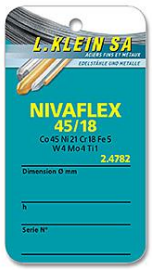


NIVAFLEX 45/18

High strength corrosion resistant Co-Ni-Cr-based alloy

Features and Peculiarities

The Co- based NIVAFLEX 45/18 alloy is melted in vacuum. This alloy is clean. It allows to reach by cold working and aging very high mechanical strengths and conserving its very good corrosion resistance, especially in salt containing mediums. This alloy is paramagnetic but is not implantable. Its high fatigue resistance indicates it for numerous aeronautic and space applications, and in the medical field as well. Furthermore its elastic properties designate it for high characteristics springs, micromechanical devices and watch movements and exteriors As wires it is of use as deep-sea, marine, and drilling lines in the gas and oil industries.

Use

The NIVAFLEX 45/18 alloy is the material of choice when high toughness, ductility, fatigue resistance, corrosion and wear resistances are required such as in the chemical industries, marine and seawater, micromechanical, watch making, aerospace etc.

Standards

Material number	2.4782
AFNOR	--
AMS	--
ISO	--
UNS	--

Chemical composition (%wt)

C	Si	Mn	P	S	Cr	Mo	Ni	Co	W	Fe
max.	max.	1.50	max.	max.	18.00	4.00	21.00	45.00	4.00	balance
0.15	1.20	2.50	0.015	0.015	-			-	--	

Executions Dimensions Delivery condition

- Round bars: 0.2-10 mm, cold drawn, straightened 3 m (2 m), ground h6
  Rm and A% see Figure 2
- Round wires: cold drawn, rings for Escomatic
  Rm < 1100 MPa, A% function of the amount of cold work
  Cold drawn surface « skin pass »

Tolerance

- Standard: ISO h8-h6

Availability

Standard dimensions on stock, see: Delivery program

Machining Machine-tools

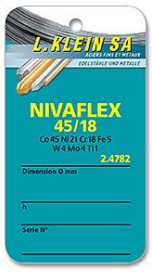
- The NIVAFLEX 45/18 alloy is tougher than the toughest stainless steels. Then its machining requires most rigid machine tools, tools holders and cutting tools.
- The use of high vibration damping tool-holders is highly recommended.

Mechanical strength

- The NIVAFLEX 45/18 alloy is relatively difficult to machine.
- The machining of the NIVAFLEX 45/18 alloy in the soft condition is not recommended. Because of its strong tendency to seize and its galling properties.
- The UTS/Rm “optimal window“ for classic machining is of ≈1200-1400 MPa, and broadened, of 1050-1600 MPa.

Machining

- Machinability: difficult
  Cutting speed: slow, Vc ≈ 20-40 m/min
  Feed: moderate to strong
  Lubricant-coolant: individual choice
- The optimal cutting conditions depend on the machine tool, the cutting tools, the chip dimensions, the lubricant-cooling fluid, as well as the tolerances and surface the roughness to be achieved.



NIVAFLEX 45/18

High strength corrosion resistant Co-Ni-Cr-based alloy

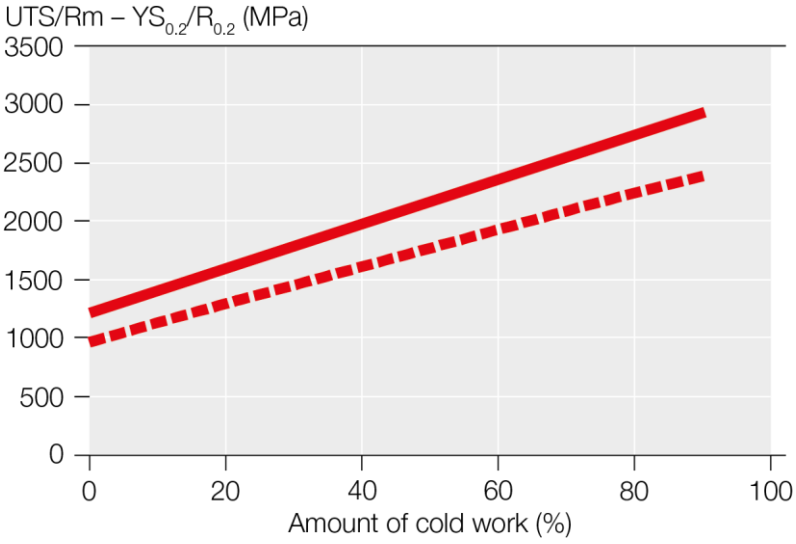
Melting

- Melting and remelting: in vacuum

Cleanliness

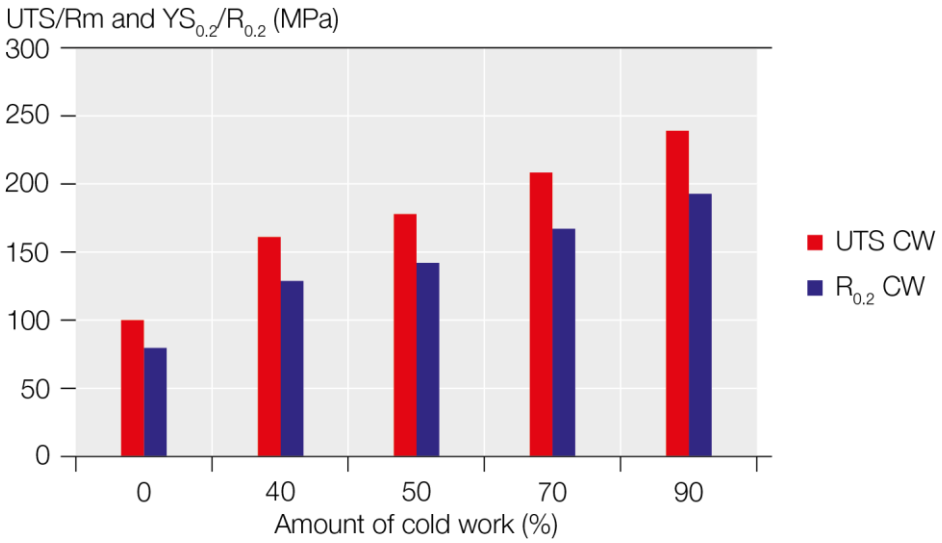
- Clean microstructure

Figure 1
Strengthening by cold working

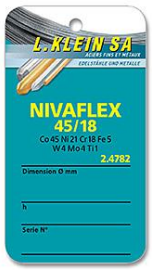


- The NIVAFLEX 45/18 alloy can be strengthened by cold working. The cold deformation results in anchoring the deformation dislocations and twins. Ti and C are both in solid solution in the annealed condition. Conjointly, they contribute to the hardening synergy responsible of the deformation hardening or strengthening.

Figure 2
Rm/UTS & $YS_{0.2}/R_{0.2}$ vs Cold strengthening Aging



- The yield strength $YS_{0.2}/R_{0.2}$ of the NIVAFLEX 45/18 alloy is in all metallurgical conditions ≥ 80% UTS/Rm.



NIVAFLEX 45/18

High strength corrosion resistant Co-Ni-Cr-based alloy

Aging

- Typical aging: 500°C/2h, preferably in vacuum.
- The activation of the aging reaction of the NIVAFLEX 45/18 alloy is independent of a previous cod deformation or strengthening.
- The aging reaction corresponds to a precipitation hardening, where the Ti content plays conjointly with the C content a pivotal role of the hardening of the NIVAFLEX 45/18 alloy.
- The ratio $R_{0.2}$/Rm is ≥80% in all conditions.

Heat treatments

- Annealing: 1050-1150°C/0.5h/ rapid cooling in air, gas or water
- Aging: 480-540°C / 2-5h, preferably in vacuum 10^{-5} T or argon. Treatment in air leads to the formation of a yellowish surface oxide.
- Stress relieving: max. 400°C. A stress relieving treatment of cold deformed products is recommended prior to the end shaping.
- Protective atmosphere containing Hydrogen should be avoided due to the potential risk of hydrogen embrittlement.

Microstructure

Delivery condition, annealed and annealed + cold worked:
Austenite: cfc cubic face centered
Microstructure for classical machining: Cold deformed austenite
Optimal microstructure optimal for polishing: >15% cold deformed austenite.

Polishing

- Well adapted to the Swiss watch making “Haut de gamme“ requirements.
- The mechanical polishing is easier in the cold deformed condition. More info

Laser marking

- The warm up of the HAZ (Heat Affected Zone) produced by a normal laser marking without overheating, should not affect the microstructure and the mechanical properties and the fatigue resistance. More info

Cleaning

- It is highly recommended to use only cleaning, pickling and passivation procedures and products which are adapted to Co-based alloys.

Pickling

- Intensive solution:
  5% hydrofluoric acid + 12% nitric acid / boiling
  + thorough rinsing with cold or warm water + drying
- Solution for pickling finished parts or fine parts:
  1. Phosphoric acid 6%/ 70°C / 15-20 minutes
  2. Nitric acid 30%/40°C / 2 to 3 minutes
  3. Hydrochloric acid 40% + nitric acid 5% / room temperature
  4. Passivation: nitric acid 40% / 25°C
  1-4. + thorough rinsing with cold or warm water + drying

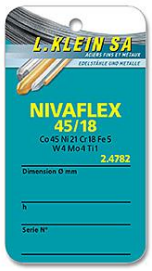
Corrosion resistance

- The NIVAFLEX 45/18 alloy has a good corrosion resistance.

Medium	Resistance	Medium	Resistance
Synthetic seawater	+++	Hydrochloric acid 10%	+
Na chloride 10% solution	+++	Hydrochloric acid 10%	++
Formic acid 10%	+++	Sulfuric acid 10%	++
Ammonium 25%	++	Phosphoric acid 10%	++
Acetic acid 10%	+++		

Corrosion: +++ <10^2µm/y, ++ <10^3 µm/an, + <3.10^3 µm/y

L. Klein AG • Längfeldweg 110 • CH-2504 Biel/Bienne
Telefon 0041 (0)32 341 73 73 • Telefax 0041 (0)32 341 97 20 • www.kleinmetals.swiss • info@kleinmetals.swiss



NIVAFLEX 45/18

High strength corrosion resistant Co-Ni-Cr-based alloy

Passivation

- The NIVAFLEX 45/18 alloy can be passivized.
  Passivation treatment: nitric acid 40% / room temperature

Austenite expansion

- The surface hardness of the NIVAFLEX 45/18 alloy can be further improved by an applying a kolsterizing treatment, or an austenite expansion with C at ≈400°C.
- This additional surface hardening is additive to the cumulated hardenings of cold word and aging. Final surface hardnesses of 800-1000 Hv, or up to 70 HRc can be reached
- The surfaces after an austenite expansion with C are milky-gray. This phenomenon is due to the enrichment of the conduction band with free electrons.

Tribological properties

- The fretting / galling resistance improves with the cold deformation grade.
- The kolsterizing treatment, or the austenite expansion with C enrichment of the surface, forms an anti-galling like surface.

Biocompatibility

- The NIVAFLEX 45/18 alloy is not a registered biocompatible alloy.

Magnetism

- The NIVAFLEX 45/18 alloy is paramagnetic.

Magnetic permeability

- The highest relative magnetic permeability NIVAFLEX 45/18 alloy is µr <1.005. It permits the displacement free use of components in this alloy in the highest achievable magnetic fields of 6-8 T of the latest generation of the magnetic resonance imaging spools.

Temperature range of use

- Continuous exposure: de -269°C (liquid helium) to max 400°C.
  Short exposure: up to max 500°C.

Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	8.5				
Young modulus E	GPa	220				
Shear modulus G	GPa	90				
Poisson coefficient	-	0.34				
Thermal conductivity	$W.m^{-1}.K^{-1}$	12.5				
Electrical resistance	µΩ.cm	1.0				
Coefficient of thermal expansion	$m/m^{-1}.K^{-1}$ 10^{-6}	20–100°C 12.5	20–200°C	20–300°C	20–500°C	20–815°C
Specific heat	$J.kg^{-1}.K^{-1}$	450				
Magnetic permeability						
5.10^{2}-10^{3} Oe, annealed	µr	<1.002				
5.10^{2}-10^{3} Oe, cold worked	µr	<1.005				

L. Klein AG • Längfeldweg 110 • CH-2504 Biel/Bienne
Telefon 0041 (0)32 341 73 73 • Telefax 0041 (0)32 341 97 20 • www.kleinmetals.swiss • info@kleinmetals.swiss