

# SUPERIMPHY 625

## HEAT- AND CORROSION-RESISTANT ALLOY

### I. INTRODUCTION

SUPERIMPHY 625 is a nickel-based austenitic alloy containing chromium and molybdenum. The content of the latter elements provides SUPERIMPHY 625 with excellent corrosion-resistance in aqueous, acid and chloride environments as well as resistance to crevice corrosion. It is not susceptible to stress corrosion cracking. It also offers excellent resistance to high-temperature oxidation. Furthermore, depending on its metallurgical condition, SUPERIMPHY 625 has good creep- and fatigue-resistance. SUPERIMPHY 625 has outstanding mechanical and hardness properties from cryogenic temperatures through to 1100°C.

Treatment	Temperature (°C)	Best properties
Anneal	930-1050	Mechanical properties
Solution anneal (air-water)	1090-1200	Creep

Therefore, due to its good corrosion-resistance and its mechanical properties, its typical fields of application are in the manufacture of components for service in seawater and all chloride solutions, as well as in phosphoric, nitric and sulphuric acid solutions... and also in the manufacture of components subjected to high temperatures. This alloy is therefore employed in numerous applications: shipbuilding, offshore, scrubbers, cryogenics, nuclear, aeronautics and chemical industries, transportation of corrosive products, pumps, compressors, fasteners.

The table below gives this alloy's nominal chemical composition by % weight:

Ni	Cr	Mo	Fe	Ti	Al	Nb
remainder	21.0	9.0	≤ 5.0	0.3	0.2	3.5

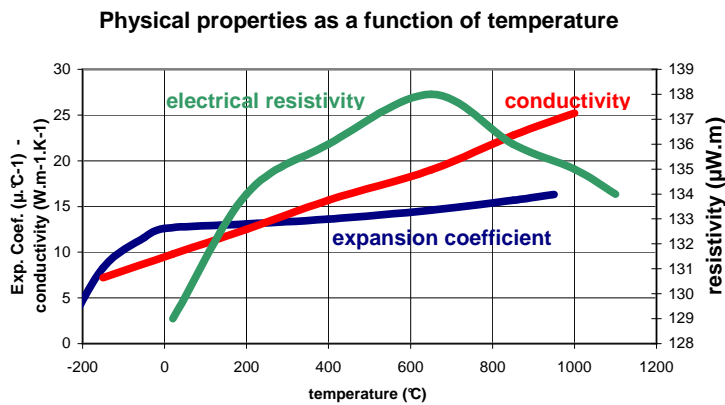
## II. PHYSICAL PROPERTIES

### II.1 General physical properties

Properties	Units	Values
Melting point	°C	1290 – 1350
Density	g.cm <sup>-3</sup>	8.44
Electrical resistivity at 20 °C	μΩ.cm	129
Thermal conductivity at 20°C	W.m <sup>-1</sup> .°C <sup>-1</sup>	9.8
Expansion coefficient between 0 and 100 °C	10 <sup>-6</sup> . °C <sup>-1</sup>	12.8
Specific heat at 20°C	J.kg <sup>-1</sup> .°C <sup>-1</sup>	410
Magnetic properties	-	non-magnetic

### II.2 Physical properties as a function of temperature

Temperature	Expansion coefficient (related to 20°C)	Electrical resistivity	Thermal conductivity	Heat capacity
°C	10 <sup>-6</sup> /°C	μ.Ω.cm	W.m <sup>-1</sup> .K <sup>-1</sup>	J.Kg <sup>-1</sup> .K <sup>-1</sup>
-250	0.6	-	-	-
-150	8.3	-	7.2	-
-50	11.6	-	-	-
0	12.6	-	-	-
20	-	129	9.8	410
200	13.1	134	12.5	455
400	13.6	136	15.7	510
650	14.6	138	19	565
850	15.7	136	22.8	618
950	16.3	-	-	-
1000	-	135	25.2	630
1100	-	134	-	670



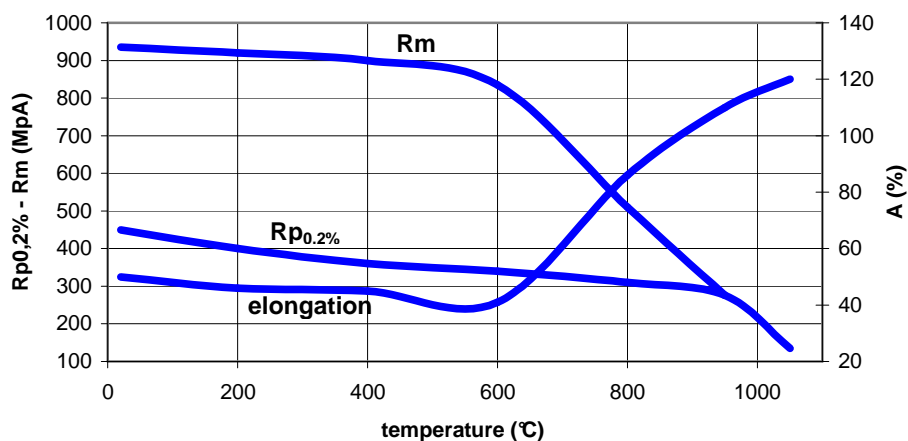
### III. TENSILE PROPERTIES

#### III.1 Annealed condition

In the case of SUPERIMPHY 625, the annealed condition is attained by means of heat treatment at a temperature between 930 and 1050°C. Typical mechanical properties at ambient temperature are given in the following table:

Properties	Units	Values
<b>Hardness</b>	HV	146-247
<b>Proof stress <math>R_{p0.2\%}</math></b>	MPa	$\geq 414$
<b>UTS <math>R_m</math></b>	MPa	$\geq 830$
<b>Elongation A (% on 50 mm)</b>	%	$\geq 30$
<b>Young's Modulus E</b>	MPa	202600

The following figure illustrates the variation in the tensile properties of SUPERIMPHY 625 in the annealed condition as a function of temperature.

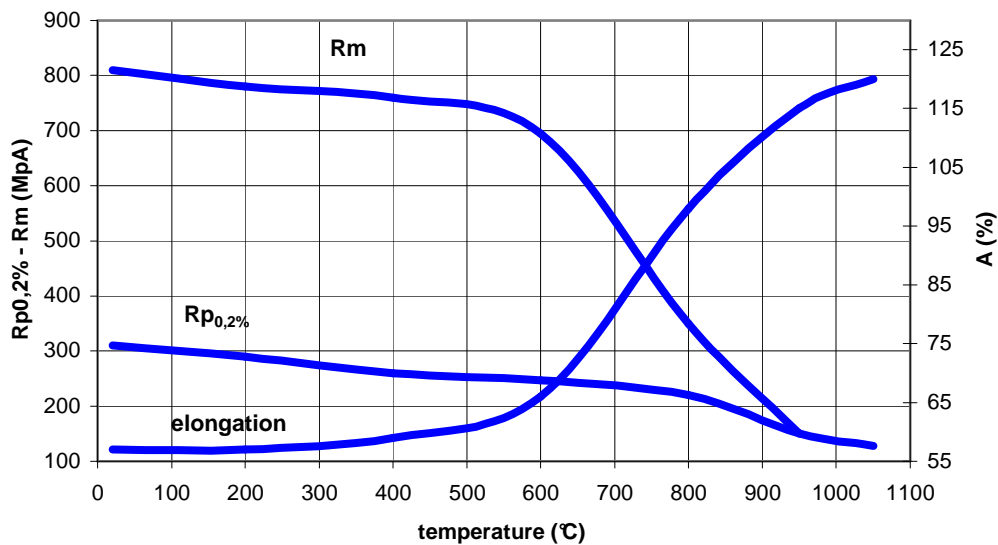


### III.2 Solution annealed condition

In the case of SUPERIMPHY 625, the solution annealed condition is attained by means of heat treatment at a temperature between 1090 and 1200°C. Typical mechanical properties at ambient temperature are given in the following table:

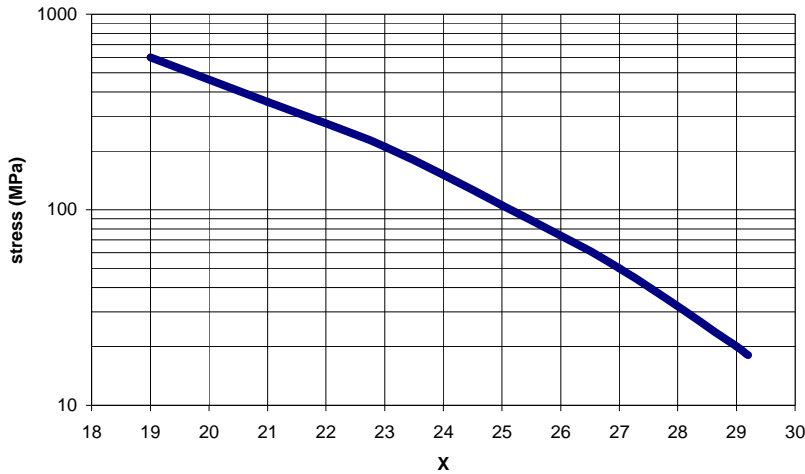
Properties	Units	Values
<b>Hardness</b>	HV	117-198
<b>Proof stress <math>R_{p0.2\%}</math></b>	MPa	$\geq 280$
<b>UTS <math>R_m</math></b>	MPa	$\geq 690$
<b>Elongation A (% on 50 mm)</b>	%	$\geq 40$
<b>Young's Modulus E</b>	MPa	202600

The following figure illustrates the variation in the tensile properties of SUPERIMPHY 625 in the solution annealed condition as a function of temperature.



## IV CREEP PROPERTIES

The following graph enables determination of the mean stress resulting in fracture as a function of the Larson-Miller parameter. The parameter combines temperature and time in accordance with the formula  $X = [20 + \log(t)] \times T/1000$ .



## V CORROSION RESISTANCE

SUPERIMPHY 625 is resistant to numerous forms of corrosion in a wide range of environments. As it is not possible to mention all environments, please consult us regarding specific cases.

### V.1 Intergranular corrosion

This alloy features a particularly high resistance to this type of corrosion. In particular, it performs very well in the HUEY test (nitric acid – ASTM A262 Practice C) and the ferric sulphate test (ASTM A262 Practice B or ASTM G28). For this reason it is not necessary to perform post-weld heat treatment.

### V.2 Atmospheric corrosion

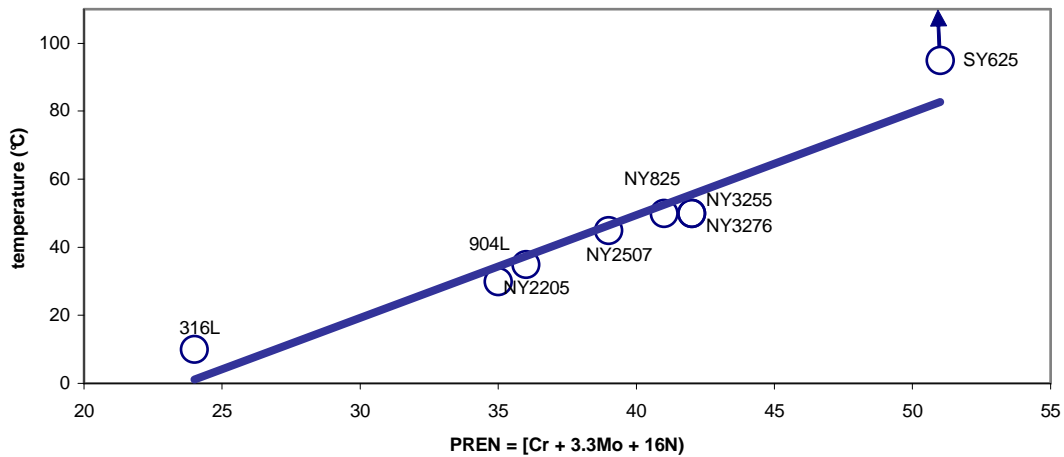
SUPERIMPHY 625 is not susceptible to marine, industrial, urban and rural atmospheres.

### V.3 Corrosion in aqueous and chloride environments

SUPERIMPHY 625 exhibits exceptional corrosion-resistance in seawater and brine. In a 5% sodium chloride solution, the pitting potential of SUPERIMPHY 625 is relatively unaffected by an 80°C increase in temperature whereas it is significantly reduced in the case of duplex stainless steels such as Z2 CND 2205 or Z2 CND 2506.

In a 10% ferric chloride solution, the critical pitting temperature is in excess of 90°C whereas in the case of the best duplex steels, the temperature does not exceed 60°C.

In corrosion-fatigue in seawater, the fatigue limit exceeds 40% of the ultimate tensile strength. These properties make SUPERIMPHY 625 an alloy of choice for use in seawater.



*Critical pitting temperature of SY625 in a 6% solution of  $FeCl_3$ ,  $6H_2O$  (ASTM – test G48A)*

#### V.4 Acid corrosion

##### ✓ hydrochloric acid

At 25°C, SUPERIMPHY 625 exhibits excellent resistance to hydrochloric acid in concentrations up to 5%, beyond which resistance remains acceptable at all concentrations. At 65°C, resistance remains excellent up to 3% in HCl and acceptable beyond 30%. From 3 to 30%, the rate of corrosion exceeds 1 mm/yr.

##### ✓ hydrofluoric acid

SUPERIMPHY 625 has good resistance to this acid at ambient temperature and in all concentrations. At high temperature, it has limited resistance.

##### ✓ sulphuric acid

In this environment, this alloy's resistance is comparable to that of 904L stainless. At 80°C, resistance is limited to a concentration in the order of 50% for an acceptable corrosion rate in the order of 0.5 mm/yr.

##### ✓ nitric acid

SUPERIMPHY 625 has good corrosion resistance in this environment ( $V_{corr} \leq 0.7$  mm/yr for boiling 65% solution of  $HNO_3$ ).

##### ✓ phosphoric acid

SUPERIMPHY 625 alloy has excellent corrosion resistance in boiling solutions of phosphoric acid at concentrations up to approximately 50%. Above 50%, the rate of corrosion increases rapidly.

##### ✓ organic acids

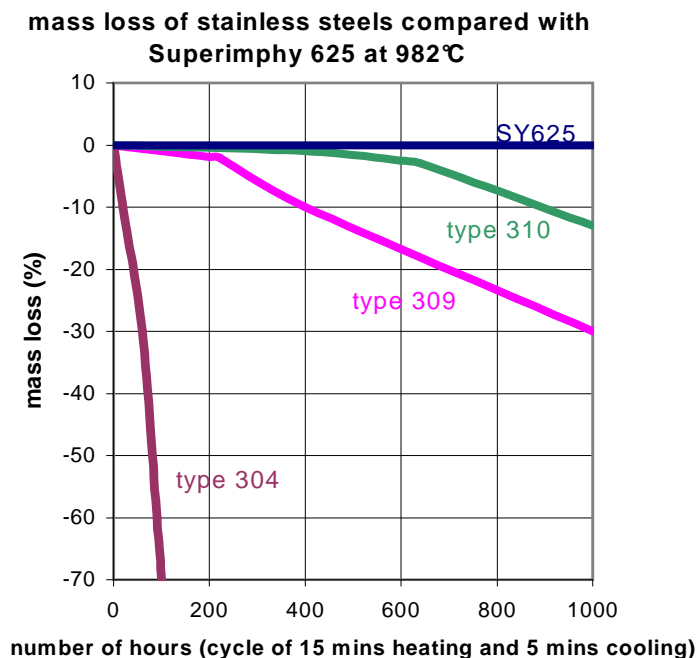
In general, SUPERIMPHY 625 has good resistance to corrosion in respect of these acids, at all concentrations and all temperatures.

##### ✓ $H_2S$ environment

SUPERIMPHY 625 has good resistance to stress corrosion cracking in  $H_2S$ ,  $CO_2$  and chloride environments at high temperatures and pressure.

## VI RESISTANCE TO OXIDATION

SUPERIMPHY 625 enjoys excellent resistance to oxidation up to 1100°C, which is higher than many other high-temperature alloys following heating and cooling cycles as shown in the following graph relating to mass loss at 982°C.



## VII TECHNOLOGICAL DATA

### VII.1 Heat treatment

The following two heat treatments are recommended:

- annealing between 930 - 1050°C
- solution annealing between 1090 - 1200°C

The rate of cooling is not critical. If the material is to be used below 650°C, hot-finished, work-hardened or annealed material can be employed. Above 650°C, the best results are obtained with annealed or solution-annealed material. Solution-annealed material offers the best creep properties. Annealed or fine-grained material has the best mechanical properties and the best fatigue-resistance.

### VII.2 Machining – forming

Particular precautions are required when machining SUPERIMPHY 625. It is recommended that you employ extremely rigid equipment, a low cutting speed, an effective lubricant with good cooling capacity, tools with large cutting angles. The use of carbide tools is strongly recommended.

### VII.3 Welding - brazing

SUPERIMPHY 625 can be welded using all conventional processes:

- Brazing with AWS ASTM class Ni-1 brazing alloy and annealing under dry hydrogen or argon at 1120°C
- Welding with coated electrodes: INCONEL 112 type electrodes can be employed.
- Gas arc welding (TIG or MIG): PHYWELD 625 filler wire
- Resistance welding

No post-weld heat treatment is necessary. The mechanical properties and corrosion-resistance of the welded joint are equivalent to those of the parent metal.

### VIII PRODUCT FORMS AND SUPPLY CONDITIONS

Standard product forms	Thickness (mm)	Maximum width (mm)	Condition
Cold-rolled strip in coil	0.2 - 5.0	260	ANNEALED or WORK-HARDENED
Hot-rolled sheet	5 - 70	2000	Dependent upon product form and customer specification

For other forms, visit the Hot Finished Products section of the [www.imphyalloys.com](http://www.imphyalloys.com) website. Imphy Alloys is at its customers' disposal for any specific requirements.