CORROSION AND STRESS CORROSION CRACKING FAILURE OF CLIMBING ANCHORS

UIAA 123 standard update, 2020

The UIAA Safety Commission is composed of national federation delegates, manufacturers and accredited testing laboratories.

The subject of corrosion and stress corrosion cracking failure has been a work in progress for the last ten years within SafeCom. December 2020, the Commission is able to release the results and update its Standard UIAA 123 Rock Anchors V4_2020. This major update is based on scientific research performed by Brest (France) and Prague (Czech Republic) laboratories, coordinated and funded by the UIAA, for the safety of all climbers worldwide.

This Standard has been updated based on SafeCom's best knowledge of atmospherically induced stress corrosion cracking, i.e. with respect mainly to chloride resistance. Nevertheless, in some locations and environments this is not the appropriate procedure and where additional tests need to be performed, e.g. under high sulphate content. Further research is ongoing to gain a clearer understanding of this phenomena and how to determine which locations are concerned.

Reminder of the quick facts

Recent incidents indicate unexpected failures of climbing anchors after being set-in place for a few months/years and under low loads. These failures occur mostly on stainless steel anchors due to environmental degradation, i.e. corrosion and more specifically stress corrosion cracking (SCC).

- In worst cases, anchors can break under the weight of ten to twenty kilograms –obviously less than the averageclimber's weight.
- Usually in coastal locations, but even up to a few kilometres away from the coast.
- All material in warm coastal areas shall be considered as potentially affected
- Corrosion is not always visible and can occur in cracks not seen by visual inspection.
- Stress corrosion cracking is the most virulent and can very rapidly initiate cracks shortly after anchor installation. In some cases, within a few months and almost certainly within a few years.
- All metallic anchors, including parts made of stainless steel or aluminium alloys are impacted, except those which are rated UIAA 123-SCC.

The most critical factors are:

- "Moderate" relative humidity locations. *(The very dry and very humid locations are OK, it is the in-between the two extremes that is a problem)*
- Areas NOT being washed clean by a rainfall *(even being washed by the sea can be OK!).*
- Temperature: SCC can occur at 20°C, higher temperatures are worse.

What are the main changes?

- The list of acceptable materials for the most corrosion resistant class have been removed.
- The new Standard now tests the complete anchor to ensure as much as possible the stresses it may endure upon installation.
- The highest corrosion resistance class is Stress Corrosion Cracking (SCC)
- The UIAA Safety Label certificate is given to anchors that have successfully passed the general corrosion and Stress Corrosion Cracking (SCC) tests as per Table 1.

Why testing the complete anchor?

Influential factors: amount of internal Stress and resistance to SCC

- the manufacturing method: bending, welding, cutting, drilling, even laser engraving adds a significant amount of internal stresses.
- the installation: expansion anchors are subject to additional stress when screwed in place. Hammering with any metallic tool is also very detrimental and should be avoided.

This is why during testing the screw-in anchors are installed in a granite block as per manufacturer's instructions for use and installation. For glue-in anchors (*it is considered that the glue does not induce significant stress),* they are fully immersed in the solution.

Why three classes?

The lastest research reveals that defining classes by only the material type is not pertinent since some anchors made of low SCC resistant alloys (e.g. 316L) could pass the test while other anchors made of high-end SCC resistant material do not pass the same test. This is mainly because the stress on the anchors from different manufactures could vary.

For these reasons, it has been decided to have three classes, and only one of them with resistance to SCC.

Table 1: UIAA 123 Rock Anchor V4_2020 Classes and Environment Characteristics

UIAA 123 Class	Signification	SCC resistance	General corrosion resistance	Characteristics of environment	Important considerations
SCC	High SCC and General Corrosion Resistance	**High**	**High**	**SCC in evidence, for example (but not only):** high chloride concentration, temperature above 30°C, humidity between 20% to 70%, sea salt and/or other chloride salts, and/or acidic environment.	Although SCC is commonly associated with seaside cliffs, it can also occur inland and in other locations, e.g. indoor swimming pools.
GC	General Corrosion Resistance	**NO (unspecified)**	**High**	**No SCC in evidence and none suspected,** some corrosion agents.	
LC	Low Corrosion Resistance	**NO (unspecified)**	**Medium**	**No SCC in evidence and none suspected.**	Rock anchors in indoor gyms and in proximity to industrial areas, swimming pools, or the sea may require use of class SCC anchor.

What is Stress Corrosion Cracking?

Stress Corrosion Cracking (SCC) is a very virulent type of corrosion that could provoke cracks very rapidly. Contrary to general corrosion, which generates sufficient amounts of well visible corrosion products such as rust, SCC can usually not be detected during on-site visual inspection. Many stainless steels, aluminium alloys and other metallic materials are affected.

SCC is influenced by many different factors, as presented in Table 2.

Table 2: Factors contributing to stress corrosion cracking of climbing anchors

FACTORS	MOST CRITICAL ONE	remarks
ENVIRONMENTAL CHARACTERISTICS		
concentration of chloride	magnesium chloride, calcium chloride, sea salt	Chloride deposits containing salts with high solubility can be formed.
temperature	NOT any cut-off/"safe" level, but above 30°C is worse	SCC could start at 20°C, a higher temperature increases the cracking speed; the temperature of a bolt in the sun can be significantly higher than the ambient air temperature.
humidity	low relative humidity, between 20% and 70%	RH close to the deliquescence point of the chloride solution poses a significant danger of SCC. Localized RH of the anchor can be significantly different from ambient RH, e.g. when exposed to the sun.
location – coastal / wind from the sea	next to the sea up to typically 30 km from the coast	**There is no clear limit;** winds from the sea with significant salt concentration can travel far inland.
washed by rain or not	not washed by rain	The absence of washing allows the chloride to concentrate locally on anchors.
rock type	Unspecified, all rock types could be affected	Some rock types can make conditions worse than others, depending on specific circumstances.
ANCHOR CHARACTERISTICS		
stresses	high tensile stress	**- from manufacturing**, due to rolling, bending, cutting, drilling, and welding **- from installation**, due e.g. to tightening, hammering **- from plastic deformation**; e.g. multiple hard falls

Which locations are affected?

Potentially all coastal areas could be affected by atmospheric induced stress corrosion cracking, including up to several kilometres from the coast. To this day, it is still not possible to clearly distinguish affected locations from safe ones. The variation of many parameters as presented in Table 2 can influence the corrosion conditions. For example, the wind can blow salt over hundreds of kms inland, and beyond the reach of sea breezes the rock itself can contain the ions that promote SCC.

The UIAA has created a Map of known corrosion locations. This map is intended only as a reference to identify areas where examples of corrosion have been logged. It is designed only as an informative guide based on data received and assessed. **It is not intended as a complete reference and is subject to changes beyond the UIAA's control.**

To support the UIAA Safety Commission with its analysis and to help add more areas to the map thereby improving the information available to climbers about dangerous or potentially dangerous areas to climb, a dedicated form is available to share information about corrosion or failed anchors.

What you should know when installing bolts

- **Use only UIAA123 – *SCC* class certified anchors. This class for locations where SCC is common. In case of doubt and for areas with rare incidence of SCC or areas where SCC is suspected but not documented always choose the highest class.**
- **Do not combine bolts, nuts, washers or hangers of dissimilar metals**, because galvanic corrosion could be initiated due to the different electrochemical potentials.
- **Use a calibrated torque wrench** to fasten the nut in order to avoid plastic deformation of the material and to keep the axial stress at moderate levels, as suggested by the manufacturers.
- If possible, **regularly inspect the material(s) in place.**
- **If corroded anchors are found, contact the UIAA. Failed anchor parts can be sent to to the UIAA or one of its national federations for analysis:** https://theuiaa.typeform.com/to/rlBZyc

How to check when climbing?

The UIAA123 V4_2020 Standard states that the anchors shall be marked with the letters *UIAA* followed by the class *SCC, GC* or *LC* as per Table 1.

Evaluating the risk due to SCC is almost impossible for individual climbers because SCC degradation is often not visible. Only destructive testing can confirm the presence/absence of SCC on installed anchors. Even anchors that have been installed in recent months and/or look brand new could be compromised by SCC or some forms of corrosion.

SCC is very difficult to predict as it depends on a complicated set of factors, especially elevated temperature, low humidity, and formation of magnesium -or calcium- rich chloride deposits at unwashed locations (Table 2). Small differences in microclimate can lead to SCC degradation for some bolts, while other bolts on the same climb are unaffected. SCC is associated with seaside climbing but can also occur in inland areas where corrosive elements are present, either naturally occurring in the rock itself or deposited inland by sea breezes.

Recommendations for climbers

When planning a trip

- Consider SCC when assessing the risk of climbing at a proposed climbing destination.
- Check with local climbers and/or climbing organizations regarding the prevalence of SCC and the corrosion resistance of local bolts.
- Be prepared for the presence of SCC, especially at hot, seaside destinations.

When climbing

- Consider SCC when assessing the risk of climbing a given route.
- Belay/lower from redundant, multi-bolt anchors.
- When in doubt, accept the need to back up bolts and belay/rappel stances with nuts, camming devices, trees, and/or threaded hourglasses.
- Be prepared to abandon projects with suspect bolts.

In the event of bolt failure (once the climbers are safe and injuries have been attended to)

- Collect the failed anchor parts; avoid disturbing the failure surface or trying to piece together the failed anchor.
- Inform the local climbing community.
- **Contact the UIAA. Faulty/failed anchor parts can be sent to the UIAA or one of its national federations for analysis:** https://theuiaa.typeform.com/to/rlBZyc

What climbing organizations should know

- SCC and/or corrosion and the aging of existing bolts present challenges to the climbing community that cannot be met by individual climbers.
- The main obstacles to use of SCC and/or corrosion resistant anchors are cost and availability. Individual bolters can be short of funds, and somewhat reluctant to spend even more of their own money. When a bolting fund is available to provide funding, the bolters are always happy to use the more resistant anchors.
- This means that the bulk of the climbing population needs to start paying more for anchors, whereas in the past most climbers had a "free ride".
- Bolting new climbs and re-bolting existing climbs to address the risks of both general corrosion and SCC will require significant investment of both time and money for the installation of new bolts that are appropriately corrosion resistant. This initial cost is offset by the increased lifespan of the resulting bolts and the decreased incidence of accident and injury.
- Quality control (QC) measures are necessary for responsible long-term management of bolts, especially documentation of both anchor failures and anchor installation dates & types.
- Monitoring of bolt integrity (pull testing of off-route bolts) is similarly important. Record keeping for these QC measures must be in place for 50+ years.

The UIAA Safety Commission urges national federations and local climbing communities to plan a future that includes responsible management of bolt corrosion and that asks for UIAA 123 v4 certified products.

References

Jiří Lieberzeit, Tomáš Prošek, Alan Jarvis, Lionel Kiener, Atmospheric Stress Corrosion Cracking of Stainless Steel Rock Climbing Anchors, Part 1, CORROSION. 2019;75(10):1255-1271.

Tomáš Prošek, Jiří Lieberzeit, Alan Jarvis, Lionel Kiener, Atmospheric Stress Corrosion Cracking of Stainless Steel Rock Climbing Anchors, Part 2: Laboratory Experiments, CORROSION. 2019;75(11):1371-1382.

https://www.theuiaa.org/safety-standards/

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