



**AGE-HARDENABLE SPRING MATERIAL
WITH MAXIMUM STRENGTH
NIVAFLEX® Plus**

ALLOY COMPOSITION (wt. %):

Co	Ni	Cr	Fe	W	Mo	Ti	Be
45	21	18	5	4	4	0,8	0,2

NIVAFLEX® Plus is a nickel-cobalt-chromium multi-phase alloy with extremely high strength, good ductility, high modulus of elasticity and outstanding corrosion resistance. The **NIVAFLEX® Plus** spring material is characterized by a high degree of formation of dislocations and twinning, which, together with the selected chemical composition, leads to a high work-hardening. Alloying with Beryllium furthermore permits extreme strength and hardness values, which has an advantageous effect particularly in miniaturization requirements. After cold forming the mechanical properties can be further improved by a subsequent age-hardening.

Compared to the other nickel-cobalt-chromium multi-phase alloy NIVAFLEX 45/5, **NIVAFLEX® Plus** is characterized by the optimized use of titanium, manganese and silicon, as well as the use of pure raw materials.

In addition to excellent mechanical properties and corrosion resistance, **NIVAFLEX® Plus** offers excellent resistance to oxidation as well as non-magnetic behavior.

NIVAFLEX® Plus is produced by vacuum-induction-melting (VIM) followed by vacuum-arc-remelting (VAR) and therefore shows a very homogeneous microstructure.

APPLICATIONS:

Highly loadable, fracture-proof spring elements such as main springs (for watches), springs for measurement and display instruments, torsion and helical springs, membranes and other springs with extremely high repetition accuracy.

Depending on the application specified, the optimum degree of cold work is selected to ensure fatigue-proof springs with very high bending fatigue strength.

Precision parts featuring extreme strength combined with high corrosion and wear resistance, such as precision axles and shafts, pivot points (bearing pins) for electric motors and water meters as well as main springs for mechanical watches.

MAIN PROPERTIES

(typical values):

Extreme strength up to 3000 MPa
Extreme hardness over 800 HV
Very high bending fatigue strength
Excellent corrosion resistance
Non-magnetic

FORMS OF SUPPLY AND STATES:

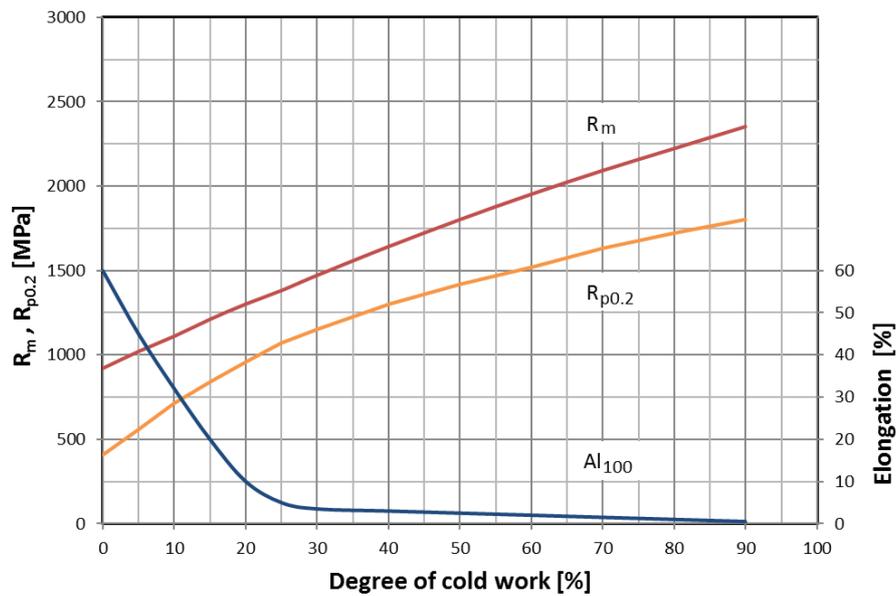
Wire Ø 0.2 – 3 mm, cold-work as specified by customer.
Other diameters and strip on request



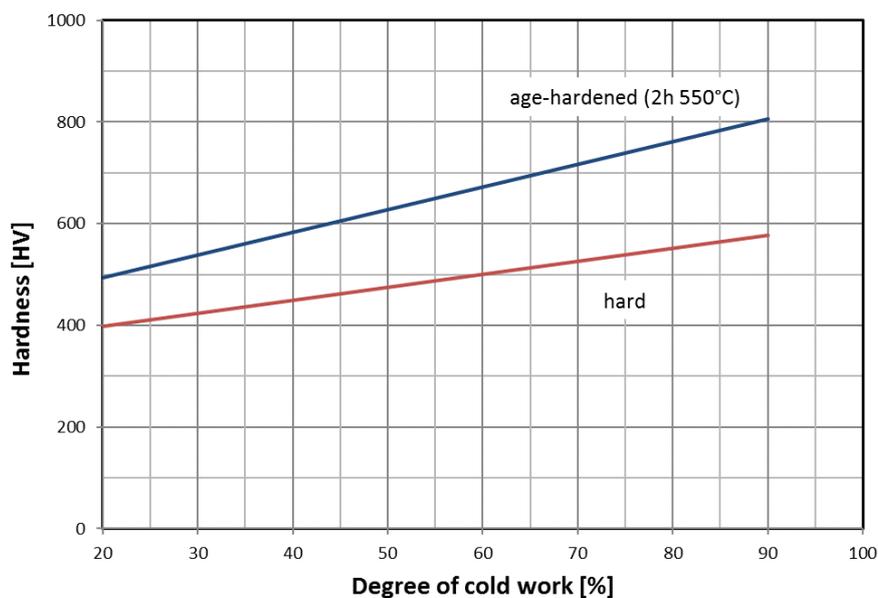
MECHANICAL PROPERTIES (typical values)

Property	Unit	State of delivery (examples)
Degree of cold work	CW (%)	50 70 90
Yield strength	$R_{p0.2}$ ($\mu\Omega \cdot m$)	1400 1650 1800
Tensile strength	R_m (GPa)	1800 2100 2350
Hardness	HV (HV)	475 / 630 * 525 / 720 * 580 / 810 *

* after age-hardening 2h 550°C



Mechanical properties of **NIVAFLEX® Plus** in dependence of the degree of cold work for the state hard.



Hardness of **NIVAFLEX® Plus** in dependence of the percentage of cold work for the state hard and age-hardened (2h 550°C) respectively.



PHYSICAL PROPERTIES (typical values)

Property		Unit	
Density	ρ	(g/cm ³)	8,5
Electrical resistance	ρ_{el}	($\mu\Omega m$)	1,0
Young's modulus ¹⁾	E	(GPa)	210
Shear modulus ²⁾	G	(GPa)	70
Ferromagnetism			No

¹⁾ Measured by tensile test after 2h 550°C

²⁾ G = 1/3xE

AGE-HARDENING

Recommended temperature range for age-hardening: 400-600 °C

CORROSION RESISTANCE (typical values)

Medium	Room Temperature corrosion resistance *	Medium	Room Temperature corrosion resistance *
sea water (synthetic)	+++	hydrochloric acid 10%	+
NaCl solution 10%	+++	nitric acid 10%	++
formic acid 10%	++	sulphuric acid 10%	++
ammonia 25%	+++	phosphoric acid 10%	++
acetic acid 10%	+++		

*) classification

+++	resistant	corrosion rate < 100 $\mu m/Year$
++	adequately resistant	corrosion rate < 1000 $\mu m/Year$
+	fairly resistant	corrosion rate < 3000 $\mu m/Year$
0	slightly resistant	corrosion rate < 10000 $\mu m/Year$
-	non-resistant	corrosion rate > 10000 $\mu m/Year$

The corrosion rates are nominal values, derived from previous NIVAFLEX 45/5 data. In practice the material must be tested in the relevant medium under fully operational conditions before use.

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