

ERASTEEL

Conventional  
and Powder Metallurgy  
High-Speed Steels

# POCKET GUIDE



## SUMMARY

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# COMPANY PROFILE

Erasteel is a major player in the HSS market with high-end conventional and powder metallurgy High Speed Steels.

With its ASP® range, Erasteel is the world leading producer of PM HSS for high performance tooling and components.

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

Erasteel is fully involved in reducing its overall environmental impact; indeed, its recycling rate to produce high speed steel is already 90% of input material. These good results are nevertheless still challenged with the objective to increase it to near 100% within 3 years by developing specific processes in order to recycle new sources of end of life material. For the most common grades, the decrease of CO<sub>2</sub> emission thanks to this recycling rate is 85% compared to a 100% production from metallic ores. This calculation includes the energy to melt and refine the scraps.

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



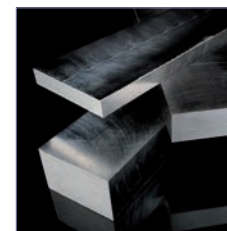
ASP® and Pearl® are registered trademarks of Erasteel.

## Products

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



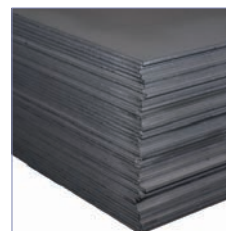
Round bars



Flat bars



Square bars



Sheets (hot rolled)



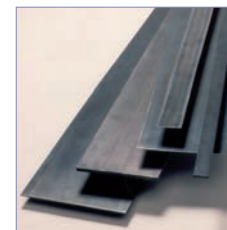
Profiled bars



LINEA™ prehardened  
HSS blanks



Profiled edges



Strips (cold rolled)



Powders

# COMPANY PROFILE

## Market Segment

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



Cutting Tools



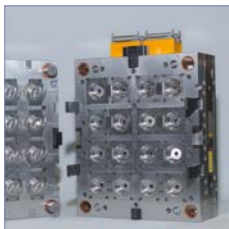
Cold Work & Hot Work



Saws



Knives



Plastics



Components

## Innovation & Expertise

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

### Customer-oriented research and development

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

### 50 years of expertise in Powder Metallurgy

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

### A wide range of competences and resources

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





# ERASTEEL



[www.erasteel.com](http://www.erasteel.com)

## TECHNOLOGY PROCESS

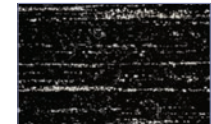
### High Speed Steel Conventional Metallurgy

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

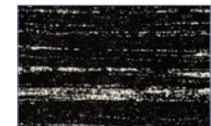
- **Process:** metallurgy, forging, rolling, drawing, heat treatment, etc.
- **Steel grades:** mechanical and physical properties, applications, etc.



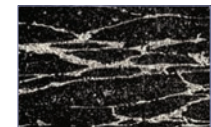
Bottom pouring



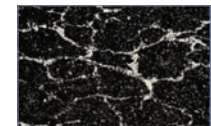
Ø 30 mm / 1,181 inch



Ø 50 mm / 1,969 inch



Ø 125 mm / 4,921 inch

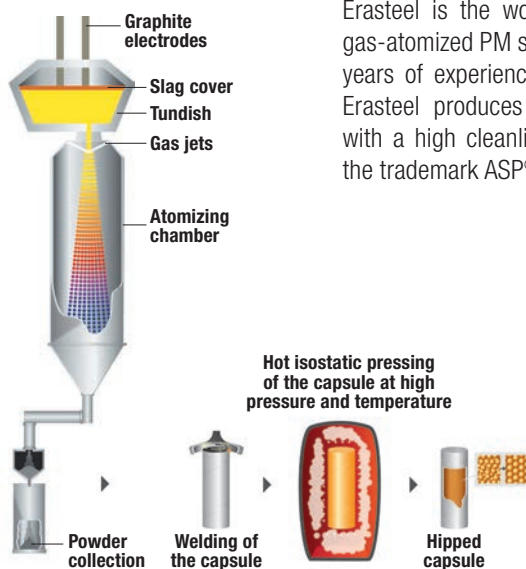


Ingot

Carbide network

# TECHNOLOGY PROCESS

## Powder Metallurgy



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

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

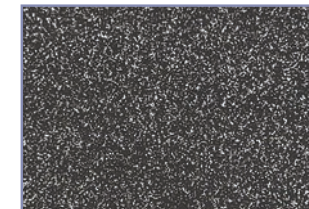
During gas atomization the molten steel is disintegrated by powerful jets of nitrogen gas into small droplets, which solidify at a very high speed. The powder is collected in a steel capsule which is then evacuated and welded. The Hot Isostatic Pressing of the ASP® powder subsequently densifies the powder.

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

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

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

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



PM 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, plastics, wood and paper processing as well as mechanical components.

ASP®, BLUETAP® AND

	ERASTEEL	Equivalent	Analysis. %					
	Grades		C	Cr	Mo	W	Co	V
ASP®, non Cobalt-grades	ASP® 2004*	PM M4	1.40	4.2	5.0	5.8	-	4.1
	ASP® 2005	-	1.50	4.0	2.5	2.5	-	4.0
	ASP® 2009	PM 9% V	1.90	5.25	1.3	-	-	9.10
	ASP® 2011	PM A11	2.45	5.25	1.3	-	-	9.75
	ASP® 2012**	-	0.60	4.0	2.0	2.1	-	1.5
	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® 2062	PM M62	1.30	3.75	10.50	6.25	-	2.0
ASP®, Cobalt-grades	ASP® 2015	PM T15	1.55	4.0	-	12.0	5.0	5.0
	ASP® 2030*	-	1.28	4.2	5.0	6.4	8.5	3.1
	ASP® 2042	PM 42	1.08	3.8	9.4	1.6	8.0	1.2
	ASP® 2048*	PM M48	1.50	3.75	5.25	9.75	8.50	3.10
	ASP® 2051	PM 51	1.27	4.0	3.6	9.5	10.0	3.2
	ASP® 2052*	-	1.60	4.8	2.0	10.5	8.0	5.0
	ASP® 2055	-	1.69	4.0	4.6	6.3	9.0	3.2
	ASP® 2060	PMHS 7-7-7-11	2.30	4.2	7.0	6.5	10.5	6.5
	ASP® 2078*	PMHS 6-7-6-10	2.30	4.2	7.0	6.5	10.5	6.5
	ASP® 2190	-	0.78	4.2	2.9	2.9	2.9	1.1
Martensitic Stainless steel	ASP APZ10	-	1.25	19.0	2.10	-	-	0.80
Blue-Tap®	BlueTap Co	M35	0.93	4.2	5.0	6.4	4.8	1.8
HSS, non Cobalt-grades	E M50	M50	0.84	4.0	4.2	-	-	1.1
	E M2	M2	0.99	4.2	5.0	6.4	-	1.8
	ABC III	-	0.99	4.1	2.7	2.8	-	2.4
	E M3:2	M3:2	1.20	4.1	5.0	6.2	-	3.0
	Grindamax V3	-	1.20	3.9	5.2	7.0	-	2.7
	E M4	M4	1.30	4.2	4.5	5.6	-	4.0
HSS, Cobalt-grades	E M35	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	M42	1.08	3.8	9.4	1.5	8.0	1.2
	WKE 42	-	1.27	4.0	3.6	9.5	10.0	3.2

\* also available with sulfur, \*\* Si 1.0%; Mn 0.3% ASP 2078\* S:0.23  
ASP®, BlueTap® are registered trademarks of Erasteel

HIGH SPEED STEEL GUIDE

	ERASTEEL	Hardness, HB <sup>(1)</sup>	Characteristics and Applications
	Grades	Soft annealed	
ASP®, non Cobalt-grades	ASP® 2004*	265	Good wear resistance and hardness
	ASP® 2005	250	Good wear resistance and toughness
	ASP® 2009	250	Wear resistance and toughness for plastics extrusion
	ASP® 2011	280	V-alloyed with high abrasion resistance
	ASP® 2012**	230	Very high toughness for hot and cold work
	ASP® 2023	260	Non-Co-grade for cold work and cutting tools Good wear resistance
	ASP® 2053	300	V-alloyed grade for abrasive wear resistance
	ASP® 2062	290	High red-hardness, good abrasive wear resistance
ASP®, Cobalt-grades	ASP® 2015	280	High W-alloyed grade for high performance cutting
	ASP® 2030*	290	Co-grade for high performance cutting and cold forming
	ASP® 2042	280	For bimetal bandsaws, with good weldability
	ASP® 2048*	300	High alloyed for high performance cutting tools
	ASP® 2051	280	For bimetal bandsaws, with excellent wear resistance and toughness
	ASP® 2052	300	High W-alloyed grade for high performance cutting Good wear resistance
	ASP® 2055	320	2.1% Nb. High alloyed Co-grade with good grindability
	ASP® 2060	345	For both hot hardness and wear resistance
	ASP® 2078*	340	High performance grade with improved machinability
	ASP® 2190	400	High performance high Co grade for PVD coated gear cutting tools.
Martensitic Stainless steel	ASP® APZ10	285	Good corrosion and wear resistance
Blue-Tap®	BlueTap Co	255	For tap manufacturing: excellent grindability, and a superior combination of hardness, wear resistance and toughness.
HSS, non Cobalt-grades	E M50	225	Low alloyed grade for “Do-It-Yourself” drills
	E2	250	Grade for general applications
	ABC III	220	Grade for metal saws and wear parts
	E M3:2	265	M2 upgraded for higher wear resistance
	Grindamax V3	270	Grade with excellent grindability, ideal for taps
	E M4	250	Excellent wear resistance, for cold forming and rolls
HSS, Cobalt-grades	E M35	260	Grade for taps and general applications
	C8	270	8% Co-grade with improved hot hardness for end mills
	E MAT II	240	Grade for bimetal saws with good toughness
	E M42	270	Co-grade for cutting tools and bimetal bandsaws
	WKE 42	280	Grade similar to M42 more wear resistance.

\* also available with sulfur, \*\* Si 1.0%; Mn 0.3% ASP 2078\* S:0.23  
(1) Typical soft annealed hardness is... / Cold drawn or cold rolled material is typically 10-40 HB harder

COMPARATIVE PROPERTIES



Density in g/ cm <sup>3</sup>		
	Grades	Density
ASP® Grades	ASP® 2004	8.0
	ASP® 2005	7.8
	ASP® 2009	7.5
	ASP® 2011	7.4
	ASP® 2012	7.8
	ASP® 2015	8.2
	ASP® 2023	8.0
	ASP® 2030	8.1
	ASP® 2042	8.0
	ASP® 2048	8.2
	ASP® 2051	8.2
	ASP® 2052	8.2
	ASP® 2053	7.7
	ASP® 2055	8.0
	ASP® 2060	7.9
Martensitic stainless steel grades	ASP® 2062	8.2
	ASP® 2078	7.9
	ASP® 2190	8.1
	ASP® APZ10	7.8
BlueTap® Grades	BlueTap Co	8.0
Standard Grades	E M50	7.8
	E M2	8.1
	ABC III	8.0
	E M3:2	8.0
	Grindamax V3	8.0
Co Grades	E M4	8.0
	E M35	8.1
	C8	8.1
	E MAT II	7.9
	E M42	8.0
	WKE 42	8.2



# ASP® GRADES DATA SHEETS



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

# ASP® GRADE DATASHEET

## ASP®2004 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

C	Cr	Mo	W	V
1.40	4.2	5.0	5.8	4.1

### STANDARDS

- Europe: HS 6-5-4
- Germany: 13361

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2004 is a high Vanadium alloyed grade with high wear resistance and toughness suitable for cold work applications.

### APPLICATIONS

- Punches
- Milling cutters
- Dies
- Taps
- Rolls
- Broaches
- Rotating multi-edge cutting tools

### FORM SUPPLIED

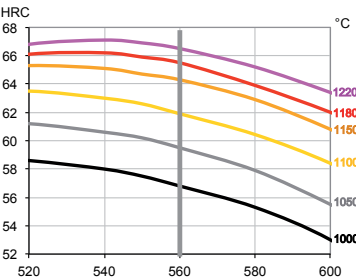
- Coils
- Forged blanks
- Flat & square bars
- Round bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with preheating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3 x 1 hour

### PROCESSING

- ASP®2004 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel makers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

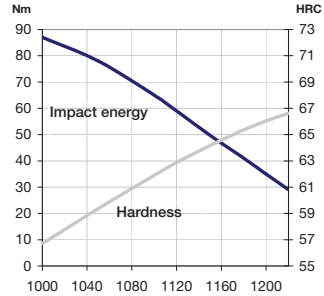
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g/cm³ (1)	8,0	7,9	7,8
Modulus of elasticity kN/mm² (2)	240	214	192
Thermal expansion ratio per °C (2)	-	12,1x10 <sup>-6</sup>	12,7x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened 1220°C and tempered 560°C, 3 x 1 hour

#### IMPACT TOUGHNESS

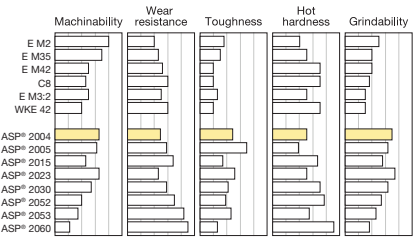


Original dimension Ø 14 mm  
Tempering 3 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

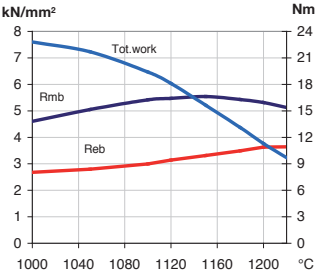
#### SAFETY DATA SHEET

SDS: A

#### COMPARATIVE PROPERTIES



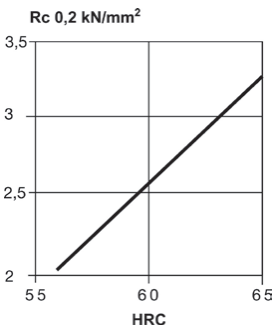
### 4-POINT BEND STRENGTH



Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560°C  
Dimension of test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

#### COMPRESSION YIELD STRESS



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2005 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 3-3-4
- Germany: 1.3377

### DELIVERY HARDNESS

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

### DESCRIPTION

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

### APPLICATIONS

Cold work tools: Powder compacting tools, cold extrusion tools, cold-heading dies, fine blanking tools

- Plastic injection moulders
- Rolls

Warm applications: extrusion dies, forging dies and punches

### FORM SUPPLIED

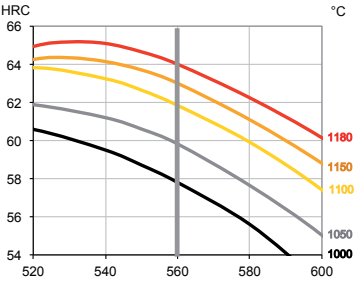
- Round bars
- Flat & square bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. 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

### PROCESSING

- ASP®2005 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

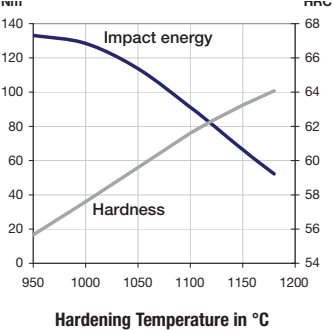
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm³ (1)	7.8	7.7	7.6
Modulus of elasticity kN/mm² (2)	220	195	175
Thermal expansion ratio per °C (2)	-	12,1x10 <sup>-6</sup>	12,7x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened 1180°C and tempered 560°C, 3 x 1 hour

#### IMPACT TOUGHNESS



Hardening Temperature in °C  
Original dimension Ø 16 mm  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

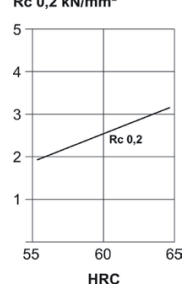
#### SAFETY DATA SHEET

SDS: A

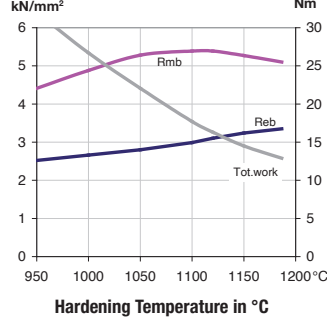
#### COMPARATIVE PROPERTIES



### COMPRESSION YIELD STRESS



#### 4-POINT BEND STRENGTH



Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560°C  
Dimension of test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2009 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

C	Cr	Mo	W	V
1.9	5.25	1.3	-	9.1

### STANDARDS

- AMS6557

### DELIVERY HARDNESS

Typical soft annealed hardness is 250 HB.

### DESCRIPTION

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

### APPLICATIONS

- Extrusion tooling
- Hot work tools
- Knives
- Cold work

### FORM SUPPLIED

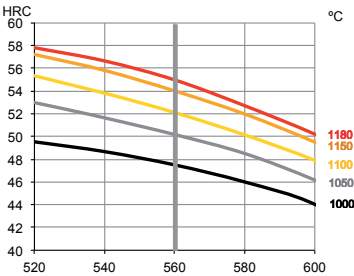
- Coils
- Forged blanks
- Round bars
- Flat & square bars

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

### HEAT TREATMENT

- Soft annealing: heat in a protective atmosphere to 850-900°C, hold for 3 hours, slow cool at 10°C/h down to 700°C, then air cooling.
- Stress-relieving: heat to 600-700°C for approximately 2 hours, slow cool down to below 500°C.
- Hardening in a protective atmosphere with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitising at a temperature, suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. 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

### PROCESSING

- ASP®2009 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

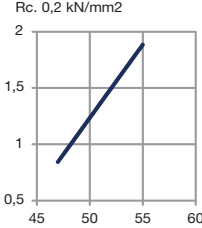
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	Temperature 400°C	600°C
Density g /cm³ (1)	7.5	7.4	7.3
Modulus of elasticity kN/mm² (2)	221	197	177
Thermal expansion ratio per °C (2)	11.1x10 <sup>-6</sup>	11.6x10 <sup>-6</sup>	11.9x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened at 1180°C and tempered at 560°C, 3 x 1 hour

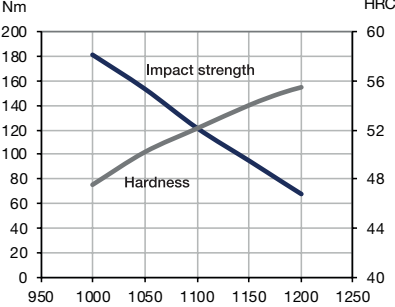
### COMPRESSION YIELD STRESS



### SAFETY DATA SHEET

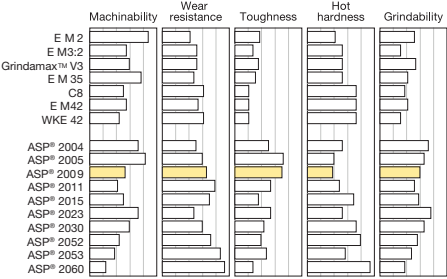
SDS: A

### IMPACT TOUGHNESS



Hardening Temperature in °C  
Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### COMPARATIVE PROPERTIES



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2011 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
2.45	5.25	1.3	-	-	9.75

### STANDARDS

- USA: AISI A11
- AMS6559

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2011 is a high Vanadium grade for wear applications.

### APPLICATIONS

- Knives
- Wear parts
- Cold work

### FORM SUPPLIED

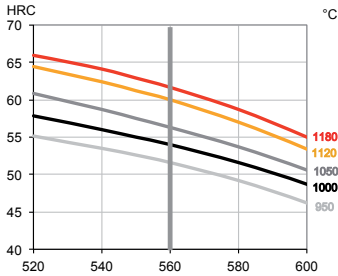
- Coils
- Flat and square bars
- Discs
- Coarse Round bars
- Sheets
- Pieces cut from sheets

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with preheating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3 x 1 hour

### PROCESSING

- ASP®2011 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

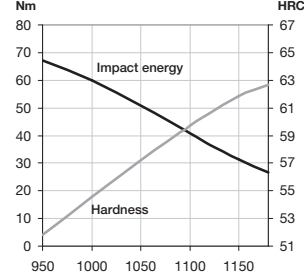
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	7.4	7.3	7.3
Modulus of elasticity kN/mm <sup>2</sup> (2)	220	197	177
Thermal expansion ratio per °C (2)	-	11.8x10 <sup>-6</sup>	12.3x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	20	25	26
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened 1180°C and tempered 560°C, 3 x 1 hour

#### IMPACT TOUGHNESS



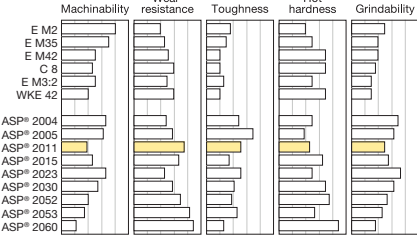
Hardening Temperature in °C

Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

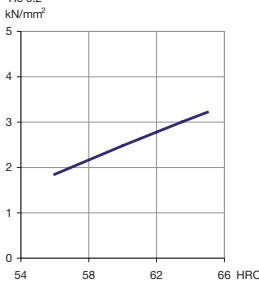
### SAFETY DATA SHEET

SDS: A

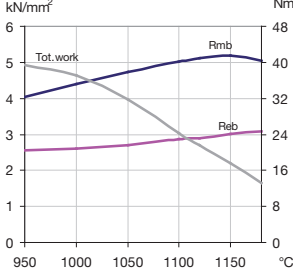
### COMPARATIVE PROPERTIES



### COMPRESSION YIELD STRESS



### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Original dimension Ø 7,5 mm  
Tempering 3 x 1 hour at 560°C  
Dimension of test piece Ø 4.7 mm

NB: High quality surface  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650





# ASP® GRADE DATASHEET

## ASP®2015 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.55	4.0	-	12	5.0	5.0

### STANDARDS

- USA: AISI T15
- Europe: HS 12-0-5-5
- Germany: 1.3202

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2015 is a high Tungsten alloy grade for high performance cutting tools.

### APPLICATIONS

- Endmills
- Shaper cutters
- Hobs
- Broaches

### FORM SUPPLIED

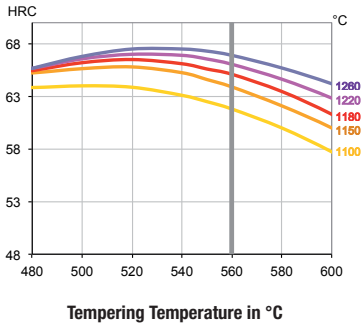
- Coils
- Round bars
- Forged blanks
- Flat & square bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3 x 1 hour

### PROCESSING

- ASP®2015 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

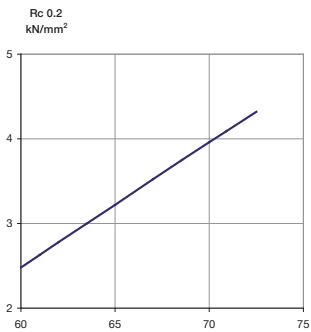
### PROPERTIES

#### PHYSICAL PROPERTIES

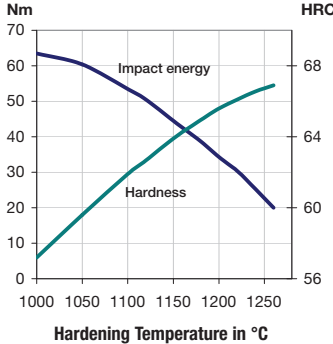
	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	8.2	8.1	8.0
Modulus of elasticity kN/mm <sup>2</sup> (2)	245	220	195
Thermal expansion ratio per °C (2)	-	11.0x10 <sup>-6</sup>	11.7x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened 1180°C and tempered 560°C, 3 x 1 hour

### COMPRESSION YIELD STRESS



### IMPACT TOUGHNESS

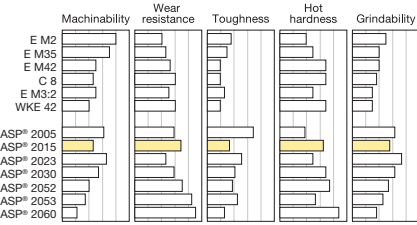


Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### SAFETY DATA SHEET

SDS: B

### COMPARATIVE PROPERTIES



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2023 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- USA: AISI M3:2
  - Germany: 1.3395
- Europe: HS 6-5-3C
  - Japan: JIS SKH53

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2023 is a non Cobalt grade for high performance cutting tools, cold work tools and rolls for cold rolling.

### APPLICATIONS

- Gear cutting tools
  - Broaches
  - Taps
  - Cold work
- Rolls
  - Knives
  - Plastic injection

### FORM SUPPLIED

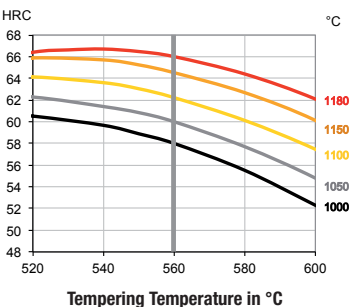
- Round bars
  - Strips
  - Discs
- Flat & square bars
  - Sheets
  - Coils

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

### HEAT TREATMENT

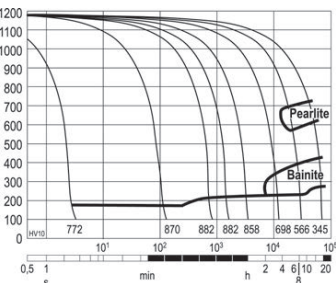
- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3 x 1 hour

### CCT CURVE



Continuous cooling transformation curve  
Hardening temperature 1180 °C

### PROCESSING

ASP®2023 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

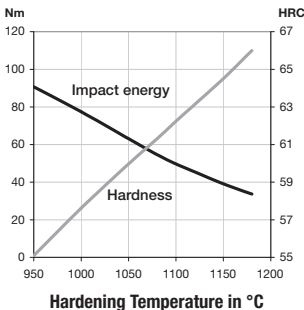
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	8.0	7.9	7.9
Modulus of elasticity kN/mm <sup>2</sup> (2)	230	205	184
Thermal expansion ratio per °C (2)	-	12.1x10 <sup>-6</sup>	12.7x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened 1180°C and tempered 560°C, 3 x 1 hour

### IMPACT TOUGHNESS

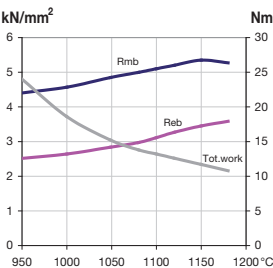


Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### SAFETY DATA SHEET

SDS: A

### 4-POINT BEND STRENGTH

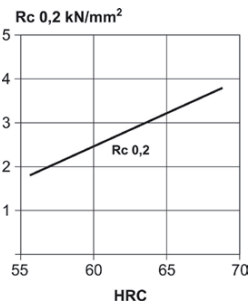


Hardening Temperature in °C

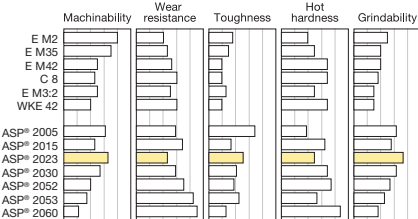
Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560° C  
Dimension of test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

### COMPRESSION YIELD STRESS



### COMPARATIVE PROPERTIES



Approximate Conversion													
°C	20	25	400	450	500	520	540	560	600	620	700	800	850
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560

# ASP® GRADE DATASHEET

## ASP®2030 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 6-5-3-8
- Germany: 1.3294

### DELIVERY HARDNESS

Typical soft annealed hardness is 290 HB  
Cold drawn and cold rolled material is typically 10-40 HB harder

### DESCRIPTION

ASP®2030 is a Cobalt grade for high performance cutting tools.

### APPLICATIONS

- End mills
- Hobs
- Shaper cutters
- Broaches
- Taps
- Drills
- Cold work tools
- Bi-metal saws
- Fine blanking
- Dies

### FORM SUPPLIED

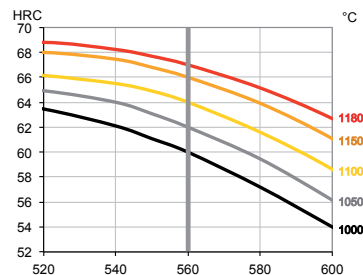
- Coils
- Round bars
- Sheets
- Flat & square bars
- Forged blanks

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

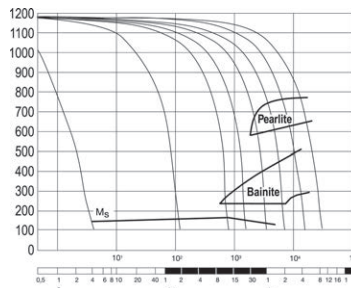
### GUIDELINES FOR HARDENING



Tempering Temperature in °C

Hardness after hardening, quenching and tempering 3 x 1 hour

### CCT CURVE



Continuous cooling transformation curve  
Hardening temperature 1180 °C

### PROCESSING

ASP®2030 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

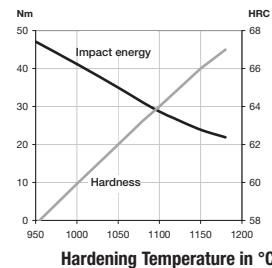
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	8.1	7.9	7.9
Modulus of elasticity kN/mm <sup>2</sup> (2)	240	214	192
Thermal expansion ratio per °C (2)	-	11.8x10 <sup>-6</sup>	12.3x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- Soft annealed
- Hardened 1180°C and tempered 560°C, 3x1 hour

### IMPACT TOUGHNESS

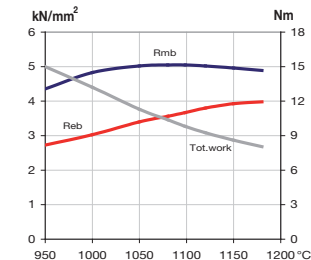


Hardening Temperature in °C  
Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560 °C  
Unnotched test piece 7 x 10 x 55 mm

### SAFETY DATA SHEET

SDS: B

### 4-POINT BEND STRENGTH

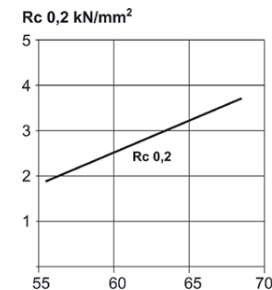


Hardening Temperature in °C

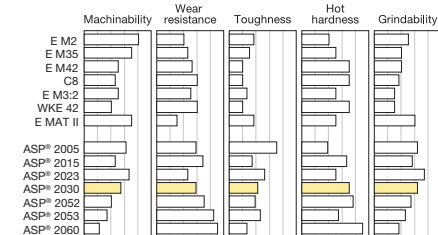
Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560 °C  
Dimension of test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

### COMPRESSION YIELD STRESS



### COMPARATIVE PROPERTIES



Approximate Conversion													
°C	20	25	400	450	500	520	540	560	600	620	700	800	850
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560

# ASP® GRADE DATASHEET

## ASP®2042 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- USA: AISI M42
- Japan: JIS SKH59
- Europe: HS 2-9-1-8
- Germany: ≈ 1.3247

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2042 is a PM HSS grade with high hardness and high toughness. It is an upgraded material in particular in applications where standard M42 is traditionally used, e.g. for laser-welded bimetal saws with improved saw performance, thanks to its higher hardness and toughness. It is also recommended for high performance components.

### APPLICATIONS

- Bandsaws, jig & sabre saws, hole saws
- High performance components
- Flat thread rolling dies for screws and bolts
- Cold forming dies for screws and bolts

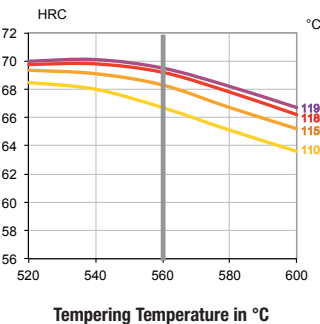
### FORM SUPPLIED

- Bimetal edge wire
- Round bars
- Flat bars

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3 x 1 hour

### PROCESSING

- ASP®2042 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - hot forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition).

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

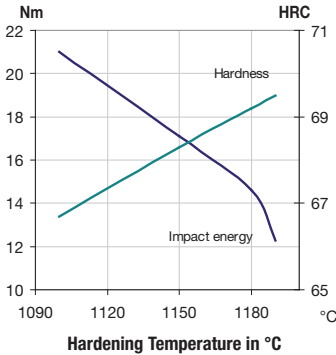
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	8.0	7.9	7.9
Modulus of elasticity kN/mm <sup>2</sup> (2)	225	200	180
Thermal expansion ratio per °C (2)	-	11.5x10 <sup>-6</sup>	11.8x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

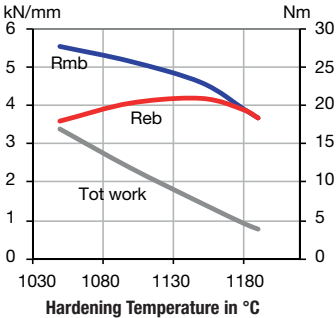
- (1) Soft annealed  
(2) Hardened 1180°C and tempered 560°C, 3 x 1 hour

#### IMPACT TOUGHNESS



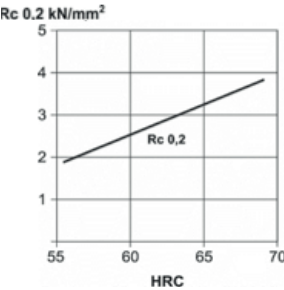
Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

#### 4-POINT BEND STRENGTH



Dimension of test piece Ø 6 mm  
Tempering 3 x 1 hour at 560°C  
Dimension of test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

#### COMPRESSION YIELD STRESS



#### SAFETY DATA SHEET

SDS: B

#### COMPARATIVE PROPERTIES

	Machinability	Wear resistance	Toughness	Hot hardness	Grindability
E MAT II					
E M2					
E M3:1					
E M3:2					
E M42					
ASP® 2042					
ASP® 2030					
ASP® 2060					

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650



# ASP® GRADE DATASHEET

## ASP®2048 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.50	3.75	5.25	9.75	8.50	3.10

Also available with sulfur

### STANDARDS

- USA: AISI M48

### DELIVERY HARDNESS

Typical soft annealed hardness is 300 HB.

### DESCRIPTION

ASP®2048 is a high alloyed PM steel for high performance cutting tools.

### APPLICATIONS

- Hobs
- End mills
- Shaper cutters

### FORM SUPPLIED

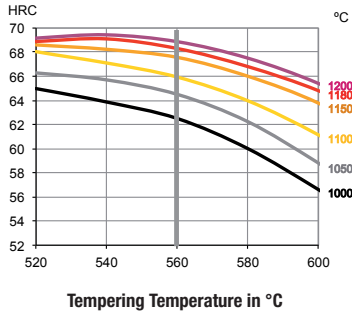
- Coils
- Round bars
- Flat & square bars

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

### HEAT TREATMENT

- Soft annealing: Heat in a protective atmosphere to 850-900°C, hold for 3 hours, slow cool at 10°C/h down to 700°C, then air cooling.
- Stress-relieving: Heat to 600-700°C for approximately 2 hours, slow cool down to below 500°C.
- Hardening: Use a protective atmosphere. Pre-heat in 2 steps at 450-500°C and 850-900°C. Austenitize at a temperature suitable for chosen working hardness. Quench down to 40-50°C or lower.
- Temper three times at 560°C. Hold at least 1 hour at temperature each time. Cool to room temperature (25°C) between tempers.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3 x 1 hour

### PROCESSING

ASP®2048 can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel makers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

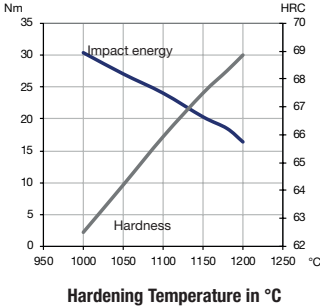
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	8.3	8.2	8.2
Modulus of elasticity kN/mm <sup>2</sup> (2)	214	185	270
Thermal expansion ratio per °C (2)	10.8x10 <sup>-6</sup>	11.4x10 <sup>-6</sup>	12.2x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

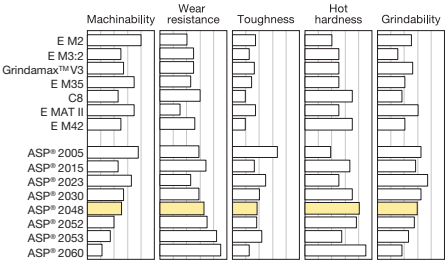
- (1) Soft annealed
- (2) Hardened 1180°C and tempered 560°C, 3 x 1 hour

#### IMPACT TOUGHNESS

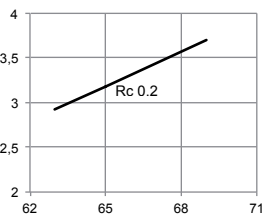


Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

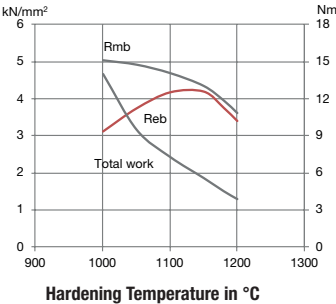
#### COMPARATIVE PROPERTIES



#### COMPRESSION YIELD STRESS



#### 4-POINT BEND STRENGTH



Dimension of test piece Ø 6 mm  
Tempering 3 x 1 hour at 560° C  
Dimensions of test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

#### SAFETY DATA SHEET

SDS: B

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2051 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 10-4-3-10
- USA : AISI M51
- France: AFNOR Z130WKCDV10.10.4.4.3
- Sweden: SS 2736
- Japan: JIS SKH57
- Germany: 1.3207

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2051 is a tungsten powder metallurgy high speed steel containing 10 percent cobalt. ASP®2051 is harder than many high speed steels and in addition it has a good toughness. ASP®2051 is used mainly for tools requiring maximum abrasion resistance and medium toughness.

### APPLICATIONS

- Toolbits
- Form tools
- Cold work tools
- Bandsaws
- Milling cutters

### FORM SUPPLIED

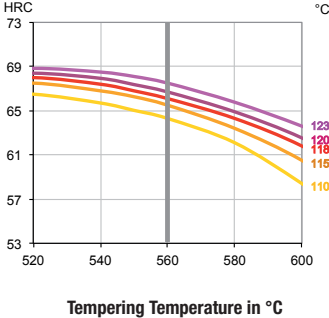
- Bimetal edge

Available surface condition: Cold rolled.

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitising at a temperature suitable for chosen working hardness.
- 3 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3x1 hour

### PROCESSING

ASP®2051 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

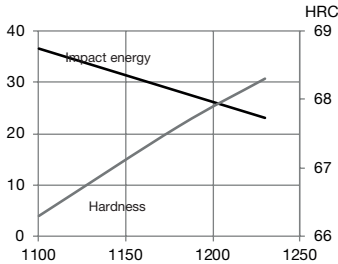
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	8.2	8.1	8.1
Modulus of elasticity kN/mm <sup>2</sup> (2)	240	215	190
Thermal expansion ratio per °C (2)	-	10.2 x 10 <sup>-6</sup>	10.9x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed
- (2) Hardened 1180°C and tempered 560°C, 3x1 hour

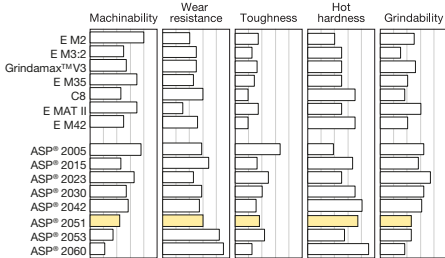
#### IMPACT TOUGHNESS



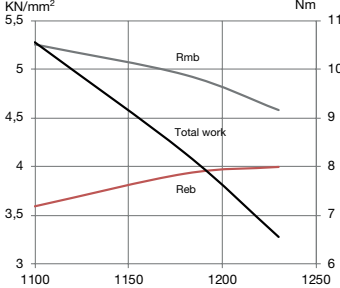
Hardening Temperature in °C

Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

#### COMPARATIVE PROPERTIES



#### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560° C  
Dimension of test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

#### SAFETY DATA SHEET

SDS: B

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2052 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.60	4.8	2.0	10.5	8.0	5.0

### STANDARDS

- Europe: HS 10-2-5-8
- Germany: 1.3253

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2052 is a high W-alloyed grade for high performance cutting tools and cold work applications like fine blanking requiring high hardness.

### APPLICATIONS

- End mills
- Shaper cutters
- Taps
- Hobs
- Fine blanking

### FORM SUPPLIED

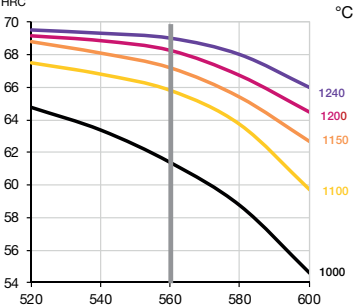
- Coils
- Round bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with preheating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C  
Hardness after hardening, quenching and tempering 3x1 hour

### PROCESSING

ASP®2052 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

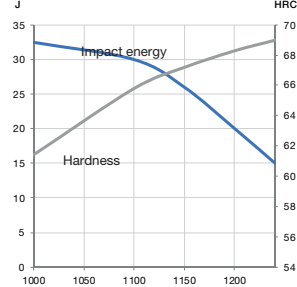
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g/cm³ (1)	8.2	8.1	8.1
Modulus of elasticity kN/mm² (2)	245	218	196
Thermal expansion ratio per °C (2)	-	11.2 x 10 <sup>-6</sup>	11.7x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened 1180°C and tempered 560°C, 3x1 hour

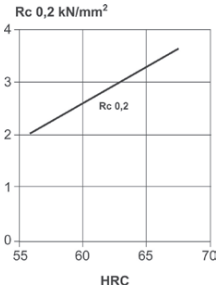
#### IMPACT TOUGHNESS



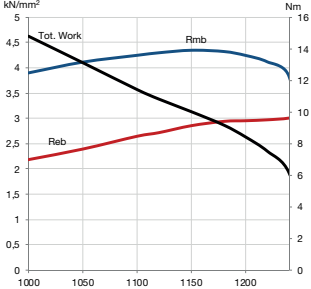
Hardening Temperature in °C

Original dimension 70 x 15 mm  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### COMPRESSION YIELD STRESS



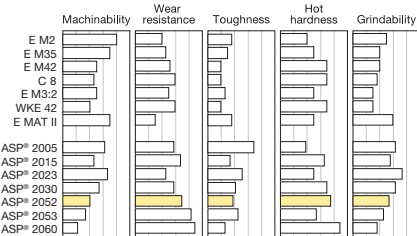
### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560° C  
Dimension of test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

### COMPARATIVE PROPERTIES



### SAFETY DATA SHEET

SDS: B

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2053 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 4-3-8
- Germany: 1.3352
- AMS6556

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2053 is a high V-alloyed grade with excellent abrasive wear resistance and toughness.

### APPLICATIONS

- Cold work tools
- Textile knives
- Wood tools
- Bi-metal saws
- Paper cutting knives
- Stamping
- Fine blanking
- Extrusion
- Rolls

### FORM SUPPLIED

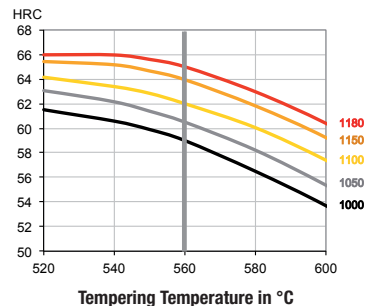
- Coils
- Sheets
- Round bars
- Discs
- Forged blanks
- Flat & square bars

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

### HEAT TREATMENT

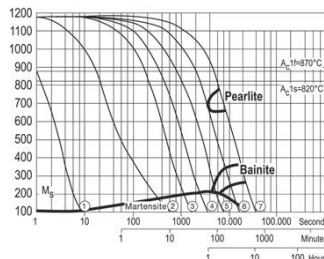
- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with preheating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3x1 hour

### CCT CURVE



Continuous cooling transformation curve  
Hardening temperature 1180 °C

### PROCESSING

ASP®2053 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

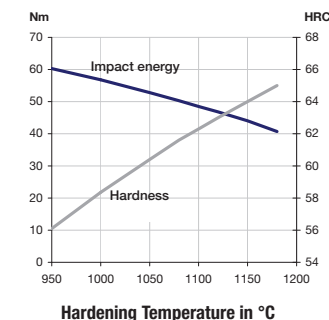
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g/cm³ (1)	7.7	7.6	7.5
Modulus of elasticity kN/mm² (2)	250	220	200
Thermal expansion ratio per °C (2)	-	11.1x10 <sup>-6</sup>	11.7x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- Soft annealed
- Hardened 1180°C and tempered 560°C, 3x1 hour

### IMPACT TOUGHNESS

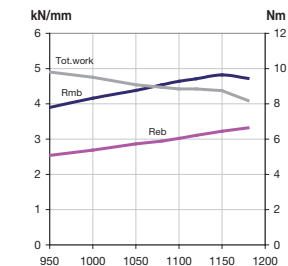


Original dimension Ø 16 mm  
Tempering 3 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

### SAFETY DATA SHEET

SDS: A

### 4-POINT BEND STRENGTH

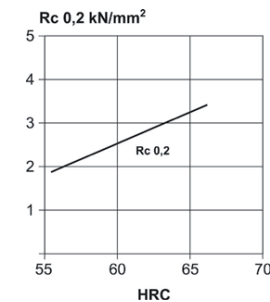


Hardening Temperature in °C

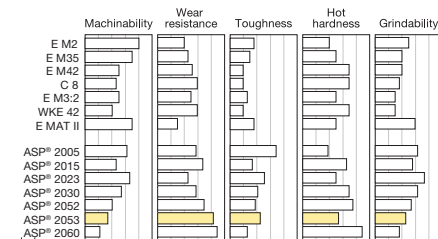
Original dimension Ø 16 mm  
Tempering 3 x 1 hour at 560°C  
Dimension of test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

### COMPRESSION YIELD STRESS



### COMPARATIVE PROPERTIES



Approximate Conversion													
°C	20	25	400	450	500	520	540	560	600	620	700	800	850
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560

# ASP® GRADE DATASHEET

## ASP®2055 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Not yet standardised

### DELIVERY HARDNESS

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

### DESCRIPTION

ASP®2055 is a high alloyed grade with a refined carbide structure for high demanding cutting tools and cold work applications like fine blanking requiring high hardness.

### APPLICATIONS

- Hobs
- Broaches
- Taps
- Fine blanking
- Shaper cutters
- End mills
- Cold work

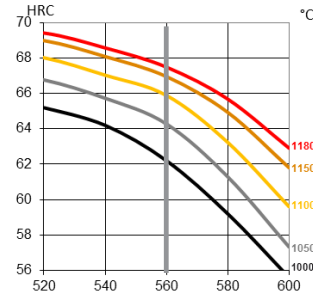
### FORM SUPPLIED

- Peeled bars
- Drawn & Ground bars

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C  
Hardness after hardening, quenching and tempering 3x1 hour

### PROCESSING

ASP®2055 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

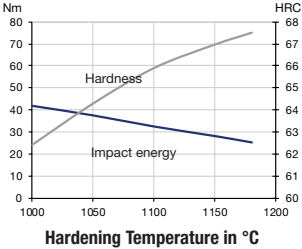
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g /cm <sup>3</sup> (1)	8.0	7.9	7.9
Modulus of elasticity kN/mm <sup>2</sup> (2)	240	214	192
Thermal expansion ratio per °C (2)	-	11.8x10 <sup>-6</sup>	12.3x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed  
(2) Hardened 1180°C and tempered 560°C, 3x1 hour

#### IMPACT TOUGHNESS

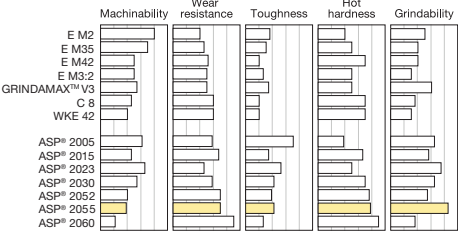


Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

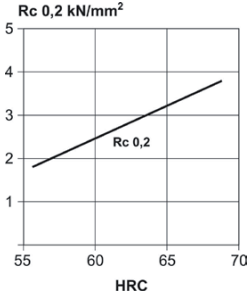
### SAFETY DATA SHEET

SDS: B

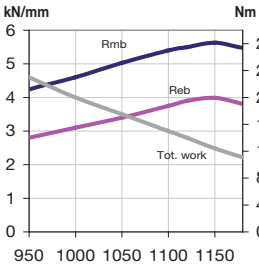
### COMPARATIVE PROPERTIES



### COMPRESSION YIELD STRESS



### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Original dimension Ø 7.5 mm  
Tempering 3 x 1 hour at 560° C  
Dimension of test piece Ø 4.7 mm

NB: High quality surface

Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650



# ASP® GRADE DATASHEET

## ASP®2060 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: Europe: HS 7-7-7-11
- Germany: 1.3292
- AMS6560

### DELIVERY HARDNESS

Typical soft annealed hardness is 345 HB.

### DESCRIPTION

ASP®2060 is a very high alloyed grade for applications requiring both hot hardness and wear resistance.

### APPLICATIONS

- Gear cutting tools
- Broaches
- End mills tools
- Taps
- Drills
- Cold work
- Bearing & other Components

### FORM SUPPLIED

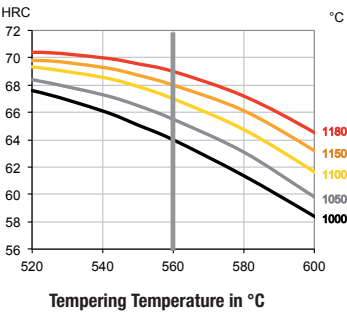
- Round bars
- Flat & square bars
- Forged bars
- Tool bit sections

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

### HEAT TREATMENT

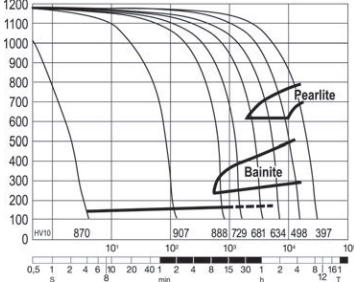
- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3x1 hour

### CCT CURVE



Continuous cooling transformation curve  
Hardening Temperature 1180°C

### PROCESSING

ASP®2060 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

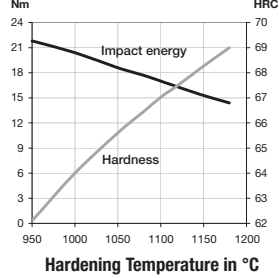
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g/cm³ (1)	7.9	7.9	7.8
Modulus of elasticity kN/mm² (2)	250	222	200
Thermal expansion ratio per °C (2)	-	10.6x10 <sup>-6</sup>	11.1x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- Soft annealed
- Hardened 1180°C and tempered 560°C, 3x1 hour

### IMPACT TOUGHNESS

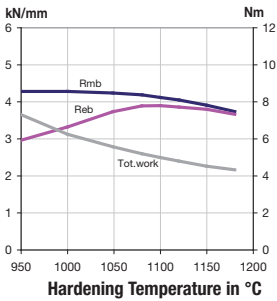


Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

### SAFETY DATA SHEET

SDS: B

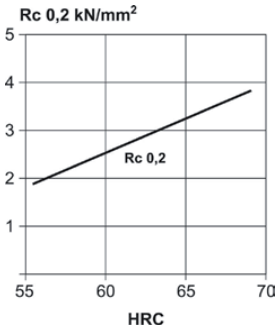
### 4-POINT BEND STRENGTH



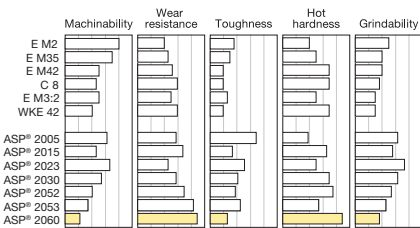
Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560°C  
Dimension of test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

### COMPRESSION YIELD STRESS



### COMPARATIVE PROPERTIES



# ASP® GRADE DATASHEET

## ASP®2062 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

C	Cr	Mo	W	V
1.30	3.75	10.50	6.25	2.0

### STANDARDS

- Europe: HS 6-10-2
- USA: Aisi M62
- AMS6558

### DELIVERY HARDNESS

Typical soft annealed hardness is 290 HB.

### DESCRIPTION

ASP®2062 is a cobalt-free high-speed steel with high red-hardness and good abrasion wear resistance.

### APPLICATIONS

- High temperature bearings
- Bearings & other components

### FORM SUPPLIED

- Round bars

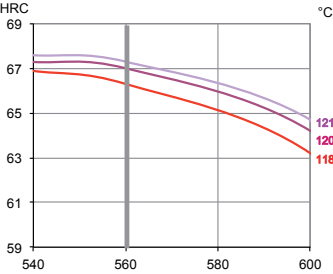
Available surface conditions: peeled and rough machined.

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitising at a temperature suitable for chosen working hardness. Cooling down to 40-50°C.
- Tempering at 560°C four times\* for at least 1 hour each time. Cooling to room temperature (25°C) between tempers.

\*Four temperings are recommended in order to remove all retained austenite and ensure a fully tempered martensitic matrix.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C  
Hardness after hardening, quenching and tempering 4x1 hour

### PROCESSING

- ASP®2062 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition).

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

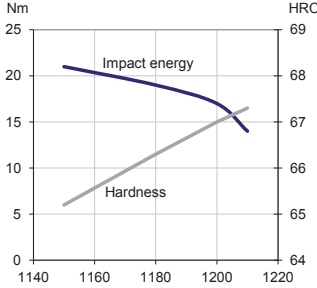
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	400°C	600°C
Density g/cm³ (1)	8.2	8.1	8.0
Modulus of elasticity kN/mm² (2)	240	214	192
Thermal expansion ratio per °C (2)	-	11.2x10 <sup>-6</sup>	11.7x10 <sup>-6</sup>

- (1) Soft annealed  
(2) Hardened 1210°C and tempered 560°C, 4x1 hour to 67 HRC

#### IMPACT TOUGHNESS

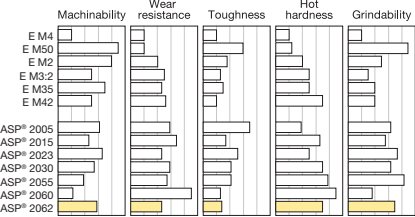


Hardening Temperature in °C  
Original dimension Ø42 mm  
Tempering 4 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

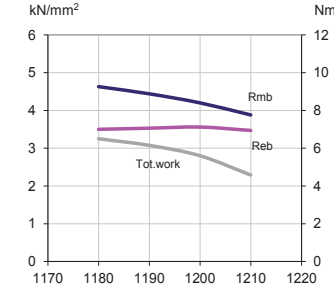
### SAFETY DATA SHEET

SDS: B

### COMPARATIVE PROPERTIES

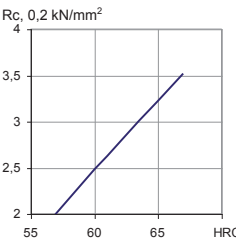


### 4-POINT BEND STRENGTH



Hardening Temperature in °C  
Original dimension Ø 5.6 mm  
Tempering 4 x 1 hour at 560°C  
Dimension of test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

### COMPRESSION YIELD STRESS



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# ASP® GRADE DATASHEET

## ASP®2078 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 6-7-6-10
- Germany: 1.3241

### DELIVERY HARDNESS

Typical soft annealed hardness is 345 HB.

### 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 machineability.

### APPLICATIONS

- Hobs
- Shaper cutters
- Milling cutters

### FORM SUPPLIED

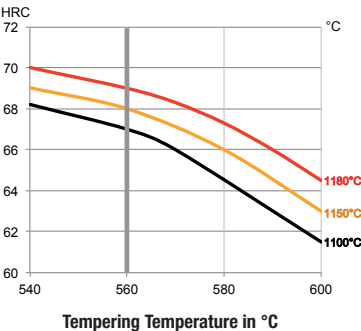
- Round bars

Available surface conditions: ground, peeled, rough machined.

### HEAT TREATMENT

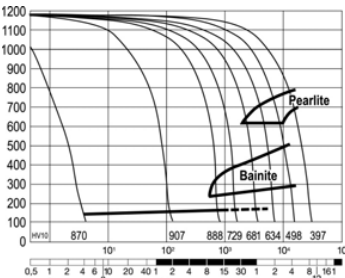
- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling at 10°C/h down to 700°C, then air cooling.
- Stress-relieving at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere at a temperature suitable for chosen working hardness. Pre-heating in 2 or 3 steps depending on tool dimension-design and austenitising temperature, last step 60°C below chosen austenitising temperature. Cooling down to 40-50°C.
- Tempering at 560°C three times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3x1 hour

### CCT CURVE



Continuous cooling transformation curve  
Hardening temperature 1150 °C

### PROCESSING

ASP®2078 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- hot forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition).

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can furnish advice on the choice of grinding wheels.

### SURFACE TREATMENT

ASP® 2078 is a good substrate for PVD and CVD coatings. The steel grade can also be nitrided, with nitriding zones up to maximum 15 µm.

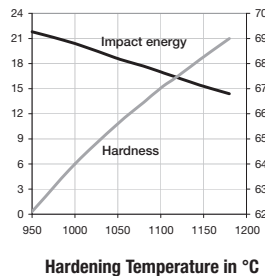
### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	Temperature	
		400°C	600°C
Density g /cm³ (1)	7.9	7.9	7.8
Modulus of elasticity kN/mm² (2)	250	222	200
Thermal expansion ratio per °C (2)	-	10.6x10 <sup>-6</sup>	11.1x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	24	28	27
Specific heat J/kg °C (2)	420	510	600

- (1) Soft annealed
- (2) Hardened 1180°C and tempered 560°C, 3x1 hour

#### IMPACT TOUGHNESS

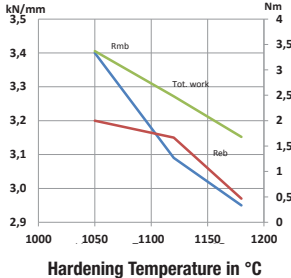


Original dimension 9 x 12 mm  
Tempering 3 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

### SAFETY DATA SHEET

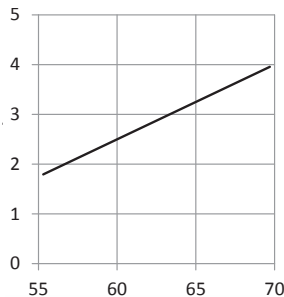
SDS: B

### 4-POINT BEND STRENGTH

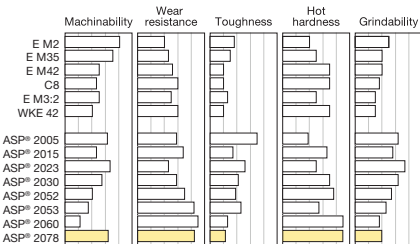


Original dimension Ø 6 mm  
Tempering 3 x 1 hour at 560° C  
Dimension of test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

### COMPRESSION YIELD STRESS



### COMPARATIVE PROPERTIES



Approximate Conversion													
°C	20	25	400	450	500	520	540	560	600	620	700	800	850
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560

# ASP® GRADE DATASHEET

## ASP®2190 POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- Not yet standardized

### DELIVERY HARDNESS

Typical soft annealed hardness is 400 HB.

### DESCRIPTION

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

### APPLICATIONS

- Gear cutting tools

### FORM SUPPLIED

- Round bars

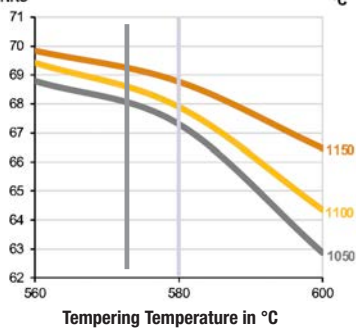
Available surface conditions: hot worked, peeled, rough machined.

### HEAT TREATMENT

- Soft annealing 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 at 600-700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening in a protective atmosphere with preheating in 2 steps at 450-500°C and 850-900°C and austenitising at a temperature suitable for the given application and wanted hardness level (max 1150°C). Cooling down to 40-50°C.
- Tempering at 580°C two times for at least 1 hour each time. Cooling to room temperature (25°C) between temperings.

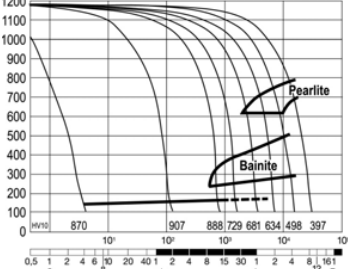
It is important to respect the maximum hardening temperature at 1150°C as any higher hardening temperature will result in a rapid decrease in toughness.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 2x1 hour

### CCT CURVE



Continuous cooling transformation curve  
Hardening temperature 1150 °C

### PROCESSING

ASP®2190 can be machined as follows:

- machining (grinding, turning, milling)
- polishing
- hot forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition).

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can provide advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

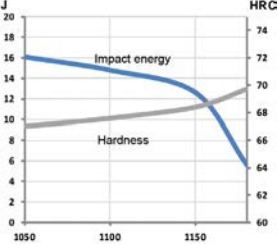
### PROPERTIES

#### PHYSICAL PROPERTIES

	Temperature		
	20°C	400°C	600°C
Density g/cm³ (1)	7.8	8.0	8.0
Modulus of elasticity kN/mm² (2)	250	222	200
Thermal expansion ratio per °C (2)	-	10.7x10 <sup>-6</sup>	11.2x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	-	-	30

- (1) Soft annealed  
(2) Hardened 1180°C and tempered 580°C, 2x1 hour

#### IMPACT TOUGHNESS



Hardening Temperature in °C

Original dimension 0103 mm  
Tempering 2 x 1 hour at 580° C  
Unnotched test piece 7 x 10 x 55 mm

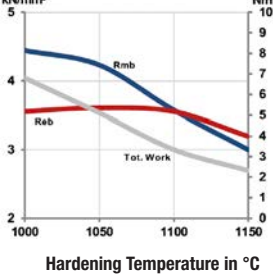
#### COMPARATIVE PROPERTIES

	Machinability	Wear resistance	Toughness	Hot hardness	Grindability
ASP® 2030					
ASP® 2052					
ASP® 2055					
ASP® 2060					
ASP® 2190					

### SAFETY DATA SHEET

SDS: B

#### 4-POINT BEND STRENGTH



Original dimension 0103 mm  
Tempering 2 x 1 hour at 580°C  
Dimension of test piece 0 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

# ASP® GRADE DATASHEET

## ASP®APZ10 POWDER METALLURGY STAINLESS STEEL

### CHEMICAL COMPOSITION

C	Cr	Mo	V	N
1,25	19,0	2,1	0,8	0,1

### STANDARDS

- Not yet standardized.

### DELIVERY HARDNESS

Typical soft annealed hardness is 280 HB.

### DESCRIPTION

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

### APPLICATIONS

- Plastic moulding applications: (corrosive and abrasive plastics)
- Food-related applications
- Medical related applications
- Industrial knives

### FORM SUPPLIED

- Round bars
- Flat & square bars

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

### HEAT TREATMENT

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

For applications requiring maximum corrosion resistance and where the temperature does not exceed 150°C, the following heat treatment is recommended:

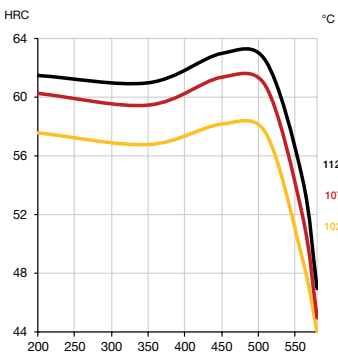
- Austenitization: 1075°C.
- Cooling: oil or gas pressure depending on the section and shape of the parts.
- Cryogenic treatment: 2 hours at -80°C.
- Tempering: 2 hours at 180-210°C.

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

For applications requiring high wear resistance or in which the temperature is 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.
- This treatment provides a lower level of corrosion resistance than the first treatment.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching, cryogenic treatment and tempering

Application	Hardening	Tempering
Requiring maximum corrosion resistance	1075°C	180-210°C
Requiring maximum wear resistance	1125°C	500-525°C

### PROCESSING

ASP®APZ10 can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- hot forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition).

### GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can provide advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a good substrate material for PVD coating as long as the temperature during coating does not exceed the tempering temperature.

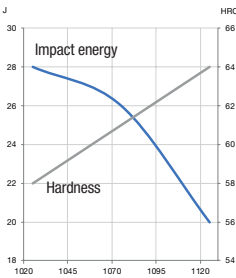
### PROPERTIES

#### PHYSICAL PROPERTIES

	Temperature		
	20°C	400°C	600°C
Density g/cm <sup>3</sup> (1)	7.6	7.5	7.5
Thermal expansion ratio per °C (2)	-	12.2x10 <sup>-6</sup>	12.9x10 <sup>-6</sup>
Thermal conductivity W/m°C (2)	15	19	21
Specific heat J/kg °C (2)	450	590	700

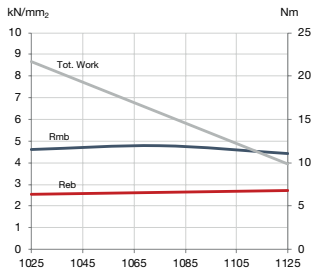
- (1)=Soft annealed  
(2)=Hardened 1125°C and tempered 510°C, 2x2 hour

### IMPACT TOUGHNESS



Hardening temperature in °C  
Original dimension Ø15 mm  
Tempering 2 x 2 hour at 510° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



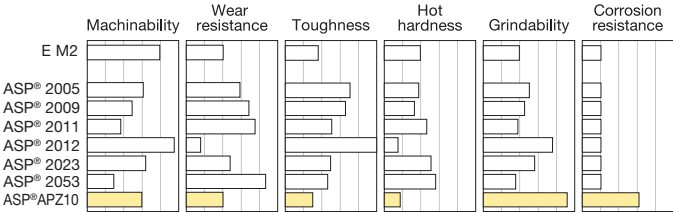
Hardening Temperature in °C  
Tempering 2 x 2 hour at 510°C  
Dimension of test piece 4.7 x 65mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

### SAFETY DATA SHEET

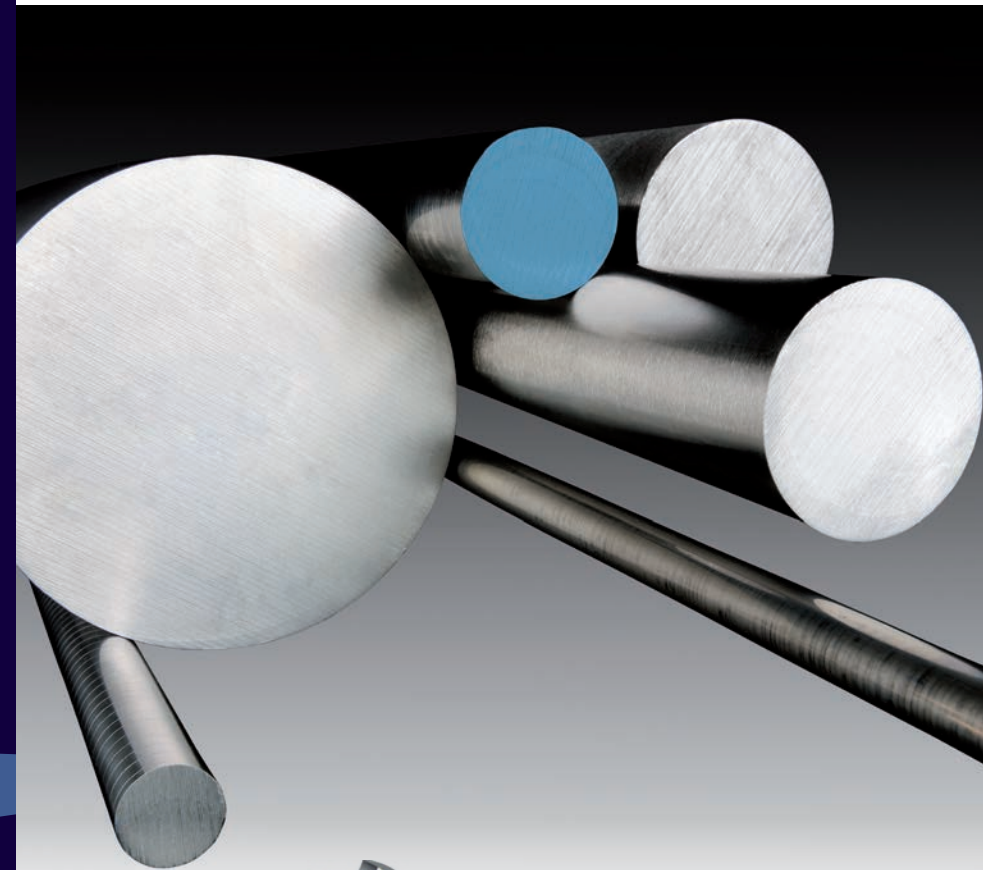
SDS: B

### COMPARATIVE PROPERTIES





# BLUETAP® DATA SHEET



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

# BLUETAP® DATASHEET

## BlueTap®Co POWDER METALLURGY HSS

### CHEMICAL COMPOSITION

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

### STANDARDS

- USA: AISI M35
- Europe: HS 6-5-2-5
- Germany: 1.3243

### DELIVERY HARDNESS

Typical soft annealed hardness is 255 HB  
Cold drawn and cold rolled material is typically 10-40 HB harder.

### DESCRIPTION

BlueTap®Co is specifically designed to address the needs of tap manufacturers. Thanks to its fine and homogeneous microstructure, it offers an excellent grindability, and a superior combination of hardness and toughness.

### APPLICATIONS

- Taps

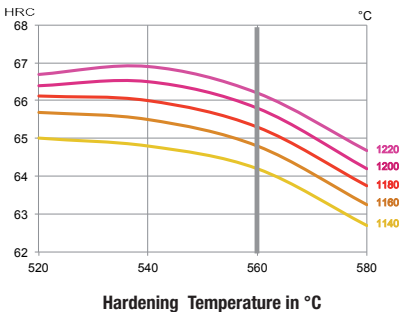
### FORM SUPPLIED

- Drawn bars
- Peeled bars up to Ø 40 mm

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 3 tempers at 560°C are recommended with at least 1 hour holding time each time, and cooling down to 25°C between each.

### GUIDELINES FOR HARDENING



Hardness after hardening  
Quenching and tempering 3 x 1 hour at 560°C

Tool	Hardening	Tempering
Multi-edge cutting tools	1180-1220°C	560°C

### PROCESSING

BlueTap®Co can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. In general, grinding must be carried out more aggressively than with traditional tap materials such as E M35, in order to avoid blunting of the wheel. Erasteel's technical support team can provide specific recommendations, and grinding wheel manufacturers can help choosing the most appropriate grinding wheels.

### SURFACE TREATMENT

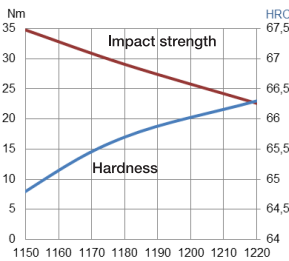
The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

#### PHYSICAL PROPERTIES

Density at 20°C: 8.0 g/cm³

#### IMPACT TOUGHNESS



Hardening Temperature in °C

Tempering 3 x 1 hour at 560°C  
Unnotched test piece 7 x 10 x 55 mm

#### SAFETY DATA SHEET

SDS: B

### COMPARATIVE PROPERTIES



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

## CONVENTIONAL GRADES



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

# CONVENTIONAL GRADES

## E M50 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
0.84	4.0	4.2	-	-	1.1

### STANDARDS

- USA: AISI M50
- Europe: HS 0-4-1
- Germany: 1.3325
- France: AFNOR Y80DCV.42.16

### DELIVERY HARDNESS

Typical soft annealed hardness is 225 HB.  
Cold drawn and cold rolled material is typically 10-40 HB harder.

### DESCRIPTION

E M50 is a low alloyed high speed steel.

### APPLICATIONS

- Twist drills

### FORM SUPPLIED

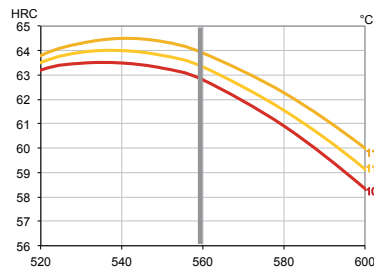
- Drawn wire
- Flat bars
- Round bars
- Square bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 2 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C  
Hardness after hardening, quenching and tempering 2 x 1 hour

Tool	Hardening	Tempering
Multi-edge cutting tools	1100-1120°C	550-570°C
Cold work tools	1080-1120°C	550-570°C

### PROCESSING

- E M50 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

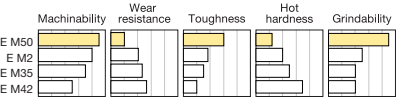
#### PHYSICAL PROPERTIES

Density at 20°C: 7.8 g/cm<sup>3</sup>

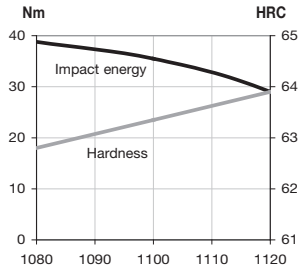
#### SAFETY DATA SHEET

SDS: A

#### COMPARATIVE PROPERTIES

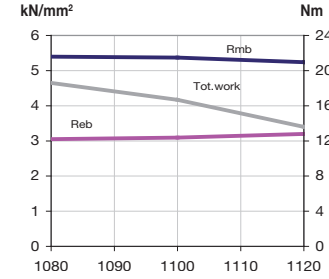


### IMPACT TOUGHNESS



Hardening Temperature in °C  
Tempering 2 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



Hardening Temperature in °C  
Tempering 2 x 1 hour at 560° C  
Dimension of test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# CONVENTIONAL GRADES

## E M2 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

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

\* 0.85 for strips

### STANDARDS

- USA: AISI M2
- Europe: HS 6-5-2
- Germany: 1.3343
- France: AFNOR Z85WDCV6.5.4.2
- Sweden: SS 2722
- UK: BM2
- Japan: JIS SKH51

### DELIVERY HARDNESS

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

### 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.

### APPLICATIONS

- Twist drills
- Broaches
- Reamers
- Knives
- Milling cutters
- Saws
- Taps & dies
- Cold work tools

### FORM SUPPLIED

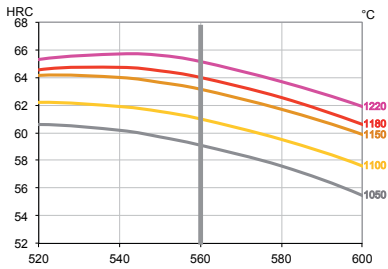
- Drawn wire
- Strips
- Wire rod
- Sheets
- Round bars
- Discs
- Flat bars
- Bi-metal edges
- Square bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 2 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C

Hardness after hardening, quenching and tempering 2 x 1 hour

Tool	Hardening	Tempering
Single-edge cutting tools	1220°C	560°C
Multi-edge cutting tools	1180-1220°C	560°C
Cold work tools	1100-1150°C	560°C

### PROCESSING

E M2 can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

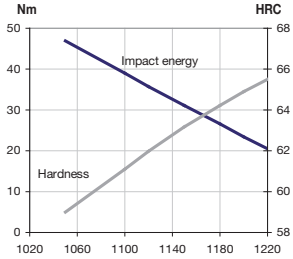
#### PHYSICAL PROPERTIES

	20°C	Temperature 400°C	600°C
Density g /cm <sup>3</sup>	8.1	8.1	8.0
Modulus of elasticity kN/mm <sup>2</sup>	225	200	180
Thermal expansion ratio per °C	-	12.1x10 <sup>-6</sup>	12.6x10 <sup>-6</sup>
Thermal conductivity W/m°C	24	28	27
Specific heat J/kg °C	420	510	600

### SAFETY DATA SHEET

SDS: A

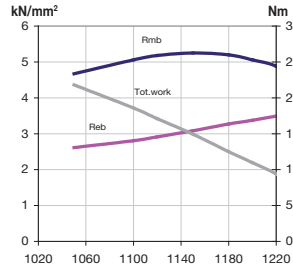
### IMPACT TOUGHNESS



Hardening Temperature in °C

Tempering 2 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Tempering 2 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

### COMPARATIVE PROPERTIES



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650



# CONVENTIONAL GRADES

## ABC III HIGH SPEED STEEL

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 3-3-2
- Germany: 1.3333

### DELIVERY HARDNESS

Typical soft annealed hardness is 220 HB.  
Cold drawn and cold rolled material is typically 10-40 HB harder.

### DESCRIPTION

ABC III is a medium alloyed high speed steel with good wear resistance.

### APPLICATIONS

- Power hacksaws
- Wear parts
- Hand hacksaws
- Vane pumps

### FORM SUPPLIED

- Strips
- Discs\*
- Sheets\*

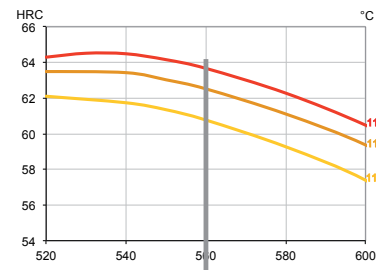
\* on request

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 2 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650



Tempering Temperature in °C  
Hardness after hardening, quenching and tempering 2 x 1 hour

Tool	Hardening	Tempering
Saws, wear parts, vane pumps, etc.	1100-1180°C	550-570°C

### PROCESSING

ABC III can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition).

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

#### PHYSICAL PROPERTIES

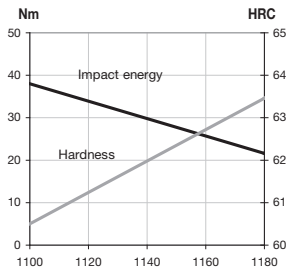
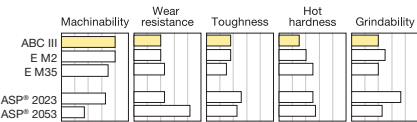
Density at 20°C: 8.0 g/cm³

#### SAFETY DATA SHEET

SDS: A

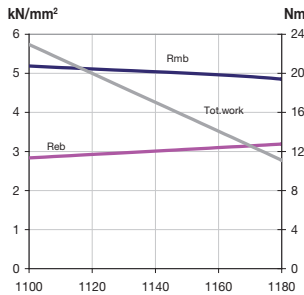
#### IMPACT TOUGHNESS

#### COMPARATIVE PROPERTIES



Hardening Temperature in °C  
Tempering 2 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

#### 4-POINT BEND STRENGTH



Hardening Temperature in °C  
Tempering 2 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

# CONVENTIONAL GRADES

## E M3:2 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.2	4.1	5.0	6.2	-	3.0

### STANDARDS

- USA: AISI M3:2
- Europe: HS 6-5-3
- Germany: 1.3344
- France: AFNOR Z120WDCV6.5.4.3
- Japan: JIS SKH53

### DELIVERY HARDNESS

Typical soft annealed hardness is 255 HB.  
Cold drawn and cold rolled material is typically 10-40 HB harder.

### DESCRIPTION

E M3:2 is a highly alloyed high speed steel for good wear resistance and high hardness.

### APPLICATIONS

- Taps & dies
- Punches
- Reamers
- Bi-metal saws
- Power hacksaws
- Hole saws

### FORM SUPPLIED

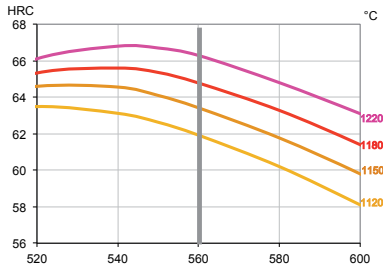
- Drawn wire
- Square bars
- Round bars
- Bi-metal edges
- Flat bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 3 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 3 x 1 hour

Tool	Hardening	Tempering
Single-edge cutting tools	1220°C	550-570°C
Multi-edge cutting tools	1180-1220°C	550-570°C
Cold work tools	1120-1180°C	550-570°C

### PROCESSING

- E M3:2 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

#### PHYSICAL PROPERTIES

Density at 20°C: 8.0 g/cm<sup>3</sup>

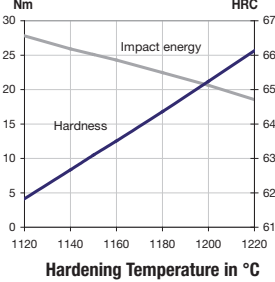
#### SAFETY DATA SHEET

SDS: A

#### COMPARATIVE PROPERTIES

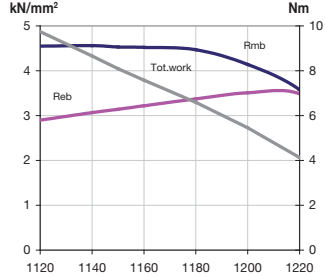


### IMPACT TOUGHNESS



Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



Tempering 3 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# CONVENTIONAL GRADES

## GRINDAMAX™ V3 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.2	3.9	5.2	7	-	2.7

### STANDARDS

- Europe: HS 7-5-3
- Germany: 1.3347

### DELIVERY HARDNESS

Typical soft annealed hardness is 265 HB.

Cold drawn and cold rolled material is typically 10-40 HB harder.

### DESCRIPTION

GRINDAMAX™ V3 is a Vanadium-based grade which has been developed to bridge the gap between conventional & PM 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.

### APPLICATIONS

- Taps & dies
- Punches
- Reamers
- Knives

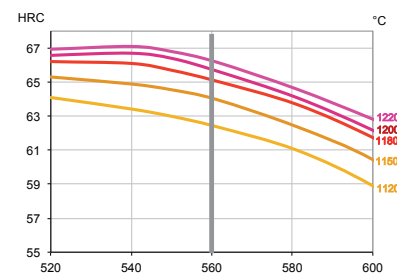
### FORM SUPPLIED

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 3 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C

Hardness after hardening, quenching and tempering 3 x 1 hour

Tool	Hardening	Tempering
Single-edge cutting tools	1220°C	550-570°C
Multi-edge cutting tools	1180-1220°C	550-570°C
Cold work tools	1120-1180°C	550-570°C

### PROCESSING

GRINDAMAX V3 can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

#### PHYSICAL PROPERTIES

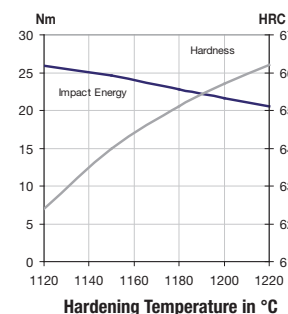
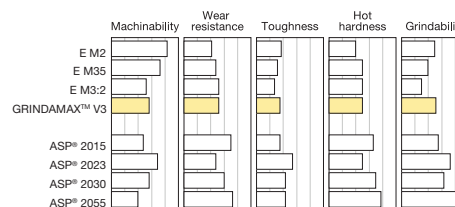
Density at 20°C: 8.0 g/cm³

#### SAFETY DATA SHEET

SDS: A

#### IMPACT TOUGHNESS

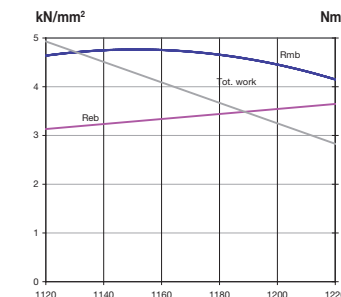
#### COMPARATIVE PROPERTIES



Hardening Temperature in °C

Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

#### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Tempering 3 x 1 hour at 560° C  
Dimension of test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm²

Reb = Bend yield strength in kN/mm²

Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# CONVENTIONAL GRADES

## E M4 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

C	Cr	Mo	W	Co	V
1.3	4.2	4.5	5.6	-	4.0

### STANDARDS

- USA: AISI M4
- Europe: HS 6-5-4
- Germany: 1.3351
- Japan: JIS SKH54
- France: AFNOR X135WMoCrV 6-5-4-4

### DELIVERY HARDNESS

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

### DESCRIPTION

E M4 is a Vanadium based grade used for cold work applications.

### APPLICATIONS

- Punches
- Form tools
- Rolls
- Broach inserts
- Dies

### FORM SUPPLIED

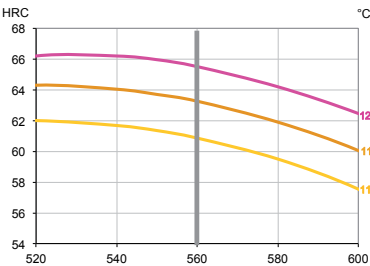
- Drawn wire
- Round bars
- Flat bars
- Square bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours followed by slow cooling at 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness.
- 2 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 2 x 1 hour

Tool	Hardening	Tempering
Single-edge cutting tools	1220°C	550-570°C
Multi-edge cutting tools	1100-1220°C	550-570°C
Cold work tools	1100-1180°C	550-570°C

### PROCESSING

E M4 can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

#### PHYSICAL PROPERTIES

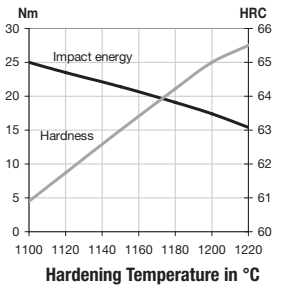
Density at 20°C: 8.0 g/cm³

#### SAFETY DATA SHEET

SDS: A

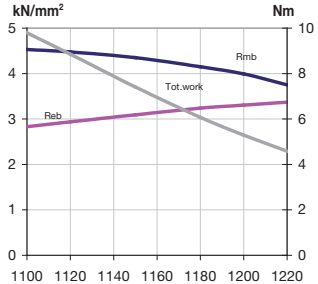
#### IMPACT TOUGHNESS

#### COMPARATIVE PROPERTIES



Tempering 2 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

#### 4-POINT BEND STRENGTH



Tempering 2 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm²  
Reb = Bend yield strength in kN/mm²  
Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# CONVENTIONAL GRADES

## E M35 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

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

### STANDARDS

- USA: AISI M35
- Europe: HS 6-5-2-5
- Germany: 1.3243
- France: AFNOR Z90WDCV6.5.5.4.2
- UK: BM35
- Japan: JIS SKH55

### DELIVERY HARDNESS

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

### 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.

### APPLICATIONS

- Reamers
- Milling cutters
- End mills
- Cutters
- Hobs
- Broaches
- Saws
- Cold work

### FORM SUPPLIED

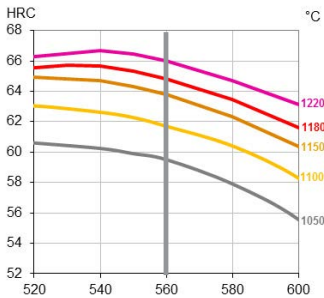
- Wire rod
- Drawn wire
- Round bars
- Flat bars
- Square bars
- Strips
- Sheets
- Discs

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 2 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Hardness after hardening, quenching and tempering 2 x 1 hour

Tool	Hardening	Tempering
Single-edge cutting tools	1220°C	560°C
Multi-edge cutting tools	1180-1220°C	550-570°C
Cold work tools	1050-1150°C	550-570°C

### PROCESSING

- E M35 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

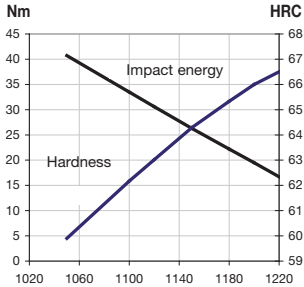
#### PHYSICAL PROPERTIES

	20°C	Temperature 400°C	600°C
Density g /cm <sup>3</sup>	8.1	8.0	8.0
Modulus of elasticity kN/mm <sup>2</sup>	230	205	184
Thermal expansion ratio per °C	-	11.6x10 <sup>-6</sup>	11.9x10 <sup>-6</sup>
Thermal conductivity W/m°C	24	28	27
Specific heat J/kg °C	420	510	600

### SAFETY DATA SHEET

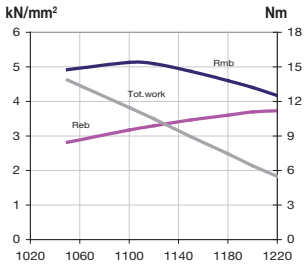
SDS: B

### IMPACT TOUGHNESS



Tempering 2 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



Tempering 2 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

### COMPARATIVE PROPERTIES



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650



# CONVENTIONAL GRADES

## C8 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 5-6-2-8

### DELIVERY HARDNESS

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

### DESCRIPTION

C8 is a conventionally manufactured Cobalt-alloyed high speed steel, characterised by a high resistance to high temperatures, a very high hardness.

### APPLICATIONS

- End mills
- Milling cutters
- Twist drills

### FORM SUPPLIED

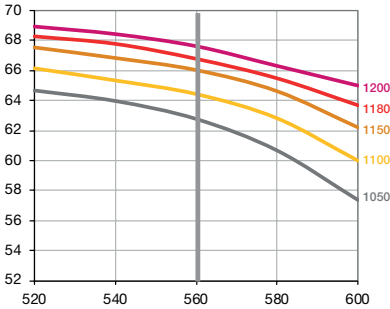
- Round bars
- Flat bars
- Square bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 3 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



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

Tool	Hardening	Tempering
Single-edge cutting tools	1200°C	550-570°C
Multi-edge cutting tools	1150-1180°C	550-570°C
Cold work tools	1050-1150°C	550-570°C

### PROCESSING

- C8 can be worked as follows:
- machining (grinding, turning, milling)
  - polishing
  - plastic forming
  - electrical discharge machining
  - welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the microstructure, must be avoided. Grinding wheel manufacturers can supply advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

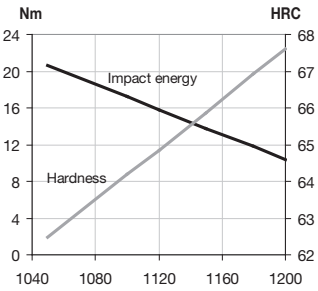
#### PHYSICAL PROPERTIES

	20°C	Temperature 400°C	600°C
Density g /cm <sup>3</sup>	8.1	8.0	7.9
Modulus of elasticity kN/mm <sup>2</sup>	230	205	184
Thermal expansion ratio per °C	-	11.5x10 <sup>-6</sup>	11.8x10 <sup>-6</sup>
Thermal conductivity W/m°C	24	28	27
Specific heat J/kg °C	420	510	600

### SAFETY DATA SHEET

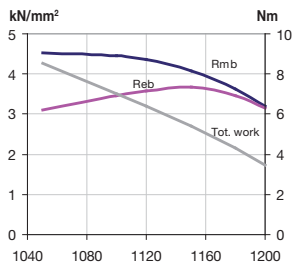
SDS: B

### IMPACT TOUGHNESS



Hardening Temperature in °C  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



Hardening Temperature in °C  
Tempering 3 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm  
Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

### COMPARATIVE PROPERTIES



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# CONVENTIONAL GRADES

## E MAT II HIGH SPEED STEEL

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 1-5-1-8

### DELIVERY HARDNESS

Typical soft annealed hardness is 240 HB.  
Cold drawn and cold rolled material is typically 10-40 HB harder.

### DESCRIPTION

E Matrix II is a high speed steel with excellent toughness combined with a good heat resistance.

### APPLICATIONS

- Bi-metal saws
- Sabre saws
- Bandsaws

### FORM SUPPLIED

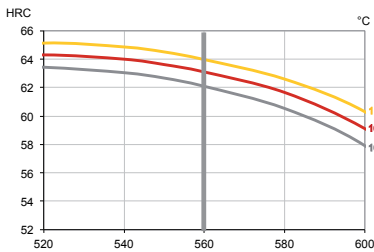
- Bi-metal edges
- Strips

Available surface conditions: cold rolled.

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 2 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C

Hardness after hardening, quenching and tempering 2 x 1 hour

Tool	Hardening	Tempering
Saws	1050-1100°C	550-570°C

### PROCESSING

E MAT II can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

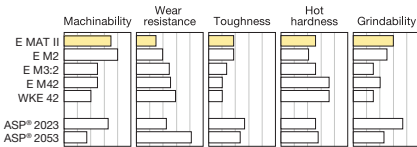
#### PHYSICAL PROPERTIES

Density at 20°C: 7.9 g/cm<sup>3</sup>

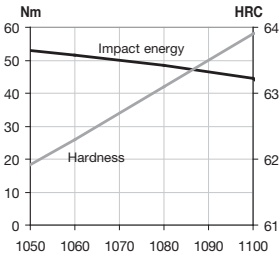
#### SAFETY DATA SHEET

SDS: B

#### COMPARATIVE PROPERTIES



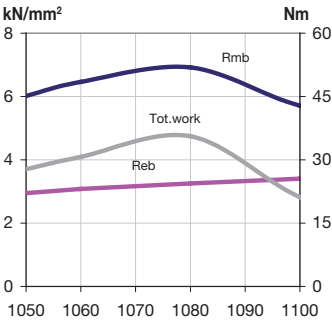
### IMPACT TOUGHNESS



Hardening Temperature in °C

Tempering 2 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Tempering 2 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# CONVENTIONAL GRADES

## E M42 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

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

### STANDARDS

- USA: AISI M42
- Europe: HS 2.9.1.8
- Germany: 1.3247
- France: AFNOR Z110DKCW9.8.4.2.1
- UK: BM42
- Japan: JIS SKH59

### DELIVERY HARDNESS

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

### DESCRIPTION

E M42 is a highly 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.

### APPLICATIONS

- Twist drills
- Broache
- Milling cutters
- Reamers
- End mills
- Bandsaws

### FORM SUPPLIED

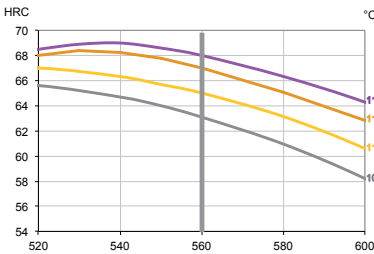
- Wire rod
- Sheets
- Drawn wire
- Discs
- Round bars
- Bi-metal edge
- Flat bars
- Square bars

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

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C, for 3 hours, followed by slow cooling at 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening with pre-heating in 2 steps at 450-500°C and 850-900°C and austenitizing at a temperature suitable for chosen working hardness.
- 3 tempers at 560°C are recommended (maintain at least 1 hour each at temperature).

### GUIDELINES FOR HARDENING



Tempering Temperature in °C

Hardness after hardening, quenching and tempering 3 x 1 hour

Tool	Hardening	Tempering
Single-edge cutting tools	1190°C	560°C
Multi-edge cutting tools	1150-1180°C	550-570°C
Cold work tools	1050-1150°C	550-570°C

### PROCESSING

E M42 can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

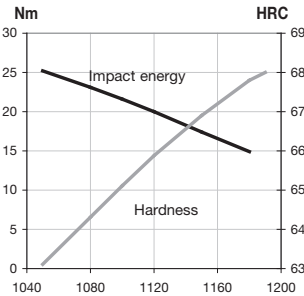
#### PHYSICAL PROPERTIES

	20°C	Temperature 400°C	600°C
Density g /cm <sup>3</sup>	8.0	7.9	7.9
Modulus of elasticity kN/mm <sup>2</sup>	225	200	180
Thermal expansion ratio per °C	-	11.5x10 <sup>-6</sup>	11.8x10 <sup>-6</sup>
Thermal conductivity W/m°C	24	28	27
Specific heat J/kg °C	420	510	600

### SAFETY DATA SHEET

SDS: B

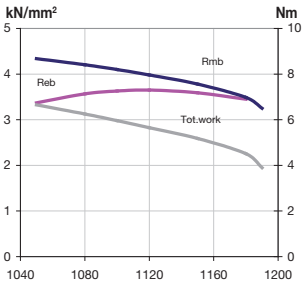
### IMPACT TOUGHNESS



Hardening Temperature in °C

Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### 4-POINT BEND STRENGTH



Hardening Temperature in °C

Tempering 3 x 1 hour at 560° C  
Unnotched test piece Ø 4.7 mm

Rmb = Ultimate bend strength in kN/mm<sup>2</sup>  
Reb = Bend yield strength in kN/mm<sup>2</sup>  
Tot. work = Total work in Nm

### COMPARATIVE PROPERTIES



Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

# CONVENTIONAL GRADES

## WKE 42 HIGH SPEED STEEL

### CHEMICAL COMPOSITION

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

### STANDARDS

- Europe: HS 10-4-3-10
- USA : AISI M51
- Germany: 1.3207
- France: AFNOR Z130WKCDV10.10.4.4.3
- Japan: JIS SKH57

### DELIVERY HARDNESS

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

### DESCRIPTION

WKE 42 is a proprietary Tungsten high speed steel containing 10 percent cobalt. WKE 42 is harder than most high speed steels and has in addition a reasonably good toughness. WKE 42 is used mainly for tools requiring maximum abrasion resistance and medium toughness.

### APPLICATIONS

- Toolbits
- Cold work tools
- Milling cutters
- Form tools
- Bandsaws

### FORM SUPPLIED

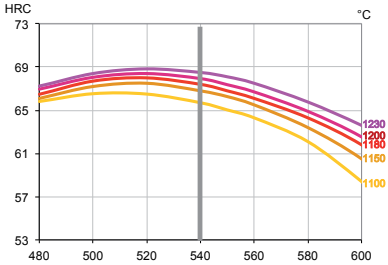
- Wire rods
- Bimetal edge
- Round bars
- Square bars
- Flat bars

Available surface conditions: ground, peeled, rough-machined.

### HEAT TREATMENT

- Soft annealing in a protective atmosphere at 850-900°C for 3 hours, followed by slow cooling 10°C per hour down to 700°C, then air cooling.
- Stress-relieving at 600°C to 700°C for approximately 2 hours, slow cooling down to 500°C.
- Hardening 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 chosen working hardness.
- 3 tempers at 560°C are recommended with at least 1 hour holding time each time.

### GUIDELINES FOR HARDENING



Tempering Temperature in °C

Hardness after hardening, quenching and tempering 3 x 1 hour

Tool	Hardening	Tempering
Single-edge cutting tools	1230°C	550°C
Multi-edge cutting tools	1220-1225°C	560-580°C
Cold work tools	1150-1200°C	560-590°C

### PROCESSING

WKE 42 can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition)

### GRINDING

During grinding, local heating of the surface, which can alter the temper, must be avoided. Grinding wheel manufacturers can give some advice on the choice of grinding wheels.

### SURFACE TREATMENT

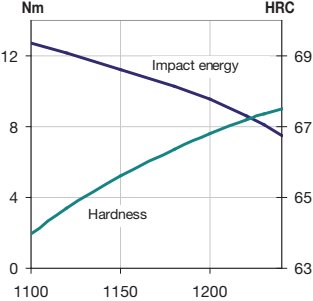
The steel grade is a perfect substrate material for PVD coating. If nitriding is requested, a small diffusion zone is recommended but avoid compound and oxidized layers.

### PROPERTIES

#### PHYSICAL PROPERTIES

	20°C	Temperature 400°C	600°C
Density g /cm <sup>3</sup>	8.2	8.1	8.1
Modulus of elasticity kN/mm <sup>2</sup>	240	215	190
Thermal expansion ratio per °C	-	10.2 x 10 <sup>-6</sup>	10.9x10 <sup>-6</sup>
Thermal conductivity W/m°C	24	28	27
Specific heat J/kg °C	420	510	600

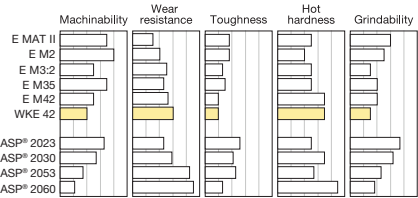
### IMPACT TOUGHNESS



Hardening Temperature in °C

Tempering 3 x 1 hour at 560° C  
Unnotched test piece 7 x 10 x 55 mm

### COMPARATIVE PROPERTIES



### SAFETY DATA SHEET

SDS: B

Approximate Conversion														
°C	20	25	400	450	500	520	540	560	600	620	700	800	850	900
°F	70	80	750	840	930	970	1000	1040	1110	1150	1290	1470	1560	1650

RECOMMENDED GRADES BY APPLICATION

Erasteel grades	Cutting Tools							
	Taps	Gear Cutting	Drills	Milling Cutters	Broaches	Deburring Tools	Tool Bits	Reamers
ASP® 2004	+	++	++	+	++	+		
ASP® 2005								
ASP® 2009								
ASP® 2011								
ASP® 2012		++						
ASP® 2015	+++	++	++	+	+++	++		
ASP® 2023	++	++	++	+	++	+		++
ASP® 2030	+++	+++	++	+++	+++	++	++	
ASP® 2042								
ASP® 2048								
ASP® 2051							+++	
ASP® 2052	+++	+++	++	++	++			
ASP® 2053								
ASP® 2055	+++	+++	++	+	+++			
ASP® 2060	+++	+++	+++	+++	+++	+++	+++	+++
ASP® 2062								
ASP® 2078		+++		+				
ASP® 2190		+++						
ASP® APZ10								
BlueTap® Co	++							
E M50			+					
E M2	+	+	+			+++	+	+
ABCIII								
E M3:2	+		+					++
Grindamax™V3	++							
E M4								
E M35	++	+	++			++	+	+
C8	+		++					
E MAT II								
E M42	+	+	++			+	++	++
WKE42							+++	

Legend: + Regular grade    ++ Better than average performance    +++ Exceptional performance

Erasteel grades	Cold Work				
	Blanking - Fine blanking	Forming	Extrusion	Powder compaction - Coining	Hot Extrusion - Hot forming
ASP® 2004	++	+	++	+	
ASP® 2005	+++	+++	++	++	+
ASP® 2009	+		+		
ASP® 2011	+		+		
ASP® 2012	++	+++	+	+++	++
ASP® 2015					
ASP® 2023	+++	+++	++	+	+
ASP® 2030	++		+		
ASP® 2042		+	+		
ASP® 2048					
ASP® 2051					
ASP® 2052	+++		+	+	+
ASP® 2053	+++	++	++	++	
ASP® 2055	+++	++	+++	++	+
ASP® 2060	++	+	++	++	+
ASP® 2062					
ASP® 2078					
ASP® 2190					
ASP® APZ10		+	++		
BlueTap® Co					
E M50					
E M2	+	+	+		
ABCIII					
E M3:2					
Grindamax™V3					
E M4	+		+		
E M35					
C8					
E MAT II					
E M42	+	+	+		
WKE42					

Legend: + Regular grade    ++ Better than average performance    +++ Exceptional performance



RECOMMENDED GRADES BY APPLICATION

Erasteel grades	Wear			
	Diesel injection	Vane pumps	Bearings	Other wear
ASP® 2004				
ASP® 2005	+++	+++		++
ASP® 2009				
ASP® 2011				
ASP® 2012				++
ASP® 2015			++	
ASP® 2023				++
ASP® 2030				
ASP® 2042	+++			++
ASP® 2048				
ASP® 2051				
ASP® 2052				
ASP® 2053				+++
ASP® 2055				
ASP® 2060			+++	
ASP® 2062			+++	
ASP® 2078				
ASP® 2190				
ASP® APZ10				
BlueTap® Co				
E M50	++		++	
E M2	+	++		
ABCIII		++		
E M3:2				
Grindamax™V3				
E M4				
E M35				
C8				
E MAT II				
E M42				
WKE 42				

Legend: + Regular grade    ++ Better than average performance    +++ Exceptional performance

Erasteel grades	Saws & Knives							
	Bandsaws	Circular saws	Hand hack saws	Hole saws	Jig & sabre saws	Power hack saws	Segment saws	Knives
ASP® 2004								
ASP® 2005								
ASP® 2009								
ASP® 2011								+
ASP® 2012								
ASP® 2015								
ASP® 2023								++
ASP® 2030	++	++			++			
ASP® 2042	++			++	++			
ASP® 2048								
ASP® 2051	++							
ASP® 2052								
ASP® 2053								++
ASP® 2055								
ASP® 2060								
ASP® 2062								
ASP® 2078								
ASP® 2190								
ASP® APZ10								
BlueTap® Co								
E M50								+
E M2		+	+	+	+	+	+	+
ABCIII			+		+	+	+	
E M3:2								++
Grindamax™V3								
E M4								+
E M35		++	++		++	++	++	
C8								
E MAT II			+	+	+			++
E M42	+							
WKE 42 (M51)	++							

Legend: + Regular grade    ++ Better than average performance    +++ Exceptional performance

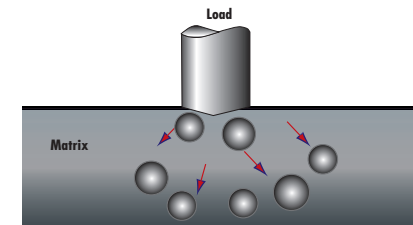
## TECHNICAL GUIDE



## HARDNESS

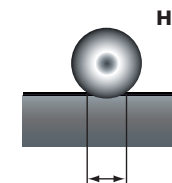
Hardness is the power needed to deform the matrix and to push the carbides away, but also a measure of how difficult it is to achieve a permanent deformation of the material.

Increased Co-content increases the matrix hardness, and increased Mo-, W- and V-content increases the amount of carbide that has to be pushed away.



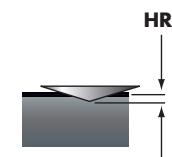
### Brinell

A hard steel, or carbide ball is pressed into the material at a given load. The diameter of the impression is measured and the hardness is obtained from a table. The hardness of soft annealed High Speed Steel is measured in Brinell.



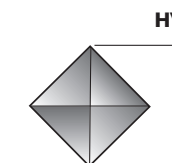
### Rockwell

A diamond cone with a top angle of  $120^\circ$  is pressed into the material at a given load. The impression depth gives the Rockwell hardness. The material surface must have a good finish, be clean and parallel with the bottom surface of the sample. The hardness of heat treated High Speed Steel is measured in Rockwell.



### Vickers

The Vickers hardness test uses a squarebase diamond pyramid. The angle between opposite faces of the pyramid is  $136^\circ$ . The diagonals of the square impression are measured under a microscope and the hardness can be obtained from a table. Vickers is commonly used today, because measurements done at different indentation loads can be compared directly. Hardness of a coating can be compared directly to a bulk hardness. The hardness of soft annealed or heat treated High Speed Steel is measured in Vickers.



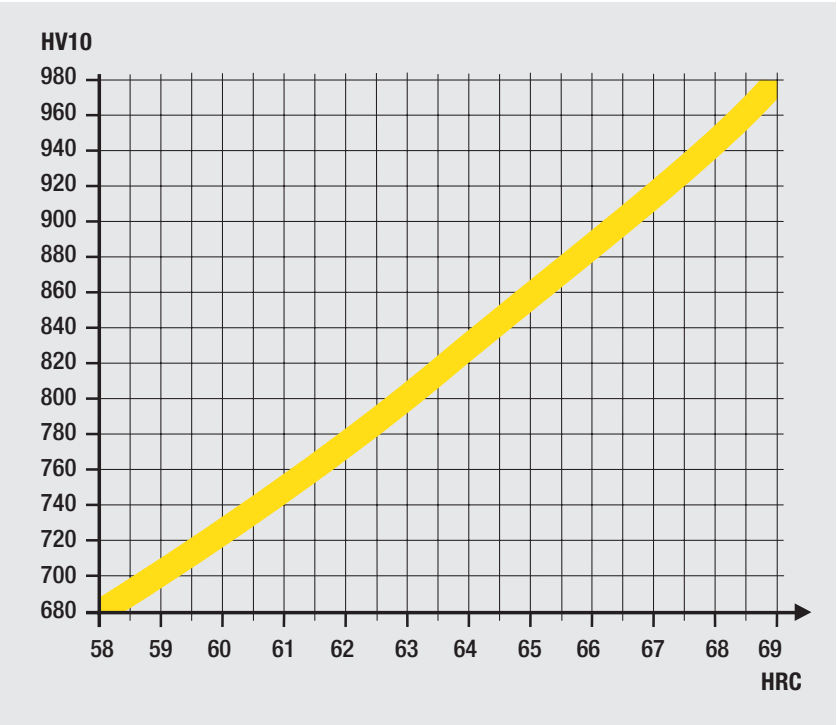
HARDNESS

Approximate conversion between  
hardness HV 10, HRC, HRB and HB

HV 10	HRC	HRB	HB
160	-	83	155
180	-	88	171
200	-	91.5	190
220	-	94.5	209
240	-	98	228
260	-	101	247
280	-	103	264
300	30	105.5	284
320	33	107	303
340	35	108	322
360	37	109	341
380	39	-	360
400	41	-	379
420	42.5	-	397
440	44	-	-
460	45.5	-	-
480	47	-	-
500	48.5	-	-
520	50	-	-
540	51	-	-
560	52.5	-	-
580	53.5	-	-
600	54.5	-	-
620	55.5	-	-
640	56.5	-	-
660	57.5	-	-
680	58	-	-
700	59	-	-
720	60	-	-
740	60.5	-	-
760	61.5	-	-
780	62.5	-	-
800	63	-	-
820	63.5	-	-
840	64.5	-	-
860	65	-	-
880	66	-	-
900	66.5	-	-
920	67	-	-
940	68	-	-
960	68.5	-	-
980	69	-	-
1000	69.5	-	-
1020	70	-	-
1040	70.5	-	-
1060	71	-	-

HARDNESS CONVERSION

HV 10/HRC, HSS tempered 3 x 560 C°

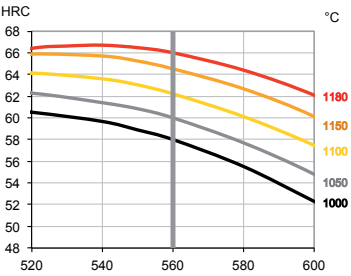


INTERNATIONAL STANDARDS

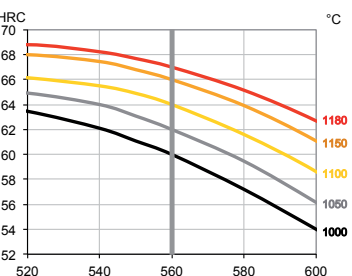
Erasteel	Europe	Germany (W.Nr.)	USA (AISI)	Japan (JIS)
ASP® 2004	HS 6-5-4	1.3361	M4	SKH54
ASP® 2005	HS 3-3-4	1.3377	-	-
ASP® 2009	-	-	-	-
ASP® 2011	-	-	A11	-
ASP® 2012	HS 2-2-2	1.3397	-	-
ASP® 2015	HS 12-0-5-5	1.3202	T15	SKH10
ASP® 2023	HS 6-5-3C	1.3395	M3:2	SKH53
ASP® 2030	HS 6-5-3-8	1.3294	-	-
ASP® 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 10-2-5-8	-	-	-
ASP® 2053	HS 4-3-8	1.3352	-	-
ASP® 2055	-	-	-	-
ASP® 2060	-	1.3292	-	-
ASP® 2062	HS 6-10-2	-	-	-
ASP® 2078	HS 6-7-6-10	1.3241	-	-
ASP® 2190				
ASP® APZ10	-	-	-	-
BlueTap Co	HS 6-5-2-5	1.3243	M35	SKH55
E M50	HS 0-4-1	1.3325	M50	-
E M2	HS 6-5-2	1.3343	M2	SKH51
ABC III	HS 3-3-2	1.3333	-	-
E M3:2	HS 6-5-3	1.3344	M3:2	SKH53
Grindamax V3	HS 7-5-3	1.3347	-	-
E M4	HS 6-5-4	1.3351	M4	SKH54
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
WKE 42	HS 10-4-3-10	1.3207	M51	SKH57

HRC – AND CCT-CURVES ASP

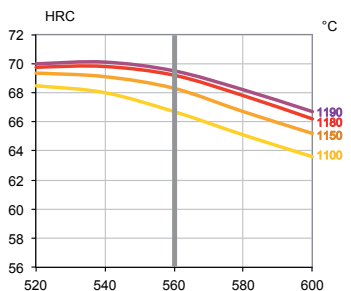
ASP®2023



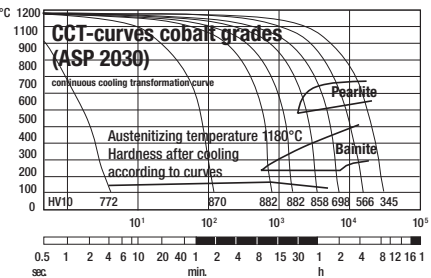
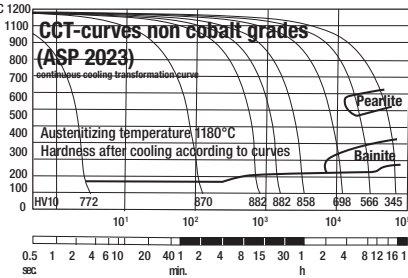
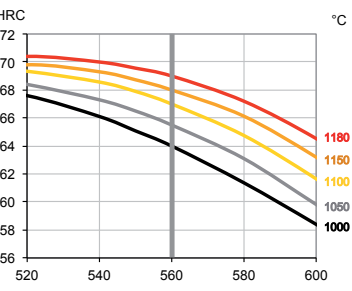
ASP®2030



ASP®2042



ASP®2060



# CONVERSION TABLES

## Temperature scales

Refer to the center column and find the number of degrees to be converted. If °F is to be converted to °C, the required figure is to be found in the left-hand column under C; for converting °C to °F refer to the right hand column.

C	o	F	C	o	F	C	o	F
-17.8	0	32	127	260	500	296	565	1049
-15.0	5	41	132	270	518	299	570	1058
-12.2	10	50	138	280	536	302	575	1067
-9.4	15	59	143	290	554	304	580	1076
-6.7	20	68	149	300	572	307	585	1085
-3.9	25	77	154	310	590	310	590	1094
-1.1	30	86	160	320	608	313	595	1103
1.7	35	95	166	330	626	316	600	1112
4.4	40	104	171	340	644	318	605	1121
7.2	45	113	177	350	662	321	610	1130
10.0	50	122	182	360	680	324	615	1139
12.8	55	131	188	370	698	327	620	1148
15.6	60	140	193	380	716	329	625	1157
18.3	65	149	199	390	734	332	630	1166
21.1	70	158	204	400	752	335	635	1175
23.9	75	167	210	410	770	338	640	1184
26.7	80	176	216	420	788	341	645	1193
29.4	85	185	221	430	806	343	650	1202
32.2	90	194	227	440	824	346	655	1211
35.0	95	203	232	450	842	349	660	1220
37.8	100	212	238	460	860	352	665	1229
43	110	230	243	470	878	354	670	1238
49	120	248	249	480	896	357	675	1247
54	130	266	254	490	914	360	680	1256
60	140	284	260	500	932	363	685	1265
66	150	302	263	505	941	366	690	1274
71	160	320	266	510	950	368	695	1283
77	170	338	268	515	959	371	700	1292
82	180	356	271	520	968	377	710	1310
88	190	374	274	525	977	382	720	1328
93	200	392	277	530	986	388	730	1346
99	210	410	279	535	995	393	740	1364
99	210	410	282	540	1004	399	750	1382
104	220	428	285	545	1013	404	760	1400
110	230	446	288	550	1022	410	770	1418
116	240	464	291	555	1031	416	780	1436
121	250	482	293	560	1040	421	790	1454

# CONVERSION TABLES

$$^{\circ}\text{F} = \frac{^{\circ}\text{C} \times 9}{5} + 32$$

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$$

C	o	F	C	o	F	C	o	F
427	800	1472	671	1240	2264	916	1680	3056
432	810	1490	677	1250	2282	921	1690	3074
438	820	1508	682	1260	2300	927	1700	3092
443	830	1526	688	1270	2318	932	1710	3110
449	840	1544	693	1280	2336	938	1720	3128
454	850	1562	699	1290	2354	943	1730	3146
460	860	1580	704	1300	2372	949	1740	3164
466	870	1598	710	1310	2390	954	1750	3182
471	880	1616	716	1320	2408	960	1760	3200
477	890	1634	721	1330	2426	966	1770	3218
482	900	1652	727	1340	2444	971	1780	3236
488	910	1670	732	1350	2462	977	1790	3254
493	920	1688	738	1360	2480	982	1800	3272
499	930	1706	743	1370	2498	988	1810	3290
504	940	1724	749	1380	2516	993	1820	3308
510	950	1742	754	1390	2534	999	1830	3326
516	960	1760	760	1400	2552	1004	1840	3344
521	970	1778	766	1410	2570	1010	1850	3362
527	980	1796	771	1420	2588	1016	1860	3380
532	990	1814	777	1430	2606	1021	1870	3398
538	1000	1832	782	1440	2624	1027	1880	3416
543	1010	1850	788	1450	2642	1032	1890	3434
549	1020	1868	793	1460	2660	1038	1900	3452
554	1030	1886	799	1470	2678	1043	1910	3470
560	1040	1904	804	1480	2696	1049	1920	3488
566	1050	1922	810	1490	2714	1054	1930	3506
571	1060	1940	816	1500	2732	1060	1940	3524
577	1070	1958	821	1510	2750	1066	1950	3542
582	1080	1976	827	1520	2768	1071	1960	3560
588	1090	1994	832	1530	2786	1077	1970	3578
593	1100	2012	838	1540	2804	1082	1980	3596
599	1110	2030	843	1550	2822	1093	2000	3632
604	1120	2048	849	1560	2840	1121	2050	3722
610	1130	2066	854	1570	2858	1149	2100	3812
616	1140	2084	860	1580	2876	1177	2150	3902
621	1150	2102	866	1590	2894	1204	2200	3992
627	1160	2120	871	1600	2912	1232	2250	4082
632	1170	2138	877	1610	2930	1260	2300	4172
638	1180	2156	882	1620	2948	1288	2350	4262
643	1190	2174	888	1630	2966	1316	2400	4352
649	1200	2192	893	1640	2984	1343	2450	4442
654	1210	2210	899	1650	3002	1371	2500	4532
660	1220	2228	904	1660	3020	-	-	-
666	1230	2246	910	1670	3038	-	-	-



CONVERSION TABLES

The effect of alloying elements on the properties of steels

Alloying element	Hardness	Strength	Yield point	Elongation	Reduction of area	Impact strength	Elasticity	High temp. stability
Silicon	+	+	++	-	≈	-	+++	+
Chromium	++	++	++	-	-	-	+	+
Aluminium					-	-		
Tungsten	+	+	+	-	-	≈		+++
Vanadium	+	+	+	≈	≈	+	+	++
Cobalt	+	+	+	-	-	-		++
Molybdenum	+	+	+	-	-	+		++
Copper	+	+	++	≈	≈	≈		+
Sulphur				-	-	-		
Phosphorus	+	+	+	-	-	---		
Carbon	+++	+++	+++	-	≈	-	-	-

**Legend:**

+ Increase

++ Large Increase

+++ Very Large Increase

- Reduction

-- Large Reduction

--- Strong Reduction

≈ ca. constant not characteristic or unknown

Alloying element	Cooling rate	Carbide formation	Resistance to wear	Machinability	Scaling	Nitrability	Resistance to corrosion
Silicon	-	-	---	-	-	-	
Chromium	---	++	+		---	++	+++
Aluminium					-	+++	
Tungsten	--	++	+++	-	-	+	
Vanadium	--	++++	++		-	+	+
Cobalt	++		+++	≈	-		
Molybdenum	--	+++	++	-	++	++	
Copper				≈	≈		+
Sulphur				+++			-
Phosphorus				++			
Carbon				-	-		≈

**Legend:**

+ Increase

++ Large Increase

+++ Very Large Increase

- Reduction

-- Large Reduction

--- Strong Reduction

≈ ca. constant not characteristic or unknown

CONVERSION TABLES

Round and square  
weights kg/m for HSS. Density 8.00

mm	●	■	mm	●	■	mm	●	■
1	0.01	0.01	45	12.7	16.2	89	49.8	63.4
2	0.03	0.03	46	13.3	16.9	90	50.9	64.8
3	0.06	0.07	47	13.9	17.7	91	52.0	66.2
4	0.10	0.13	48	14.5	18.4	92	53.2	67.7
5	0.16	0.20	49	15.1	19.2	93	54.3	69.2
6	0.23	0.29	50	15.7	20.0	94	55.5	70.7
7	0.31	0.39	51	16.3	20.8	95	56.7	72.2
8	0.40	0.51	52	17.0	21.6	96	57.9	73.7
9	0.51	0.65	53	17.6	22.5	97	59.1	75.3
10	0.63	0.80	54	18.3	23.3	98	60.3	76.8
11	0.76	0.97	55	19.0	24.2	99	61.6	78.4
12	0.90	1.15	56	19.7	25.1	100	62.8	80.0
13	1.06	1.35	57	20.4	26.0	105	69.3	88.2
14	1.23	1.57	58	21.3	26.9	110	76.0	96.8
15	1.41	1.80	59	21.9	27.8	115	83.1	106
16	1.61	2.05	60	22.6	28.8	120	90.5	115
17	1.82	2.31	61	23.4	29.8	125	98.2	125
18	2.04	2.59	62	24.2	30.8	130	106	135
19	2.27	2.89	63	24.9	31.8	135	115	146
20	2.51	3.20	64	25.7	32.8	140	123	157
21	2.77	3.53	65	26.5	33.8	145	132	168
22	3.04	3.87	66	27.4	34.8	150	141	180
23	3.32	4.23	67	28.2	35.9	155	151	192
24	3.62	4.61	68	29.1	37.0	160	161	205
25	3.93	5.00	69	29.9	38.1	165	171	218
26	4.25	5.41	70	30.8	39.2	170	182	231
27	4.58	5.83	71	31.7	40.3	175	192	245
28	4.93	6.27	72	32.6	41.5	180	204	259
29	5.28	6.73	73	33.5	42.6	185	215	274
30	5.65	7.20	74	34.4	43.8	190	227	289
31	6.04	7.69	75	35.3	45.0	195	239	304
32	6.43	8.19	76	36.3	46.2	200	251	320
33	6.84	8.71	77	37.3	47.4	210	277	353
34	7.26	9.25	78	38.2	48.7	220	304	387
35	7.70	9.80	79	39.2	49.9	230	332	423
36	8.14	10.37	80	40.2	51.2	240	362	461
37	8.60	10.95	81	41.2	52.5	250	393	500
38	9.07	11.55	82	42.2	53.8	260	425	541
39	9.56	12.17	83	43.3	55.1	270	458	583
40	10.05	12.80	84	44.3	56.4	280	493	627
41	10.56	13.45	85	45.4	57.8	290	528	673
42	11.08	14.11	86	46.5	59.2	300	565	720
43	11.62	14.79	87	47.6	60.6	310	604	769
44	12.16	15.49	88	48.7	62.0	320	643	819

Weights kg/m  
for flat HSS. Density 8.00

Thickness mm	Width mm									
	10	12	14	16	18	20	25	30	35	40
5	0.40	0.48	0.56	0.64	0.72	0.80	1.00	1.20	1.40	1.60
6	0.48	0.58	0.67	0.77	0.86	0.96	1.20	1.44	1.68	1.92
7	0.56	0.67	0.78	0.90	1.01	1.12	1.40	1.68	1.96	2.24
8	0.64	0.77	0.90	1.02	1.15	1.28	1.60	1.92	2.24	2.56
9	0.72	0.86	1.01	1.15	1.30	1.44	1.80	2.16	2.52	2.88
10	0.80	0.96	1.12	1.28	1.44	1.60	2.00	2.40	2.80	3.20
11		1.06	1.23	1.41	1.58	1.76	2.20	2.64	3.08	3.52
12		1.15	1.34	1.54	1.73	1.92	2.40	2.88	3.36	3.84
13			1.46	1.66	1.87	2.08	2.60	3.12	3.64	4.16
14			1.57	1.79	2.02	2.24	2.80	3.36	3.92	4.48
15				1.92	2.16	2.40	3.00	3.60	4.20	4.80
16				2.05	2.30	2.56	3.20	3.84	4.48	5.12
17					2.45	2.72	3.40	4.08	4.76	5.44
18					2.59	2.88	3.60	4.32	5.04	5.76
19						3.04	3.80	4.56	5.32	6.08
20						3.20	4.00	4.80	5.60	6.40
25							5.00	6.00	7.00	8.00
30								7.20	8.40	9.60
35									9.80	11.2
40										12.8
45										
50										
55										
60										
65										
70										
75										
80										
85										
90										
95										
100										
110										
120										
130										
140										
160										
180										
200										
250										
300										

CONVERSION TABLES

Weights kg/m  
for flat HSS. Density 8.00

Thickness mm	Width mm											
	45	50	55	60	70	80	90	100	110	120	130	
5	1.80	2.00	2.20	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	
6	2.16	2.40	2.64	2.88	3.36	3.84	4.32	4.80	5.28	5.76	6.24	
7	2.52	2.80	3.08	3.36	3.92	4.48	5.04	5.60	6.16	6.72	7.28	
8	2.88	3.20	3.52	3.84	4.48	5.12	5.76	6.40	7.04	7.68	8.32	
9	3.24	3.60	3.96	4.32	5.04	5.76	6.48	7.20	7.92	8.64	9.36	
10	3.60	4.00	4.40	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.4	
11	3.96	4.40	4.84	5.28	6.16	7.04	7.92	8.80	9.68	10.6	11.4	
12	4.32	4.80	5.28	5.76	6.72	7.68	8.64	9.60	10.56	11.5	12.5	
13	4.68	5.20	5.72	6.24	7.28	8.32	9.36	10.4	11.4	12.5	13.5	
14	5.04	5.60	6.16	6.72	7.84	8.96	10.1	11.2	12.3	13.4	14.6	
15	5.40	6.00	6.60	7.20	8.40	9.60	10.8	12.0	13.2	14.4	15.6	
16	5.76	6.40	7.04	7.68	8.96	10.2	11.5	12.8	14.1	15.4	16.6	
17	6.12	6.80	7.48	8.16	9.52	10.9	12.2	13.6	15.0	16.3	17.7	
18	6.48	7.20	7.92	8.64	10.1	11.5	13.0	14.4	15.8	17.3	18.7	
19	6.84	7.60	8.36	9.12	10.6	12.2	13.7	15.2	16.7	18.2	19.8	
20	7.20	8.00	8.80	9.60	11.2	12.8	14.4	16.0	17.6	19.2	20.8	
25	9.0	10.0	11.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	
30	10.8	12.0	13.2	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.2	
35	12.6	14.0	15.4	16.8	19.6	22.4	25.2	28.0	30.8	33.6	36.4	
40	14.4	16.0	17.6	19.2	22.4	25.6	28.8	32.0	35.2	38.4	41.6	
45	16.2	18.0	19.8	21.6	25.2	28.8	32.4	36.0	39.6	43.2	46.8	
50		20.0	22.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	
55			24.2	26.4	30.8	35.2	39.6	44.0	48.4	52.8	57.2	
60				28.8	33.6	38.4	43.2	48.0	52.8	57.6	62.4	
65					36.4	41.6	46.8	52.0	57.2	62.4	67.6	
70					39.2	44.8	50.4	56.0	61.6	67.2	72.8	
75						48.0	54.0	60.0	66.0	72.0	78.0	
80						51.2	57.6	64.0	70.4	76.8	83.2	
85							61.2	68.0	74.8	81.6	88.4	
90							64.8	72.0	79.2	86.4	93.6	
95								76.0	83.6	91.2	98.8	
100									88.0	96.0	104	
110									96.8	106	114	
120										115	125	
130											135	
140												
160												
180												
200												
250												
300												

Weights kg/m  
for flat HSS. Density 8.00

Thickness mm	Width mm											
	140	150	160	180	200	225	250	275	300	350	500	400
5	5.60	6.00	6.40	7.20	8.00	9.00	10.0	11.0	12.0	14.0	16.0	20.0
6	6.72	7.20	7.68	8.64	9.60	10.8	12.0	13.2	14.4	16.8	19.2	24.0
7	7.84	8.40	8.96	10.1	11.2	12.6	14.0	15.4	16.8	19.6	22.4	28.0
8	8.96	9.60	10.2	11.5	12.8	14.4	16.0	17.6	19.2	22.4	25.6	32.0
9	10.1	10.8	11.5	13.0	14.4	16.2	18.0	19.8	21.6	25.2	28.8	36.0
10	11.2	12.0	12.8	14.4	16.0	18.0	20.0	22.0	24.0	28.0	32.0	40.0
11	12.3	13.2	14.1	15.8	17.6	19.8	22.0	24.2	26.4	30.8	35.2	44.0
12	13.4	14.4	15.4	17.3	19.2	21.6	24.0	26.4	28.8	33.6	38.4	48.0
13	14.6	15.6	16.6	18.7	20.8	23.4	26.0	28.6	31.2	36.4	41.6	52.0
14	15.7	16.8	17.9	20.2	22.4	25.2	28.0	30.8	33.6	39.2	44.8	56.0
15	16.8	18.0	19.2	21.6	24.0	27.0	30.0	33.0	36.0	42.0	48.0	60.0
16	17.9	19.2	20.5	23.0	25.6	28.8	32.0	35.2	38.4	44.8	51.2	64.0
17	19.0	20.4	21.8	24.5	27.2	30.6	34.0	37.4	40.8	47.6	54.4	68.0
18	20.2	21.6	23.0	25.9	28.8	32.4	36.0	39.6	43.2	50.4	57.6	72.0
19	21.3	22.8	24.3	27.4	30.4	34.2	38.0	41.8	45.6	53.2	60.8	76.0
20	22.4	24.0	25.6	28.8	32.0	36.0	40.0	44.0	48.0	56.0	64.0	80.0
25	28.0	30.0	32.0	36.0	40.0	45.0	50.0	55.0	60.0	70.0	80.0	100
30	33.6	36.0	38.4	43.2	48.0	54.0	60.0	66.0	72.0	84.0	96.0	120
35	39.2	42.0	44.8	50.4	56.0	63.0	70.0	77.0	84.0	98.0	112	140
40	44.8	48.0	51.2	57.6	64.0	72.0	80.0	88.0	96.0	112	128	160
45	50.4	54.0	57.6	64.8	72.0	81.0	90.0	99.0	108	126	144	180
50	56.0	60.0	64.0	72.0	80.0	90.0	100	110	120	140	160	200
55	61.6	66.0	70.4	79.2	88.0	99.0	110	121	132	154	176	220
60	67.2	72.0	76.8	86.4	96.0	108	120	132	144	168	192	240
65	72.8	78.0	83.2	93.6	104	117	130	143	156	182	208	260
70	78.4	84.0	89.6	101	112	126	140	154	168	196	224	280
75	84.0	90.0	96.0	108	120	135	150	165	180	210	240	300
80	89.6	96	102	115	128	144	160	176	192	224	256	320
85	95.2	102	109	122	136	153	170	187	204	238	272	340
90	101	108	115	130	144	162	180	198	216	252	288	360
95	106	114	122	137	152	171	190	209	228	266	304	380
100	112	120	128	144	160	180	200	220	240	280	320	400
110	123	132	141	158	176	198	220	242	264	308	352	440
120	134	144	154	173	192	216	240	264	288	336	384	480
130	146	156	166	187	208	234	260	286	312	364	416	520
140	157	168	179	202	224	252	280	308	336	392	448	560
160			205	230	256	288	320	352	384	448	512	640
180				259	288	324	360	396	432	504	576	720
200					320	360	400	440	480	560	640	800
250							500	550	600	700	800	1000
300									720	840	960	1200

CONVERSION TABLES

ISO-tolerances

The tolerance range IT in mm is given according to the international ISO-system.

Diameter (mm)		Tolerance range						
over	up to	IT8	IT9	IT10	IT11	IT12	IT13	IT14
	3	0.014	0.025	0.040	0.060	0.100	0.140	0.250
3	6	0.018	0.030	0.048	0.075	0.120	0.180	0.300
6	10	0.022	0.036	0.058	0.090	0.150	0.220	0.360
10	18	0.027	0.043	0.070	0.110	0.180	0.270	0.430
18	30	0.033	0.052	0.084	0.130	0.210	0.330	0.520
30	50	0.039	0.062	0.100	0.160	0.250	0.390	0.620
50	80	0.046	0.074	0.120	0.190	0.300	0.460	0.740
80	120	0.054	0.087	0.140	0.220	0.350	0.540	0.870
120	180	0.063	0.100	0.160	0.250	0.400	0.630	1.000
180	250	0.072	0.115	0.185	0.290	0.460	0.720	1.150
250	315	0.081	0.130	0.210	0.320	0.520	0.810	1.300
315	400	0.089	0.140	0.230	0.360	0.570	0.890	1.400
400	500	0.097	0.155	0.250	0.400	0.630	0.970	1.550
500	630	0.110	0.175	0.280	0.440	0.700	1.100	1.750
630	800	0.125	0.200	0.320	0.500	0.800	1.250	2.000

Tolerance location for external dimensions:

- h = minus only
- js = half minus, half plus
- k = plus only

Inches and fractions to millimetres

Inches	0	1/64	1/32	1/16	1/8	3/16	1/4	5/16
	Millimetres							
0		0.40	0.79	1.59	3.18	4.76	6.35	7.94
1	25.40	25.80	26.19	26.99	28.58	30.16	31.75	33.34
2	50.80	51.20	51.59	52.39	53.98	55.56	57.15	58.74
3	76.20	76.60	76.99	77.79	79.38	80.96	82.55	84.14
4	101.60	102.00	102.39	103.19	104.78	106.36	107.95	109.54
5	127.00	127.40	127.79	128.59	130.18	131.76	133.35	134.94
6	152.40	152.80	153.19	153.99	155.58	157.16	158.75	160.34
7	177.80	178.20	178.59	179.39	180.98	182.56	184.15	185.74
8	203.20	203.60	203.99	204.79	206.38	207.96	209.55	211.14
9	228.60	229.00	229.39	230.19	231.78	233.36	234.95	236.54
10	254.00	254.40	254.79	255.59	257.18	258.76	260.35	261.94
11	279.40	254.40	280.19	280.99	282.58	284.16	285.75	287.34
12	304.80	254.40	305.59	306.39	307.98	309.56	311.15	312.74

Inches	3/8	7/16	1/2	9/16	5/8	3/4	7/8
	Millimetres						
0	9.53	11.11	12.70	14.29	15.88	19.05	22.26
1	34.93	36.51	38.10	39.69	41.28	44.45	47.63
2	60.33	61.91	63.50	65.09	66.68	69.85	73.03
3	85.73	87.31	88.90	90.49	92.08	95.25	98.43
4	111.13	112.71	3114.30	115.89	117.48	120.65	123.83
5	136.53	138.11	3139.70	141.29	142.88	146.05	149.23
6	161.93	163.51	3165.10	166.69	168.28	171.45	174.63
7	187.33	188.91	3190.50	192.09	193.68	196.85	200.03
8	212.73	214.31	3215.90	217.49	219.08	222.25	225.43
9	238.13	239.71	3241.30	242.89	244.48	247.65	250.83
10	263.53	265.11	3266.70	268.29	269.88	273.05	276.23
11	288.93	290.51	3292.10	293.69	295.28	298.45	301.63
12	314.33	315.91	3317.50	319.09	320.68	323.85	327.03

CONVERSION TABLES

Millimetres to inches

mm	inch	mm	inch	mm	inch	mm	inch
1	0.039	31	1.220	61	2.402	91	3.583
2	0.079	32	1.260	62	2.441	92	3.622
3	0.118	33	1.299	63	2.480	93	3.661
4	0.157	34	1.339	64	2.520	94	3.701
5	0.197	35	1.378	65	2.559	95	3.740
6	0.236	36	1.417	66	2.598	96	3.780
7	0.276	37	1.457	67	2.638	97	3.819
8	0.315	38	1.496	68	2.677	98	3.858
9	0.354	39	1.535	69	2.717	99	3.898
10	0.394	40	1.575	70	2.756	100	3.937
11	0.433	41	1.614	71	2.795	110	4.331
12	0.472	42	1.654	72	2.835	120	4.724
13	0.512	43	1.693	73	2.874	130	5.118
14	0.551	44	1.732	74	2.913	140	5.512
15	0.591	45	1.772	75	2.953	150	5.906
16	0.630	46	1.811	76	2.992	160	6.299
17	0.669	47	1.850	77	3.031	170	6.693
18	0.709	48	1.890	78	3.071	180	7.087
19	0.748	49	1.929	79	3.110	190	7.480
20	0.787	50	1.969	80	3.150	200	7.874
21	0.827	51	2.008	81	3.189	210	8.268
22	0.866	52	2.047	82	3.228	220	8.661
23	0.906	53	2.087	83	3.268	230	9.055
24	0.945	54	2.126	84	3.307	240	9.449
25	0.984	55	2.165	85	3.346	250	9.843
26	1.024	56	2.205	86	3.386	260	10.236
27	1.063	57	2.244	87	3.425	270	10.630
28	1.102	58	2.283	88	3.465	280	11.024
29	1.142	59	2.323	89	3.504	290	11.417
30	1.181	60	2.362	90	3.543	300	11.811

Length

	m	mm	inch	foot	yard
1 m	1	10 <sup>3</sup>	39.3701	3.2808	1.0936
1 mm	10 <sup>-3</sup>	1	39.37 x10 <sup>-3</sup>	3.281 x10 <sup>-3</sup>	1.094 x10 <sup>-3</sup>
1 inch	25.4 x10 <sup>-3</sup>	25.4	1	83.33 x10 <sup>-3</sup>	27.78 x10 <sup>-3</sup>
1 foot	0.3048	304.8	12	1	0.3333
1 yard	0.9144	914.4	36	3	1
1 mile (eng.)	1.6093 x10 <sup>3</sup>	1.6093 x10 <sup>6</sup>	63.36 x10 <sup>3</sup>	5.28 x10 <sup>3</sup>	1.76 x10 <sup>3</sup>
1 mile (nautic)	1.852 x10 <sup>3</sup>	1.852 x10 <sup>6</sup>	72.91 x10 <sup>3</sup>	6.076 x10 <sup>3</sup>	2.025 x10 <sup>3</sup>

1 km = 0.6214 mile (eng.) = 0.5396 mile (nautic)  
1 A.U. = 10<sup>-10</sup>m = 10<sup>-4</sup>µm

Area

	m <sup>2</sup>	mm <sup>2</sup>	inch <sup>2</sup>	foot <sup>2</sup>	yard <sup>2</sup>
1 m <sup>2</sup>	1	10 <sup>6</sup>	1.55 x10 <sup>3</sup>	10.76	1.196
1 mm <sup>2</sup>	10 <sup>-6</sup>	1	1.55 x10 <sup>-3</sup>	10.76 x10 <sup>-6</sup>	1.196 x10 <sup>-6</sup>
1 inch <sup>2</sup>	0.645 x10 <sup>-3</sup>	645.16	1	6.944 x10 <sup>-3</sup>	0.772 x10 <sup>-3</sup>
1 foot <sup>2</sup>	92.9 x10 <sup>-3</sup>	92.9 x10 <sup>3</sup>	144	1	0.1111
1 yard <sup>2</sup>	0.8361	836.1 x10 <sup>3</sup>	1.296 x10 <sup>3</sup>	9	1
1 acre	4.047 x10 <sup>3</sup>	4.047 x10 <sup>9</sup>	6.273 x10 <sup>6</sup>	43.56 x10 <sup>3</sup>	4.84 x10 <sup>3</sup>
1 mile <sup>2</sup> (eng.)	2.5907 x10 <sup>6</sup>	2.5907 x10 <sup>12</sup>	4.014 x10 <sup>9</sup>	27.88 x10 <sup>6</sup>	3.0976 x10 <sup>6</sup>

1 km<sup>2</sup>= 247 acre    1 acre = 0.3861 mile<sup>2</sup> (eng)

Volume

	m <sup>3</sup>	l = dm <sup>3</sup>	inch <sup>3</sup>	foot <sup>3</sup>	yard <sup>3</sup>
1 m <sup>3</sup>	1	10 <sup>3</sup>	61.0237 x10 <sup>3</sup>	35.3147	1.308
1 l = 1 dm <sup>3</sup>	10 <sup>-3</sup>	1	61.02	35.31 x10 <sup>-3</sup>	1.3 x10 <sup>-3</sup>
1 inch <sup>3</sup>	16.387 x10 <sup>-6</sup>	16.387 x10 <sup>-3</sup>	1	0.579 x10 <sup>-3</sup>	21.43x10 <sup>-6</sup>
1 foot <sup>3</sup>	28.317 x10 <sup>-3</sup>	28.317	1.728 x10 <sup>3</sup>	1	37.04 x10 <sup>-3</sup>
1 yard <sup>3</sup>	0.76455	764.55	46.656 x10 <sup>3</sup>	27	1
1 gallon (UK)	4.546 x10 <sup>-3</sup>	4.5461	277.4	0.1605	5.946 x10 <sup>-3</sup>
1 gallon (US)	3.785 x10 <sup>-3</sup>	3.7854	231	0.1337	4.951 x10 <sup>-3</sup>

1 l = 1 dm<sup>3</sup>= 0.219969 gallon (UK) = 0.264172 gallon (US)  
1 cm<sup>3</sup>= 61 x10<sup>-3</sup>in<sup>3</sup>

CONVERSION TABLES

Velocity

	m/s	km/h	ft/s	mile/h	kn (knot)
1 m/s	1	3.6	3.2808	2.2369	1.9438
1 km/h	0.2778	1	0.9113	0.6214	0.54
1 ft/s	0.3048	1.0973	1	0.6818	0.5925
1 mile/h	0.447	1.6093	1.4666	1	0.869
1 kn (knot)	0.5144	1.852	1.6878	1.1508	1

1 knot = 1 nautic mile                      1 mach = ca. 1.2 x10³km/h

Mass

	kg	g	lb (pound)	slug	oz (ounce)
1 kg	1	10³	2.2046	68.52 x10 <sup>-3</sup>	35.274
1 g	10 <sup>-3</sup>	1	2.2 x10 <sup>-3</sup>	68.52 x10 <sup>-6</sup>	35.274 x10 <sup>-3</sup>
1 lb (pound)	0.4536	453.59	1	31.08 x10 <sup>-3</sup>	16
1 slug	14.594	14.5939 x10³	32.17	1	514.8
1 oz (ounce)	28.35 x10 <sup>-3</sup>	28.35	62.5 x10 <sup>-3</sup>	1.943 x10 <sup>-3</sup>	1
1 long cwt (UK)	50.8023	50.8023 x10³	112	3.481	1.792 x10³
1 long ton (UK)	1.016 x10³	1.016 x10⁶	2.24 x10³	69.62	35.84 x10³
2 short cwt (US)	45.3592	45.3592 x10³	100	3.108	1.6 x10³
1 short ton (US)	907.185	907.185 x10³	2 x10³	61.16	32 x10³

1 long ton (UK) = 20 long cwt (UK)    1 short ton (US) = 20 short cwt (US)  
1 kg = 0.9842 x10<sup>-3</sup> long ton (UK) = 1.1023 x10<sup>-3</sup> short ton (US)  
1 kg = 19.684 x10<sup>-3</sup> long cwt (UK) = 22.046 x10<sup>-3</sup> short cwt (US)

Density

	kg/m³	g/cm³	lb/in³	lb/ft³
1 kg/m³	1	10 <sup>-3</sup>	36.13 x10 <sup>-6</sup>	62.43 x10 <sup>-3</sup>
1 g/cm³	10³	1	36.13 x10 <sup>-3</sup>	62.428
1 lb/in³	27.6799 x10³	27.68	1	1.728 x10³
1 lb/ft³	16.0185	16.02 x10 <sup>-3</sup>	0.579 x10 <sup>-3</sup>	1

Force

	N	dyn	kp	lbf
1 N	1	0,1 x10⁵	0.10197	0.2248
1 dyn	10 x10 <sup>-6</sup>	1	1.02 x10 <sup>-6</sup>	2.248 x10 <sup>-6</sup>
1 kp	9.80665	980.665 x10³	1	2.2046
1 lbf	4.448	444.8 x10³	0.4536	1

Power

	W	kpm/s	kcal/h	hk	ft x lbf/s
1 W	1	0.102	0.8598	1.36 x10 <sup>-3</sup>	0.7376
1 kpm/s	9.80665	1	8.432	13.33 x10 <sup>-3</sup>	7.233
1 kcal/h	1.163	0.1186	1	1.581 x10 <sup>-3</sup>	0.8578
1 hk	735.5	75	632.5	1	542.5
1 ft x lbf/s	1.356	0.1383	1.166	1.843 x10 <sup>-3</sup>	1
1 hp (UK, US)	745.7	76.04	641.2	1.014	550
1 Btu/h	0.2931	29.89 x10 <sup>-3</sup>	0.252	398.5 x10 <sup>-6</sup>	0.2162

1 kcal/s = 4.1868 x10<sup>-3</sup>W                      1 W = 238.8 x10<sup>-6</sup> kcal/s = 1.341 x10<sup>-3</sup> hp

Pressure, stress

	Pa = N/m²	MPa = N/mm²	bar	kp/mm²	lbf/in² (psi)
1 Pa = 1 N/m²	1	10 <sup>-6</sup>	10 x10 <sup>-6</sup>	0.102 x10 <sup>-6</sup>	0.145 x10 <sup>-3</sup>
1 MPa = 1 N/mm²	10⁶	1	10	0.102	145
1 bar	100x10³	0.1	1	10.2 x10 <sup>-3</sup>	14.5
1 kp/mm²	9.80665 x10⁶	9.807 x10 <sup>-6</sup>	98.0665	1	1.4223 x10³
1 lbf/in²= psi	6.895 x10³	6.895 x10 <sup>-3</sup>	68.95 x10 <sup>-3</sup>	703 x10 <sup>-6</sup>	1

Energy, work

	J	kWh	kpm	kcal	ft x lb
1 J	1	0.278 x10 <sup>-6</sup>	0.102	0.239 x10 <sup>-3</sup>	0.7376
1 kWh	3.6 x10⁶	1	367.1 x10³	859.8	2.655 x10⁶
1 kpm	9.80665	2.724 x10 <sup>-6</sup>	1	2.342 x10 <sup>-3</sup>	7.233
1 kcal	4.1868 x10³	1.163 x10 <sup>-3</sup>	426.9	1	3.088 x10³
1 ft x lbf	1.356	376.6 x10 <sup>-9</sup>	0.1383	323.8 x10 <sup>-3</sup>	1



# TECHNICAL GLOSSARY

- **Annealing**

A process involving heating and soaking at a suitable temperature followed by a slow cooling applied in order to alter the mechanical or physical properties. After return to ambient temperature, the metal will almost be in an equilibrium state. After annealing, steel normally exhibits a low hardness, so that machining or other operations are easier.

- **Austenitizing**

Operation that enables austenite to be created by heating a ferrous alloy into the transformation range (partial austenitizing) or above the transformation range (complete austenitizing). The structure of the material then becomes austenitic. Austenitizing is the first step of a typical heat treating process for steels.

- **Carbide**

A compound of carbon in chemical combination with one or more metallic elements, such as V, W, or Mo. Carbides are hard and brittle. Carbides are present in the microstructure of high speed steel and tool steel to increase wear resistance.

- **Carburizing / case hardening**

Introduction of Carbon into the surface layer of a ferrous alloy in the austenitic state. The process is carried out by heating the components in a Carbon containing medium. The depth of penetration of Carbon into the surface is controlled by the time and temperature of the treatment. After carburizing, it is necessary to harden the components by heating to a suitable temperature and quenching.

- **Cold drawing**

Process of reducing the cross sectional area of wire, bar or tube by drawing the material through a die without any pre-heating. The process changes the mechanical properties of the steel and the finished product is accurate to size, free from scale with a bright surface finish.

- **Cold rolling**

Process to roll metal at a temperature below the softening point of the metal to create strain hardening (work-hardening). Cold rolling changes the mechanical properties and produces certain useful combinations of hardness, strength, stiffness, ductility and other characteristics known as tempers.

- **Cold working**

Plastic deformation to create strain-hardening at normal temperatures.

- **Drawing (Cold/Hot)**

Process to reduce the cross section of wire, bar or tube by drawing the material through a die. This process changes the dimension of the product and its tolerances but also the mechanical properties and the microstructure. Drawing may be performed at room temperature (cold drawing) or at an elevated temperature (hot drawing). Cold drawn products are accurate to size, free from scale with a bright surface finish.

- **Forging**

Process of working metal to a finished shape by hammering, forging or pressing. It is primarily a "hot" operation. It is applied to the production of shapes either impossible or too costly to make by other methods or to obtain properties not feasible by casting.

- **Grinding**

Machining process to obtain a high degree of dimensional accuracy and surface finish on a component. Ground surface finishes are usually smoother than peeled or turned surfaces.

- **Hardening**

Increase of the hardness by suitable treatment, usually involving heating and cooling.

- **Heat treatment**

Operation or combination of operations involving the heating and cooling of a metal or an alloy in the solid state to obtain certain conditions or properties.

- **Hardenability**

Ability of a ferrous alloy to form martensite when quenched from a temperature above the upper critical temperature. Hardenability is commonly measured with the Jominy test. Hardenability is a measure of how easily a material may be quenched to reach a desired hardness.

- **Nitriding**

Introduction of nitrogen into the surface layer of a solid ferrous alloy.

# TECHNICAL GLOSSARY

- **Peeling or Turning**

Machining process to obtain a high degree of dimensional accuracy and surface finish on a component. Peeling involves feeding a moving bar through a stationary cutting head (the bar moves), while turning involves rotating a bar in place while a cutting head moves along the length of the bar (the cutter moves).

- **Quenching**

Cooling quickly from a high temperature to a lower temperature. Quenching may be performed in water, oil, molten salt, or high pressure gas, depending on the grade of steel and type of heat treating equipment. Quenching is typically the second part of a heat treating operation, following austenitizing.

- **Quench hardening**

This operation consists in heating the material to the proper austenitizing temperature, maintain that temperature for a sufficient time to change into crystalline structure, and quench in water, oil or gas depending on the chemical composition. After quenching, the material is reheated to a predetermined temperature below the critical range and then cooled under suitable temperatures (tempering).

- **Rolling**

Process of shaping metal by passing it between rolls revolving at the same peripheral speed and in opposite directions. In the steel industry, there are a number of different types of rolling mills to process the ingot to its finished shape.

- **Tempering**

Reheating steel to an intermediate temperature after quenching, and holding at that temperature for a specified time. Tempering is typically the third part of a heat treating operation, following quenching. Tempering produces improved toughness in heat treated steels, which may be brittle after quenching.

# WORLDWIDE PRESENCE

Erasteel has 5 production sites, as well as 3 service centers and 9 sales offices on all continents.





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