High Yield Strength Alloys

DURIMPHY

DURIMPHY® is a 250 KSI (kilo-pound square inch) maraging steel. In addition to having a very high yield strength, it offers a range of complementary properties (physical, chemical and technical) that enable its optimized use with a variety of applications.

General characteristics

Annealing at around 830°C results in a softened condition with a soft martensite structure. Ageing treatment with tempering at a moderate temperature (480°C) results in major precipitation hardening of the Ni3Ti and Fe2Mo type intermetallic compounds. This hardening is achieved without having a noticeable impact of on the material's dimensions.

Hardening treatment can also be applied to the material in a work-hardened condition. As tempering is performed at a relatively low temperature, it is possible to benefit from both the work-hardening and the precipitation hardening, resulting in an even stronger material.

Supplied in strip form and in a wide range of dimensions, DURIMPHY® is offers identical properties to another high yield strength alloy (PHYNOX). However, DURIMPHY®'s superior formability gives it the advantage for certain applications (although, it does not possess the distinctive non-magnetic and corrosion-resistant qualities of PHYNOX).

DURIMPHY®'s principal characteristics:

- Superior formability, elevated mechanical properties by precipitation hardening through heat treatment at moderate temperature (which can be carried out after forming). Hardening treatment does not cause any dimensional change.
- No low-temperature embrittlement.
- Excellent fatigue-resistance.
- Structural stability after ageing.
- A low thermoelastic coefficient.
- Excellent weldability. Post-weld hardening treatment enables significant reduction of differences in properties between welded and non-welded zones, thus eliminating weak spots.

Chemical composition

Elements (% weight)	Ni	Co	Mo	Ti
Typical value	18	9	5	0.5

DURIMPHY® has numerous applications:

- Springs for clock motors.
- Springs for rough watch movements.
- Form springs for analogue quartz watches.
- Springs for miscellaneous applications.
- Weighing machines.
- Precision ball bearings.
- Ball bearing cages.
- Electrical and electronic apparatuses.
- Plastics industry.
- Defense industry.
- Missile and rocket fins.
- Satellites.
- Automatic gearbox belt.
- Printer type-carrying band.

Physical properties

Properties	Units	Values
Melting point	°C	1430 - 1460
Density	$g.cm^{-3}$	8.1
Electrical resistivity* at 20 °C	µΩ.cm	44
Thermal conductivity*	$W.m^{-1}.°C^{-1}$	19.7
Expansion coefficient* between 0 and 100 °C	$°C^{-1}$	9.5×10^{-6}
Thermoelastic coefficient* between 0 and 50 °C	$°C^{-1}$	-200×10^{-6}
Magnetic properties* : Saturation Induction	T	1.9
Magnetic properties* : Curie Point	°C	450

** These values are given for the standard temper at 480°C. They can vary considerably according to the tempering temperature.*

Mechanical properties

Annealed condition

The annealed condition is obtained following treatment at 830°C. Cooling can be conducted at any rate, (i.e. without special precautions). This condition is only used for intermediate forming operations.

Typical values are given in the following table:

Property	Units	Values
Vickers hardness	HV	330
Ys 0.2 %	MPa	1010
Ultimate tensile stress	MPa	1040
Elongation	%	7*

** Minimum value depending on material thickness*

Hardener condition

The standard hardening treatment is 3 hours at 480°C.

This treatment causes the precipitation of intermetallic compounds. This precipitation treatment can be combined with work-hardening.

Figure 1 illustrates the variation in mechanical properties as a function of the cold work rate. It shows that:

- Hardening due to cold working only becomes significant at high levels (> 70%).
- The effect of the hardening treatment is virtually unrelated to the material's cold work rate.
- The effects of the hardening treatment and cold working are practically cumulative.

It is important to remember that hardening by heat treatment conducted at a moderate temperature occurs without significantly changing the material's dimensions. In most cases, this enables (formed) components to be finished on soft metal without the need to rework after heat treatment.

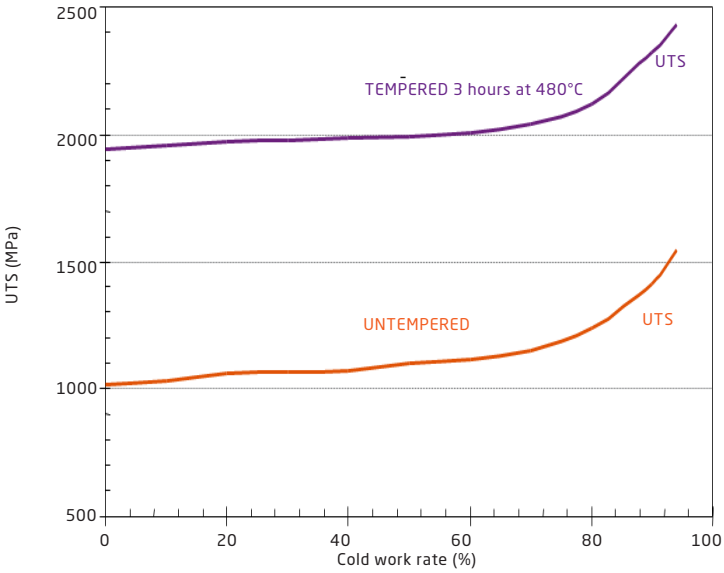
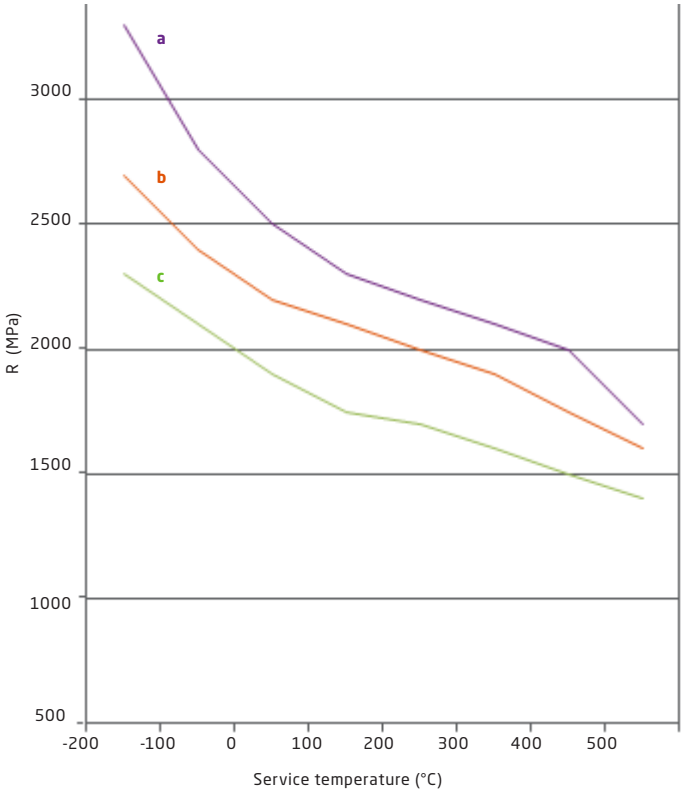


Figure 1: variation of typical longitudinal mechanical properties at 20°C as a function of cold work rate

Although treatment in air does not impair the material's properties, it does spoil its appearance, with the metal taking on a blue hue. For this reason, we recommend treating under deep vacuum in the order of 10-5 Torr or under inert atmosphere such as argon.
Certain atmospheres regarded as inert due to the absence of colouration are in reality chemically active and may cause the material to become extremely brittle. This is particularly true in the case of hydrogen and cracked ammonia.

Influence of service temperature

Following tempering, the tensile and yield strengths of this alloy decreases slower with temperature than those of traditional "piano wire" type spring steels or 18-8 stainless steels (cf. figure 2). This is due to dislocation locking by the precipitates formed during the temper hardening treatment.
Variations in the modulus of elasticity (Young's modulus) as a function of temperature are similar to those of other alloys.
DURIMPHY® does not experience any structural change even at the lowest temperatures and does not exhibit any particular cold-brittleness.



a – highly cold-worked (approx. 98%) + tempered
b – moderately cold-worked (approx. 88%) + tempered
c – annealed + tempered

Figure 2: Variations in longitudinal tensile strength with service temperature for strip in various conditions

Corrosion - Resistance

Although this alloy is not a stainless alloy, it can withstand the humid atmospheres typical of temperate climates better than carbon and low-alloy steels.

In the case of harsher atmospheres, DURIMPHY® must be protected.

Precautions should be taken when of electroplating to avoid the risk of hydrogen embrittlement.

Technological Data

Machining - Forming

Formability is dependent on the degree of work-hardening, which must be suited to the user's requirements:

- In the annealed condition, DURIMPHY® offers excellent formability.
- In the moderately work-hardened condition, formability remains good, particularly in the case of bending.
- Even in highly work-hardened conditions, severe bending can be performed perpendicular to the direction of rolling (e.g. for clock and watch springs).

In the case of some deep drawing forming operations, deformability can be improved by means of a partial austenitising treatment at around 670°C.

DURIMPHY® responds well to chemical machining.

DURIMPHY® can be surface-hardened by nitriding.

Welding - Brazing

DURIMPHY® welds well: electric spot-welding, electron beam welding, argon arc welding (generally TIG). DURIMPHY® can be brazed.

It should be noted that the weld bead zone can be hardened similar to the parent metal by means of a simple heat treatment at 480°C. When welding work-hardened metal, the advantage of the work-hardening in the heat-affected zone is lost. Localized (spot-welding) or low-impact (electron beam) techniques can be employed

Pickling

PHYTIME® can be chemically pickled (for example in an 18% solution of H2SO4 at 65°C). As this alloy is typically used for its high yield strength, it is advised that the pickling operation be conducted in such a way as to avoid forming fracture initiation sites.

Available Forms

DURIMPHY® is delivered in as cold, hot rolled strip and wire. Contact us for specific formats.

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