

Enhanced Visual Inspection Aids Corrosion Measurement

Corrosion is defined as a chemical or electrochemical reaction between a material, usually a metal, and its environment that produces a deterioration of the material and its properties [1].

Furthermore, corrosion complies with the Second Law of Thermodynamics. Metals have the natural tendency to combine with other chemical elements and return to their lowest energy state. That chemical interaction starts at the boundary between the metal and its environment and propagates through its thickness.

Consider corrosion of iron, at the onset of corrosion iron oxide is formed on the surface, refer to equation (1), and results in a 43% mass increase per iron atom!



As the corrosion process continues, the iron oxide is more susceptible to impact, abrasion, wind and gravity with iron oxide particles being removed from the uncorroded substrate. This facilitates the corrosion of the uncorroded substrate since it is easier for the migration of water and oxygen to that surface.

There are several means of quantifying corrosion, two of which shall be discussed here; visual inspection and mass loss. Meaningful quantification of the extent of the corrosion depends upon at whether the metal is experiencing the onset of corrosion or whether substantial corrosion has already occurred.

At the onset of corrosion ASTM D610 provides a means of visual inspection to quantify spot, general and pinpoint rust [2]. As the degree of corrosion increases standard test method include either a mechanical, chemical or electrolytic means of removing the corrosion byproduct, for example, iron oxide, from the substrate and to quantify the mass loss measured from a pristine rust-free datum. ASTM G1 an example of a mass loss standard [3] also provides a means of calculating the corrosion rate based on the mass loss, coupon specifications and time of exposure.

In 2013, at the request of the Florida National Guard, a Satellite Transportable Terminal was protected by Transshield XT cover for 45 days [4]. Paired coupons, inside and outside the cover after the trial are shown.

While it may be feasible to remove the iron oxide from the coupon on the right, it becomes more problematic to clean

the left coupon protected by the Transshield XT cover, and not remove some un-corroded substrate.



Figure 1. Typical coupon results showing coupons protected by an XT cover and exposed to the environment.

Transshield has enhanced the concept behind visual inspection process of ASTM D610 and employ an algorithm analyze a digital picture and quantify those pixels which reflect surface corrosion or protection [5]. Protection provided by a cover is quantified after exposure by equation (2).

$$Protection\% = \frac{\sum \text{Uncorroded Pixels}}{\sum \text{Corroded and Uncorroded Pixels}} \times 100 \quad (2)$$

Consider a 10x10 grid where black squares represent surface corrosion as shown in Figure 2. The specimen on the left has experienced 10% corrosion. If that coupon was protected by an advanced protective cover, the cover provided 90% protection.

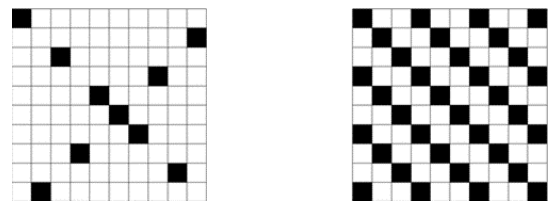


Figure 2. 90% protection and 66% protection

References

- [1] Corrosion Understanding the Basics, David, J. R. editor, ASM International, Materials Park Ohio, 2000
- [2] ASTM D610-12, Standard Test Method of Evaluating Degree of Rusting on Painted Steel Surfaces, ASTM International, West Conshohocken, PA, 2012
- [3] ASTM G1-11, Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens, ASTM International, West Conshohocken, PA, 2011
- [4] Sharman, D. J. Washburn, M., Ozol, S., The Wide-Ranging Benefits of Corrosion Inhibitors, The Society for Protective Coatings (SSPC) Department of Defense Allied Nations Technical Corrosion Conference, August 2017
- [5] Ozol, S, Todt, G. L., Method of Testing Corrosion Control Covers, NACE Corrosion Conference 2013, Paper 2166