Industeel

ArcelorMittal

UR™ 2304

UR™ 2304: A 23Cr free Mo duplex stainless steel with PREN ≥ 24

UR™ 2304 is a 23% Cr, 4% Nickel, Mo free duplex stainless steel (2304). The alloy UR™ 2304 has a corrosion resistance similar to 316L. Furthermore, its mechanical properties i.e. yield strength, are twice those of 304/316 austenitic grades. This allows the designer to save weight, particularly for properly designed pressure vessel applications. The alloy is particularly suitable for applications covering the - 50°C/+300°C (- 58°F/572°F) temperature range. Lower temperatures may also be considered, but are subject to restrictions, particularly for welded structures. With its duplex microstructure, low nickel and high chromium contents, the alloy has improved stress corrosion resistance properties compared to 304 and 316. An enhanced version with a PREN ≥ 28 is also available on request.

PROPERTIES

STANDARDS

> EURONORM: EN 1.4362 X2 Cr Ni N 23 - 4

> ASTM: A240 - UNS S32304

CHEMICAL ANALYSIS - WEIGHT %

Typical values

C	Cr	Ni	Mo	N
0.02	23	4	0.2	0.14

PREN = [Cr %] + 3.3 [Mo %] + 16 [N %] ≥ 24

PHYSICAL PROPERTIES

Density: 7.85 kg/dm^3

Interval temperature (°C)	Thermal expansion (α x10^{-6} K^{-1})	T (°C)	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	80	17	450	200	75
20 - 100	13	100	92	18	500	190	73
20 - 200	13.5	200	100	19	530	180	70
20 - 300	14	300	105	20	560	170	67

MECHANICAL PROPERTIES

Tensile properties - Minimum values

°C	$R_{p0.2}$ (MPa)	$R_{p1.0}$ (MPa)	R_m (MPa)	°F	YS 0.2% (ksi)	YS 1.0% (ksi)	UTS (ksi)	A/ Elongation (%)
20	400	440	600	68	58	64	87	25
100	330	365	570	212	48	53	83	25
200	280	310	530	392	41	45	77	20
300	230	260	490	572	33	38	71	20

Values obtained for hot rolled plates (th < 50 mm). UR™ 2304 must not be used for a long time at temperatures higher than 300°C (572°F), where precipitation hardening occurs.

Toughness values (KCV minimum values)

Temp.	- 50°C	+20°C	- 60°F	+70°F
Single	75J/cm²	90J/cm²	54 lbs/ft²	65 lbs/ft²
Average (5)	90J/cm²	150J/cm²	65 lbs/ft²	87 lbs/ft²

Hardness (Typical values)

Average (5)	HV_{10} 180 - 230	HB: 180 - 230	HRC: ≤ 20

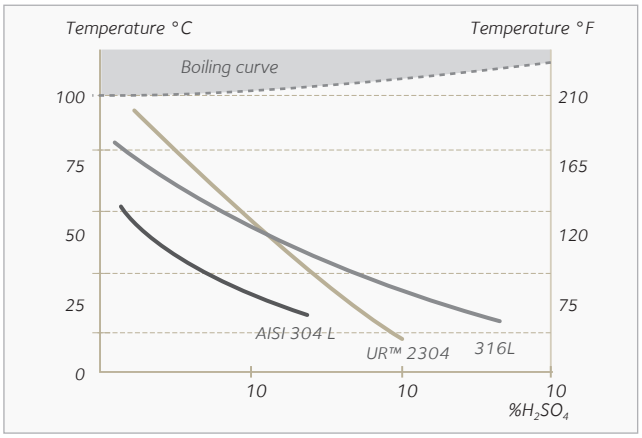
Copper additions may be considered as UR™ 2304 Cu may be hardenned by heat treatment to improve abrasion - corrosion resistance properties.

STRUCTURE

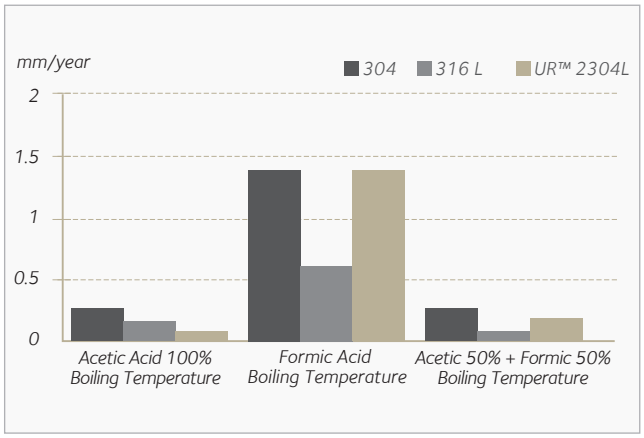
The chemical analysis of UR™ 2304 is optimised to obtain a typical 50 α / 50 γ microstructure after solution annealing treatment at 950°/1050°C (1742/1922°F). The microstructure of UR™ 2304 duplex is very stable compared to molybdenum containing duplex stainless steels. Intermetallic phases (σ, ϰ) are present only after 10 hours holding time in the 750°/850°C (1382°/1562°F) temperature range. Copper additions to UR™ 2304 grade, when specified, increase the hardness of the steel after heat treatment in the 350/500°C (662/932°F) temperature range.

IN SERVICE CONDITIONS

CORROSION RESISTANCE



Corrosion resistance to stagnant sulfuric acid (0.3 mm/year)



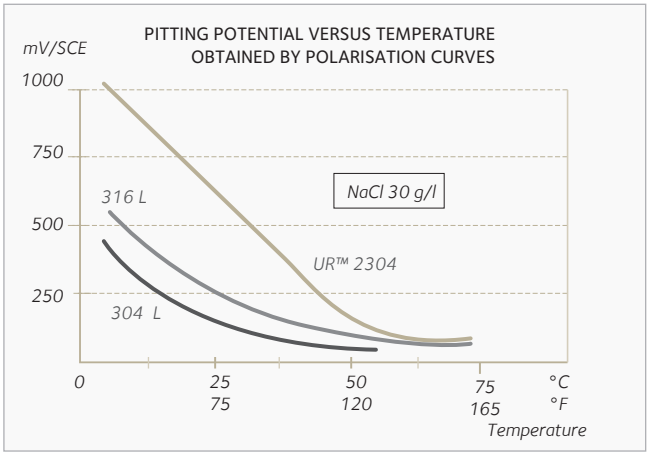
Corrosion resistance in different organic acids

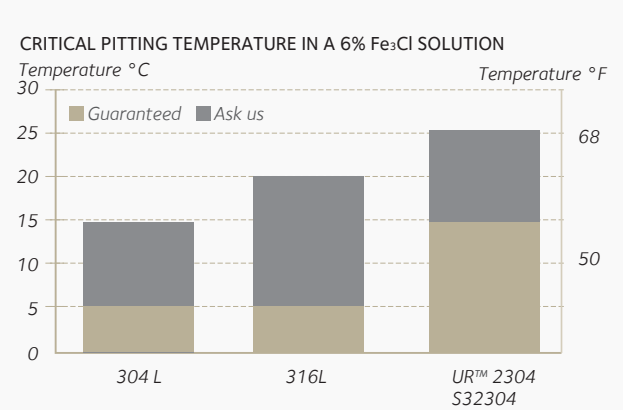
General corrosion

Because of its high chromium content (23%) the corrosion resistance of UR™ 2304 is almost equivalent to those of 316L.

Localised corrosion resistance

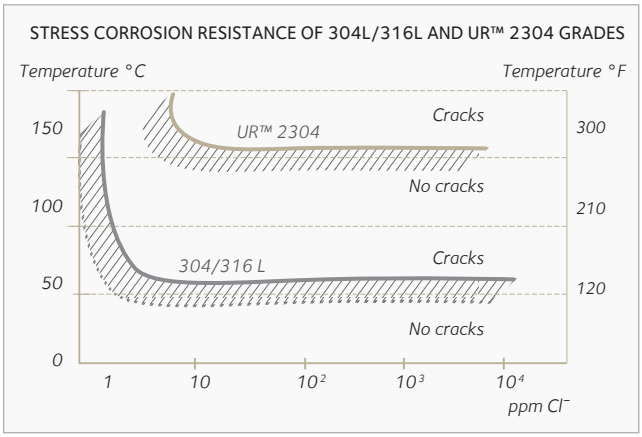
The 23% chromium and 0.1N% additions explain why UR™ 2304 duplex stainless steel behaves much better than 316L grade when considering pitting and crevice corrosion.





Stress corrosion resistance

Stress corrosion resistance test results in Chloride containing aqueous solutions (8ppm O_2) pH = 7, > 1000h, applied stresses higher than the yield strength) show that UR™ 2304 outperforms 304L and 316L grades, thanks to its high Chromium additions and low nickel contents. This is a typical feature of duplex stainless steels. UR™ 2205 outperforms UR™ 2304 in similar conditions.



Other corrosion resistance properties

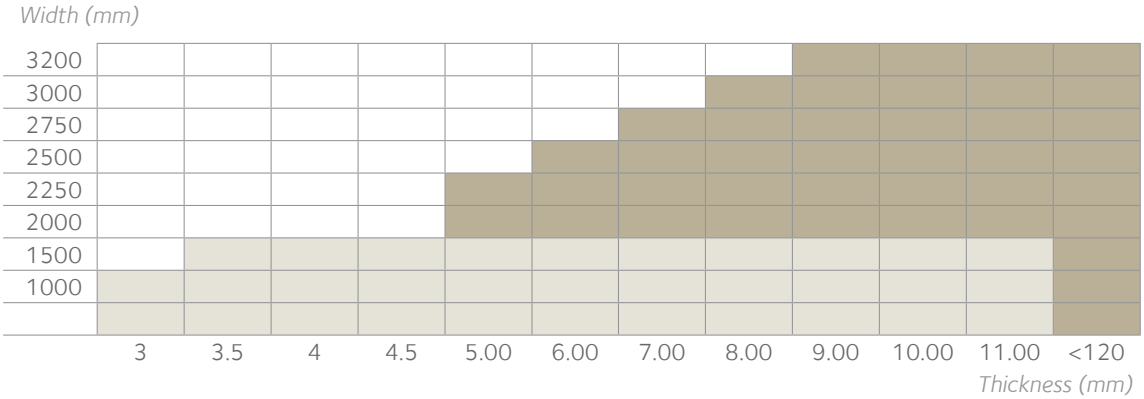
UR™ 2304 duplex stainless steel successfully passes most of the standard intercristalline test procedures such as ASTM A262E and C tests. Its corrosion rate in boiling nitric acid (65%) is higher than that of 316. Due to its high yield strength, the alloy performs well in abrasion/corrosion applications.

DELIVERY CONDITIONS

SIZE RANGE

Hot rolled HRAP 1D (Aperam)
Quarto plates (ArcelorMittal Industeel)

Hot rolled plates



For coils and CMP, consult APERAM.
For 2304 clad plates, consult INDUSTEEL CREUSOT.

HOT FORMING

Hot forming must be carried on in the 900/1150°C (1650/2100°F) temperature range. After forming, a new solution annealing treatment is recommended in the 950/1050°C (1742/1922°F) temperature range to fully restore corrosion resistance properties and mechanical properties. Parts of UR™ 2304 must be supported carefully during heating to avoid creep deformation.

COLD FORMING

UR™ 2304 may be cold formed without any problem. The same equipments as those used for the cold forming of 304 and 316 grades can be used. Due to its higher mechanical properties, including the yield strength, higher stresses are required for cold forming. A final solution annealing heat treatment is also recommended after cold forming in order to restore the mechanical and corrosion resistance properties, as decribed in 'hot forming'.

DESCALING

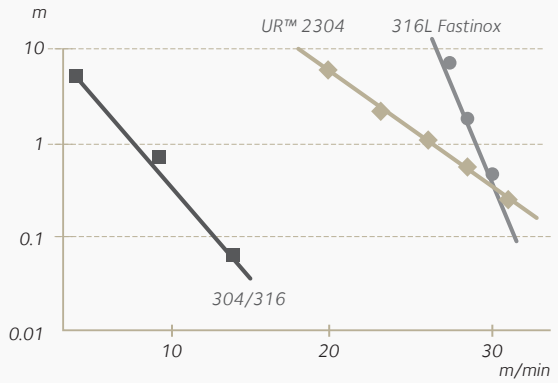
Use the same solutions and pastes as for 304/316L. The pickling time will be higher than for austenitic grades due to the corrosion resistance properties of the alloy.

MACHINABILITY

UR™ 2304 duplex exhibits improved machinability particularly when considering drilling. Its behaviour is equivalent to that of 316L FASTINOX(*). Furthermore UR™ 2304 has better corrosion resistance and cleanliness properties as no sulphur additions are necessary. Localised corrosion resistance behavour is improved.

**316L FASTINOX is a 316L type grade with improved machinability properties*

TOTAL DRILLING LENGTH VERSUS SPEED



WELDING

> **UR™ 2304** can be successfully welded by the following processes:
- TIG, manual and automatic
- PLASMA, MIG, SMAW, SAW, FCAW...

> The duplex microstructure renders the alloy less sensitive to hot cracking.

> The welding parameters must be optimized to obtain a controlled ferrite level (20 - 70%). Typical recommended heat inputs are 10 - 25 kJ/cm with a 150°C (302°F) max interpass temperature. These conditions must be optimized taking into account the thickness of the products and welding equipments (Consult if necessary). We do not recommend pre or post - welding heat treatments. Only complete solution annealing heat treatment may be considered (please, contact us).

APPLICATIONS

- > Generally in substitution to 304L and 316L
- > Pulp and paper industry (chip storage tank, white and black liquor tanks...)
- > Caustic solutions, organic acids (SCC resistance)
- > Food industry
- > Safety panels (high mechanical properties)
- > Pressure vessels (weight savings...)
- > Mining (abrasion/corrosion)

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.