

Galvanic corrosion in bolted Aluminium joints

Highrise Design has executed the initial batch of lab-testing on a series of bolted joints to determine the optimal remedy against unfavorable corrosion of aluminium structures in offshore & marine applications. This first test piece has recently endured 1.500 hrs salt spray test in the M2LAB in Udenhout, providing very clear insights.

Corrosion of Aluminium



lab

168 hrs

336 hrs

504 hrs

960 hrs

672 hrs

A common perception is that aluminium is a non-corrosive material. But aluminium is extremely corrosive. Its specific corrosion-process will however form a thin protective layer of aluminium oxides, shielding the material from further oxygen access. With that protective layer in place, the corrosion process of aluminium normally comes to an early halt. However, under certain circumstances this shielding process cannot fully protect against corrosion: galvanic or bimetallic corrosion can cause sustained corrosion of aluminium.

Galvanic corrosion in bolted aluminium joints

Especially in seaside, maritime or offshore applications, where sodium chloride (sea salt) containing water can cover the metal connections, an 'ideal' galvanic cell may be created. Under these conditions, it is important that bolted joints are carefully designed to avoid galvanic corrosion between the aluminium structure and the metal bolts. Selecting proper materials for these bolted connections is however not easy: various solutions all come with their pro's and con's.



1.500 hrs



Tested samples

To generate further insights in the effectiveness of various bolted solutions, Highrise Design has initiated a salt spray test, comparing the influence of various available metallic coatings on galvanic corrosion of bolted aluminium joints. The following specimens have endured 1500 hours of spraytesting according to ISO 9227-NSS:

- Zn Al flake coating (Geomet 500A)
- Zn Al flake coating (Delta Protect KL 100)
- Untreated stainless-steel bolting (A4 quality)
- Duplex Coating (Stafa P2000)

Results

Geomet bolts



Findings: The Zn/Al coated bolts perform outstanding regarding the prevention of galvanic corrosion of the aluminium materials. After 1.500 hrs it is however visible that this coating is reaching the end-of-life stage, not being able anymore to effectively protect the carbon steel bolts from rusting. The prolonged attacks of the salt spray has used-up the Zinc-anodic reserves.

EJOT bolts





Findings: These Zn/Al coated bolts are a match to the Geomet bolts, regarding the prevention of galvanic corrosion of the aluminium materials. It would appear that the coating is slightly longer lasting. Only very minor signs of some early rust of the Carbon steel bolts is showing, certainly less pronounced than with the Geomet bolts.

Stainless Steel bolts



Findings: The stainless steel bolts are clearly showing that the aluminium has suffered minor galvanic corrosion, resulting from contact between stainless steel and aluminium. Although the aluminium has slightly suffered, it is in no way hampering the integrity of the bolted connection after 1.500 hrs of aggressive salt spray-testing.

Duplex bolts



Findings: The Duplex bolts outperform the other samples by far: the aluminium remains pristine, fully unharmed. The duplex is further not showing any signs that the protective coating is reaching an end-of-life state after 1.500 hrs of testing.



Conclusion



The above picture best illustrates the findings of the test:

After 1.500 hours of spray-testing, around the heads of the stainless-steel bolts (on right-hand side), clearly visible showing signs of aluminium-oxides, resulting from galvanic corrosion. The zinc/aluminium-flaked head (in the middle) shows some minor residues of zinc-oxides, but the aluminium remains unharmed. In a way more form of pollution, of the sacrificial zinc elements. At the left-hand side, the Duplex bolthead show a very pristine condition of the joint after a severe 1.500 hrs test.

Although the forming of a very limited form of galvanic corrosion around the stainless steel bolt can be considered a success, proving that the integrity of the joint is unhampered after 1.500 hrs of tested, it is clear that both the AL/Zn flaked coating and the Duplex coating perform much better in preserving the aluminium material. From these two coatings, the Duplex coating proves to a more long-lasting coating, preserving the carbon steel bolt and the aluminium for an extremely long time.

