

Industeel



ArcelorMittal

Steel solutions for marine scrubbers



Our business

Leading supplier of high quality steel plates

A subsidiary of ArcelorMittal, Industeel is dedicated to the production of hot rolled steel plates, ingots and formed pieces in the widest range of dimensions. Specializing in carbon and stainless steels, Industeel offers a complete range of high quality steel grades designed to meet the most severe specifications.

High quality materials designed to meet the most strict specifications.

The widest dimensional range to meet all customer requirements due to our 3 integrated mills.

A high level of technical support provided by a dedicated research & development centre.

Steel casting



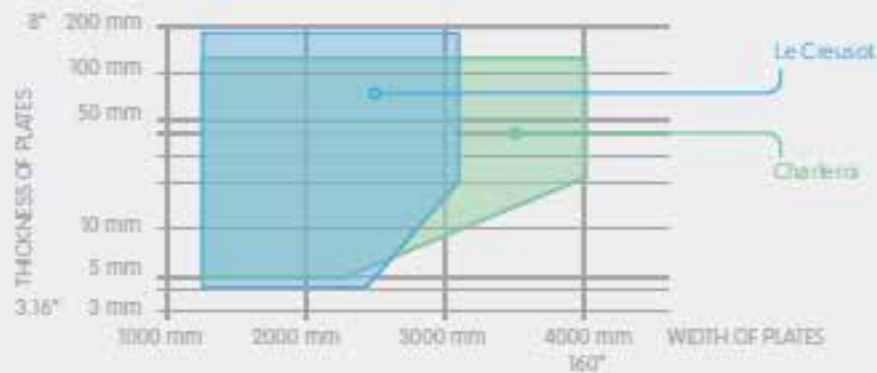
Steel plate



High level of technical support



The widest dimensional range of plates



Our expertise

First-class producer of stainless steel and nickel based alloy plates for corrosive applications

With over 150 years experience, the Industeel name stands for high performance steel at its best.

Careful selection of raw materials to produce high purity steel melted by electric arc furnace.

Fine tuned secondary metallurgy, vacuum and special degassing processes for high cleanliness steels.

Continuous casting or bottom-poured ingot programs and latest industrial techniques.

Computer controlled high plate rolling mills.

Automatic quenching devices and high precision tempering furnaces to create homogeneous hardness and microstructure through the cross section.

As a result, materials with uniform properties, providing consistent performance in service.



It all starts with advanced metallurgical processes to produce premium corrosion resistant alloys



Materials for cleaner oceans

To comply with the environmental regulations defined by the IMO (International Maritime Organization), cleaner exhaust gases are mandatory by 2020 for merchant ships.

Exhaust gas cleaning systems, also known as marine scrubbers, are one of the possible solutions chosen by shipowners to reduce the SOx emissions and particles. In these systems, materials have to face very aggressive conditions with low pH and high concentration of chlorides.

Industeel has proven track records in the inland exhaust gas cleaning systems (in particular for coal-fired power plant) and can offer a wide range of solutions to preserve marine scrubber integrity.



Scrubber for Reliant Project for Keystone USA

Three main scrubbing technologies are available on the market and commonly considered:

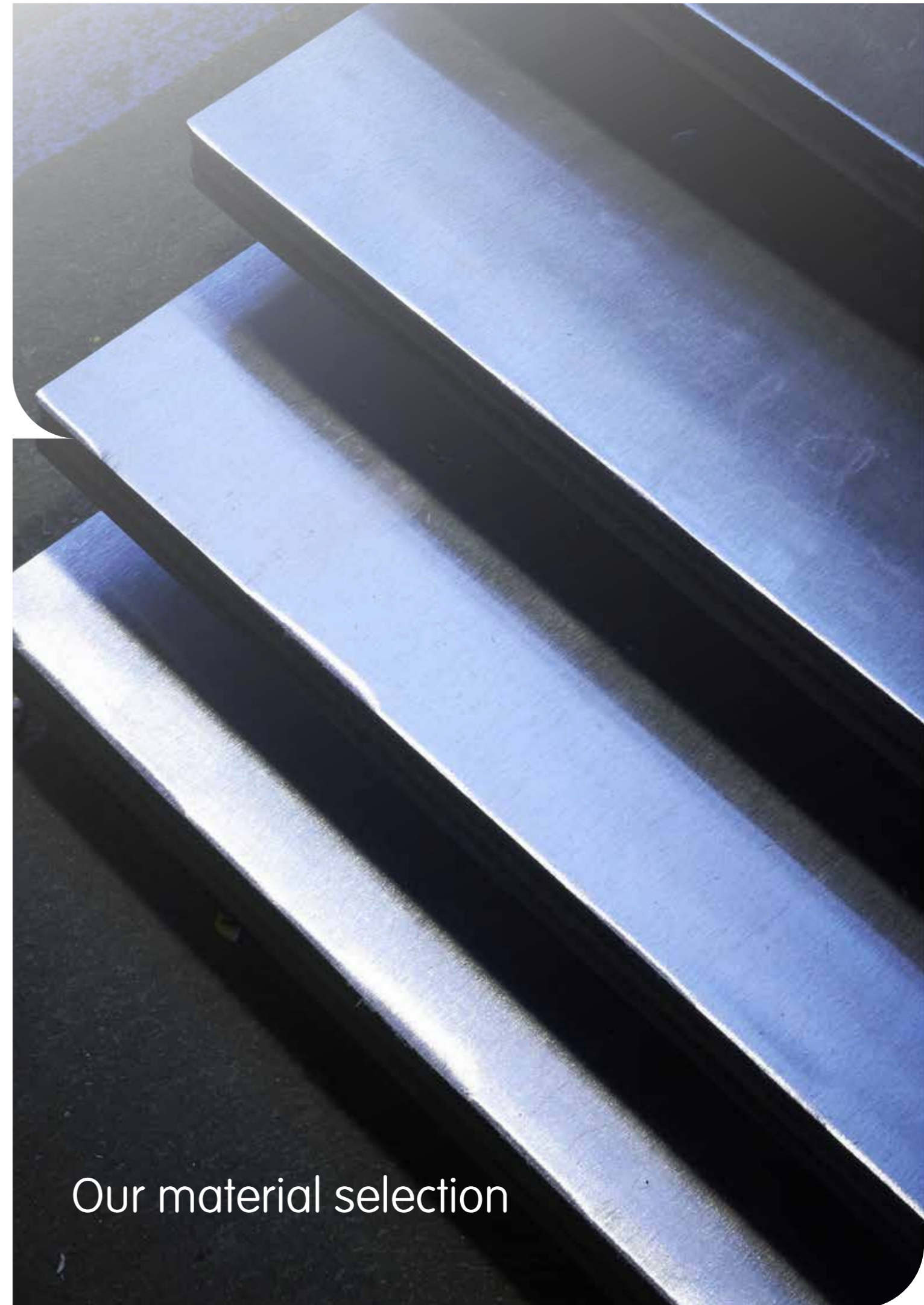
- **Open loop:** seawater is pumped and sprayed in the flue gas, its alkalinity is used to transform SOx into sulfates. The wash water is then treated, diluted, discharged in the sea. Residues are stored in a sludge tank, and disposed in harbors. The system can be used in areas where the alkalinity of the seawater is sufficient.



- **Closed loop:** the wash water is used in a closed circuit. An alkaline agent (NaOH or MgO) reacts with the exhaust gas to reduce the SOx level. As for the open loop, system residues are collected in a sludge tank and disposed in harbors. The system can be used without considering the seawater alkalinity and where wash water discharged is banned.



- **Hybrid system:** this technology is flexible to operate in both open and closed loop conditions.



Our material selection

Adapted steel solutions for marine scrubbers

ALLOYS FOR TOP & SHELL CONDITIONS

- super-austenitic grades UR™ 4565, UR™ 254, UR™ 367, UR™ 904L, UR™ 926
- austenitic-ferritic duplex grade UR™ 2507



BOTTOM, ALLOYS FOR MORE STRINGENT CONDITIONS

- nickel based alloys grades UR™ 276, UR™ 625
- super-austenitic grades UR™ 31, UR™ 4565, UR™ 66

Adapted steel solutions for marine scrubbers

UR™ 2507

Super-duplex stainless steels have a very high resistance to localized corrosion in chloride media, combined with a high mechanical strength (>550 MPa) allowing for leaner design in load bearing applications. UR™ 2507 provides a cost-effective alternative for a wide range of applications, including offshore, oil & gas production, phosphoric and sulfuric acid production as well as flue gas desulphurisation.

UR™ 904L

UR™ 904L is a multipurpose stainless steel recommended for most applications dealing with medium corrosive environments. UR™ 904L has improved stress corrosion resistance properties and is particularly used in sulfuric and phosphoric acid applications.



UR™ 254

UR™ 254 super-austenitic stainless steel grade is particularly designed to be cost effective. The 18% nickel and 0.7% copper additions combined with the chromium and molybdenum additions enhance the performance of the steel in many corrosive solutions encountered for example in chemical and petrochemical processes or chloride-containing solutions. The alloy is also seawater resistant and has extensively been used in offshore applications and desalination plant.

UR™ 926

UR™ 926 is a super-austenitic stainless steel grade with a 0.2% nitrogen addition, particularly designed for high structural stability and high corrosion resistance. Its composition improves the behavior of the steel in many corrosive environments encountered for example in chemical and petrochemical processes. This alloy behaves particularly well in sulfuric acid solutions and is well adapted for pollution control equipment i.e. scrubbers. The alloy is also seawater resistant and has extensively been used in the offshore industry.

Adapted steel solutions for marine scrubbers

UR™ 367

UR™ 367 is a super-austenitic stainless steel grade with a 0.2% nitrogen addition, particularly designed for high structural stability and high corrosion resistance. This alloy can be used in many corrosive solutions met, for example, in chemical and petrochemical processes. The alloy behaves particularly well in sulfuric acid solutions and is well adapted for pollution control equipment. The alloy is also seawater resistant and has extensively been used in the offshore industry.



UR™ 4565

UR™ 4565 is a super-austenitic stainless steel grade with 0.4 % nitrogen addition, particularly designed for high mechanical and high corrosion resistance properties (PREN 46). The alloy behaves particularly well in chloride containing solutions and is well considered for pollution control equipment. The alloy is also resistant to seawater and is used in offshore industries.



UR™ 31

UR™ 31 is a super-austenitic stainless steel with very high contents of nickel, chromium and molybdenum. The alloy is designed to give corrosion properties in-between super-austenitic and nickel base alloys for very demanding applications. The high content of chromium and molybdenum gives an excellent resistance to localized corrosion. The high nickel provides a very good resistance to stress corrosion cracking.

Adapted steel solutions for marine scrubbers

UR™ 66

UR™ 66 is a super-austenitic stainless steel with mechanical properties equivalent to the alloy 625 and with very high corrosion resistance (PREN> 55). UR™ 66 alloy exhibits a very stable microstructure, less prone to intermetallic phase precipitation than the other highly alloyed super-austenitic stainless steels. Thanks to its improved corrosion resistance compared to conventional 6%Mo grades, it can be used in the most severe conditions, particularly in seawater, sour environments and acid media.

UR™ 625

UR™ 625 is an austenitic nickel-based alloy presenting excellent resistance to oxidation and corrosion over a broad range of corrosive conditions, it is virtually immune to chloride stress corrosion cracking. It has high strength and toughness at temperatures ranging from cryogenic temperature to 1100°C.

UR™ 276

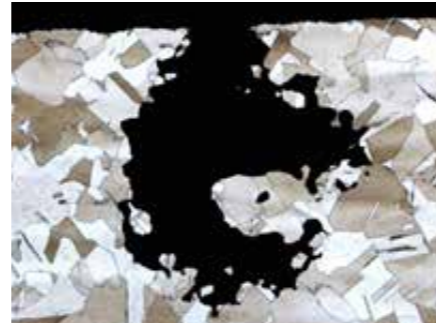
UR™ 276 is an austenitic nickel-based alloy used in multiple applications: petrochemical, chemical, pulp and papers, marine scrubbers, and process industries for highly corrosion environments. The alloy is highly resistant to oxidizing and reducing media. UR™ 276 can be used for hot, contaminated mineral acids, organic acids as well as seawater environments. UR™ 276 is also resistant to localized attack and stress-corrosion cracking in processes containing chlorides.



Choosing the right Corrosion Resistant Alloy

Material selection for marine scrubbers will depend on the technology selected, and on the following parameters:

- Process temperature
- Halide content (chlorides, fluorides)
- Deposit formation
- pH
- Presence of abrasive particles



Pitting corrosion

The environment found in marine scrubbers can be very aggressive, especially when considering the bottom part of the equipment due to the presence of a large amount of chlorides combined with the process temperature deposits and acidic conditions. Choosing an inappropriate material may induce severe corrosion, leading to the leakage of the scrubber.

The risk of pitting corrosion must be considered for material choice. This degradation phenomenon is caused most of the time by the presence of chlorides and characterized by cavities or "holes" produced in the material. Alloying elements such as chromium, molybdenum, tungsten and nitrogen have a beneficial influence on the pitting corrosion resistance of stainless steel materials.

The Pitting Resistance Equivalent Number (PREN) is a useful empirical tool that can be used to predict the pitting resistance of stainless alloys. It is expressed as $PREN = \%Cr + 3.3 (\%Mo + 0.5\%W) + 16\%N$.

Stainless steel materials like 6%Mo super-austenitic grades, UR™ 4565, UR™ 31, UR™ 66 and UR™ 625 present a very good resistance to pitting corrosion.

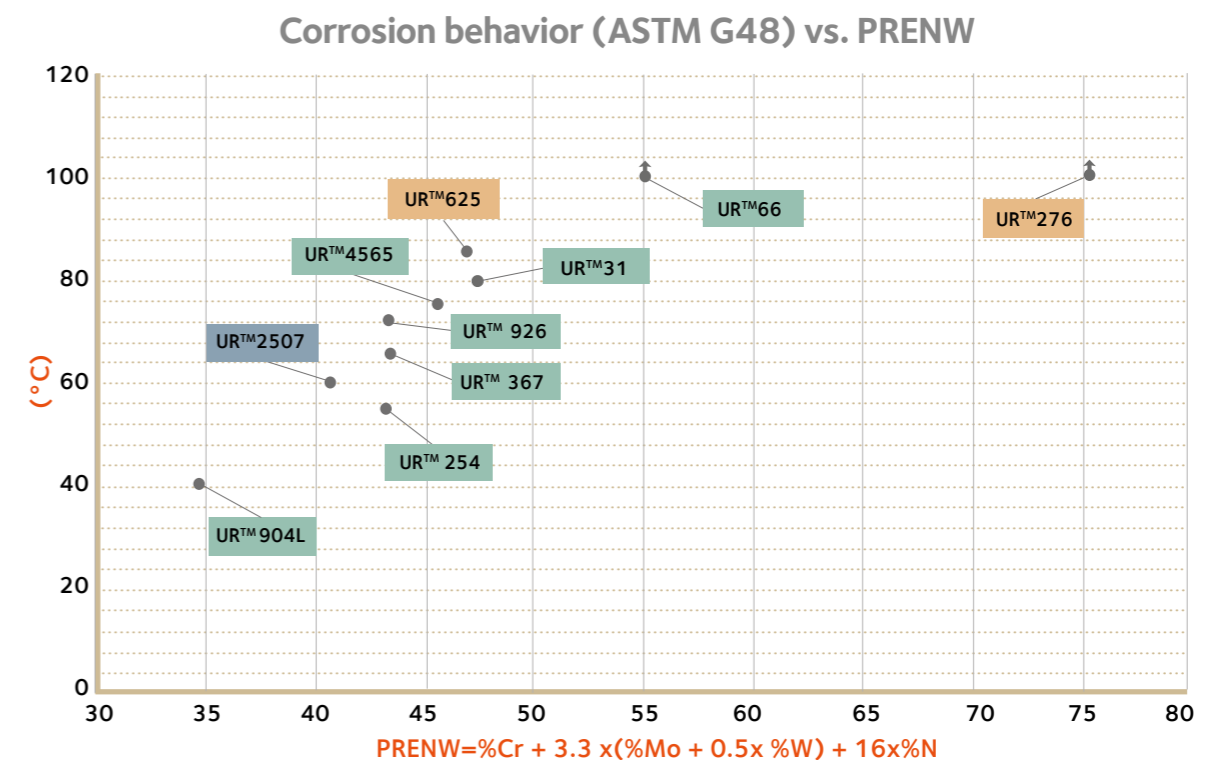
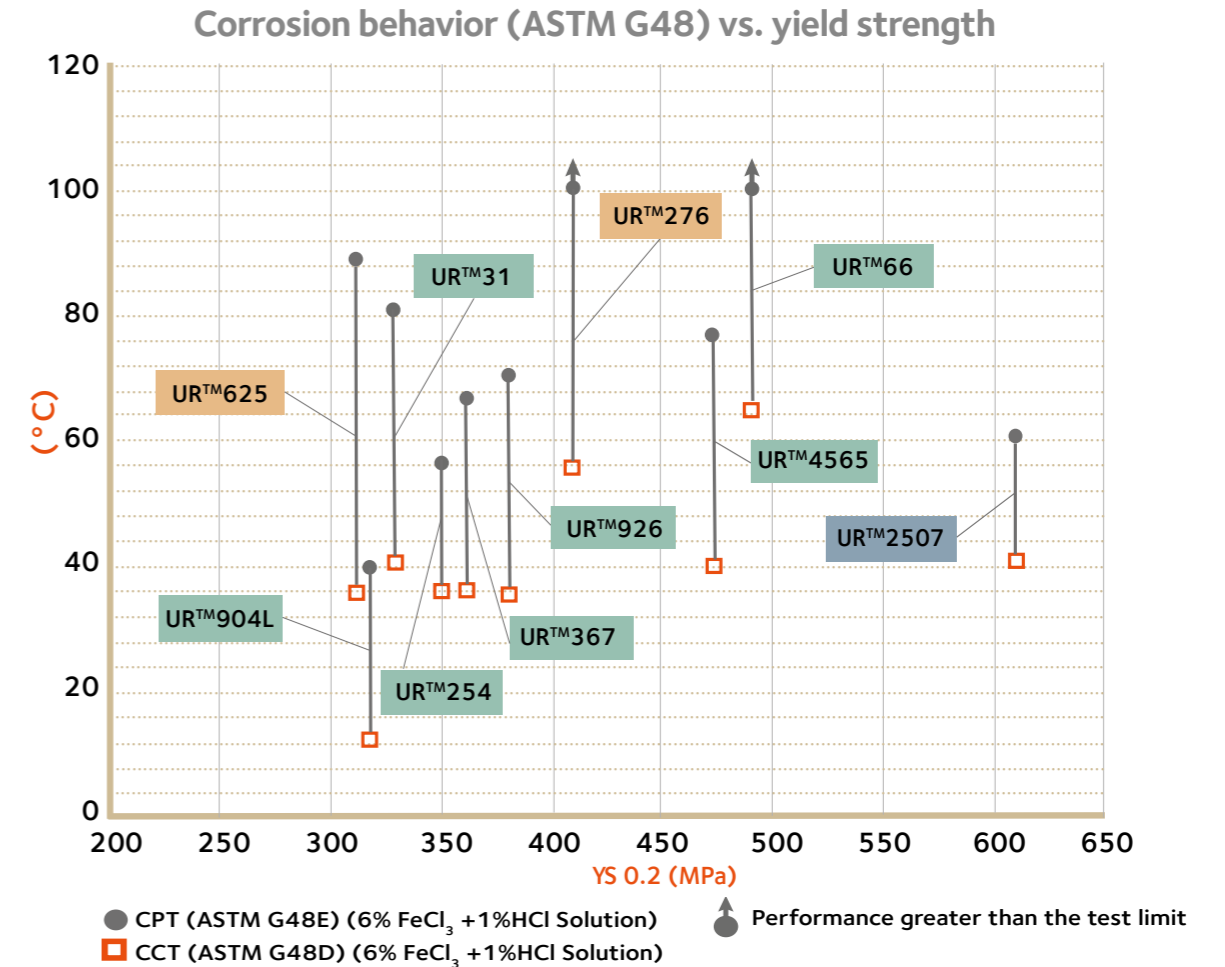
For the bottom part of the marine scrubber, material selection must also be driven by the risk of crevice corrosion. Crevice corrosion is caused by the combined influence of a stagnant solution with the presence of halide ions. It typically occurs under deposit, washers, gaskets or threads.

Stainless steel materials such as UR™ 31, UR™ 66 and UR™ 276 present an excellent resistance to crevice corrosion.

Highly alloyed stainless steels and nickel base alloys have proven to be corrosion-resistant in many aggressive environments and have been successfully used in various industrial sectors for decades: chemical industry, hydrometallurgy, power generation, water treatment and Oil & Gas. They are increasingly used for marine scrubbers.

Corrosion Resistant Alloys selection guideline

Industeel offers a wide range of cost effective stainless steel material solutions.



Our offer

With more than 150 years of experience in steelmaking, Industeel is able to put all its know-how and expertise in the production of high end alloys.

Thanks to our offer we are able to accompany your projects for the most demanding environments such as marine scrubbers.

	GRADE	EURONORM ASTM ASME	CHEMICAL ANALYSIS % C < 0.030 (% WEIGHT)					0,2 Y.S. - Rp 0,2 min ASTM / EN	UTS - Rm min ASTM / EN	EI - A (%)	PREN _W
			Cr	Ni	Mo	N	OTHERS	MPa	MPa		
Nickel based alloys	UR™ 276	EN 2.4819 NiMo16Cr15W UNS N10276 SB-575	16	bal.	16	-	W = 4 Co < 2.5	380	700	50	75
	UR™ 625	EN 2.4856 Ni Cr22 Mo9 Nb UNS N06625 SB-443	21	bal.	8	-	Nb + Ta = 3.5	276	690	40	47
Superaustenitic	UR™ 66	EN 1.4659 X1CrNiMoCuNW 24-22-6 UNS S31266	24	22	6	0.45	Mn = 3 W = 2 Cu = 1.5	420	800	50	55
	UR™ 31	EN 1.4562 UNS N08031	26.5	31	6.3	0.2	-	276	650	40	48
	UR™ 4565	EN 1.4565 X2CrNiMnMoN25-20-7 UNS S34565	24	17	4.5	0.45	Mn = 4.5	420	800	35	46
	UR™ 926	EN 1.4529 X1NiCrMoCuN25-20-7 UNS N08926	20	25	6	0.23	Cu = 1	300	650	40	43
	UR™ 367	UNS N08367	20	24.5	6	0.23	-	310	655	35	43
	UR™ 254	EN 1.4547 X1CrNiMoCu 20-18-7 UNS S31254	27	31	3.5	-	Cu = 1	310	655	35	43
	UR™ 904L	EN 1.4539 X1NiCrMoCu25-20-5 UNS N08904	20	24	4	0.1	Cu = 1.5	220	520	40	35
Duplex	UR™ 2507	EN 1.4410 X2CrNiMoN	25	7	3.5	0.27	-	550	795	25	41

Our experience in metallurgy



Need help to find the best solution?

A world class facility with 50 researchers dedicated to our customers

Innovation

Located in France, Industeel's Research Centre (CRMC - Centre de Recherche des Matériaux au Creusot) is a world-class partner to respond to new market requirements with innovative products and high-value solutions. We continuously improve the durability, fabricability and in-service performance of our products dedicated to highly corrosive environments.

R&D

Representative experiments in scrubber environments can be performed. Industeel is able to help you to find the best solution for your project.

Technical assistance

Our corrosion and metallurgy team can provide technical assistance for:

- Material selection taking into account the aggressiveness of the environment including welded joints.
- Extensive laboratory testing, metallurgical investigation and field test performance.
- Continuous improvement of existing products to follow requirements of new applications.
- Patented grades to provide enhanced solutions fully adapted to customers needs.

Characterization ▾



Field tests ▾



Technical assistance ▲

Our Research Center is able to perform corrosion tests dedicated to marine scrubber applications:

- Pitting corrosion and crevice corrosion tests as per ASTM G48
- Electrochemical tests
- Long-term immersion tests
- Field tests

Welding and forming

Technical assistance in order to help customers with fabrication

Cutting

Plasma or other high-power thermal cutting methods can be used. Mechanical cutting is also suitable (shearing, stamping, cold sawing...).

After cutting, pickling or grinding are necessary to eliminate the oxide layer and heat tint that has formed.



Forming

Forming operations for marine scrubbers are mainly cold forming processes: rolling and curling.

Nickel based alloys and super-austenitic grades have equivalent mechanical properties at ambient temperature. To remove forming stresses, an annealing heat treatment may be necessary.

Due to their higher yield strengths, super-duplex grades require higher forces for cold forming.

If hot forming is needed e.g. for pressed heads, some more information is available in each material datasheet on Industeel's website.



Welding

Welding can be easily performed by conventional processes : SMAW, GTAW (with filler), GMAW, PAW.

- Super-austenitic and nickel base grades must be welded with a low heat input and controlled interpass temperature: below 1 to 1.5 kJ/mm and 100 to 150°C depending on the grade. Matching filler material is mainly recommended for these materials. Specific welding recommendations are available on corresponding datasheets.

- Super-duplex welding procedures are similar to those of other duplex stainless steels:

- no pre-heating
- heat input between 0.5 > 2 kJ/mm is recommended (depending on the process and on the thickness of the plate)
- Interpass temperature lower than 120°C
- no PWHT

- Dissimilar welds can be performed. Consider the most restrictive material welding recommendation (lower heat input, lower interpass temperature, and higher mechanical and corrosion resistance filler material). Some specific recommendations are available upon request.





ArcelorMittal

With 40 sales offices in 40 different countries around the world, Industeel stands as one of the foremost international steel makers, with an unmatched capacity of support everywhere.



For more information on Industeel, on product offer and your local representative, please consult our dedicated website.

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tomorrow

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