

Corrosion Isms: Unravelling the Mysteries of Steel Corrosion.

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Corrosionists Rules to Persevere By

Can you clearly define
the problem? Do you
know what it is costing
you?? Do you want to
fix the problem???

Corrosionisms

Preserving structures without having a fundamental understanding of active corrosion is like driving whilst blindfolded.

What is Happening Here???

The difference is the medium that causes the process. Obviously oxygen causes oxidation, while corrosion is the term applied to a similar electrochemical process caused by many other atoms and molecules.



Electrolytic Corrosion Commonly called Crevice Corrosion or Pack Rust



**EXPLANATION OF THE
CREVICE CORROSION
AND PACK RUST PHENOMENON
IN LIGHT OF THE CREATION OF
AN OXYGEN CONCENTRATION
CELL**

“Metallic corrosion can produce very corrosive environments through the chemical change of water into acid, called hydrolysis. This phenomenon is particularly noticeable when the environment is confined; such as in most forms of localized corrosion (pitting, crevice, environmental cracking).

“Crevice corrosion is a localized form of corrosion, under the influence of crevice geometries. Stagnant solutions play an important role in setting up of highly corrosive micro-environments inside such crevices. A metallic material tends to assume a more anodic character in the stagnant crevice solution compared with the bulk surface (exposed to the bulk environment).

The highly corrosive micro-environment of crevices tends to be similar to the micro-environment established at the base of corrosion pits. Crevice corrosion is usually a result of a differential oxygen concentration cell, in which the mouth of the crevice is richer in oxygen than the metal within the crevice, which therefore becomes anodic and dissolves.

Subsequent pH shifts within the crevice may lead to even more intensified attack, associated with the induction (initiation) and propagation phases of the corrosion cycle.”

The chemical change in question is true of most metals since the metallic ions produced by the corrosion processes are not soluble in their ionic forms.

These ions will then react and form more stable species such as oxides and hydroxides. In aerated environments iron oxidizes to ferric ions that subsequently react with water.”

In the final stage of development of crevice corrosion a few more accelerating factors fully develop:

1. The metal ions produced by the anodic corrosion reaction readily hydrolyze giving off protons and forming corrosion products. The pH in a crevice can reach very acidic values, sometimes equivalent to pure acids.

2. The acidification of the local environment can produce a serious increase in the corrosion rate of most metals.

3. The corrosion products seal and further accelerate corrosion in the crevice environment.

4. The accumulation of positive charge in the crevice becomes a strong attractor to negative ions in the environment, such as chlorides and sulfates, that can be corrosive in their own right.”

**The corrosion process will
not be stopped by caulking or
sealing up the exterior of the
connections**

Corrosionism

You Can Not Cover Up

An Active Corrosion Cell

Application of film forming sacrificial zinc coatings systems designed for new steel to crevice corroded joints that cannot be cleaned to the cleaning standard the coating manufacturers specified



1 yr old 3 coat zinc epoxy urethane over pack rust

Pack rust and Crevice corrosion creates stresses on structures



#357 - Pack Rust Smart Flag

Unit of Measure (Ea.)

This defines only those connections (including shapes in contact in built-up members) of steel bridges which are already showing signs of rust packing between steel plates.

Condition State Descriptions and Feasible Actions:

NOTE: Use only one condition state.

- 1 The connection is showing signs of rusting between plates. Seams of the connections exhibit rust staining.
- 2 Rusting between plates is beginning to distress the connection. Minor swelling exists.
- 3 Rusting between plates has caused serious distress to the connection. The plates may be badly distorted, however, all connectors (rivets/bolts) are still functioning.
- 4 Rusting between plates has caused serious distress to the connection, which warrants analysis of the bridge to ascertain the impact on the serviceability of the bridge. Some rivets or other connectors may have popped or are no longer effective.



Condition State 1



Condition State 2



Condition State 3



Condition State 4

Oxidation



Oxidation

Oxidation is the process where electrons (which bind atoms together to create materials) are drawn away by free oxygen molecules which are relatively unstable and looking for available electrons.

Corrosion



Corrosion

Corrosion is very similar, in that when material such as steel is exposed to an environment that causes it to come into contact with either a liquid, or dissimilar metal, a galvanic reaction occurs where molecules seek to find a balance between unequal numbers of electrons, the material giving up more electrons tends to show a greater rate of corrosion. As this happens the bonds are broken between molecules. Taken far enough this can further reduce these molecules back to the state of being atoms once again.

You Cannot Coat a salt contaminated surface and expect the coating to last.

Salts are the fuel for the fire. Coatings are permeable and all have moisture vapor transmission rates. If you leave salts on surface they will draw moisture right through the coating film. The moisture will combine with the salt creating an acid thru hydrolysis. The acid or electrolyte now is under the film and the corrosion process has started.



Do not bolt dissimilar metals together

The worst case we have seen is an engineer specified a bearing replacement using galvanized bearings and bolted it to an A588 (CORTEN) steel bridge.



There are 3 categories of coatings:

Barrier Coatings, Sacrificial Barrier Coatings, Chemically Active Corrosion Mitigation Coatings. If your coating projects do not last, then you are probably not selecting the system best suited for the job.

Barrier Coatings (No Zinc Primer)



[0 hr]



4320 hrs

ASTM D5894-05 Cyclic Corrosion Test with a 24 hr Freeze thaw at -40C

Sacrificial Barrier Coatings With a Zinc Primer



[0 hr]



4320 hrs

ASTM D5894-05 Cyclic Corrosion Test with a 24 hr Freeze thaw at -40C

Chemically Active Corrosion Mitigation Coatings



0 hr



6840 hrs

ASTM D5894-05 Cyclic Corrosion Test with a 24 hr Freeze thaw at -40C

UNDERCUTTING Test results from FHWA Mclean Research Lab ASTM D5894 Accelerated Cyclic Corrosion Rust Creepage – Laboratory Testing (ALT)

3-COAT SYSTEM

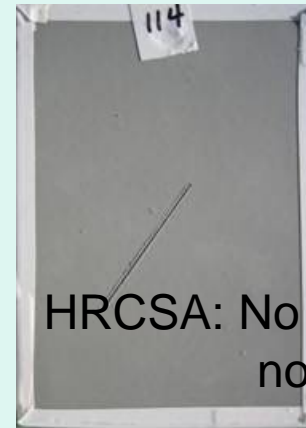


[0 hr]

Zinc Primer



[6840 hrs]



[0 hr]

HRCSA: No Undercutting
no rust creepage!



[6840 hrs]

HRCSA

SLX



[0 hr]

No Zinc Primer



[4320 hrs]



[0 hr]

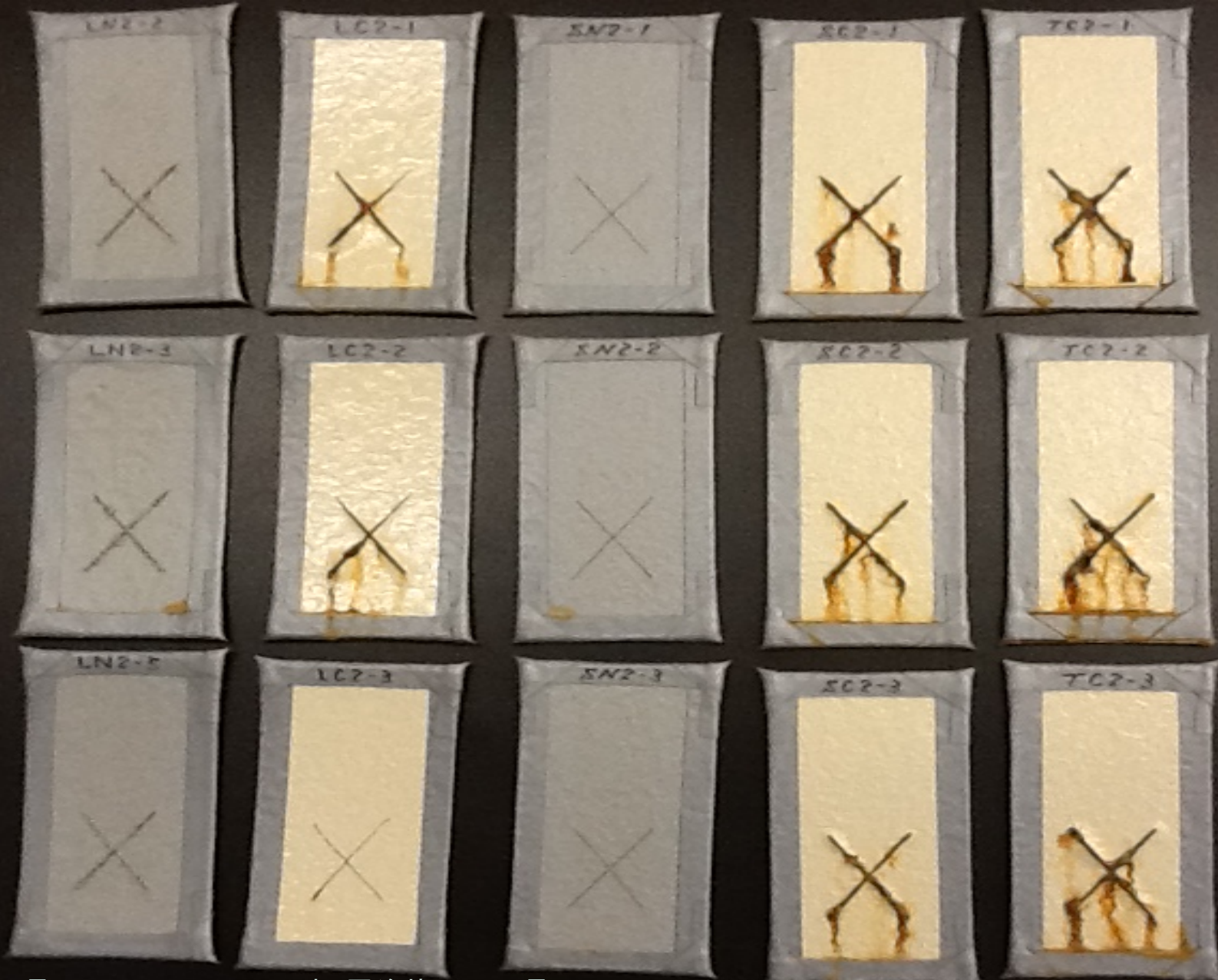
No Zinc Primer



[4320 hrs]

UMI

塩水噴霧試験結果



Termarust
レーザブラスト
塩分 0PPM

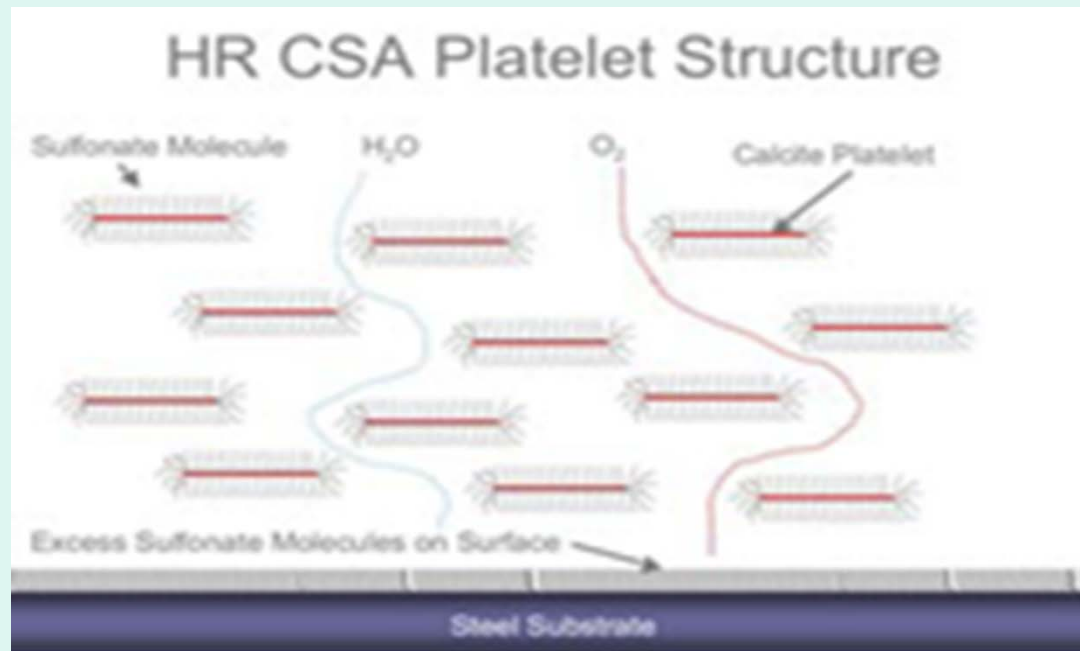
フッ素5層塗装
レーザブラスト
塩分 0PPM

Termarust
サンドブラスト
塩分 7PPM

フッ素5層塗装
サンドブラスト
塩分 7PPM

フッ素5層塗装
3種ケレン
塩分60PPM以上

Polar Bonding The Secret to HRCSA Rust Mitigation



The chemical reason the HRCSA coated steel test panels on the previous slide show no under cutting as reported in the FHWA Test results.

Disappearing Crevice Corroded Infrastructure

Some Solutions That Have
Been Utilized to Try to Solve
the Problem

The use of Weathering steel and new designs has been proposed as a solution to corrosion of bridges. The design component is very effective because they limit the joints and connections where crevice corrosion can develop. In areas where chlorides are present, premature failure and section loss occurs at a rapid rate. Properly spec'd coatings are a viable solution.



When cost is not an issue metallizing is an alternative. The white spots are where the contractor after one year has repaired the failing joints. The zinc is not designed to be applied to pack rust and crevice corrosion that can not be cleaned.



Some jurisdictions have chosen to caulk joints. Caulking is very expensive and usually delaminates due to different expansion contraction coefficients and only masks the problem as the electrolyte is still active in the joints.



Crevice Corrosion is Like a Open Wound and Must be Treated Properly

Laceration



Puncture wound



ADAM.

Would we just cover these wounds up with a bandage? We do it to Steel structures all the time and this is the end result. Crevice corrosion and pack rust need to be treated like an open wound. Proper cleaning, disinfected, antibiotic applied and then covered with a good bandage.



SSPC SP10 and 3 coat ZEU system. Flat surfaces are perfect joints are failing.

Conclusion

- Understanding and using Corrosionism as our infrastructure continues to age and disappear will help you to wade thru the confusion and misinformation you encounter while trying to stop corrosion.
- To insure the survival of our aging infrastructure owners need to address these problems by asking the coatings industry for chemistries that solve the corrosion problem present on there structures.