Corrosion Coupon Testing

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Corrosion coupons are an inexpensive, effective method for monitoring the corrosion rate in any system or structure. However, obtaining meaningful results from these tests is not always as simple as measuring the weight loss and calculating the uniform corrosion rate. Surface finish, coupon placement and test duration significantly affect the caliber of your data. The following is designed to be an overview of corrosion coupon testing and how to obtain the most reliable data.

Corrosion coupon testing is an in-line monitoring technique; coupons are placed directly in the process stream and extracted for measurement. This monitoring technique provides a direct measurement of metal loss that allows you to calculate~the general corrosion rate. Also, when using corrosion coupons, your results are not dependent on the phase of the environment in which the measurement is performed.

Benefits of Corrosion Coupon Testing

- Simple and straightforward principle
- Provides specimens for post-test examinations
- Allows comparison between different alloys and inhibitors
- Assesses all forms of corrosion   Low cost

Corrosion coupons are most frequently used to investigate general corrosion and determine the corrosion rate based on weight loss of the coupon. However, various other forms of corrosion can be examined with these coupons:

- Crevice corrosion - Special washers/spacers are available to simulate crevices where the coupon surface is partially blocked from the liquid.
- Pitting - This type of attack may be evaluated by visual or microscopic examination of the coupon. Use large surface area coupons since the number of initiated pits is proportional to the surface area of the specimen.
- Galvanic corrosion - Coupons of different alloys may be placed in electrical contact.
- Susceptibility to stress corrosion cracking - Special coupons such as Crings and U-bends are available to investigate the occurrence of this form of corrosion.
- Scaling - Special coupons with various hole diameters are used to visually assess the extent and severity of scaling problems.

Limitations of Corrosion Coupon Testing

- Measures only the average corrosion rate during the time of exposure.
- Corrosion rates can only be calculated after coupon removal.
- Short exposure periods can yield unrepresentative corrosion rates, especially for alloys that form passive films, such as stainless steels. Normal exposure periods frequently approach 90 days. For example, ASTM G311 recommends minimum exposure time, in hours, as:

Exposure with hours =

2000

Expected corrosion rate in mpy

Therefore, if a corrosion rate of one mil per year (0.001 inches) is expected, the minimum recommended exposure time would be 2000 hours or 83 1/3 days.

Selecting Coupons and Exposure Locations Selecting the correct alloy to use as your corrosion coupon is by far the most important step in this process. If concerned with the general corrosion rate of a system or structure, designate a material that is identical, or as close as possible, to the material of construction. For example, select mild steel coupons (UNS G10100 or G10200) for use in most cooling towers and copper coupons (UNS C11000 or C12200) for service in copper heat exchangers. If unsure of the material of construction, consult your vendor. Also, test duplicate specimens to validate your results.

To obtain the most meaningful results, the surface finish and stress condition of the coupon should be identical to that of the structure of interest. This is usually impossible because it is difficult to duplicate mill scale and heat treatments of large structures in individual coupons. The best advice is to be consistent in your tests and specify a particular surface finish, such as 120 grit or glass beaded.

Contaminants from surface preparation may also affect the accuracy of your results. Many coupons are polished on aluminum oxide or silicon carbide abrasive paper. During polishing, these particles may become imbedded in the coupon, modifying the chemistry of the surface. A finishing technique that employs vitrified stone grinding wheels, such as double disc grinders, will minimize the contamination of the coupon surface. Frequently, coupons are sand or glass bead blasted during finishing. The blasting material penetrates the surface and remains imbedded in the coupon. This is especially true for softer metals and alloys such as aluminum or copper. Glass beading is preferred because it reduces surface damage; it is less abrasive than sand blasting.'

The location of the coupon in the process often dictates coupon size and dimensions. Obviously, if the coupon must be inserted into the process through a one inch full port valve, the coupon width must be less than one inch. Test racks allow for the simultaneous testing of multiple coupons. Be sure that the test rack can be inserted and retrieved at appropriate times. Confirm that test racks and insertion rods are resistant to corrosive attack from the test environment. Also, to eliminate any galvanic effects, check that the coupons are electrically isolated from the test rack. Broken test racks or loose coupons can destroy pumps, mixers and tanks. For example, consider a coupon that, for whatever reason, has broken away from its test rack. The coupon drops to the bottom of the pipeline or storage tank, Galvanic corrosion and/or crevice corrosion sites can be created, resulting in the rapid attack of the pipeline or storage tank.

The corrosion behavior of many alloys depends significantly on the presence of dissolved oxygen. Place corrosion coupons in locations that are representative of the degree of aeration normally encountered in the environment of interest.

The accumulation of corrosion products on the test coupons, whether it is from corroding plant equipment or other coupons, can adversely influence the results. For example, the presence of cupric ions in solution, resulting from the corrosion of heat exchangers or coupons, will enhance the corrosion resistance of stainless steel coupons.

Additional guidelines for selecting coupon geometries and locations are detailed in ASTM G4-84.1

Post Exposure Inspections

Test coupons should be rinsed with distilled water or a suitable solvent, air dried and placed in a sealed bag. Plastic bags treated with vapor phase corrosion inhibitors are useful. Weigh the cleaned coupon to a tenth of a milligram. Specific cleaning and weighing procedures are outlined in ASTM G- 1.4 The formula for calculating the corrosion rate in mils per year is: Corrosion Rate in mils per year 534xW-- (DxAxT)

Where W is the weight loss in milligrams, D is the density of the coupon in gramS/CM3 , A is the exposed area in square inches and T is the exposure time in hours .5

Occasionally, users will obtain the weight loss data and then dispose of the coupon. This is unfortunate; important information may be obtained from these coupons. For example, a visual or microscopic inspection shows whether the attack was uniform or localized (pitting or crevice corrosion) in nature. Maintain a record of the condition and appearance of the coupons, especially if any coatings or films are present.

Advanced Test Methods

Planned Interval Tests are somewhat more involved than individual coupon analyses, but the additional information obtained justifies the additional effort. This technique identifies the accumulated effects of corrosion at several time intervals such as: the initial corrosion rate of fresh metal, the initial corrosion rate of fresh metal after long exposures and the corrosion rate of metal after long exposures. Essentially, this technique allows you to monitor the corrosiveness of the liquid and the metal corrodibility as a function of time. It is an effective tool for monitoring inhibitor effectiveness over time. Specific guidelines and procedures for conducting planned interval tests are detailed elsewhere .6,1

Additional Uses for Corrosion Coupon Analyses

Although the primary reason for coupon testing and analyses may be to monitor corrosion rates, several other "real-world" reasons exist:

- Defend yourself against the competition's claims of inferior corrosion control program. A competitor may try to discredit the effectiveness of your corrosion control program by placing a coupon in a process that uses your inhibitors and comparing its appearance and weight loss to a coupon from a similar process that uses his chemicals. Find out where these coupons were placed in each process. It is likely that the coupon from your process was suspended from a copper wire into a high velocity turbulent location whereas your competitor's coupon was fixed to an insulating insertion rod into a deaerated reservoir.

- Oversee the effectiveness of your vendor's corrosion control program. If you employ a vendor for corrosion control services, installing your own coupons may be a costeffective method of evaluating their results, thus ensuring that you are getting what you are paying for.

- Evaluate inhibitor performance and dosing levels. Microscopic examinations of the coupon surface and weight loss data are valuable tools for evaluating the long-term performance of inhibitors.

- Monitor cleaning procedures and shutdowns. Inserting coupons at the beginning of cleaning or shutdown and removing them before start-up identifies any corrosive damage that may have occurred during these periods.

Summary

Several ASTM Standards have been referenced in this document. Recommended practices for field couponcorrosion testing and surface finish on corrosion coupons are currently being written by the National Association of Corrosion Engineers and ASTM, respectively. These standards and practices attempt to cover applications ranging from the oil patch to chemical process plants to water treatment facilities.

Reviewing these documents and applying their recommendations will aid you in obtaining meaningful results from corrosion coupon testing, whatever your area of specialization.

Survey your needs and requirements in your business and explore opportunities where corrosion coupon testing and analyses may be beneficial to you. When you perform coupon tests, ask: "Why am I conducting these tests and what do I hope to gain from this work?" then design your experiments accordingly. Record your results in a database to assist in making accurate comparisons and recommendations for future projects.V

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