ESCHMANNSTAHL

Contents

Perfect service and rapid delivery time -

We extend our advantage to you

Achieving targets together – we are your professional partners in the tool steel sector. Our employees, an exceptionally large warehouse capacity and high-performance machinery form the basis of your success.

Leading from the outset

Since the company was founded in 1953, EschmannStahl has grown steadily and now provides comprehensive services in Germany and abroad – from supplying steel as raw material to machining and graining of completed moulds by our subsidiary EschmannTextures.

Absolute confidence in constructional design is deci

We leave nothing to chance, enabling you to put yo

Reliability in all processes: our approved management systems document our information-orientated organisation ensuring quality, environmental protection and occupational safety.

Optimal material performance results from a precise analysis of customer requirements, comprehensive consultation regarding application and high product and manufacturing quality.

sive factor –

ur heart and soul into your tasks

Approved safety

In our laboratory steel products undergo extensive metallurgical tests and analyses on a daily basis. Furthermore, we improve existing tool steels and manufacture new special products to meet increasing material requirements presenting additional state-of-the-art properties.

Product types and machining allowances

How we supply and machine our steels:

In addition to raw steel material EschmannStahl also supplies machined tool steel, which can result in enormous practical advantages.

Our product groups always represent the state of the art in terms of technology and application.

The tool steels we supply are in accordance with DIN EN ISO 4957. The steels can be forged or rolled and/or premachined.

Black material

Certain machining allowances are required to be sure that mill scale and decarburisation are properly removed.

The tolerance ranges comply with the standards for

- steel forgings to DIN 7527
- hot rolled round steel bars to DIN EN 10060
- hot rolled square bars to DIN 1014
- hot rolled flat steel bars to DIN EN 10058
- hot rolled wide flats to DIN 59200
- hot rolled steel plates EN 10029

The following machining allowances can be used as the basis for black material (extract from DIN 7527, page 6).

Machined tool steels

Machined tool steels guarantee you clean surfaces and reduced tolerances. Savings of between 7 - 10 % by weight can be made, depending on the particular dimensions.

We supply machined tool steel in bar and plate form, as precision flat and square steel and as rough-ground tool steel.

Our particular strength is the manufacture of premachined tools, moulds and construction elements, which we can supply to suit your particular requirements on the basis of drawings or specifications.

Finished size		*Cross section*	
f1 or f2		*Allowance*	
over	**to**	**2z**	**Permissible variation**
16	25	2.6	± 0.6
25	40	3	± 0.7
40	63	4	± 0.9
63	80	5	± 1.1
80	100	6	± 1.3
100	125	7	± 1.5
125	160	9	± 1.8
160	200	11	± 2.2
200	250	13	± 2.6
250	315	16	± 3.2
315	400	19	± 4.0
400	500	24	± 4.9
500	630	30	± 6.0
630	800	37	± 7.4
800	1000	46	± 9.3

ES ULW 65

Name:
C 45 U

Material No.:
1.1730

Typical analysis in %:

C	Si	Mn
0.45	0.3	0.7

As-supplied condition:
Annealed to a hardness of about 190 HB (approx. 650 N/mm²)

Characteristics:
Unalloyed tool steel, good machinability, shallow depth case hardening steel

General fields of application:
Mould frames, components for plastic moulds, blow and foaming moulds with low polishability requirements, unhardened components in moulds, tools, jigs and fixtures

Special note:
Shallow depth case hardening steel

Through-hardening diameter:
15 mm (water)

Hardening depth for ☐ 30 mm:
3.5 mm

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	680 - 710 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	800 - 830 °C	Group I	water, oil
Tempering	160 - 300 °C	min. 2 h	still air
	see tempering curve	depending on cross section	

Physical characteristics:

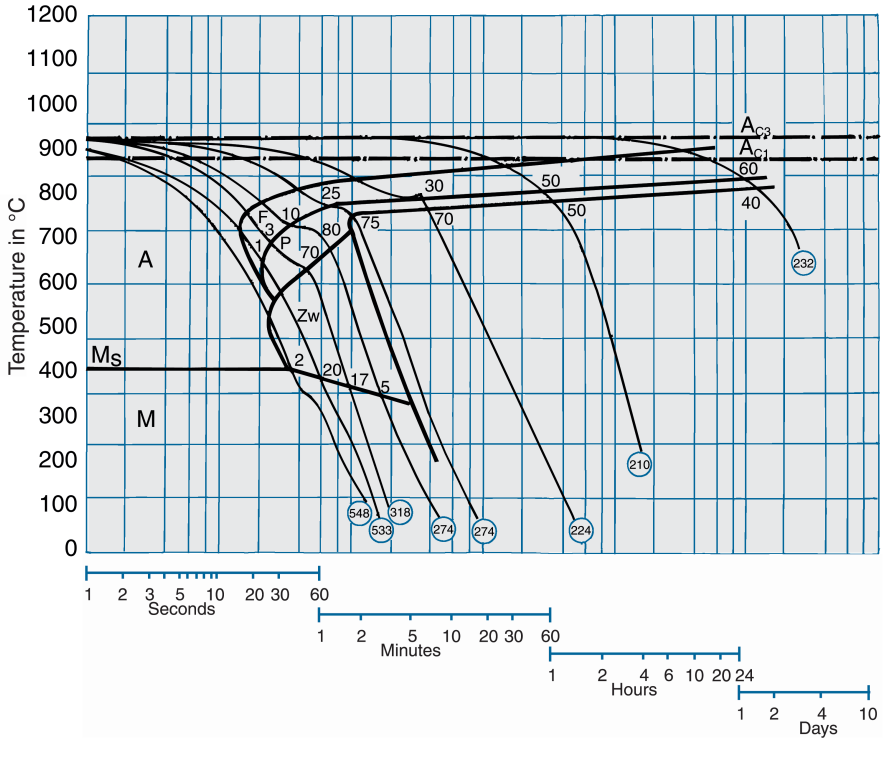
Coefficient of thermal expansion: between 20 °C and:

10^{-6} x m / m x K	100	200	300	400	500	600 °C
	11.0	12.0	13.0	13.5	14.0	14.2

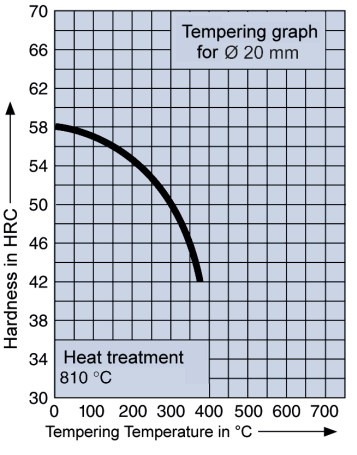
Thermal conductivity: W / m x K — 20 °C: 50

Normal working hardness: 650 N/mm², generally used in the as-supplied condition

Continuous time-temperature-transformation diagram



Tempering curve



ES 50 S

Name:
X 210 Cr 12

Material No.:
1.2080

Typical analysis in %:

C	Cr
2.1	12.0

As-supplied condition:
Soft-annealed to max. 248 HB (840 N/mm²)

Characteristics:
Ledeburitic 12% chromium steel with good dimensional stability and high wear resistance, very good compressive strength combined with adequate toughness.

General fields of application:
Cutting tools, shearing knives, broaches, woodworking tools, profile and flanging rollers, thread rolling tools, deep drawing and pressing tools, drawing cones, guide rails, extrusion dies, sand blast nozzles, rotary shear knives

Special note:
Not suitable for larger wire sections; for this we recommend ES 70 S, Mat. No. 1.2379.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	800 - 840 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C		
Hardening	940 - 970 °C	Group III	oil, WB 500° C
Tempering	200 - 350 °C	min. 2 h	still air
	see tempering curve	depending on cross section	

Through-hardening diameter for
64 HRC: 50 mm
62 HRC: 80 mm
60 HRC: 90 mm
58 HRC: 120 mm

Core hardness at ø 300 mm: 44 HRC

Cooling: oil

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

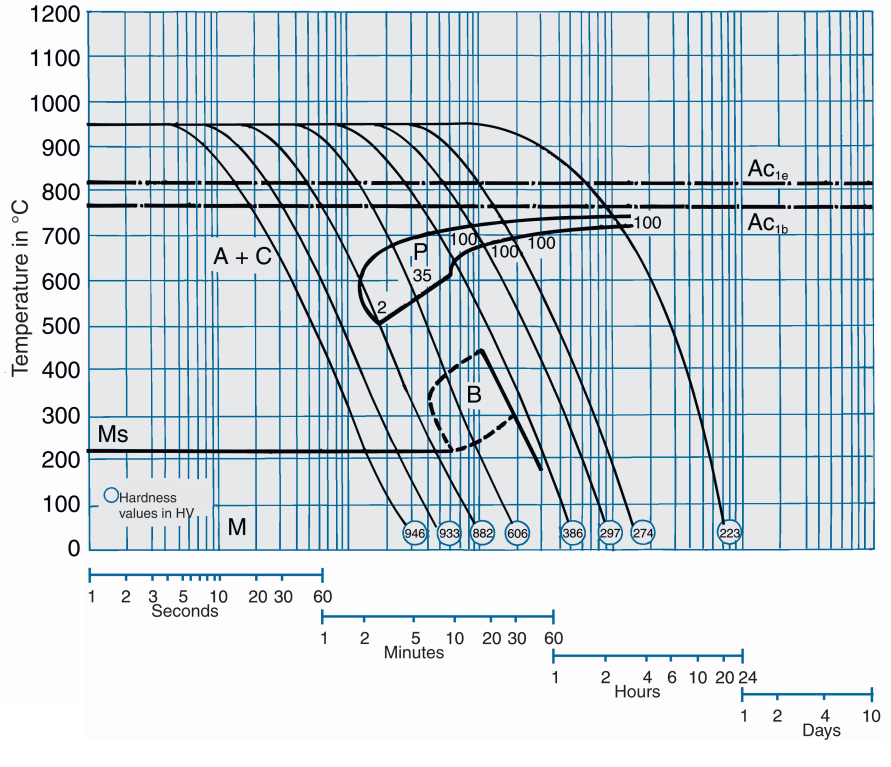
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	10.8	11.7	12.2	12.6	12.8	13.1	13.3

Thermal conductivity:

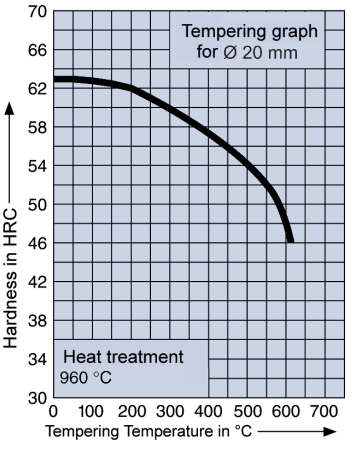
W	20	350	700 °C
m x K	16.7	20.5	24.2

Normal working hardness: 58 - 62 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 120 K

Name:
X 40 Cr 14

Material No.:
1.2083

Typical analysis in %:

C	Cr
0.4	14.0

As-supplied condition:
Soft-annealed to max. 241 HB
(810 N/mm²)

Characteristics:
Corrosion-resistant mould steel, highest cleanliness and good polishability, good machinability, low distortion through-hardening steel, high hardenability, high wear resistance

General fields of application:
Tools for processing corrosive plastics

Special note:
Best corrosion resistance is obtained in the hardened and low tempered condition with a polished surface.

Also available in EST and ESR grades.

If grained or polished only ES 120 K EST should be used.

For the highest polishability requirements we recommend ES 120 K in ESR grade.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	760 - 800 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1000 - 1050 °C	Group II	oil, air, WB 500 °C
Tempering	250 - 570 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

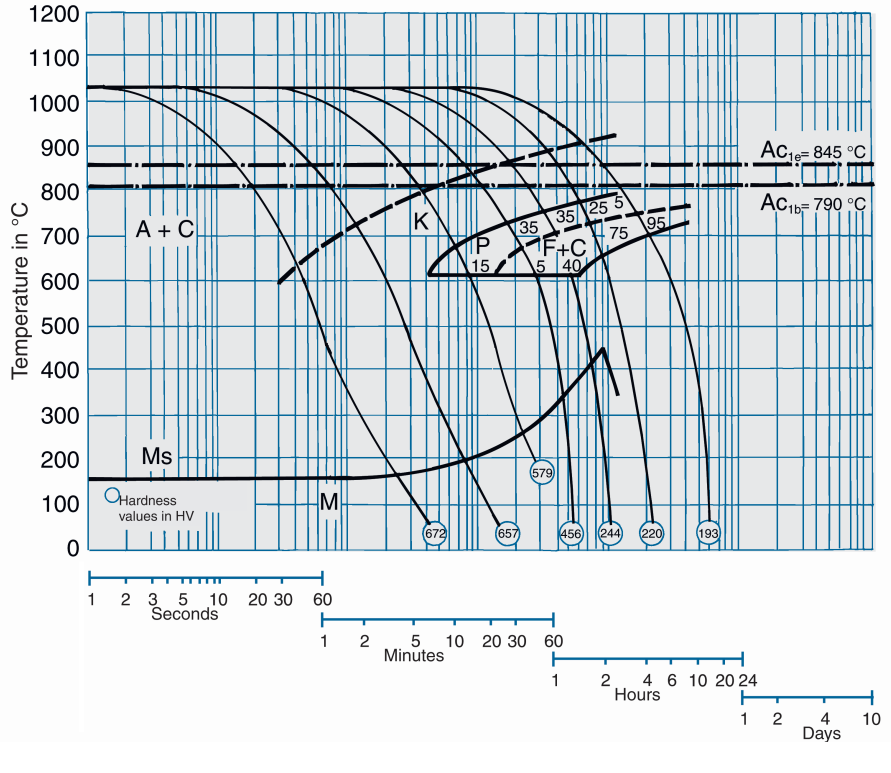
10^{-6} x m	100	200	300	400 °C
m x K	10.5	11.0	11.6	11.9

Thermal conductivity:

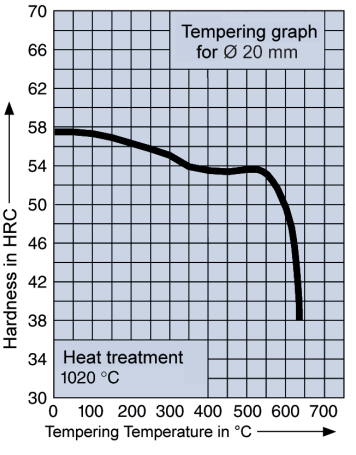
W	20	200	300	400 °C
m x K	21.0	22.0	23.8	24.7

Normal working hardness: 50 - 55 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 120 K ESR

Name:
X 40 Cr 14

Material No.:
1.2083

Typical analysis in %:

C	Cr
0.4	14.0

As-supplied condition:
Soft-annealed to max. 241 HB
(810 N/mm²)

Characteristics:
Corrosion-resistant mould steel, with highest cleanliness and very good polishability, good machinability, low distortion through-hardening steel, high hardenability, high wear resistance.

General fields of application:
Tools for use on corrosive plastics.

Special note:
Best corrosion resistance is obtained in the hardened and low tempered condition with a polished surface.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	760 - 800 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1000 - 1050 °C	Group II	oil, air WB 500° C
Tempering	250 - 570 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

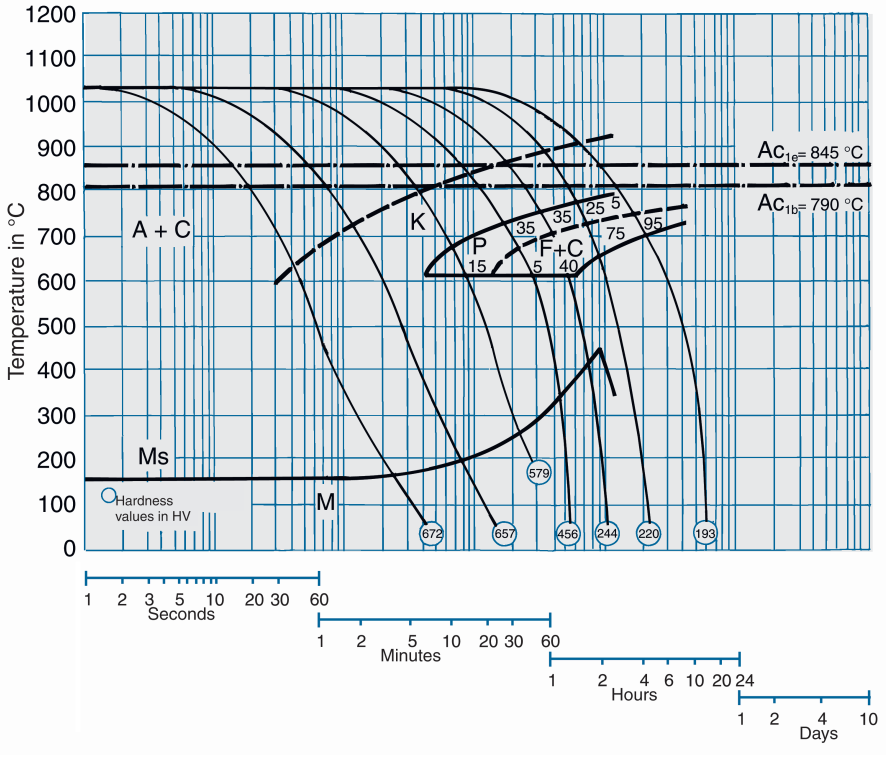
10^{-6} x m	100	200	300	400 °C
m x K	10.5	11.0	11.6	11.9

Thermal conductivity:

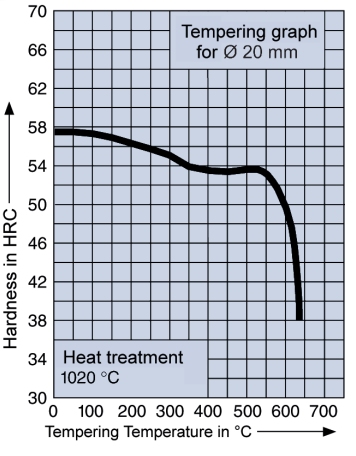
W	20	200	300	400 °C
m x K	21.0	22.0	23.8	24.7

Normal working hardness: 50 - 55 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES Antikor S

Name:
X 33 CrS 16

Material No.:
1.2085 mod.

Typical analysis in %:

C	Si	Mn	Cr	S
0.3	0.5	1.0	16.0	0.1

As-supplied condition:
Quenched and tempered to 280-325 HB (950-1100 N/mm²)

Characteristics:
Corrosion-resistant steel with considerably better machinability compared to material 1.2316

General fields of application:
Mould frames, tools for processing corrosive plastics. This steel is recommended where the main requirement is for machinability with good corrosion-resistance.

Special note:
Normally ES Antikor S is used in the as-supplied condition. Further heat treatment is not recommended. ES Antikor S is suitable for technical polishing only. For other types of polished surfaces we recommend ES Antikor in EST grade.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480 °C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30% machining before finish machining

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

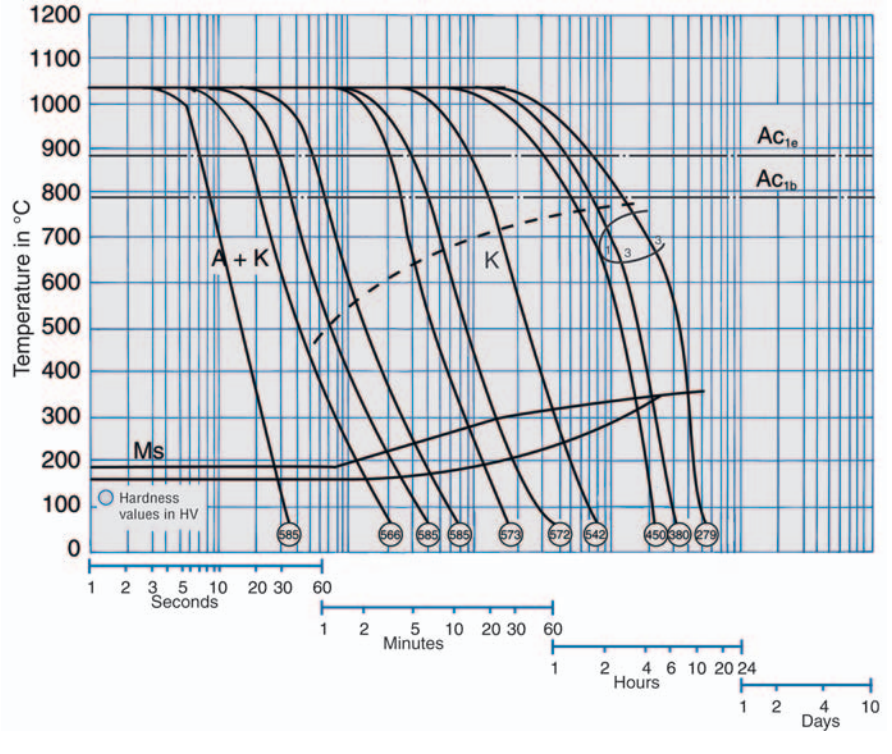
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	12.2	12.9	13.5	13.9	14.2	14.5	14.8

Thermal conductivity:

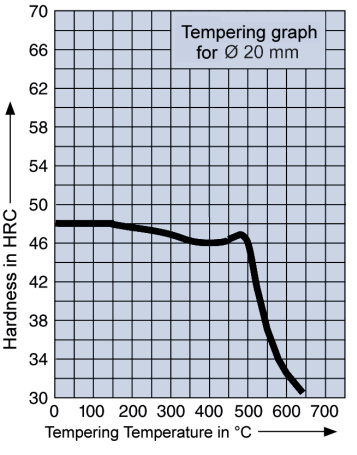
W	20	350	700 °C
m x K	39.5	36.5	33.5

Normal working hardness: Used in the as-supplied condition

Continuous time-temperature-transformation diagram



Tempering curve



ES Antikor SL

Name:
Special alloy

Typical analysis in %:

C	Mn	S	Cr
0.04	1.2	0.12	13.0

+ trace elements

As-supplied condition:
Quenched and tempered to a hardness of 280-325 HB
(approx. 950-1100 N/mm²)

Characteristics:
This newly developed special material is a further development of the well-known steel ES Antikor S.

Heat treatment data:

Stress-relief annealing: 480 °C min. 2 h at core temperature

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

10^{-6} x m	100	200	300	400	500 °C
m x K	10.0	10.6	11.0	11.3	11.6

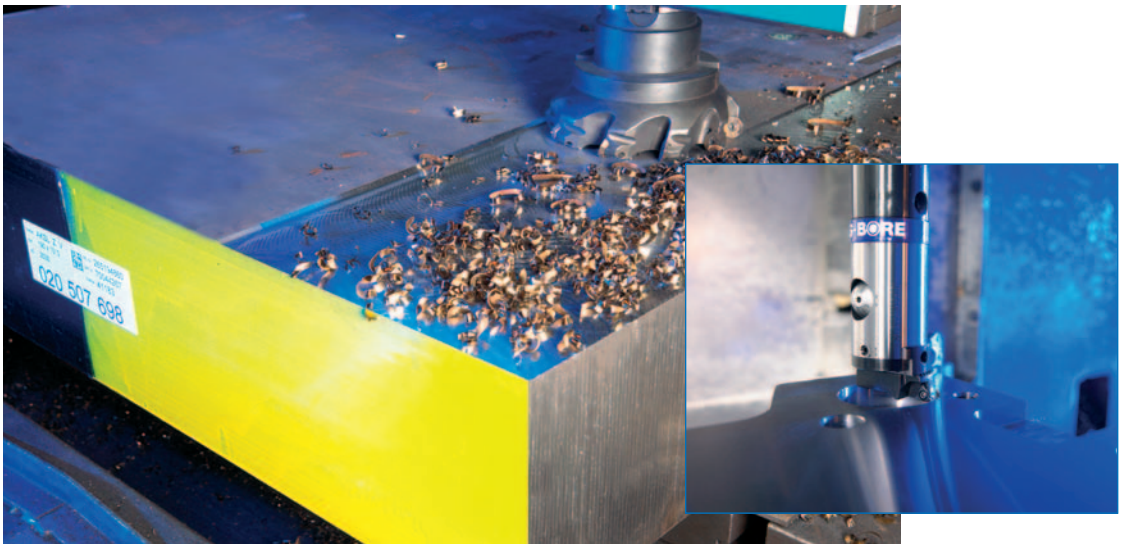
Thermal conductivity:

W	20	150	350 °C
m x K	21.6	23.2	24.9

The special chemical composition and manufacturing variants of this new and innovative tool steel provides it with the following special properties:

- excellent machinability
- uniform hardness throughout the cross section
- adequately high corrosion resistance
- high dimensional stability
- high toughness
- highest weldability
- high thermal conductivity

General fields of application:
Mould frames and tools for processing aggressive plastics or for use with highly corrosive media.



ES 100 K

Name:
21 MnCr 5

Material No.:
1.2162

Typical analysis in %:

C	Mn	Cr
0.21	1.3	1.2

As-supplied condition:
BG-annealed to maximum
210 HB (approx. 710 N/mm²)

Characteristics:
Standard case hardening steel, easily machined, good polishability, suitable for cold hobbing, high surface hardness with high core toughness can be achieved with appropriate heat treatment

General fields of application:
Tools for plastic processing (thermoplastic and thermosetting), pinions, gear wheels, gear racks, shafts etc.

Special note:
Case hardening in powder at:
870 - 900 °C
Case hardening in salt bath:
900 - 930 °C
Intermediate annealing temperature:
630 - 650 °C

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	670 - 710 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	810 - 840 °C	Group II	oil, WB 200 °C
Tempering	180 - 300 °C	min. 2 h	still air
	see tempering curve	depending on cross section	

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

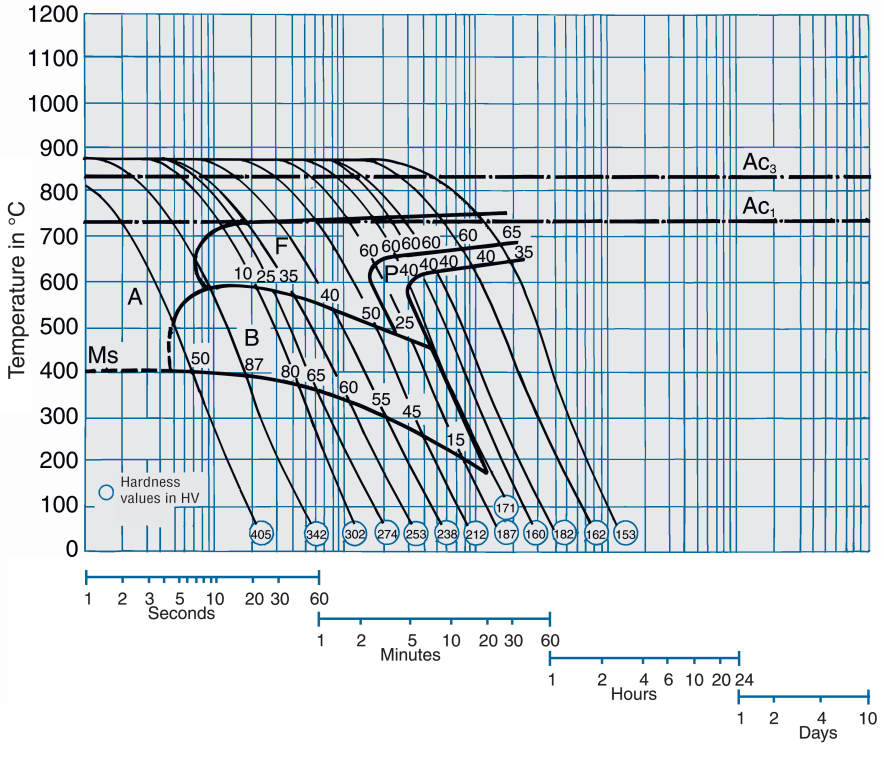
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	12.2	12.9	13.5	13.9	14.2	14.5	14.8

Thermal conductivity:

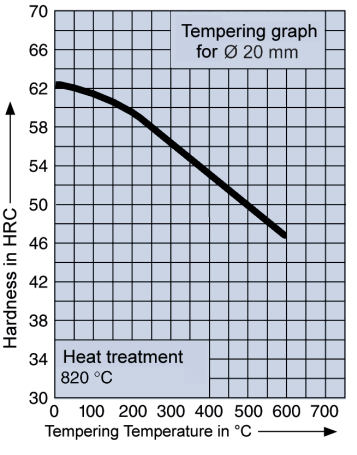
W	20	350	700 °C
m x K	39.5	36.5	33.5

Normal working hardness: 58 - 61 HRC (after hardening, core strength approx. 1000 - 1200 N/mm²)

Continuous time-temperature-transformation diagram



Tempering curve



ES Aktuell

Name:
40 CrMnMo 7

Material No.:
1.2311

Typical analysis in %:

C	Mn	Cr	Mo
0.4	1.5	1.9	0.2

As-supplied condition:
Quenched and tempered to a hardness of 280 to 325 HB (950 - 1100 N/mm²)

Characteristics:
Quenched and tempered plastic mould steel, good polishability, nitridable, suitable for chromium plating, uniform hardness throughout the cross section up to a thickness of approx. 400 mm

General fields of application:
Plastic moulds, mould frames for plastic and die casting moulds

Special note:
Can also be supplied in EST grade with improved grain and polishability.

If grained only ES Aktuell in EST grade should be used.

We recommend stress-relief annealing for more than 30% machining before finish machining.
For material cross sections over 400 mm we recommend ES Aktuell 1000 or ES Aktuell 1200 for their better through tempering.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480°C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30% machining before finish machining.

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

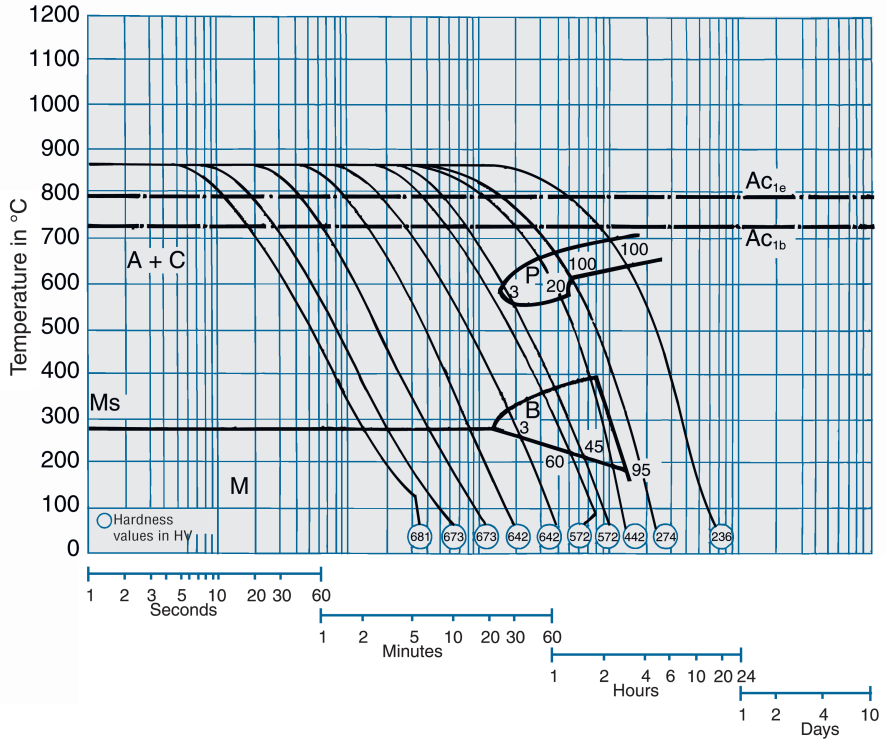
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	11.1	12.9	13.4	13.8	14.2	14.6	14.9

Thermal conductivity:

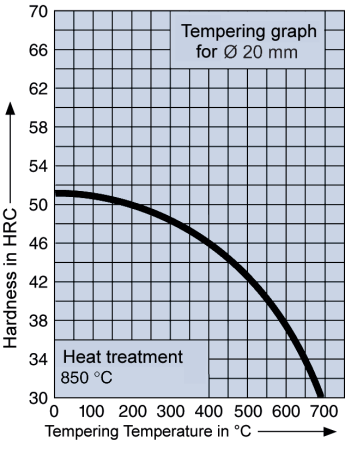
W	20	350	700°C
m x K	34.5	33.5	32.0

Normal working hardness: Used in the as-supplied condition

Continuous time-temperature-transformation diagram



Tempering curve



ES Aktuell S

Name:
40 CrMnMo S 8-6

Material No.:
1.2312

Typical analysis in %:

C	Mn	S	Cr	Mo
0.4	1.5	0.07	1.9	0.2

As-supplied condition:
Quenched and tempered to a hardness of 280 to 325 HB (950 - 1100 N/mm²)

Characteristics:
The very best machinability, high compressive loads

General fields of application:
Plastic moulds, for which the main requirement is for machinability; mould frames and mould plates; mould frames for plastic and die casting moulds

Special note:
ES Aktuell S can be nitrided to improve its wear resistance.

ES Aktuell S is not suitable for graining or polishing. For this we recommend ES Aktuell EST, Mat.-No. 1.2311.

For material cross sections over 400 mm we recommend ES Aktuell 1000 or ES Aktuell 1200 for better full quenching and tempering.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480°C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30% machining before finish machining.

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

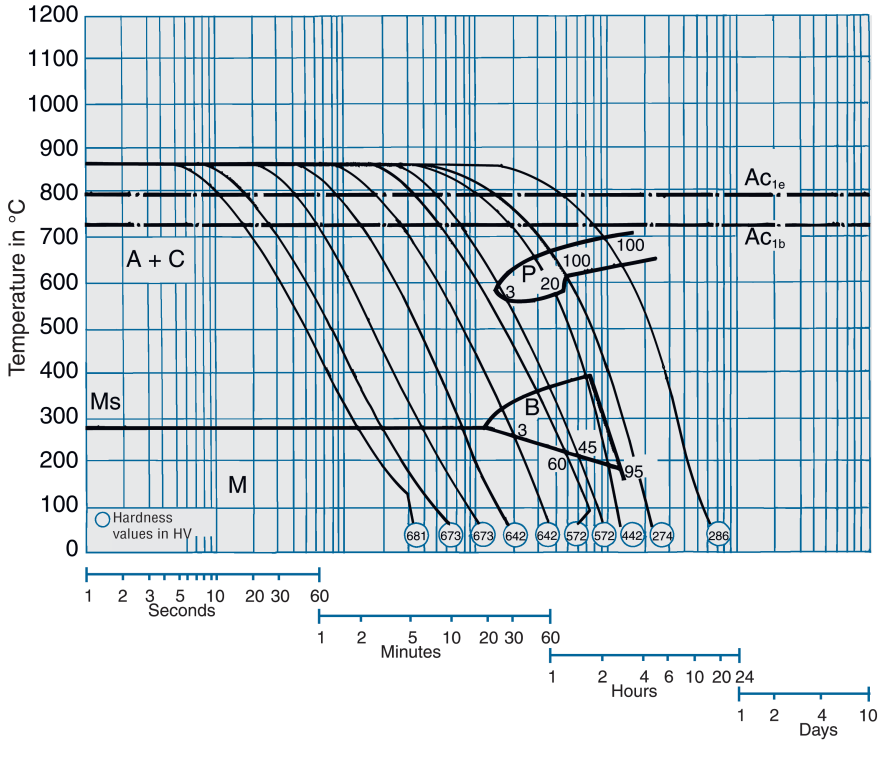
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	12.2	12.9	13.5	13.9	14.2	14.5	14.8

Thermal conductivity:

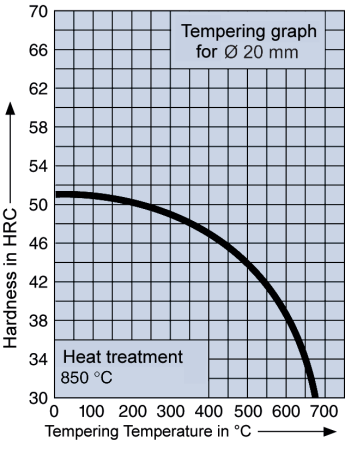
W	20	350	700 °C
m x K	39.5	36.5	33.5

Normal working hardness: Used in the as-supplied condition

Continuous time-temperature-transformation diagram



Tempering curve



ES Antikor

Name:
X 38 CrMo 16

Material No.:
1.2316

Typical analysis in %:

C	Cr	Mo	Ni
0.38	16.0	1.2	≤ 1.0

As-supplied condition:
280 - 325 HB
(950 - 1100 N/mm²)

Characteristics:
Corrosion resistant, polishable, quenched and tempered mould steel

General fields of application:
Tools for processing corrosive plastics

Special note:
Highest corrosion resistance with polished surface.

Nitriding ES Antikor reduces its corrosion resistance.

Also available in EST and ESR grades.

If it is to be grained or polished only ES Antikor EST grade should be used.

We recommend ES Antikor for graining or technical polishing.

ES Antikor ESR should be used for higher quality polishing.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480 °C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30% machining before finish machining

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

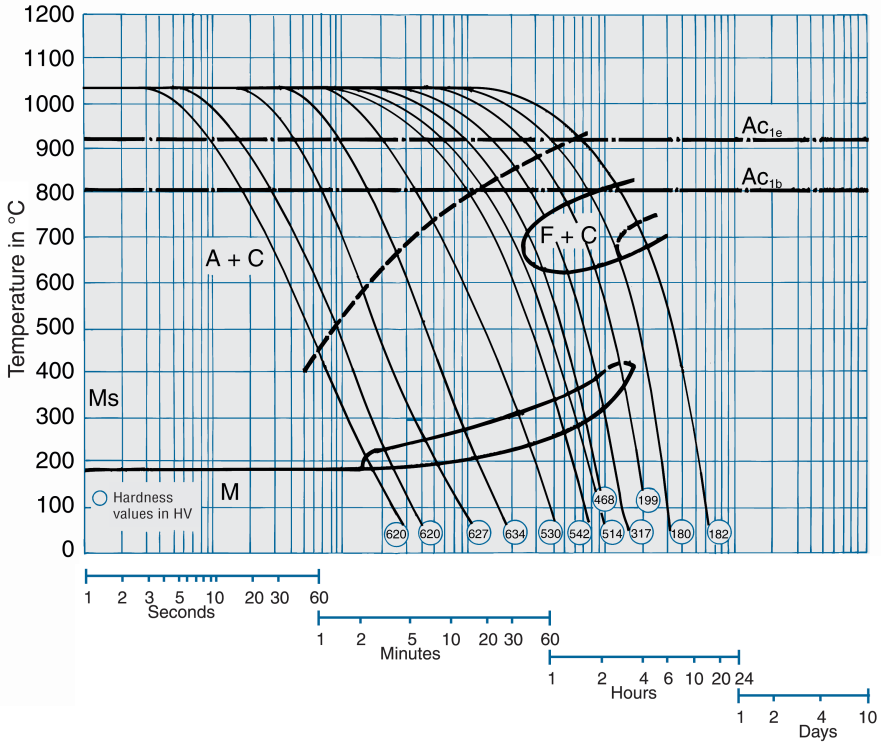
10^{-6} x m / m x K	100	200	300	400 °C
	10.5	11.0	11.0	12.0

Thermal conductivity:

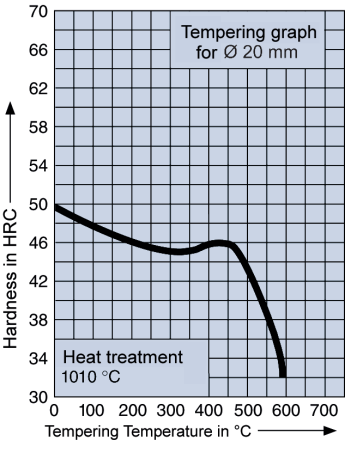
W / m x K	20	350	700 °C
	17.2	21.0	24.7

Normal working hardness: Used in the as-supplied condition

Continuous time-temperature-transformation diagram



Tempering curve



ES 235 W

Name:
X 37 CrMoV 5-1

Material No.:
1.2343

Typical analysis in %:

C	Si	Cr	Mo	V
0.37	1.0	5.3	1.3	0.4

As-supplied condition:
Soft-annealed to max. 229 HB (770 N/mm²)

Characteristics:
Hot work steel with good high temperature strength and very good toughness, high resistance to thermal shock and wear, nitridable, good polishability

General fields of application:
Tools for forging machines, dies, die inserts, extrusion tools, hot shearing knives and tools for plastics processing

Special note:
If nitrided, the nitriding depth should not be too deep otherwise increased thermal cracking may occur.

Preheating to 200 - 300 °C before starting work is recommended.

Also available in EST and ESR grades.

If grained or polished ES 235 W in EST grade should be used.

We recommend our ES Maximum 500 steel for highly polished mirrored finishes and for the highest toughness requirements.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	800 - 860 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1020 - 1060 °C	Group II	oil, air, WB 500 °C
Tempering	530 - 700 °C	min. 2 h	still air
	3 x, see tempering curve	depending on cross section	

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

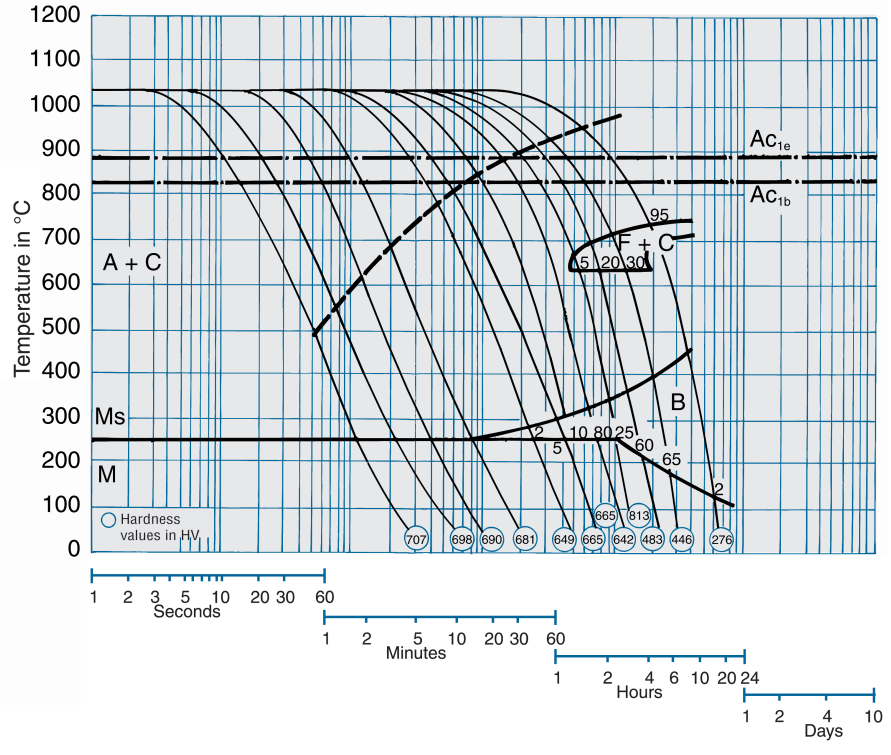
10⁻⁶ x m	100	200	300	400	500	600	700 °C
m x K	10.8	11.4	11.8	12.0	12.4	12.8	12.9

Thermal conductivity:

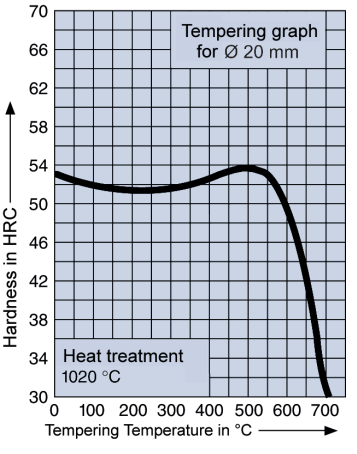
W	20	350	700 °C
m x K	25.3	27.2	30.5

Normal working hardness: 30 - 53 HRC (1000 - 1850 N/mm²)

Continuous time-temperature-transformation diagram



Tempering curve



ES Maximum 500

Name:
X 37 CrMoV 5-1

Material No.:
1.2343 ESR

Typical analysis in %:

C	Si	Cr	Mo	V
0.37	1.0	5.3	1.3	0.4

As-supplied condition:
Structurally treated to max. 229 HB (770 N/mm²)

Characteristics:
Good high temperature strength, resistance to thermal shock and high temperature wear with the very highest toughness, a combination of characteristics to match the highest requirements encountered in use; compliance with all requirements of SEP 1614, VDG and the DGM conditions of delivery for extrusion tools.

General fields of application:
For particularly high requirements for homogeneity and toughness for pressure die casting tools for light metal; tools for forging machines, dies, die inserts, extrusion tools, punches and press dies for light metal processing, tools for screw, nut and bolt manufacturing, hot shearing knives, highly polished plastic moulds.

Special note:
ES Maximum 500 is manufactured using the latest secondary metallurgy techniques. Numerous complementary quality improvement processes result in an extremely homogenous hot work steel with isotropic properties.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	800 - 840 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1000 - 1040 °C	Group II	oil, air, WB 500 °C
Tempering	530 - 680 °C	min. 2 h	still air
	3 x, see tempering curve	depending on cross section	

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

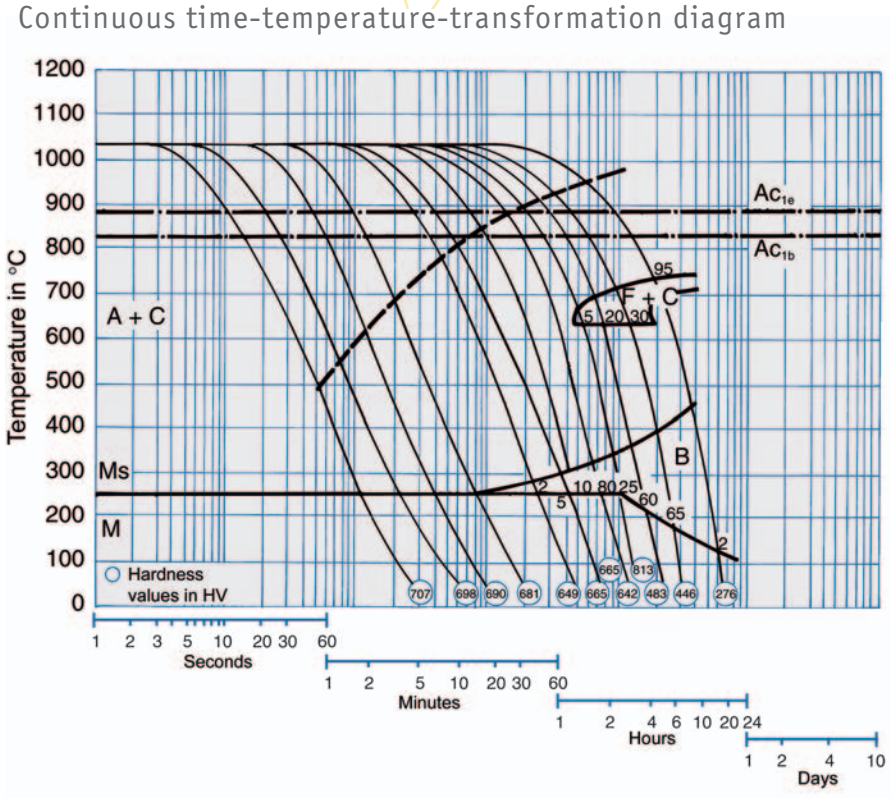
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	10.8	11.4	11.8	12.0	12.4	12.8	12.9

Thermal conductivity:

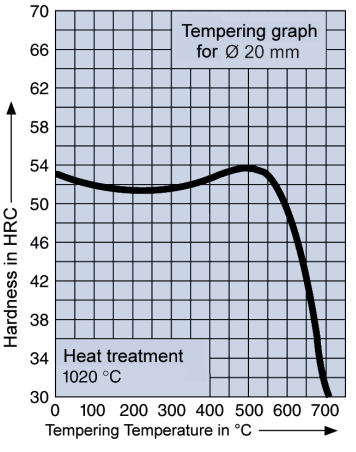
W	20	350	700 °C
m x K	25.3	27.2	30.5

Normal working hardness: 30 - 53 HRC (1000 - 1850 N/mm²)

Continuous time-temperature-transformation diagram



Tempering curve



ES 245 W

Name:
X 40 CrMoV 5-1

Material No.:
1.2344

Typical analysis in %:

C	Si	Cr	Mo	V
0.4	1.0	5.3	1.4	1.0

As-supplied condition:
Soft-annealed to max. 229 HB (770 N/mm²)

Characteristics:
CrMoV alloyed hot work steel with excellent high temperature strength and good toughness, good high temperature wear resistance, highest thermal shock resistance, very good cleanliness factor and excellent homogeneity, nitridable

General fields of application:
Tools for forging machines, dies, die inserts, extrusion tools, hot shearing knives and tools for plastics processing

Special note:
If nitrided, the nitriding depth should not be too deep otherwise increased thermal cracking may occur.

Preheating to 200 - 300 °C before starting work is recommended.

Also available in EST and ESR grades.

If grained or polished only ES 245 W in EST grade should be used.

We recommend ES 245 W steel in ESR grade for highly polished mirrored finishes.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	800 - 860 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1020 - 1060 °C	Group II	oil, air WB 500 °C
Tempering	530 - 700 °C 3 x, see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

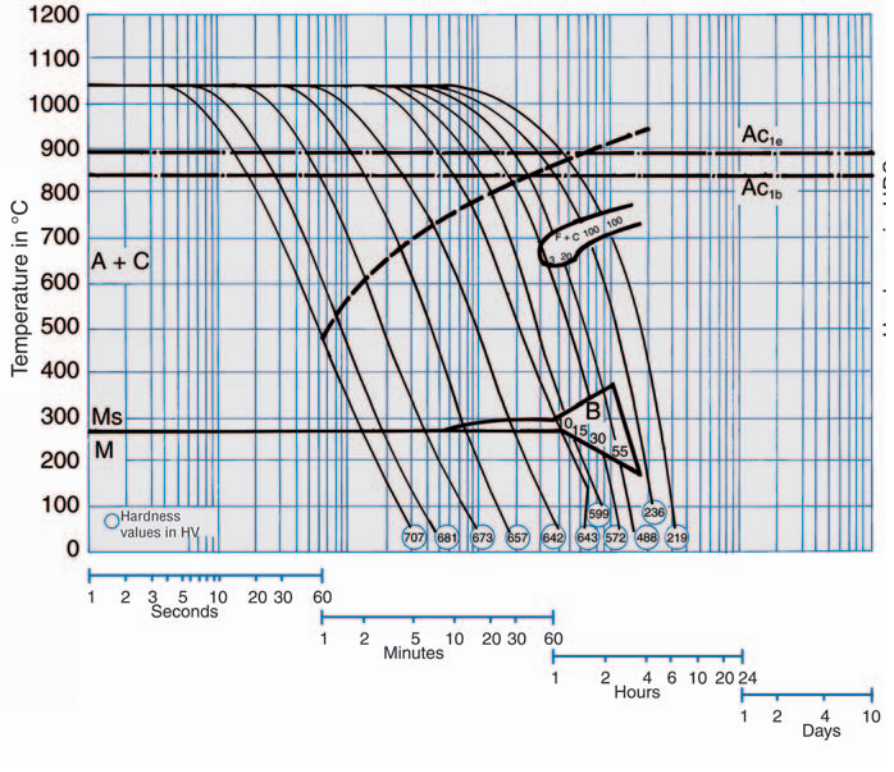
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	10.9	11.9	12.3	12.7	13.0	13.3	13.5

Thermal conductivity:

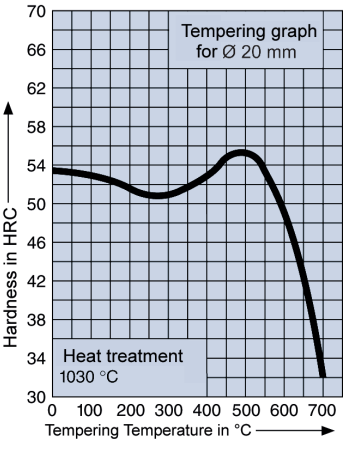
W	20	350	700 °C
m x K	24.5	26.8	28.8

Normal working hardness: 30 - 54 HRC (1000 - 1900 N/mm²)

Continuous time-temperature-transformation diagram



Tempering curve



ES 245 W ESR

Name:
X 40 CrMoV 5-1

Material No.:
1.2344 ESR

Typical analysis in %:

C	Si	Cr	Mo	V
0.4	1.0	5.3	1.4	1.0

As-supplied condition:
Structurally treated to max. 229 HB (770 N/mm²)

Characteristics:
Cr-Mo-V alloyed hot work steel with very high homogeneity and cleanliness factor, excellent high temperature strength, good high temperature wear resistance and the highest thermal shock resistance. These characteristics match the highest requirements encountered in use.

General fields of application:
Extremely highly loaded hot work tools with particular requirements for homogeneity and toughness in injection moulds. Tools for forging machines, dies, extrusion tools such as press dies for light metal processing. Tools for hot shearing knives and plastic processing.

Special note:
If nitrided, the nitriding depth should not be too deep otherwise increased thermal cracking may occur.

Preheating to 200 - 300 °C before starting work is recommended.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	820 - 860 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1020 - 1060 °C	Group II	oil, air WB 500° C
Tempering	530 - 700 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

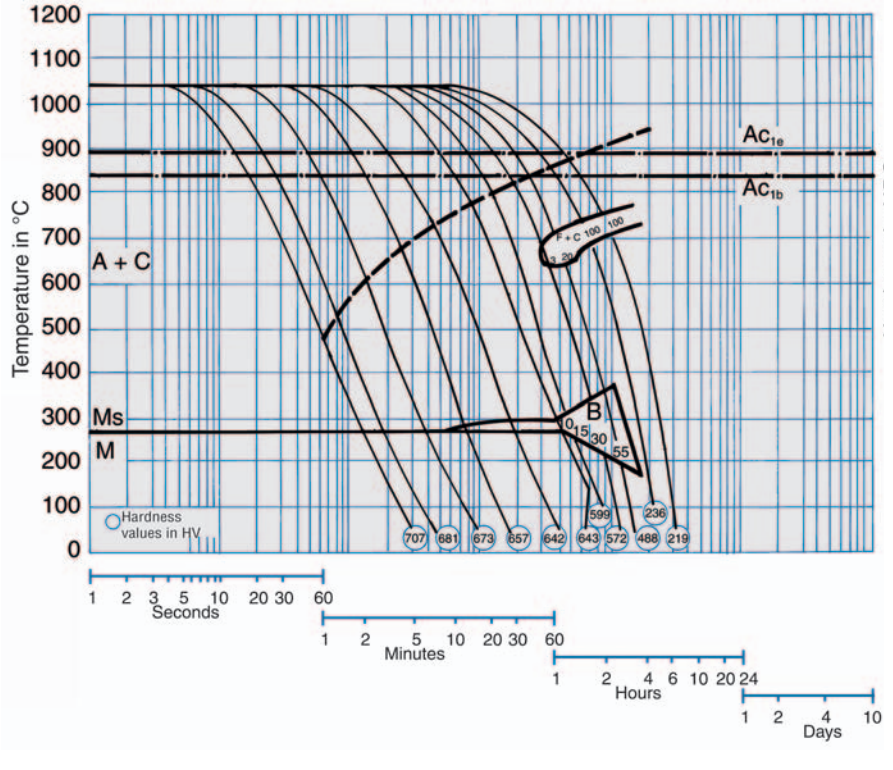
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	10.9	11.9	12.3	12.7	13.0	13.3	13.5

Thermal conductivity:

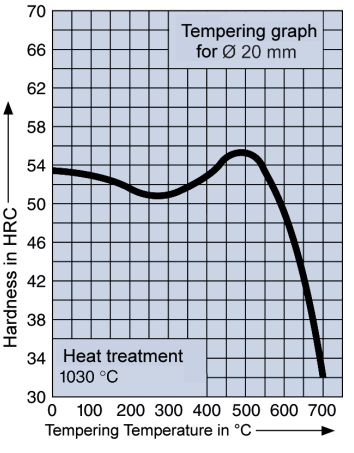
W	20	350	700 °C
m x K	24.5	26.8	28.8

Normal working hardness: 30 - 54 HRC (1000 - 1900 N/mm²)

Continuous time-temperature-transformation diagram



Tempering curve



ES 65 S

Name:
X 100 CrMoV 5

Material No.:
1.2363

Typical analysis in %:

C	Cr	Mo	V
1.0	5.2	1.2	0.3

As-supplied condition:
Soft-annealed to max. 241 HB
(810 N/mm²)

Characteristics:
Air-hardening special cold work steel, with respect to toughness and wear resistance it is between medium and high alloyed steels; good machinability, high hardenability, low dimensional changes as a result of heat treatment, good through-hardening properties and excellent compressive strength

General fields of application:
Cutting and pressing tools, rollers, shearing knives, thread rolling dies, cold stamping tools, calibration and pilger mandrels, moulds for plastic processing, gauges and measuring tools

Special note:
If electrical discharge machining takes place after hardening then the material should be tempered three times above 520 °C after quenching.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	820 - 850 °C	4 - 6 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	950 - 980 °C	Group II	oil, air, WB 500 °C
Tempering	180 - 600 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

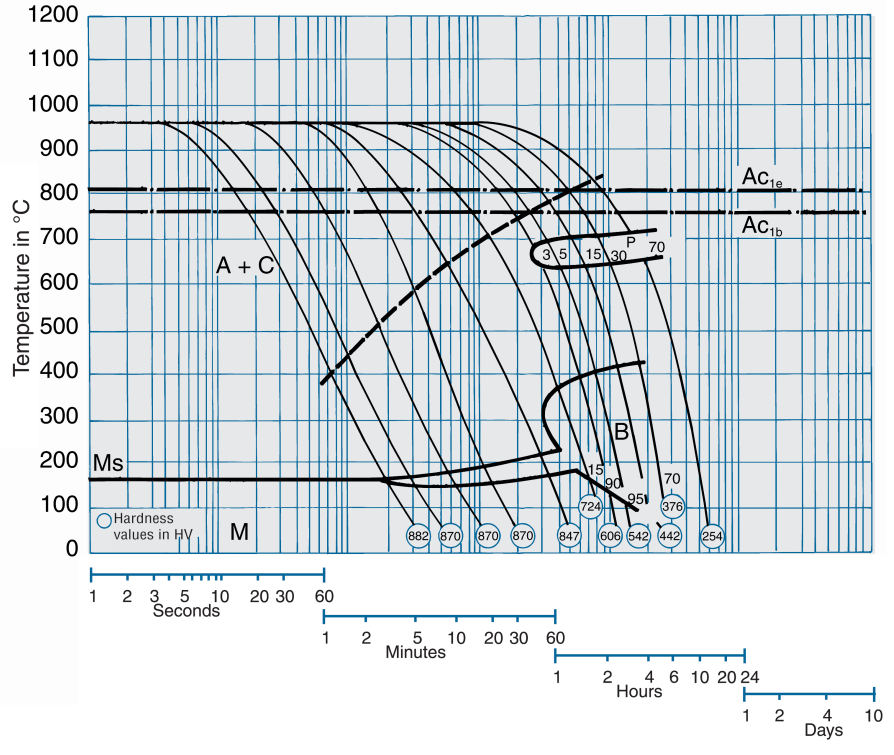
10^{-6} x m	100	200	300	400 °C
m x K	9.9	12.5	13.2	14.5

Thermal conductivity:

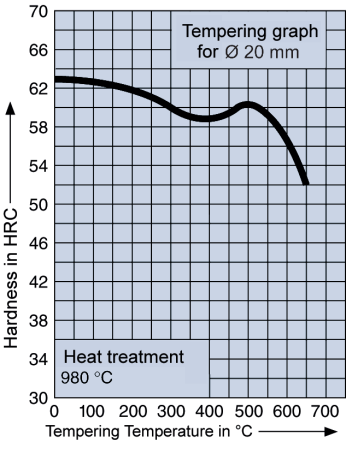
W	20	350	700 °C
m x K	15.8	26.7	29.1

Normal working hardness: 58 - 62 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 265 W

Name:
X 38 CrMoV 5-3

Material No.:
1.2367

Typical analysis in %:

C	Si	Mn	Cr	Mo	V
0.38	0.4	0.5	5.0	3.0	0.6

As-supplied condition:
Soft-annealed to max. 229 HB (770 N/mm²)

Characteristics:
CrMoV alloyed hot work steel with excellent high temperature strength and good high temperature toughness

General fields of application:
Extrusion tools, die inserts, injection moulds, mandrels

Special note:
Also supplied as EST and ESR grades for the highest requirements.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	820 - 840 °C	4 - 6 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1030 - 1060 °C	Group II	oil, air, WB 500-550°C
Tempering	500 - 700 °C	min. 2 h	still air
	3 x, see tempering curve	depending on cross section	

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

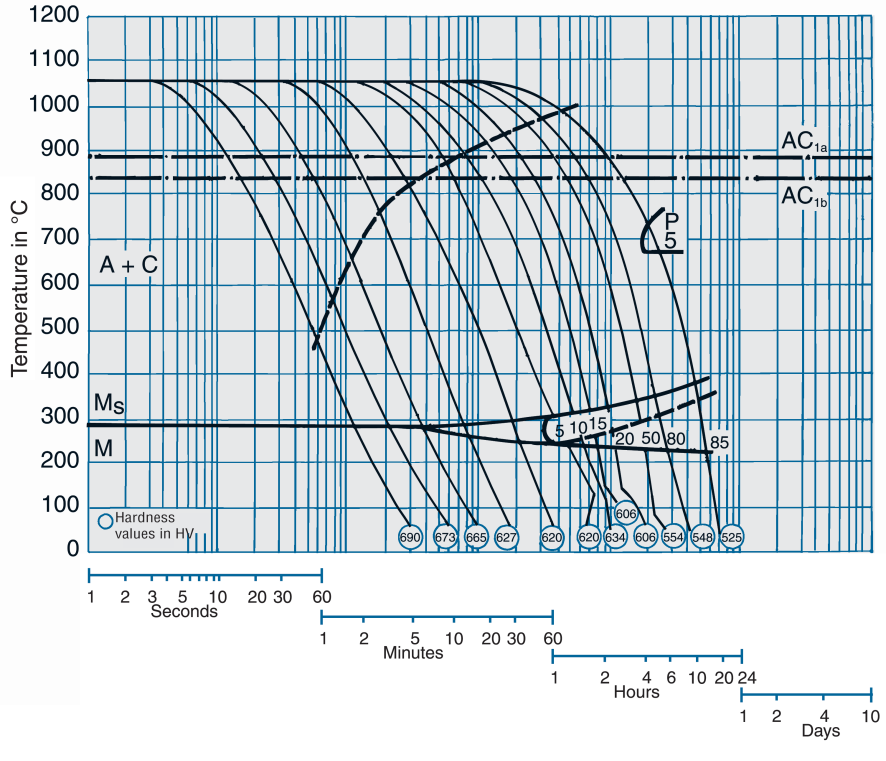
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	11.9	12.5	12.6	12.8	13.1	13.3	13.5

Thermal conductivity:

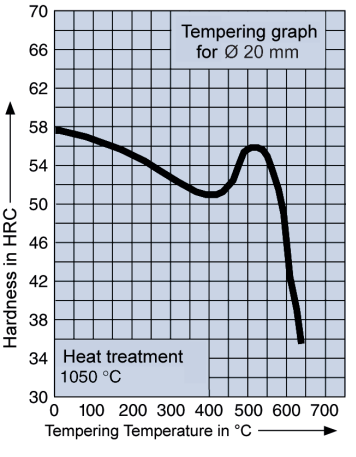
W	20	350	700 °C
m x K	36.4	32.2	27.5

Normal working hardness: 35 - 52 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 265 W ESR

Name:
X 38 CrMoV 5-3

Material No.:
1.2367 ESR

Typical analysis in %:

C	Si	Mn	Cr	Mo	V
0.38	0.4	0.5	5.0	3.0	0.6

As-supplied condition:
Structurally treated to max. 229 HB (770 N/mm²)

Characteristics:
CrMoV alloyed hot work steel with excellent high temperature strength and good high temperature toughness.

General fields of application:
Extrusion tools, die inserts, injection moulds, mandrels

Special note:
We recommend triple tempering to increase toughness. Preheating before bringing into operation to at least 300 °C is a mandatory requirement.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	820 - 840 °C	4 - 6 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1030 - 1060 °C	Group II	oil, air WB 500-550° C
Tempering	500 - 700 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

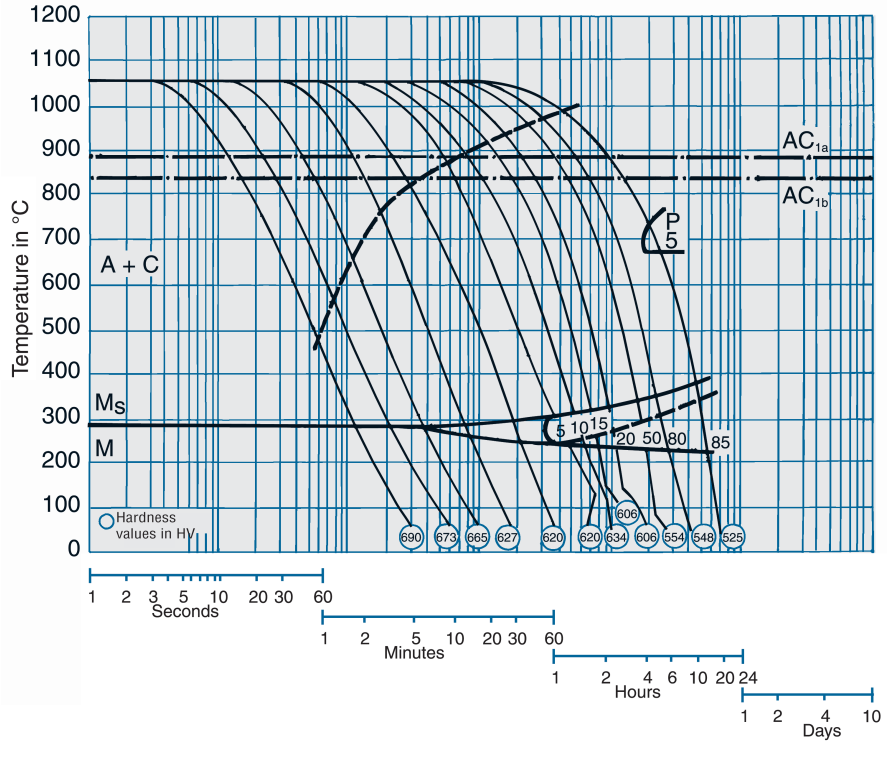
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	11.9	12.5	12.6	12.8	13.1	13.3	13.5

Thermal conductivity:

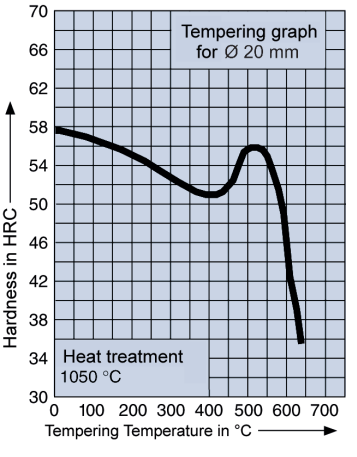
W	20	350	700 °C
m x K	36.4	32.2	27.5

Normal working hardness: 35 - 52 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 70 S

Name:
X 153 CrMoV 12

Material No.:
1.2379

Typical analysis in %:

C	Cr	Mo	V
1.53	12.0	0.7	1.0

As-supplied condition:
Soft-annealed to max. 255 HB (860 N/mm²)

Characteristics:
Ledeburitic 12 % chromium steel, high wear resistance, good toughness, high compressive strength, low distortion, nitridable.

General fields of application:
Deep drawing tools, sections susceptible to fracture, shearing knives, trimming dies, thread rolling tools, woodworking tools, hobbing tools, extrusion dies; compression and injection moulds for filled plastics, sprue bushings

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	820 - 850 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	1000 - 1050 °C	Group III	oil, air, WB 500 °C
Tempering	480 - 580 °C	min. 2 h	still air
	3 x, see tempering curve	depending on cross section	

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

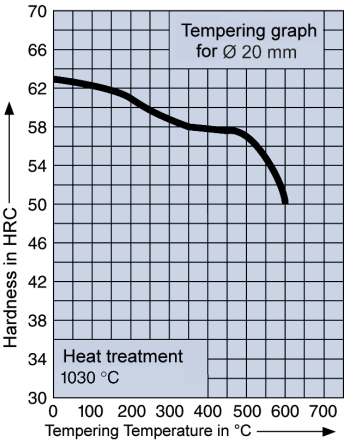
10^{-6} x m	100	200	300	400 °C
m x K	10.5	11.5	12.0	12.2

Thermal conductivity:

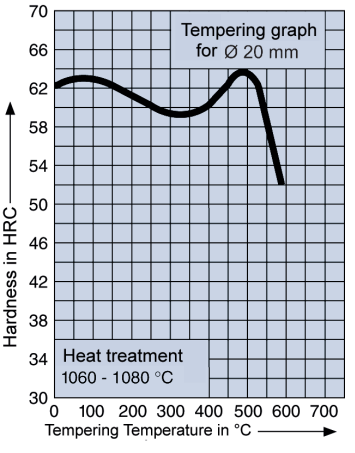
W	20	350	700 °C
m x K	16.7	20.5	24.2

Normal working hardness: 58 - 62 HRC

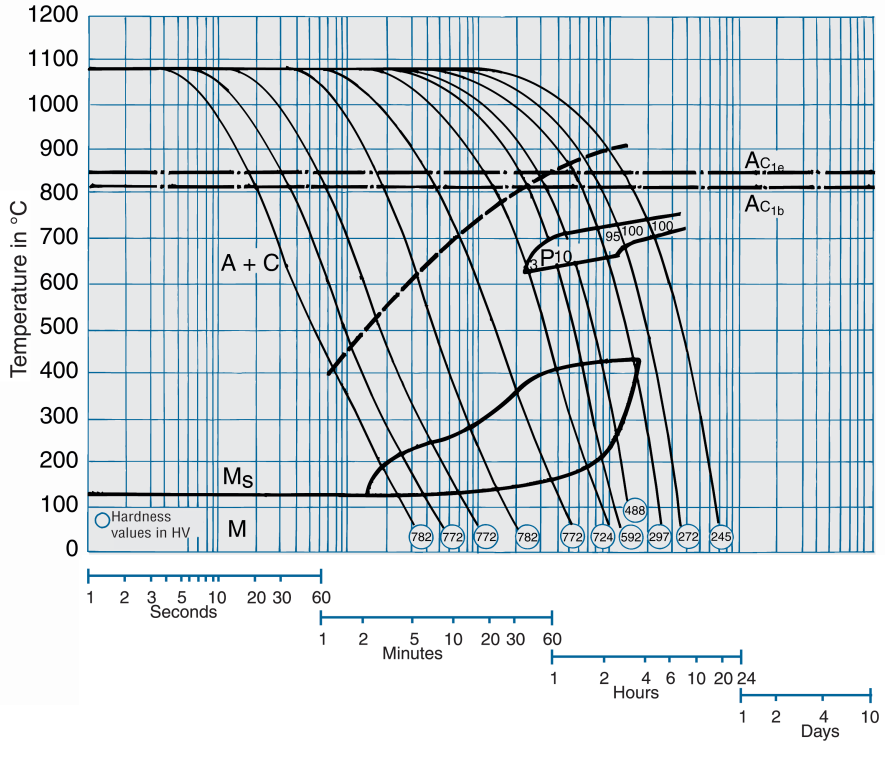
Tempering curve



Special heat treatment:
If the steel is electrical discharge machined or nitrided the tempering temperature must be above the secondary maximum. Triple tempering is recommended.



Continuous time-temperature-transformation diagram



ES 50 SW

Name:
X 210 CrW 12

Material No.:
1.2436

Typical analysis in %:

C	Cr	W
2.1	12.0	0.7

As-supplied condition:
Soft-annealed to max. 255 HB (855 N/mm²)

Characteristics:
Ledeburitic 12 % chromium steel, characteristics as ES 50 S but with improved hardenability and wear resistance.

General fields of application:
Cutting tools, shearing knives, broaches, woodworking tools, profile and flanging rollers, thread rolling tools, deep drawing and pressing tools, drawing mandrels, guide rails, extrusion dies, sand blast nozzles, rotary shear knives

Special note:
Not suitable for larger wire sections; for this we recommend ES 70 S, Mat. No. 1.2379.

Through-hardening workpiece ø for
64 HRC: 75 mm
62 HRC: 85 mm
60 HRC: 100 mm
58 HRC: 250 mm

Core hardness for ø 300 mm:
approx. 56 HRC

Core hardness for ø 500 mm:
approx. 41 HRC

Cooling:
blown air

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	800 - 840 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	950 - 980 °C	Group III	oil, air, WB 500 °C
Tempering	200 - 550 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

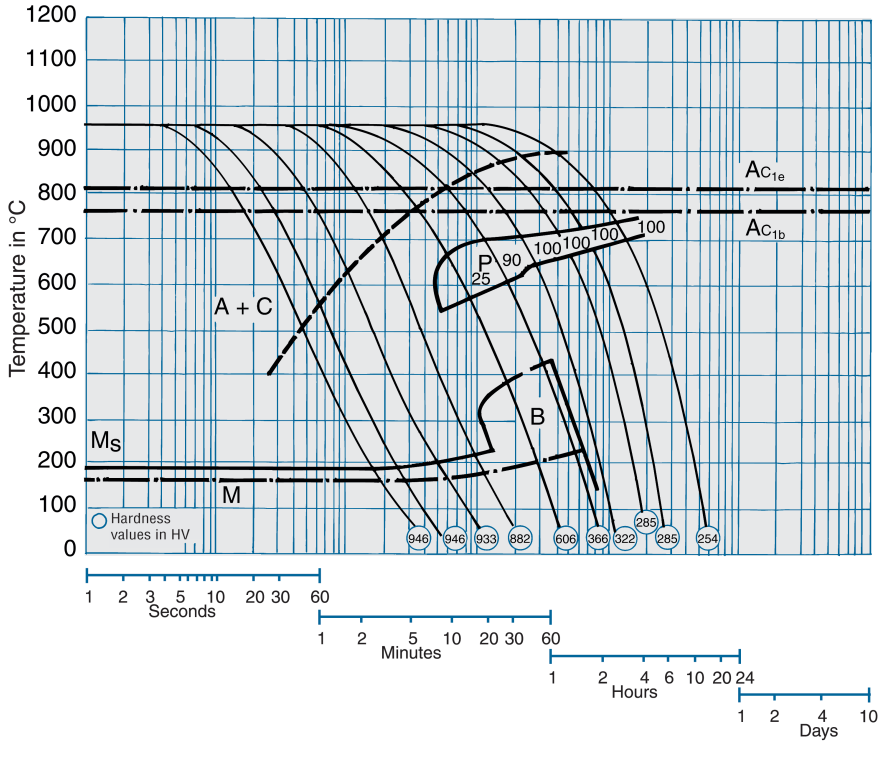
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	10.9	11.9	12.3	12.6	12.9	13.0	13.2

Thermal conductivity:

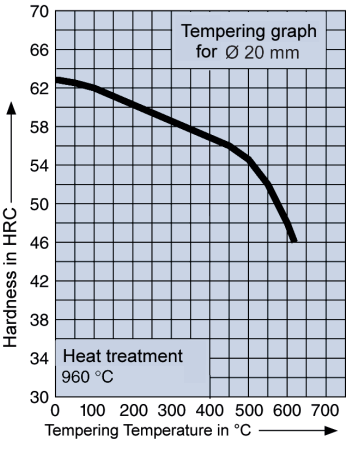
W	20	350	700 °C
m x K	16.7	20.5	24.2

Normal working hardness: 59 - 63 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 370 G

Name:
55 NiCrMoV 7

Material No.:
1.2714

Typical analysis in %:

C	Cr	Mo	Ni	V
0.55	1.1	0.5	1.7	0.1

As-supplied condition:
Soft-annealed to max. 248 HB (830 N/mm²)

Characteristics:
Oil and air hardening die steel with good through hardenability, good toughness and high temperature strength

General fields of application:
For drop forging up to the largest sizes, forging saddles, hot shearing knives, extrusion tools, die holders, support tools

Special note:
ES 370 G is also available in quenched and tempered form.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	680 - 720 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	830 - 870 °C 860 - 900 °C	Group II	oil, air
Tempering	300 - 600 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

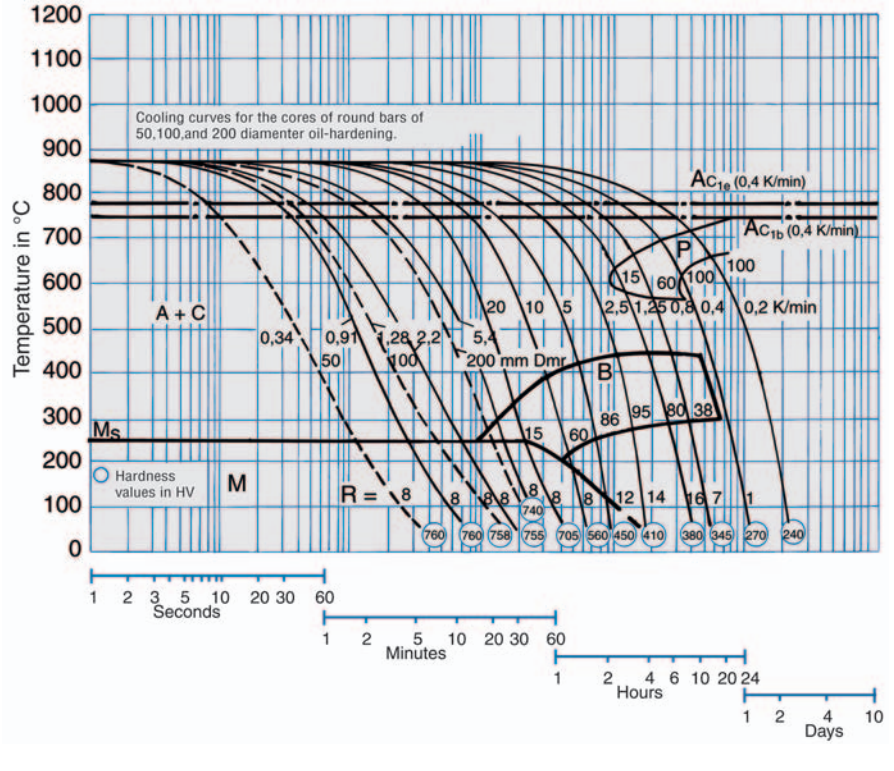
10^{-6} x m	100	200	300	400	500	600 °C
m x K	12.2	13.0	13.3	13.7	14.2	14.4

Thermal conductivity:

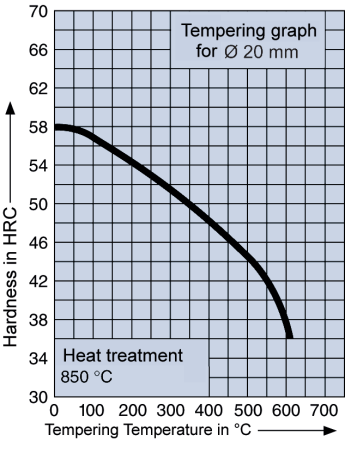
W	20	350	700 °C
m x K	36.0	38.0	35.0

Normal working hardness: 36 - 52 HRC (1200 - 1800 N/mm²)

Continuous time-temperature-transformation diagram



Tempering curve



ES Aktuell 1000

Name:
40 CrMnNiMo 8-6-4

Material No.:
1.2738

Typical analysis in %:

C	Mn	Cr	Mo	Ni
0.4	1.5	2.0	0.25	1.0

As-supplied condition:
Quenched and tempered to a hardness of 280 to 325 HB (950 - 1100 N/mm²)

Characteristics:
Uniform hardness throughout the cross section, good polishability, good machinability, nitridable, suitable for chromium plating, weldable to standards using all welding processes

General fields of application:
Mould steel for plastic moulds with plate thicknesses of approx. 400 mm upwards if uniform hardness, increased toughness and polishability are required, even in the base of the mould. Moulds for television casings and backs, copier bodies, bumper moulds, moulds for vehicle dashboards and large external car body parts, refuse container moulds, die casting frames

Special note:
ES Aktuell 1000 – a tool steel designed for the largest plastic moulds.
The additional 1 % nickel content considerably improves full thickness heat treatability compared with material 1.2311. Preworking the mould in the annealed condition followed by hardening and tempering after rough machining is not required.

Also available in EST grade.

If grained or polished only ES Aktuell 1000 in EST grade, Mat. No. 1.2738 EST should be used.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480 °C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30 % machining before finish machining.

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

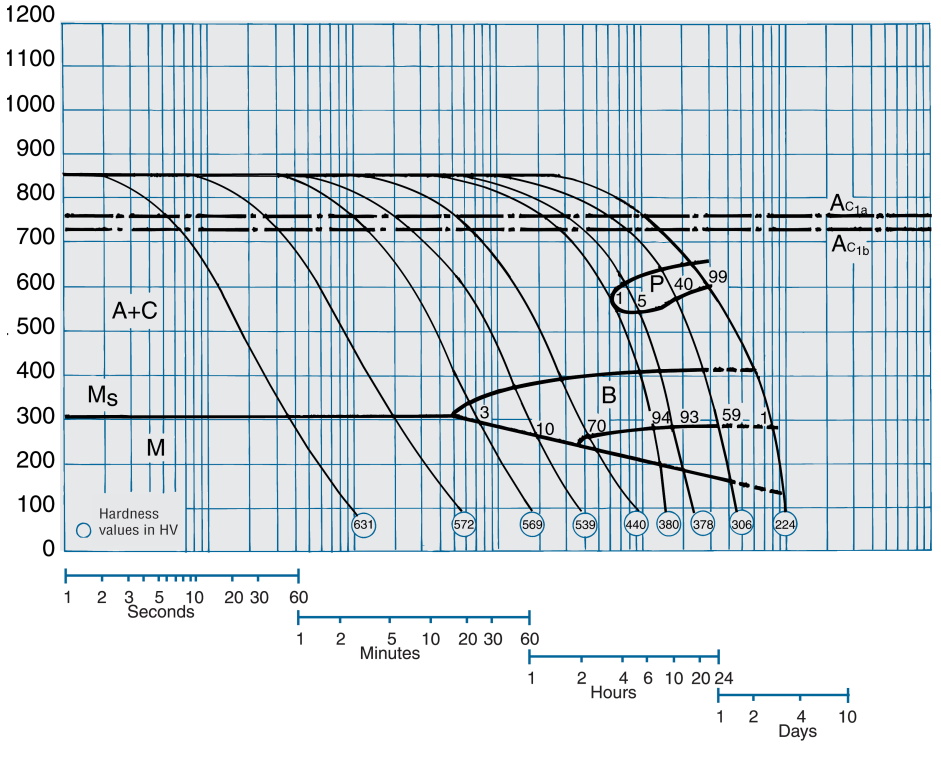
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	11.1	12.9	13.4	13.8	14.2	14.6	14.9

Thermal conductivity:

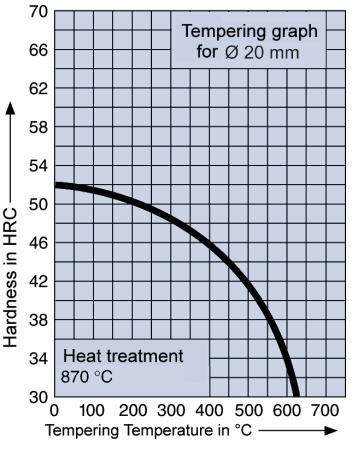
W	20	350	700 °C
m x K	35.5	33.2	31.9

Normal working hardness: Used in the as-supplied condition

Continuous time-temperature-transformation diagram



Tempering curve



ES Aktuell 1200

Name:

Special alloy

Typical analysis in %:

C	Mn	Cr	Ni	Mo
0.25	1.4	1.3	1.0	0.5

+ trace elements

As-supplied condition:

Quenched and tempered to a hardness of 310-355 HB (1050-1200 N/mm²)

Characteristics:

Uniformly high hardness over the cross section, very good weldability, good polishability and graining suitability, high thermal conductivity, higher tool service life

General fields of application:

Plastic mould steel for large moulds with high wear resistance, moulds for vehicle bumpers, dashboards, moulds for the largest external car body parts, refuse container moulds and other large moulds

Special note:

ES Aktuell 1200 – a steel designed for the harshest conditions with uniform high strength right into the core – perfectly engineered for the best mould.

Improved specifications for increased quality and productivity in the mould making and plastics industries.

ES Aktuell 1200 is usually supplied in EST grade.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480 °C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30 % machining before finish machining.

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

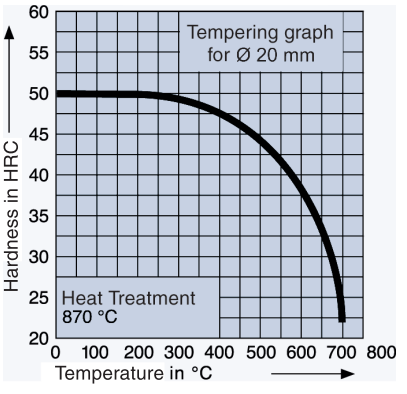
10^{-6} x m	100	200	300	400	500	600 °C
m x K	10.9	12.6	13.0	13.5	13.8	14.2

Thermal conductivity:

W	20	350	700°C
m x K	38.0	40.1	40.8

Normal working hardness: Used in the as-supplied condition

Tempering curve



ES 106 K

Name:
X 19 NiCrMo 4

Material No.:
1.2764

Typical analysis in %:

C	Cr	Mo	Ni
0.19	1.3	0.3	4.1

As-supplied condition:
Soft-annealed to max. 255 HB (855 N/mm²)

Characteristics:
Very tough, air hardening case hardening steel, low dimensional change, excellent polishability, very high core strength of up to 1500 N/mm²

General fields of application:
Moulds for plastics processing involving deep and complicated impressions

Special note:
Case hardening temperature in powder: 850 - 880 °C

In salt bath: 880 - 930 °C

Intermediate annealing temperature: 600 - 650 °C

Core strength after oil or WB hardening: 1200 - 1500 N/mm²

After air or compressed air hardening: 1100 - 1300 N/mm²

After hardening in case hardening box: 900 - 1100 N/mm²

Surface hardness after oil hardening: approx. 60 HRC

After air hardening: approx. 55 - 60 HRC

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	620 - 650 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	780 - 810 °C	Group II	oil,
	800 - 830 °C		air
Tempering	180 - 300 °C	min. 2 h	still air
	see tempering curve	depending on cross section	

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

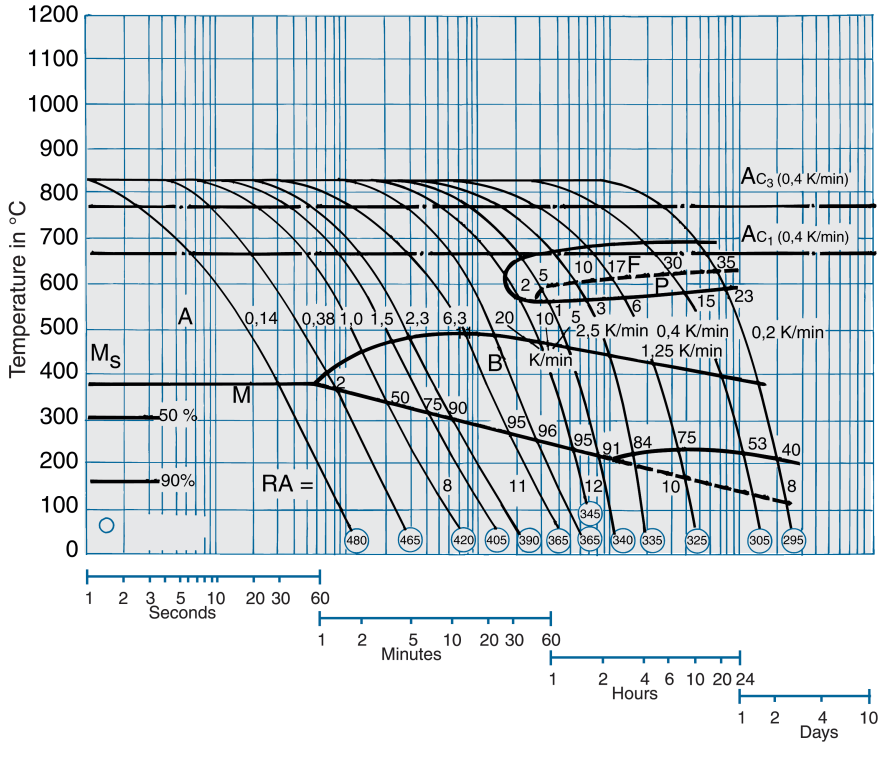
10^{-6} x m	100	200	300	400 °C
m x K	12.2	13.0	12.1	13.5

Thermal conductivity:

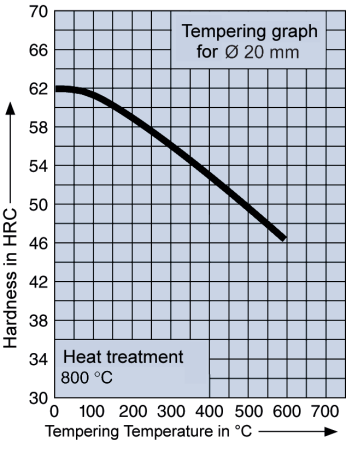
W	20	350	700°C
m x K	33.5	32.2	32.0

Normal working hardness: 50 - 60 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 275 K

Name:
45 NiCrMo 16

Material No.:
1.2767

Typical analysis in %:

C	Cr	Mo	Ni
0.45	1.4	0.3	4.0

As-supplied condition:
Soft-annealed to max. 285 HB (965 N/mm²)

Characteristics:
Through-hardening steel with the highest toughness, low distortion, good polishability

General fields of application:
Solid coining dies for the highest toughness requirements, extremely highly loaded cutlery presses, tools for heavy cold forming, hobbing tools, shearing blades and cutters for cutting very thick material; plastic, compression and injection moulds, which require high hardness combined with the highest toughness

Special note:
Also available in EST and ESR grades.

If grained only ES 275 K in EST grade should be used.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	620 - 650 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	840 - 870 °C	Group II	oil, air, WB 200 °C
Tempering	180 - 600 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

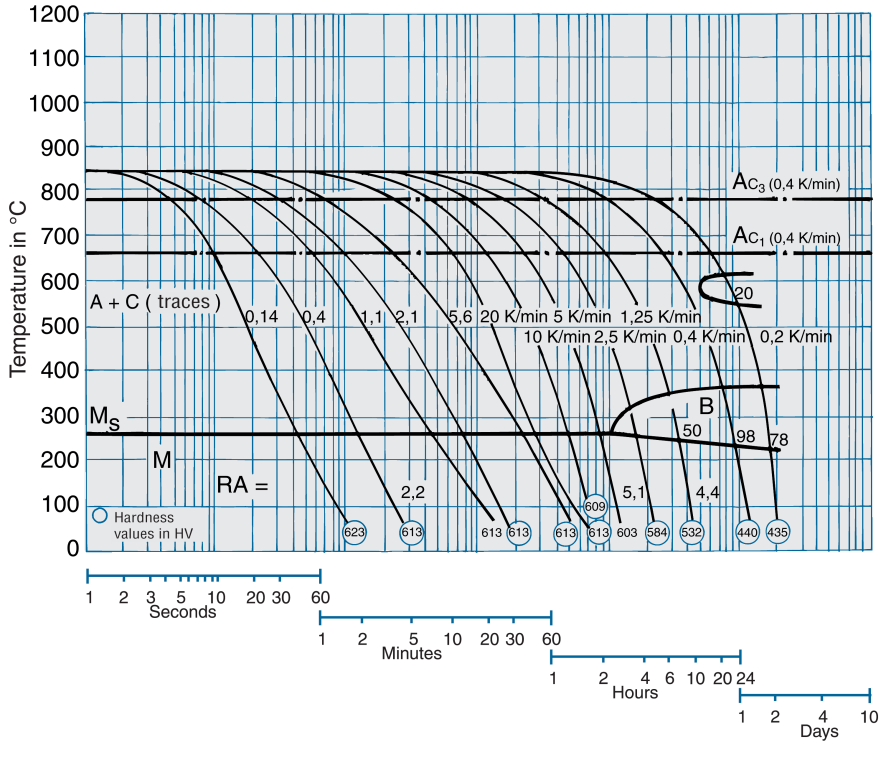
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	11.8	12.5	12.8	13.1	13.4	13.8	13.6

Thermal conductivity:

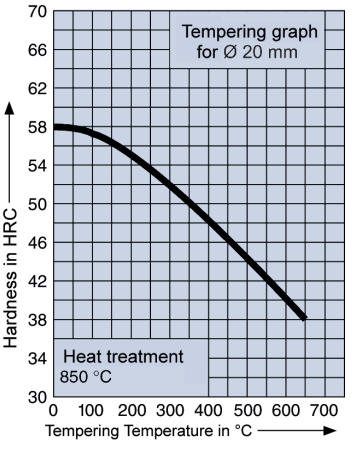
W	20	350	700 °C
m x K	30.0	30.5	32.0

Normal working hardness: 50 - 56 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 275 K ESR

Name:
45 NiCrMo 16

Material No.:
1.2767 ESR

Typical analysis in %:

C	Cr	Mo	Ni
0.45	1.4	0.3	4.0

As-supplied condition:
Soft-annealed to max. 285 HB (965 N/mm²)

Characteristics:
Through-hardening steel with the highest toughness, low distortion. ESR technology provides this material with high polishability.

General fields of application:
Solid coining dies for the highest toughness requirements, extremely highly loaded cutlery presses, tools for heavy cold forming, hobbing tools, shearing blades and cutters for cutting very thick material; plastic, compression and injection moulds, which require high hardness combined with the highest toughness.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	620 - 650 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	840 - 870 °C	Group II	oil, air WB 200° C
Tempering	180 - 600 °C see tempering curve	min. 2 h depending on cross section	still air

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

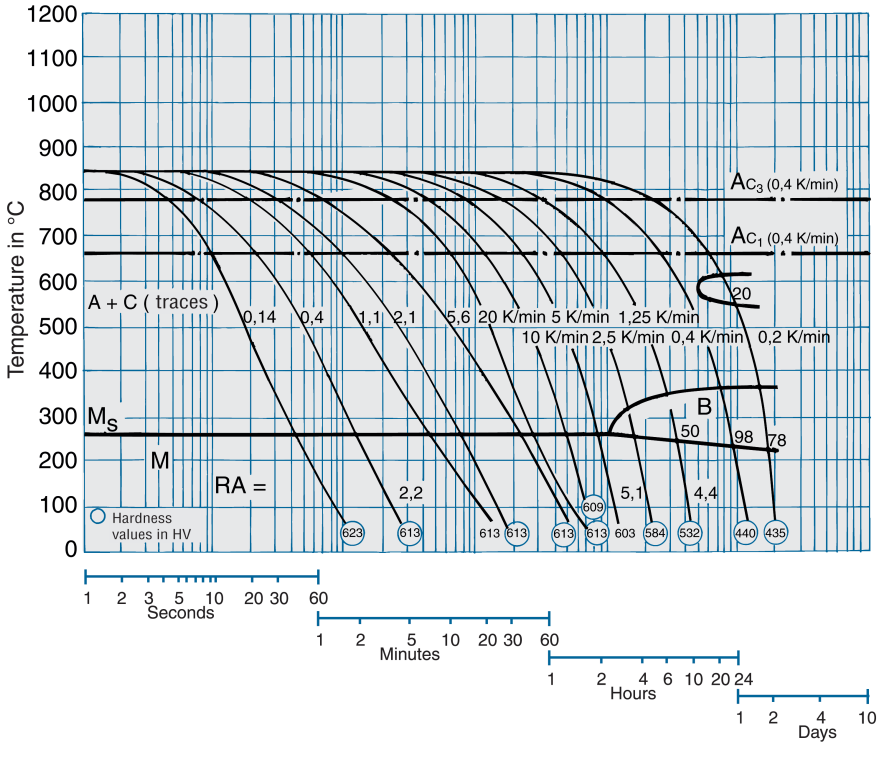
10^{-6} x m	100	200	300	400	500	600	700 °C
m x K	11.8	12.5	12.8	13.1	13.4	13.8	13.6

Thermal conductivity:

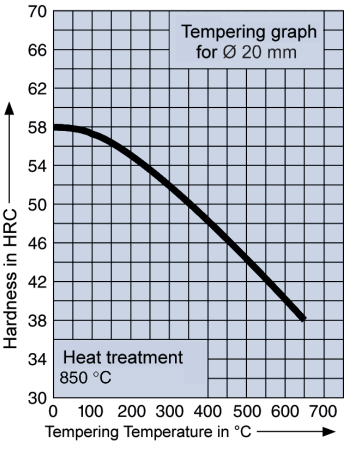
W	20	350	700 °C
m x K	30.0	30.5	32.0

Normal working hardness: 50 - 56 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 60 S

Name:
90 MnCrV 8

Material No.:
1.2842

Typical analysis in %:

C	Mn	Cr	V
0.9	2.0	0.4	0.1

As-supplied condition:
Soft-annealed to max. 229 HB
(770 N/mm²)

Characteristics:
Oil hardening steel with simple heat treatment, especially easy to machine, high hardenability, good dimensional stability

General fields of application:
Punching, cutting, deep drawing tools, stamps, industrial knives, cutting tools, measuring tools, compression and injection moulds, sprue bushings, clamping plates, guide columns

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Soft annealing	680 - 720 °C	2 - 5 h	furnace
Stress-relief annealing	600 - 650 °C	min. 4 h	furnace
Hardening	790 - 820 °C	Group II	oil
Tempering	180 - 250 °C	min. 2 h	still air
	see tempering curve	depending on cross section	

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

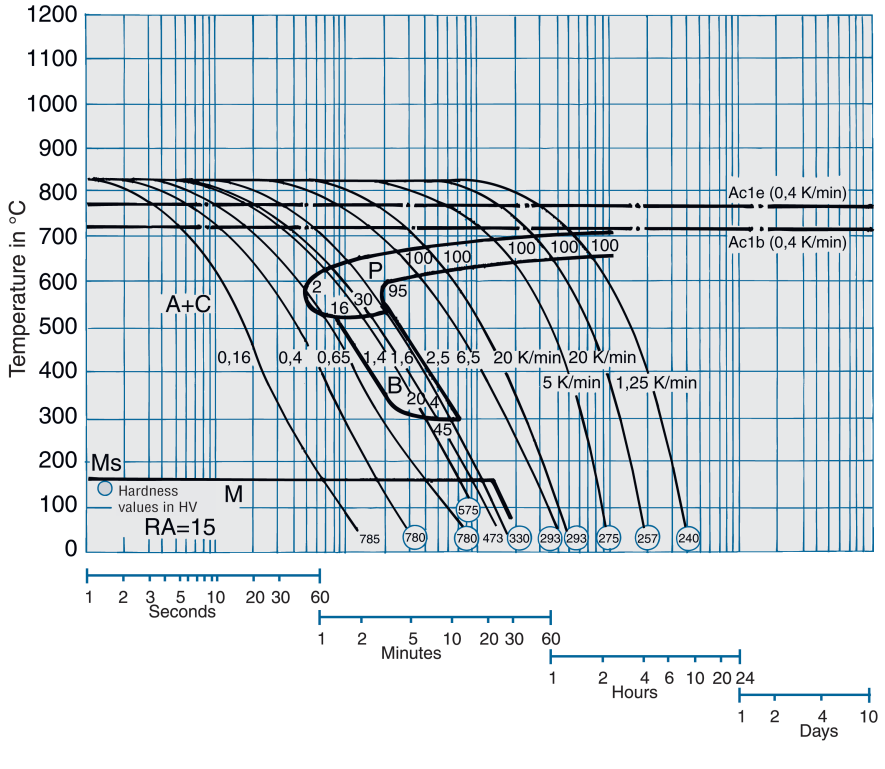
10^{-6} x m / m x K	100	200	300	400	500	600	700 °C
	12.2	13.2	13.8	14.3	14.7	15.0	15.3

Thermal conductivity:

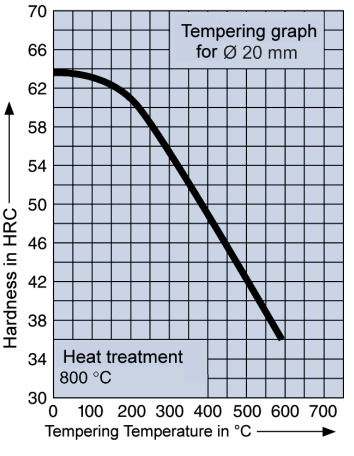
W / m x K	20	350	700 °C
	33.3	32.0	31.3

Normal working hardness: 57 - 62 HRC

Continuous time-temperature-transformation diagram



Tempering curve



ES 4122

Name:
X 39 CrMo 17-1

Material No.:
1.4122 mod.

Typical analysis:

C	Cr	Mo	Ni
0.39	17.0	1.0	≤ 1.0

As-supplied condition:
Quenched and tempered:
280-325 HB
(950-1100 N/mm²)

Characteristics:
17% chromium steel with good corrosion resistance

General fields of application:
Pump shafts, pipe fittings and compressor components, steam and water valves

Special note:
Nitriding the steel causes it to lose corrosion resistance

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480 °C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30 % machining before finish machining.

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

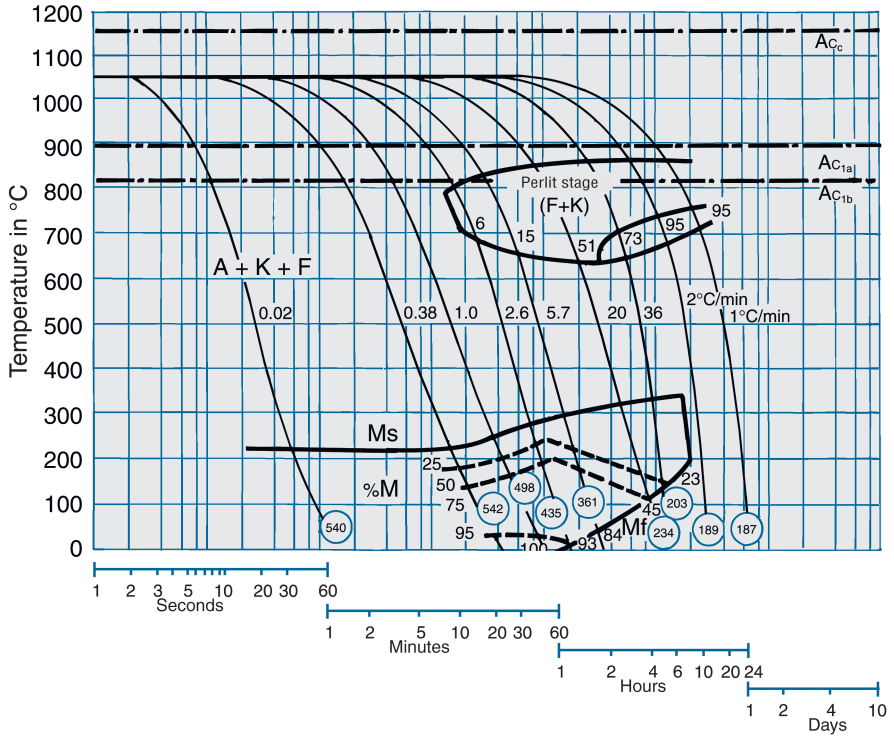
10^{-6} x m	100	200	300	400	500 °C
m x K	10.5	11.0	11.0	11.5	12.0

Thermal conductivity:

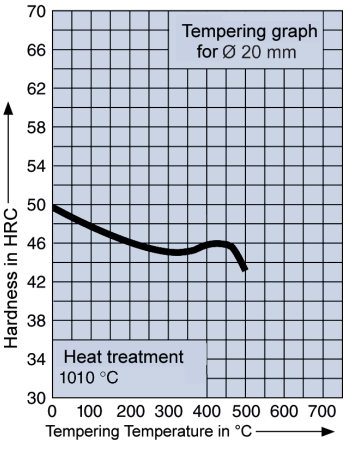
W	20	350	700 °C
m x K	17.2	21.0	24.7

Normal working hardness: Used in the as-supplied condition

Continuous time-temperature-transformation diagram



Tempering curve



ES LB 100

Name:
Special alloy

Typical analysis in %:

C	Mn	Cr	Mo
0.4	1.0	1.5	0.2

As-supplied condition:
Quenched and tempered to approx. 300 HB (1000 N/mm²)

Characteristics:
Special alloyed improved heat-treatable steel with increased mechanical properties compared to normal grade, nitridable by all usual processes

General fields of application:
The ideal material for structural steelwork.

Special note:
If machinability is the main requirement we recommend the sulphur alloyed variant ES LB 100 S.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480 °C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30 % machining before finish machining .

Physical characteristics:

Coefficient of thermal expansion: between 20 °C and:

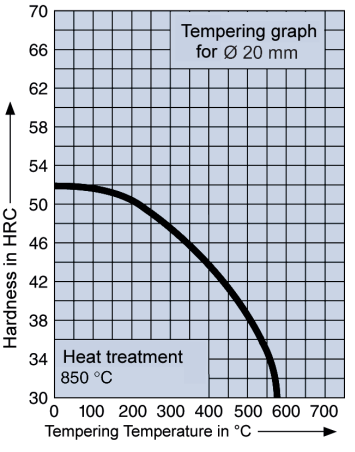
10^{-6} x m / m x K	100	200	300	400	500	600 °C
	11.0	12.0	13.0	13.5	14.0	14.3

Thermal conductivity:

W / m x K	20 °C
	40.0

Normal working hardness: Used in the as-supplied condition

Tempering curve



ES LB 100 S

Name:
Special alloy

Typical analysis in %:

C	Mn	Cr	Mo	S
0.4	1.0	1.5	0.2	0.07

As-supplied condition:
Quenched and tempered to approx. 300 HB (approx. 1000 N/mm²)

Characteristics:
Improved machinability by addition of sulphur compared with ES LB 100

General fields of application:
Applications for which machinability is a main requirement.

Heat treatment data:

	Temperature	*Duration*	*Cooling*
Stress-relief annealing	max. 480 °C	min. 4 h	furnace

We recommend stress-relief annealing for more than 30 % machining before finish machining.

Physical characteristics:

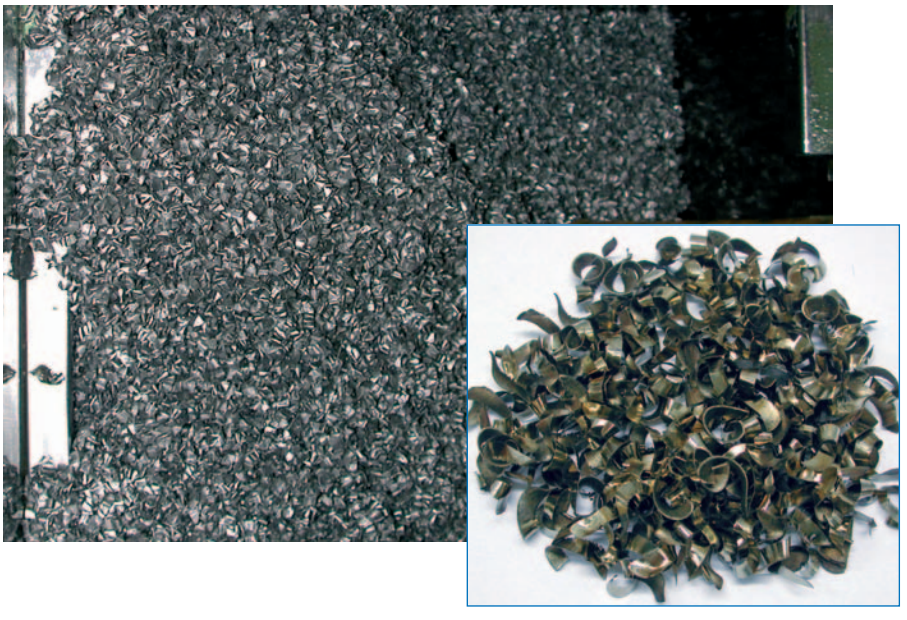
Coefficient of thermal expansion: between 20 °C and:

10^{-6} x m / m x K	100	200	300	400	500	600 °C
	11.0	12.0	13.0	13.5	14.0	14.3

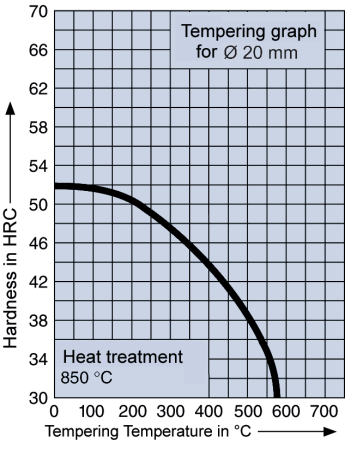
Thermal conductivity:

W / m x K	20 °C
	40.0

Normal working hardness: Used in the as-supplied condition



Tempering curve



Quality and production standards

Our tool steel is produced by applying our know-how with the greatest of care in state-of-the-art metallurgical facilities, rolling mills and forging machines.

All our steel grades fulfil the requirements of the German tool steel standard **DIN EN ISO 4957**.

Many of our tool steel grades, particularly our plastic mould and hot work steels, considerably exceed the steel properties requirements of the **DIN**.

This provides greater safety even with tools subject to the severest of demands. This is specially indicated the grade designations **EST** and **ESR**.

EST – Extra Structure

From steel manufacture to heat treatment, our special processes ensure considerable improvements over normal steel grades.

In particular the improvements include:

- Better cleanliness factor
- Higher toughness
- More homogenous microstructure after annealing/hardening/tempering
- Structural treatment
- Greater dimensional stability during heat treatment
- Improved polishability and suitability for graining

Hot work steels comply with the requirements of SEP 1614, VDG and DGM.

ESR – Electroslag Remelting

Remelting the already cast steel ingot in a synthetic slag under controlled conditions further improves the properties of the steel with respect to:

- Reduction of ingot segregation
- Minimum sulphur and phosphorus content
- Hardly any sulphide or oxide inclusions
- Highest toughness both longitudinally and transversely
- Fine grained microstructure due to continuous solidification
- Highest homogenity
- Highest suitability for highly polished mirrored finishes and graining

Heat treatment

The primary influence on the characteristics of tool steel is its heat treatment. In the following sections we would therefore like to give some brief details about this important stage in its manufacture.

1. Soft annealing

In most cases steel in the soft annealed condition is mainly used for machining and cold forming and provides the most favourable microstructure for hardening.

Soft annealing is the result of

- slowly heating the steel to its annealing temperature,
- keeping it for an hour or more at this temperature and
- then cooling it slowly at 10 to 20 °C/h (furnace cooling).

Annealing temperatures can be found in the material specification sheet for each steel. Where necessary the appropriate measures need to be taken to avoid decarburisation and scaling (e.g. packing in cast iron chips, protective film or similar).

2. Stress-relief annealing

Machining and forming the steel causes stresses additional to those already existing in the material. These additional stresses can give rise to large irregular changes in shape of the steel during subsequent heating to the hardening temperature. We therefore recommend that workpieces with irregular or complicated shapes are annealed for at least 2 hours at 480 °C to relieve these stresses before final machining and thus limit the amount of costly reworking of the finished tool. Final cooling should take place in a furnace for as long as possible.

Note:

In the case of quenched and tempered steel the stress-relief annealing is carried out at 30 - 50 °C less than the last tempering temperature so as to avoid a reduction in hardness.

3. Hardening

3.1 Heating to the hardening temperature

The workpieces are heated slowly to the hardening temperature in order to keep thermal stresses and distortion low. In the case of facilities that heat up quickly such as salt baths you are strongly recommended to split the heating up process into stages. The initial preheating stage generally goes up to about 400 °C (in air circulation furnaces). Further conventional heating stages are shown in the time-temperature-transformation diagrams below. The aim of this preheating is to achieve a uniform temperature over the whole cross section of the workpiece.

3.2 Austenisation

From the last preheating stage the workpiece is heated to a hardening temperature within the range given in the material specification sheets. After the workpiece has reached the hardening temperature over its whole cross section it is held at this temperature (with the exception of high speed steel tools). The time required for the hardening temperature to be reached throughout the section depends on the wall thickness of the workpiece.

Once the hardening temperature is achieved the tool must be held at this temperature irrespective of the wall thickness.

3.3 Quenching

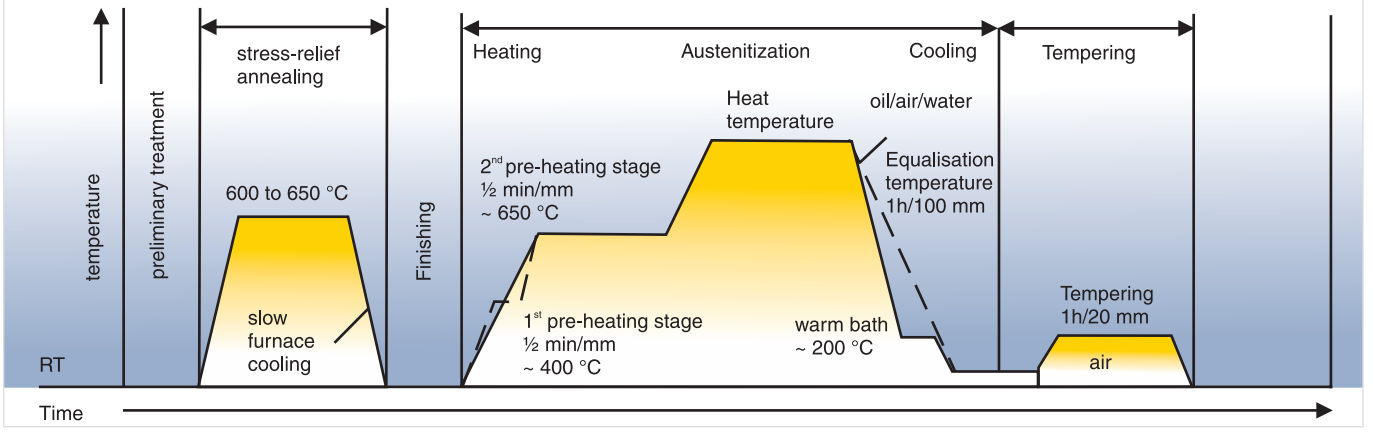
After austenisation the tools are cooled in the appropriate hardening medium The attainable hardness depends on what speed of cooling can be achieved from the hardening temperature. It is therefore influenced by the cooling medium and the size of the workpiece. On the other hand the speed of cooling should not be higher than is necessary to achieve the maximum hardness whilst keeping the thermal stresses due to cooling as small as possible. If the transformation behaviour of the steel allows, a temperature equalisation stage is incorporated at ≈ 550 °C. If this is possible it is detailed in the material specification sheet. After the parts are cooled to ≈ 100 °C, they are transferred directly into a furnace at a temperature of between 100 and 150 °C to prevent possible quenching cracks from developing if cooled to room temperature. Temperature equalisation in an equalisation furnace is often necessary, particularly with large tools, in order to achieve full transformation in the core before tempering.

4. Tempering

After quenching, the steel is brought to the specified hardness by tempering. The appropriate temperature for tempering can be estimated from the hardness-tempering temperature graph (see material specification sheet). Even if the maximum hardness is the same as the intended working hardness, the steel must still be tempered at between 180 and 220 °C. The respective curves apply only for the hardening temperatures given in the diagrams. However, there are a number of tool applications in which deviations from the usual hardening temperatures are advantageous. The hardness-tempering temperature curves cannot be used for these. Heating to the tempering temperature should take place slowly. The whole time in the tempering oven should be approx. 1 hour for every 20 mm wall thickness, with a minimum of 2 hours. Then follows cooling in air.

It is advantageous to temper at least twice in order to temper the martensite formed from the residual austenite during the first cooling from the tempering temperature. In the case of hardness-tempering curves with a secondary hardening maximum always select the highest tempering temperature in order to achieve the desired hardness.

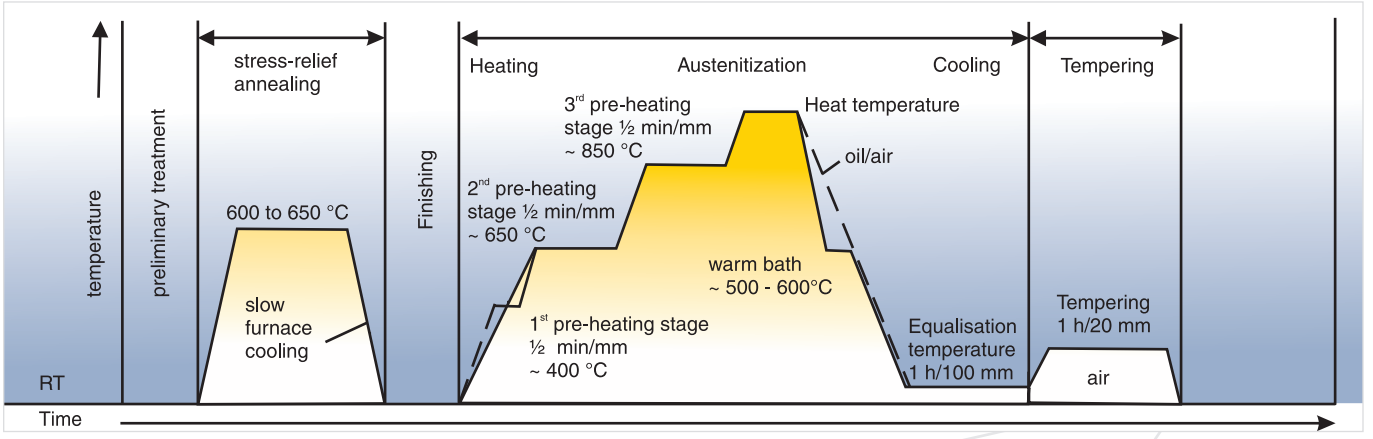
Diagram 1



Time-temperature-transformation diagram for the heat treatment of unalloyed and alloyed cold and hot work steels with hardening temperatures of up to 900 °C

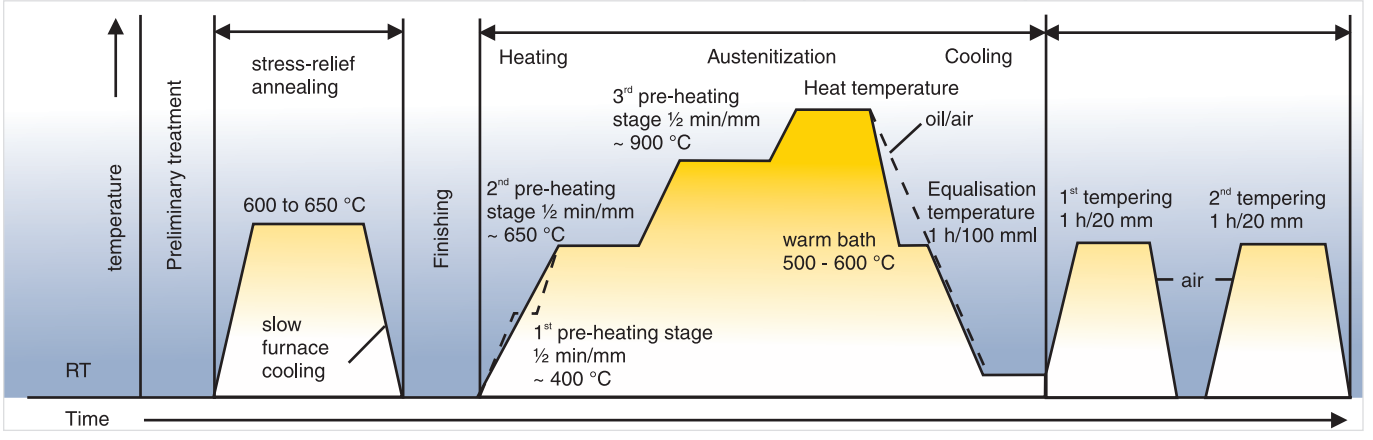
Heat treatment

Diagram 2



Time-temperature-transformation diagram for the heat treatment of alloyed cold work steels with hardening temperatures over 900 °C

Diagram 3



Time-temperature-transformation diagram for the heat treatment of hot work steels with hardening temperatures over 900 °C and for special treatment of e.g. 1.2379

Welding

1. Problem

In order to achieve specific characteristics, for example high hardness, good wear resistance, good through-hardenability etc., steels for tool making are always incorporate a number of alloying elements. This inevitably leads to a substantial reduction in their weldability, especially if the carbon content is high (>0.5 %). During cooling of the weld, when the temperature falls below a specific temperature (defined for the steel involved) the micro-structure can change though the formation of martensite, i.e. the weld affected zone hardens and this can lead to the formation of stress cracks. In the light of this problem we recommend that the important fundamental advice outlined in section 3 is always observed.

2. Welding process

Most repair welding in tool making is carried out using the TIG process or with covered stick electrodes. TIG welding is used to rectify small defects, whilst stick electrodes are more suitable for application to larger surfaces.
The welding process selected has no influence on the pre and post heat treatments to be used, which must be carried out as stipulated in every case. Only when welding low alloy case hardening steels and when using covered electrodes is it possible to omit post-weld treatment, as cooling in these circumstances takes place relatively slowly and thus results in no seriously increased hardening.

3. General advice

Please ensure you observe the following points:

3.1

Prepare the surface appropriately before welding. For example, cracks should be ground open to form a U-shaped cross section. Grind away all visible traces of cracks.

3.2

In order to make the repair site as unnoticeable as possible (important for plastic mould tools) it is necessary to use a filler metal with a similar chemical composition to the parent metal. This requirement is also emphasised by the desirability of uniform hardness and internal stresses in the weld and parent material.

3.3

Tool steels must always be preheated in order to counteract increased hardening and the risk of stress cracks.

3.4

In the case of quenched and tempered steels or hardened tools, the preheat temperature should be 30 - 50 °C below the last tempering temperature (protective atmosphere) in order to avoid reduction in hardness.

3.5

Use an electrode with as small a diameter or cross section as possible for the work.

3.6

For longer duration welding operations the preheat temperature must be maintained by the application of intermediate heat.

3.7

Larger applications should be welded in strips, which are joined afterwards in order to keep distortion as low as possible.

3.8

After welding the tools should be allowed to cool to no lower than 100 °C.

3.9

Annealed materials must be soft-annealed immediately afterwards. This involves heating quenched and tempered steel to a temperature if at all possible 30 - 50 °C below the last used tempering temperature (protective atmosphere) to prevent a reduction in strength.

Welding

4. The welding process

All welding operations consist of 3 stages:

- Preheating
- Welding with subsequent cooling (not below 100 °C)
- Immediate post-weld heat treatment

Recommended pre and post-treatment temperatures can be found in Table 1.

Table 1:

Works name	Material No.	Heat treatment condition	Preheating temperature	Reheating temperature
Unalloyed steel				
ES ULW 65	1.1730	annealed	350 - 450 °C	650 - 700 °C
Case hardening steels				
ES 100 K	1.2162	annealed	400 - 450 °C	680 - 710 °C
		quenched and tempered	160 - 200 °C	160 - 200 °C
ES 106 K	1.2764	annealed	400 - 450 °C	620 - 650 °C
		quenched and tempered	160 - 200 °C	160 - 200 °C
Quenched and tempered steels				
ES Aktuell	1.2311	quenched and tempered	350 - 480 °C	480 °C
ES Aktuell S	1.2312	quenched and tempered	350 - 480 °C	480 °C
ES Aktuell 1000	1.2738	quenched and tempered	350 - 480 °C	480 °C
ES Aktuell 1200	Special alloy	quenched and tempered	350 - 480 °C	480 °C
Through-hardening steels				
ES 235 W	1.2343	annealed	350 - 450 °C	820 - 860 °C
		quenched and tempered	350 - 450 °C	480 °C
ES 245 W	1.2344	annealed	350 - 450 °C	820 - 860 °C
		quenched and tempered	350 - 450 °C	480 °C
ES 70 S	1.2379	annealed	300 - 400 °C	800 - 850 °C
		quenched and tempered	160 - 250 °C	160 - 250 °C
		hardened, special heat treatment	350 - 500 °C	480 °C
ES 50 SW	1.2436	annealed	300 - 400 °C	780 - 820 °C
		quenched and tempered	160 - 240 °C	160 - 240 °C
ES 370 G	1.2714	annealed	400 - 500 °C	680 - 720 °C
		quenched and tempered	300 - 400 °C	480 °C
ES 275 K	1.2767	annealed	300 - 400 °C	620 - 650 °C
		quenched and tempered	160 - 300 °C	160 - 300 °C
ES 60 S	1.2842	annealed	300 - 400 °C	680 - 720 °C
		quenched and tempered	160 - 240 °C	160 - 300 °C
Corrosion resistant steels				
ES 120 K	1.2083	annealed	400 - 500 °C	780 - 820 °C
		quenched and tempered	250 - 350 °C	250 - 500 °C
ES Antikor	1.2316	quenched and tempered	400 - 500 °C	500 - 550 °C
ES Antikor S	1.2085 mod.	quenched and tempered	400 - 500 °C	500 - 550 °C

Polishing

Polishing of tool steels

Different products require different grades of surface finish. Their quality is primarily dependent on the quality of the mould surface.

The factors influencing polishability are:

- Cleanliness factor
- Appropriate heat treatment, properly carried out
- Grade of the grinding or polishing materials

When considering the cleanliness factor, it is essential to consider the specific types of inclusions present in the steel. These inclusions can never be totally avoided. Hard, brittle oxides and silicates are detrimental as they are torn out of the steel during polishing and leave behind small pin-prick holes.

Non-metallic, low-hardness inclusions such as sulphides do not normally have any detrimental effect on polishability. However the low hardness of these sulphides compared with the steel matrix can give rise to hollows in highly polished mirrored finishes with the result that these steels cannot be used for making this type of mould (e.g. 1.2312 or 1.2085 mod.).

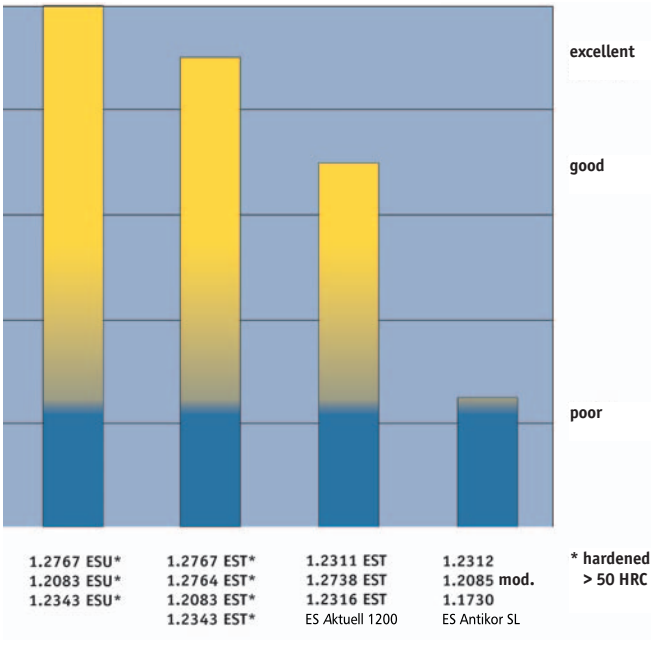
Modern deoxidisation processes and treating the steel melt under vacuum allow us nowadays to avoid detrimental inclusions to a large extent or to limit them to a size at which they do not cause any damage.
Our EST grades allow very good technical polishing.
For highly polished or mirrored finishes we recommend that ESR materials are used.

Heat treatment can affect polishability in a number of ways. The microstructure of over-carburised case hardening steel is not very suitable for polishing. It actually has no oxide particles under the surface. Variations or decarburisation or carburisation of the shallow surface zone caused by heat treatment can lead to variations in hardness at the surface and detrimentally effects on polishability.

Our quenched and tempered plastic mould steels, e.g. 1.2311 or 1.2738, strength approx. 1000 N/mm², are not normally subject to further heat treatment. These steels in EST grade show good polishability in the as-supplied condition.

If steel with a higher strength is used a better polished surface can be produced. Longer polishing times are required on harder steels to produce a high degree of uniformity.

Polishability of plastic mould steels



Note:

Polishability in this case relates to quenched and tempered or hardened steels. Our EST and ESR grades further improve polishability.
You may also see ESR referred to ESU elsewhere in other German steel industry literature.

Surface texturing

For technical and aesthetic reasons many plastic products are given a textured surface.

A wide range of surface textures can be achieved by photochemical etching of the tool surface.

Steel quality is largely determined by production methods. A high cleanliness factor with regard to oxides and sulphides, a uniform, fine microstructure and little segregation within the steel lead to a good final product.

ES tool steel meets all the prerequisites for attaining a good grain surface texture.

The quality of the surface texture is also extremely dependent on the machined surface of the tool mould. Weld repair sites or residual eroded material can lead to defects in the grain texture.

This is where the know-how of graining experts is necessary to detect these defects before texturing begins. In many circumstances the graining process can then be suitably adapted to suppress the appearance of these defects in the surface texture.

Eschmann Textures International GmbH has particular expertise with all ES steel grades. The combination of experience of tool steel and etching techniques assures the best texture quality is achieved.

Plastic mould steels

The development of plastics processing, which imposes increasing requirements on tool moulds, demands continuous improvements in material properties. The development of these properties is an integral part of the rapidly expanding plastics processing industry.

Plastic moulds are subject to more than a million stress cycles over their long life, which means that excellent wear resistance is required in addition to high toughness.

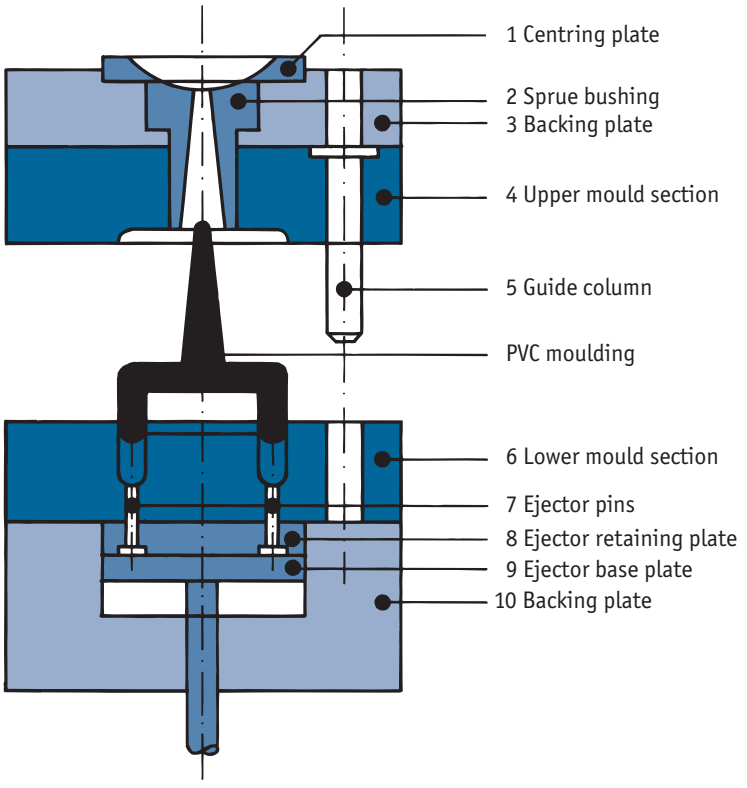
The requirement for surface finish quality of the plastic components and the associated quality of the moulds with respect to polishability and suitability for graining necessitate a uniform (isotropic) microstructure over the whole ingot cross section.

EschmannStahl has been the leading producer of plastic mould steels for many years and has always been a pioneer in the introduction of new and improved steels.

Product range:

Works name	*Material No.*	*Name*	*Chemical composition (typical values in %)*							
			C	*Si*	*Mn*	*S*	*Cr*	*Mo*	*Ni*	*V*
Mould frame steel										
ES ULW 65	1.1730	C 45 U	0.45	0.3	0.7	-	-	-	-	-
Case hardening steel										
ES 100 K	1.2162	21 MnCr 5	0.21	0.3	1.3	-	1.2	-	-	-
ES 106 K	1.2764	X 19 NiCrMo 4	0.19	0.3	0.3	-	1.3	0.2	4.1	-
Quenched and tempered steels										
ES Aktuell	1.2311	40 CrMnMo 7	0.40	0.3	1.5	-	1.9	0.2	-	-
ES Aktuell S	1.2312	40 CrMnMo S 8-6	0.40	0.4	1.5	0.07	1.9	0.2	-	-
ES Aktuell 1000	1.2738	40 CrMnNiMo 8-6-4	0.40	0.3	1.5	-	2.0	0.2	1.0	-
ES Aktuell 1200	**Special alloy**		0.25	-	1.4	-	1.3	0.5	1.0	-
ES Antikor	1.2316	X 38 CrMo 16	0.38	1.0	1.0	-	16.0	1.2	1.0	-
ES Antikor S	1.2085 mod.	X 33 CrS 16	0.30	0.50	1.0	0.1	16.0	-	1.0	-
Corrosion resistant steels										
ES 120 K	1.2083	X 40 Cr 14	0.42	0.4	0.3	-	13.0	-	-	-
ES Antikor	1.2316	X 38 CrMo 16	0.38	1.0	1.0	-	16.0	1.2	1.0	-
ES Antikor S	1.2085 mod.	X 33 CrS 16	0.33	1.0	1.0	0.1	16.0	-	1.0	-
ES Antikor SL	**Special alloy**		0.04	-	1.2	0.12	13.0	-	-	-
Special steels										
ES LB 100	-	-	0.40	0.3	1.0	-	1.5	0.2	-	-
Through-hardening steels										
ES 235 W	1.2343	X 37 CrMoV 5-1	0.37	1.0	0.4	-	5.3	1.3	-	0.4
ES 245 W	1.2344	X 40 CrM V 5-1	0.40	1.0	0.4	-	5.3	1.4	-	1.0
ES 275 K	1.2767	45 NiCrMo 16	0.45	0.3	0.3	-	1.4	0.3	4.0	-

Schematic diagram of a plastic injection moulding tool



Example: PVC moulding

	Tool	*Works name*	*Material No.*	*Hardness in HRC / Strength in N/mm²*
1	Centring plate	ES ULW 65	1.1730	approx. 650 N/mm²
2	Sprue bushing	ES 120 K	1.2083	54-56 HRC
3	Backing plate	ES ULW 65	1.1730	approx. 650 N/mm²
4	Upper mould section	ES Antikor	1.2316	approx. 1000 N/mm²
5	Guide column	ES 60 S	1.2842	58-60 HRC
6	Lower mould section	ES Antikor	1.2316	approx. 1000 N/mm²
7	Ejector pins	ES 245 W	1.2344	approx. 1500 N/mm²
8	Ejector retaining plate	ES ULW 65	1.1730	approx. 650 N/mm²
9	Ejector base plate	ES ULW 65	1.1730	approx. 650 N/mm²
10	Backing plate	ES ULW 65	1.1730	approx. 650 N/mm²

A tip on the selection of steel

As mould maintenance (repolishing, cleaning, replacement of worn parts) is a not inconsiderable part of the overall tool costs, the selection of the right mould steel can reduce costs substantially.

Steel selection for plastics processing

Example: PVC moulding

Steel selection for plastics processing

Description	*Works name*	*Material No.*	*Strength / hardness (typical values)*
Case-hardening steel	ES 100 K	1.2162	Surface hardness 60 HRC Core strength 1000 - 1200 N/mm²
	ES 106 K	1.2764	Surface hardness 60 HRC Core strength 1200 - 1400 N/mm²
Quenched and tempered steels	ES Aktuell	1.2311	950 - 1100 N/mm²
	ES Aktuell S	1.2312	950 - 1100 N/mm²
	ES Aktuell 1000	1.2738	approx. 1000 N/mm²
	ES Aktuell 1200	**Special alloy**	approx. 1100 N/mm²
	ES Antikor	1.2316	approx. 1000 N/mm²
	ES LB 100	**Special alloy**	approx. 1000 N/mm²
Corrosion resistant steels	ES 120 K	1.2083	50 - 55 HRC
	ES Antikor	1.2316	approx. 1100 N/mm²
	ES Antikor S	1.2085 mod.	approx. 1000 - 1200 N/mm²
	ES Antikor SL	**Special alloy**	
Through-hardening steels	ES 245 W	1.2344	40 - 54 HRC
	ES 275 K	1.2767	50 - 56 HRC
	ES 50 S	1.2080	58 - 62 HRC
	ES 70 S	1.2379	58 - 62 HRC
	ES 60 S	1.2842	57 - 62 HRC

Example: PVC moulding

Selection of steel for supplementary mould tools (examples)

Description	*Works name*	*Material No.*	*Strength / hardness (typical values)*
Sprue bushing	ES 120 K	1.2083	approx. 56 HRC
	ES 70 S	1.2379	approx. 60 HRC
Centring flange	ES ULW 65	1.1730	approx. 650 N/mm²
Clamping plate	ES 50 S	1.2080	approx. 60 HRC
	ES 60 S	1.2842	approx. 60 HRC
Ejector	ES 245 W	1.2344	approx. 1500 N/mm², nitrided if necessary
Ejector plate	ES ULW 65	1.1730	approx. 650 N/mm²
Guide column	ES 60 S	1.2842	approx. 60 HRC
Backing plate	ES ULW 65	1.1730	approx. 650 N/mm²

Cold work steels

Cold work steels are generally used at working temperatures of under 200 °C . High hardness, adequate toughness and wear resistance characterise this group of steels. These materials are usually supplied in the soft-annealed condition and machined then hardened.

Typical areas of application include stamping and cutting tools for dies and knives, tools for cold massive forming, punching and hobbing, for thread rolling dies, shearing knives etc.

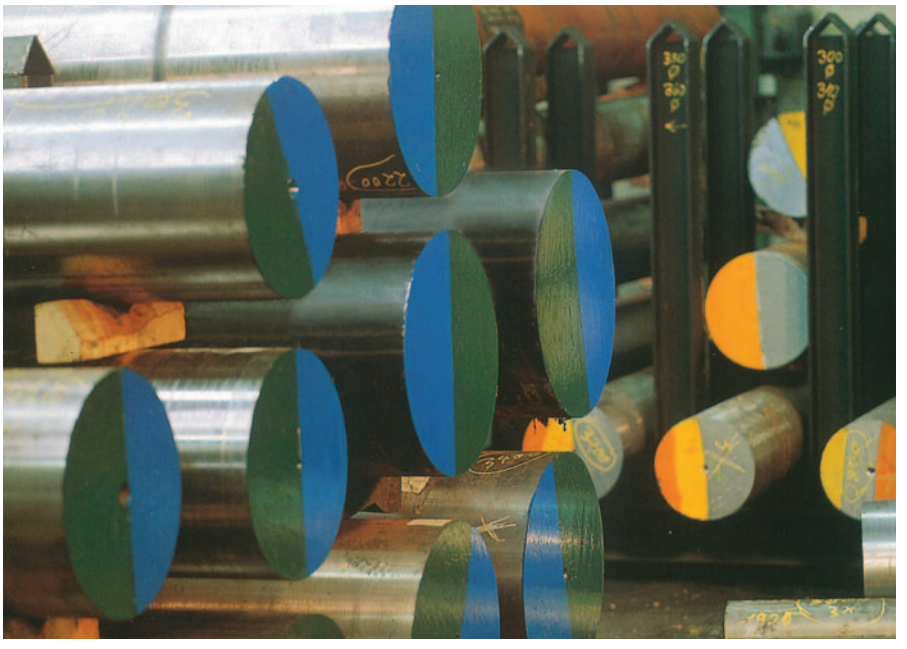
The particular requirements applying to cold work steels include the following:

- High wear resistance
- Adequate toughness
- Sufficient fatigue strength
- Ease of machinability
- Very good dimensional stability during heat treatment

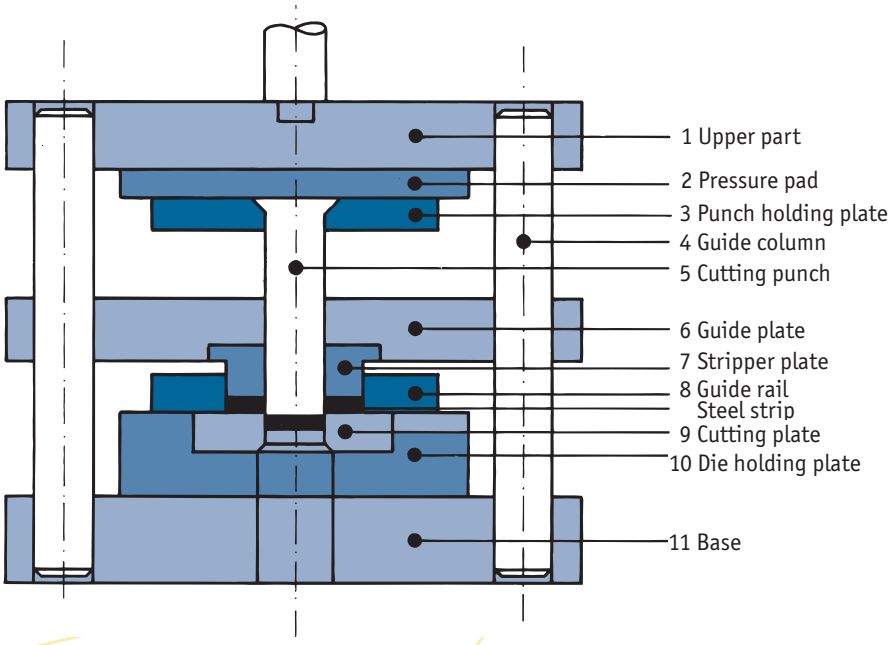
Which of the above properties is most important depends on the particular application. EschmannStahl will be delighted to advise you on this.

Product range:

Works name	*Material No.*	*Name*	*Chemical composition (typical values in %)*							
			C	*Si*	*Mn*	*Cr*	*Mo*	*Ni*	*V*	*W*
ES ULW 65	1.1730	C 45 U	0.45	0.3	0.7	–	–	–	–	–
ES 50 S	1.2080	X 210 Cr 12	2.00	0.3	0.3	12.0	–	–	–	–
ES 65 S	1.2363	X 100 CrMoV 5	1.00	0.3	0.6	5.3	1.0	–	0.2	–
ES 70 S	1.2379	X 153 CrMoV 12	1.53	0.3	0.3	12.0	0.7	–	0.9	–
ES 50 SW	1.2436	X 210 CrW 12	2.10	0.3	0.3	12.0	–	–	–	0.7
ES 275 K	1.2767	45 NiCrMo 16	0.45	0.3	0.3	1.4	0.3	4.0	–	–
ES 60 S	1.2842	90 MnCrV 8	0.90	0.3	2.0	0.4	–	–	0.1	–



Schematic diagram of a cutting tool



Tool	Works name	Material No.	Hardness in HRC / Strength in N/mm²
1 Upper part	ES ULW 65	1.1730	approx. 650 N/mm²
2 Pressure pad	ES 60 S	1.2842	58 – 60 HRC
3 Punch holding plate	ES Aktuell S	1.2312*	approx. 1000 N/mm²
4 Guide column	ES 60 S	1.2842	56 – 58 HRC
5 Cutting punch	ES 70 S	1.2379	58 – 62 HRC
6 Guide plate	ES Aktuell S	1.2312*	approx. 1000 N/mm²
7 Stripper plate	ES 60 S	1.2842	58 – 60 HRC
8 Guide rail	ES 60 S	1.2842	58 – 60 HRC
9 Cutting plate	ES 50 SW	1.2436	62 – 64 HRC
10 Die holding plate	ES Aktuell S	1.2312*	approx. 1000 N/mm²
11 Base	ES ULW 65	1.1730	approx. 650 N/mm²

Selection of steel for cold work tools

A tip on the selection of steel:

As the cost of the materials is normally less than 10 % of the total manufacturing cost of a tool, selecting the optimum quality of the steel is absolutely necessary to eliminate any risk in the future.

The table below gives just a few examples of common steels to help you in the selection of the right material. The shape of the tool, its manufacture and the appropriate heat treatment all play a decisive role in determining the life of a tool.

1. Cutting tools

1.1. Steels for punches and dies

Material to be cut	*Material thickness in mm*	*Works name*	*Material No.*	*Hardness in HRC (typical values)*
Steel plate and strip,	up to 3	ES 50 S	1.2080	60 - 64
Al and Al alloys,		ES 50 SW	1.2436	60 - 64
Cu and Cu alloys	up to 6	ES 70 S	1.2379	58 - 62
strength up to 600 N/mm²		ES 60 S	1.2842	58 - 62
	over 12	ES 275 K	1.2767	50 - 54
Steel plate and strip	up to 3	ES 50 S	1.2080	58 - 62
and metal alloys		ES 50 SW	1.2436	56 - 60
strength over 600 N/mm²	up to 6	ES 70 S	1.2379	56 - 60
	over 12	ES 275 K	1.2767	50 - 56
Transformer and dynamo plate	up to 1	ES 50 SW	1.2436	63 - 65
and strip	up to 3	ES 50 SW	1.2436	62 - 64
		ES 50 S	1.2080	62 - 64
	up to 6	ES 70 S	1.2379	60 - 62
Austenitic steels	up to 3	ES 50 S	1.2080	62 - 64
		ES 50 SW	1.2436	62 - 64
	up to 6	ES 70 S	1.2379	58 - 62
	over 12	ES 275 K	1.2767	52 - 56
Non-metallic materials		ES 50 S	1.2080	58 - 64
such as leather, plastic,		ES 50 SW	1.2436	58 - 64
wood, rubber, textiles,		ES 70 S	1.2379	58 - 64
paper		ES 60 S	1.2842	58 - 64

Selection of steel for cold work tools

1.2. Steels for attachments

Material to be cut	*Works name*	*Material No.*	*Hardness in HRC / Strength in N/mm²*
Thrust pad, pressure plate,	ES 60 S	1.2842	56 - 60 HRC
intermediate plate	ES 275 K	1.2767	50 - 54 HRC
Stripper	ES 60 S	1.2842	58 - 60 HRC
Stripper plate	ES ULW 65	1.1730	approx. 650 N/mm²
Spring bolts	ES 60 S	1.2842	58 - 62 HRC
Guide pin	ES 100 K	1.2162	58 - 60 HRC
Guide column	ES 106 K	1.2764	58 - 60 HRC
Ejector plate	ES 60 S	1.2842	56 - 60 HRC
Punch holding plate Base plate	ES ULW 65	1.1730	approx. 650 N/mm²
Blank holder	ES 70 S	1.2379	58 - 62 HRC
	ES 60 S	1.2842	58 - 62 HRC

2. Shearing knives

Knife type	*Thickness of material to be cut*	*Works name*	*Material No.*	*Hardness in HRC*
Shearing knives	up to 2 mm	ES 70	1.2379	58 - 62
(longitudinal		ES 50 SW	1.2436	58 - 62
and round)	up to 6 mm	ES 70 S	1.2379	58 - 60
		ES 60 S	1.2842	56 - 60
	over 10 mm	ES 275 K	1.2767	48 - 54
Paper knives	all thicknesses	ES 65 S	1.2363	56 - 60
		ES 70 S	1.2379	58 - 62
		ES 50 SW	1.2436	58 - 62
Knives for	all thicknesses	ES 65 S	1.2363	56 - 60
plastics		ES 70 S	1.2379	58 - 62
processing		ES 60 S	1.2842	56 - 60
Knives for	all thicknesses	ES 235 W	1.2343	54 - 56
woodworking		ES 65 S	1.2363	56 - 60

Selection of steel for cold work tools

3. Steels for forming tools

Tools for producing screws, nuts, rivets, bolts and balls	*Tool*	*Works name*	*Material No.*	*Hardness in HRC*
	Shearing knives	ES 70 S	1.2379	58 - 62
	Die inserts	ES 70 S	1.2379	58 - 62
	Reinforcing rings	ES 235 W	1.2343	46 - 52
		ES 275 K	1.2767	48 - 52
	Thread rolling dies	ES 70 S	1.2379	60 - 62
Cold extrusion tools	Die inserts,	ES 70 S	1.2379	58 - 62
	Punch	ES 50 SW	1.2436	58 - 62
		ES 360 G	1.2714	54 - 56
	Reinforcing rings	ES 235 W	1.2343	46 - 52
		ES 360 G	1.2714	48 - 52
		ES 275 K	1.2767	48 - 52
	Shearing bushes	ES 65 S	1.2363	56 - 60
		ES 70 S	1.2379	58 - 62
Coining tools, cutlery presses and hobbing punches	Coining tools	ES 360 G	1.2714	54 - 56
		ES 275 K	1.2767	48 - 54
		ES 60 S	1.2842	58 - 62
	Cutlery presses	ES 275 K	1.2767	52 - 55
	Hobbing punches	ES 70 S	1.2379	60 - 62

Hot work steels

Hot work steels are used in the manufacture of tools that are normally subject to prolonged temperatures in excess of 200 °C.
The main uses are as materials for die casting, extrusion and drop forging.

Recently hot work steels are also increasingly used in plastic mould making due to their universal material properties.

The following properties are expected in particular from a hot work steel:

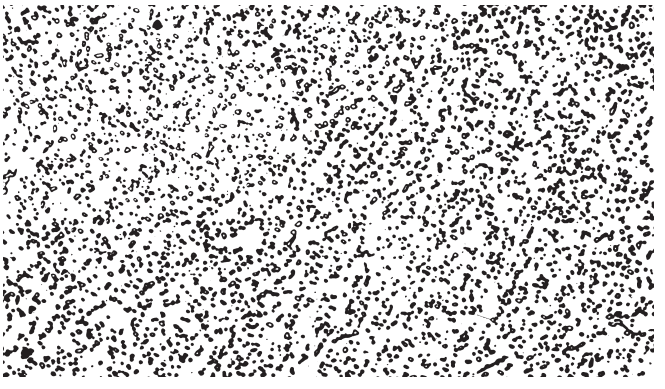
- Good high temperature strength and high temperature toughness
- Good high temperature wear resistance
- Good resistance to thermal shock
- Resistance to erosion by molten metal
- Good tempering resistance
- Good machinability
- High dimensional stability during heat treatment

Modern manufacturing methods – e.g. EST, ESR (electroslag remelting) or ESR + EST processes (ES Maximum 500) – ensure the above listed properties are always achieved with Eschmann hot work steels.

Works name	*Material No.*	*Name*	*Alloy content in %*							
			C	*Si*	*Mn*	*S*	*Cr*	*Mo*	*Ni*	*V*
Low temperature tools										
ES Aktuell	1.2311	40 CrMnMo 7	0.40	0.3	1.5	-	1.9	0.2	-	-
ES Aktuell S	1.2312	40 CrMnMoS 8-6	0.40	0.4	1.5	0.07	1.9	0.2	-	-
ES 370 G	1.2714	55 NiCrMoV 7	0.55	0.3	0.8	-	1.1	0.5	1.7	0.1
High temperature tools										
ES 235 W	1.2343	X 37 CrMoV 5-1	0.37	1.0	0.4	-	5.3	1.3	-	0.4
ES Maximum 500	1.2343	X 37 CrMoV 5-1	0.37	1.0	0.4	-	5.3	1.3	-	0.4
ES 245 W	1.2344	X 40 CrMoV 5-1	0.40	1.0	0.4	-	5.3	1.4	-	1.0
ES 265 W	1.2367	X 38 CrMoV 5-3	0.38	0.4	0.5	-	5.0	3.0	-	0.6

ES hot work steels and special alloys are manufactured using the latest production techniques. Special smelting processes and structural treatments ensure an excellent standard of quality.

EST and ESR hot work steels are characterised by their uniform microstructure, which provides them with good isotropy, an important prerequisite for achieving a long service life for these high performance tools.



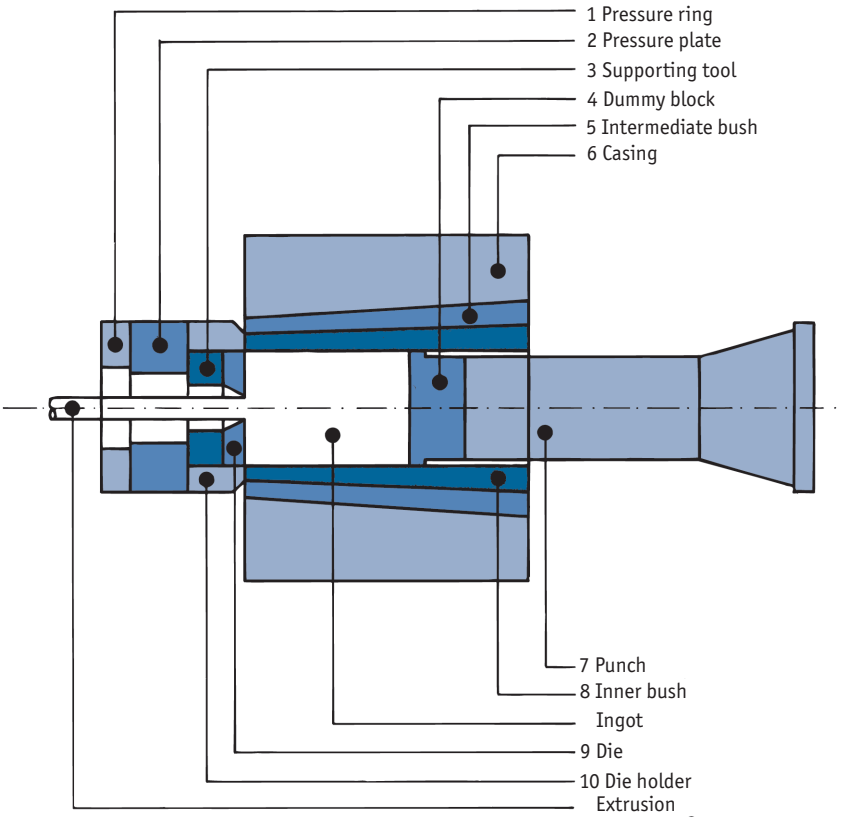
Microstructure of ES Maximum 500 in the annealed condition (500 x magnification)

Extrusion

Extrusion is a technically important forming process for manufacturing semi-finished rods from metals.

The tools in extrusion presses are subject to high mechanical and thermal loads. The tool material is therefore required to have:

- Excellent high temperature strength with high wear resistance
- Tempering resistance with good toughness
- Tolerance to alternating thermal stresses



Example: Aluminium alloy window profile

Tool	*Works name*	*Material No.*	*Hardness in HRC / Strength in N/mm²*
1 Pressure ring	ES 370 G	1.2714	1200 - 1500 N/mm²
2 Pressure plate	ES 370 G	1.2714	1200 - 1500 N/mm²
3 Supporting tool	ES 370 G	1.2714	1100 - 1300 N/mm²
4 Dummy block	ES 245 W	1.2344	1400 - 1700 N/mm²
5 Intermediate bush	ES 235 W	1.2343	1300 - 1500 N/mm²
6 Casing	ES 235 W	1.2343	1000 - 1200 N/mm²
7 Punch	ES 245 W	1.2344	1500 - 1700 N/mm²
8 Inner bush	ES 245 W	1.2344	1300 - 1500 N/mm²
9 Die	ES 245 W	1.2344	1400 - 1700 N/mm²
10 Die holder	ES 235 W	1.2343	1300 - 1500 N/mm²

Selection of steel for extrusion tools

A tip on the selection of steel:
The right steel, a tried and tested design and the correct heat treatment are crucial to good tool performance.

1. Ingot holders

Name of part	*Thermal stress*	*Works name*	*Material No.*	*Strength N/mm²*
Forged alloy				
Inner bush				
Light metal alloys	high	ES 235 W	1.2343	1300 - 1500
Heavy metal alloys	high	ES 265 W	1.2367	1300 - 1500
Intermediate bush	high	ES 235 W	1.2343	1100 - 1300
Casing	high	ES 235 W	1.2343	1000 - 1200

Selection of steel for extrusion tools

2. Punches and solid dummy blocks

Tool name / *Application*	*Works name*	*Material No.*	*Strength N/mm²*
Solid dummy blocks			
Primarily for light metal alloys	ES 245 W	1.2344	1500 - 1800
Hollow and solid punches			
for light and heavy metal alloys	ES 370 G	1.2714	1500 - 1800
	ES 235 W	1.2343	1500 - 1800
	ES 245 W	1.2344	1500 - 1800
	ES 265 W	1.2367	1500 - 1800
for steel	ES 245 W	1.2344	1500 - 1800

3. Ancillary tools

Tool name / *Application*	*Works name*	*Material No.*	*Strength N/mm²*
Die holder			
Generally determined by thermal stress	ES 235 W	1.2343	1300 - 1500
(similar to the selection of the die material)	ES 370 G	1.2714	1300 - 1500
Supporting tools			
Generally determined by thermal stress	ES 235 W	1.2343	1200 - 1500
(similar to the selection of the die material)	ES 370 G	1.2714	1100 - 1300
Pressure ring, pressure plate, pressure chamber			
	ES 370 G	1.2714	1200 - 1500
Tool holder, tool clamp			
	ES 370 G	1.2714	1100 - 1400
Mandrel holder			
	ES 370 G	1.2714	1200 - 1400
Upsetting ram, shearing punch, shearing mandrel			
Generally determined by thermal stress	ES 235 W	1.2344	1300 - 1600
	ES 265 W	1.2367	1300 - 1600

Selection of steel for extrusion tools

4. Tube and rod extruder tools subject to wear

Forged alloy	*Application*	*Works name*	*Material No.*	*Strength N/mm²*
Dies, bridges, chamber and spider tools (including spiders and inserts for the above tools)				
Zinc and lead alloys	for tubes, bars and	ES 235 W	1.2343	1400 - 1600
	sections	ES 245 W	1.2344	1400 - 1600
Light metal alloys	for bars, sections, tubes	ES 235 W	1.2343	1400 - 1600
	subject to normal stress			
	for special sections and tubes	ES 245 W	1.2344	1400 - 1600
	subject to normal stress			
	subject to high stress	ES 265 W	1.2367	1400 - 1600
Heavy metal alloys	for sections, wires and tubes	ES 265 W	1.2367	1400 - 1600
Steel	for sections	ES 235 W	1.2343	1400 - 1600
	and tubes	ES 245 W	1.2344	1400 - 1600
Extrusion mandrel and mandrel tip				
Zinc and lead alloys	for mandrels	ES 245 W	1.2344	1500 - 1700
Light metal alloys	for mandrels of diameter	ES 235 W	1.2343	1500 - 1700
	> 50 mm	ES 245 W	1.2344	1500 - 1700
Heavy metal alloys	for water cooling	ES 245 W	1.2344	1500 - 1700
	for air cooling	ES 265 W	1.2367	1500 - 1700
Steel	general use	ES 245 W	1.2344	1500 - 1700
Dummy block and cleaning pad				
Zinc and lead alloys	general use	ES 370 G	1.2714	1300 - 1500
Light metal alloys	general use	ES 235 W	1.2343	1400 - 1600
	general use	ES 245 W	1.2344	1400 - 1600
	high stress	ES 265 W	1.2367	1400 - 1600
Heavy metal use	normal stress	ES 235 W	1.2343	1400 - 1600
Steel	general use	ES 245 W	1.2344	1400 - 1600
		ES 265 W	1.2367	1400 - 1600

Selection of steel for extrusion tools

Our products and services

Hot work steel stocks:

We maintain a wide-ranging special stock of steel to meet the requirements of the extrusion industry, which enables us to guarantee delivery at short notice.

Technical advisory service:

We endeavour to maintain close contact with our customers. You can expect us to provide solutions to your problems and advice on the choice of the appropriate material and heat treatment.

Works name	*Material No.*	*Name*	*Alloy content in %*							
			C	*Si*	*Mn*	*S*	*Cr*	*Mo*	*Ni*	*V*
Low temperature tools										
ES Aktuell	1.2311	40 CrMnMo 7	0.40	0.3	1.5	-	1.9	0.2	-	-
ES Aktuell S	1.2312	40 CrMnMoS 8-6	0.40	0.4	1.5	0.07	1.9	0.2	-	-
ES 370 G	1.2714	55 NiCrMoV 7	0.55	0.3	0.8	-	1.1	0.5	1.7	0.1
High temperature tools										
ES 235 W	1.2343	X 37 CrMoV 5-1	0.37	1.0	0.4	-	5.3	1.3	-	0.4
ES 245 W	1.2344	X 40 CrMoV 5-1	0.40	1.0	0.4	-	5.3	1.4	-	1.0
ES 265 W	1.2367	X 38 CrMo V 5-3	0.38	0.4	0.5	-	5.0	3.0	-	0.6

Die casting

Warm work steel for die casting

Die casting is a mechanical casting process in which the molten metal is forced under pressure into the cavity between split halves of a metal mould. The process is ideal for producing large quantities of complicated parts from aluminium, zinc, magnesium, copper, lead and tin, the first named material being the most important.

Typical die cast products:

- Aluminium:
  cylinder heads, oil tanks and gears
- Zinc:
  carburettors etc.
- Copper brass:
  taps, water valves etc

Die casting moulds have to last a long time; die casting foundry owners like long periods of continuous operation and prefer to avoid interruptions due maintenance work as much as possible.

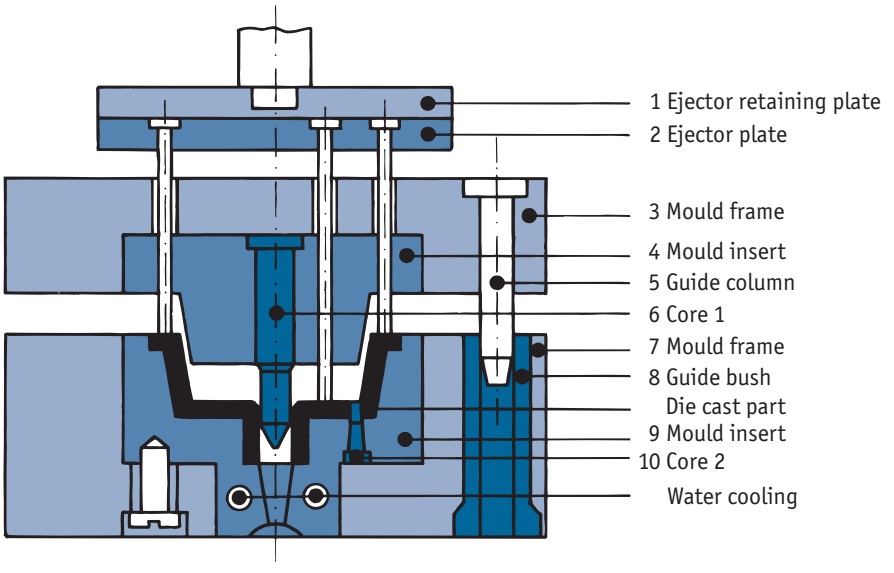
The mould steel must therefore have the following characteristics:

- High thermal shock resistance
- Excellent high temperature strength
- Good tempering resistance
- Optimum high temperature toughness and high temperature wear resistance
- High thermal conductivity
- Minimal tendency to stick

The die casting mould steels we supply are manufactured using the following special processes:

ES EST
ES ESR (electroslag remelting)
ES ESR + EST (Maximum 500)

The special measures we employ from the production of the steel to the final structural treatment ensure that it meets the requirements of SEP 1614, VDG and DGM.



	Tool	*Works name*	*Material No.*	*Hardness in HRC / Strength in N/mm²*
1	Ejector retaining plate	ES ULW 65	1.1730	approx. 650 N/mm²
2	Ejector plate	ES ULW 65	1.1730	approx. 650 N/mm²
3	Mould frame	ES Aktuell 1000	1.2738	approx. 1000 N/mm²
4	Mould insert	ES 235 W/245 W	1.2343/44	44 - 46 HRC
5	Guide column	ES 60 S	1.2842	58 - 60 HRC
6	Core 1	ES 235 W/245 W	1.2343/44	44 - 46 HRC
7	Mould frame	ES Aktuell 1000	1.2738	approx. 1000 N/mm²
8	Guide bush	ES 235 W/245 W	1.2343/44	46 - 48 HRC
9	Mould insert	ES 235 W/245 W	1.2343/44	46 - 48 HRC
10	Core 2	ES 235 W/245 W	1.2343/44	44 - 46 HRC

Selection of steel for die casting machines and die casting moulds

A tip on the selection of steel:
The diversity of applications often gives rise to questions about tool materials.
Our technicians will be pleased to assist you.

1. Die casting machines

Name of machine part	*Forged alloy*	*Works name*	*Material No.*	*Reference values for hardness in installed condition*
Die casting process				*Strength N/mm²*
Molten metal containers				
Hot chamber process	ZnSnPb alloys	ES 245 W	1.2344	900 -1100
Casting chamber				
Hot chamber process	ZnSnPb alloys	ES 235 W	1.2343	1500 -1650
Cold chamber process	AlMg alloys	ES 235 W	1.2343	1500 -1650
		ES 245 W	1.2344	1500 -1650
	Cu alloys	ES 265 W	1.2367	1300 -1500
Casting plunger, counter plunger, plunger rings				
Hot chamber process	ZnSnPb alloys	ES 235 W	1.2343	1400 -1550
Cold chamber process	AlMg alloys	ES 235 W	1.2343	1400 -1550
		ES 245 W	1.2344	1400 -1550
	Cu alloys	ES 265 W	1.2367	1200 -1400
Nozzle, adapter, reducer				
		ES 235 W	1.2343	800 -1400
		ES 245 W	1.2344	800 -1400
	Mg alloys	ES 235 W	1.2343	800 -1400
		ES 245 W	1.2344	800 -1400
Cold chamber process	AlMg alloys	ES 235 W	1.2343	1400 -1550
		ES 245 W	1.2344	1400 -1550
	Cu alloys	ES 265 W	1.2367	1300 -1500

2. Die casting moulds

Name of the mould part	*Forged alloy*	*Works name*	*Material No.*	*Reference values for hardness in installed condition Strength N/mm²*
Mould frame		ES Aktuell S	1.2312	950 -1100
		ES ULW 65	1.1730	approx. 650
Mould inserts	ZnSnPb alloys	ES 235 W	1.2343	1300 -1500
Nozzle	AlMg alloys			
Sprue pins				
Cores		ES 235 W/ ES 245 W	1.2343/44	1400 -1800
Valve cores	Cu alloys	ES 265 W	1.2367	1300 -1500
Ejector		ES 235 W/ ES 245 W	1.2343/44	1400 -1650

Drop forging

Drop forging with hammers and presses is forming with a tool in two parts moving in opposite directions – the dies. This process has become very important in manufacturing because it offers the following advantages and possibilities:

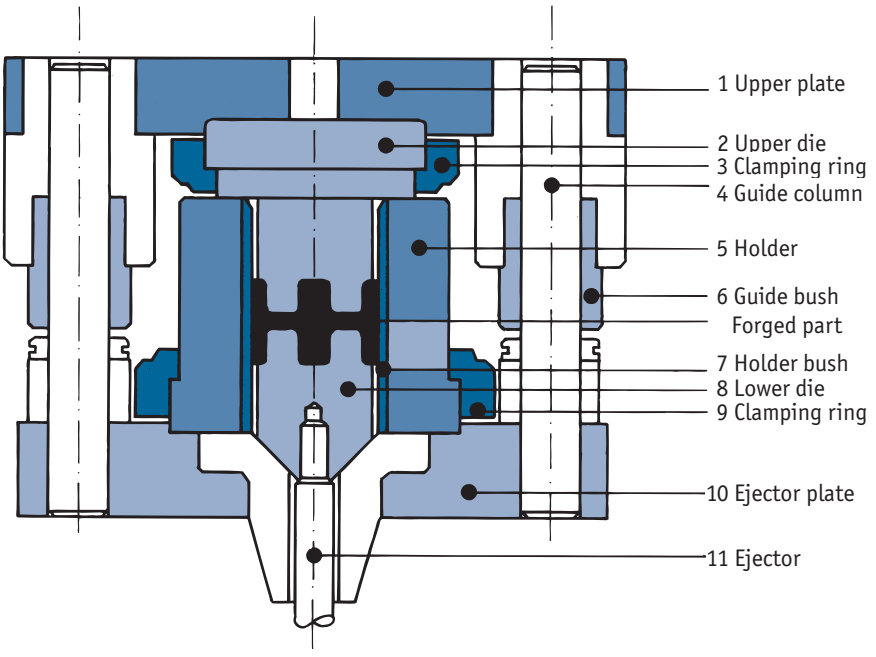
- Optimum utilisation of the forged material
- Low machining allowances
- Narrow tolerances
- Homogeneous and pore-free microstructure

The type of stresses on the dies give rise to the following requirements for the swage material:

- High hardness, toughness and fatigue strength
- High yield strength and elongation
- Excellent high temperature strength
- Tolerance of short-term temperature fluctuations
- Highest wear resistance

During forging under the action of a hammer a die requires great toughness to withstand the impact loading. Tough NiCrMoV alloys have proved themselves in use for some time now. The properties of these alloys have been systematically improved by modern smelting, forming and heat treatment processes.

The primary factor with regard to presses and forging machines is the temperature load on the tool caused by the long cycle time of the forged item in contact with the die. High alloyed CrMo steels are used in these circumstances, in particular for the advantages arising from their tempering resistance, thermal conductivity and high temperature wear resistance. These steels are also available in EST and ESR grades.



Tool		Works name	Material No.	Hardness in HRC / Strength in N/mm²
1	Upper plate	ES ULW 65	1.1730	approx. 65 N/mm²
2	Upper die	ES 235 W/ ES 265 W	1.2343/1.2367	1400-1600 N/mm²
3	Clamping ring	ES Aktuell	1.2311	approx. 1000 N/mm²
4	Guide column	ES 60 S	1.2842	58 - 60 HRC
5	Holder	ES Aktuell	1.2311	approx. 1000 N/mm²
6	Guide bush	ES Aktuell	1.2311	approx. 1000 N/mm²
7	Holder bush	ES 245 W	1.2344	1400-1500 N/mm²
8	Lower die	ES 235 W/ ES 265 W	1.2343/1.2367	1400-1600 N/mm²
9	Clamping ring	ES Aktuell	1.2311	approx. 1000 N/mm²
10	Lower plate	ES ULW 65	1.1730	approx. 650 N/mm²
11	Ejector	ES 245 W	1.2344	1400-1500 N/mm²

Selection of steel for drop forging

A tip on the selection of steel:
It is often service life that determines whether or not the forming process is economic. EschmannStahl can provide you with the appropriate steels for your particular area of application.

Forging method	*Tool*	*Works name*	*Material No.*	*Reference values in installed condition Strength N/mm²*
Hammer	Complete die	ES 370 G	1.2714	1100 - 1600
	Female die	ES 370 G	1.2714	1000 - 1400
	Die insert	ES 370 G	1.2714	1300 - 1800
		ES 245 W	1.2344	1300 - 1800
		ES 265 W	1.2367	1300 - 1600
	Impact rim	ES 370 G	1.2714	1600 - 1800
Press	Complete die	ES 370 G	1.2714	1200 - 1700
		ES 235 W	1.2343	1300 - 1700
		ES 245 W	1.2344	1300 - 1700
		ES 265 W	1.2367	1300 - 1700
	Female die	ES 370 G	1.2714	1000 - 1400
	Die insert	ES 235 W	1.2343	1300 - 1800
		ES 245 W	1.2344	1300 - 1800
		ES 265 W	1.2367	1300 - 1800
	Impression insert	ES 265 W	1.2367	1500 - 1800
Horizontal forging machine	Mandrel	ES 265 W	1.2367	1500 - 1800
	Die	ES 245 W	1.2344	1300 - 1800

Hardness conversion table

Tensile strength N/mm²	Brinell hardness	Vickers hardness HV (F ≥ 98 N)	Rockwell hardness HRC	Tensile strength N/mm²	Brinell hardness	Vickers hardness HV (F ≥ 98 N)	Rockwell hardness HRC	Tensile strength N/mm²	Brinell hardness	Vickers hardness HV (F ≥ 98 N)	Rockwell hardness HRC
255	76.0	80		915	271	285	27.8			680	59.2
270	80.7	85		930	276	290	28.5			690	59.7
285	85.5	90		950	280	295	29.2			700	60.1
305	90.2	95		965	285	300	29.8			720	61.0
320	95.0	100		995	295	310	31.0			740	61.8
335	99.8	105		1030	304	320	32.2			760	62.5
350	105	110		1060	314	330	33.3			780	63.3
370	109	115		1095	323	340	34.4			800	64.0
385	114	120		1125	333	350	35.5			820	64.7
400	119	125		1155	342	360	36.6			840	65.3
415	124	130		1190	352	370	37.7			860	65.9
430	128	135		1220	361	380	38.8			880	66.4
450	133	140		1255	371	390	39.8			900	67.0
465	138	145		1290	380	400	40.8			920	67.5
480	143	150		1320	390	410	41.8			940	68.0
495	147	155		1350	399	420	42.7				
510	152	160		1385	409	430	43.6				
530	156	165		1420	418	440	44.5				
545	162	170		1455	428	450	45.3				
560	166	175		1485	437	460	46.1				
575	171	180		1520	447	470	46.9				
595	176	185		1555	(456)	480	47.7				
610	181	190		1595	(466)	490	48.4				
625	185	195		1630	(475)	500	49.1				
640	190	200		1665	(485)	510	49.8				
660	195	205		1700	(494)	520	50.5				
675	199	210		1740	(504)	530	51.1				
690	204	215		1775	(513)	540	51.7				
705	209	220		1810	(523)	550	52.3				
720	214	225		1845	(532)	560	53.0				
740	219	230		1880	(542)	570	53.6				
755	223	235		1920	(551)	580	54.1				
770	228	240	20.3	1955	(561)	590	54.7				
785	233	245	21.3	1995	(570)	600	55.2				
800	238	250	22.2	2030	(580)	610	55.7				
820	242	255	23.1	2070	(589)	620	56.3				
835	247	260	24.0	2105	(599)	630	56.8				
850	257	265	24.8	2145	(608)	640	57.3				
865	257	270	25.6	2180	(618)	650	57.8				
880	261	275	26.4			660	58.3				
900	266	280	27.1			670	58.8				

(the figures in brackets are measured using carbide spheres)