SUPERIMPHY 286

IRON-BASE SUPERALLOY

I. INTRODUCTION

SUPERIMPHY 286 is an austenitic iron-base alloy containing nickel, chromium, molybdenum and titanium. The presence of titanium enables the alloy to be strengthened by homogeneous precipitation of the intermetallic gamma prime (□') phase. The resulting hardening gives good tensile and creep strength up to around 700 - 750℃. Furthermore, the concentrations of chromium and nickel give Superimphy 286 excellent oxidation resistance. The combination of these two properties makes the alloy suitable for applications similar to those of the nickel-base superalloys. Finally, the chromium and molybdenum contents confer a resistance to aqueous corrosion comparable to those of the austenitic stainless steels.

The nominal composition of SY 286, in weight %, is given in the following table :

Fe	Cr	Ni	Ti	Mo
bal	15	25	2.2	1.25

The typical fields of application are :

- aeronautical engineering (compressor valves, exhaust components, fasteners, etc.)
- automotive engineering (turbine components, exhaust manifolds, etc.)
- power engineering (turbine components, etc.)
- the oil and gas industries.

The alloy is also used for various applications requiring a combination of corrosion resistance, high strength and the absence of ferromagnetism.

II. PHYSICAL PROPERTIES

II.1 General physical properties

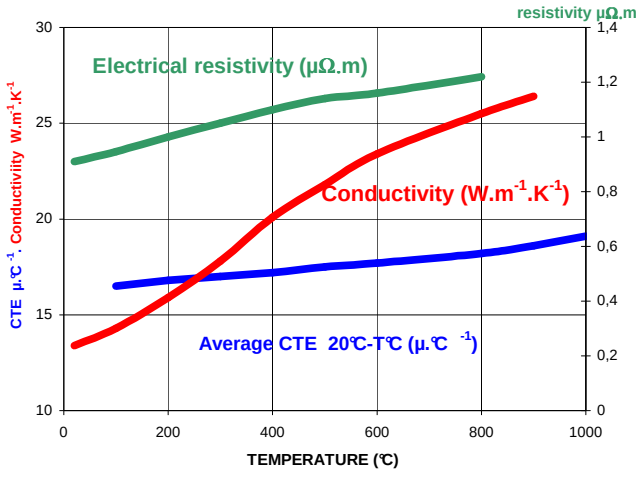
Property	Units	Values
Melting range	℃	1370 – 1425
Density	$g.cm^{-3}$	7.92 (solution annealed) 7.94 (aged)
Electrical resistivity at 20 ℃	μΩ.cm	91
Thermal conductivity at 20℃	$W.m^{-1}.C^{-1}$	14.2
Expansion coefficient between 0 and 100 ℃	$℃^{-1}$	16.5
Specific heat at 20℃	$J.kg^{-1}.℃^{-1}$	461
Magnetic properties	-	Non magnetic

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.2 Physical properties as a function of temperature

Temperature T	Expansion coefficient (20℃ – T℃)	Electrical resistivity	Thermal conductivity	Specific heat
℃	10^{-6}/℃	µ.Ω.cm	$W \cdot m^{-1} \cdot K^{-1}$	$J \cdot Kg^{-1} \cdot K^{-1}$
20	-	91	13.4	461
100	16.5	-	14.2	-
200	16.8	100	15.9	-
300	17.0	-	17.8	502
400	17.2	110	20.1	-
500	17.5	114	21.8	-
600	17.7	116	23.4	-
800	18.2	122	-	-
900	18.9	-	26.4	-
1000	19.1	-	-	628

Physical properties as a function of temperature



III. MECHANICAL PROPERTIES

III.1 Annealed condition

The annealed condition in Superimphy 286 is obtained by heat treatment at a temperature of about 980℃ followed by rapid cooling. The typical mechan ical properties at room temperature are given in the table below.

Property	Units	Values
Hardness	HV	155
0.2% proof stress (0.2% PS)	MPa	280
Ultimate tensile strength (UTS)	MPa	640
Elongation on 50 mm (El)	%	35
Young's modulus (E)	MPa	200 000

A cold rolling reduction of 20% increases the room temperature strength and lowers the elongation.

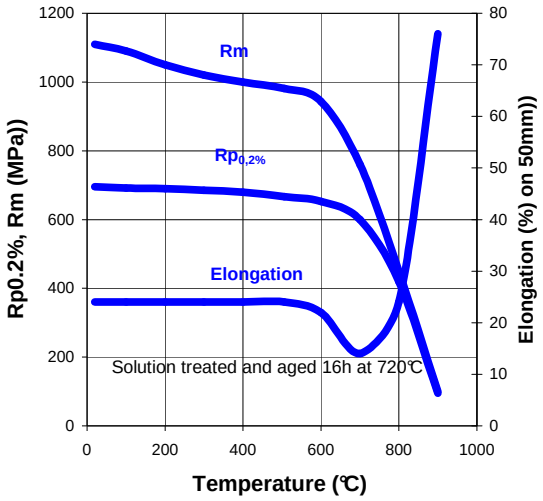
Property	Units	Values
Hardness	HV	250
0.2% proof stress (0.2% PS)	MPa	750
Ultimate tensile strength (UTS)	MPa	800
Elongation on 50 mm (El)	%	10

III.2 Influence of age hardnening

A fine homogeneous precipitation of γ' phase is obtained by heat treatment for several hours in the range 680-750℃, producing significant hardening. T he room temperature hardness and tensile properties obtained after a treatment of this type are summarised in the table below.

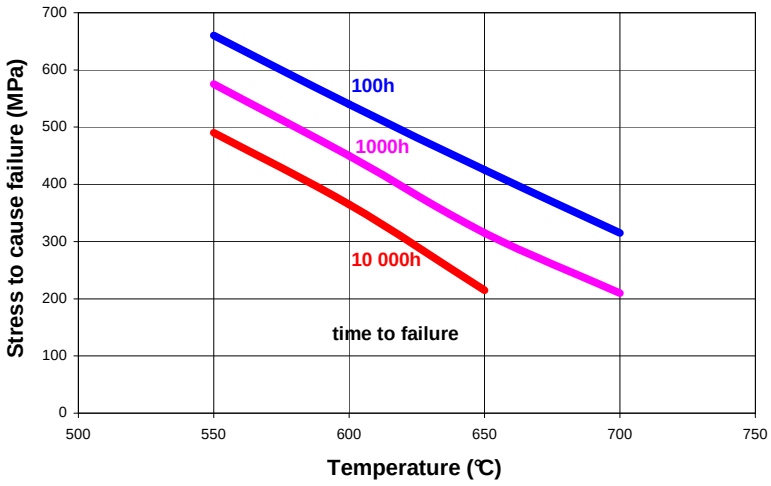
Aging treatment	0.2% PS	UTS	Elongation	Hardness
	MPa	MPa	% on 50 mm	HV
720℃ for 16 hours	740	1070	20	320
Cold rolled 20% then 680℃ 16 hours	1130	1250	10	380

The figure below shows the variation of the tensile properties with temperature for Superimphy 286 aged at 720℃ for 16 hours.

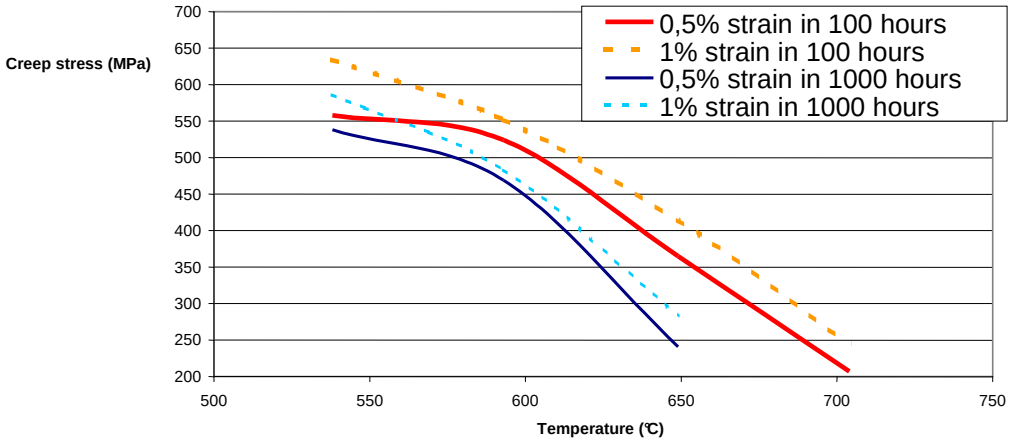


IV. CREEP PROPERTIES

The most remarkable property of Superimphy 286 in the aged condition is its creep strength at temperatures up to around 700℃. The figure below s hows the creep strength for failure in different times as a function of temperature.

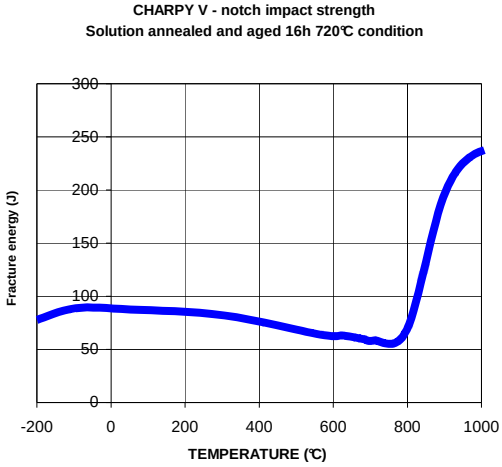


The figure below shows the stress to produce given creep strains in a constant time as a function of temperature.



V. IMPACT STRENGTH

The figure below shows the variation of the Charpy V-notch impact strength as a function of temperature after aging at 720℃ for 16 hours. Coar sening of the hardening precipitates above about 750-800℃ causes a sharp increase in toughness. Fur thermore, this austenitic alloy shows no ductile-brittle transition at low temperatures.



VI. CORROSION AND OXIDATION RESISTANCE

VI.1 High temperature corrosion

Superimphy 286 has a good oxidation resistance, enabling it to be used at peak temperatures up to 900℃ or even 1000℃. However, beyond about 700℃ t o 750℃, the creep properties related to precipitation hardening are gradually degraded if the holding times are long, due to coarsening and solutioning of the γ' phase.

VI.2 Wet corrosion resistance

The chromium and molybdenum contents of Superimphy 286 give it a wet corrosion resistance comparable to or even better than many standard austenitic stainless steels. The table below gives the mean corrosion rate in mm/year for Superimphy 286 in various acids.
In a salt spray (NaCl concentration of 5%), no trace of corrosion is observed after exposure for 100 hours.

	20% CH_3COOH	1% HCl	10% H_2SO_4	20% H_3PO_4
Mean corrosion rate (mm/year)	<0.1	84	29	13

VII. TECHNOLOGICAL PROPERTIES

VII.1 Heat treatment

The optimum heat treatments are summarised in the table below.

Solution treatment	Aging
900℃*/1h/oil***	720℃/16h/air
980℃**/1h/oil***	

* Leads to a fine grain size and good tensile properties.
** Leads to a coarser grain size and improved creep properties.
*** Heavy section components must be oil quenched. Air cooling is possible for strip.

VII.2 Machining

The machinability of Superimphy 286 is comparable to that of austenitic stainless steels. It is easier to machine in the aged or cold worked conditions than after solution treatment.

VII.3 Welding

This grade is liable to hot cracking if it is welded in the aged condition. It is therefore preferable to weld Superimphy 286 in the solution treated condition. Furthermore, the extent of the fusion and heat affected zones must be limited as much as possible. The TIG and MIG processes can be employed. If filler metal is used, it is preferable to choose a nickel base material.

VIII. DELIVERY FORMS

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

Imphy Alloys is at its customers' disposal for any specific requirements.