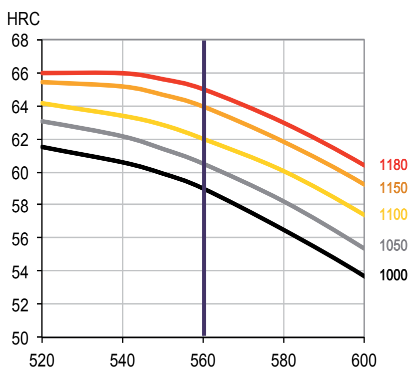
- Round bars
- Flat & square bars
- Coils
- Forged blanks
- Discs

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



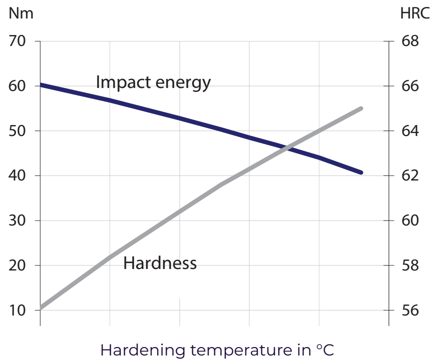
Tempering temperature in °C
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

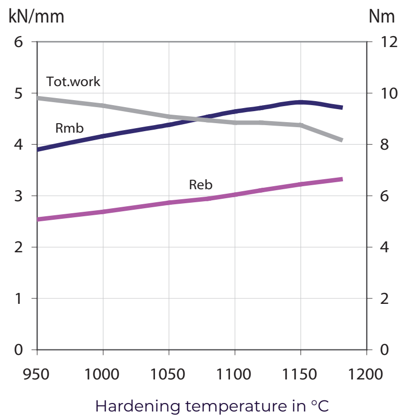
C	Cr	Mo	W	Co	V
2.48	4.2	3.1	4.2	-	8.0

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 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

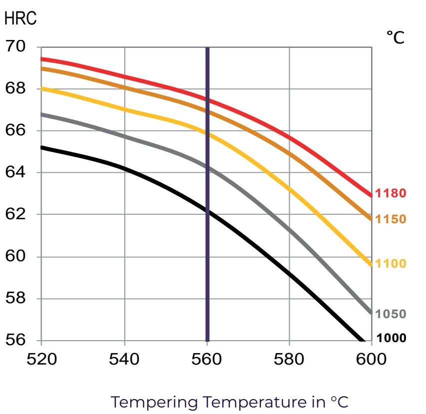
- Round bars
- Drawn & ground bars

Available surface conditions: drawn, ground, and peeled.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



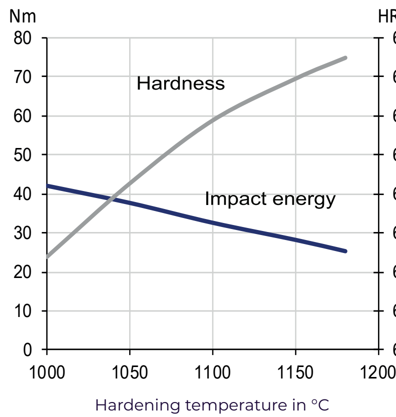
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

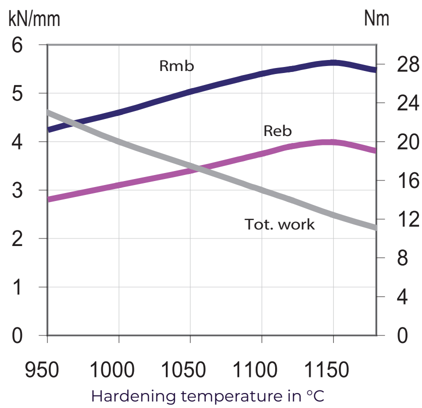
C	Cr	Mo	W	Co	V	Nb
1.69	4.0	4.6	6.3	9.0	3.2	2.1

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2060 POWDER METALLURGY HSS

EN 10027-1: HS 7-7-7-11 / EN 10027-2: 1.3292

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

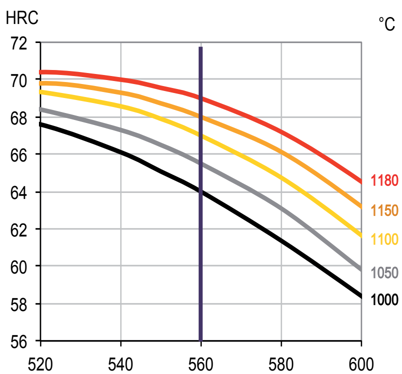
- Round bars
- Flat & square bars
- Forged bars
- Tool bit sections

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

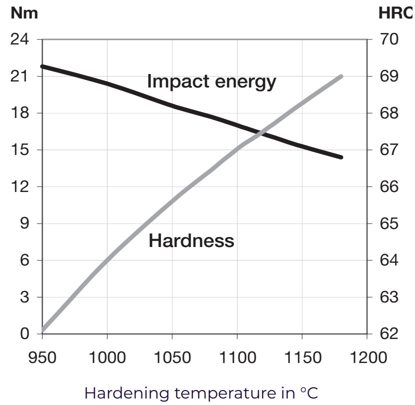
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

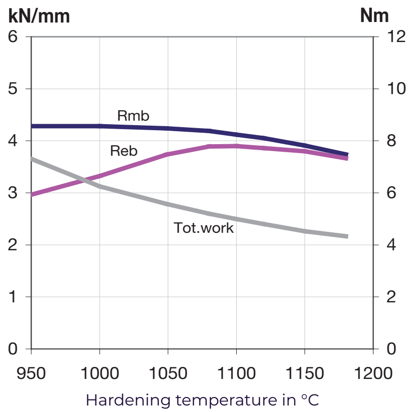
C	Cr	Mo	W	Co	V
2.30	4.2	7.0	6.5	10.5	6.5

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2078 POWDER METALLURGY HSS

EN 10027-1: HS 7-7-7-11S / EN 10027-2: 1.3292

DESCRIPTION

ASP®2078 is a highly alloyed grade for applications needing high hardness, high hot hardness and wear resistance. Sulphur addition gives it an improved machinability.

DELIVERY HARDNESS

- Typical soft annealed hardness is 345 HB

FORM SUPPLIED

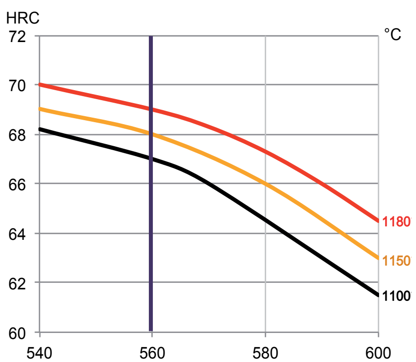
- Round bars

Available surface conditions: ground, peeled, rough machined.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

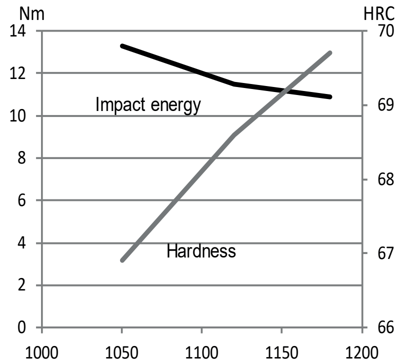
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V	S
2.30	4.2	7.0	6.5	10.5	6.5	0.23

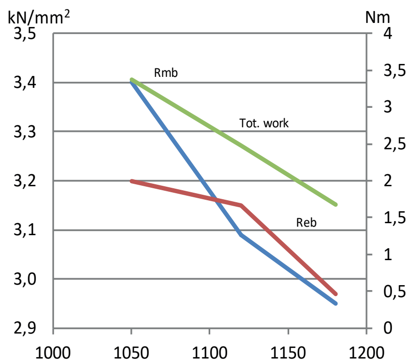
PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

4-POINT BEND STRENGTH



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 hour at 560°C.

ASP®2190 POWDER METALLURGY HSS

Not yet standardized

DESCRIPTION

ASP®2190 is a high Cobalt content grade design for Physical Vapor Deposition coated gear cutting tools. The grade is designed to maximize hot hardness, while allowing the Physical Vapor Deposition coating to protect the tool for adhesive and abrasive wear.

DELIVERY HARDNESS

- Typical soft annealed hardness is 400 HB

FORM SUPPLIED

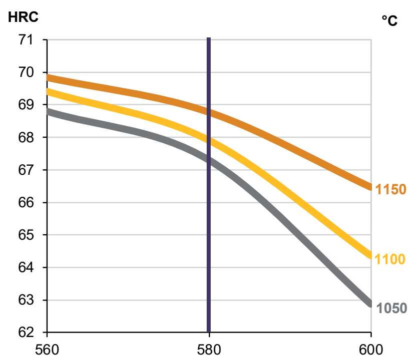
- Round bars

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

HEAT TREATMENT

- Please refer to page 64 for specific heat treatment recommendation
- Tempering at 580°C two times at 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

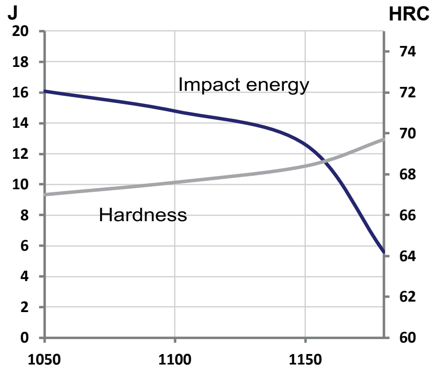
Hardness after hardening, quenching and tempering 2 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V	Nb
0.78	4.2	2.9	2.9	29.0	1.1	1.1

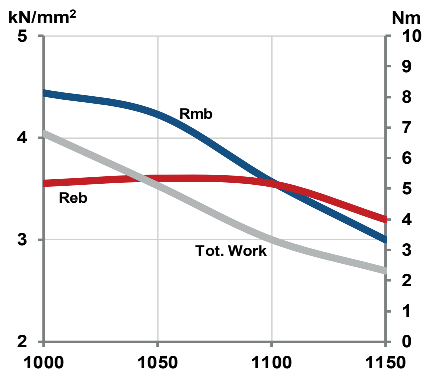
PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

4-POINT BEND STRENGTH



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 2 x 1 hour at 580°C.

ASP®APZ10 POWDER METALLURGY HSS

Not yet standardized

DESCRIPTION

ASP®APZ10 is a martensitic Chromium Powder Metallurgy 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

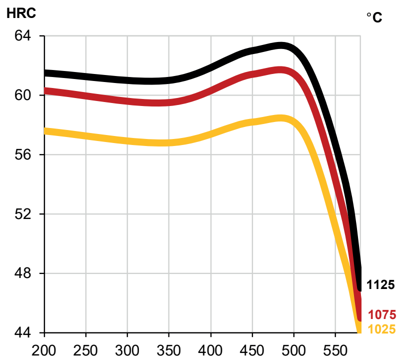
- Round bars
- Flat & square bars

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

HEAT TREATMENT

- Please refer to page 63 for specific heat treatment recommendation

GUIDELINES FOR HARDENING



Tempering temperature in °C

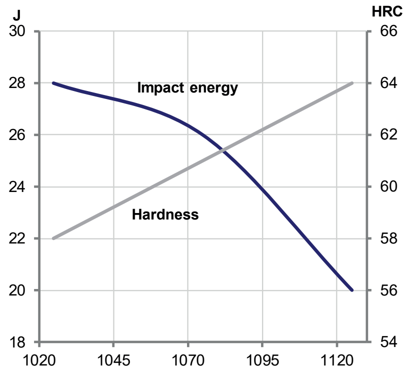
Hardness after hardening, quenching and tempering 2 x 2 hours

CHEMICAL COMPOSITION

C	Cr	Mo	V	N
1.25	19.0	2.1	0.8	0.1

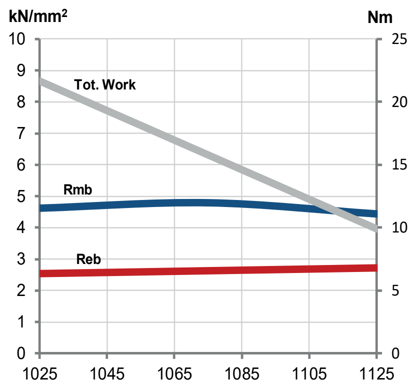
PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

4-POINT BEND STRENGTH



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 2 x 2 hours at 525°C.

ASP®420H

Not yet standardized

DESCRIPTION

ASP®420H powder manufactured grade combines high wear resistance, from the high V and C content, with corrosion resistance from the high Cr content. Thanks to the high cleanliness obtained with the ASP® process, high toughness, chipping resistance, polishability and corrosion resistance are obtained.

DELIVERY HARDNESS

- Typical soft annealed hardness is 280 HB

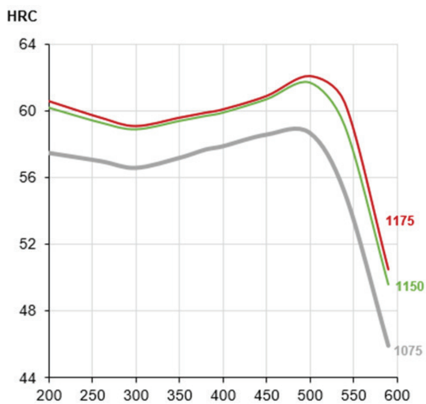
FORM SUPPLIED

- Round bars
- Flat & square bars

HEAT TREATMENT

- Please refer to page 64 for specific heat treatment recommendation

GUIDELINES FOR HARDENING



Tempering temperature in °C

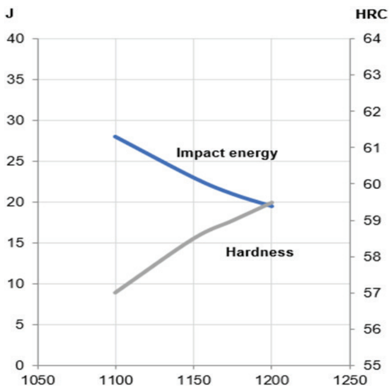
Hardness after austenitization, quenching and tempering 2 x 2 hours

CHEMICAL COMPOSITION

C	Cr	Mo	V
2.30	14.0	1.0	9.0

PROPERTIES

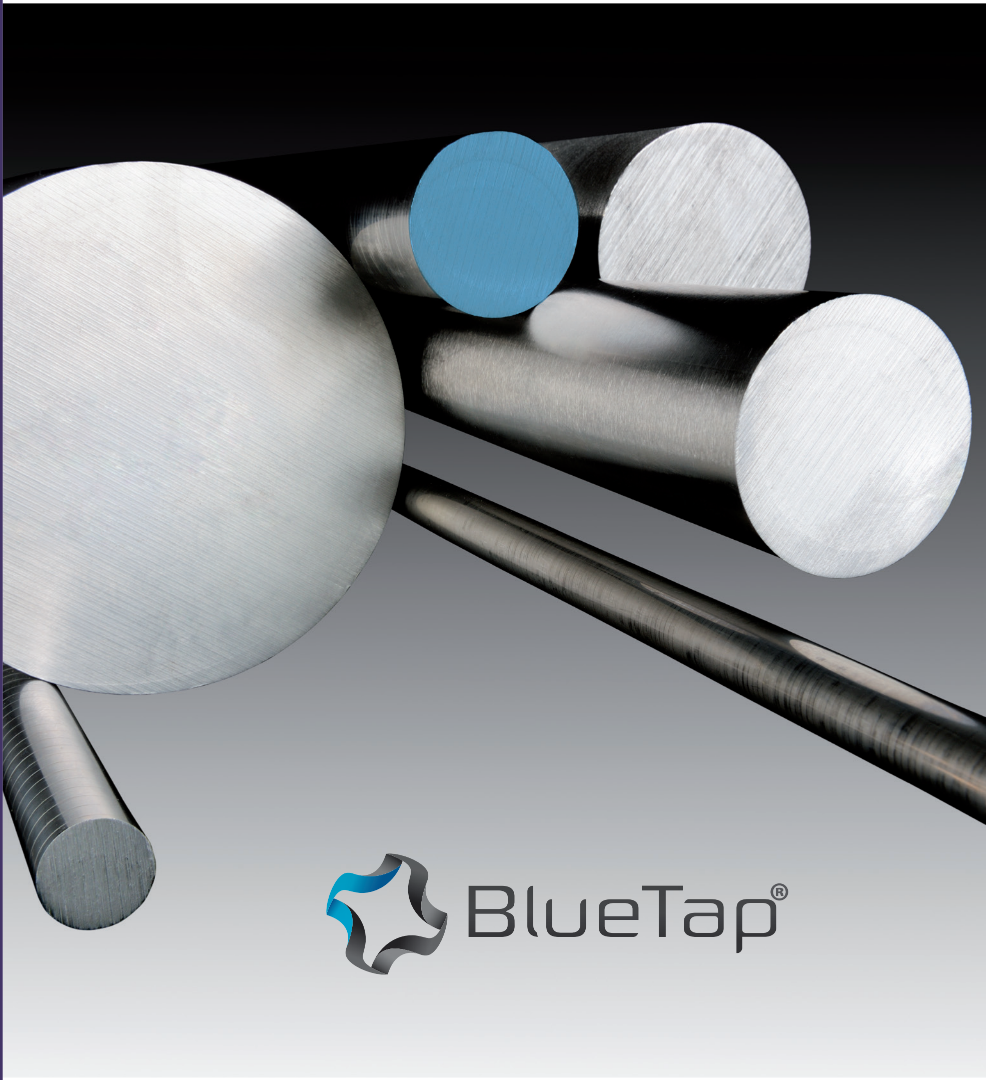
IMPACT TOUGHNESS



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 2 x 2 hours.

BlueTap® GRADES



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

BlueTap®

BLUETAP® BRAND: THE BEST SOLUTION FOR YOUR TAPS

BlueTap®, an exclusive Erasteel's range of Powder Metallurgy High-Speed Steels designed for high-performance taps.

Focusing on the core needs of tap producers and end users and on their growing requirements, Erasteel introduced the BlueTap® brand of grades. Through an innovative Powder Metallurgy process, BlueTap® grades achieve state of the art performance.

The signature properties of ASP® and the Powder Metallurgy process, like grindability, reliability and performance are maintained or even exceeded with this new process, while enabling an optimized Total Cost of Ownership (TCO).

BlueTap®, combining the ASP® performance with an optimized Total Cost of Ownership

GRINDABILITY
Up to 125%* higher

RELIABILITY
10 times* higher

PERFORMANCE
Up to 100%* higher

* compared to conventional High-Speed Steels

BlueTap®Max - patent application filed

BlueTap® MAX

A NEW GRADE WITH UNRIVALLED PROPERTIES FOR HIGH-PERFORMANCE TAPS

Building upon the success of BlueTap®Co launched 10 years ago, Erasteel set out to develop a new grade, BlueTap®Max, that exceeds the best performing grades used in tapping today.

+ Performance

Extremely high hardness while maintaining a good toughness for the most demanding applications and machining conditions

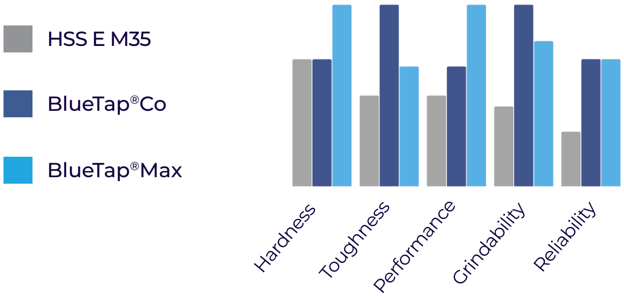
+ Reliability

Like BlueTap®Co, a higher cleanliness and finer structure compared to conventional High-Speed Steel grades giving a better and more reliable tool life

+ Grindability

Much easier to grind than conventional High-Speed Steels as well as highly alloyed Powder Metallurgy High-Speed Steel grades offering a unique advantage for both tap producers and end users

This grade offers an unrivalled performance with an optimized Total Cost of Ownership (TCO)



PVD coated BlueTap®Max combines all benefits!

- wear resistance
- hardness
- toughness
- hot hardness
- excellent grindability

HIGH-PERFORMANCE SOLUTIONS FOR HIGH-END TAPS

BlueTap®

BlueTap®Co POWDER METALLURGY HSS

ASTM: AISI M35 / EN 10027-1: HS 6-5-2-5 / EN 10027-2: 1.3243 / JIS SKH55

DESCRIPTION

BlueTap®Co is specifically designed to address the needs of tap manufacturers and users. This grade offers an excellent grindability, high reliability as well as good toughness.

DELIVERY HARDNESS

- Typical soft annealed hardness is 255 HB
- Cold drawn material is typically 10-40 HB harder

FORM SUPPLIED

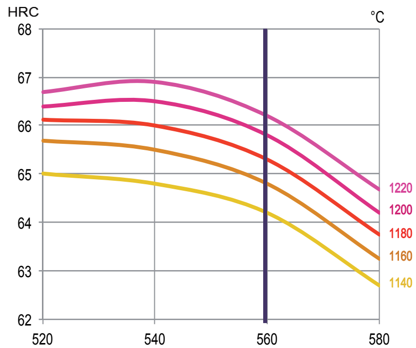
- Drawn bars
- Peeled bars up to Ø 40 mm

Available surface conditions: drawn, peeled.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

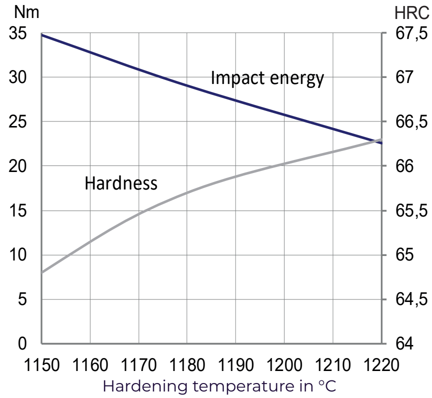
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

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

PROPERTIES

IMPACT TOUGHNESS



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C.

BlueTap®Max POWDER METALLURGY HSS

DESCRIPTION

BlueTap®Max is a grade with unrivalled properties for high-performance taps combining the ASP® performance with an optimized Total Cost of Ownership. This grade offers an excellent grindability, higher reliability as well as high hardness and good toughness.

DELIVERY HARDNESS

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

FORM SUPPLIED

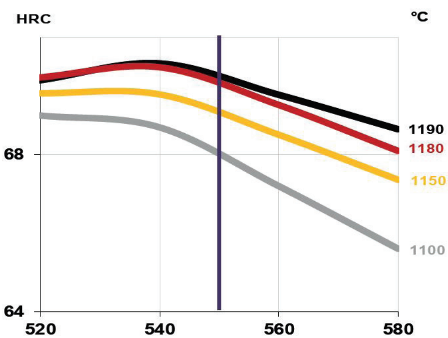
- Drawn bars
- Drawn and ground bars
- Peeled bars

Available surface conditions: drawn, peeled.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



Tempering temperature in °C

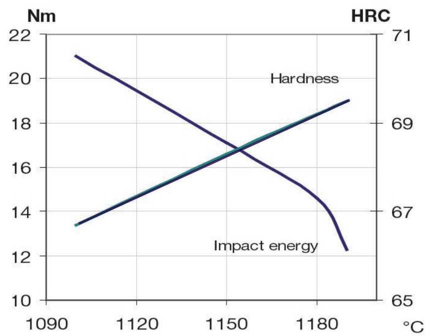
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.08	3.8	9.3	1.5	7.8	1.1

PROPERTIES

IMPACT TOUGHNESS



Hardening temperature in °C

For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 3 x 1 hour at 560°C.

CONVENTIONAL GRADES

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 10027-1: HS 6-5-2C / EN 10027-2: 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

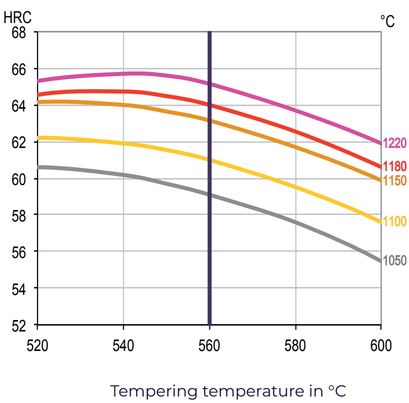
- Drawn wires
- Wire rods
- Flat bars
- Strips
- Square bars
- Bi-metal edges
- Round bars

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C two times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



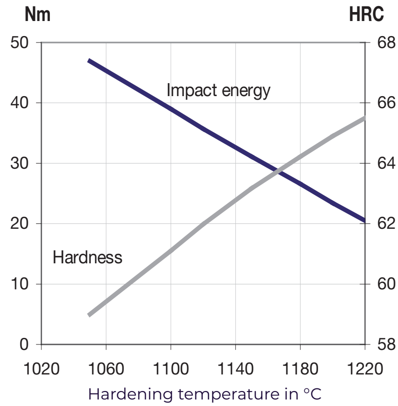
Hardness after hardening, quenching and tempering 2 x 1 hour

CHEMICAL COMPOSITION

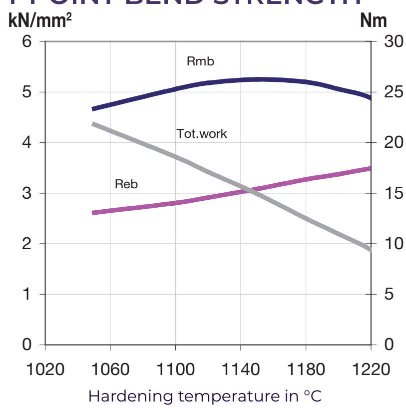
C	Cr	Mo	W	Co	V
0.90	4.2	5.0	6.4	-	1.8

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 2 x 1 hour at 560°C.

ABC III HIGH-SPEED STEEL

EN 10027-1: HS 3-3-2 / EN 10027-2: 1.3333

DESCRIPTION

ABC III is a medium alloyed High-Speed Steel with good wear resistance.

DELIVERY HARDNESS

- Typical soft annealed hardness is 220 HB
- Cold drawn material is typically 10-40 HB harder

FORM SUPPLIED

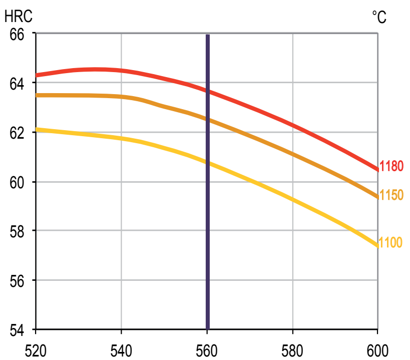
- Strips

Available surface condition: cold rolled.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C two times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



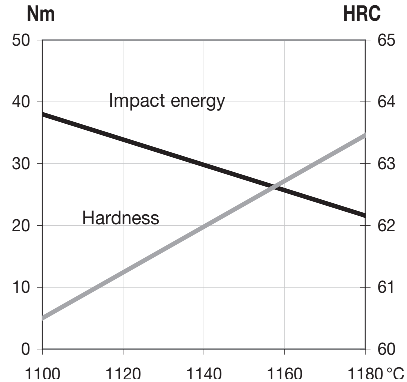
Hardness after hardening, quenching and tempering 2 x 1 hour

CHEMICAL COMPOSITION

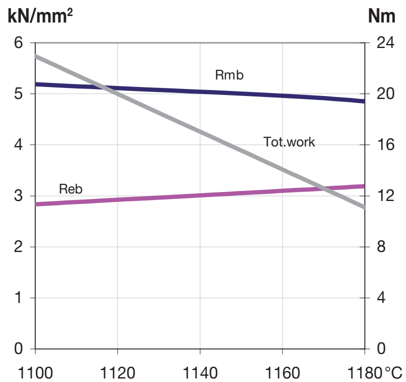
C	Cr	Mo	W	Co	V
0.99	4.1	2.7	2.8	-	2.4

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 2 x 1 hour at 560°C.

GRINDAMAX™V3 HIGH-SPEED STEEL

EN 10027-1: HS 7-5-3 / EN 10027-2: 1.3347

DESCRIPTION

GRINDAMAX™V3 is a Vanadium-based grade which has been developed to bridge the gap between conventional & Powder Metallurgy High-Speed Steels in terms of both performance and grindability. Its chemistry is a very effective combination of alloying elements allowing high wear resistance and excellent toughness.

DELIVERY HARDNESS

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

FORM SUPPLIED

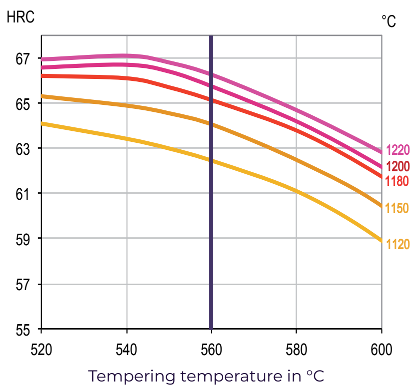
- Drawn bars
- Peeled bars
- Ground bars
- Flat bars
- Square bars

Available surface conditions: drawn, ground, peeled.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



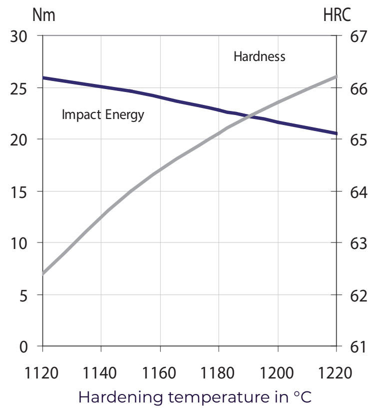
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

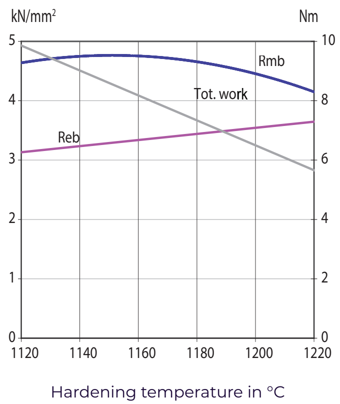
C	Cr	Mo	W	Co	V
1.20	3.9	5.2	7.2	-	2.7

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C

E M35 HIGH-SPEED STEEL

ASTM: AISI M35 / EN 10027-1: HS 6-5-2-5 / EN 10027-2: 1.3243 / JIS SKH55

DESCRIPTION

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

DELIVERY HARDNESS

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

FORM SUPPLIED

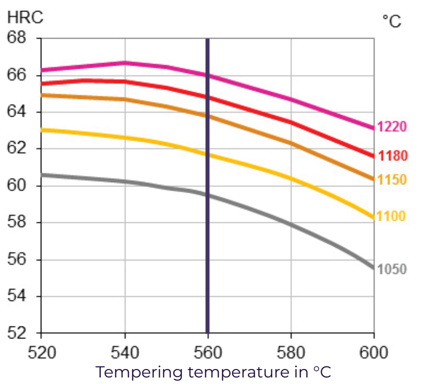
- Wires rods
- Drawn wire
- Round bars
- Square bars
- Flat bars
- Strips

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C two times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



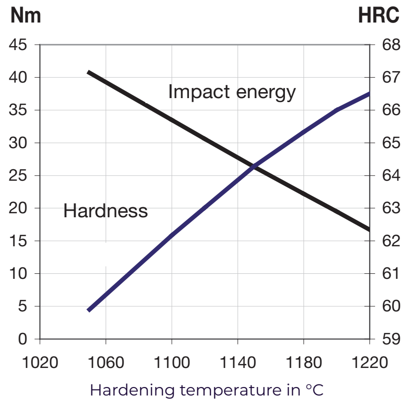
Hardness after hardening, quenching and tempering 2 x 1 hour

CHEMICAL COMPOSITION

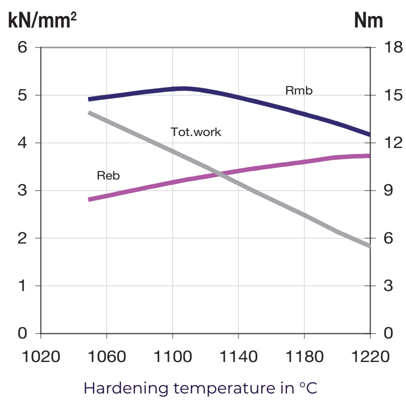
C	Cr	Mo	W	Co	V
0.93	4.2	5.0	6.4	4.8	1.8

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 2 x 1 hour at 560°C

C8 HIGH-SPEED STEEL

EN 10027-1: HS 5-6-2-8 / EN 10027-2: 1.3209

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

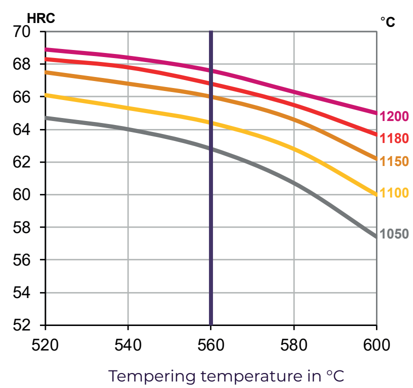
- Round bars
- Flat bars
- Square bars

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



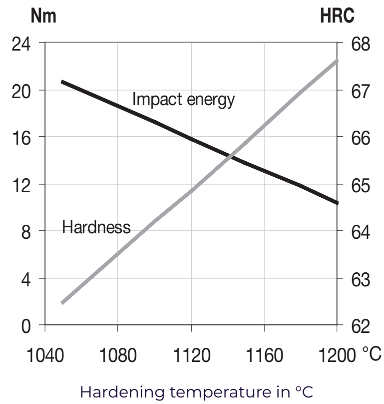
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

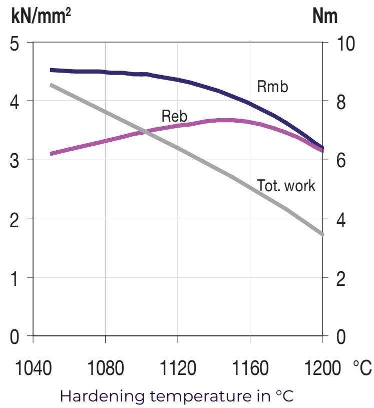
C	Cr	Mo	W	Co	V
1.05	4.0	6.0	5.0	7.8	1.6

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C

E MAT II HIGH-SPEED STEEL

EN 10027-1: HS 1-5-1-8 / EN 10027-2: 1.3270

DESCRIPTION

E MATRIX II is a High-Speed Steel with excellent toughness combined with a good heat resistance.

DELIVERY HARDNESS

- Typical soft annealed hardness is 240 HB
- Cold drawn material is typically 10-40 HB harder

FORM SUPPLIED

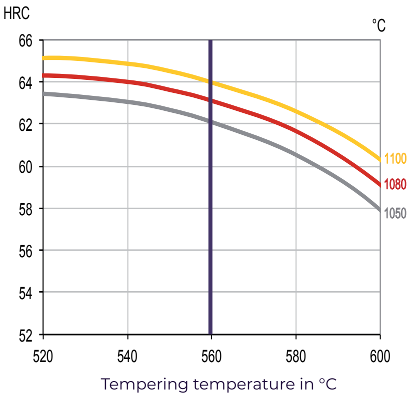
- Bi-metal edges
- Strips

Available surface conditions: cold rolled.

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C two times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



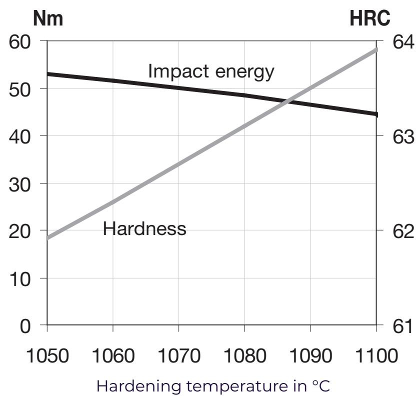
Hardness after hardening, quenching and tempering 2 x 1 hour

CHEMICAL COMPOSITION

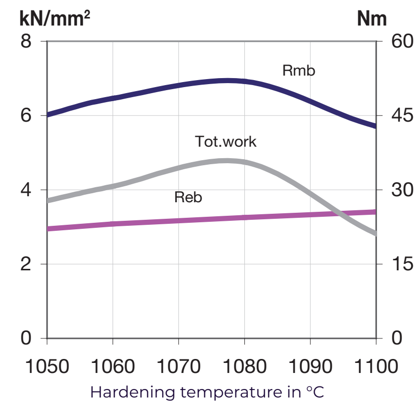
C	Cr	Mo	W	Co	V
0.72	4.0	5.0	1.0	8.0	1.0

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.
All tests carried out on samples tempered 2 x 1 hour at 560°C

E M42 HIGH-SPEED STEEL

ASTM: AISI M42 / EN 10027-1: HS 2-9-1-8 / EN 10027-2: 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

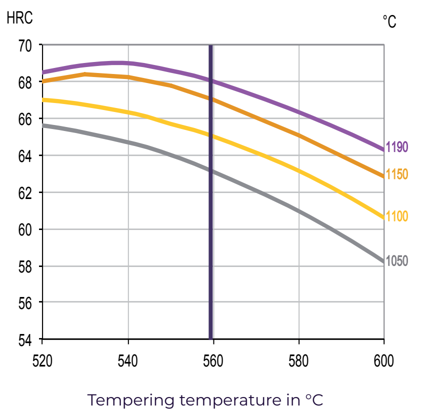
- Wire rods
- Drawn wires
- Round bars
- Square bars
- Flat bars
- Bi-metal edges

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

HEAT TREATMENT

- Please refer to page 62 for general heat treatment recommendation
- Tempering at 560°C three times for at least 1 hour each time and cooling to room temperature <25°C between temperings

GUIDELINES FOR HARDENING



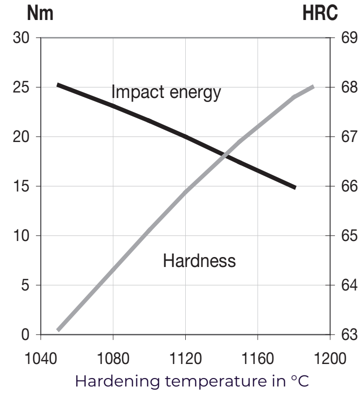
Hardness after hardening, quenching and tempering 3 x 1 hour

CHEMICAL COMPOSITION

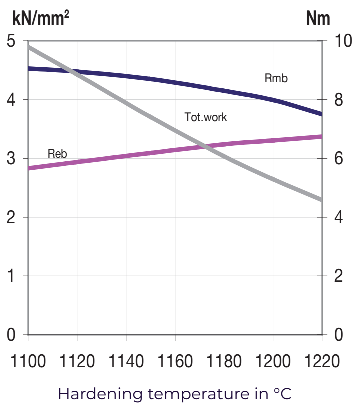
C	Cr	Mo	W	Co	V
1.08	3.8	9.4	1.5	8.0	1.2

PROPERTIES

IMPACT TOUGHNESS



4-POINT BEND STRENGTH



For more information on mechanical tests and how to read the graphs see pages 52-53.

All tests carried out on samples tempered 3 x 1 hour at 560°C

MECHANICAL PROPERTIES

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

MECHANICAL PROPERTIES INTERPRETATION

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

IMPACT TOUGHNESS

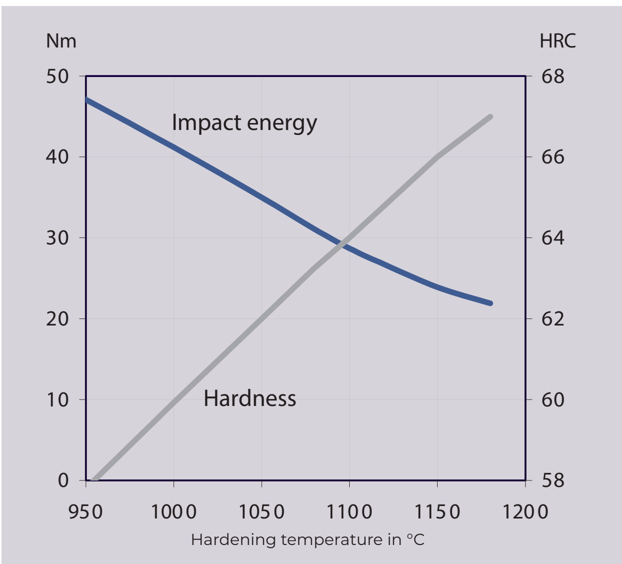
Impact toughness indicates how much energy a material can absorb before rupturing. For a material to be tough it needs to have both high strength and high ductility.

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 Nm
- On the right Y-axis the corresponding hardness from heat treatment can be read from the grey curve in HRC



4-POINT BEND STRENGTH

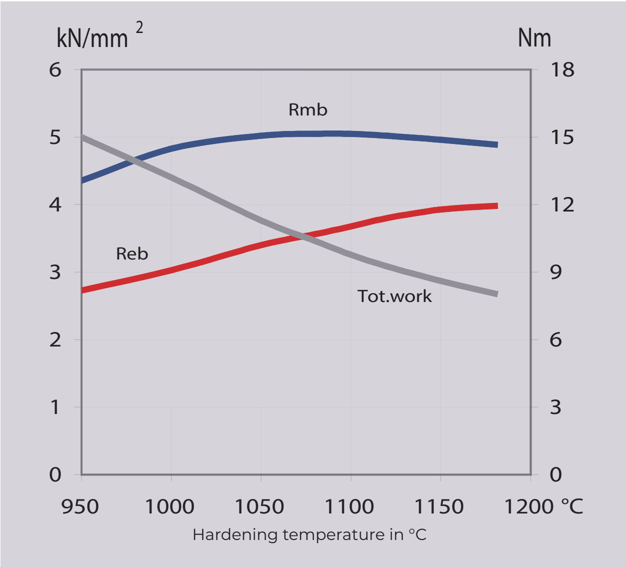
Strength indicates how much load a material can withstand without failure or plastic deformation.

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 High-Speed Steel due to difficulty to perform tensile strength tests
- samples are longitudinal with a finished dimension of Ø4.7 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/mm²
- On the right Y-axis the total work can be read from the grey curve in Nm



SULPHURIZED GRADES

Erasteel offers many ASP® grades in sulphurized versions to improve the machinability of the steels.

High-Speed Steels are highly alloyed and can be challenging to machine. In order to increase productivity, increase tool life and get a better surface finish after machining, some tool manufacturers prefer to have their ASP® sulphurized.

The expertise of Erasteel in High-Speed Steel manufacturing has enabled us to find a balance with other alloying elements to create the proper sulphides that improve the machinability of the steel with very limited impact on other properties.

Standard sulphurized with around 0.1% sulphur.

Highly sulphurized with around 0.2% sulphur.

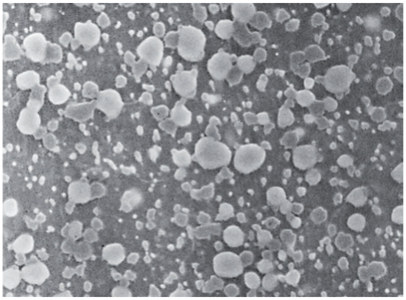
Please contact our Customer Technical Support team or Sales teams to learn more about our sulphurized products.

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

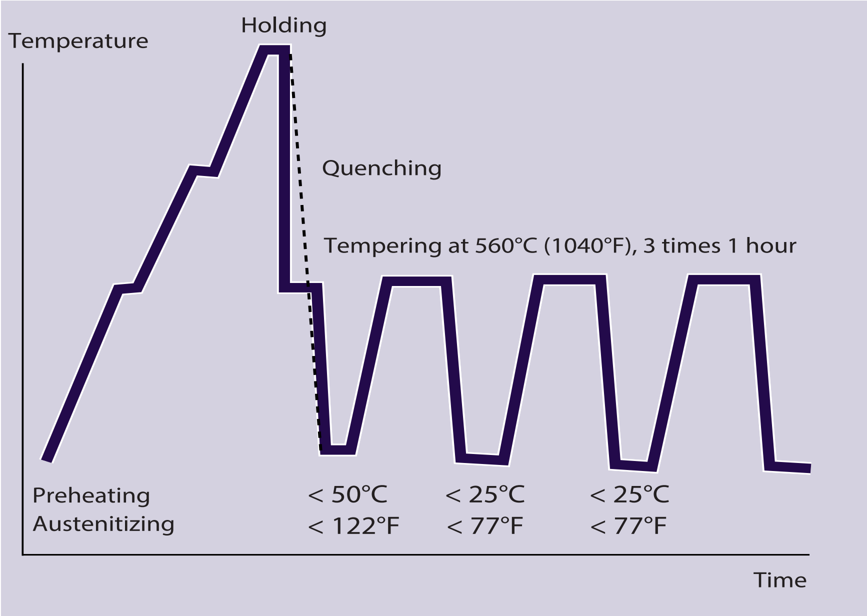
Material from Erasteel is supplied in a soft-annealed condition. The structure consists of a ferritic matrix containing primary carbides and smaller carbides which are formed during soft-annealing.



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

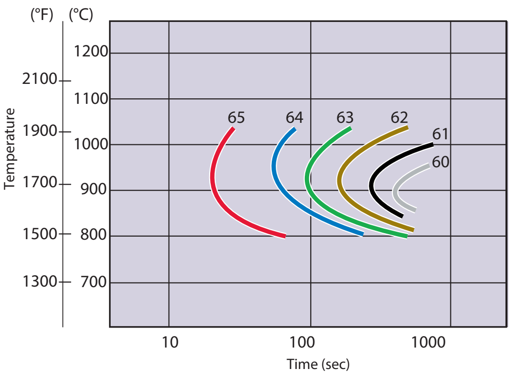
In the austenitizing process, the steel is heated up to a temperature corresponding to the wanted hardness (see below table or datasheets). The maximum recommended austenitizing temperature set by Erasteel should not be exceeded. The ferritic matrix is transformed into austenite and part of the carbides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

	Austenitizing temperature (°C)						Tempering 3 x 560°C			
					ASP®					
HRC	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			1020		
60	1060	1120	1060	1050	1000			1040		
61	1080	1150	1080	1080	1020		990	1070		
62	1100	1180	1100	1100	1050		1010	1100	1000	950
63	1120		1130	1120	1075		1030	1130	1020	980
64	1150		1150	1140	1100		1060	1150	1050	1000
65	1170		1180	1160	1130	1000	1080	1180	1070	1030
66	1200		1220	1180	1150	1050	1110		1100	1070
67			1260		1180	1100	1140		1150	1100
68						1150	1180			1150
69						1180				1180

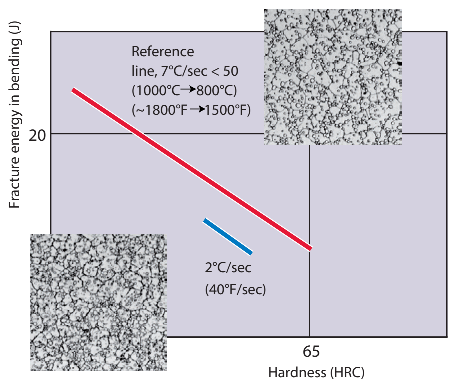
	Austenitizing temperature (°F)						Tempering 3 x 1040°F			
					ASP®					
HRC	2004	2011	2015	2023	2030	2042	2052	2053	2055	2060
50										
52										
54		1830								
55		1870								
56		1920								
57		1940								
58		1980	1830	1830	1760			1810		
59	1910	2010	1910	1890	1800			1870		
60	1940	2050	1940	1920	1830			1910		
61	1980	2100	1980	1980	1870		1810	1960		
62	2010	2160	2010	2010	1920		1850	2010	1830	1740
63	2050		2070	2050	1970		1890	2070	1870	1800
64	2100		2100	2090	2010		1940	2100	1920	1830
65	2140		2160	2120	2070	1830	1980	2160	1960	1890
66	2190		2270	2160	2100	1920	2030		2010	1960
67					2160	2010	2080		2100	2010
68						2100	2160			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.



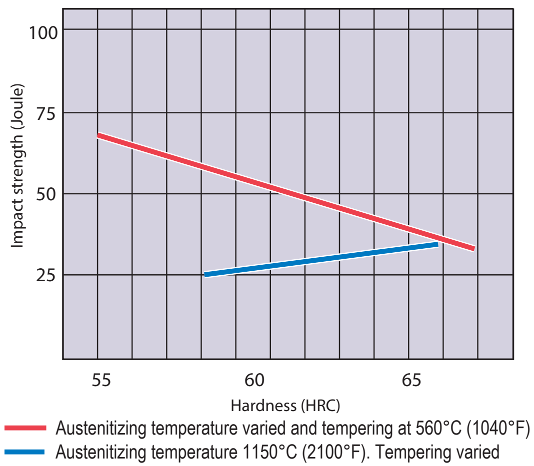
Hardness as function of temperature and quenching time.
Austenitizing temperature:
1180°C (2160°F).
Tempering:
3 x 1h at 560°C (1040°F).



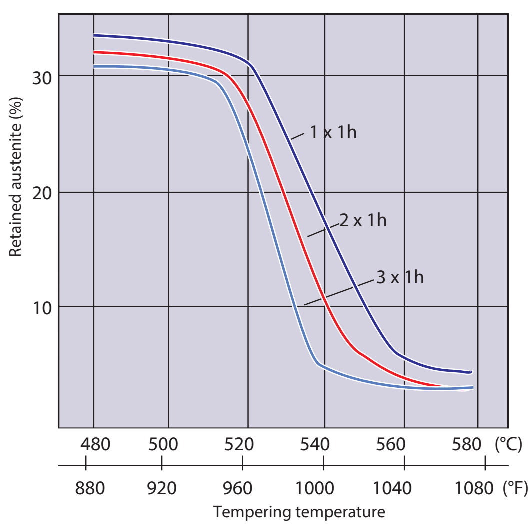
The effect of PEC on the toughness.
ASP®2023 tempered 560°C (1040°F), 3 x 1h (structures after hardening, before tempering).

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 hour are 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.



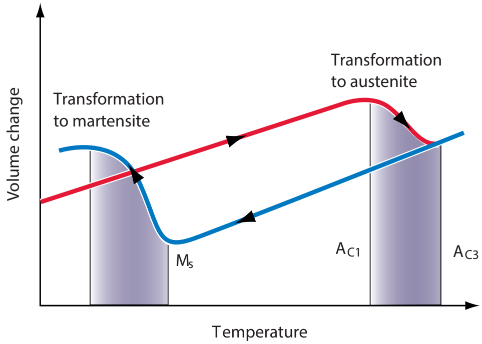
Retained austenite content in ASP®2023 as a function of tempering temperature and number of temperings.

ASP®2023 austenized at 1180°C prior to tempering.

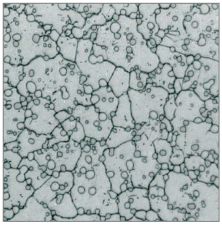
PHASE TRANSFORMATION AND VOLUME CHANGE

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.

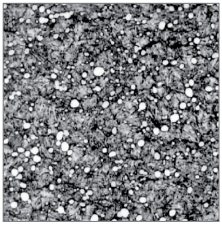
Temperature gradients are impossible to avoid and there is always a difference between surface and core. However, the general rule is to keep the gradient as symmetrical as possible.



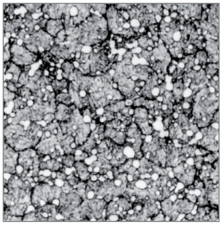
Volume change during hardening



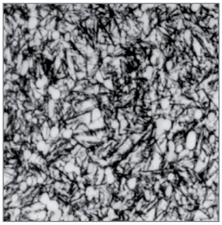
Structure only austenitized



Structure after proper tempering



Structure after overtempering

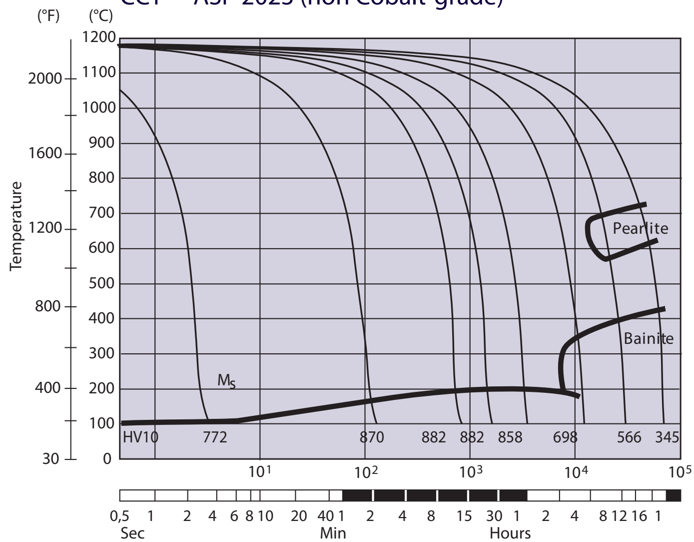


Structure after insufficient tempering

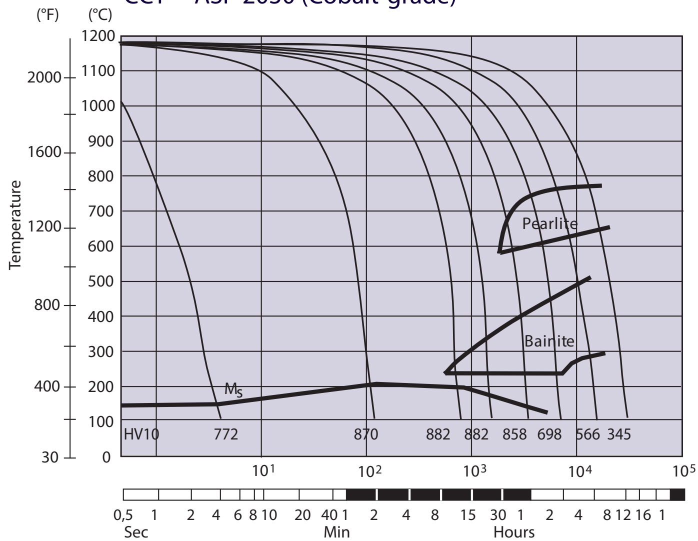
CCT PHASE DIAGRAMS

EXAMPLES OF CONTINUOUS COOLING TRANSFORMATION CURVES

CCT – ASP®2023 (non Cobalt-grade)



CCT – ASP®2030 (Cobalt-grade)



HEAT TREATMENT GUIDELINE

The following recommendations are valid for most of our ASP® and High-Speed Steel 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 temperature 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®2190

Soft annealing

Soft annealing is done in a protective atmosphere at 920-950°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

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 given application and wanted hardness level (max 1150°C). Quenching rapidly down to 40-50°C.

Tempering

Tempering is done at 580°C two times for 1 hour each. Cooling to room temperature (<25°C) between temperings.

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.

ASP®420H

Soft annealing

Soft annealing is done in a protective atmosphere at 930-970°C for 3 hours, followed by slow cooling at 10°C/h down to 750°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

Harden at 1075°C for chosen hardness..

Tempering

- Temper for best corrosion resistance at 200-400°C (260°C recommended) 2 times for 2 hours each (minimum). Deep cooling after first tempering is possible and highly recommended for low temperature tempering to ensure thermal stability.
- Temper at 530-550°C can be used for best dimension stability and stress relieving.

TOOL SURFACES

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

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?

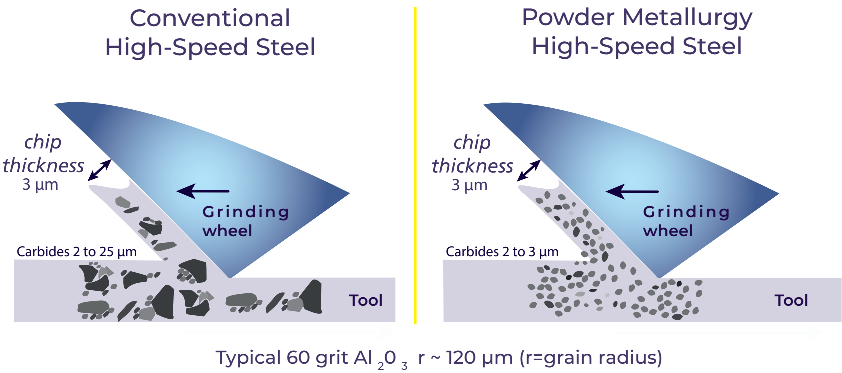
Grinding is a process of abrasive cutting where the grit of the grinding wheel acts as a cutting tool and the bond material serves as a tool holder. Similar to turning and milling, grinding is a process of chip formation. However, the chips produced are extremely small and the cutting edges are numerous,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

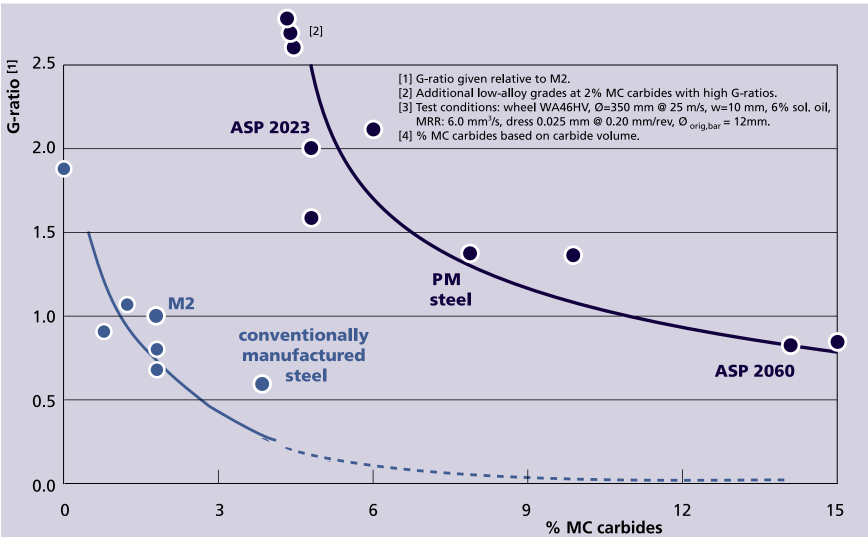
The rate at which a grinding wheel wears depends on the type of wheel selected and the grinding conditions, but it is also greatly affected by the steel grade. Just as High-Speed Steel has a high wear resistance it is also difficult to grind due to its hardness and large volume of hard carbides. A newly 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 High-Speed Steel 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® and BlueTap® grades as it is produced by Powder Metallurgy. The Powder Metallurgy 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.



Grit, carbide and chip sizes when grinding of Powder Metallurgy steel and conventionally manufactured steel.

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, Powder Metallurgy steel is always easier to grind than conventionally manufactured steel.

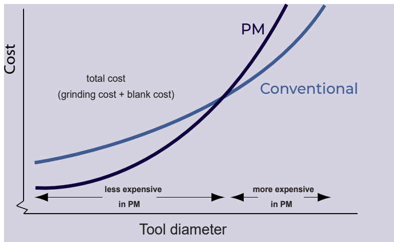
G-ratio is the relative wear of the grinding wheel compared to material removed. It is calculated by dividing the amount of High-Speed Steel removed by the wear of the grinding wheel.

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 High-Speed Steel 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 High-Speed Steel removed by the wear of the grinding wheel.



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

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.

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.

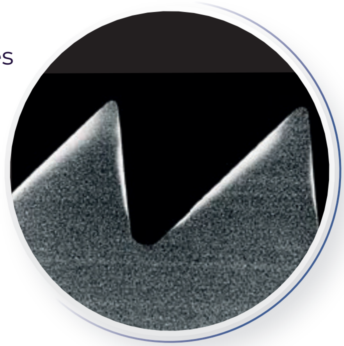
Residual tensile stress

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 austenizing 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.



Rehardening burn in a thread milling cutter. The white sections show where a phase change in the material occurred.

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

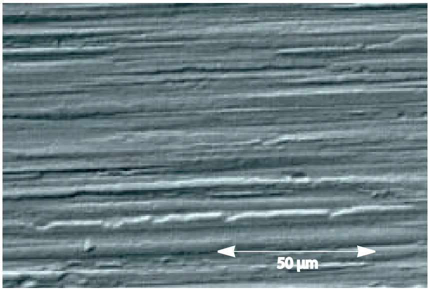
Correctly prepared surfaces are essential to maximize the potential of your tool. With the advances in powder metallurgical High-Speed Steel manufacturing and the latest generation of ASP®, the microstructure and cleanliness of our products are finer than ever. This allows for high performance tools, 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.

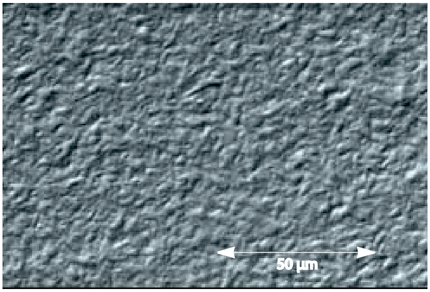
Surface roughness

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 (Ra = 0.12 µm),
5000 MPa bending strength



Homogeneous surface (Ra = 0.18 µm),
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 66).

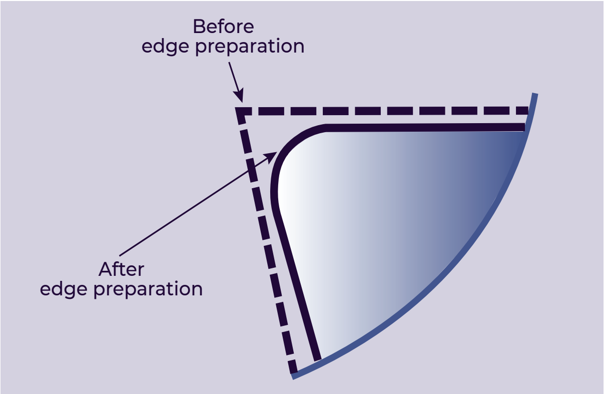
Edge preparation

The cutting edge of a tool is fragile and if it breaks down, increased cutting forces will lead to fast wear of the tool. In order to avoid these issues an edge preparation is often given to a finished high-performance tool before coating.

Benefits include:

- stabilizing the cutting edge
- increased performance
- better coating adhesion
- decreased friction
- improved surface quality of machined parts

This is typically done by giving the edge a defined radius instead of the edge coming to a perfect point. Increasing the size of the radius will increase cutting forces so there is a limit to how much the edge should be rounded.



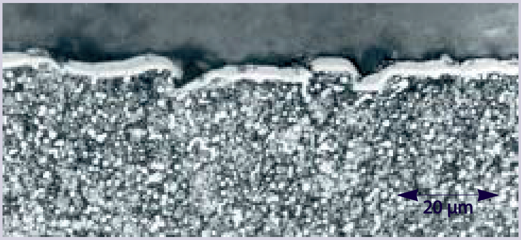
COATINGS - SURFACES

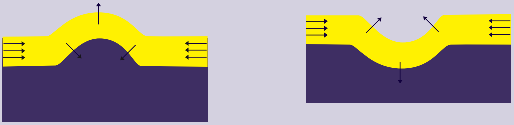
Surface coatings

PVD coatings are often applied to a variety of High-Speed Steel 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 (High-Speed Steel 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 Physical Vapor Deposition coatings require also high quality surface preparation.

COATINGS - PVD / CVD

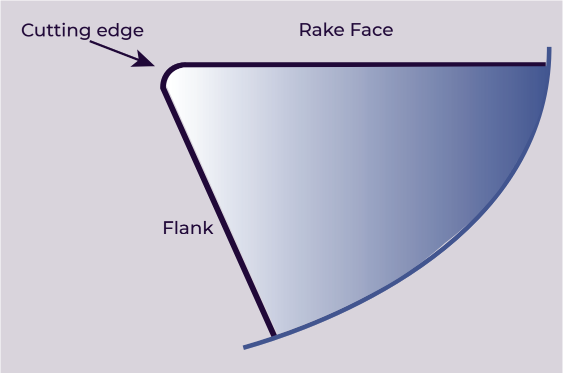
Following is a list of popular Physical Vapor Deposition coatings applied at maximum 500°C for cutting tools made in High-Speed Steel or ASP®.

Coating material	Colour	Hardness GPa	Max. working temperature °C	Areas of usage
TiN	Gold	30	600	General machining lowering friction and abrasion in many applications.
TiCN	Grey-Violet	35	400	General machining in well lubricated conditions.
TiAlN, TiAlCN or AlTiN	Variants of grey	30-40	900 - 1000	Medium cutting speeds in a variety of lubrication conditions. A broad range of work piece materials including stainless steels and nickel alloys.
AlCrN	Light grey	40	1100	Suitable for machining a wide range of materials. Suitable for high cutting speeds and dry machining.
AlTiN / TiSiXN	Bronce / 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	For aluminum alloys and other non-iron alloys like copper, silver or gold, GRP, CFRP and organic materials.

WEAR MECHANISMS

Wear mechanisms are different ways to classify how a certain tool is failing and why it will eventually have to be re-ground or replaced. If you understand and can identify the predominant wear mechanism in the tool you are supplying 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.

To correctly identify a wear mechanism, you typically need to look at a worn tool with the help of a magnifying device, like a loupe or stereo microscope.



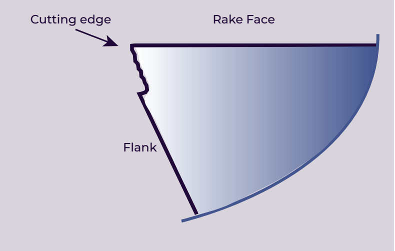
Cutting edge before wear

The following are some examples of typical wear that can be seen on cutting tools, what is causing the wear, and how to improve it.

Flank wear

Explanation: caused by friction and abrasion between the work piece and the flank of the tool.

Improvements: flank wear can be controlled by changing the clearance angle of the tool. However, flank wear is typically the best type of wear to have as it is slow and stable.

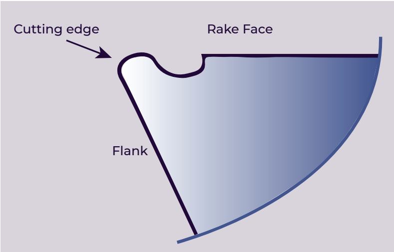


Flank wear

Crater wear

Explanation: crater wear is formed on the rake face of the tool, typically some distance away from the actual cutting edge. Friction between the chip and the tool creates a lot of heat in the material on the rake. This heat softens the tool material giving rise to a zone wearing down more quickly.

Improvements: choose a grade with higher hot hardness, typically grade alloyed with more Co, Mo and W.

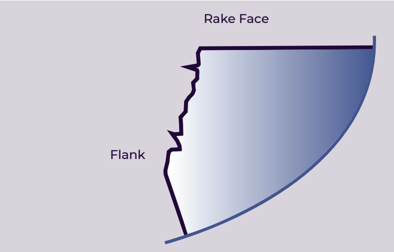


Crater wear

Fracture

Explanation: high loads on the cutting edge can induce fractures that completely breaks the cutting edge or parts of the tool. This can happen when a tool has worn down too much weakening the cutting edge, or if unstable conditions are applied, like wrong cutting data or vibrations.

Improvements: choose a grade with higher toughness that can withstand the harsh conditions or fix the root cause giving rise to the fractures by changing machining data or reduce vibrations.

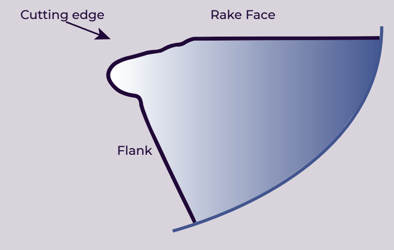


Fracture

Plastic deformation

Explanation: the tool becomes permanently deformed due to cutting forces exceeding the yield strength of the tool material. This can more easily occur when the tool is subjected to high temperatures.

Improvements: choose a grade that has a higher hardness after heat treatment in order to withstand the high forces. Hot hardness can also be beneficial here.

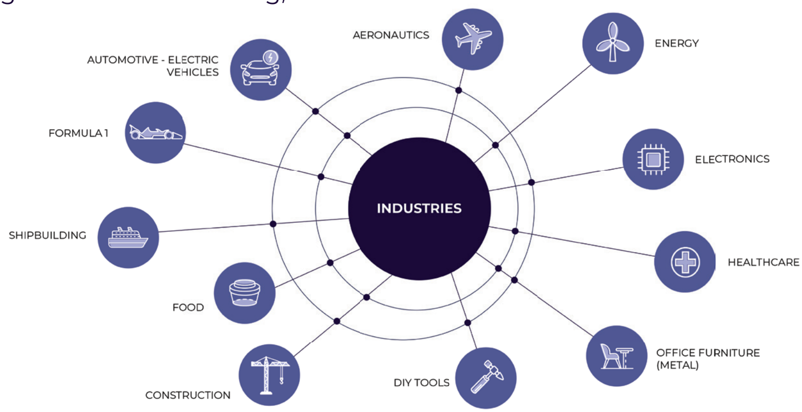


Plastic deformation

COMPANY PROFILE

Erasteel is the **only player in the world dedicated to High-Speed Steels** with comprehensive know-how: design, development, production, atomization, processing and direct sales of conventional and Powder Metallurgy (ASP®/ BlueTap®/PEARL®) High-Speed Steels.

Erasteel is a **privileged partner of today's and tomorrow's industry:** automotive, motorsports, aeronautics, electronics, energy, construction, high value-added tooling, etc.



To meet the growing challenges related to the supply of strategic metals and the preservation of natural resources, Erasteel has also developed a **unique activity in the world of recycling strategic metals with high added value** through the recycling of batteries and spent oil catalysts.

OUR VISION

Innovating together is essential if we are to design a **more efficient and greener industry.**

The metals and materials used are at the heart of this challenge. They must combine **performance, durability, respect of environment and preservation of natural resources.**

OUR MISSION

Erasteel has set itself the mission of **offering the global industry ever more innovative, efficient and sustainable metallurgical solutions** designed to meet current and future technological and environmental challenges.

For our dedicated teams, high product quality and performance, the protection of natural resources and the energy transition are all part of a single, unifying mission.

ASP®, BlueTap® and Pearl® are registered trademarks of Erasteel

HIGH-SPEED STEELS PRODUCED BY POWDER METALLURGY

Erasteel has been the leader on this market for more than 50 years.

3 PREMIUM RANGES

ASP ERASTEEL · PEARL · BlueTap®

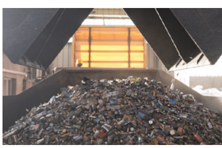
Focused on the highest quality, the ASP®, PEARL® and BlueTap® ranges achieve outstanding performance.

HIGH-END CONVENTIONAL HIGH-SPEED STEELS PRODUCED WITH A LOW CARBON FOOTPRINT

Drawing on centuries of expertise and innovation, Erasteel offers:

1 COMPLEXE ALLOYS RANGE

A range of high-end conventional High-Speed Steels produced with a low carbon footprint.



RECYCLING OF STRATEGIC METALS FROM BATTERIES AND OIL CATALYSTS

Since 2016, Erasteel has been developing the recycling of batteries and oil catalysts by pyrometallurgy.

3 FERRO-ALLOYS

3 SECONDARY PRO

This activity focused on the recycling of strategic metals with high value-added is unique in the world.

Erasteel High-Speed Steels are produced from
more than 92% of recycled materials

Erasteel's 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.

HIGH-SPEED STEELS PRODUCED BY POWDER METALLURGY

HIGH-END CONVENTIONAL HIGH-SPEED STEELS PRODUCED WITH A LOW CARBON FOOTPRINT

PROFILED BARS

ROUND BARS

PROFILED EDGES

POWDERS

FLAT/SQUARE BARS

FORGED BLOCKS

STRIPS

WIRES

ALLOYS FROM RECYCLING BATTERIES AND OIL CATALYSTS

ZINC OXYDE BIG BAG, MANGANESE AND ALUMINATE SLAG IN BULK

ALLOY INGOTS

ERASTEEL'S HIGH-SPEED STEELS

A benchmark choice for 3 main types of application.

CUTTING TOOLS

TAPS

SAWS

DRILLS

GEAR CUTTING TOOLS

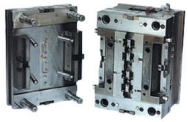
BROACHES

COLD WORK AND TOOLS

PUNCHES

THREAD ROLLING DIE

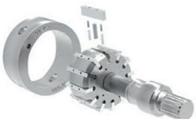
ROLLERS



PLASTIC INJECTION MOULDS AND SCREW

SPECIALITIES

INJECTORS



VANE FOR OIL PUMPS

CAMSHAFT

BEARING

HIP POWDERS

INNOVATION IS OUR DNA

Custom solutions that are efficient and sustainable.

CUSTOMIZED

Our sales teams and Customer Technical Support teams track changes in market needs and developments.

They meet the:

- technical
- commercial
- environmental challenges specific to each of our customers.

EFFICIENT

Erasteel's R&D teams provide their expertise throughout the development, testing and industrialization phases.

The high value-added products they develop achieve the highest performance, significantly extending tool lifetimes and optimizing returns on investments.

SUSTAINABLE

Every day, we strive to produce "greener" products through:

- innovative industrial processes
- optimal energy management
- a stringent supplier selection policy
- preservation of natural resources

In 2022, **10% OF TURNOVER** was generated through new Erasteel's products and grades

11 REGISTRED PATENTS over half of which were granted in the last 5 years

Our product ranges are manufactured with more than 92% RECYCLED MATERIAL

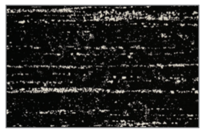
The carbon footprint for Erasteel productions is **7 TO 38 TIMES** less than that of alternative processes

PROCESS TECHNOLOGY

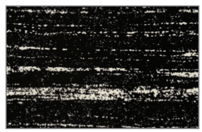
High-Speed Steel Conventional Metallurgy

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

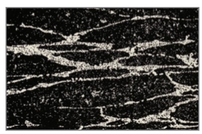
- process: metallurgy, forging, rolling, drawing, heat treatment, etc.
- steel grades: mechanical and physical properties, applications, etc.



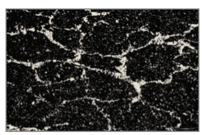
Ø30 mm/1,181 inch



Ø50 mm/1,969 inch



Ø125 mm/4,921 inch



Ingot

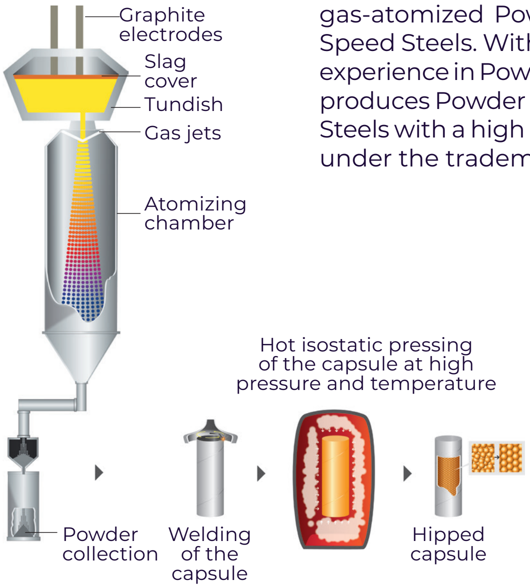
Bottom pouring

Carbide network

PROCESS TECHNOLOGY

Powder Metallurgy

Erasteel is the world leading producer of gas-atomized Powder Metallurgy High-Speed Steels. With more than 50 years of experience in Powder Metallurgy, Erasteel produces Powder Metallurgy 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.

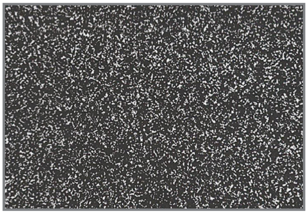
During gas atomization the molten steel is disintegrated by powerful jets of nitrogen gas into small droplets, which solidify at a very high speed. The powder is collected in a steel capsule which is then evacuated and welded. The capsule with powder is Hot Isostatically Pressed (HIP) to a 100% dense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

Bars, wire rods and strips 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 link 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 Powder Metallurgy High-Speed Steels (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**

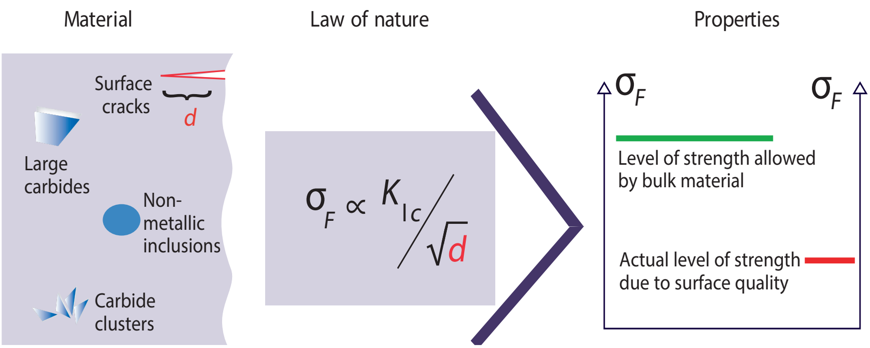


Powder Metallurgy steel has small, evenly distributed carbides

Thanks to these properties, Erasteel's ASP® grades are widely used in many high performance applications such as tooling for metal, plastic, 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.

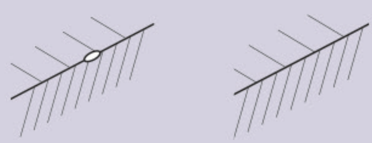
Non-metallic inclusions (NMI)

Excellent strength

Without Dvalin™
The inclusions cause crack initiation and failure

With Dvalin™
Excellent strength

Perfect edges



Without Dvalin™
Micro chipping (inclusions are removed during grinding or use)

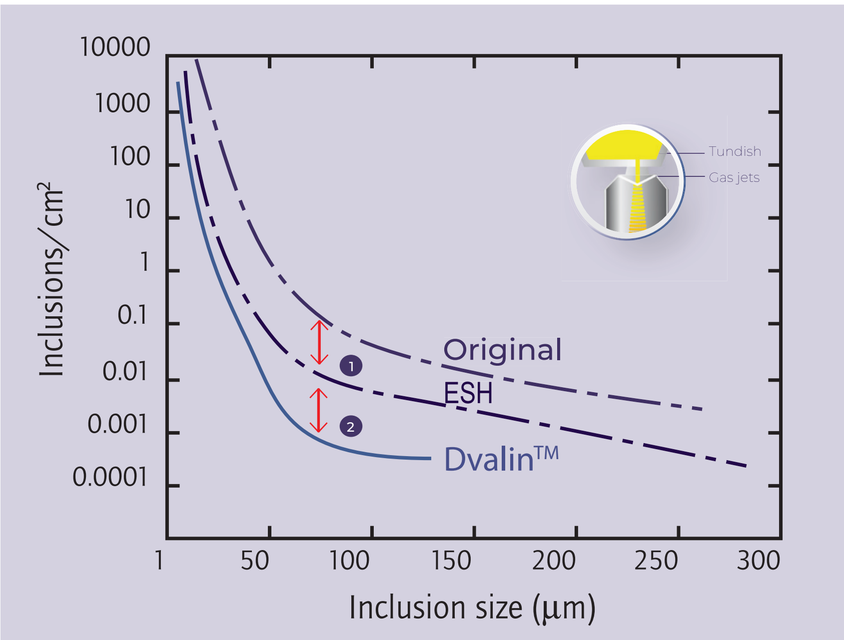
With Dvalin™
Perfect and smooth edge for a long and reliable product life

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 NMI's.

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.

Powder Metallurgy processes improvements



Number of large non-metallic inclusions:
1 ESH process = 90% reduction
2 Dvalin™ process = additional 90% reduction

ASP ® and BlueTap ® are registered trademarks of Erasteel

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