Formadur 2083 / 2083 Superclean

X40Cr14 | **C** 0.40 **Cr** 13.00

Steel properties

Corrosion-resistant, good polishability. We recommend the use of Formadur 2083 Superclean for the highest demands on polishability.

Standards

AISI 420 **AFNOR** Z40C14

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	11.1	11.3	11.6	11.8	12.0	12.3	12.4	12.5	12.6

Quenched and tempered

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	22.6	24.0	24.6	24.9	24.4	23.7

Quenched and tempered

Applications

Moulds for processing plastics with corrosive reactions.

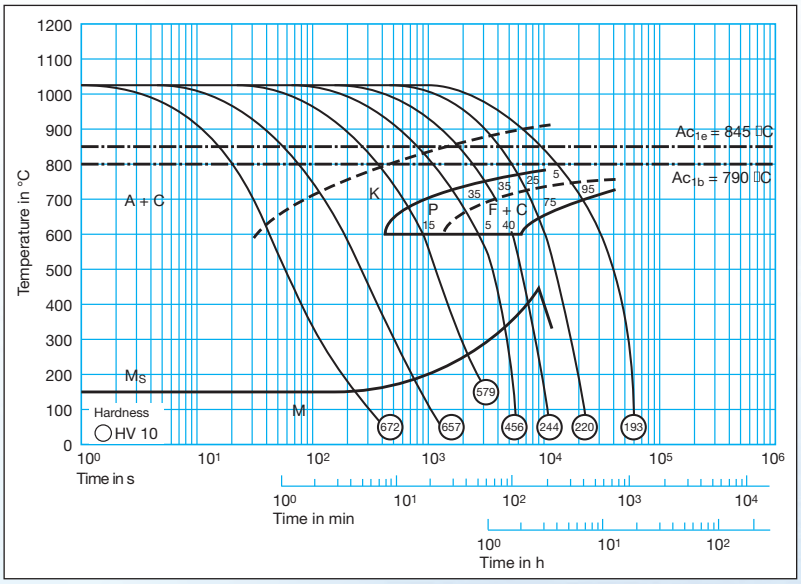
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
760 – 800	Furnace	max. 230

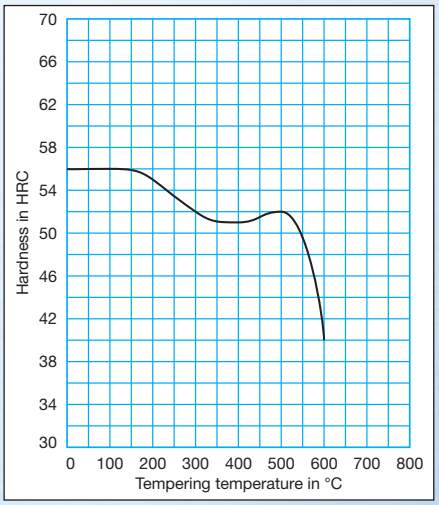
Hardening °C	**Quenching**	**Hardness after quenching HRC**
1000 – 1050	Oil or saltbath, 500 – 550 °C	56

Tempering °C	100	200	300	400	500	600
HRC	56	55	52	51	52	40

Time-temperature-transformation diagram



Tempering diagram



Formadur 2085

X33CrS16

C 0.33 **Cr** 16.00 **S** 0.05 **Ni** 0.50

Steel properties

Pre-hardened corrosion-resistant mould frame steel, hardness in as-delivered condition of 280 to 325 HB. Improved machinability in comparison to Formadur 2316.

Standards

AISI ~420FM

Applications

Mould frames, components, plastic moulds.

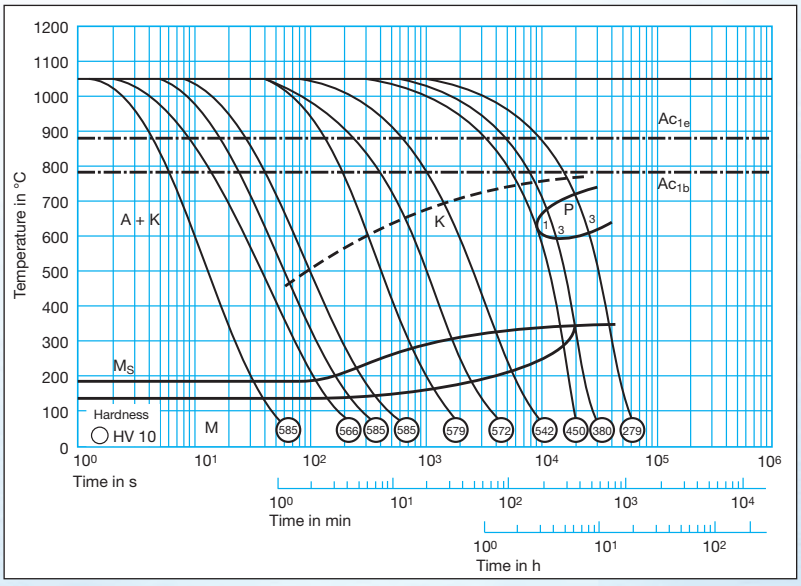
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
850 – 880	Furnace	max. 230

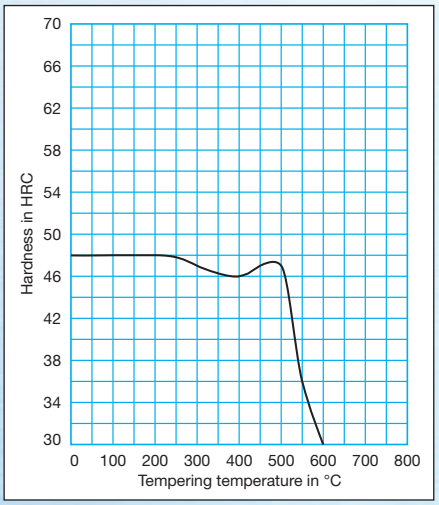
Hardening °C	**Quenching**	**Hardness after quenching HRC**
1000 – 1050	Oil	48

Tempering °C	100	200	300	400	450	500	550	600
HRC	48	48	47	46	47	47	36	30

Time-temperature-transformation diagram



Tempering diagram



Formadur 2162

21MnCr5 | **C** 0.21 **Mn** 1.30 **Cr** 1.20

Steel properties

Case hardening steel, good polishability, suitable for cold hobbing.

Standards

AISI ~P2

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 200	20 – 300	20 – 400	20 – 500	20 – 600	20 – 700
10^{-6} m/(m • K)	12.2	12.9	13.5	13.9	14.2	14.5	14.8

Thermal conductivity

at °C	20	350	700
W/(m • K)	39.5	36.5	33.5

Applications

Mirror-finished plastic moulds and guide pins.

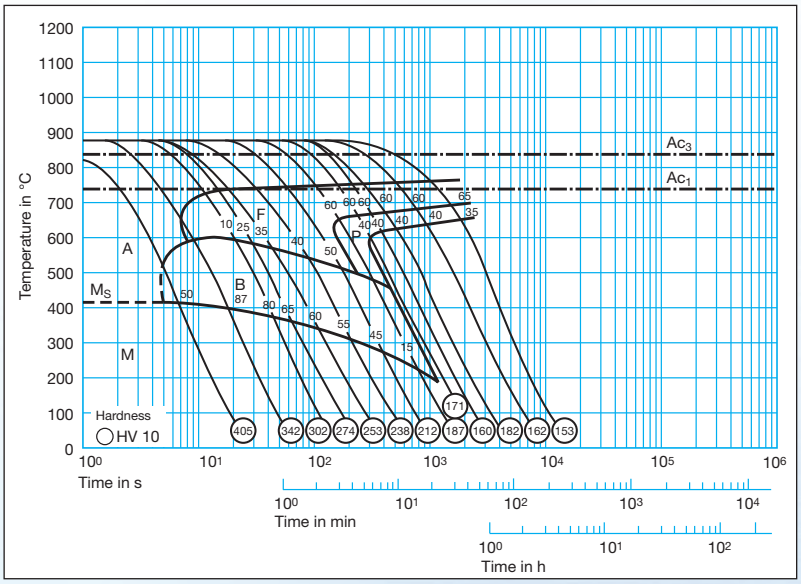
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
670 – 710	Furnace	max. 210

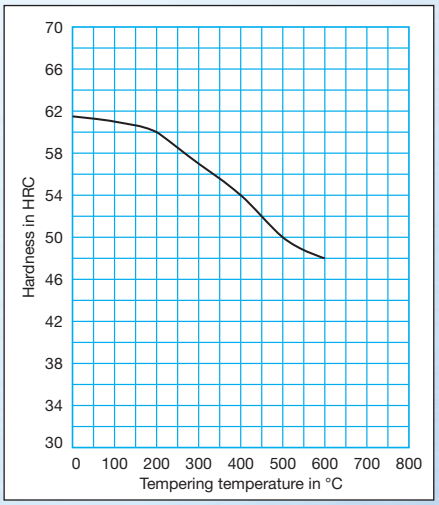
Carburizing °C	**Intermediate annealing °C**	**Hardening °C**	**Quenching**	**Surface hardness after quenching HRC**
870 – 900	620 – 650	810 – 840	Oil or saltbath, 180 – 220 °C	62

Tempering °C	100	200	300	400	500	600
HRC	61	60	57	54	50	48

Time-temperature-transformation diagram



Tempering diagram



Formadur 2190 Superclean

(X37Cr13)

C 0.37 **Si** 0.90 **Mn** 0.50 **Cr** 13.6 **V** 0.30

Steel properties

Corrosion-resistant, very good polishability.

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	10.7	11.0	11.2	11.5	11.7	11.9	12.1	12.3	12.4

Quenched and tempered

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	21.5	23.2	23.9	24.3	24.2	24.0

Quenched and tempered

Applications

Moulds for processing of corrosive plastics.

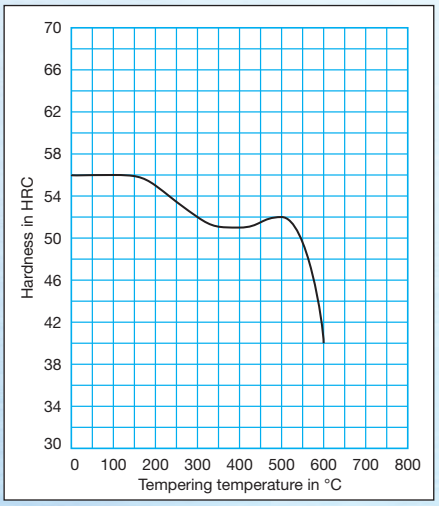
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
760 – 800	Furnace	max. 230

Hardening °C	**Quenching**	**Hardness after quenching HRC**
1000 – 1050	Oil or saltbath, 500 – 550 °C	56

Tempering °C	100	200	300	400	500	600
HRC	56	55	52	51	52	40

Tempering diagram



Reference numbers in brackets are not standardized in EN ISO4957.

Formadur 2311

40CrMnMo7

C 0.40 **Mn** 1.50 **Cr** 1.90 **Mo** 0.20

Steel properties

Pre-hardened plastic mould steel, hardness in as-delivered condition 280 to 325 HB. Good machinability, suitable for texturing, better polishability than Formadur 2312.

Standards

AISI P20

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	12.6	12.8	13.0	13.3	13.5	13.7	13.9	14.1	14.3

Quenched and tempered

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	32.5	32.9	31.3	30.2	29.5	27.4

Quenched and tempered

Applications

Plastic moulds, mould frames for plastic moulds and pressure casting moulds and recipient sleeves.

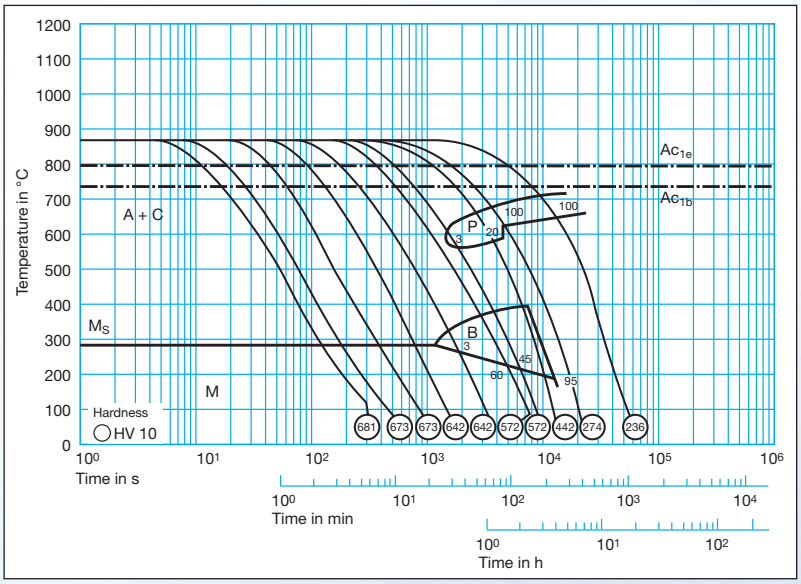
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
710 – 740	Furnace	max. 235

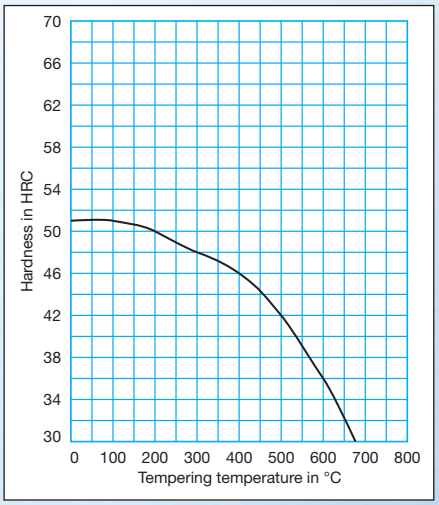
Hardening °C	**Quenching**	**Hardness after quenching HRC**
840 – 870	Oil or saltbath, 180 – 220 °C	51

Tempering °C	100	200	300	400	500	600	700
HRC	51	50	48	46	42	36	28

Time-temperature-transformation diagram



Tempering diagram



Formadur 2312

40CrMnMoS8-6[1)]

C 0.40 **Si** 0.35 **Mn** 1.50 **Cr** 1.90 **Mo** 0.20 **S** 0.05

Steel properties

Quenched and tempered plastic mould steel with a hardness in as-delivered condition of 280 to 325 HB. Improved machinability in comparison with Formadur 2311. Polishable.

Standards

AISI P20+S

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 200	20 – 300
10^{-6} **m/(m • K)** Annealed	12.5	13.4	13.9
10^{-6} **m/(m • K)** Quenched and tempered	12.3	13.0	13.7

Thermal conductivity

at °C	100	150	200	250	300
W/(m • K) Annealed	40.2	40.9	40.3	40.0	39.0
W/(m • K) Quenched and tempered	39.8	40.4	40.4	39.9	39.0

Applications

Plastic moulds, mould frames for plastic and pressure casting moulds, recipient sleeves, brake dies.

Heat treatment

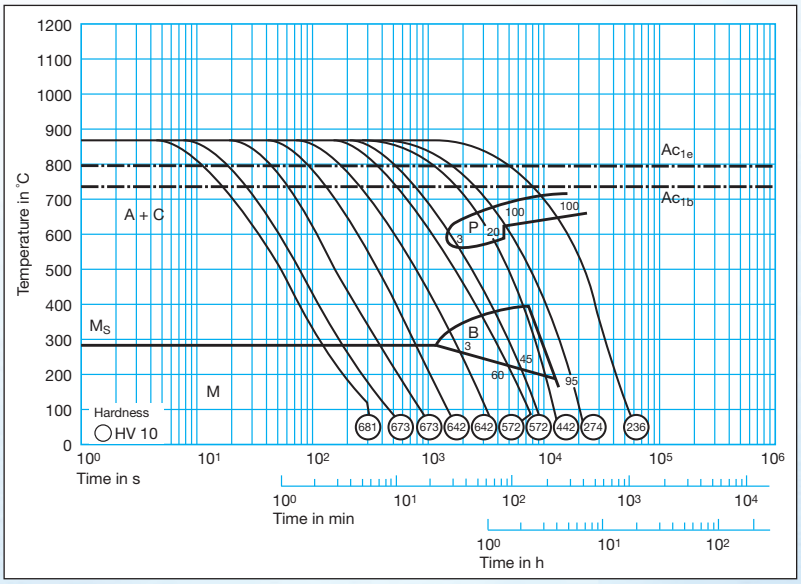
Soft annealing °C	**Cooling**	**Hardness HB**
710 – 740	Furnace	max. 235

Stress-relief annealing °C (Annealed)	**Stress-relief annealing °C** (Quenched and tempered)	**Cooling**
approx. 600	approx. 30 – 50 under tempering temperature	Furnace

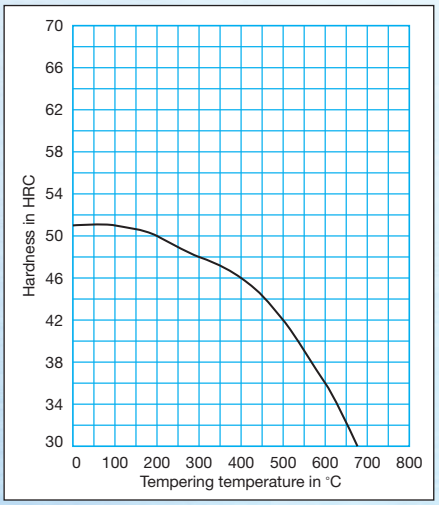
Hardening °C	**Quenching**	**Hardness after quenching HRC**
840 – 870	Oil or saltbath, 180 – 220 °C	51

Tempering °C	100	200	300	400	500	600	700
HRC	51	50	48	46	42	36	28

Time-temperature-transformation diagram



Tempering diagram



[1)] S can be raised between 0.05 and 0.1 % whereas Ni can be left out completely.

Formadur 2316 / 2316 Superclean

X38CrMo16 | **C** 0.36 **Cr** 16.00 **Mo** 1.20

Steel properties

Increased corrosion resistance in comparison to Formadur 2083, good polishability. Usually this steel grade is supplied in a quenched and tempered condition with a working hardness of approx. 300 HB.

Standards

AISI 420mod

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	10.5	10.7	10.8	10.9	11.1	11.3	11.5	11.6	11.7

Quenched and tempered

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	23.5	24.2	24.3	24.4	24.1	23.2

Quenched and tempered

Applications

Moulds for processing plastics with corrosive reactions.

Heat treatment

Soft annealing °C
760 – 800

Cooling
Furnace

Hardness HB
max. 230

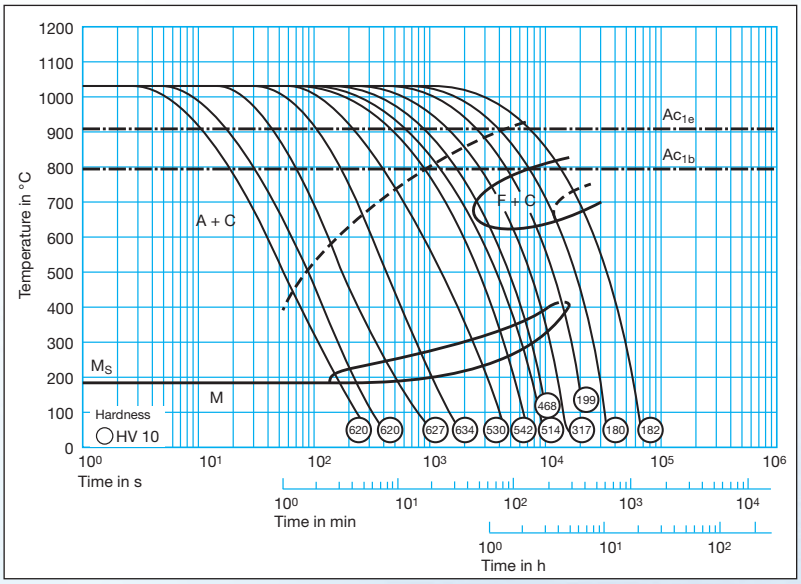
Hardening °C
1020 – 1050

Quenching
Oil or
saltbath, 500 – 550 °C

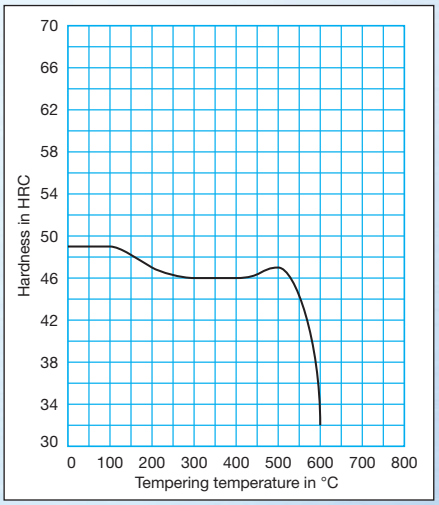
Hardness after quenching HRC
49

Tempering °C	100	200	300	400	500	600
HRC	49	47	46	46	47	32

Time-temperature-transformation diagram



Tempering diagram



Formadur 2361

X91CrMoV18

C 0.90 **Si** < 1.00 **Cr** 18.00 **Mo** 1.00 **V** 0.10

Steel properties

Corrosion-resistant steel for plastic moulding characterized by a very good wear resistance.

Physical properties

Coefficient of thermal expansion

at °C	20 100	20 200	20 300	20 400
10^{-6} m/(m • K)	10.5	11.0	11.0	12.0

Thermal conductivity

at °C	20
W/(m • K)	29

Applications

Plastic moulds, injection nozzles, valve components and ball bearings.

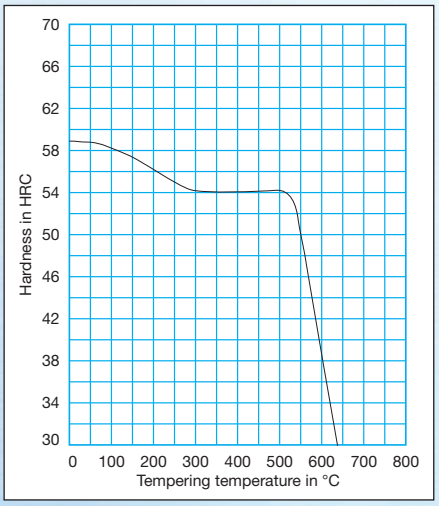
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
800 850	Slow, e.g. furnace	max. 265

Hardening °C	**Quenching**	**Hardness after quenching HRC**
1000 1050	Oil	59

Tempering °C	100	200	300	400	500	550	600
HRC	58	56	54	54	54	50	40

Tempering diagram



Formadur 2711

54NiCrMoV6

C 0.55 **Cr** 1.10 **Ni** 1.70 **Mo** 0.50 **V** 0.10

Steel properties

Pre-hardened plastic mould steel, hardness in as-delivered condition 355 to 400 HB (square, flat) and 370 – 410 HB (round). Increased compressive strength in comparison to Formadur 2738, good polishability.

Standards

AISI ~L6

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	12.2	12.5	12.7	13.0	13.3	13.5	13.8	13.9	14.1

Quenched and tempered

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	30.5	32.1	30.8	29.6	28.7	26.5

Quenched and tempered

Applications

Plastic moulds with increased demands on compression strength and wear resistance.

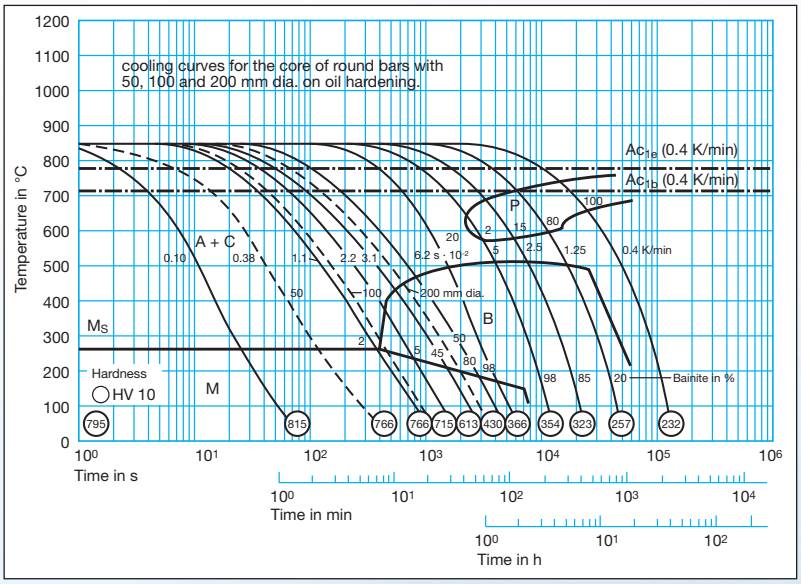
Heat treatment

Soft annealing °C	**Cooling**	**Hardness H**
650 – 700	Furnace	Max. 240

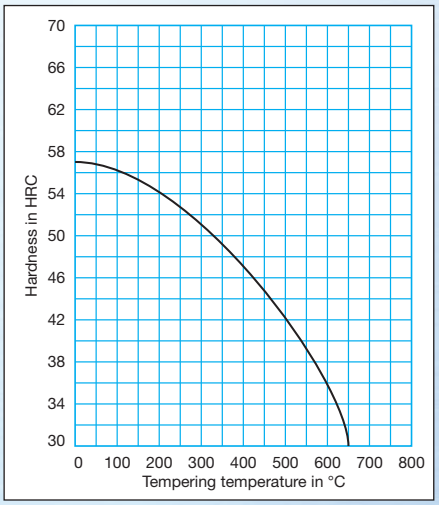
Hardening °C	**Quenching**	**Hardness after quenching HRC**
830 – 870	Air or oil	57

Tempering °C	100	200	300	400	450	500	550	600	650
HRC	56	54	51	47	44	42	39	36	30

Time-temperature-transformation diagram



Tempering diagram



Formadur 2738

40CrMnNiMo8-6-4

C 0.40 **Mn** 1.50 **Cr** 1.90 **Ni** 1.00 **Mo** 0.20

Steel properties

Pre-hardened plastic mould steel, hardness in as-delivered condition 280 to 325 HB. Good machinability, suitable for texturing, improved through hardening in comparison to Formadur 2711, good polishability.

Standards

AISI P20+Ni

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 200	20 – 300	20 – 400	20 – 500	20 – 600	20 – 700
10^{-6} m/(m • K)	11.1	12.9	13.4	13.8	14.2	14.6	14.9

Thermal conductivity

at °C	20	350	700
W/(m • K)	34.5	33.5	32.0

Applications

Large plastic moulds with deep engravings and intensive impacts on the core. Formadur 2738 is the logical development of Formadur 2311, a pre-hardened plastic mould steel for use in large moulds, which also have to display high core strength. The additional nickel content of 1 % increases through hardening. Formadur 2738 ia a micro-alloyed, vacuum-degassed steel with the following excellent features: good machinability, outstanding polishability, good texturing properties.

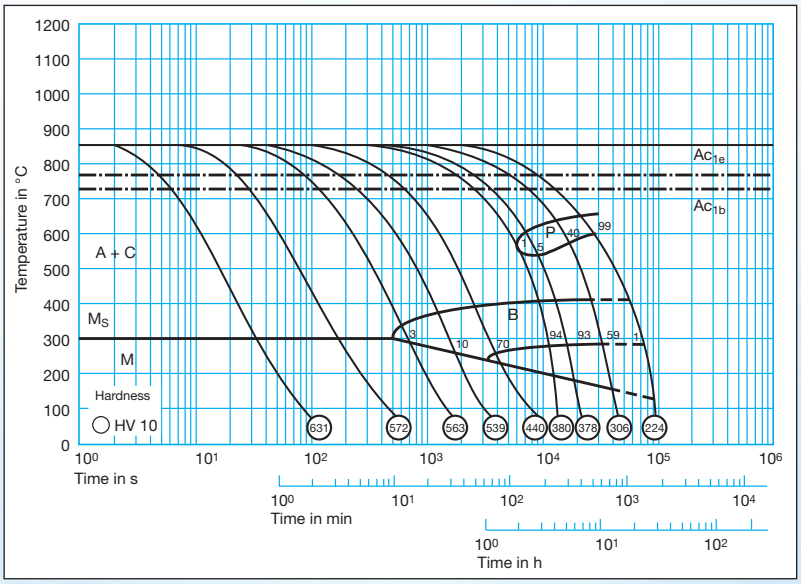
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
710 – 740	Furnace	max. 235

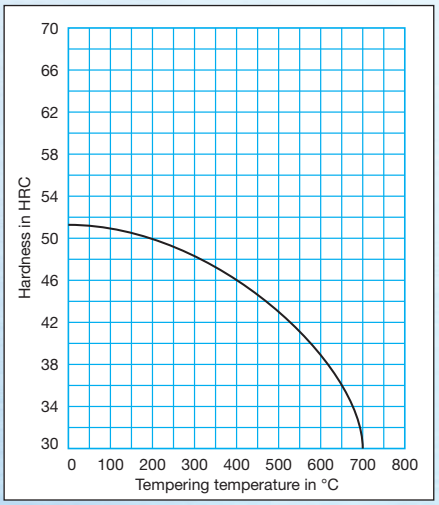
Hardening °C	**Quenching**	**Hardness after quenching HRC**
840 – 870	Polymer or oil	51

Tempering °C	100	200	300	400	500	600	700
HRC	51	50	48	46	42	39	28

Time-temperature-transformation diagram



Tempering diagram



Formadur 2764

(X19NiCrMo4) | **C** 0.19 **Cr** 1.30 **Mo** 0.20 **Ni** 4.10

Steel properties

Case-hardening steel, high core strength, good polishability.

Standards

AISI ~P21

Physical properties

Coefficient of thermal expansion				
at °C	20 – 100	20 – 200	20 – 300	20 – 400
10^{-6} m/(m • K)	12.1	13.0	13.1	13.5

Thermal conductivity			
at °C	20	350	700
W/(m • K)	33.5	32.5	32.0

Applications

Highly stressed plastic moulds, tool holders for cutter picks.

Heat treatment

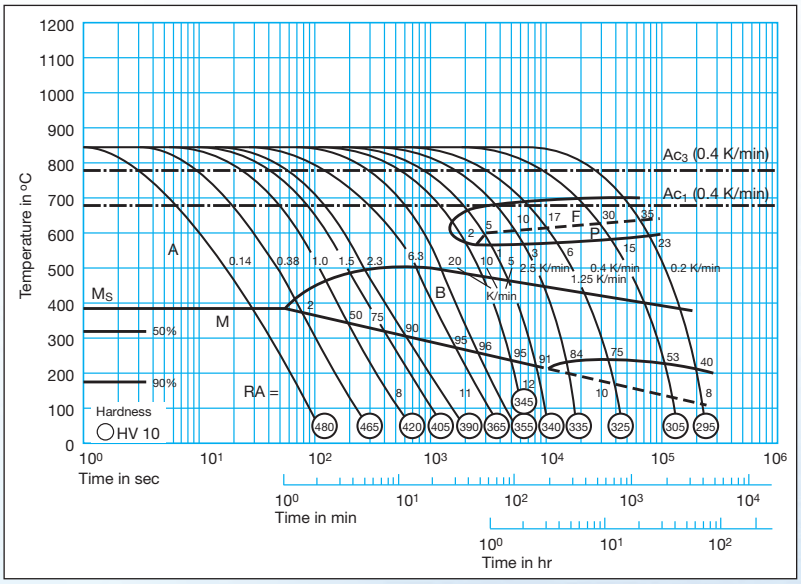
Soft annealing °C	**Cooling**	**Hardness HB**
620 – 660	Furnace	Max. 250

Stress-relief annealing °C	**Cooling**
600	Furnace

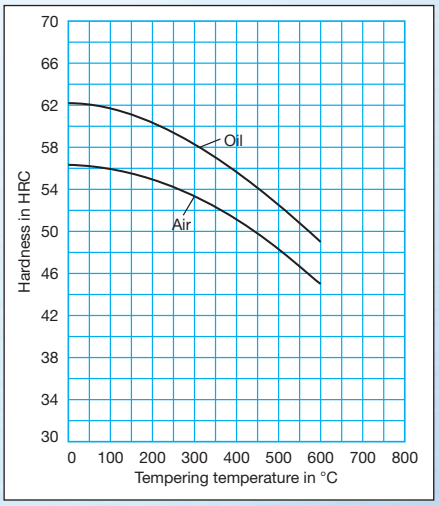
Carburizing °C	**Intermediate annealing °C**	**Hardening °C**	**Quenching**	**Hardness after quenching HRC**
860 – 890	600 – 630	780 – 810	Oil or saltbath, 180 – 220 °C	62
860 – 890	600 – 630	800 – 830	Air	56

Tempering °C	100	200	300	400	500	600
after oil hardening HRC	62	60	58	56	52	49
after air hardening HRC	56	55	53	51	48	45

Time-temperature-transformation diagram



Tempering diagram



Reference numbers in brackets are not standardized in EN ISO 4957.

Formadur 2891

34CrAlNi7

C 0.35 **Si** 0.40 **Al** 1.00 **Cr** 1.70 **Mo** 0.20 **Ni** 1.00

Physical properties

Quenched an tempered QT

Heat treatment diameter in mm Ø	Yield stress in MPa $R_{p0,2}$ min.	Tensile strength in MPa R_m	Elongation at fracture in % A min.	Reduction of area at fracture in % Z min.	Notched impact energy (ISO-V) in J Av min.
16 – 40	680	900 – 1100	10	–	30
> 40 – 100	650	850 – 1050	12	–	30
> 100 – 160	600	800 – 1000	13	–	35
> 160 – 250	600	800 – 1000	13	–	35

Applications

Aluminium-alloyed nitriding steel for large cross sections, suitable for piston rods, extruders, cylinders.

Hardness at different treatment stages

Soft-annealed HB
max. 248

Nitrided surface hardness HV1
approx. 950

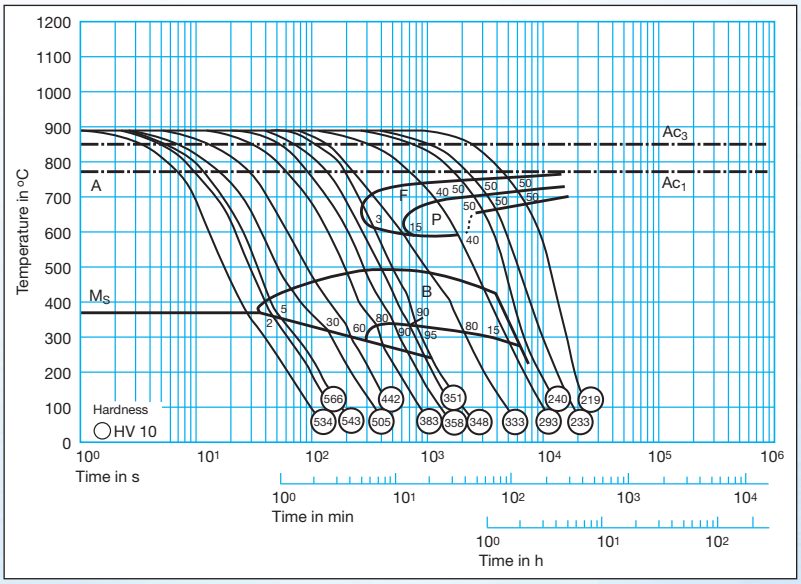
Heat treatment

Soft annealing °C	Hardening °C	Quenching	Tempering °C	Nitriding °C
680 – 720	Furnace	Polymer or oil	580 – 700	480 – 570

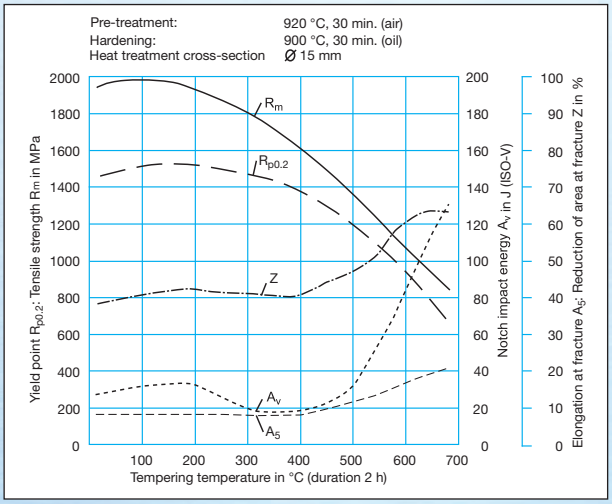
Thermal expansion

Tempering °C	-191 – +16	20 – 100	20 – 200	20 – 300	20 – 400	20 – 500
Linear coefficient of thermal expansion α 10^{-6} K^{-1}	9.1	11.1	12.1	12.9	13.5	13.9

Time-temperature-transformation diagram



Tempering diagram



Formadur 320

C 0.34 **Mn** 0.80 **Cr** 1.70 **Ni** 0.50 **Mo** 0.40

Steel properties

Heat-treated mould steel with improved quenching and tempering properties in comparison to 1.2738. Good machinability, polishable, weldable and can easily be textured. Formadur 320 is either available at a hardness of 280 – 325 HB or 310 – 355 HB. This grade offers substantial improvements, especially for building larger and complex moulds. Specific modifications of the grade's components as well as additional smelting and secondary metallurgy ensure Formadur 320's outstanding properties.

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 200	20 – 300	20 – 400	20 – 500	20 – 600	20 – 700
10^{-6} m/(m • K)	11.1	12.9	13.4	13.5	13.8	14.1	14.3

Thermal conductivity

at °C	20	350	700
W/(m • K)	36.0	37.4	33.0

Applications

Formadur 320 is highly suitable for large-format plastic injection and extrusion moulds with deep engraving and high demands on core strength, such as with bumpers, tailgates, fenders, spoilers, instrument panels and TV housings to name a few. At a supplied hardness of 310 – 355 HB, maximum wear resistance is guaranteed.

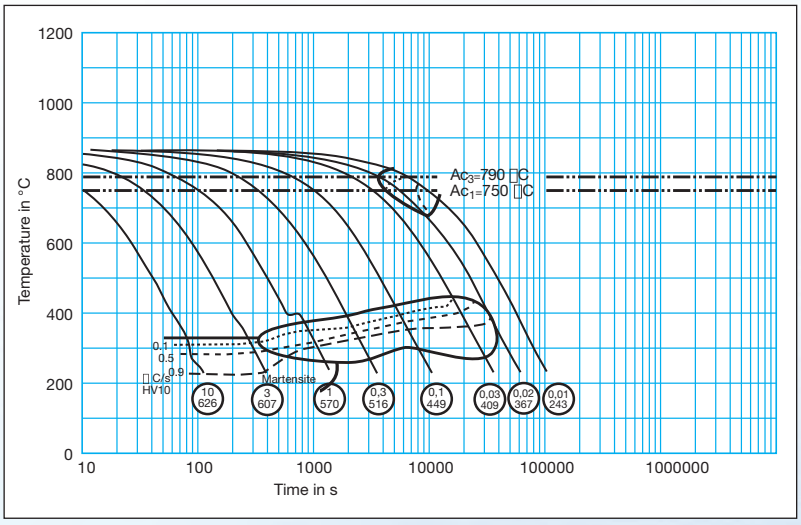
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
710 – 740	Furnace	max. 235

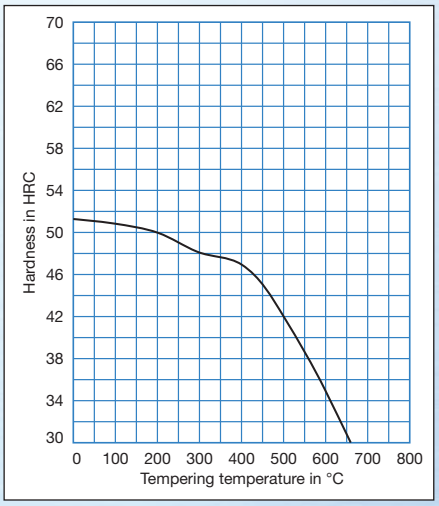
Hardening °C	**Quenching**	**Hardness after quenching HRC**
820 – 850	Polymer or oil	51

Tempering °C	100	200	300	400	500	600	700
HRC	51	50	48	47	42	35	28

Time-temperature-transformation diagram



Tempering diagram



Formadur PH X Superclean

(X5CrNiCuNb15-5)

C 0.05 **Cr** 15.00 **Ni** 4.50 **Cu** 3.50 **Nb** +

Steel properties

Formadur PH X Superclean is a corrosion-resistant, precipitation hardened steel with high strength. It shows excellent polishability due to the applied remelting process. Compared to Formadur 2316, hardness in as-delivered condition and corrosion resistance are improved.

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	10.4	10.6	10.9	11.1	11.4	11.5	11.7	11.9	12.0

Precipitation hardened

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	16.8	20.1	22.1	22.8	23.3	24.1

Precipitation hardened

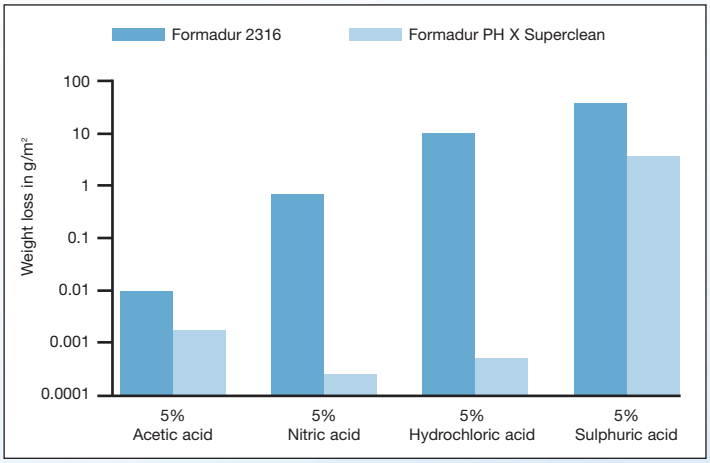
Applications

Formadur PH X Superclean is recommended for tools used in the processing of corrosive plastics. Further applications for components in aircraft and chemical industries.

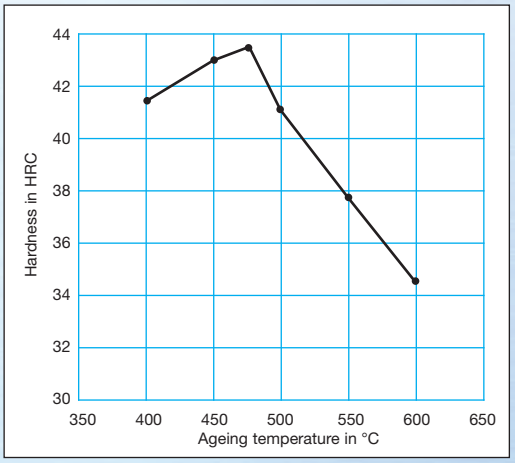
Heat treatment

Formadur PH X Superclean usually is supplied in precipitation-hardened condition with a hardness of 40 HRC.

Weight loss diagram



Ageing diagram



Reference numbers in brackets are not standardized in EN ISO4957.

Formadur PH 42 Superclean

(15NiCuAl12-10-10)

C 0.15 **Mn** 1.50 **Ni** 3.00 **Cu** 1.00 **Al** 1.00

Steel properties

As-delivered hardness approx. 38 HRC (approx. 1200 MPa). Precipitation hardened, remelted plastic mould steel with exellent polishability and suitability for texturing. Good electrical discharge machinability, machinability and weldability, suitable for nitriding. Improved compressive strength due to higher hardness compared to conventional plastic mould steels.

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	12.6	12.8	13.0	13.3	13.5	13.7	13.9	14.0	14.2

Precipitation hardened

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	25.7	29.4	29.8	29.6	29.2	28.2

Precipitation hardened

Modulus of elasticity

at °C	20
MPa	206000

Applications

Formadur PH 42 Superclean is suitable for all kinds of tools in plastic processing with high demands on strength, such as highly stressed plastic injection moulds, compression moulds and hot-runner systems.

Heat treatment

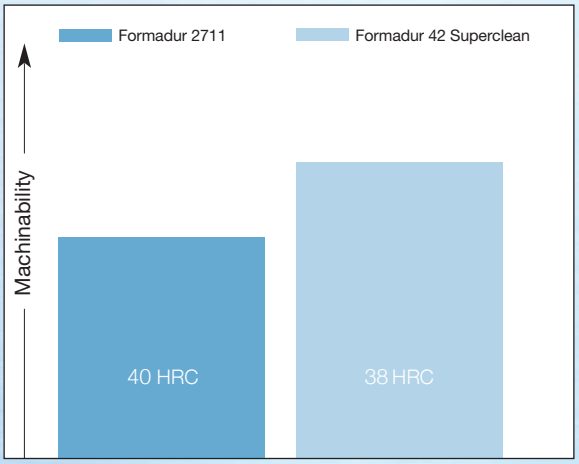
Formadur PH 42 Superclean is supplied in precipitation hardened condition with a hardness of approx. 38 HRC. No additional heat treatment is necessary. After repair welding an ageing at 520 °C/1 hr is recommended.

Special information

Due to its well-balanced composition and its high homogeneity, Formadur PH42 Superclean has a comparable machinability to Formadur 2311 and 2738 even at a higher as-delivered hardness approx. 38 HRC. Compared to Formadur 2711, machinability is significantly improved with a similar hardness level.

Machinability

Comparison of machinability of conventional plastic mould steel Formadur 2711 with Formadur PH 42 Superclean.



Reference numbers in brackets are not standardized in EN ISO4957.

Corroplast

C 0.05 **Mn** 1.30 **S** 0.15 **Cr** 12.50 **Additions** +

Steel properties

Corroplast is a new corrosion-resistant steel for plastic moulding, featuring extremely good machinability at a supplied hardness of approx. 320 HB. The reduced carbon content endows Corroplast with excellent welding properties.

Physical properties

Coefficient of thermal expansion

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	10.3	10.6	10.9	11.1	11.2	11.4	11.6	11.8	12.0

Precipitation hardened

Thermal conductivity

at °C	23	150	300	350	400	500
W/(m • K)	24.6	25.7	25.8	25.7	25.4	24.7

Precipitation hardened

Density

at °C	20
kg/dm³	7.7

Modulus of elasticity

at °C	20	150	350
MPa	214600	208600	198000

Applications

Base plates, mould bases and plastic moulds with standard requirements on polishability, as well as being resistant to condensation and cooling water.

Typical mechanical properties

in as-delivered condition

Heat treatment diameter in mm Ø	**Yield stress in MPa $R_{p0,2}$ min.**	**Tensile strength in MPa R_m**	**Elongation at fracture in % A min.**	**Reduction of area at fracture in % Z min.**
170	890	1100	13	42

Machinability of X33CrS16 and Corroplast in % (hardness 325 HB)