

STAINLESS AND DUPLEX STEELS

TECHNICAL INFORMATION 1

DIFFERENT TYPES OF STAINLESS STEELS AND THEIR USE IN WATER TREATMENT

It is always very uncertain to be able to predict the behavior over time of a particular metallic material if put in contact with a certain environment.

Stainless steels, thanks to their chemical composition, have the possibility of self-passivation and being able to cope with the most diverse conditions of aggression. In the case of water, the main factors to keep in mind are:

- *the chemical composition of the material;*
- *the chlorides present;*
- *the sanitizers;*
- *the flow conditions;*
- *the bacterial load (microbiological corrosion, MIC).*

In this brief technical information we will focus on the effect of the chemical composition of the various materials, referring the effects of the other factors to specialist readings.

The chemical composition of the material

The chemical composition is one of the indicative factors of the resistance to corrosion, because this is linked to the "strength" of the passivity film and therefore the material's ability to cope with corrosive attacks.

As already mentioned, the fundamental element is chromium (Cr). The higher its alloy content, the higher the corrosion resistance in general.

Molybdenum (Mo) provides a great help to chromium, strengthening the passivity film.

Nickel (Ni), although it does not intervene in preventing the starting of corrosion, slows down its propagation, favoring repassivation.

Always indirectly, elements such as titanium (Ti) and niobium (Nb) called "stabilizers" intervene, thanks to their ability to prevent "sensitization" phenomena and the consequent intergranular corrosion, which can also be controlled through a containment of the carbon content in the austenitics (types L Low Carbon, low carbon).

Based on the percentage of these elements in alloy, on which the corrosion resistance directly depends, it is possible to obtain the value of a parameter, the PREN (Pitting Resistance Equivalent Number), which provides a rough indication of the capacity of a stainless steel to resist pitting or, more generally, localized corrosion. It should be emphasized that the PREN is still a parameter indicative of the whole character, which cannot be taken as the only choice of a stainless steel parameter.

TAB|01| Pren per alcune tipologie di acciai inossidabili

	EN	AISI/ASTM	Cr	Mo	N	PREN
AUSTENITICI	1.4301	304 – S 30400	17,0÷19,5	-	0,11 max	17,00-21,26
	1.4373	202 – S 20200	17,0-19,0	-	0,05-0,25	17,8-23,00
	1.4401	316 – S 31600	16,5÷18,5	2,00÷2,50	0,11 max	24,75-28,51
	1.4438	317L – S 31703	17,5-18,5	3,0-4,0	0,11 max	27,40-34,46
	1.4539	904L – S 08904	19,0-21,0	4,0-5,0	0,15 max	32,20-39,90
	1.4547	S 31254	19,5-20,5	6,0-7,0	0,18-0,25	42,18-47,60 (*)
FERRITICI	1.4016	430 – S 43000	16÷18	-	-	16,00-18,00
	1.4509	(441) – S 43932	17,5-18,5	-	-	17,50-18,50
	1.4513	436 – S 43600	16,0-18,0	0,80-1,40	0,020 max	18,64-22,62
	1.4521	444 – S 44400	17,0-20,0	1,80-2,50	0,030 max	22,94-28,25
	-	S 44735	28,0-30,0	3,6-4,2	0,045 max	39,88-43,86 (*)
DUPLEX	1.4162	S 32101	21,0-22,0	0,10-0,80	0,20-0,25	24,53-28,64
	1.4362	2304 – S 32304	22,0-24,0	0,10-0,60	0,05-0,20	23,13-29,18
	1.4462	2205 – S 32205	21,0-23,0	2,5-3,5	0,10-0,22	30,85-38,06
	1.4410	2507 – S 32750	24,0-26,0	3,0-4,5	0,24-0,35	37,74-46,45 (*)

(*) quando il Pren è superiore a 40 si parla di “super” inox: super-austenitico, super-ferritico, super-duplex

The chlorides present

The corrosion phenomenon must always be seen in the context of the totality of the factors that characterize an application; in the case of water, the chloride content is certainly one of the main. There are many studies in the literature about this aspect.

The English Drinking Water Inspectorate (DWI) in the "DWI Ref. 56.4.477 - Operational Guidelines and Code of Practice (OGCP) for stainless steel products in drinking water supply" as regards the suitability of stainless steels in various types of water at the temperatures normally encountered in the supply or treatment, it offers what is contained in tab. 2.

The same document specifies that for higher temperatures and pH lower than 6 it is good to refer to the experience of specialists and also underlines how the presence of specific conditions of use can affect the limits proposed above. For example, in the presence of interstices, the limits of use are cautiously reduced from 200 to 50 ppm for 304 (or 304L) and from 1000 to 250 ppm for 316 (or 316L).

TAB|02| Le indicazioni del Drinking Water Inspectorate - DWI Ref. 56.4.477

Tipo di acqua	Livello di Cloruri ppm	Commenti	Tipo di acciaio inossidabile – Nome più conosciuto
Acqua pura	-	-	304
Acqua di rete	<350	1.4301 (304) utilizzabile fino a 200 ppm	304, 316
Acqua dolce o di falda	<1000	1.4301 (304) utilizzabile solo fino a 200 ppm	304, 316 2205, superaustenitici, superduplex
Acqua salmastra	10.000-15.000	Per acque du estuario o di zone costiere il 2205 è utilizzabile solo fino a 3.600 ppm	2205, superaustenitici, superduplex
Acqua di mare	15.000-26.000 (2,5-4 % NaCl)	-	Superduplex, superaustenitici

Stainless steels and drinking water

The stainless steels which, at present, have found greater use in the water cycle are those of the austenitic chromium-nickel or chromium-nickel-molybdenum series, in particular the types AISI 304 / 304L (EN 1.4301 / 1.4306) and AISI 316 / 316L (EN 1.4401 / 1.4404), in the commercial formats readily available on the market, although the duplex types, type 2205 (EN 1.4462) and ferritic types, type 444 (EN 1.4521), already boast numerous applications.

TAB|03| Composizione chimica degli inox generalmente impiegati nel settore dell'acqua potabile

EN	AISI/ Type ASTM	C max	Si max	Mn max	P max	S max	N max	Cr	Ni	Mo	Altri
1.4301	304	0,07	1,00	2,00	0,045	0,015	0,11	17,0÷19,5	8,0÷10,5	-	-
1.4307	304L	0,03	1,00	2,00	0,045	0,015	0,11	17,0÷19,5	8,0÷10,5	-	-
1.4401	316	0,07	1,00	2,00	0,045	0,015	0,11	16,5÷18,5	10,0÷13,0	2,00÷2,50	-
1.4404	316L	0,03	1,00	2,00	0,045	0,015	0,11	16,5÷18,5	10,0÷13,0	2,00÷2,50	-
1.4521	444	0,025	1,00	1,00	0,040	0,015	0,030	17,0-20,0	-	1,80-2,50	Ti: da [4x(C+N)+0,15] a 0,80
1.4462	2205	0,030	1,00	2,00	0,035	0,015	0,10- 0,22	21,0-23,0	4,5-6,5	2,5-3,5	-

At the level of decrees and standards, confirming this fact, in Italy there is a positive list of stainless steels contained in the Ministerial Decree of 21 March 1973 which establishes the "Hygienic discipline of packaging, containers, utensils intended to come into contact with substances. for food use or with substances for personal use ". This list includes, with the relative updates, more than thirty stainless steels, among which the most used are certainly AISI 304 and 316 (EN 1.4301 and 1.4401) with the relative low carbon variants, 304L and 316L.

TAB[05] Inox per contatto alimenti previsti dal DM 21.3.1973

Austenitici	202 – 301 – 302 – 303 – 303Se – 304 – 304L – 305 – 308 – 316 – 316 L – 316Ti – 316N – 321 – 347 – NTK D11
Ferritici	430 – 430F – 1.4590
Martensitici	410 – 414 – 416 – 420 – 431 – 440
Duplex	329 – 329N – 2205 – 2304 – 2101
PH	630

The same decree refers to art. 37 specific migration limits for stainless steel objects intended for prolonged or short contact with food substances. These limits, set at 0.1 ppm maximum for both trivalent chromium (Cr III) and nickel (Ni), are well above the actual values found in practice. The limits of the Italian decree have been set on the basis of conventional tests to rightly safeguard the health of the consumer. Furthermore, in Italy, Ministerial Decree no. 174 "Regulation concerning the materials and objects that can be used in fixed systems for the collection, treatment, adduction and distribution of water intended for human consumption", a specific law for materials suitable for contact with drinking water; as regards stainless steel, this document refers to the positive list contained in the aforementioned Ministerial Decree 21/3/73 (table 5) to establish the types of stainless steel suitable for contact with the staple food, i.e. water.

At Community level, in repeal of the EEC directives 80/590 and 89/109, the EC regulation 1935/2004 of 27 October 2004 was issued, concerning materials and objects intended to come into contact with food products which, in the case stainless steel refers to the individual laws of the countries of the European Community. There are also some national laws and regulations relating to the use of stainless steel in the drinking water sector.

Speaking instead of water quality, "Council Directive 98/83 / EC of 3 November 1998 will concern the quality of water intended for human consumption" establishes the requirements for it to be considered drinkable. Regarding the influence that the material may have on the characteristics of the water, it should be noted, however, that transfer tests, commissioned by the European Community to some national laboratories, revealed extremely positive results for stainless steel.