Industeel

ArcelorMittal

UR™ 66

UR™ 66: A high strength super austenitic stainless steel with PRENW = 55

The composition of UR™ 66 shows that combined additions of chromium, tungsten, molybdenum, nitrogen and copper, make it possible to design a super austenitic stainless steel with mechanical properties equivalent to the alloy 625 and with very high corrosion resistance. Due to 22% Ni and 0.4% N additions, **UR™ 66** alloy exhibits a very stable microstructure, less prone to intermetallic phase precipitations than the other highly alloyed austenitic stainless steels. The **UR™ 66** alloy has improved corrosion resistance properties compared to 6 Mo grades particularly in seawater, sour environments and acid media. Due to the optimum "cocktail" of alloying elements, the grade can be used in most very severe corrosive environments where it behaves almost equivalent or better than alloy 625.

PROPERTIES

STANDARDS

> EURONORM: EN 1.4659 X1Cr Ni Mo Cu N W 24-22-6

> ASTM: UNS S31266

CHEMICAL ANALYSIS - WEIGHT %

Typical values

Ni	Cr	Mo	W	Mn	N	Others
22	24	6	2	3	> .4	Cu = 1.5

PRENW = [Cr%] + 3.3 ([Mo%] + 0.5 [W%]) + 16 [N%] = 55

PHYSICAL PROPERTIES

Density: 8.2 kg/dm³ - 0.29lb/in³

Temperature interval °C (°F)	Thermal expansion (α x10^{-6} K^{-1})	T °C (°F)	Resistivity (µΩ.cm)	Thermal conductivity (W m^{-1} K^{-1})	Specific heat (J kg^{-1} K^{-1})	Young modulus E (GPa)	Shear modulus G (GPa)
20 - 100 (68 - 212)	15	20 (68)	100	12	450	195	75
20 - 300 (68 - 572)	16	200 (392)	115	13	550	180	70
20 - 500 (68 - 932)	16.5	400 (752)	125	14	620	165	66

MECHANICAL PROPERTIES

Tensile properties - Guaranteed values

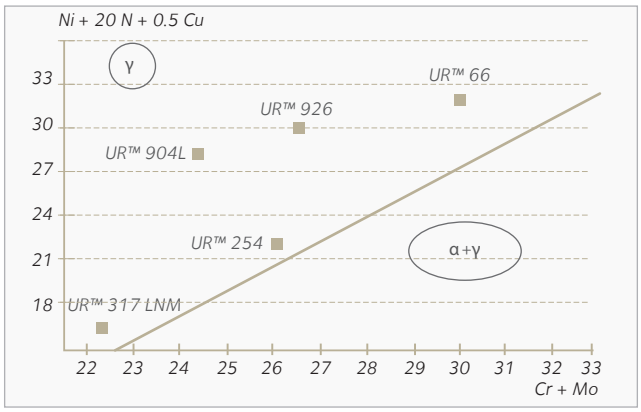
°C	$R_{p0.2}$	$R_{p1.0}$	R_m	°F	YS 0.2%	YS 1.0%	UTS	A/Elongation
	MPa				ksi			%
20	420	440	750	68	61	64	109	50
100	350	380	730	212	51	55	106	50
200	300	330	670	392	44	48	97	50
300	280	310	630	572	41	45	91	50

Impact values: >100J/cm² (70ft lbs) at -196°C (-320°F)

Hardness values: HV_{10}: [220-260]

STRUCTURE

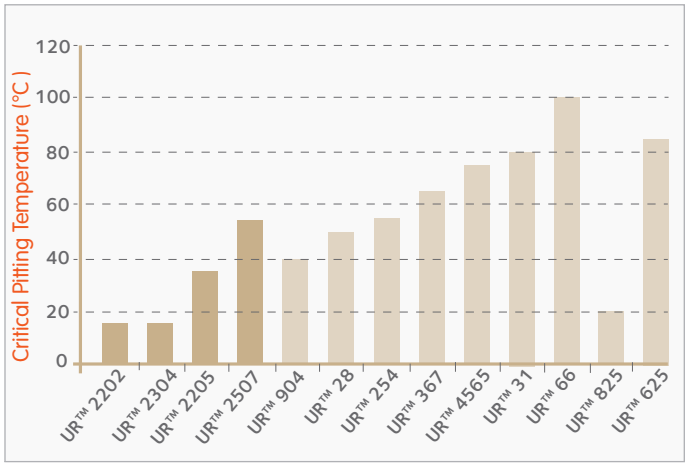
UR™ 66 chemical analysis (22%Ni, 0.4%N) is optimized in order to obtain a fully austenitic structure. The synergetic effects of nitrogen and tungsten additions result in drastic decrease in the gamma to sigma phase kinetic of transformation compared to high molybdenum low nitrogen grades.
Due to the high chromium and molybdenum additions, the alloy must be water-quenched from 1150°C (2100°F).

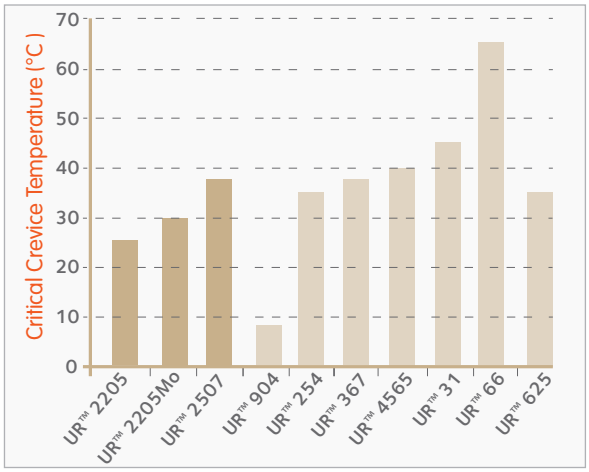


IN SERVICE CONDITIONS

CORROSION RESISTANCE

Pitting and crevice corrosion resistance (ASTM G48)





Thanks to its chromium, molybdenum, tungsten and nitrogen contents, UR™ 66 presents an excellent resistance to localized corrosion, much better than conventional 6%Mo and 7%Mo grades, and 625 alloy when tested according to the most common standards.

Grades	CPT °C (ASTM G48E)	CPT °C (green death)	CCT °C (ASTM G48D)
UR™ 66	> 100	> 100	55
UR™ 625	85	70	35
UR™ 31	80	65	40
UR™ 254	55	-	35

Typical pitting and crevice results.

Environments

Hydrochloric acid

Hydrochloric acid is a very aggressive reducing acid, meaning that the passive layer of most stainless steels is most stable in this environment. Nickel, molybdenum and tungsten have a beneficial influence on the corrosion resistance of CRA materials in hydrochloric environments.

At room temperature, UR™ 66 is resistant to hydrochloric acid up to a concentration of 3%. A 50°C (122°F) and 80°C (176°F), it is resistant up to 1%. These results were obtained in de-aerated conditions, in the absence of any other impurity.

Phosphoric acid

Phosphoric acid is a weak acid, mainly used in the fertilizer industry and as food additive. This acid is generally produced using a wet process route where phosphate rock is converted by reaction with concentrated sulfuric acid into phosphoric acid and calcium sulfate. Impurities contained in the phosphate rock increase the corrosivity of the phosphoric acid production process.

In pure phosphoric acid, UR™ 66 is corrosion-resistant up to the boiling temperature regardless of the acid concentration.

In environments representative of phosphoric acid production*, UR™ 66 is resistant up to 110°C (230°F). If the sulfuric acid concentration is increased to 8%**, UR™ 66 is resistant up to 80°C (176°F).
*41% H_3PO_4 + **2% H_2SO_4** + 1.5% H_2SiF_6 + 0.2% HF + 0.3% Fe^{3+} + 0.3% Al^{3+} + 1000 ppm Cl^-
** 41% H_3PO_4 + **8% H_2SO_4** + 1.5% H_2SiF_6 + 0.2% HF + 0.3% Fe^{3+} + 0.3% Al^{3+} + 1000 ppm Cl^-

Sulfuric acid

Sulfuric acid concentration	Max temperature (°C)
< 10%	boiling
20%	80
40%	70
60%	60
80%	40

Temperature limits in industrial sulfuric acid without any impurity

Please ask for data with chloride contamination.

IN SERVICE CONDITIONS

Water and Seawater
In fresh water, UR™ 66 is almost not susceptible to corrosion.

Long-term immersions of UR™ 66 coupons have demonstrated that it is very resistant to pitting and crevice corrosion in renewed natural seawater up to 50°C (122°F), even if 0.5 ppm of free chlorine are added.

Pollution control
UR™ 66 presents an excellent resistance to localized corrosion in environments representative of inland wet FGD systems and marine open loop scrubbers. It is particularly recommended in case of under-deposit corrosion risk (bottom parts).

Sour environments
UR™ 66 has proven to be resistant in a solution containing 150 000 ppm of chlorides at pH 4.5 and 150°C under a H_2S partial pressure of 14 bar. This environment is representative of very aggressive conditions encountered in Oil & Gas production units, and is much more aggressive than the current NACE MR0175 / ISO15156 limits. In these conditions, standard 6% Mo grades suffer from stress corrosion cracking.

DELIVERY CONDITIONS

SIZE RANGE

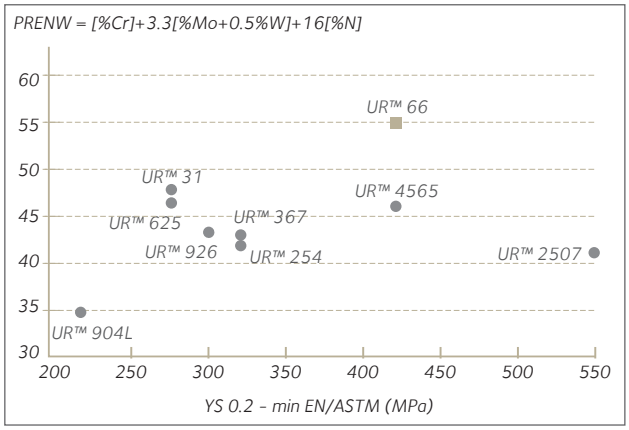
	Plates	
Thickness	5 to 50 mm 3/16" to 6"	
Width	Up to 3300 mm Up to 130"	
Length	For thickness > 9 mm	Up to 12000 mm Up to 472"
	For thickness < 9 mm	Up to 8000 mm Up to 315"

Other sizes are available on request, including 4100 mm (161,4") width plates.

DESIGN

In most of the very severe media, the alloy UR™ 66 behaves much better than 6 Mo super austenitic grades and exhibits equivalent, or better corrosion resistance properties than nickel based alloy 625.
The alloy is particularly well designed for pollution control equipment even in abrasion-corrosion conditions. The alloy is also designed for pulp and paper applications and chemical industry where mixed polluted acids and temperature are encountered together.

UR™ 66 has a unique position in the stainless steel family when comparing the combined PRENW value and mechanical properties. The use of the high mechanical properties allows the designer to reduce the costs. Another cheaper way to design vessels is the use of cladded UR™ 66 grade.



HOT FORMING

Furnace atmosphere must be slightly oxidising and free from sulphur contaminations. Load the plate in the furnace at specified temperature. Temperature range is 1200°C to 900°C (2190°F to 1650°F) reheat as often as necessary to reduce hardening and structural effects.

Solution annealing is necessary after hot working:

> Temperature: 1150°C to 1180°C (2100°F to 2150°F)

> Soaking time: 1.5 min /mm of thickness at annealing temperature

> Cooling: water quench.

COLD FORMING

The cold formability of UR™ 66 is good, but due to high Mo content, the work hardening rate is higher than for 316L. Intermediate annealing may be necessary. Remove forming stresses by annealing heat treatment.

PICKLING

The cleanliness of the surface is very important to maintain the high corrosion resistance properties of this alloy. Use 6 Mo super austenitic pickling conditions. Pickling time will be higher.

WELDING

Due to the highly alloyed and fully austenitic microstructure, UR™ 66 may be sensitive to phase transformations and hot cracking. Moderate heat input and low interpass temperature are recommended to avoid these phenomena. Pre-heating and post weld heat treatments are also not recommended. Dilution of the base metal must be kept below 50%. The weld area must be carefully cleaned and degreased before welding, and the finished weld must be descaled and cleaned (strike marks and welding defects must also be ground).

UR™ 66 can be welded by the following processes: GTAW (TIG), GMAW or pulsed GMAW (MIG or pulsed MIG), SMAW (MMA) and PAW (PLASMA).

Typical electrodes or filler materials to be used are alloy C22 (E(R)NiCrMo-10) or alloy 59 (E(R)NiCrMo-13). Do not use alloys 625 (E(R)NiCrMo-3) filler metal classification. Welding without filler metal is also possible, in this case solution annealing heat treatment is preferred after welding, to obtain good ductility and corrosion resistance.

APPLICATIONS

- **Seawater applications**
- **Pollution control equipments:** FGD absorbers and ducts, marine scrubbers
- **Pulp and paper industry:** bleaching equipment
- **Chemical industries**
- **Geothermal energy, hydrometallurgy**
- **Oil and Gas applications**

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