



## UR™ 66

UR™ 66: A high strength super austenitic stainless steel with PREN<sub>W</sub> = 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 |

$$\text{PREN}_W = [\text{Cr}\%] + 3.3 ([\text{Mo}\%] + 0.5 [\text{W}\%]) + 16 [\text{N}\%] = 55$$

## PHYSICAL PROPERTIES

Density: 8.2 kg/dm<sup>3</sup> - 0.29lb/in<sup>3</sup>

| Temperature interval<br>°C (°F) | Thermal expansion<br>( $\alpha \times 10^{-6} \text{ K}^{-1}$ ) | T<br>°C (°F) | Resistivity<br>( $\mu\Omega \cdot \text{cm}$ ) | Thermal conductivity<br>( $\text{W m}^{-1} \text{ K}^{-1}$ ) | Specific heat<br>( $\text{J kg}^{-1} \text{ K}^{-1}$ ) | Young modulus<br>E (GPa) | Shear modulus<br>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  | Rp0.2 | Rp1.0 | Rm  | °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           |

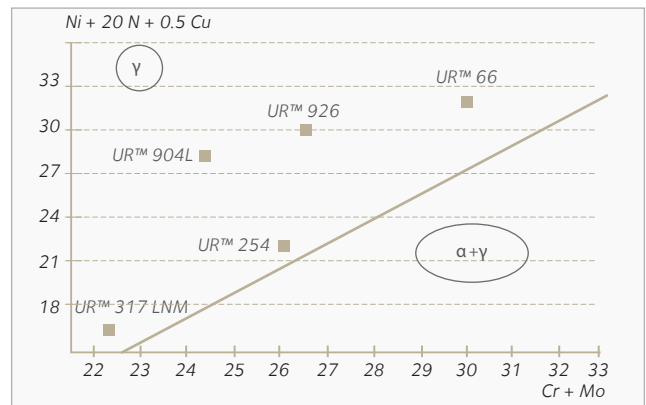
Impact values: >100J/cm<sup>2</sup> (70ft lbs) at -196 °C (-320 °F)

Hardness values: HV<sub>10</sub>: [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.

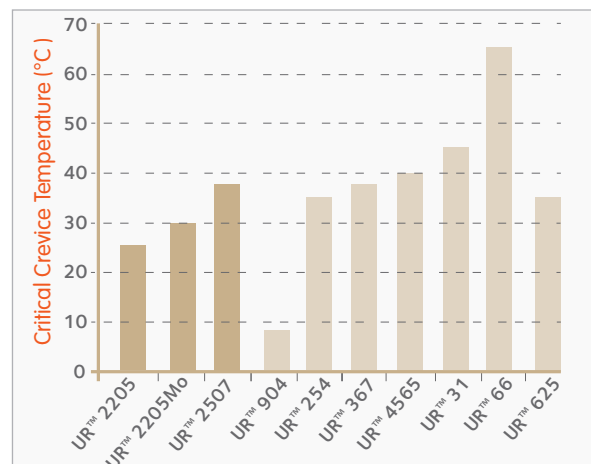
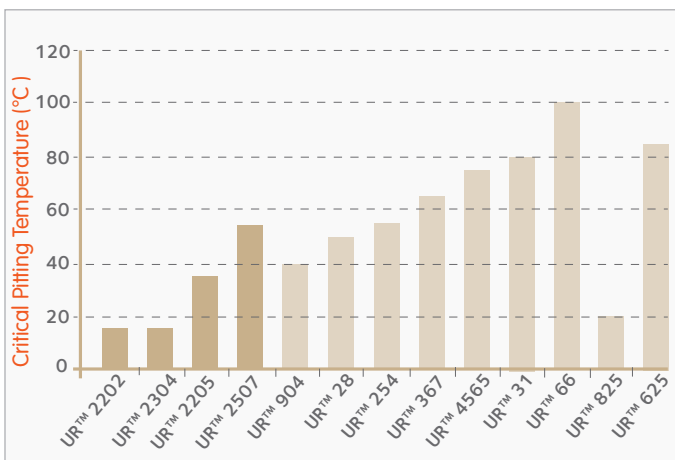
Due to the high chromium and molybdenum additions, the alloy must be water-quenched from 1150 °C (2100 °F).



## 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<sub>3</sub>PO<sub>4</sub> + **2% H<sub>2</sub>SO<sub>4</sub>** + 1.5% H<sub>2</sub>SiF<sub>6</sub> + 0.2% HF + 0.3% Fe<sup>3+</sup> + 0.3% Al<sup>3+</sup> + 1000 ppm Cl<sup>-</sup>

\*\* 41% H<sub>3</sub>PO<sub>4</sub> + **8% H<sub>2</sub>SO<sub>4</sub>** + 1.5% H<sub>2</sub>SiF<sub>6</sub> + 0.2% HF + 0.3% Fe<sup>3+</sup> + 0.3% Al<sup>3+</sup> + 1000 ppm Cl<sup>-</sup>

### 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<sub>2</sub>S 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<br>3/16" to 6"   |                              |
| Width     | Up to 3300 mm<br>Up to 130" |                              |
| Length    | For thickness > 9 mm        | Up to 12000 mm<br>Up to 472" |
|           | For thickness < 9 mm        | Up to 8000 mm<br>Up to 315"  |

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

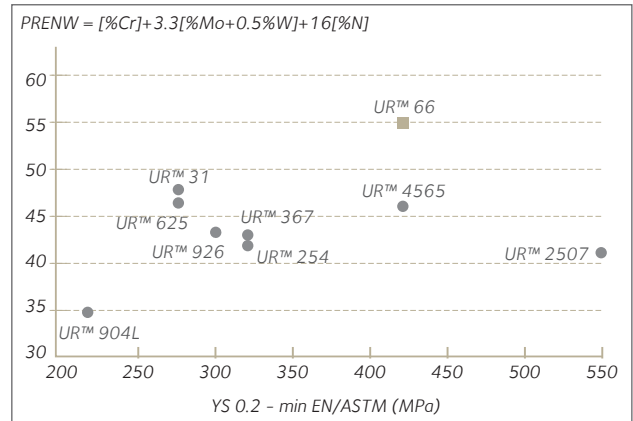


## DESIGN

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 clad 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**



## YOUR CONTACTS

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*Technical data and information are to the best of our knowledge at the time of printing. However, they may be subject to some slight variations due to our ongoing research programme on steels. Therefore, we suggest that information be verified at time of enquiry or order. Furthermore, in service, real conditions are specific for each application. The data presented here are only for the purpose of description, and considered as guarantees when written formal approval has been delivered by our company. Further information may be obtained from the address opposite.*