WHITE PAPER

WHAT'S IN YOUR STAINLESS STEEL?

This White Paper discusses the facts around the various types of stainless steel used in the evaporative cooling industry. EVAPCO wants to debunk claims, being made by a single manufacturer, that Type 301L Stainless Steel is superior to Type 304 Stainless Steel.

It is safe to say that an owner expects a new evaporative unit to meet the capacity it was designed for. It should also be made of high-quality materials to maintain a long service life.

CTI (Cooling Technology Institute) certification gives buyers peace of mind that the unit will meet the design capacity when it is commissioned in the field. There is no "third party" validating appropriate grades of stainless steel when upgrading an evaporative unit's materials of construction. Every equipment manufacturer has been able to use whatever grade they choose. This has allowed one manufacturer to supply a lower grade, less corrosion resistant stainless steel while marketing it as a superior product.

Marketing claims continue to swirl around Series 300 stainless steel in the evaporative cooling industry. Used in a broad range of industries, type 304 stainless steel is the most widely used of all stainless steels.[1] Other types of austenitic stainless steel used to manufacture evaporative cooling equipment are shown in the table below.

Type	Chromium Content wt%	Nickel Content wt%	Molybdenum Content wt%	Carbon Content wt%
301L	16.0-18.0	6.0-8.0	0.0	0.03
304	18.0-20.0	8.0-12.0	0.0	0.08
304L	18.0-20.0	8.0-12.0	0.0	0.03
316	16.0-18.0	10.0-14.0	2.0-3.0	0.08
316L	16.0-18.0	10.0-14.0	2.0-3.0	0.03

Table 1 – Design guideline for the selection and use of stainless steel

Evapco and other leading evaporative equipment manufacturers all used grade 304, 304L, 316 & 316L stainless steel for their upgraded materials of construction – up until around 2008. As seen in the graph to the right, the price of nickel increased at that time which led some manufacturers to seek lower cost options. "301 SST is a lower cost alternative to the conventional high nickel austenitic stainless steels, such as 304 SST."[2]

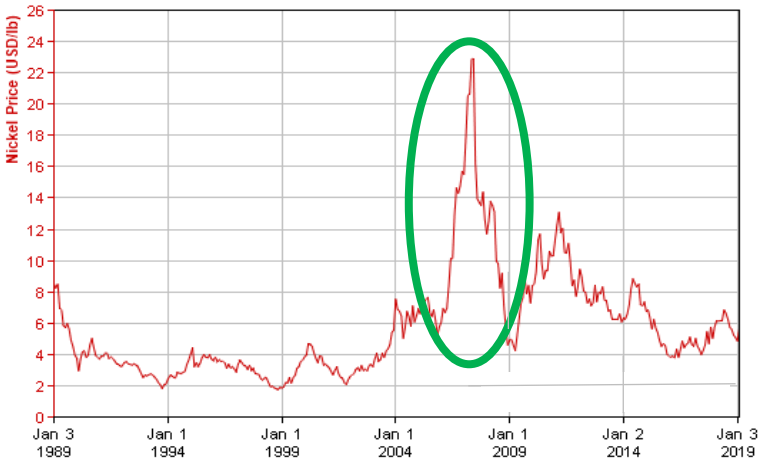

Figure 1 - Historical nickel prices[3]

Let's explore some of the marketing claims being made by a single manufacturer.

Marketing Claim 1: "Away from the weld, 301L and 304 steel show equal corrosion resistance."

Analysis 1: High levels of chromium allow stainless steel to form a renewable chromium-oxide layer. This ultra-thin layer (passive film) protects wetted areas, such as the cold and hot water basins, from general corrosion. "The elements with the greatest *positive* effect on resistance to general corrosion are; chromium, molybdenum, nickel and copper."[4]

The primary difference between 301L and 304/304L grades of stainless steel is the amount of chromium and nickel added to the alloy as neither include molybdenum. "In general, the greater the amount of chromium added, the higher the corrosion resistance."[5]

Nickel serves two purposes in the alloying of stainless steel. "The primary function of the nickel is to stabilize the austenitic structure of the steel at room temperature and below. The minimum amount of nickel that can stabilize the austenitic structure at room temperature is around 8%, which is why it is the percentage present in the most widely used grade of stainless steel, namely Type 304."[4] Nickel can also reduce the rate of general corrosion since it is a more noble metal than chromium or iron.

The higher chromium and nickel content afforded by 304/304L stainless steel also greatly impacts local corrosion properties. "Pitting corrosion and crevice corrosion are both quite common and are often collectively referred to as 'local corrosion'."[4] Due to the localized nature of the attack, crevice and pitting corrosion typically create leaks or failures more quickly than general corrosion.

Aggressive anions in the water are the most common instigators of pitting and crevice corrosion on stainless steel. Individual alloys resistance to pitting can be calculated using the following Pitting Resistance Equivalent Number (PREN) formula.

$$PREN = \%Cr + (16.0 \times \%N) + (3.3 \times \%Mo)$$

Stainless Steel Type	Chromium wt %	Nitrogen wt %	Molybdenum wt %	PREN
301	16.0-18.0	0.1	0.0	17.6-19.6
304	18.0-20.0	0.1	0.0	19.6-21.6
316	16.0-18.0	0.1	2.0-3.0	24.2-29.5

Table 2 – PRENs for various stainless steel

Table 2 illustrates that Type 301 stainless steel has a PREN up to 19% less than 304 stainless steel and a PREN up to 40% less than 316 stainless steel. The higher the PREN, the more resistant the stainless steel is to chloride induced pitting.[5] The majority of stainless steel technical websites do not even list 301/301L when comparing the different grades of stainless steel and their corrosion resistance. This is because 301/301L is a stainless steel not commonly used for welded fabrication and thus is not typically used in corrosive environments like 304/304L and 316/316L.

Marketing Claim 2: "At the weld, 301L is more corrosion resistant than 304 steel due to its low carbon content."

Analysis 2: Carbide precipitation, also called sensitization, can occur during welding of stainless steel with higher carbon content (0.08% max). The "L" refers to stainless steel with *lower carbon content* (0.03% max), which reduces the risk of carbide precipitation. EVAPCO uses both 304 and 304L, not 301L, for exceptional quality. The entire unit needs to be protected against corrosion – not just the welded regions. This is why a 304/304L stainless steel unit is superior to one made of 301L.

Industrial applications, coastal and harsh environments

There are times when upgrading from 304/304L to 316/316L stainless steel is the right choice. This is true for coastal regions, high temperature applications, and areas with high chloride concentration in the makeup water.[5] The steel's ability to resist chloride pitting rapidly reduces when the recirculating water temperature increases inside the evaporative unit. 316/316L stainless steel is comprised of 2-3% molybdenum which gives the surface film a high degree of protection against chloride attack.

EVAPCO's Water Analytical Lab is equipped to test for chlorides and other ions in the makeup water; helping owners decide on the best materials of construction for their unit. Some manufacturers do not encourage the use of 316 stainless steel, regardless of the environment, because they will lose their low-cost edge.

Figure 2 – Stainless steel cooling towers

Regardless of application, a 304/304L or 316/316L evaporative unit is superior to one made of 301L. Cutting costs on the materials of construction *NOW* puts a building or process at risk of downtime *LATER*.

Contact EVAPCO for more information when selecting a stainless steel unit

References

1. Covert, R. (2000, July) *Stainless Steel: An Introduction to Their Metallurgy and Corrosion Resistance*
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