

## URANUS® 2205

A 22Cr duplex

URANUS® 2205 is a nitrogen alloyed ( $\geq 0.15\%$ ) austenitic-ferritic stainless steel with improved structure stability and high general, localised and stress corrosion resistance.

UR 2205 with 22% Cr and 3% Mo additions, performs much better than 316L grade in almost all corrosive media.

The yield strength is about twice that of austenitic stainless steels. This allows the designer to save weight and makes the alloy more cost competitive compared to 316L grade.

Typical operation temperatures are  $-50^{\circ}\text{C}/+280^{\circ}\text{C}$  ( $-58^{\circ}\text{F}/+536^{\circ}\text{F}$ ). Lower temperatures could be considered, but require additional precautions, in particular for welded structures.

UR 2205 is a multi-purpose material which can be used in various corrosive media. Typical applications are Pulp and Paper, Oil and Gas, Pollution control equipments, Chemical industry and Chemical tankers.

### Standard

**EURONORM :** 1.4462 - X2 Cr Ni Mo N 22-5-3

**ASTM :** A240 - UNS S31803

### Chemical analysis

#### Typical values (Weight %)

C	Cr	Ni	Mo	N
0.020	22	5.3	3	0.16

$$\text{PREN} = [\text{Cr \%}] + 3.3 [\text{Mo \%}] + 16 [\text{N \%}] \geq 33 \text{ or } 34$$

Mo content is optimised in the 2.7 – 3.1% range

### Mechanical properties

#### Tensile properties - Minimum values

$^{\circ}\text{C}$	$R_p 0.2 \text{ MPa}$	$R_p 1.0 \text{ MPa}$	$R_m \text{ MPa}$	$^{\circ}\text{F}$	YS 0.2% KSI	YS 1.0% KSI	UTS KSI	A/EI%
20	460	490	680	68	67	71	98	25
50	430	470	660	122	62	68	96	25
100	360	400	630	212	52	57	92	25
150	340	380	605	302	49	54	88	20
200	320	360	590	392	46	52	86	20
250	305	345	590	482	44	50	86	20
300	290	330	590	572	42	48	86	20

For solution annealed condition and plate thickness  $\leq 50\text{mm}$  (2").

UR 2205 grade should not be used over  $280^{\circ}\text{C}$  ( $530^{\circ}\text{F}$ ) for extended periods of time.

### Impact strength (KV minimum values)

Temp.	-50°C	-20°C	+20°C	-60°F	0°F	+70°F
Single	75J	90J	120J	54ft.lbs	65ft.lbs	87ft.lbs
Average (5)	90J	120J	150J	65ft.lbs	87ft.lbs	109ft.lbs

### Hardness values - Typical values

Average (5)	HV <sub>10</sub> 210 - 260	HB: 210 - 240	HRC: 15 - 20
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## Physical properties

Density: 7,85kg/dm<sup>3</sup>

Temperature interval (°C)	Thermal expansion x10 <sup>-6</sup> K <sup>-1</sup>	T (°C)	Resistivity (μΩ cm)	Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> )	Specific heat (J kg <sup>-1</sup> K <sup>-1</sup> )	Young modulus E (GPa)	Shear modulus G (GPa)
		20	80	17	450	200	75
20 - 100	13.5	100	86	18	450	190	73
20 - 200	14	200	92	19	500	180	70
20 - 300	14.5	300	100	20	550	170	67

Density: 0.282Lb/in<sup>3</sup>

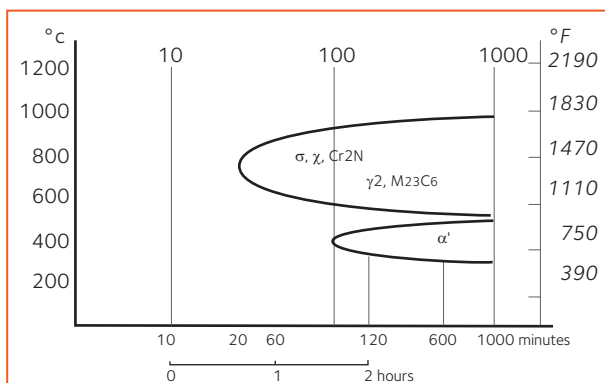
Temperature interval (°F)	Thermal expansion x10 <sup>-6</sup> °F <sup>-1</sup>	T (°F)	Resistivity (μΩ.in)	Thermal conductivity (Btu.hr <sup>-1</sup> .ft <sup>-1</sup> .°F <sup>-1</sup> )	Specific heat x10 <sup>6</sup> (Btu.lb <sup>-1</sup> .°F <sup>-1</sup> )	Young modulus E x10 <sup>6</sup> (psi)	Shear modulus G x10 <sup>6</sup> (psi)
		68	31.5	11	0.11	29	10.9
70 - 210	7	212	33.8	11.5	0.12	28	10.5
70 - 400	7.5	392	36.2	12	0.12	27	10.1
70 - 600	8	572	39.3	12.5	0.13	26	9.7

## Structures

URANUS<sup>®</sup> 2205 is a duplex stainless steel; its chemical composition is optimized in order to present, after a solution annealing treatment at 1040-1080°C (1900-1975°F) followed by water quenching, a nearly 50% α /50% γ microstructure.

Heat treatments performed at 1100°C (2010°F) and higher may result in an increase of the ferrite content.

Typical TTP-diagram (temperature time precipitation) shows the two-phase transformation areas. At high temperature : 1000°-600°C (1830-1110°F), the α phase may transform in σ, χ, ... intermetallic phases which makes the alloy brittle. At lower temperature (300-500°C - 570-930°F) the α phase transforms in α' resulting in a hardening of the structure after several hours holding time.

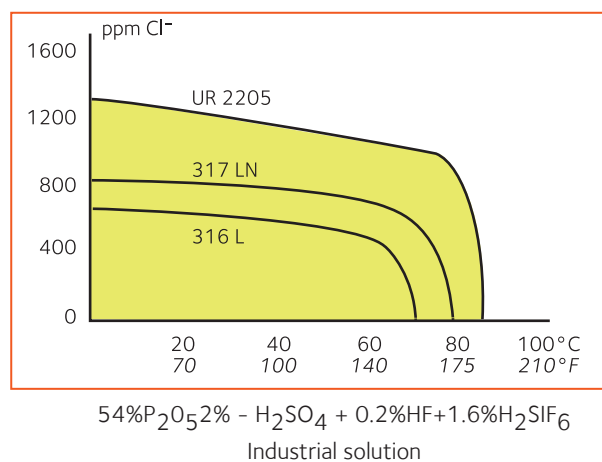
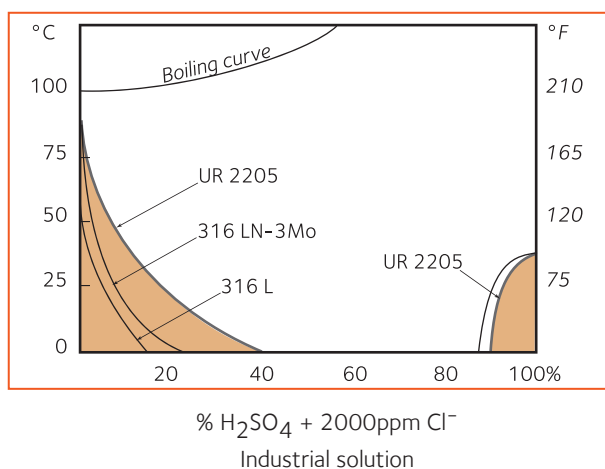


TTP DIAGRAM of  
UR 2205 duplex stainless steel

## Corrosion resistance

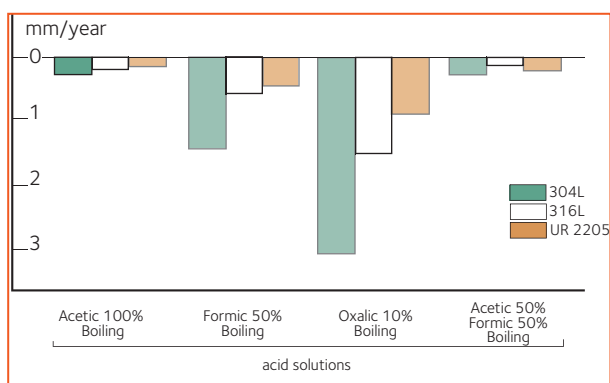
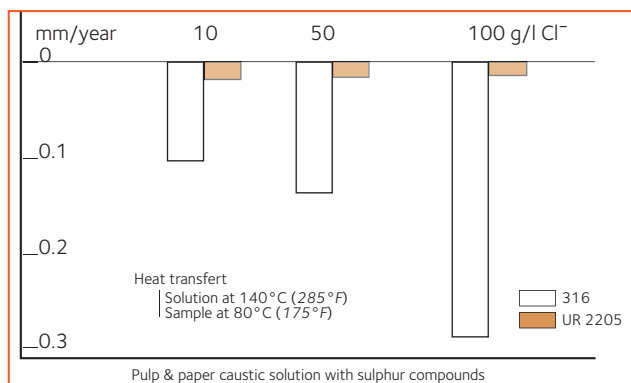
### General corrosion resistance

#### a) Sulfuric and phosphoric acids



General corrosion resistance properties of UR 2205 alloy are generally much better than austenitic 316L and 317LN alloys. UR 2205 alloy is now used extensively in newly designed chemical tankers.

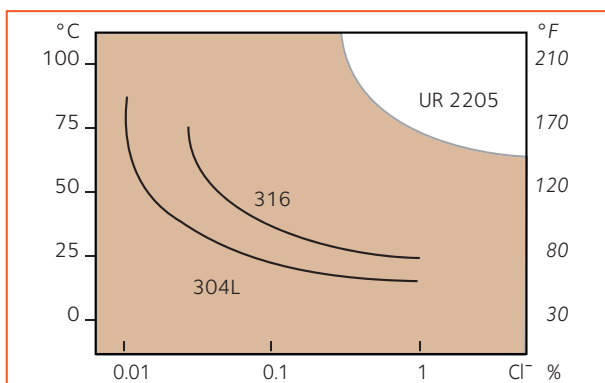
#### b) Caustic media (pulp and paper) and organic acids



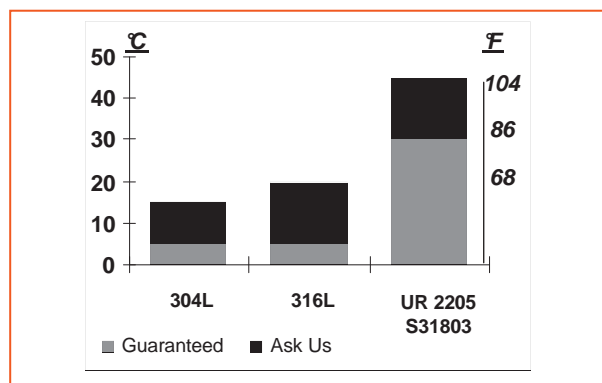
General corrosion resistance in organic solutions or caustic solutions is improved by the use of UR 2205 instead of 304 or 316 L grades. UR 2205 is extensively used in chemical industries (organic and inorganic) and in the pulp and paper industry.

## Localised corrosion resistance

### a) Pitting corrosion



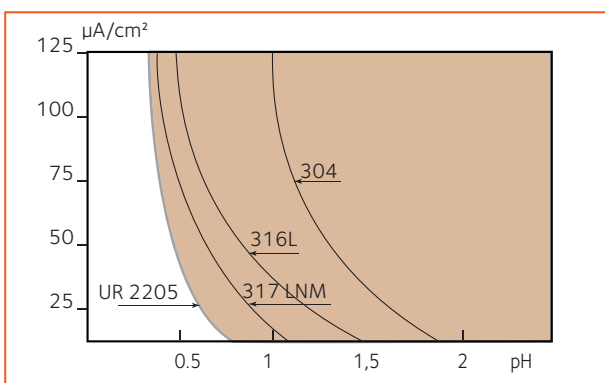
Sensitivity to pitting corrosion  
Effects of temperature and chloride content



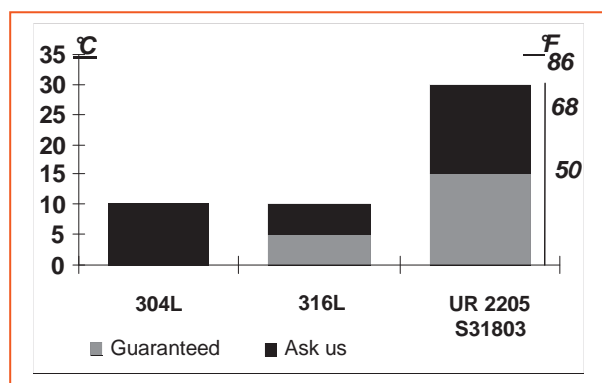
ASTM G48A Test results  
10%  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$

The high chromium (22%) and molybdenum (3%) combined with 0.16% nitrogen all contribute to the high pitting resistance of UR 2205. It outperforms 304 and 316L, even in very oxidizing and acidic solutions.

### b) Crevice corrosion resistance



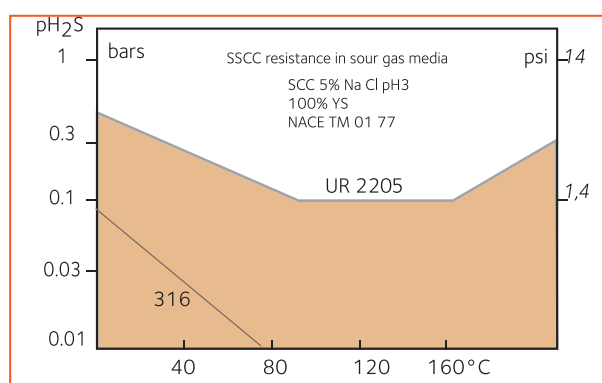
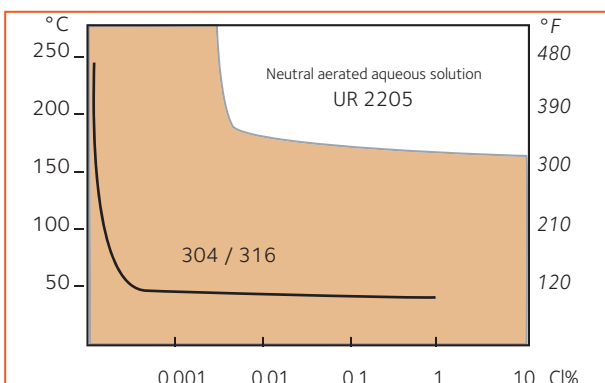
Depassivation conditions of several stainless steels  
Solution: 30g/l NaCl 20 $^{\circ}\text{C}$



ASTM G78 - Crevice  
10%  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$  solution

The improved crevice corrosion resistance of UR 2205 explains its use in chloride/fluoride processes containing deposits. Typical applications are Pulp and Paper industry, Pollution Control equipments, On/Offshore applications.

## Stress corrosion cracking resistance

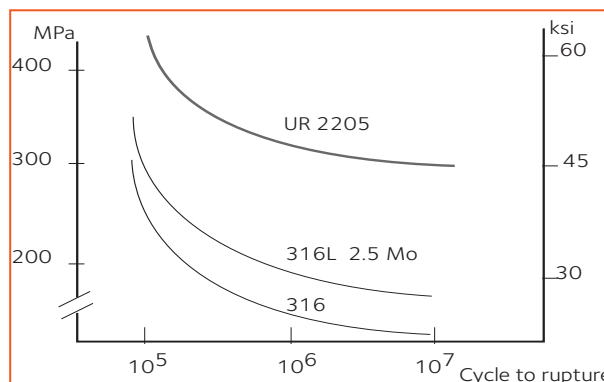


The duplex microstructure is known to improve the stress corrosion cracking resistance of stainless steels. This is the case in neutral aerated aqueous solutions containing chlorides and in sour gas conditions in the oil and gas industry. UR 2205 is used extensively for welded pipe.

## Corrosion fatigue resistance

Duplex stainless steels combine high mechanical and corrosion resistance. The fatigue corrosion data presented are very attractive results since after  $10^7$  cycles, fatigue limit remains at least twice that of 316 austenitic stainless steels.

Synthetic sea water solution  
(smooth samples)



## Processing

### Hot forming

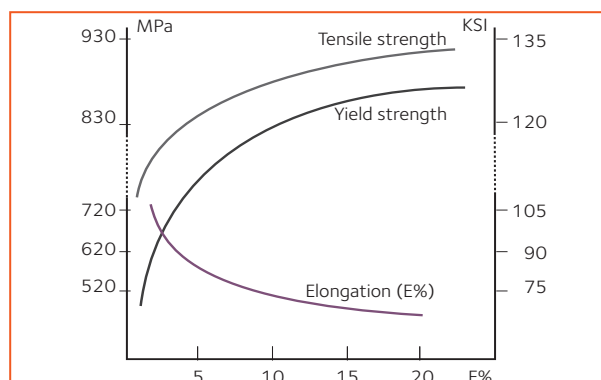
Hot forming should be carried out in a temperature range of 950/1150°C (1750/2100°F) after the piece has been uniformly heated. At temperatures lower than 950°C (1750°F), the alloy is very prone to intermetallic phase precipitation, such as sigma phase. This affects the toughness and corrosion resistance properties of UR 2205.

A final full annealing heat treatment (1040–1080°C / 1900–1975°F) followed by rapid quench, is required to restore phase balance, mechanical and corrosion resistance properties.

Special precautions must be taken during heat treatment to avoid deformation.

### Cold forming

UR 2205 can be cold formed without any problem using equipment suited to work stainless steel. The duplex UR 2205 alloy requires more power than austenitic stainless steels due to its higher mechanical properties and work hardening (which is lower than for austenitic steels). Cold working ratios exceeding 20% require an intermediate full annealing heat treatment (1040/1080°C - 1900/1975°F). Such heat treatment is also recommended after cold forming of more than 10 % in order to restore its properties.



### Pickling

Pickling solutions or pastes acceptable for alloy 316 L may be used. The pickling time required is at least twice that of 316L. A slight increase of the temperature of the pickling bath reduces the pickling time. Typical pickling conditions are (10 %  $\text{HNO}_3$  - 2% HF) 60°C (140°F). Passivation decontamination treatments may be performed with a 10–25% nitric acid solution.

## Machining

Machining is another example of a fabrication process where the techniques employed (eg. tools and lubricants) for UR 2205 are very similar to those used for conventional stainless steels).

Machining characteristics of UR 2205 are better than those of 316L.

Operation	Tool	Lubrication	CONDITIONS					
			Depth of cut (mm) (inch)	Feed (mm) (inch)	SPEED (m/min) SPEED (feet/min)			
Turning	High speed steel	Cutting oil			18/8	18/12 Mo	UR 904	UR 2205
			6 0.23	0.5 0.019	13-18 427-59.1	11-16 36.1-52.5	6-11 19.7-36.1	15-20 49.2-65.6
			3 0.11	0.4 0.016	20-25 65.6-82	18-23 59.1-75.5	9-14 29.5-45.9	23-28 75.5-91.9
			1 0.04	0.2 0.008	26-31 85.3-101.7	25-30 82-98.4	15-20 49.2-65.6	30-35 98.4-114.8
			6 0.23	0.5 0.019	75-85 246.1-278.9	70-80 229.7-262.5	25-35 82-114.8	75-85 246.1-278.9
			3 0.11	0.4 0.016	90-100 295.3-328.1	85-95 278.9-312.7	45-55 147.6-180.4	90-100 295.3-328.1
	Carbide	Dry or cutting oil	1 0.04	0.2 0.008	110-120 360.9-393.7	100-110 328.1-360.9	65-70 213.3-229.7	110-120 360.9-393.7
			Blade width		Feed			
			SPEED (m/min) (feet/min)					
Parting off	High speed steel	Cutting oil	1.5 0.06	0.03 0.0012	21-26 68.9-85.3	17-22 55.8-72.2	10-13 32.8-42.7	23-28 75.5-91.9
			3 0.11	0.04 0.0016	22-27 72.2-88.6	18-23 59.1-75.5	11-14 36.1-45.9	24-29 78.7-95.1
			6 0.23	0.05 0.0020	23-28 75.5-91.9	19-24 62.3-78.7	12-15 39.4-49.2	25-30 82-98.4
			Drill dia.		Feed			
Drilling	High speed steel	Cutting oil	1.5 0.06	0.25 0.0010	10-14 32.8-45.9	10-14 32.8-45.9	6-10 19.7-32.8	10-14 32.8-45.9
			3 0.11	0.06 0.0024	11-15 36.1-49.2	11-15 36.1-49.2	7-11 23-26.1	11-15 36.1-49.2
			6 0.23	0.08 0.0031	11-15 36.1-49.2	11-15 36.1-49.2	7-11 23-26.1	11-15 36.1-49.2
			12 0.48	0.10 0.0039	11-15 36.1-49.2	11-15 36.1-49.2	7-11 23-26.1	11-15 36.1-49.2
			Feed		SPEED (m/min) (feet/min)			
Milling profiling	High speed steel	Cutting oil		0.05-0.10 0.002-0.0039	12-22 39.4-72.2	10-20 32.8-65.6	10-20 32.8-65.6	12-22 39.4-72.2

## Welding

- UR 2205 is easily welded by the following processes :

- TIG welding, both manual and automatic,
- Plasma welding,
- MIG welding,
- SMAW,
- SAW
- FCAW

- Austenitic-ferritic structure of UR 2205 steel (ferrite primary solidification) limits hot cracking risks in the HAZ.

- Special care must be taken in controlling the ferrite content of the weld deposit which is usually between 25 and 60 % ; a lower ferrite content will be recommended (20-40 % of  $\alpha$  , for some welding procedures) i.e. for SMAW, SAW and FCAW.

- Chemical composition has to be adapted to stabilize austenite (generally, nickel or nitrogen overalloyings compared to the base metal).

Cr and Mo overalloyed filler metals are also recommended in order to increase the corrosion resistance properties of welded structures.

- As for austenitic grades, no preheat is necessary prior to welding,
- The heat input must be controlled (about 10 to 25 kJ/cm is generally counselled) – Consult our technical staff for more accurate information if needed. Optimum heat input is related to plate thicknesses.
- Interpass temperature must be limited to 150°C (302°F), preferably 120°C (248°F).
- Post weld heat treatment is normally not necessary. In some cases, it might be needed to obtain a low ferrite content when welding without filler metal. Heat treatment will be realised at a sufficient temperature to avoid phase transformation.
- Usual precautions including cleaning and degreasing of weld area, protection against weld spatters must be taken to ensure corrosion resistance of the finished product.
- Careful final mechanical or/and chemical cleaning of the weld is strongly recommended.

#### Plasma + TIG welding:

Typically used for thicknesses of 5 to 12 mm.

If no filler metal is used for the plasma pass, Ar + (2-3)% N<sub>2</sub> will be used as shielding gas.

Ferrite content will be between 30 and 60 %. Complementary TIG welding will also be realised with a duplex or super-duplex wire. The ferrite content will also be kept between 30 and 60 %.

Nitrogen additions (2-3%) in the protective gas improve the corrosion behaviour and stabilize the microstructure. Technical is available for special cases. Contamination of the shielding gas by hydrogen must be avoided.

#### Manual arc welding:

A standard duplex or super-duplex electrode will be used. The ferrite content is between 20 and 40%. Avoid hydrogen pick up (moisture, hydrogen containing gases...) which can result in cold cracking.

For further information, please contact us (choice of the electrode depending on the application).

#### Submerged arc welding:

This process can be used for single pass or multipass welds for high thicknesses (≥10 mm) or to complete a plasma pass. The filler metal is a duplex wire, basic fluxes should be preferred.

Ferrite content will be controlled between 20 and 40 % in order to avoid cold cracking risks; Use only well dried fluxes to avoid hydrogen uptake.

## Design

UR 2205 is particularly cost effective when its high mechanical strength of the alloy are taken into account to design vessels.

Allowable design stress values: ASME boiler and pressure vessel codes.  
Section VIII – Division 1, Stress, MPa – KSI

Grade	-30/40°C (-20/100°F)		205°C (400°F)		260°C (500°F)	
	MPa	KSI	MPa	KSI	MPa	KSI
316L	108	15.7	74	10.8	68.9	10
904L	123	17.8	95	13.8	87	12.7
UR 2205	155	22.5	144	20.9	141	20.4

These higher design stress values allow the fabricator to reduce the weight of the equipment which, combined with the high corrosion resistance properties, provide additional cost savings.

## Applications

- Oil and Gas industry including sour gas applications
- Pulp and Paper industry (digesters...)
- Chemical industry (reactor vessels...)
- Acetic acid distillation towers
- Phosphoric acid plants (reactors...)
- Sulphuric acid processes (hydrometallurgy...)
- Pollution control equipments
- Trucks, lorries
- Chemical tankers

## Size range

Plates	
Thickness	5 to 150mm <i>3/16" to 6"</i>
Width	Up to 3300mm <i>Up to 130"</i>
Length	Up to 12000mm <i>Up to 472"</i>

Other sizes are available on request, including 4100mm (161.4") width plates.

2205 coils: consult ArcelorMittal Stainless Europe

2205 clad plates: consult Industeel Creusot

### For any information

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tomorrow

This technical data and information represent our best knowledge at the time of printing. However, it may be subject to some slight variations due to our ongoing research programme on corrosion resistant grades.

We therefore 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 is only for the purpose of description, and may only be considered as guarantees when our company has given written formal approval.