AUBERT&DUVAL

ML340

X23NiCoCrMoAl13-6-3

Very high strength steel for high temperature applications

CONTINUOUS
METALLURGICAL
INNOVATION

SPECIAL STEELS

DEVELOPMENT

RESEARCH

SERVICE

Enhancing your performance

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THE INDUSTRIAL ENVIRONMENT

Numerous applications require higher strength combined to high impact resistance. The constant research for weight saving and harsher operating conditions led to the development of improved maraging grades.

ML340 was developed by AUBERT&DUVAL for applications requiring a steel grade capable of 2340 MPa / 340 Ksi and operating at relatively high temperatures (450°C / 840°F), like engine shafts. The grade is mainly used for UTS 2230 MPa / 323 Ksi.

The grade is developed for maximum fatigue resistance using vacuum melting and remelting, homogeneous structure and high UTS.

DEVELOPMENT OF ML340

Maraging grades capable of 340ksi already exist. They contain high level of Co (8%). AUBERT&DUVAL has developed a grade with similar properties and reduced Co, down to 5.8%. Hardening is achieved by combining secondary carbides (Mo and V) and precipitates (NiAl).

The Ni-Co martensite exhibits high toughness.

The grade also contains Cr and is therefore capable of developing high surface hardness through diffusion of nitrogen.

CHARACTERISTICS OF THE GRADE

ML340 is a « duplex hardening » grade: Ni-Co martensite

- with carbon chromium and molybdenum (forming secondary Cr-Mo carbides)
- aluminium and molybdenum forming intermetallic precipitation of NiAl

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HEAT TREATMENT

Delivery condition

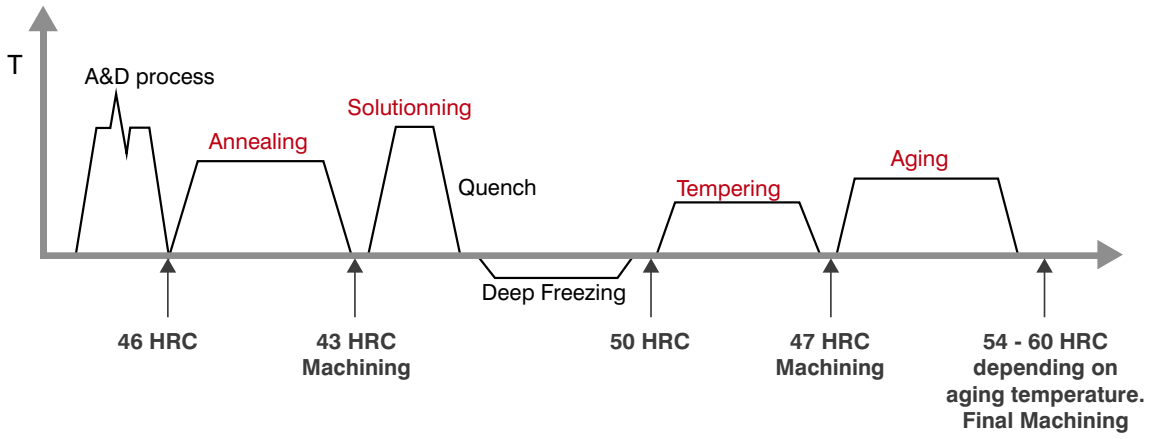
This steel is delivered annealed:

650°C / 1200°F – 8 hrs – A

Maximum hardness: 400 HB

Aging

This grade is duplex hardened. After solution treatment, a temper at 200°C / 390°F is recommended for machining. The final properties are obtained by aging at 480°C / 896°F to 520°C / 968°F.



APPLICATIONS

- Aerospace applications, especially engine shafts
- Nitriding parts (crankshafts,…)

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CHEMICAL COMPOSITION

C	Ni	Cr	Mo	Al	Co	V
0.23	13.00	3.30	1.50	1.50	5.80	0.25

SPECIFICATION

- X23NiCoCrMoAl13-6-3

COMPARISON WITH MARAGING 250

- Composition

	C	Ni	Cr	Mo	Al	Co	Ti	V
ML340	**0.23**	**13.00**	**3.30**	**1.50**	**1.50**	**5.80**	**-**	**0.25**
Maraging 250	0.03	18.00		5.00		8.00	0.50	

- Typical mechanical properties

	UTS (N/mm^2 *Ksi*)	**0.2% YS** (N/mm^2 *Ksi*)	**KV** (J *ft.lb*)	**K1c** (MPa√m *Ksi√in*)	**Endurance limit 10^7 cycles** (Rotative bending)
ML340	2200 *320*	1900 *280*	24 *17*	41 *37.3*	950 MPa *138 Ksi*
Maraging 250	1850 *270*	1780 *260*		65 *59*	950 MPa *138 Ksi*

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PHYSICAL PROPERTIES

Density

7.8

Mean coefficient of expansion in m.m.°C

- between 20°C / 68°F and 100°C / 212°F: 10.7 x 10-6
- between 20°C / 68°F and 300°C / 572°F: 11.6 x 10-6
- between 20°C / 68°F and 500°C / 932°F: 12.3 x 10-6

TRANSFORMATION POINTS

Ac 1	605 °C / 1121 °F
Ac 3	855°C / 1571°F
Ms	135 °C / 275 °F

MACROSTRUCTURE

The segregation observed on the ingots are well within the limits of the aerospace industry requirement

Class	Type	Severity
1	Freckles	A
2	White spots	A
3	Radial segregation	A
4	Ring pattern	B

Macrostructure according to ASTM A 604

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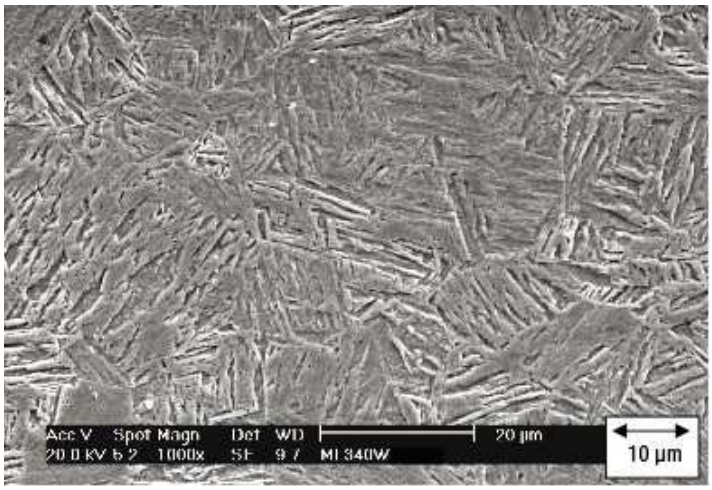
MICROGRAPHIC CHARACTERIZATION

Aged Condition



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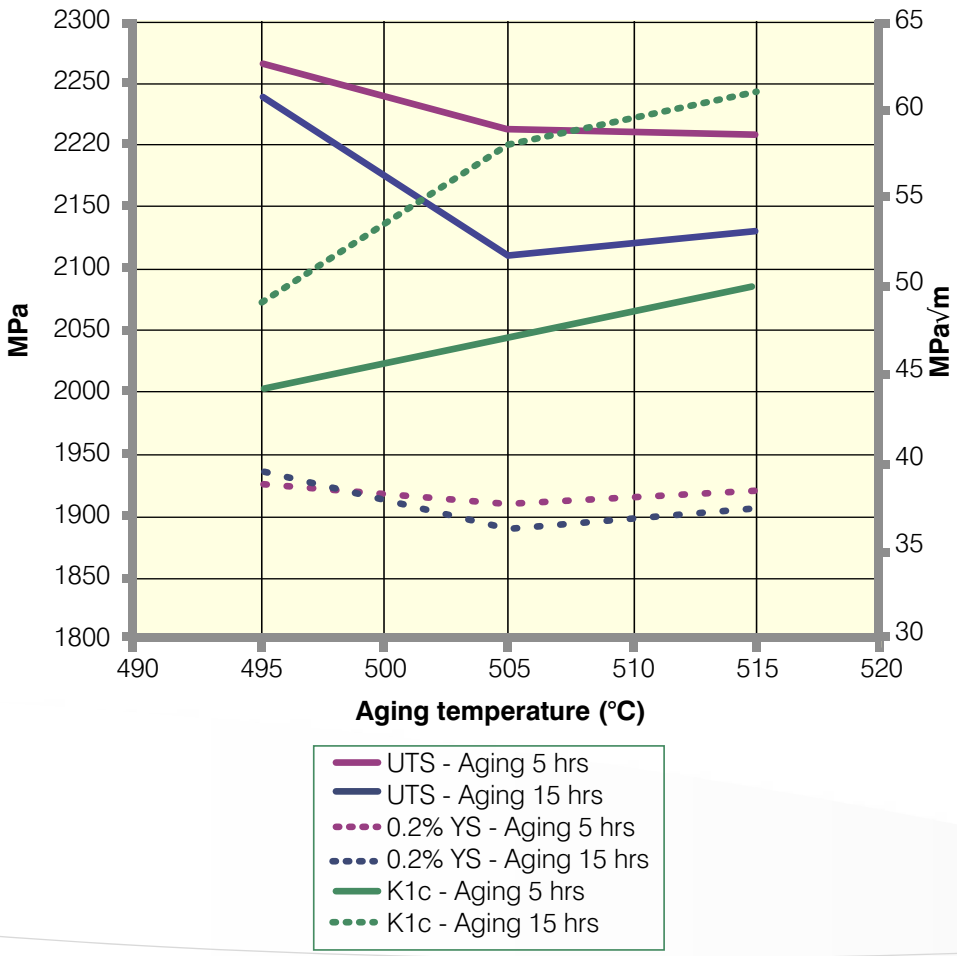
MECHANICAL CHARACTERISTICS

Typical characteristics as a function of aging temperature

Heat Treatment:

- 900°C / 1650°F – 1 hr – Air
- Deep Freezing below -80°C / -112°F – 1 hr
- 200°C / 390°F – 8 hrs - Air
- Aging

The graph below shows the typical properties.



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Evolution of characteristics for a fixed aging temperature

Heat Treatment:

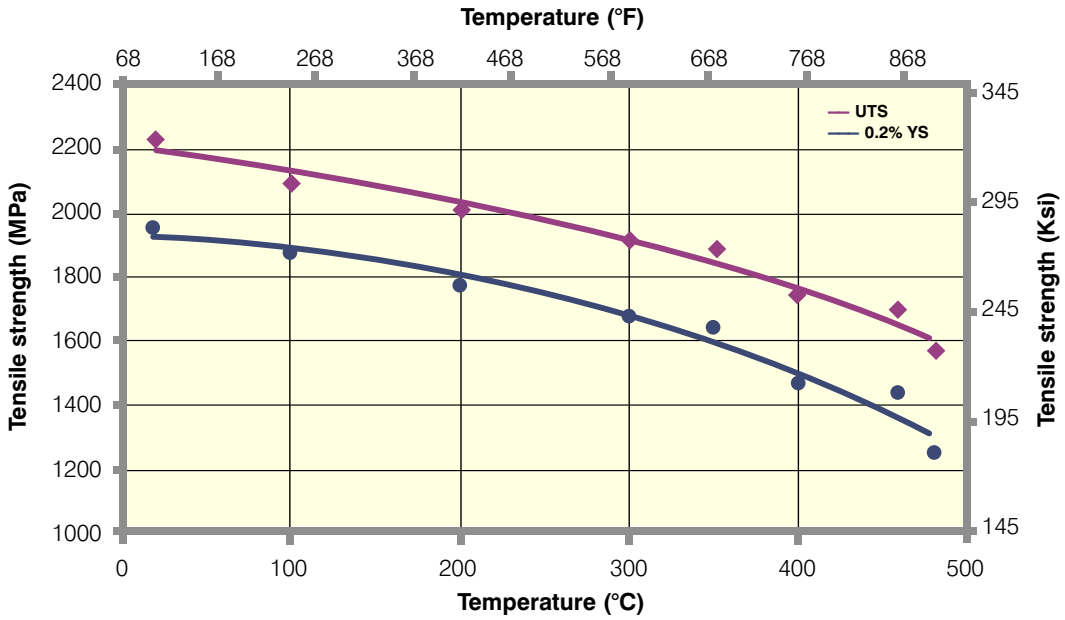
900°C / 1650°F – 1 hr – Air

Deep Freezing below -80°C / -112°F – 1 hr

200°C / 390°F – 8 hrs - Air

Aging 495°C / 923°F – 10 hrs

Evolution of tensile properties as a function of temperature



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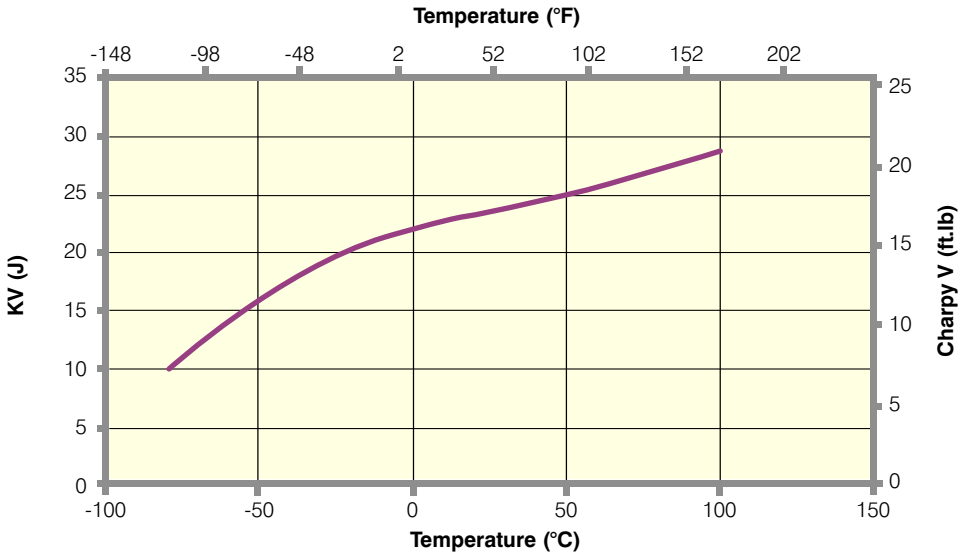
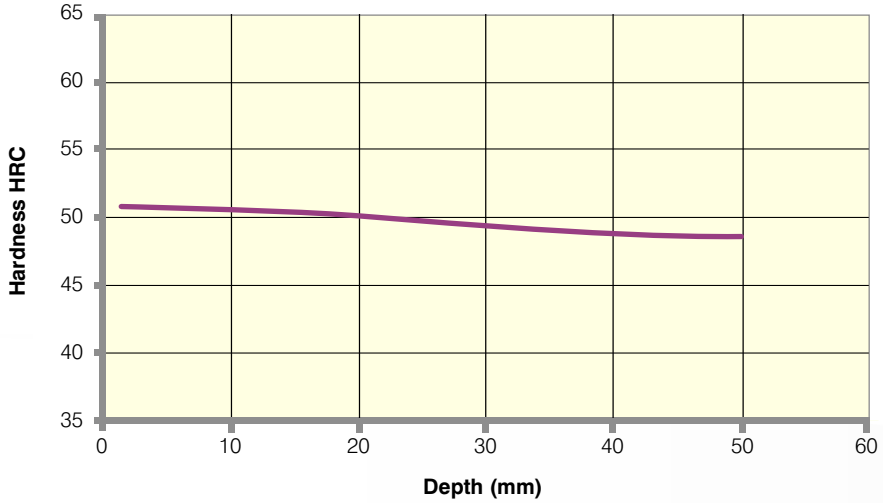
Evolution of Charpy-V notch impact resistance as a function of temperature



Jominy curve



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