STAINLESS STEELS AND THEIR CORROSION

All you need to know about stainless anchors and so far (ahi!) we have not yet said …

INTRODUCTION

The problems encountered in recent years in this regard , especially after the incidents successes in 2012 in some coastal areas of the world, lead us to take stock of the situation to study the issue, to understand logic and limits of " what to do " and finally propose possible remedies and the best lines , in our opinion , of conduct.
Our company, since its inception in 1993, has always thought of entering in the market of the mountain with the best possible products. And so, with regard to the anchorages, propose them all exclusively in stainless steel.
It was a strategic innovative choice, thinking first of all to quality and safety.
The few other manufacturers of the same items diversify the offering proposing also galvanized steel or aluminium. They're also excellent materials, but less suitable for “universal” use.
We chosen a “integralist” course of action and so, the adopted material was exclusively the stainless steel AISI 304 (standard EN 10088/3 - X5CrNi 18-10 - W. 1.4301).
It is a great stainless steel, a noble material created for specific uses and details and very well used in various industries such as food, chemical and mechanical.
The caracteristics of mechanical strenght, corrosion resistance, tenacy (resilience) and not excessive costs, made it the ideal material for the realization of anchors in alpine environment and of mountain in general.
We can say that none of our anchors, sold and held in place in the walls of the hinterland around the world, has never expressed corrosive problems.
If in some cases there still was corrosion, this was caused by factors of mismanagement, incorrect “modis operandi” generated by an approximate preparation of the positioning of the anchors.
But certainly we do not want to point the finger at anyone, but rather a part of "guilt" was even ours because we not have properly informed the climbers about the fixing mode and told them how to better "move" to protect adequately their climbing routes.
Unforunately in marine environment or close to the sea (even for a few km ...) this material has proved not just ideal, showing corrosive problems with extremely dangerous consequences.

We should be emphasized that, however, the breakage cases are extremely rare, or very rare, especially in relation to the amount of material placed in this environment.
This document seeks briefly, to open a possibly definitive chink of light about the topic.
Understand what you are talking about.
What scares all the humans, like in general, the animals is the unknown, that is what you can not kept under control.
A danger or a threat if well known, not scary because we know how to address them. Here, we hope that after reading this paper you better know how to deal with the issue, and aware about where the dangers are hiding and how to avoid them.
Warning! Some problems are not entirely circumvented, in any case, but they are still faced and must eventually be aware of the risks to which it meets.
We'll only talk about the topic that competes us and that is relative to our production.
The anchor types are varied but those who are outside the traditional “spit” are out of our discussion.
“Spit” mean all those expansion “nails” that to be used, require the making of a hole in the rock. They are also called “CHIPER”, an acronym that stands for “CHIodi a PERforazione” (perforation nails).
At the end of the document we'll try to draw clear conclusions and especially to argue why we've finally decided to change all the material used for our anchors and adopted a certainly better one.
In order to understand the most of everything and to be better informed about the characteristics of the products it's good to read the following elaborate that we think quite exhaustive about stainless steels.
Everyone can find this material navigating the immense on the Web but here it's condensed into a few synthetic paragraphs. The argument on stainless steels is actually very complex and yet we believe that what is reported below is sufficiently exhaustive.

STAINLESS STEELS AND THEIR CORROSION

Stainless steels are **alloys based on iron, chromium and carbon**, optionally containing other elements such as Nickel, Molybdenum, Silicon, Titanium, Niobium, Sulfur, Phosphorus, Manganese, Nitrogen, Copper, etc.
They are defined **steels** for the fact that, in the presence of an oxidizing environment (therefore also in contact with the air that contains oxygen), **on their surface is formed a protective layer** consisting of adsorbed oxygen. It's the so-called phenomenon of **passivation**.
This phenomenon in stainless steel, in ideal conditions, occurs naturally and immediately. As soon as this metal is nicked or cut, removing a part, the protective layer is regenerated immediately (if conditions persist ...) However, this protection can be artificially induced and in a optimally way, carrying out a particular chemical treatment by immersing in sequence the products, before in a pickling acid and subsequently in a passivating acid.
This treatment exalts in a very significant way the corrosion resistance. This invisible layer has the thickness of a few atoms (about 0,002 microns) and which reform spontaneously, as already pointed out, in case of destruction, constitutes an excellent barrier to the continuation of **oxidation**, and thus **corrosion**.

Indispensable condition because such a protective layer is forming is the **presence of a sufficient amount of Chromium.**

TYPES OF STAINLESS STEEL

In order to their **structural behavior**, which varies as a function of their chemical composition, you can divide stainless steels in:

- **martensitic**
- **ferritic**
- **austenitic**
- **austenitic - ferritic**

MARTENSITIC STAINLESS STEEL

They are essentially the only **chromium steels** (11-18 %) that may contain small amounts of other elements. These steels can **increase their mechanical characteristics** of tensile strength, elastic limit and hardness, by means of a tempering treatment. [By varying the heat treatment temperature and the percentage of Carbon and chrome present, you can get a very wide range of mechanical properties*].*

Following the tempering treatment, **to decrease the excessive embrittlement** of the martensitic steels, it's desirable (and often necessary), to follow a second process, called tempering. It is a **heat treatment at 150-200 °C**, which also ensures the best conditions of **corrosion resistance.**

A tempering at **600-650 °C** after hardening, ensures the best conditions of workability, while maintaining good mechanical characteristics and corrosion resistance.

Martensitic steels are particularly suitable for the **construction of mechanical parts subjected to substantial loads and to the wear** in not excessively corrosive environments (eg. Blades for steam turbines).

FERRITIC STAINLESS STEEL

They are essentially alloys of Iron-Chromium-Carbon with possibly minor additions of other elements. Their main characteristic is to have a ferritic structure at all the temperatures, and therefore they are not likely to increase their mechanical characteristics for effect of the heat treatments.

These steels are characterized by a **sharp drop in toughness** at temperatures just below at those of the environment, for this they are **the less suitable steels for use at low temperatures**.

We must take into account that these materials, if not "stabilized" by the presence of suitable ligands, **posing a significant phenomenon of embrittlement** for stays at temperatures between

400 and 600 °C, although not overly prolonged. This phenomenon occurs when the material returns to room temperature. Hence the need of **particular measures during the welding processes.**

Their **ease of cold forming**, their **corrosion resistance** in environments of medium aggressiveness, combined with the **good polishability of the surfaces** (which improves the resistance to the corrosive agents, providing an aesthetically very appreciable look), gives to these materials a very wide field of use, from automotive industry to construction, from household appliances to cutlery.

AUSTENITIC STAINLESS STEEL

They are characterized by a stable austenitic structure at any temperature, so they are not likely to improve their mechanical characteristics for effect of heat treatments. Depending on their chemical composition and their characteristics of use, they can be divided into three groups:

- **Austenitic Cr-Ni**, characterized by the presence of 16-20% Cr and 7-12% Ni , with possible addition of other elements such as sulfur and selenium, which facilitate machining by chip removal, or Titanium or Niobium such as stabilizers of the Carbonium to prevent the formation of chromium carbides. Possesses not high mechanical properties at room temperature, but remain high at very low temperatures. Also they have a good resistance to fatigue and corrosion in almost all aggressive environments. For this they are very used in the food and chemical industries, in medical appliances, utensils for the kitchen and cookware.

- **Austenitic Cr-Ni-Mo**, characterized in chemical composition from 16 to 18 % of Cr, from 10 to 18 % of Ni and 2-6 % of Mo. The presence of the latter element (molybdenum) gives to these steels a particular resistance to pitting corrosion, thus allowing the use even in stronger chemically aggressive environment and also in the presence of solutions containing Chlorine ions. The excellent corrosion resistance of this class of steels permits their use in the **manufacture of installations for the processing of nitrates, of cellulose, of natural and synthetic fibers.** They are also used in shipbuilding and in the food industry with machining of particularly aggressive products (fruit pickles , fruit juices) and in the wine industry, for the storage of white wines and vermouth, particularly sensitive to any trace of iron that enters into solution.

- **Refractory**, are distinguished by the characteristics of **mechanical strength** and **corrosion resistance** which maintain even at rather high temperatures. They are used in the manufacture of elements of furnaces for heat treatments, of ovens and coolers for the cement plant, molds and equipment for the processing of glass, manifolds of endothermic engines.

AUSTENITIC-FERRITIC STAINLESS STEEL

Commonly referred as **"duplex"**, they are steels with Chromium contents of more than 16% and other elements such as nickel, molybdenum, manganese, silicon. They have a mixed structure of austenite and ferrite.

They offer a considerably better weldability than that of ferritic steels and at the same time characteristics of resistance to corrosion under tension, higher than those of austenitic steels. They are also almost free from the danger of intergranular corrosion. They have a **resistance to pitting corrosion superior to the ferritic types** and a resistance to corrosion in strongly acidic environment similar to that of austenitic steels.

The **mechanical characteristics** at room temperature are superior to those of the ferritic types, the fatigue strength is higher than austenitic steels. It follows the interest that is actually shown in respect of these steels in the case of **applications in the marine environment**, strongly subject to corrosion, and also in the case of **treatment of salted food substances**.

THE SUPERFICIAL FINISHES

Whether on finished products of steel, both in the artifacts of stainless steel, the surface condition has a not only aesthetic high importance, but also of the inherent resistance to the corrosion of the material.

The corrosion resistance, in principle, will be much higher the greater will be the sanding of the surface, that is, the lower will be the surface roughness of the stainless steel element.

In addition to these factors it must be considered also others, such as the **bond** that exists between the **cleanability** and the **greater or lesser smoothness of a surface.**

PRINCIPAL TYPES OF FINISHING

- **2B finish:** it's the finish made by a cold rolling skin pass with polished cylinders. Its appearance is bright silvery gray and it is the most common finish for cold-rolled sheet.

- **BA finish:** it's a finish of sheets and cold-rolled strip obtained by the thermal annealing treatment, re-cristalizzation or solubilization in an inert atmosphere after rolling and the subsequent degreasing. Given the type of heat treatment, the material is not oxidized and therefore it is not need the pickling operation, thus maintaining a very bright and shiny aspect, almost perfectly specular, which results from the cold rolling. *(Followed to a possible further rolling skin pass).*

THE “ENEMY” OF THE STAINLESS STEELS: THE CORROSION

One the peculiar characteristics of the stainless steels and one of the reasons for the continuing spread of their use is certainly their **resistance to corrosion**.

It would be wrong to think that these materials can hold wherever and however, to that **set of phenomena of degradation** that goes by the name of corrosion.

Their resistance depends in fact from many factors:

- the intrinsic conditions (mainly on their constitution analytical and structural)
- the type of environment in which they are
- the way in which they are coupled together or with other materials
- the technological events which they have been subjected
- the conditions of implementation
- the design of the particulars and from the whole … and so on ...

The phenomenon of corrosion, if observed more carefully, can show up in a very different way and therefore it is important to know the **mechanism** and **causes** that generate it, in order to take appropriate action in the choice of materials to use.

The most dangerous types of corrosion are usually those **localized**, which may give rise to the formation of cracks, holes, etc ...

On the contrary, generalized phenomena are the least dangerous, because they manifest in a form of progressive aggression and fairly constant in time. This allows to determine, with sufficient approximation, the duration of the material concerned from corrosion. However determine quite precisely the duration of an artefact placed in an aggressive environment it's a very difficult task, because the parameters which determine it are extremely complex and diversified between them.

MAIN TYPES OF CORROSION

GALVANIC CORROSION

It occurs when, in the presence of an electrolyte (an acid solution, saline, atmospheric humidity), two different metallic elements are directly connected to each other with electrical continuity, forming a real "battery”.

Among them what will corrode faster will be the one that will be more anodic. Therefore it is not recommended to combine it with nails or screws of aluminum or of common steel, stainless steel parts immersed in corrosive environments.
Also it is not be recommend to contaminate the stainless steels with more anodic materials (for example common steels) given that **small traces of these would corrode more quickly.**

Instead it is always desirable, when there are the conditions for the occurrence of a galvanic corrosion, to unite stainless steels with other parts made of stainless steel.

CREVICE CORROSION

Crevice corrosion is a type of localized corrosion and it can arise when an artifact presents the interstices between two coupled surfaces. It is manifested in the presence of solutions containing reducing ions, such as the chlorine ion, within the interstices created by the surface contact between different artifacts, including organic, in such a way that the fluid inside the interstice is not requited with the outer.

Initially the solution inside the interstice is equal to the outside to it and the passive anode current and it is balanced by the cathodic reduction of oxygen. **Due to the size of the interstice and to the slow diffusive motions, the oxygen inside the interstice it is consumed and it is not completely replaced from the outside oxygen.**

When all the oxygen is consumed within the interstitium, the metal is still passive, but the passivity current within the interstitium is balanced by the reduction of outside oxygen and thus there is a separation between anodic and cathodic area.

The passivity current continues to transfer metal ions through the passive film but while outside the phenomenon is balanced by the oxide reduction, inside the interstice there are the hydrolysis of metal ions and the migration of chloride ions from the outside, which generate acidity, bringing the pH values more and more low.

When the pH, because of acid hydrolysis of the chloride ions, reaches a critical threshold, which depends on the intrinsic characteristics of the material, there is the breaking of the passive film and begins the phase of deep corrosion with a controlled speed of ohmic drops between anodic area (internal to the interstice) and cathode area (outside the interstice).

PITTING CORROSION

Pitting corrosion is a localized corrosion that it is manifested superficially with small holes, in certain cases invisible to the human eye, surrounded by a halo of dark color and a series of underlying cavity that develop in depth. The corrosive phenomenon is preceded by a step of trigger that tears the oxide protective film, because of the condition of the surface of the article and the environment in which it operates.

It's a type of “localized” corrosion that, for its characteristics is very dangerous, since it acts in depth on very restricted areolas. These effects can easily escape to a visual inspection, and so the damage progresses until to perforate the part attacked.

Factors that may facilitate the onset are different: surface roughness (as smooth is a surface as much less it's subject to corrosion) , surface chips or ferrous contamination. Typical environments suitable to develop pitting corrosion are the **sea water** and, in general, **the water containing**

chlorine ions, especially if stagnant. In general, the maximum corrosion resistance there will be using special steels with high molybdenum content.

Other regimens that can put in place are: ensure the highest **decontamination of surfaces** from traces ferrous, employ corrosion inhibitors, avoid the presence of the interstices between the surfaces of the article in contact with the medium aggressive.

STRESS CORROSION CRACKING

Stress corrosion cracking “SCC” is a localized corrosion that is manifested when, under particular environmental conditions, the material is subjected to the combined action of a mechanical stress, in particular a tensile stress, and also a corrosive environment of mild corrosive action that, in the absence of the state of tension, would have given rise to a different kind of attack.
The cracks are usually also branched inside the material and have a trend almost perpendicular to the direction of tensile stress; they have a trend:
Transgranular: when cracks cross the grain structure.
Intergranular: when cracks propagate along the grain boundaries.

This is, as already said, a phenomenon of localized corrosion and it is particularly worrying because it grows in depth and very fast in the article attacked.
Generally occurred without any particular warning signs and stops when the tensile stress is terminated.
The cause of the onset of this phenomenon is due usually to states of external stress, temperature fluctuations or from internal stresses, generated by plastic deformation such as bending, welding, padding etc.

The precautions to be taken to avoid the occurrence of this type of corrosion are: remove the tensions generated by machining, accurately study, during the project phase, the artefact or the installation, so as to prevent, during its realization and exercise, to generate states of tensile stress.
Use designed materials conceived to be inherently suitable to resist better to this type of corrosion,“SCC”.

CORROSION FATIGUE

It is manifested **on the entire surface of the element** subjected to the coincident action of the cyclic stress and of the environmental aggression, with the appearance of cracks. The environments that favor the occurrence of this type of corrosion are the **sea water** and the **solutions of chlorides**.
To prevent the phenomenon it's necessary to operate simultaneously in different directions: in the choice of the more suitable to use type of steel, in the design phase, trying to minimize the vibratory phenomena that generate the states of cyclic stresses.

INTERGRANULAR CORROSION

It's a type of corrosion **caused by aggressive agents** which attack the grain boundaries of stainless steels, when, after the occurrence of thermal events, they prove to be sensitized.
A **stainless steel is *sensitized*** when it remains also for a short time, at certain temperatures, which cause **the loss of mechanical strength and toughness characteristics of the material**.
The **temperature to be harmful** is between 450 °C and 850 °C for austenitic stainless steels, higher than 950 °C for ferritic steels, and between 250 °C and 1300 °C for austenitic steels.

For the **danger of intergranular corrosion**, when operating in environments such as to provoke it, it is appropriate to consider some warnings, such as: **avoid the use of materials sensitized**, **employ stabilized stainless steels** or with low carbon content.

CORROSION EROSION

It's is originated from the flow of a fluid, even mildly corrosive, when are present, on the stainless steel surface, solid particles capable of causing a mechanical wear.
This is the case of **brackish water or wastewater** containing abrasive particles in suspension. The attack occurs much more severely than is the greater the amount of solid in suspension in the fluid. It therefore occurs, in particular, in correspondence of **tight bends of pipes, in the grafts "T" of pipes, in the pump rotors and in the turbine blades.**
To overcome this type of corrosion is necessary to predispose a careful design of the parts so as to avoid turbulent motions of the fluid, sudden changes in direction in the flow velocity, avoid or reduce the presence of suspended solids.

[Obviously, when this is not possible beyond a certain limit, it is necessary to choose between stainless steels than have a greater corrosion resistance or a good wear resistance].

It should however be remembered that stainless steels usually have a good resistance to this kind of corrosion and are able to withstand higher fluid velocity, compared to other alloys.

CAVITATION CORROSION

It occurs by attack of the metal surface of a fluid, even in the absence of abrasive solid particles, for causes purely fluid dynamics, when the speed of the fluid-wall is very high.
In these conditions, that may occur on pumps, turbines, propellers, rotating parts or subjected to vibration in a fluid, can form low pressure areas which generate bubbles in the fluid.

They are formed and burst with extreme rapidity and generate shock waves, capable of accelerating the corrosive phenomenon, which therefore has essentially mechanical origin.

The methods to overcome this attack are: first, to provide, during the planning and design of the particular fluid dynamics, the way to avoid the onset of a phenomenon of cavitation. Or to use austenitic steels of considerable elastoplastic characteristics or stainless steels of high hardness and strength.

RUBBING CORROSION

It can occur when two non-lubricated surfaces, in the atmospheric environment, are variously in contact between them and pressed one against the other, so as to cause small local deformations, subjected to vibrations or in any case to a continuous rubbing cyclic, also of limited amplitude.

The phenomenon is formed due to localized mechanical destruction of the passive layer and occur with the appearance of small surface ulcers, of pitting type.
To overcome to this type of corrosion, it needs to modify, as far as is possible, the regime of movement between the parts and act to prevent friction between them, or at least to increase the amplitude of the same.

It may also resort to **a good lubrication** with fluids of appropriate viscosity, extended to the whole contact surface, or interposing between the parts with good plastic characteristics.
It thus seeks to move outside of the critical conditions of formation of the phenomenon.

CONCLUSIONS

Stainless steels are materials thet are used for many applications in various fields in which it is required to resist to the aggression of various environments. The knowledge of the main factors which determine the corrosion resistance and other aspects that can determine the trigger is essential for a correct choice of the right league. By contrast, recognize the type of corrosive phenomenon that occurred is surely basic to be able to make a proper resolutive action.

So, back to our products or services, about anchors of type "chiper", it's worth to pointing out, for each specific case, as it is better to move in relation to different types of corrosion and identify what are the appropriate materials that make to our case.
As can be seen from the listing of the different types of stainless steel mentioned above, those which would probably make to our case are those with "biphasic" matrix, called "duplex" - they austenitic-ferritic steels, because they certainly offer the best performances in the mechanical strength and corrosion.

On the market there are many types of steels and some specialized foundries also "bring out" more specific and innovative steels.
Generally these Bi - phasic steels are:

Duplex Stainless Steel
Superduplex
Super Austenitics as:
AISI 904L
AISI 2205
Hastelloy
Incoloy

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Inconel
Monel
and many others ...

When we decided to take to the "horns" the problem of corrosion, our company has carefully perused the commercial world of the companies offering these products on the market and found that these special steels bring with them problems of no small importance.
First, the supply difficulties. Being "special", their production is relatively limited. The alloying elements, usually formed in high percentages, and their high cost have also determined a strong limitation in the availability of the measures and bases available.
Many distributing businesses, keep the stocks of only the measures and the sections that are most frequently requested. All the more, today the strategic choices are to do not "warehouse" for the many economic factors that determine it.

Unfortunately, most of the items that produces our company are made using ribbed bars of small diameter (approximately Ø 6mm/Ø 18mm) and these are the most difficult to find. You can get it but only with a specific order and with the purchase of large quantities. We have not even found the metal sheet that serves for the production of plates, as delivery condition, and we don't know if somewhere is available, for this type of steels ...

It doesn't work well, because instead our warehouse needs a lot of flexibility and little inertia in purchasing.
An even more serious situation is that the price of these alloys is in fact very high, for a number of valid reasons that is not the case to list here. The ideal material would be the <u>titanium</u> because it offers a monstrous resistance to corrosion, but it is equally monstrous its price as well as are evident the same supply problems above.
We realized, in addition to the mentioned problems, that there are some other problems related and consequential. Just to mention one example: how many climbers would be able to buy some necessarily so expensive products? And so on ...
The production and sale of stainless steels is mainly limited on two canonical types: the AISI 304 and AISI 316. They are also available in the version "L" which stands for "low carbon", low carbon content. We discarded the 304 for known reasons and we well examine the quality and the characteristics of stainless steel AISI 316L (norma EN 10088/3: X2CrNiMo 17-12-2 --/-- W. 1.4404).

<u>Our company finally chose this type of steel to achieve all its anchors.</u>

It was a carefully reasoned choice because, basically, there is no alternative.
<u>It will certainly be hard to see on the market, some anchors proposed in super-special steel ...</u>
Anyway already the AISI 316L stainless steel is great and costs significantly more than the 304, because it has alloy elements that making it much more resistant to marine corrosion.

Its "highlights" features are:

- Low carbon content (C). For this reason it is virtually impervious to the intergranular corrosion (intergranular). In other words, the post weld treatment is not necessary. Don't happen then the phenomenon of precipitation of chromium carbides in the matrix and consequently the protective oxide film remains unchanged.
- Presence of a molybdenum (Mo) percentage (2-2.5 %). The presence of this element increases the stability of the passive layer in the presence of environments that containing high concentrations of chlorides. It's an element that increase iron, and so also increases the resistance to corrosion (crevice corrosion) and the stress corrosion.
- The high percentage of Chromium (Cr) increases the resistance to pitting corrosion.
- The content of Nickel (Ni) provides excellent ductility and high toughness, good corrosion resistance in low-oxidants environments (crevice corrosion).
- The presence of other stabilizing elements in the alloy as Silicon (Si), manganese (Mn), phosphorus (P), sulfur (S) and nitrogen (N) gives to the molecular structure an excellent balance between the various components.

It is objectively a good material to use to make anchorages that can be positioned in the marine environment. Perhaps the best compromise. But ATTENTION, in the end it is still a compromise! (There isn't the perfect material against any kind of corrosion!). To make it a "good" material for this purpose, it's necessary to act on two fronts, one is internal to the company, in the production phase and one is for the user, which is the toolmaker that will place it on the sea cliffs.

Our company has created in this regard a special part of products in stainless steel AISI 316L, called **"Marine Line"** which involves treatments and special finishes that enhance significantly the marine corrosion resistance.
Despite this type of steel, as it has been said, by its nature does not require a particularly heat treatment we decided to do it. This is called **"hardening of solubilization"**.

This process consists to bring the finished material, with an appropriate furnace, at the temperature of solubilization of chrome carbides (about 1050 °C) and to throw it suddenly into water. The chromium is thus homogeneously distributed in the matrix, which allows the optimal formation on the metal of the passivating film of protective oxide. After this operation, the parts are properly pickled by dipping them in a special acid.

This is done to "clean" and thoroughly destroy any possibly disturbing element due to the heating and of the possible contamination of the pieces. After a subsequent washing, products are finally immersed in another acidic solution based on nitric acid, to artificially create the ideal thickness of the adsorbed oxide, called "passivation”. Now the anchors are ready to face the best conditions of corrosive attacks . A bit painful point is: they cost a bit more ...
At this point the second front to work on is the climber/toolmaker who must proceed with the placement of the anchors following some basic rules.
First you should take care to avoid the use of composite anchors (made of different materials). For example, don't use plates made of stainless steel and galvanized steel anchors and vice versa. In aggressive environment there will be galvanic corrosion effects.

Stainless steel is a noble material which acts as a cathode and the galvanized iron and other metals (such as aluminum) as the anode. The iron attacked from the stainless steel will quickly create rust and contaminate the steel, triggering the corrosion effects of the type "pitting corrosion". (not to mention that the iron dowel was destroyed...).

It's necessary to avoid as far as possible, the contamination of the stainless steel from ferrous metals, of any whatsoever nature. For example, even in the same beat on the head of the shank of the dowel with an iron hammer, to introduce it into the rock, it release small traces of metal that soon will result in rust spots that can, in the long run, trigger the corrosion process. The same applies if you attach an iron carabiner or a galvanized quick link to a a plate.

There are many borderline cases. In some areas of Sardinia for example, but also in many other parts, the walls of the cliffs are reddish, clear sign of obstruction of ferrous type. Equipping these walls means decreasing departing the corrosion resistance. In these areas you will have to pay special attention.

In the choice of the anchors you must be careful to avoid those types which by their nature have intrinsic handicaps, structural and of shape, such as expansion anchors (Fix, for exemple). The use of these anchorages requires this sequence of steps: drilling and subsequent cleaning of the hole in the rock, introduction of the dowel with the relative plate in the hole and then the final tightening of the nut, with adequate torque.

Let's look in an imaginary section what we did.

We will see the rock. We will see the insert that comes out with the threads and behind the plate retained by the nut, and when all is under tension. The possible corrosion that may arise in an aggressive environment (and here is absolutely "aggressive") and potentially deadly and it means: possible Interstitial corrosion, because at the beginning of the slightly flared hole, the seawater inevitably will deposits small amounts of salted water; the plate will protect this area from the replacement and from dry and will cause, in the interstice, that the oxygen will slowly fail because the minute space is always busy from the stagnant water, that will release another chlorine ion and so on ...

The passivating film over time will break down and start a corrosive phenomenon dramatically faster . Other concomitant problem is the fact that the dowel/plate is in fact constantly under tension and then (always in an aggressive environment), can occur the phenomenon of decay for **"stress corrosion cracking"**. And, finally, to make matters worse, by the very nature of the type of anchor, an heavy use can cause corrosion problems of **"fatigue".**

What to do? Well, in this case it may be useful to identify anchorages that eliminate these problems. "Resin"anchors are a good solution. The recommended diameters will be minimum of 10mm, ideal are those of 12mm. The depth of insertion has a relative important, are subject to the general rules which take into account of the nature of the rock.

But be careful because the toolmaker will pay close attention to produce a final quality work.

First of all, by choosing an anchor of the “Marine Line".

The placement must be perfectly done "dipping" as much as possible the anchor into the hole in the rock, even the undercut part of the eye, by permeating thoroughly with the resin along the entire length of the shank and particularly in the proximity of the exterior, so as to isolate perfectly the beginning of the hole by the possibility of infiltrations of chlorinated water. The outside part of the anchor will be clearly visible and easy to inspect. Anchoring is by nature

absolutely not in tension (no tensile corrosive effect) and positioning as well as also recommended cancel of fact problems of “hard”working because, when using, they do not occur noteworthy cyclical fluctuations.
Safety does not compromise!
Will be good to do not ever overlook a key point: never hang on only one anchor!!!
If this is basic in any general mountain environment, in the marine environment it is vital. In case of descent or safety position is indispensable to rely on at least two anchors concurrent. If there is no place, <u>always</u> create them in person, perhaps connecting them with a piece of rope or cord!
It's about our life!
Attention, sporting activities as mountaineering, climbing, caving and canyoning as that carried out at height are dangerous and in many cases can cause serious injuries as well as death. Every person who practices these disciplines must be aware of them and if he is not feel able to assume all risks and responsibilities should not engage in them and should not use at all our products. Who, anyway does it, assumes all responsibility towards himself and his comrades. The company RAUMER srl disclaims from now any responsibility.

Schio, April 2013.