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RESEARCH ON DEGRADATION BY CORROSION OF SOME COMPONENTS OF BUILDINGS ROOFS

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Abstract: *Fasteners used to fix roofing, walling and accessory products manufactured from steel strip and sheet are required to give long, trouble free service when exposed to the atmosphere in environments ranging from benign to severe in terms of corrosive effect. The obvious way to prevent galvanic corrosion is to select suitably compatible materials at design stage. If the materials that have to be used could interfere with each other, protective measures must be taken.*
Keywords: *corrosion, fasteners, roof*

1. INTRODUCTION

Corrosion can be defined as the degradation of a material due to a reaction with its environment. Degradation implies deterioration of physical properties of the material. This can be a weakening of the material due to a loss of cross-sectional area, it can be the shattering of a metal due to hydrogen embrittlement, or it can be the cracking of a polymer due to sunlight exposure.
Materials can be metals, polymers (plastics, rubbers etc.), ceramics (concrete, brick etc.) or composites-mechanical mixtures of two or more materials with different properties. Metals corrode because we use them in environments where they are chemically unstable. Only copper and the precious metals (gold, silver, platinum etc.) are found in nature in their metallic state. All other metals, to include iron-the metal most commonly used-are processed from minerals or ores into metals which are inherently unstable in their environments [7].
Corrosion of steel is affected by three main variables - liquid moisture, oxygen and temperature. If either moisture of oxygen or both are not present corrosion stops. Corrosion increases with temperature until liquid water evaporates away. When any two dissimilar metals are in close proximity, and separated by a conductive film of water, an electrolytic charge is set up between the two metals and corrosion results. Consequently it is never a good practice to have say copper and aluminum sheets in contact with each other or with steel sheet or fasteners. A thick zinc coating over sheet steel material protects the steel by becoming a sacrificial anode when a conductive film of water is on the deck surface. This means that zinc in an area will continue to be oxidized until it is all consumed before the steel will be oxidized or rusted. Oxidized zinc ("white rust") has a white color and may appear as a fine powder coating.
Polymeric coatings protect steel sheet and fasteners by keeping moisture from their surfaces. United States roofing practice does not require zinc-coated decks. The major portion of their installed decks have paint primer coatings to protect the steel until it is installed. This paint does not have any significant corrosion inhibiting properties and can be easily scratched and damaged.
The surfaces of these decks in contact with insulation become corroded when liquid water through membrane leaks or condensation moisture accumulates in the interface due to the lack of a vapor retarder in the majority of their roof systems.
Moisture films or droplets on steel with salts, acids or bases will accelerate corrosion reactions in proportion to their concentration and strength [4].

2. THE GALVANIC CORROSION

The Galvanic Corrosion is a localized corrosion mechanism by which metals can be preferentially corroded. Sometimes is also called metal to metal corrosion.

This type or form of corrosion has the potential to attack junctions of metals, or regions where one construction metal is changed to another. Frequently this condition arises because different metals are more easily fabricated into certain forms; an example might be a door frame manufactured from aluminum extrusions, but with a door handle fabricated from stainless steel tube to exploit its higher strengths and abrasion resistance [8].
Galvanic corrosion may arise when dissimilar metals are in contact in aqueous solution. The potential difference between them will initiate attack, the corrosion rate depends on the surface reactions of (usually) both metals [5].
The risk of galvanic corrosion occurring depends on a multitude of factors. Beside the materials used, environment and design are crucial.
For galvanic corrosion to occur there must be:

- ✓ different corrosion potentials of the metals within a given system
- ✓ a conductive connection between the two metals
- ✓ an electrically conductive humidity film (electrolyte) connecting both metals.

Figure 1 shows the three prerequisites in graphic form. If galvanic corrosion occurs, the less noble material – the anode- is preferentially attacked whilst the more noble material – the cathode is even protected against corrosion. In fact, the principle of cathodic protection is based on sacrificial anodes providing protection from corrosion.

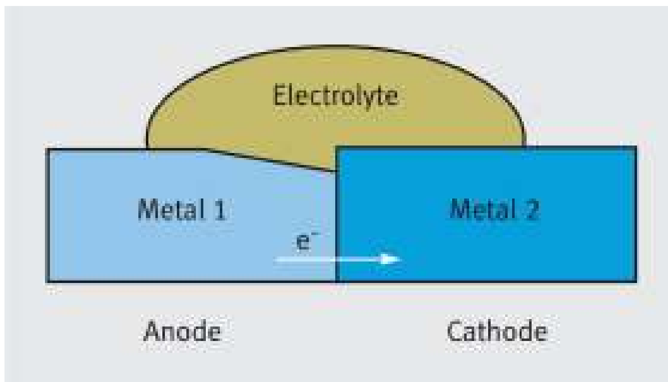

Figure 1: The three prerequisites in graphic form [9]

The contact of two metals with different potentials in an electrically conductive solution leads to a flow of electrons from the anode to the cathode. The electro-chemical reactions are the same as those that would naturally occur in the metal isolation. However, the corrosive attack on the anode is greatly accelerated. In some cases, the formation of galvanic elements can lead to corrosion in materials that would otherwise be corrosion resistant in the environment in question. This can be the case for passive materials such as aluminium, which can be locally polarized in a certain environment. In such cases, localized corrosion phenomena such as crevice corrosion or pitting corrosion can be observed, which would not have occurred without the shift in potential caused by the formation of galvanic elements [9].
Figure 2 shows conditions in which galvanic corrosion cannot occur.

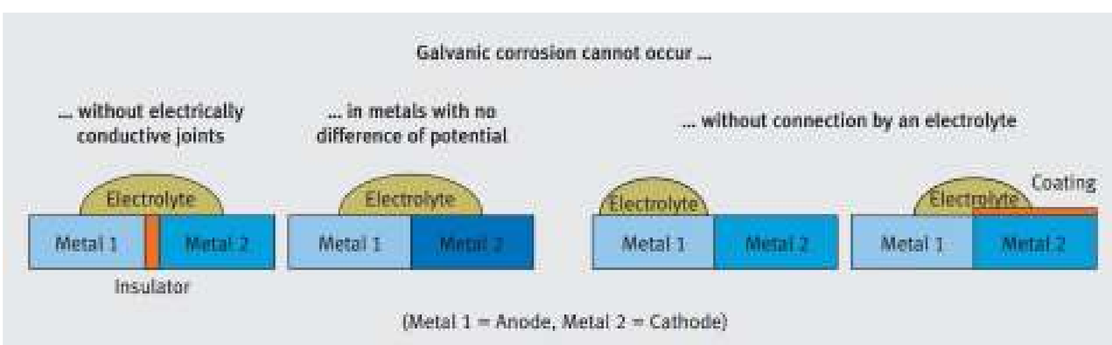

Figure 2: Conditions in which galvanic corrosion cannot occur [9]

The obvious way to prevent galvanic corrosion is to select suitably compatible materials at design stage. If the materials that have to be used could interfere with each other, protective measures must be taken.
In order to prevent galvanic corrosion must choose metal combinations in which the constituents are as close as possible in the corresponding galvanic series, avoid an unfavorable surface area ratio. Wherever possible using a seal, insulator, coating etc. it can be avoided direct contact between two different metals [6].

In roofing technology – both in new build and renovation – stainless steel is predominantly used for fasteners which are in contact with other metallic materials or materials with metallic coatings. Due to the favorable ratio of anodic and cathodic surfaces, there is generally no corrosion risk in such material combinations. In roof repairs, it is not uncommon to join larger surfaces of stainless steel with other metals. Such combinations can also be considered uncritical unless the ratio between the stainless steel part and the aluminium or galvanized part significantly exceeds 1:1 [9].

2. STRUCTURAL ROOF DECK CORROSION

The steel decks under roof insulations which have become saturated due to leaks tend to develop corrosion on all wet surfaces. Leaking water brings small amounts of salts and acids from the roof surface and in some cases from insulation surfaces it has passed over or through.

Corrosion has been found under all types of insulation following long term membrane leakage. Numerous reports exist in regards to severe primer coated deck corrosion under wet phenolic insulation. Water passing through the foam material liberated quantities of acid catalyst.

A film of rust has been found on the bearing flute areas of certain insulated decks with older design phenolic insulation having a standard glass mat facer but no vapour retarder in the assembly. New designs of this phenolic insulation have upper and lower filled glass facers which appear to inhibit corrosion by neutralizing leachate at the foam-steel interface [4].

3. FASTENER CORROSION

For steel deck assemblies fastening of at least the bottom layer of insulation or board is required. Insulation fastening is present on most conventional membrane roofs. Long term performance of the fasteners and the penetrated deck is necessary to protect the roof from wind uplift failure. Fasteners used to fix roofing, walling and accessory products manufactured from steel strip and sheet are required to give long, trouble free service when exposed to the atmosphere in environments ranging from benign to severe in terms of corrosive effect [3].

The presence of adequate insulation on decks during winter prevents condensation at the fastener deck interface by keeping this area above the dew-point temperature.

The lack of liquid moisture restricts the amount of deck or fastener corrosion. The presence of a vapor retarder restricts the amount of moisture that can accumulate in a roof assembly during winter. Accumulated moisture is driven from the top of the assembly to lower regions by warmer weather and solar loads. As long as interior and supporting deck temperatures are above the dew point of the assembly air, no condensation occurs.

If the temperatures are lower, the condensation occurs on the vapor retarder and not the deck, in the absence of vapor retarder corrosion is accelerated at the fastener-deck interface or unprotected deck surfaces [4].

4. FASTENER CORROSION IN CONTACT WITH PRESERVATIVE-TREATED WOOD

Fasteners with base coatings appear to be insufficiently protected when reroofing over wetted wood fiberboard insulation whereas fasteners with heavy mill coatings or fabricated from stainless steel appear to resist corrosion in the same environment [1].

Due to environmental and regulatory concerns, the wood industry began using new preservative chemicals. Concern has been expressed that some of these new chemicals may cause corrosion of certain types of metal fasteners.

Historically, the most prevalent preservative used was Chromated Copper Arsenate (CCA). Effective January 2004, the use of this preservative has been banned for residential use due to health and environmental concerns, but substitutes for CCA that emerged were: Alkaline Copper Quaternary (ACQ) and Copper Boron Azole (CA-B).

Preservative-treated lumber is used as nailers for securement of roof membranes and roof edge products. The nailers are attached to the building structure with metallic fasteners, which are then in direct contact with the preservative-treated lumber. In many applications, the wood nailer is also in direct contact with a steel roof deck. If corrosion of the metallic fasteners were to occur and weaken the attachment of the edge securement system, the entire roof assembly would be more susceptible to damage during high-wind events.

Post hurricane investigations conducted by the Roofing Industry Committee on Weather Issues (RICOWI) have consistently shown that in many cases, damage to a low-slope roof system during high-wind events begins when the edge of the assembly becomes disengaged from the building structure and once this occurs, the components of the roof system (membrane, insulation, etc.) are exposed.

The relative humidity has to be sustained at high levels approaching 90% in order for the wood to retain sufficient moisture for a galvanic cell to be functional and, thus, is a requirement for corrosion to occur.
Temperature appears to be the key driver to the extent of corrosion, though a sustained presence of moisture within the wood is also required for corrosion to occur.
The Alkaline Copper Quaternary (ACQ) and Copper Boron Azole (CA-B) demonstrate higher rates of corrosion if sufficient moisture is present. No measurable corrosion was noted on stainless-steel [2].

3. CONCLUSION

- Corrosion of steel is affected by three main variables - liquid moisture, oxygen and temperature. If either moisture of oxygen or both are not present corrosion stops. Corrosion increases with temperature until liquid water evaporates away.
- The risk of galvanic corrosion occurring depends on a multitude of factors. Beside the materials used, environment and design are crucial. The obvious way to prevent galvanic corrosion is to select suitably compatible materials at design stage. If the materials that have to be used could interfere with each other, protective measures must be taken.
- In order to prevent galvanic corrosion must choose metal combinations in which the constituents are as close as possible in the corresponding galvanic series, avoid an unfavorable surface area ratio. Wherever possible using a seal, insulator, coating etc. it can be avoided direct contact between two different metals.

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