UGINOX

MA2 MA3

MA3M MA4 MA5MV

Martensitic stainless steels

UGINOX MA2	UGINOX MA3	UGINOX MA3M	UGINOX MA4	UGINOX MA5MV
European designation[(1)]	European designation[(1)]	European designation[(1)]	European designation[(1)]	European designation[(1)]
X20Cr13	X30Cr13	X38CrMo14	X46Cr13	X50CrMoV15
1.4021	1.4028	1.4419	1.4034	1.4116
American designation[(2)]	American designation[(2)]			
AISI 420	AISI 420			

(1) According to NF EN 10088
(2) According to ASTM A 176

These grades are in accordance with:
- UGINE & ALZ Material Safety Data Sheet n°1: stainless steels (European Directive 2001/58/EC).
- NFA 36 711 Standard «Stainless steel intended for use in contact with foodstuffs, products and beverages for human and animal consumption» (non packaging steel).

Chemical composition
Mean values
(weight %)

Grades	C	Si	Mn	Cr	Mo	V
UGINOX MA2	0.21	0.35	0.35	13.3	–	–
UGINOX MA3	0.33	0.20	0.30	13.7	–	–
UGINOX MA3M	0.38	0.30	0.35	14.0	0.8	-
UGINOX MA4	0.46	0.35	0.30	13.8	–	–
UGINOX MA5MV	0.48	0.35	0.30	14.4	0.6	0.12

General characteristics and applications

The characteristic feature of these martensitic grades is their ability to be hardened by heat treatment. Thus, in the quenched and tempered condition, they attain high strength levels enabling the achievement of a sharp cutting edge.
Combined with their good corrosion resistance, this aptitude meets the requirements of numerous applications, such as:
- blades for knives and various food preparation utensils
- blades for industrial equipment
- cutting tools
- mechanical parts and miscellaneous tools.

For kitchen knife blades and those used in food preparation utensils, the molybdenum-containing Uginox MA3M and Uginox MA5MV grades are to be preferred, due to their improved corrosion resistance and the possibility of achieving high hardness levels in the quenched and tempered condition.

Physical properties (cold rolled sheet)

Density	d	–	4 °C	7.7
Melting temperature (solidus)		°C		1420
Specific heat	c	J/kg.K	20 °C	460
Thermal conductivity	k	W/m.K	20 °C 200 °C	30 31
Mean coefficient of Thermal expansion	α	10^{-6}/K	20 - 200 °C 20 - 400 °C	11 12
Electric resistivity	ρ	$\Omega.mm^2/m$	20 °C	0.62
Magnetic permeability	H	at 0.8 kA/m DC or top AC	20 °C	700
Young's modulus	E	$MPa.10^3$	20 °C	215

Curie point: 700°C

Tensile properties

Annealed condition
According to NF EN 10002-1 (July 2001), specimen perpendicular to the rolling direction

Specimen
Lo = 80 mm (thickness < 3 mm)
Lo = 5,65 √ So (thickness ≥ 3 mm)

1 MPa = 1 N/mm^2

Grades		R_m (1) (MPa)	$Rp_{0,2}$ (2) (MPa)	A (3) (%)	HRB
UGINOX MA2	According to NF EN10088	≤ 700	-	≥ 15	≤ 95
	Typical value	550	320	28	81
UGINOX MA3	According to NF EN10088	≤ 740	-	≥ 15	≤ 97
	Typical value	600	340	26	85
UGINOX MA3M	According to NF EN10088	≤ 760	-	≥ 15	≤ 97
	Typical value	640	360	24	89
UGINOX MA4	According to NF EN10088	≤ 780	-	≥ 12	≤ 99
	Typical value	650	360	24	89
UGINOX MA5MV	According to NF EN10088	≤ 850	-	≥ 12	≤ 99
	Typical value	650	360	24	89

(1) Ultimate Tensile Strength (UTS) (2) Yield Strength (YS) (3) Elongation (A)

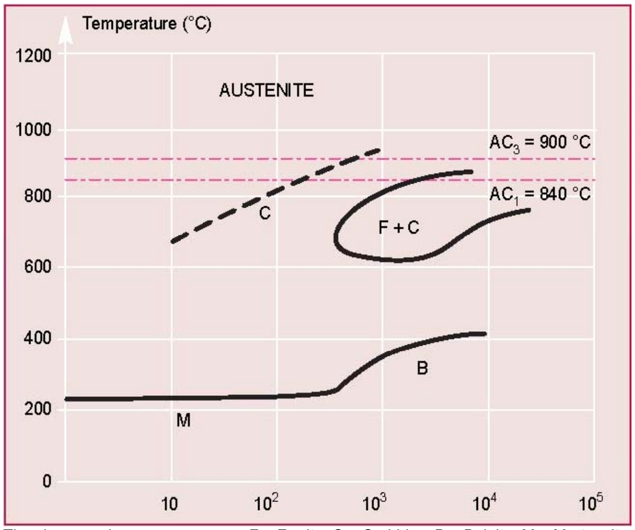
Hardness after 0il Quenching and Tempering
Oil quenched at 1050°C – Tempered at 250°C

Grades	According to NF EN 10088-2		Typical value	
	HRC	HV	HRC	HV
UGINOX MA2	44 to 50	440 to 530	45	450
UGINOX MA3	45 to 51	450 to 550	51	540
UGINOX MA3M	-	-	55	610
UGINOX MA4	-	-	55	610
UGINOX MA5MV	-	-	55	610

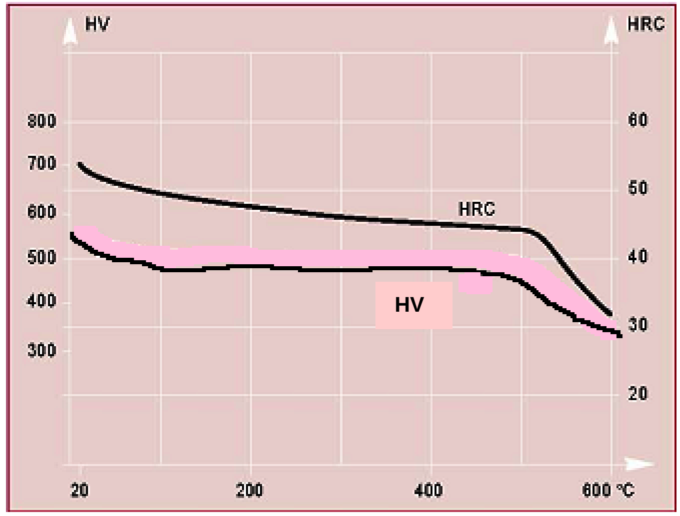
CCT DIAGRAM

HARDNESS AFTER OIL QUENCHING (1 050°C) AND TEMPERING

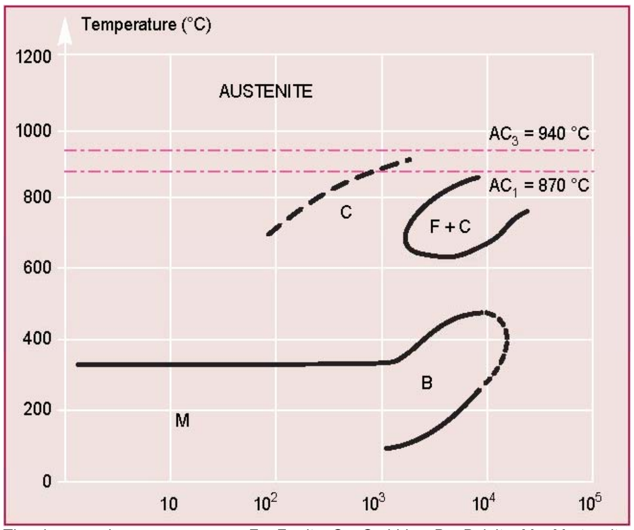
MA2



Time in seconds F = Ferrite C = Carbides B = Bainite M = Martensite
AC1 = beginning of transformation α→γ AC3 = end of transformation α→γ
α= ferrite γ= austenite



MA3



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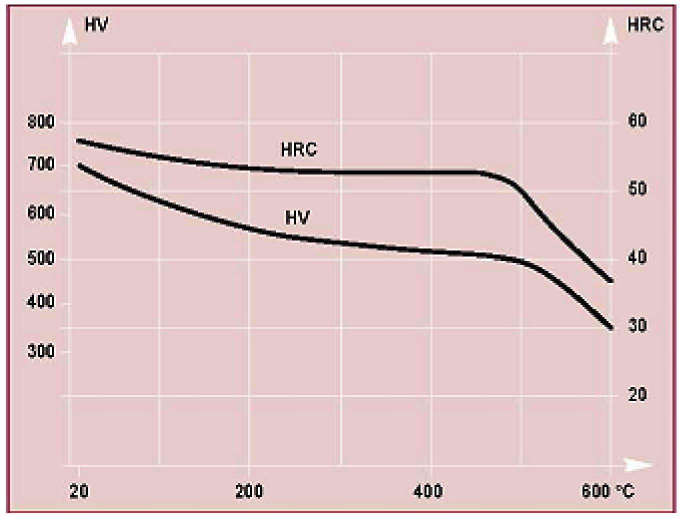
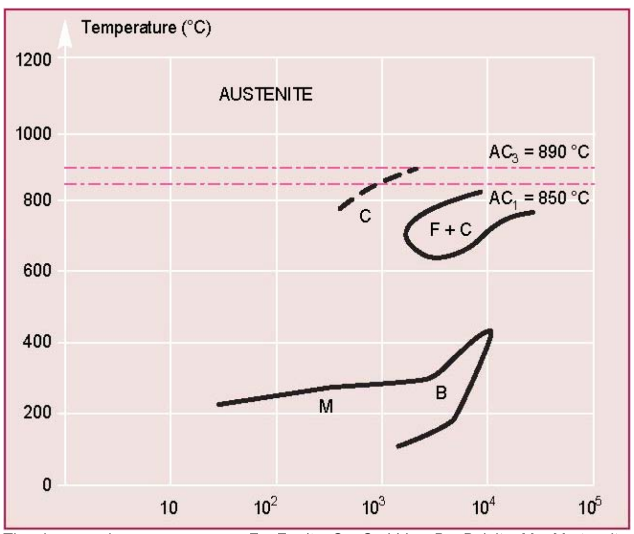


MA3M



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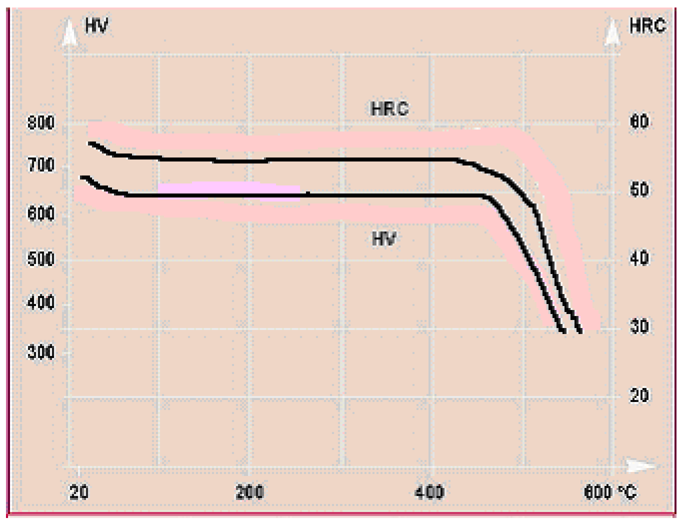
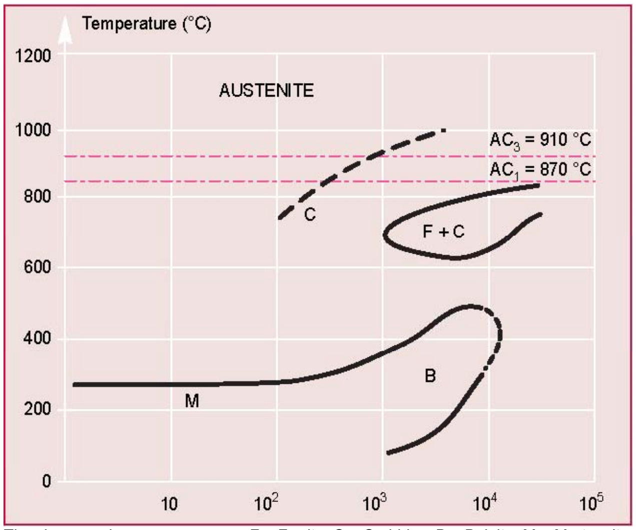


CCT DIAGRAM

HARDNESS AFTER OIL QUENCHING (1 050°C) AND TEMPERING

MA4



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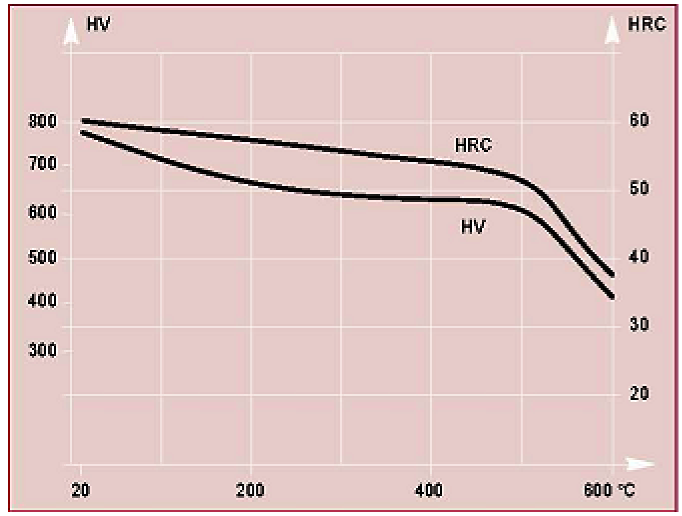
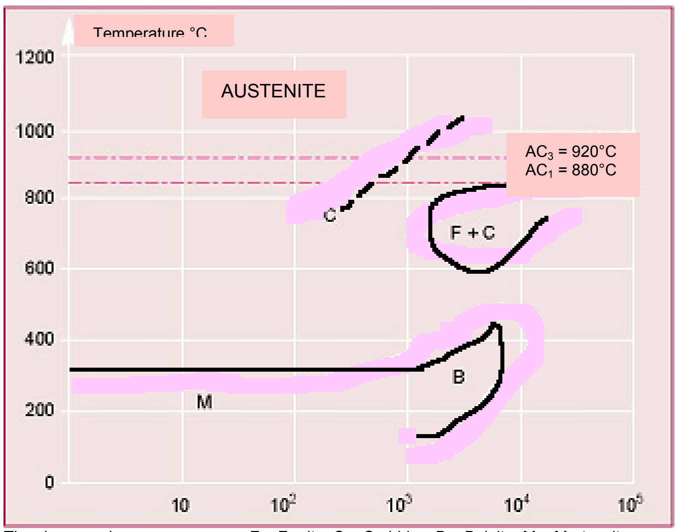


MA5MV



Time in seconds F = Ferrite C = Carbides B = Bainite M = Martensite
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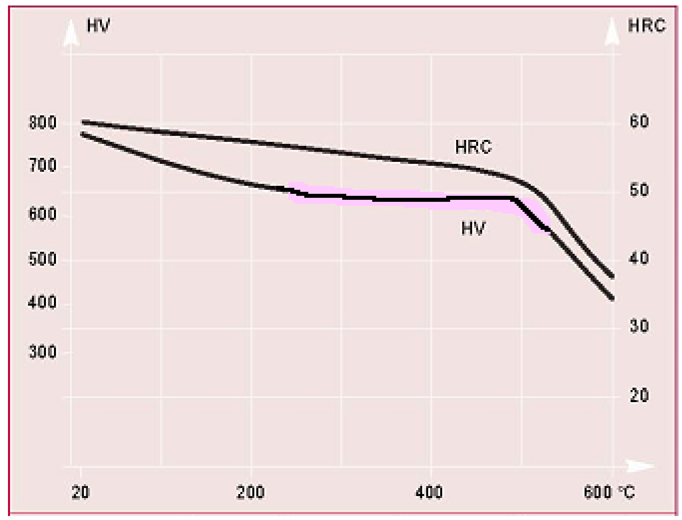

Heat treatment

Delivery in the annealed condition
The martensitic stainless steels possess high mechanical strength after full heat treatment. In order to avoid a loss in corrosion resistance and to facilitate subsequent polishing operations, it is recommended to carry out the austenitizing and tempering treatments under vacuum or under a reducing atmosphere of cracked ammonia.

Austenitizing at 1050-1060°C must be followed by rapid cooling (1050 to 20 °C in less than 60 seconds) in a stream of cracked ammonia or pulsed air, or preferably, by quenching in an oil bath.

Cooling can be continued to sub-ambient temperatures (-40 °C) to eliminate all traces of residual austenite, which can create a risk of cracking during grinding.
A tempering treatment is performed at 250 °C to relieve stresses.

A properly conducted heat treatment is a guarantee of good corrosion resistance.

Corrosion resistance

The corrosion resistance depends strongly on the quenching and tempering conditions employed. Optimum behaviour is obtained when quenching is performed from a temperature in the range 1040 to 1070°C.
Close control of the quenching speed is essential to achieve good corrosion resistance. Below a critical cooling rate, a loss in pitting corrosion resistance is observed, due to the precipitation of chromium-depleting carbides. In practice, this means that cooling in still air must be avoided, and should be replaced by oil quenching or forced air or gas cooling.
The tempering temperature also has a decisive influence. If it is too high, it can also cause the formation of chromium-depleting carbides that impair the corrosion resistance. For this reason, the recommended tempering range is 230 to 300°C.

Furthermore, local heating due to mechanical component finishing operations such as grinding, forming of the cutting edge, serration, sharpening and polishing, must not induce temperatures higher than that recommended for tempering.

Finally, the surface condition is another factor that can affect corrosion : a polished surface, with low roughness, is always beneficial.

Welding

Certain operating precautions are necessary when welding martensitic stainless steels, since the martensite transformation tends to cause cracking (sometimes of a delayed nature) at temperatures below 400 °C.
It is recommended to preheat parts to between 200 and 300 °C before welding.

In welding processes requiring the use of shielding gas (TIG, MIG, plasma), the use of hydrogen and nitrogen is strictly forbidden. These martensitic stainless steels can be joined by spot and seam resistance welding and by spark welding.

A post-weld heat treatment is recommended for grades whose carbon content is greater than 0.2%.

When welding is performed without filler metal, the following post-weld heat treatments can be used:
- softening between 650 and 800 °C
- quenching from 1 050 °C, followed by tempering at 250 °C.

When welding is performed with a filler metal, the choice is between:
- an alloy with the same composition as the base metal (AWS 420 electrode or wire), possibly with post-weld heat treatment as above
- an alloy of different composition from the base metal (ER 308 L, 309 L or 310 electrode or wire), possibly without a post-weld heat treatment, although the latter is recommended to avoid embrittlement of the HAZ.

Welding process	No filler metal	With filler metal			Shielding gas*
	Typical thicknesses	Thickness	Filler metal		*Hydrogen and nitrogen forbidden in all cases
			Rod	Wire	
Resistance Spot Seam	 ≤ 2 mm ≤ 2 mm				
TIG	< 1.5 mm	> 0.5 mm	ER 309 L (Si) ER 420 (1)	ER 309 L (Si) ER 420 (1)	Argon Argon + Helium
PLASMA	< 1.5 mm	> 0.5 mm		ER 309 L (Si) ER 420 (1)	Argon
MIG		> 0.8 mm		ER 309 L (Si) ER 420 (1)	Argon + 2% CO_2 Argon + 2% O_2
S.A.W		> 2 mm		ER 309 L (Si) ER 420 (1)	
Electrode		Repairs	ER 309 L (Si) ER 420 (1)		
Laser	< 5 mm				Helium

(1) The homogeneous filler metal ER 420 should be used when subsequent quenching and tempering is to be performed in order to obtain the same hardness in the weld and the base metal.

The welds must be mechanically or chemically descaled, and preferably repassivated.

Pickling
Nitric-hydrofluoric acid mixture (15 % HNO_3 +1 % HF).

Passivation
25 % HNO_3 solution (nitric acid), either at 20 °C for 2 hours, or at 50 °C for 10 minutes, followed by abundant rinsing with cold water.

Product range

Annealing
- Forms: sheets, blanks, coils, foils
- Thicknesses: 0.5 to 6 mm, depending on the finish
- Width: according to thickness, maximum 1000 mm
- Finish: cold rolled and hot rolled, depending on the thickness

Temper - Rolled condition
C 700 - C 850

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