WHITEPAPER

UNDERSTANDING CORROSION PROTECTION TESTING

HERESITE
PROTECTIVE COATINGS, LLC

In the HVAC-R industry, corrosion happens, it is inevitable. Air, fume, and heat transfer equipment is often exposed to harsh conditions which leads to atmospheric corrosion. However, all is not lost. Commercial heating, cooling, refrigeration, and other industrial process coils can be protected using coatings specifically developed to protect critical equipment while maintaining performance.

The appropriate coating for the environment is often selected based upon the coating's corrosion test performance. As a result of air, fume, and heat transfer equipment operating in a wide variety of environments, the type of protective coating needed varies from application to application. Therefore, it is extremely important to understand the types of corrosion testing available as well as their ability to predict coating behavior.

Table of Contents

UNDERSTANDING THE USE CASE FOR YOUR TEST

There are many ways to test corrosion protection. Corrosion protection tests should be selected based upon the properties of the environment in which the equipment will operate as well as the substrate properties of the equipment to be coated.

Environmental Properties

Environmental properties to be considered include the types of exposure (atmospheric, splash, or immersion) as well as the aggressiveness of the atmosphere itself. Consider the following factors when evaluating the aggressiveness of the atmosphere:

- Temperature
- Moisture
- Salts
- Bacteria
- Time
- Water
- Gases
- Chemicals
- UV Radiation

Atmospheric aggression is an important factor because environments are not uniform. Coatings used in an environment with atmospheric exposure will be subject to alternating conditions including UV radiation, temperature, and chemical concentration. The atmosphere will also vary depending on climate and proximity to known corrosive elements such as salt or chemicals.

Once you understand the type of exposure and aggressiveness of the atmosphere, you can determine the level of corrosivity protection needed. Atmospheric corrosivity categories are determined by the International Standards Organization (ISO) and are based on long-term material mass loss and thickness loss testing. There are five corrosivity categories:

- **C1 – Very Low** – Example of environments include heated buildings with clean atmospheres such as schools or offices.
- **C2 – Low** – Example of exterior environments include atmospheres with low levels of pollution, mostly rural areas. Example of interior environments include unheated buildings where condensation may occur such as depots or sports halls.
- **C3 – Medium** - Example of exterior environments include urban and industrial atmospheres, moderate sulfur dioxide pollution, or coastal areas with low salinity.
  Example of interior environments include production rooms with high humidity and some air pollution such as food processing plants, laundries, breweries, or dairies.
- **C4 – High** - Example of exterior environments include industrial areas and coastal areas with moderate salinity. Example of interior environments include chemical plants, swimming pools, coastal ship and boat yards.
- **C5-X – Very High Industrial or Marine** - Example of exterior industrial environments include industrial areas with high humidity and aggressive atmospheres.
  Example of interior industrial environments include buildings are areas with almost permanent condensation and with high pollution.
  Example of exterior marine environments include coastal and offshore areas with high salinity.
  Example of interior marine environments include buildings or areas with almost permanent condensation and with high pollution.

When the corrosivity category is known, it can be a useful tool for selecting the right coating for your HVAC/R equipment. However, it is important to note that a coating capable of providing protection at a higher level also protects well at every corrosivity level below the level tested – without impacting coil efficiency. Therefore, to provide maximum life extension and coil efficiency, it is best to choose a coating that has been tested for a higher corrosivity category.

Substrate properties

In addition to the atmospheric considerations, the performance of a coating is also impacted by the material to be coated and the surface preparation used prior to application. Equipment can be manufactured using a variety of metals, often including more than one type of metal on a single piece of equipment. Each metal is subject to different levels of vulnerability to corrosion. The composition of the entire piece of equipment might need to be considered when selecting the corrosion test to be used as a predictor of equipment life, depending on the equipment's application.

Understanding surface preparation is also critical when evaluating corrosion test performance. The application (or absence of) topcoat will impact overall test results. You should understand the type of primer and/or topcoat used, as they will most certainly impact test results.

POSSIBLE TESTING ENVIRONMENTS

Today's protective coatings exhibit levels of strength and durability which make natural environment testing impractical from an R&D perspective. Therefore, laboratory settings are used to accelerate the impact of environmental exposure, allowing new coatings to be developed at a much more reasonable pace.

Environmental exposure can be tested in a laboratory environment using several types of tests including:

- Salt spray chamber testing which involves placing coated panels into a test cabinet that delivers an aerosol of 5% salt solution into the chamber, exposing the test panels to a continuous saline environment for a prescribed length of time.
- Humidity chamber testing which simulates temperature and humidity conditions to assess the prolonged effect of humidity on a coating.
- Chemical gas chromatography which separates the elements of a compound. It is useful when understanding atmospheric conditions, such as pollutants.

CORROSION PROTECTION TESTS – AN OVERVIEW

There are many tests that can be used to measure the potential impact of corrosion on protective coatings. These tests have evolved along with coating and testing technology.

ASTM B-117 - Originally developed in 1939, ASTM B-117 was the first internationally recognized salt spray standard. For years, it was the gold standard in corrosion testing. ASTM B-117 is a non-cyclic test, which means that the surface is continually exposed to "salt air." In this test, the panels are exposed at a 15 to 30-degree angle from vertical to continuous deposition of an atomized 5% NaCl (sodium chloride or salt) solution at 35 degrees Celsius and 97% humidity. Although ASTM B-117 remains a commonly used test, its major fault is that there is limited correlation to a real-world environment in which weather conditions fluctuate.

ISO-9227 - ISO-9227 is nearly identical to ASTM B-117. The biggest difference between the two tests is that ASTM B-117 is a U.S. standard, while ISO-9227 is recognized nearly worldwide. Like ASTM B-117, the ISO-9227 test is a continuous test in which the testing atmosphere does not change. Although it is also a widely accepted test, it suffers from the same fault found in ASTM-B117 – it does not mimic real world conditions.

ISO-12944-6 - Published in 1998, ISO-12944-6 is a standard originally developed to evaluate corrosion protection of steel structures. This standard is an improvement over ASTM B-117 and ISO-9227 because it is a cyclic test. Test panels are exposed to water condensation, salt spray, and in some cases, 168 hours of chemical spot testing consisting of 10% Sodium Hydroxide, 10% Sulfuric Acid, and 18% Mineral Spirits. The length of exposure is dependent upon the corrosivity category of C1 – C5-I or C5-M. (C5-I/M is the most severe).

ISO 12944-9 - ISO 12944-9 is the most demanding corrosion testing standard available for marine/salt air environments. It is a cyclic test and better correlated to the real-world environments of harsh marine conditions than other standards. ISO 12944-9 has been adopted as the pre-qualification offshore performance standard for barrier coatings that may be broken down due to long term exposure to sunlight, moisture, sea water spray, and wind chills. We believe it should be the baseline test for HVAC/R systems in offshore and coastal marine environments. This test runs for 25 weeks (4,200 hours). During the test, the environmental conditions cycle between 72 hours of UV, 72 hours of salt spray, and 24 hours of low temperature exposure (-20 – 2 degrees Celsius).

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SWAAT: ASTM G85 – An acronym for Sea Water Acetic Acid Test, SWAAT: ASTM G85 is a corrosion test that uses synthetic sea salt made with the addition of glacial acetic acid instead of traditional sodium chloride. This test measures the resistance to corrosion when exposed to a changing climate of acidified seawater spray, followed by high humidity, with both at an elevated temperature.

ASTM D2247 – This test measures a coating's ability to resist water by placing the test subject in a controlled environment with 100% humidity. Condensation can form on all surfaces. The test subject is left in the controlled environment for a set period. For example, Heresite's VR-514 has passed ASTM D2247 at 250 hours, while HL-300 has been tested at 2,500 hours of continuous exposure.

SAE J2334 – Primarily used in the automotive industry, SAE J2334 is used at Heresite to validate the use of coatings in the transit industry. J2334 is a cyclic test in which the specimen is exposed to a three part repeating cycle consisting of 6 hours exposure to a water fog/ condensing humidity at a climate of 100%RH at +50C, followed by 15 minutes of salt water immersion or direct spray, followed by 17 hours 45 minutes of air drying in a climate of 50% RH at +60C.

COMPARING ASTM B117 AND ISO 12944-9

ASTM B-117 was the first nationally recognized salt spray standard. Published in 1939, this salt spray test is widespread and often recognized as the "gold standard" in corrosion testing. However, ISO 12944-9 offers a more realistic and updated method of testing, representing a significant improvement over ASTM B-117.

When the ASTM B-117 test is conducted, the coating to be tested is exposed to continuous salt spray for a pre-determined period. Panels are exposed at a 15 to 30-degree angle from vertical to continuous deposition of an atomized 5% NaCl solution at 35C and 97% humidity. While this test can measure resistance to corrosion in a continuous salt environment, it does not correlate well to real world atmospheric conditions. In addition, the wording of this standard provides opportunity for reduced consistency of testing because there is room for interpretation of the standard in how the panel is prepared and what substrates are used, among other variables. However, it is relatively inexpensive, reasonably well standardized, and reasonably repeatable.

By contrast, ISO 12944-9 is a cyclic test. The goal of this test is to more closely approximate the harsh atmospheric conditions that exist in marine environments. In the ISO 12944-9 test, the coating is exposed to 72 hours of UV, followed by 72 hours of salt spray, followed by 24 hours of freezing conditions. This cycle is repeated 25 times for a total of 4,200 hours of exposure. The inclusion of a freeze cycle results in a more advanced method of testing and introduces additional stress on the coating, providing results that are more closely related to the exposure seen in the field. In addition, the wording of the ISO 12944-9 test provides much stronger guidance on panel preparation and evaluation.

ASTM B-117 has been tested for correlation to real world environments many times over the past 20+ years. Each time, the evaluation produced the same results – the correlation coefficient of ASTM B-117 to real-world exposure is around 0.11. A perfect correlation coefficient is 1, which means that the number correlates 100% of the time. A correlation coefficient of 0.11, such as the results of the ASTM B-117 test, is very close to a pure random number – meaning there is almost no correlation. For this reason, ISO 12944-9 is a much better testing procedure for coatings that will be used in highly corrosive environments.

CONCLUSION

Choosing the right protective coating for your environment is an important decision. While corrosion testing cannot guarantee performance in your environment, it can help improve your selection process. It is important to understand the meaning of a coating spec and how it was tested when comparing coatings, as well as the correlation to your real-world application. This knowledge will help ensure you evaluate the potential performance of your coating as accurately as possible.

ABOUT HERESITE PROTECTIVE COATINGS

Established in 1935, Heresite Protective Coatings has spent more than 80 years developing and perfecting protective coatings that solve corrosion problems in a variety of applications including commercial heating, cooling, refrigeration or other industrial process coils, as well as components that are regularly exposed to corrosive conditions, including coastal and marine environments. The company's ongoing focus on technology leadership, rigorous quality with process controls, and customer satisfaction has led to the development of multiple industry-leading coatings based on phenolic, epoxy phenolic, urethane and silicone chemistries. Heresite coatings not only provide protection in corrosive high salinity marine conditions, but also industrial applications such as wastewater treatment, swimming pools, food processing, mining, oil and gas, semi-conductor production, pulp and paper, textile factories and other environments where these systems are exposed to chemical fumes. For more information visit heresite.com or call 800-558-7747.

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