NICRIMPHY 600

HEAT RESISTING ALLOY

I. INTRODUCTION

NICRIMPHY 600 (AFNOR designation : NC15 Fe) is a nickel base alloy designed to offer good corrosion and oxidation resistance. It also has good mechanical properties over a wide range of temperatures.

The nominal composition, in weight %, is given in the following table :

Fe	Cr	Ni	Ti	Al
9.5	16	bal	0.2	0.15

The high nickel content of Nicrimphy 600 confers good corrosion resistance in various organic and inorganic media (organic acids and compounds, hot concentrated caustic soda solutions, chloride-containing media). The alloy is also insensitive to stress corrosion cracking.

The presence of chromium ensures good resistance to high temperature corrosion in oxidising atmospheres, including those containing sulphur.

The alloy is not precipitation hardened. It can be strengthened by cold work.

Because of its properties, Nicrimphy 600 is used for a wide range of applications, from cryogenic temperatures up to about 1100°C. The main fields of use include the following :

- the automotive industry (airbag components, heat screens, couplings, exhaust systems, etc.) due to its high temperature qualities
- the chemicals industry for its corrosion resistance
- the heat treatment industry (muffles, furnace components, electrical heating elements, radiant tubes, baskets, thermocouple sheaths) for its oxidation resistance
- the aircraft industry (engine components, exhaust systems, etc.) for its overall high temperature behaviour
- for colour TV cathode ray tubes (getter holders, etc.)
- the food and pharmaceuticals industries

ArcelorMittal | Stainless & Nickel Alloys
Innovatis
5 rue Luigi Cherubini
93212 SAINT DENIS Cedex
FRANCE

t +33 (0)1 71 92 00 00
e info@imphy.com

www.imphy.com

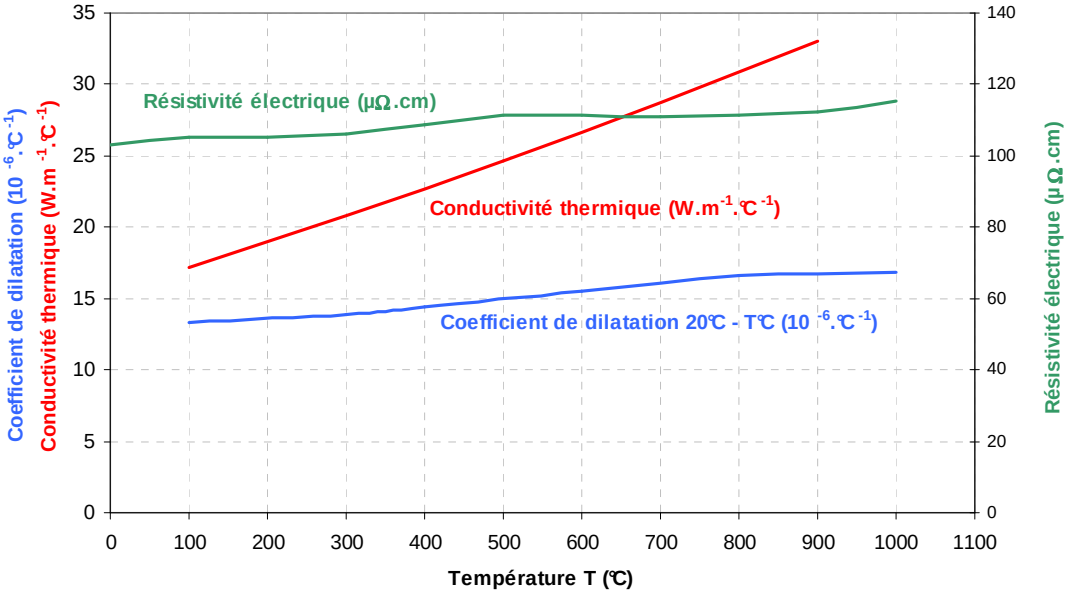
II. PHYSICAL PROPERTIES

II.1 General physical properties

Property	Units	Values
Melting range	℃	1370 – 1425
Density	$g.cm^{-3}$	8.4
Electrical resistivity at 20 ℃	µΩ.cm	103
Resistivity variation between 0 and 300 ℃ : annealed condition	$℃^{-1}$	
Resistivity variation between 0 and 300 ℃ : cold worked condition	$℃^{-1}$	
Thermal conductivity	$W.m^{-1}.C^{-1}$	14.7
Coefficient of thermal expansion between 0 and 100 ℃	$℃^{-1}$	13.3
Specific heat at 20℃	$J.kg^{-1}.℃^{-1}$	460
Magnetic properties	-	Non magnetic

II.2 Physical properties as a function of temperature

Temperature T	**Expansion coefficient (20℃ – T℃)**	**Electrical resistivity**	**Thermal conductivity**
℃	**$10^{-6}.℃^{-1}$**	**µΩ.cm**	**$W·m^{-1}·℃^{-1}$**
20	-	103	-
100	13.3	-	17.2
200	-	105	-
300	13.9	106	-
400	14.4	109	-
500	-	-	24.6
600	15.5	111	-
800	16.6	-	-
900	-	112	33.0
1000	16.8	115	-



III. MECHANICAL PROPERTIES

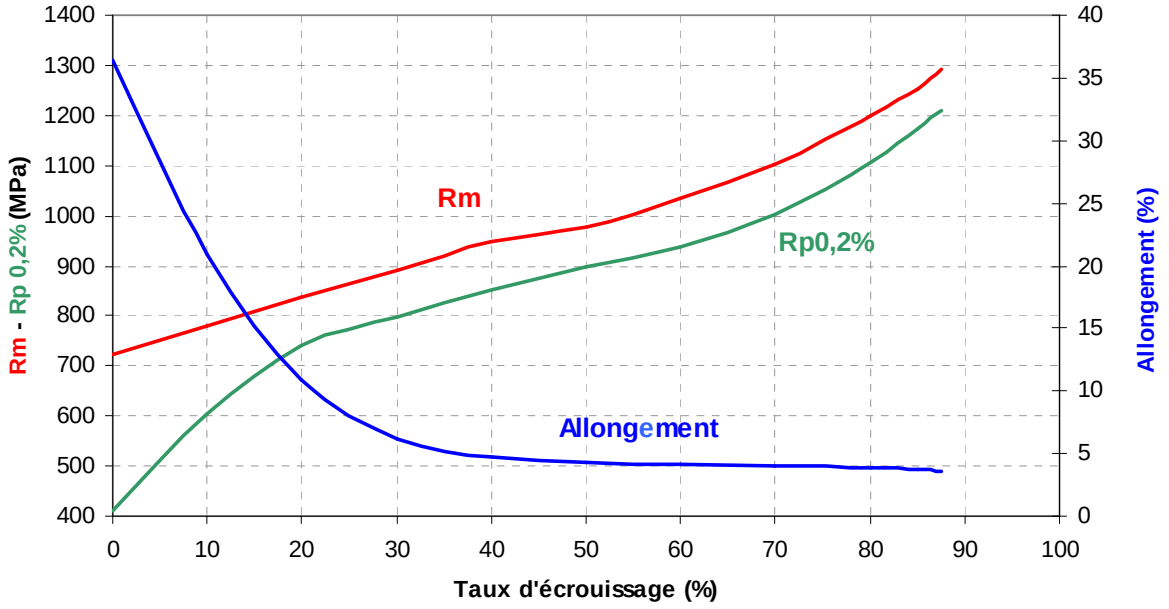
III.1 Annealed condition

In general, Nicrimphy 600 is annealed by heat treatment at a temperature above 700℃. The typical mechanical properties in this condition are given in the following table.

Property	Units	Values
Hardness	HV	160
0.2% proof stress (0.2% PS)	MPa	300
Ultimate tensile stress (UTS)	MPa	650
Elongation (El)	%	40
Youngs modulus (E)	MPa	210 000

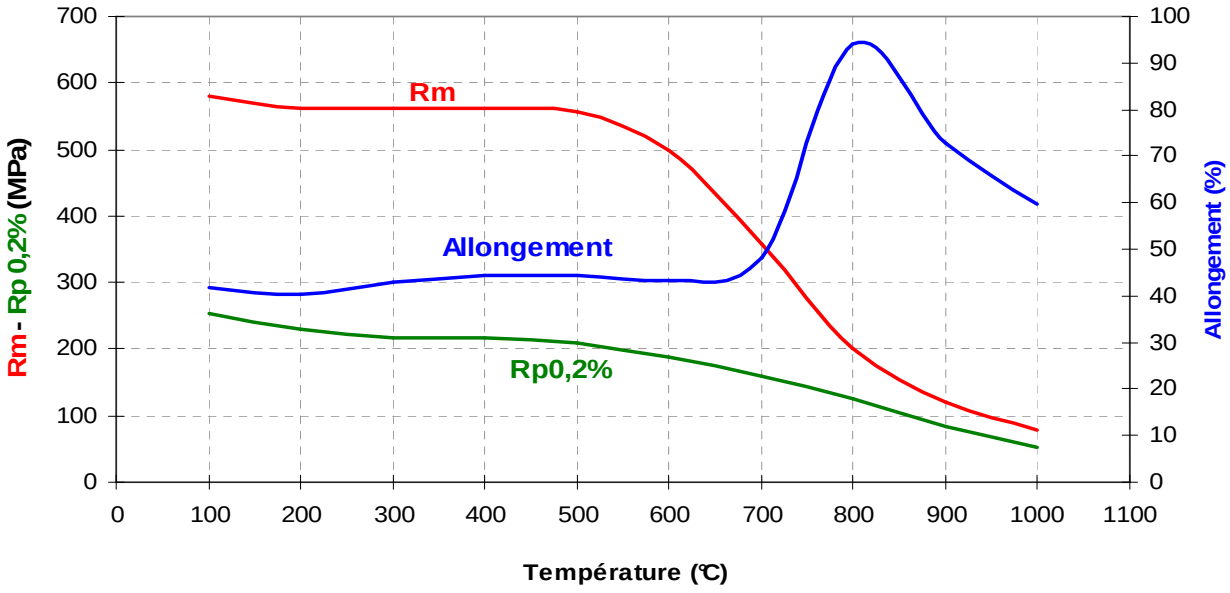
III.2 Influence of cold work

Nicrimphy 600 remains fully austenitic at all temperatures and cannot be hardened by heat treatment. The only means of strengthening is by cold work at relatively low temperatures.



% cold work

III.3 Influence of temperature



IV. OXIDATION AND CORROSION RESISTANCE

IV.1 High temperature behaviour

Nicrimphy 600 has very good corrosion resistance in hot gases :

- in pure air up to 1175°C
- in sulphur-free reducing atmospheres up to 1150°C
- in sulphur-containing oxidising atmospheres up to 800°C
- in sulphur-containing reducing atmospheres up to 550°C
- in ammonia gas and nitrogen-hydrogen mixtures up to 980°C
- in dry hydrochloric acid gas up to 540°C
- in hydrofluoric acid gas up to 650°C

IV.2 Wet corrosion resistance

The composition of Nicrimphy 600 confers good resistance to corrosion in a wide variety of media,

leading to extensive industrial applications.

In acids, the corrosion resistance of Nicrimphy 600 is comparable to that of stainless steels.
In organic acids and compounds, the excellent corrosion resistance of Nicrimphy 600 leads to numerous applications in the food industry (fruit juices, alcoholic solutions).
Nicrimphy 600 is used in the pharmaceuticals industry where purity is an essential factor. It has particularly good resistance to hot fatty acids.
Nicrimphy 600 is insensitive to stress corrosion cracking in chloride-containing solutions. However, it can be liable to stress corrosion cracking in pure water or caustic solutions after very long incubation times. It has good resistance to sulphurous alkaline solutions (papermaking) and to ammoniacal solutions.
Nicrimphy 600 is insensitive to the majority of neutral and alkaline salt solutions.

V. TECHNOLOGICAL PROPERTIES

V.1 Machining

The machinability of Nicrimphy 600 is comparable to that of the stainless steels. However, it is recommended to increase the cutting angles and to use lubricants with a high cooling capacity in order to compensate the greater heat generation.

V.2 Welding

In the annealed condition, the weldability of Nicrimphy 600 is excellent and the alloy can be readily welded using all the conventional processes. No pre- or post-weld treatment is necessary. However, for applications involving a risk of stress corrosion cracking, a stress-relieving treatment is recommended after welding.

V.3 Pickling

The following two processes can be used :

Nitric-hydrofluoric acid bath

Nitric acid (HNO_3) at 36°Bé : 10 to 20%
Hydrofluoric acid (HF) at 65% : 1.5 to 5%
Water : remainder

Residence time :

1 hour at ambient temperature
20 minutes at 50°C

In order to avoid all risk of intergranular attack, the temperature must not exceed 50°C.

Nitric-hydrochloric acid bath

Hydrochloric acid (HCl) at 22° Bé : 3 to 4%
Nitric acid (HNO_3) at 36°Bé : 40%
Water : remainder

Residence time :

30 minutes between 40°C and 60°C

VI. DELIVERY FORMS

Grade	Cold rolled strip	Long and massive products (1)
Nicrimphy 600	∎	∎

(1) : bars, profiles, forgings, hot rolled sheet

VI.1 Flat products

Standard delivery forms	Thickness (mm)	Maximum width (mm)	Condition
Cold rolled strip delivered in coils	0.05 to 1.5	640 mm for thicknesses > 0.07mm	Cold worked or annealed
Hot rolled sheet	5 to 50	500 to 2 000	As rolled Pickled

Imphy Alloys is at the customer’s disposal for specific requirements.

VI.2 Bars

Diameter (mm)	Standard production lengths (mm)
$\phi \leq 13$	2000 to 3000
$14 \leq \phi \leq 80$	3000 to 4000
$\phi > 80$	Depending on the diameter and the quantity ordered

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VI.3 Castings and forgings

Study on request.