Technical Data Sheet

UGI® PHYNOX®

General presentation:
UGI® PHYNOX® 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 embrittlement,
- 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 basis alloy.

Designation and Standard:

<table>
<thead>
<tr>
<th>Material No</th>
<th>Europe</th>
<th>USA</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN</td>
<td>UNS</td>
<td>SUS</td>
<td></td>
</tr>
<tr>
<td>R30003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R30008</td>
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</table>

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

<table>
<thead>
<tr>
<th>Inclusions</th>
<th>Index of the thinnest inclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>A SULFIDES</td>
<td>1</td>
</tr>
<tr>
<td>B ALUMINATES</td>
<td>3</td>
</tr>
<tr>
<td>C SILICATES</td>
<td>1</td>
</tr>
<tr>
<td>D GLOBULAR OXIDES</td>
<td>3</td>
</tr>
</tbody>
</table>

Mechanical properties:

<table>
<thead>
<tr>
<th></th>
<th>20°C</th>
<th>100°C</th>
<th>200°C</th>
<th>300°C</th>
<th>400°C</th>
<th>500°C</th>
<th>600°C</th>
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</thead>
<tbody>
<tr>
<td>Young’s modulus, E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPA x 1000 (Annealed)</td>
<td>198</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPA x 1000 (As drawn)</td>
<td>182</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPA x 1000 (As drawn &amp; heat treated 520°C/3H)</td>
<td>208</td>
<td>207</td>
<td>205</td>
<td>203</td>
<td>201</td>
<td>197</td>
<td>186</td>
</tr>
<tr>
<td>G modulus (torsion)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPA x 1000 (Annealed)</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPA x 1000 (As drawn)</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPA x 1000 (As drawn &amp; heat treated 520°C/3H)</td>
<td>82</td>
<td>81</td>
<td>79.5</td>
<td>78</td>
<td>75</td>
<td>72</td>
<td>68</td>
</tr>
</tbody>
</table>

The UGI® 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

Ugitech SA
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Chemical analysis (%)

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Ni</th>
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<th>Co</th>
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<tbody>
<tr>
<td></td>
<td>&lt;0,15</td>
<td>&lt;1,20</td>
<td>1,50 - 2,50</td>
<td>15,00 - 18,00</td>
<td>19 - 21</td>
<td>39,00 - 41,00</td>
<td>6,50 - 7,50</td>
<td>&lt;0,001</td>
<td>&lt;0,015</td>
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Wire in coils

<table>
<thead>
<tr>
<th></th>
<th>MPa</th>
<th>Annealed MPa Min</th>
<th>Hard 1650</th>
<th>Hard 1850</th>
<th>Hard 2000</th>
<th>Hard 2150</th>
</tr>
</thead>
<tbody>
<tr>
<td>As shipped UTS</td>
<td>950</td>
<td>1550 - 1750</td>
<td>1750 - 1950</td>
<td>1900 - 2100</td>
<td>2050 - 2250</td>
<td></td>
</tr>
<tr>
<td>After heat treatment 3 h @ 520°C</td>
<td>950</td>
<td>1850-2050</td>
<td>2100 - 2300</td>
<td>2350 - 2550</td>
<td>2550 – 2750</td>
<td></td>
</tr>
</tbody>
</table>

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

Example: Spring: wire diameter 1,50 mm
As drawn: UTS > 1750 Mpa
After aging: UTS > 2030 Mpa

Resistance to fatigue

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

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Physical properties

Specific weight 8.30 g/cm³
Range of temperature -269°C to 500°C
Melting range 1450 – 1460 °C
Resistivity 20°C μΩcm
Specific heat 20°C J Kg⁻¹°C⁻¹
Mean coefficient of thermal expansion 0 - 100°C °C⁻¹ (x 10⁻⁶)
Thermoelastic coefficient 0 - 50°C °C⁻¹ (x 10⁻⁶)
Magnetic permeability μ max. 600 / 1000 Oersted
Magnetic annealed. 1.002
Heat treated. 1.005

Tests practised on prostheses made from UGI PHYNOX® placed in a field of 2.5 Tesla of a spectro-imager show an absence of displacement. The artifacts depend primarily on the positioning of the axis of the prosthesis compared to the direction of the principal magnetic field. (Communication aux trente-septièmes JOURNEES FRANCAISES DE RADIOLOGIE- PARIS 7-10 Novembre 1988)

Corrosion resistance:

The UGI® 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 UGI PHYNOX has been used for more than twenty five years in surgical implants.

Examples of corrosion resistance:

- 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
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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 COOH 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/mm²
YS 0.2% ≥ 1130 N/mm²

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 cleaning:

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:**
UGI® 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 oxide 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.
UGI® PHYNOX® can be electrochemically 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

<table>
<thead>
<tr>
<th>Product</th>
<th>Form</th>
<th>Finition</th>
<th>Tolerance</th>
<th>Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawn wire</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wire rod</td>
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<td></td>
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</table>

Other formats: contact us

**Applications:**