cobra consultancy

Investigation report microbiology corrosion Stainless steel

Wine tanks and heat exchangers.

Customer: Two companies

Auteur: J. van Duijn Cobra Consultancy
Report number: 1- 15043
Data: December 2025
Page number: 1
Pages 8. incl. Attachment

Stainless steel AISI 304 winetanks

Stainless steel AISI 316 heat exchanger

Introduction

France is known for its most famous and leading wines, with Europe's largest vineyards and an enormous diversity of quality wines from regions such as Bordeaux, Burgundy, Alsace, and the Loire.
In one of those regions, stainless steel wine tanks were manufactured.
These stainless steel wine tanks are equipped with stainless steel cooling fins to precisely control the temperatures during wine fermentation. This prevents the yeast from dying due to overheating and ensures the desired development of aromas and flavors.

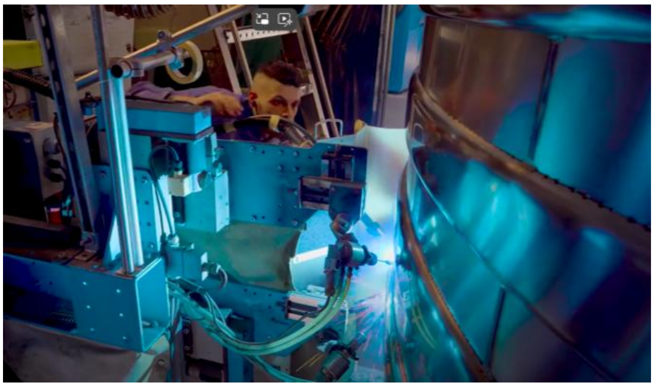
Manufacturing Process

The cooling fins are first tack-welded around the circumference and then automatically welded around the circumference (orbital welding). See photos.
Based on experience working at Vecom at the time (see Publications www.cobraconsultancy.nl) , the ultra-thin oxide layer that protects stainless steel against corrosion must be pickled after welding.

Post-Welding Concerns

No forming gas and no pickling process after welding?
During the welding of the stainless steel cooling fins, one should purge or make the inside oxygen-free, for example, with argon gas. However, this is difficult to achieve during this welding procedure, which is all the more reason to pickle the welds after welding.
If this has not been done, corrosion can occur more readily, especially because the so-called heat-affected zone next to the weld is more susceptible to corrosion.

Tack welds



All-round welding automatic orbital.

The wine tanks were pressure tested after welding using local drinking water containing elements such as calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate ($HCO3^-$), and traces of others like iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and sometimes chlorine for disinfection. These elements were present in significant amounts based on the drinking water analysis results. After manufacturing, the tanks were not immediately put into use but stood for months on the winery grounds exposed to sun, weather, and wind due to limited space at the tank supplier.

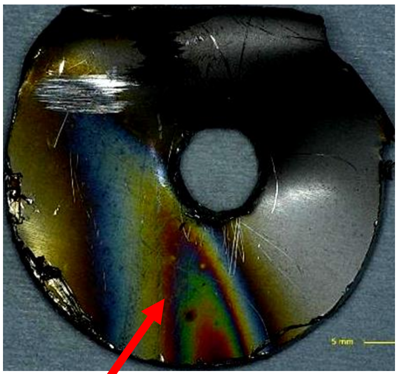
Storage and Initial Issues

The tanks were not purged after testing—ideally with nitrogen, but not even with air—leaving water residues in the cooling fins for months before installation. The first tanks showed leaks immediately upon commissioning, with 27 out of 54 tanks exhibiting leakage symptoms in total.

Cobra Consultancy Rechthuisstraat 19 2391 DB Hazerswoude dorp
Tel.: (+31)172 586002 /Fax.:(+31)847194990/ Internet: http://www.cobraconsultancy.nl / E-mail:info@cobraconsultancy.nl
KvK Leiden 28066857 / BTW NL 06.74.88.341.B.01

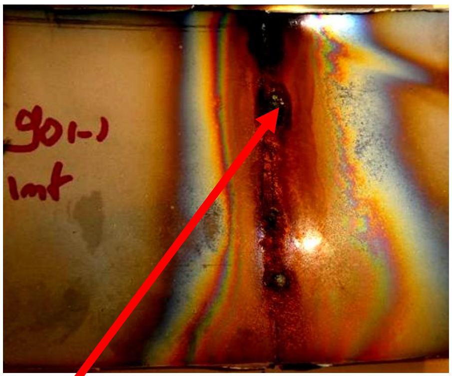
Leakage Cause

The leaks in the stainless steel wine tanks are definitively due to residual water in the cooling fins. Sections of stainless steel were cut from the cooling fins for investigation, and given the discolorations and black areas in the welds, microbiological corrosion is suspected as the cause of the cooling fin leaks. To confirm microbiological corrosion, residues near one of the many leak sites were scraped with a cotton swab and sent for microbial analysis, yielding the following results.



M.I.C. wine tank

Example M.I.C. other company



M.I.C. wine tank

Sulphate-reducing bacteria (SRB) are most commonly associated with MIC. These bacteria utilize sulphate as an energy source, thereby releasing highly toxic hydrogen sulphide (H_2S) into their environment. Besides generalized corrosion, H_2S causes other significant issues, including the characteristic rotten egg Odor, material blackening, and slime buildup. They grow under anaerobic conditions (without using oxygen) in environments containing sufficient sulphate and organic matter. To determine the role of microorganisms in this corrosion problem, a sample was taken from the system for analysis. Based on this investigation, a total bacterial count of 1.8×10^4 and sulphur-oxidizing bacteria of 2.2×10^5 were detected in relatively large numbers. The high total bacterial count indicates that a biofilm formed on the surface where the swab (swab tube containing cotton swab) was taken. Of the MIC targets, sulfur-oxidizing bacteria were demonstrated. These bacteria use sulphide (S^{2-}) or sulphur (S) as an energy source and thereby produce sulphate (SO_4^{2-}). This group of microorganisms directly influences the corrosion process through production of sulfuric acid (H_2SO_4). Given the aforementioned discolorations of the stainless steel and the analysis, microbiologically induced corrosion has occurred here.

microbial analysis

Microbiële qPCR analyseresultaten

Monstercode	Uw monsternaam	Datum bemonstering	Monstertype
001	901	-	Swab

Per monster wordt de detectielimiet van de analyses bepaald aan de hand van interne controles, deze kunnen daarom per monster variëren. De eenheid van de detectielimieten en van de analyses is aantal cellen per swab, waarbij wordt aangenomen dat 1 DNA-kopie gelijk staat aan 1 cel.

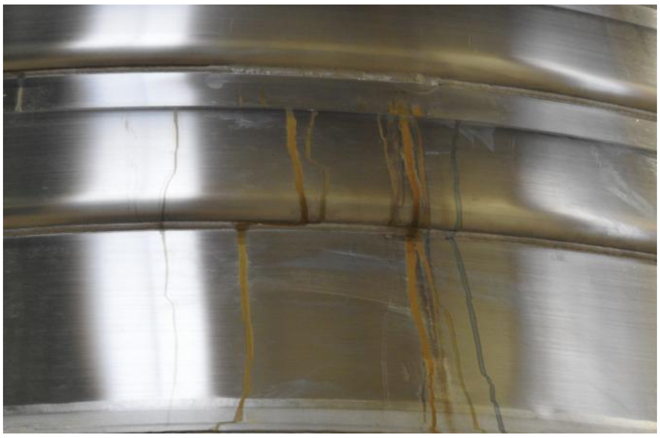
Monstercode	001 (cellen/swab)
Monsterspecifieke detectielimiet	3,3x10^4
Totaal Bacteriën	1,8x10^8
Totaal Archaea	2,4x10^5
IJzeroxiderende bacteriën (*Gallionella* spp.)	n.a.
IJzerreducerende bacteriën (*Geobacter* spp.)	n.a.
Sulfaatreducerende bacteriën	n.a.
Zwaveloxiderende bacteriën	2,2x10^5
Zwavelcyclus gerelateerde bacteriën	n.a.
Methanogene archaea	n.a.

De spreiding van de analyseresultaten ligt tussen 0,5*N en 2*N (N=aantal gedetecteerde cellen of DNA-kopieën)
n.a. niet aangetoond

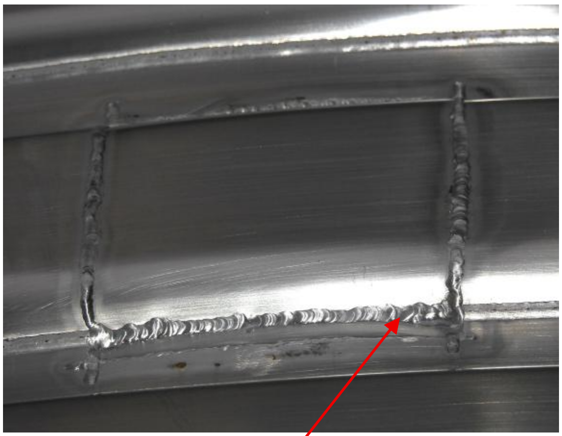
Cobra Consultancy Rechthuisstraat 19 2391 DB Hazerswoude dorp
Tel.: (+31)172 586002 /Fax.:(+31)847194990/ Internet: http://www.cobraconsultancy.nl / E-mail:info@cobraconsultancy.nl
KvK Leiden 28066857 / BTW NL 06.74.88.341.B.01

Inspection

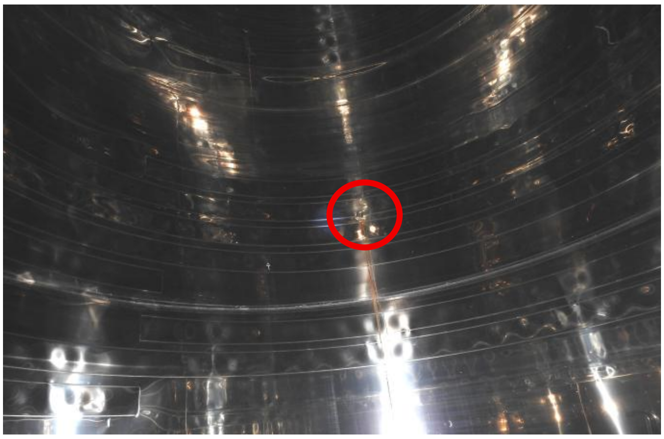
Leakage



leakage



Repair



Repair and leak again

Repair old leakage

Total 57 wine tanks

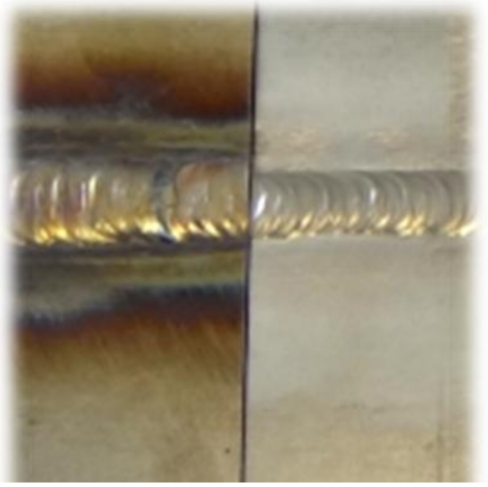
Cobra Consultancy Rechthuisstraat 19 2391 DB Hazerswoude dorp
Tel.: (+31)172 586002 /Fax.:(+31)847194990/ Internet: http://www.cobraconsultancy.nl / E-mail:info@cobraconsultancy.nl
KvK Leiden 28066857 / BTW NL 06.74.88.341.B.01

Conclusion and Recommendations

The leaks have arisen due to stagnant water in the stainless steel cooling fins of the AISI 304 stainless steel wine tanks, which stood outdoors exposed to the elements for months. In southern France, where the wine tanks are located, temperatures are higher than in the north, which also promotes the development of microbiological corrosion. Additionally, the cooling fins were not internally passivated, preventing the formation of the essential protective oxide layer on the stainless steel. Stagnant water in the cooling fins can lead to microbiological corrosion, which is clearly evident here from the cutaways (see photos on page 3) at the leak locations and the microbial analysis results. It is also recommended that the stainless steel wine tank manufacturer clean the cooling fins internally after welding and then passivate them with pickling solution followed by nitric acid. Once the aforementioned chemicals have restored the oxide layer on the stainless steel, the final step is to rinse the cooling fins internally with demineralized water until no iron (Fe) is detected. The aforementioned process unfortunately did not take place here, increasing the risk of corrosion of the protective oxide layer, particularly adjacent to the welds in the heat-affected zone. Failure to remove the local drinking water also contributed to the onset of microbiological corrosion, a rapidly progressing form that led to the existing leaks and may cause further ones.

Attachment: Vecom Pickling Process

None of the mechanical post-treatments provide sufficient corrosion resistance in critical applications, although all methods can achieve a clean weld appearance. The reason is that mechanical post-treatments can reintroduce contaminants, such as particles from removed oxide material, into the surface. These embedded contaminants, particularly foreign iron particles, can then act as initiation sites for corrosion in aggressive environments. In contrast, pickling only removes surface material, exposing the base stainless steel without contaminants and fully restoring its natural corrosion resistance. A pickling treatment is the only post-treatment that returns the corrosion resistance of the weld to the pre-welding level of the stainless steel, regardless of the steel grade, with no difference in effectiveness between immersion, pickling paste, or spray (Practical Recommendation No. LM.94.04 NIL, TNO – Netherlands Institute for Metals Research). It is crucial to rinse thoroughly with water after pickling to remove all pickling residues, with the final rinse using demineralized water.



Not pickling treatment. **After pickling treatment.**

Cobra Consultancy Rechthuisstraat 19 2391 DB Hazerswoude dorp
Tel.: (+31)172 586002 /Fax.:(+31)847194990/ Internet: http://www.cobraconsultancy.nl / E-mail:info@cobraconsultancy.nl
KvK Leiden 28066857 / BTW NL 06.74.88.341.B.01

What is MIC corrosion?

Everybody is familiar with the phenomenon of corrosion. Corrosion is the degradation of materials (particularly metals) through electrochemical reactions. Corrosion is the biggest threat to various materials that we are dependent on, such as potable water pipes, oil and gas pipelines, windmills, storage tanks, our car fleet and constructions like bridges. Worldwide, the annual costs of corrosion are estimated at 2500 billion dollars. A study from the Netherlands shows that corrosion damage is about 3% of the gross national product in our country (±27 billion euros).

Corrosion caused by microorganisms

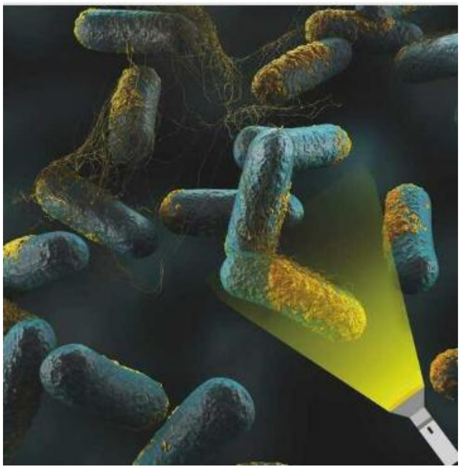
A lesser-known fact is that corrosion can also be caused or accelerated by microorganisms. This process is called corrosion or MIC (Microbiologically Influenced Corrosion).

We can explain the process of corrosion and MIC corrosion by using an apple as an example. If you cut an apple in half, it will become brown very fast. The substances in the apple that are reacting with the oxygen from the atmosphere cause this process. It looks as if the apple is rusting. If you leave these pieces of apple for a few days, bacteria and fungi from the environment will speed up the process of degradation. A similar process can occur with metals.

In approximately a third of the corrosion cases, microorganisms are involved. They are able to speed up the corrosion process by 10 to 100 times. Not only does MIC corrosion cause the degradation of the materials, it can lead to clogging problems as well. The clogging is induced by the slimy and stringy waste products that the microorganisms secrete. Furthermore, the metal particles that are released can also lead to the clogging of the filters.

MIC corrosion is a complex process. Microorganisms are capable of influencing or even initiating corrosion processes in various ways:

- Some microorganisms can cause the corrosion of metals through direct electron transfer (EMIC). With EMIC, the electrons are directly exchanged with the metal surface. As a consequence, the corrosion process is (strongly) accelerated locally.
- Microorganisms can form a biofilm when they stick to a surface. This process is similar to the formation of dental plaque on our teeth, which can lead to dental decay. Biofilms can consist of different layers. This three-dimensional structure is an ideal environment for microorganisms that attack metals.
- A lot of microorganisms produce acids. These acids accelerate the electron transfer and the corrosion process.
- The activity of the bacteria removes the formed corrosion products and therefore prevents a chemical equilibrium, which causes the corrosion process to continue.



Cobra Consultancy Rechthuisstraat 19 2391 DB Hazerswoude dorp
Tel.: (+31)172 586002 /Fax.:(+31)847194990/ Internet: http://www.cobraconsultancy.nl / E-mail:info@cobraconsultancy.nl
KvK Leiden 28066857 / BTW NL 06.74.88.341.B.01

Identifying the problem is the start of the solution

Do you suspect that microorganisms are the cause of your corrosion problems? Then it is important to determine this, because MIC corrosion requires a totally different approach from other forms of corrosion. In the absence of any intervention, the costs to solve the problems can be very high. In many cases materials need to be replaced sooner than initially expected and you could face consequential damages, such as leakage.

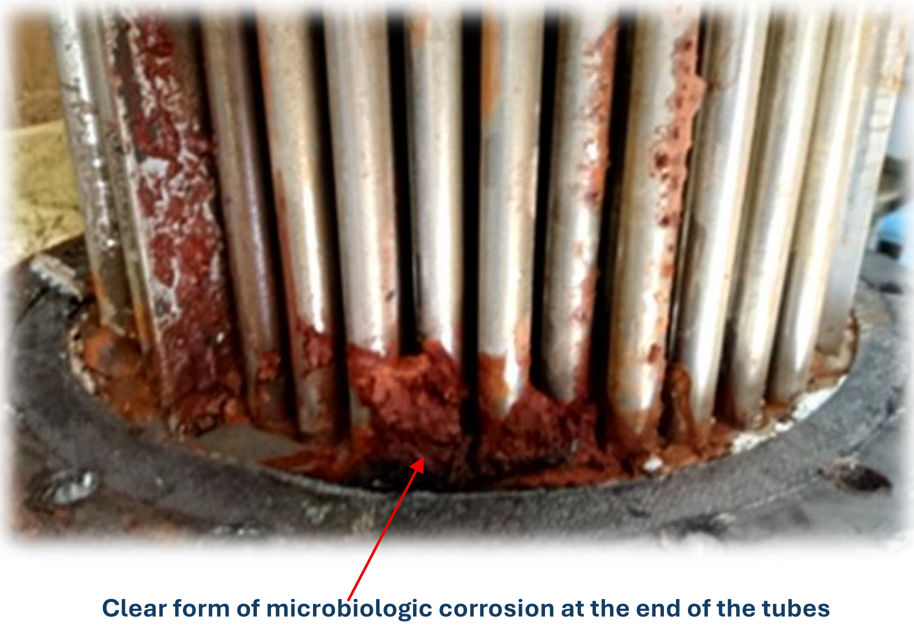
Microbial Analysis is specialized in diagnosing microbiologically influenced corrosion. We test whether MIC corrosion is present and determine the mechanisms that influence the formation of the corrosion in your situation. Our experience has taught us that in some cases, well-intentioned measures to prevent problems within a system can actually foster MIC corrosion. Therefore, identifying the problem is the start of the solution.

MIC corrosion of Stainless AISI 316L steel heat exchangers.

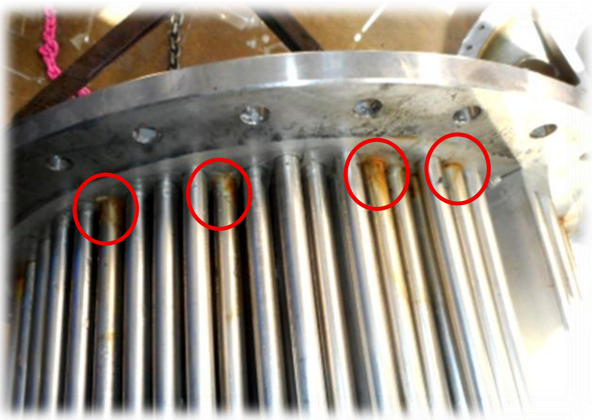
At the beginning of 2020, SARS-CoV-2 – the coronavirus that causes COVID-19 – was first detected in the Netherlands. This lasted until May 2022. During this time, many swimming pools were closed in which stainless steel mainly contained AISI 316L heat exchangers. These were also stopped during this period but not completely drained, so that water remained in them. And see here in the following photos the results of microbiological of stagnant water in the heat exchangers. More than 20 heat exchangers showed leaks during start-up!

Microbiologic corrosion AOSI 316L stainless steel heat exchangers

Cobra Consultancy Rechthuisstraat 19 2391 DB Hazerswoude dorp
Tel.: (+31)172 586002 /Fax.:(+31)847194990/ Internet: http://www.cobraconsultancy.nl / E-mail:info@cobraconsultancy.nl
KvK Leiden 28066857 / BTW NL 06.74.88.341.B.01



As leaky as a sieve **Clear form of microbiologic corrosion at the end of the tubes**



Incipient corrosion-elements from the drinkingwater to give rise to create microbiologic corrosion

When the heat exchangers are idle (regardless of the type of water), the risk of bacteria is much greater than when the installation is in operation. In addition to the fact that dirt and bacteria have a greater chance of precipitating and/or adhering to stagnant water, the quality of the water deteriorates due to the standstill and bacteria also have a greater chance of multiplying. The temperature of the pool water is within the range of temperatures, at which the bacteria can grow. Stagnation of the water in the heat exchanger should always be avoided. When the installation is shut down for some time, the heat exchanger must be drained and blown dry. Within the heat exchanger there are always a number of 'blind spots' and 'gaps', where there is less flow during operation. For example, in the (measuring) socks and in the support of the bundle and the bundle pipes. There is no escaping that. This again indicates that it is important that the bacteria (or algae) do not get a chance to get into the heat exchanger, are given time to nest and grow. The material used for the heat exchangers (AISI 316L) is suitable for swimming pool water.

Note:

Austenitic stainless steels such as AISI 304 and 316 are not suitable for fastenings in the vapour phase of swimming pools because of the risk of stress corrosion cracking when tensile stresses are applied to them, in the vapour phase of swimming pools, such as for ceiling fasteners and so on. But Cobra Consultancy has paid a lot of attention to this over the years and even rejected swimming pools for it. See Publications www.cobraconsultancy.nl

Cobra Consultancy Rechthuisstraat 19 2391 DB Hazerswoude dorp
Tel.: (+31)172 586002 /Fax.:(+31)847194990/ Internet: http://www.cobraconsultancy.nl / E-mail:info@cobraconsultancy.nl
KvK Leiden 28066857 / BTW NL 06.74.88.341.B.01