National Coil Coating Association

Corrosion and Corrosion Testing

Introduction

Much coil coated material is used for applications that require long service life in an exterior environment. A key performance attribute is coil coating's resistance to corrosion. Corrosion is an electrochemical reaction between a material and its environment. This deterioration may be limited to the material's appearance, or it may lead to mechanical and structural deterioration. For more information about the process of corrosion, see NCCA Tool Kit #4, Fundamentals of Corrosion.

The entire coil coating value chain is well aware of the need to resist corrosion. To achieve the appropriate level of corrosion resistance for an intended end use application, proper substrate selection is critical, as is proper pretreatment and paint system selections and painting of this substrate. The necessary material parameters to prevent or reduce corrosion are well known, as are the necessary material handling, fabricating, transporting and installation needs within the metal construction industry. There are NCCA resources available that are useful when considering this topic, such as:

- Toolkit #1 Preventing Job Site Storage Corrosion of Prepainted Building Panels
- Toolkit #4 Fundamentals of Corrosion and Their Application to Coil Coated Metal
- Toolkit #5 Cut Edge Protection Using Prepainted Sheet
- Toolkit #23 Storage Guidelines for Prepainted Metal
- Toolkit #30 Guide to Metal Substrates for the Coil Coating Industry

The coil coating industry attempts to gauge the performance of prepainted metal in actual conditions by conducting tests that are intended to accelerate the corrosion process. This tool kit provides information regarding accelerated corrosion tests and the industries where they are commonly used.

Corrosion is a complex topic, primarily because there are many microclimates that drive the corrosion process. If a coil coated product is located in an aggressive industrial environment, the conditions under which the metal is exposed are far different than a similar coil coated product installed near an ocean. A coil coated panel that is installed under cover (an eave, a breezeway, etc.), where moisture may collect, but never completely evaporates, will perform differently than a roofing panel which receives hours of sunshine each day. Couple these complexities with the desire to study corrosion effect under accelerated conditions in an effort to learn as much as quickly as possible and you have a demanding set of parameters with which to contend. This tool kit, of course, cannot address all the variables that should be considered when performing corrosion testing, but it will detail the various test methods that are common in the industry.

Testing may be done under accelerated conditions or real-time conditions. No matter the test protocol, however, it is critical that results from the test perform similarly to that of the prepainted material during its service life.

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Real-Time Outdoor Testing

Real-time testing is normally conducted in an aggressive environment, and—for corrosion resistance—the usual choice is a test site where high-chloride concentrations and long wet times exist. Of course, this is a single environment, and it may not be the appropriate test if the prepainted metal is exposed to an aggressive chemical environment (*i.e.*, high acid levels, highly alkaline conditions, etc.)

In the U.S., two commercial sites are commercially available:

- Battelle's Florida Materials Research Facility, Ponce Inlet, Florida (about 12 miles south of Daytona Beach); on the shore of the Atlantic Ocean. Panels are attached to racks, and the producer needs to specify the rack angle and direction. Some prefer to test panels at this site under an eave (or cover). This creates an even more aggressive condition since salt deposits are less effectively washed away during a rainstorm.
- Atlas Material Testing Solutions, Jacksonville, FL; located on Blount Island in the Port of Jacksonville. This coastal, industrial environment is favored by automotive coating suppliers for its acid-rich (acid etch) environment.

In Europe, the European Coil Coating Association recommends three sites:

- Brest, France: aggressive marine environment
- Hoek van Holland, Netherlands: marine/industrial environment
- Sines, Portugal: very aggressive marine-industrial environment

Accelerated Cabinet Testing

There are a variety of accelerated cabinet tests that may be run to assess the corrosion resistance and the quality of a product. Most modern test methods use a cyclic approach that is intended to more closely replicate actual environmental conditions. The tests typically involve a series of wet and dry cycles, and some include additional exposure to ultraviolet light, heat, humidity, etc.

No one test method is suitable for all end use applications, and no accelerated corrosion test can predict how all products will perform under all conditions. In service, a metal roof may show different performance than a wall panel, since each has a different set of exposure conditions.

NCCA has conducted an extensive review of the many test methods that are in use today. Following are NCCA recommended test methods for various applications, along with a brief explanation of what the test entails:

- ASTM G85-Annex 2: For aluminum automotive applications; was found to be the most representative of on-vehicle corrosion tests in a United States Automotive Materials Partnership LLC (USAMP) industry/government initiative sponsored by the U.S. Department of Energy (DOE). The test involves a wet/dry cycle and acidification.
- B368 Standard Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test). The presence of a copper cation in this test exacerbates corrosion of aluminum substantially.
- ASTM G85-Annex 5: For steel building products; a cyclic test employing a dilute electrolyte solution of both chloride and sulfate accelerants.

- ASTM D5894: A cyclic test exposing the product to alternating weeks of G85-Annex 5 (see above) with ASTM G154 UV-A (340 nm) exposure. This test is more laborious to run, but may be a better predictor of field performance rankings for prefinished steel materials due to the inclusion of weathering stresses on the product.

- SAE J2334: For automotive applications in which the customer has not dictated the test method, this is a commonly accepted test. It is a cyclic test developed through joint efforts of the steel and automotive industries, comparing field exposure data. The test involves a humidity stage, a salt dip stage, and a drying stage.

- ASTM B117 Salt Spray is a common test that you may encounter. It is *not* a cyclic; rather it subjects the coating to a constant spray of 5% NaCl solution at a constant temperature. Much has been written about the shortcomings of this test, and the GalvInfo Center has an excellent article on the tests and its shortcomings, which can be found at: http://www.galvinfo.com/ginotes/GalvInfoNote_3_4.pdf

- The following ASTM moisture resistance tests may also provide insight regarding the long-term performance of prepainted metal:

  - D1735 Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
  - D2247 Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
  - D4585 Standard Practice for Testing Water Resistance of Coatings Using Controlled Condensation (Cleveland Condensing Humidity)

Note about ASTM B117 Salt Spray testing: Despite the known shortcomings of the B117 test method, manufacturers, product designers, and specifiers still use it. At one time, the B117 test was the only option available. As it became more widely known and used, it became embedded into myriad internal documents, procedures, forms, specifications, etc. Users of the test have a lengthy history of results for their products, sometimes spanning decades, and may have little interest in changing to a new method. They have developed some familiarity with the results and what they mean for their specific products. Some may see no need or perceived benefit to changing tests, and may lack awareness that better options exist.

Ongoing Research

Additional alternative test methods to gauge corrosion performance are being developed. These methods typically also use a cyclic approach. The developers of these methods hope the results will also replicate actual performance and accurate product ranking in environmental conditions. Evaluation of these newer test methods is a long process, since materials must be exposed to various environments for decades to determine the effectiveness of the test methods in predicting performance. NCCA is monitoring the newer alternative test methods to ascertain their suitability for prepainted metal.

For instance, the European Coil Coating Association (ECCA) funded work to be done by the French Corrosion Institute. A proposed test, Coil Test 1A has been proposed and can be used for product development work. In the paper, a helpful table is shown that details the many variables in various accelerated corrosion tests. Some key parameters are shown below:

Accelerated cabinets (selected parameters)

	Electrolyte	pH	Approx. Total Cl (mg/cm2)	Time of Wetness (%)*	Basic Duration (days)
Neutral Salt Spray (ASTM B117)	5% NaCl	6.5-7.2	568	100	42
ASTM G85-A5	0.05% NaCl, 0.35% $(NH_4)_2SO_4$	5.0-5.5	2.8	60	42
CCT-1 (ASTM D5894)	5% NaCl	6.5-7.2	284	75	42
N-VDA	1% NaCl	6.5-7.2	8	53	42
Coil Test 1A	1.3% NaCl, 0.2% Na_2SO_4	3.0	5.3	58	84

*At 100% Time-of-Wetness, the sample is never dry. Other time-of-wetness values means the samples are dried under some defined schedule.

Other ASTM Standards when Considering Corrosion Testing

- ASTM D6675 Standard Practice for Salt-Accelerated Outdoor Cosmetic Corrosion Testing of Organic Coatings on Automotive Sheet Steel NOTE: This is test where panels, which are undergoing typical, real-time weathering on racks, are sprayed at a given period each day, with a salt solution.
- ASTM G1: Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens
- ASTM G16: Standard Guide for Applying Statistics to Analysis of Corrosion Data
- ASTM G46: Standard Guide for Examination and Evaluation of Pitting Corrosion
- ASTM G50: Standard Practice for Conducting Atmospheric Corrosion Tests on Metals
- ASTM G60: Standard Practice for Conducting Cyclic Humidity Exposures
- ASTM G67: Standard Test Method for Determining the Susceptibility to Intergranular Corrosion of 5XXX Series Aluminum Alloys by Mass Loss After Exposure to Nitric Acid (NAMLT Test)
- ASTM G71: Standard Guide for Conducting and Evaluating Galvanic Corrosion Tests in Electrolytes
- ASTM G82: Standard Guide for Development and Use of a Galvanic Series for Predicting Galvanic Corrosion Performance
- ASTM G87: Standard Practice for Conducting Moist SO_2 Tests
- ASTM G91: Standard Practice for Monitoring Atmospheric SO_2 Deposition Rate for Atmospheric Corrosivity Evaluation
- ASTM G140: Standard Test Method for Determining Atmospheric Chloride Deposition Rate by Wet Candle Method
- ASTM G161: Standard Guide for Corrosion-Related Failure Analysis
- ASTM G193: Standard Terminology and Acronyms Relating to Corrosion