High Yield Strength Alloys

PHYTIME

The patented PHYTIME® is a 300 KSI (kilo-pound square inch) martensitic alloy ideal for hardening by ageing heat treatment. Its outstanding mechanical and metallurgical properties make it particularly suitable for applications requiring resistance to fatigue damage.

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 Fe2Mo type intermetallic compounds. This hardening is achieved without having a noticeable impact 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, PHYTIME® offers identical properties to another high yield strength alloy (PHYNOX). However, PHYTIME®'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).

PHYTIME®'s principal characteristics:

- Superior formability and extremely high mechanical properties after ageing, thanks to intensive precipitation hardening heat treatment at moderate temperature. This treatment can be carried out after forming as it does not cause any dimensional change.
- No low-temperature embrittlement.
- Outstanding fatigue-resistance.
- Structural stability after ageing.
- A low thermoelastic coefficient.
- Excellent weldability. Post-weld hardening treatment enables significant reduction of the differences in properties between welded and non-welded zones, thus eliminating weak spots.

PHYTIME® is specifically designed for all applications requiring high fatigue resistance, such as those used in the automotive industry:

- Belt for automatic gearbox transmission.
- Cable connectors to motors.
- Springs.

Chemical composition

Elements (% weight)	Ni	Co	Mo
Typical value	18	16.5	5

Physical properties

Melting T° (C°)	Density (g/cm^3)	Expansion coefficient* between 0 and 100 (°C - 1)	Magnetic property*: Saturation Induction (T)
1430 - 1460	8.14	9.5×10^{-6}	1.9

** This value is given for the standard temper at 480°C. It 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:

Vickers hardness (HV)	Ys 0.2 % (MPa)	UTS (MPa)	Elongation (%)
300	1000	1030	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 is linearly increasing.
- 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.

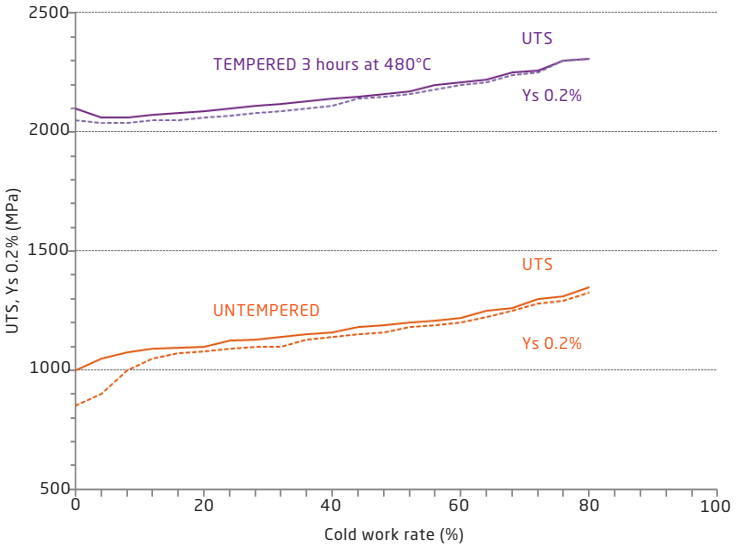

Figure 1: variation of typical longitudinal mechanical properties at 20°C as a function of cold work rate

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 thus may cause the material to become extremely brittle. This is particularly true in the case of hydrogen and cracked ammonia.

Corrosion - Resistance

Although this alloy is a not 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, PHYTIME® must be protected.

Precautions should be taken when 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, PHYTIME® 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.

PHYTIME® responds well to chemical machining.
PHYTIME® can be surface-hardened by nitriding.

Welding - Brazing

PHYTIME® welds well: electric spot-welding, electron beam welding, argon arc welding (generally TIG). PHYTIME® 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 H_2SO_4 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

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

www.aperam.com
nickel.alloys@aperam.com
YouTube

Aperam Alloys Imphy
B.P. 1
Avenue Jean Jaurès
F- 58160 Imphy

Aperam Alloys Imphy