Technical Data Sheet
PHYNOX®

Chemical composition (%)

C	Si	Mn	Ni	Cr	Co	Mo	Be	P	S	Fe	Autres
≤0,15	≤1,20	1,50 – 2,50	15,0 - 18,0	19,0 – 21,0	39,0 – 41,0	6,50 – 7,50	≤0,001	≤0,015	≤0,015	BAL.	≤1,00

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General presentation

PHYNOX®[1] is an austenitic cobalt basis alloy with high yield strength which offer multiple properties:

Age hardening by heat treatment after cold forming without any distortion,

Excellent corrosion resistance in several medias, stress corrosion cracking and absence of hydrogen embrittle-ment,

Excellent fatigue resistance without any relaxation,

Non magnetic in all temper: annealed, cold drawn or aged,

Can be used in a wide range of temperature: from liquid helium to 500°C,

Perfectly biocompatible, it has been used for more than twenty five years in surgical implants.

Classification

Austenitic cobalt based alloy.

Designation and Standard

Material No

Europe	USA	Japan
EN	**UNS**	**SUS**
	R30003 R30008	

AFNOR K13C20N16Fe15D07

ISO 5832-7 - STM F1058 - AMS 5833, AMS 5834

Microcleanliness

Cleanliness conforms to standards AFNOR NF S 90 - 403 and ISO 5832/7

Inclusions	Indicex of the thinest inclusion
A SULFIDES	1
B ALUMINATES	3
C SILICATES	1
D GLOBULAR OXIDES	3

Mechanical properties

Young's modulus , E	20°C	100°C	200°C	300°C	400°C	500°C	600°c
MPa x 1000 (Annealed)	198						
MPa x 1000 (As drawn)	182						
Mpa x 1000 (As drawn & heat treated 520°C/3H)	208	207	205	203	201	197	186

G modulus (torsion)	20°C	100°C	200°C	300°C	400°C	500°C	600°c
MPa x 1000 (Annealed)	77						
MPa x 1000 (As drawn)	75						
MPa x 1000 (As drawn & heat treated 520°C/3H)	82	81	79.5	78	75	72	68

The PHYNOX® can be produced to answer specific requirements.

It is, possible to manufacture this alloy in a large range of mechanical properties.

The table, below, indicates the values of mechanical resistance obtained at several levels of cold drawing (this list is not exhaustive, intermediate values of UTS can be achieved).

[1] PHYNOX® is a trademark from APERAM

Swiss Steel Group

Production sites: Ugitech SA
www.swisssteel-group.com

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Wire in coils

MPa	Annealed MPa Min	Hard 1650	Hard 1850	Hard 2000	Hard 2150
As shipped UTS	950	1550 - 1750	1750 - 1950	1900 -2100	2050 - 2250
After heat treatment 3 h at 520°C	950	1850-2050	2100 - 2300	2350 - 2550	2550 – 2750

The influence of the heat treatment, negligible in the annealed condition, becomes more important as the cold drawn hardening increases.

However, even if the level of the request mechanical resistance can be reached only by cold drawing, it is preferable to use lighter cold drawing temper and achieve the requested mechanical properties after heat treatment; the heat treatment stabilizing the material.

Bars

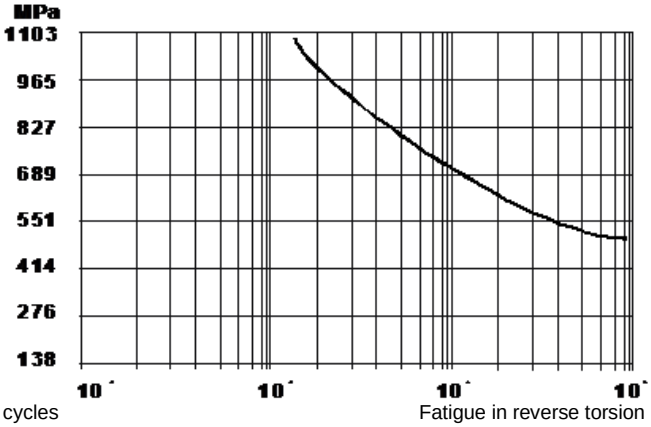
These bars are obtained by straightening from coil. On same level of cold drawing, this process involves a decrease of around 10% of the UTS compared to the coil form.

Mechanical properties on a spring

Exemple : Spring : wire diameter 1,50 mm

- As drawn : UTS > 1750 Mpa
- After aging : UTS > 2030 Mpa

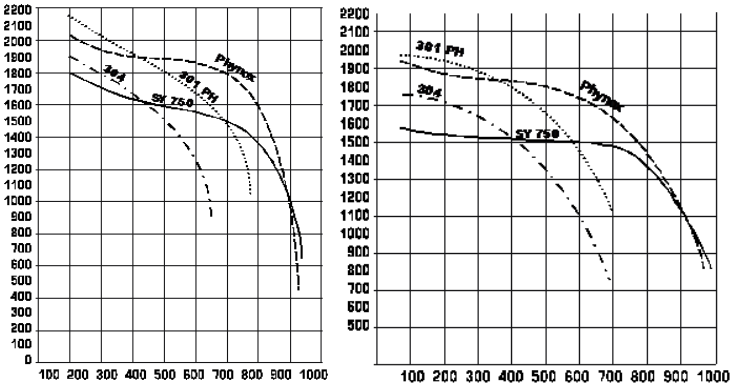
Resistance to fatigue



cycles

Fatigue in reverse torsion

Mechanical properties as a function of temperature for several materials (T °C)



Physical properties

Properties	
Specific weight	8.30 g/cm^3
Range of temperature	- 269°C to 500°C
Melting range	1450 – 1460 °C
Resistivity	20°C
µΩcm	95
Specific heat	20°C
J Kg-1°C-1	430
Mean coefficient of thermal expansion	**0 - 100°C**
°C-1 (x 10^{-6})	12.50
Thermoelastic coefficient	0 - 50°C
°C-1 (x 10^{-6})	- 400
Magnetic permeability µ max.	500 / 1000 Oersted
Temper Annealed.	1.002
Heat Treated.	1.005

Tests practised on prostheses made from PHYNOX® placed in a field of 2,5 Tesla of a spectro-imagor show an absence of displacement. The artifacts depend primarily on the positioning

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of the axis of the prosthesis compared to the direction of the principal magnetic field. (Communication aux trente-septièmes JOURNEES FRANÇAISES DE RADIOLOGIE- PARIS 7-10 Novembre 1988)

Corrosion resistance

The PHYNOX® is not attacked by the organic acids. It resists the salt spray perfectly and its behavior with the mineral acids is definitely higher than that of the best stainless steels In addition, its perfect passivity in contact with human tissues, explains why PHYNOX® has been used for more than twenty five years in surgical implants.

Examples of corrosion résistance :

– Losses of material in mm/y :

- A: <0.05 mm/y
- B: 0.05 to 0.25 mm/y
- C : 0.25 to 0.50 mm/y
- D: 0.50 to 1.25 mm/y
- E: >1.25 mm/y

Media	Concentration	°C	Indice
Acetic acid	50 %	100 °	A
Chlorhydric acid	Concentrated	110 °	E
Chlorhydric acid	50 %	110 °	E
Sulfuric acid	50 %	150 °	E
Calcium chloride	10 %	100 °	A
Ferric chloride	10 %	25 °	A
Citric acid	10 %	100 °	A
Lactic acid	10 %	100 °	A
Nitric acid.	50 %	100 °	B
Nitric acid	10 %	100 °	B
Phosphoric acid	50 %	120 °	C
Sodium chloride	10 %	100 °	A

Stress corrosion as per NACE STANDARD TM.01.07
aqueous Solution NaCl à 50 g/l + CH3 C00H à 5 g/l, saturated in H2S under 1 atmosphere (PH 3).
Temperature: 24 à 26,8°C
Tensile strength: :90% of yield strength
Test piece as per TM.01.07 with :
- UTS ≥ 1600 N/mm^2
- YS 0,2% ≥ 1130 N/mm^2

Minimum guaranteed time :720 hours without failure
Result : no failure after 720 hours.

Complementary test:
Increase in the temperature with 150°C
Increase in the pressure
Result: no rupture, nor cracking after 1370 hours.
Test stopped

Heat treatment and cleanning:

Heat treatment

520°C / 3 hours – Air cooled

The heat treatment is performed after cold forming or machining without any deformation of the treated part.

This treatment must be realized preferably in a vacuum furnace(10-5 Torr) or under protective atmosphere (Argon)

Processing in open air doesn't affect the mechanical properties of the material, but alters its aspect.

The influence of the treatment on annealed material is negligible but become very important on cold drawn products.

Cleaning of parts

3 methods for removing the lubricating film and pickling after heat treatment

1. Phosphoric Acid 6% at 70°C
   Immersion 15 to 20 minutes
   Rinsing hot or cold water & drying
2. Acid nitric 30% with 40°C
   Immersion 2 to 3 minutes
   Rinsing hot or cold water & drying
3. Acid hydrochloric 40% + Acid nitric 5% at room temp
   Nitric passivation (40%) at room temp
   Rinsing hot or cold water

Machinability

The high mechanical properties in the as drawn condition and the ability of cold hardening during machining, need to take particular precautions for machining:

– Robust and rigid machines
– moderate Cutting speeds
– Carbides tools, or brazed pastilles, with large rake angles

Cutting fluid with high performances of cooling and lubrication

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Welding

PHYNOX® can be readily welded: resistance spot welding, electron beam welding, laser, argon arc welding.

It can also be brazed. However, since age hardening can only obtained in cold worked area, this must be taken into account by placing the weld or braze joint in positions where it is not heavily loaded or by using a discontinuous joint

Pickling and polishing:

Apart from mechanical descaling, the oxyde film formed during heating in air can be removed by immersing the parts in a boiling aqueous solution containing 5% hydrofluoric acid and 12% nitric acid.

PHYNOX® can be electro chemically polished with products used for dental alloys cobalt basis

Products available :

- Available in wire (coil form) and in straightened ground bars (minimum diameter: 1 mm)
- Annealed condition: ø 0,60 mm up to 18 mm
- Hard condition : ø 0,012 mm up to 15 mm

Other formats: contact us

Applications :

- Aeronautic : springs, torsion bars, and parts for gyroscopes
- Marine : fittings, springs and cables
- Arms : ammunition springs, missiles
- Watch industry: mechanism springs, bracelet pins, pivots, crowns, push springs,
- Automotive: injection systems,
- Electrical and electronic industry: various non-magnetic parts,
- Medical: osteosynthesis prostheses and screws, pacemaker electrodes, vascular endoprostheses, aneurysm clips, vena cava filters, orthodontics...
- Force & pressure sensors