Corrosion Tests: Laboratory Testing of Surface Coatings

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Surface coatings need to be precisely tailored to meet the application's specific requirements.

Steel parts and components installed in machines, vehicles, equipment or structures are required to withstand a range of stresses and environmental influences, particularly when located outdoors. To achieve this, they need a surface coating tailored precisely to the respective requirements. A range of different corrosion tests are conducted to simulate the corrosion effects in nature as realistically as possible in a short period.

Corrosion tests – A Complex Field

Essentially, the following applies—corrosion tests examine how long a material or component, coated or uncoated, resists corrosion. However, the diverse uses and framework conditions mean that designing and implementing such a test is typically a complex and time-consuming process.

For outdoor corrosion tests especially, initial corrosion damage is only visible after many years. Conditions over time vary greatly for so-called outdoor weathering. To be able to realistically simulate the various weathering conditions when testing outdoors a distinction is made between different climates from dry desert climates to tropical and/or salty conditions by the sea. The problem with this approach is the length of time for intensive testing and the achievement of dependable quality or development findings is generally too long. Special laboratory tests are instead carried out to simulate the life of a coating significantly faster and as realistically as possible. This involves materials or components being exposed to artificially created "corrosion promoting atmospheres" in test chambers.

Constant Climate Testing in Accordance with ASTM B117/ISO 9227 NSS

One classic corrosion test under constant conditions is neutral salt spray testing also known as constant climate testing in accordance with *ASTM B117* or *ISO 9227 NSS*. This involves materials and coatings being continuously exposed in spraying chambers at 35°C with a 5% salt solution, sometimes for over 1000 hours. Sodium chloride (NaCl) is used as salt, with the pH-value at 6.5 to 7.2, relative humidity at almost 100%. In addition, the condensation quantity is also collected according to defined criteria.

Due to the uniform test setup and the specified framework conditions according to *ASTM B117/ISO 9227*, the test procedure typically delivers reproducible or reliable findings regarding the corrosion resistance of a part or component. In addition, numerous values are also available based on experience. For example, a rule of thumb says that 720 hours of spraying corresponds to seven to fifteen years of corrosion exposure (C5 in accordance with *ISO 12944-6*) in outdoor weathering conditions.

A test chamber for the conducting of neutral salt spray testing in accordance with *ASTM B117/ISO 9227 NSS*.

In addition to the NSS variants, further salt spray tests are also employed. In acetic acid salt spray testing, acetic acid is added to the NaCl solution. This lowers the pH level to 3.1 to 3.3. In the copper accelerated salt spray test, CASS for short, the acetic acid NaCl solution receives the addition of copper chloride (CuCl2). This test variant is used to examine how well aluminum-oxide coats and decorative coatings consisting of copper, nickel and chrome (Cu-Ni-Cr) or nickel and chrome (Ni-Cr) protect.

Climatic Extremes Tests

Corrosion tests that expose components to multiple climates, so-called climatic extremes tests, often prove to be more realistic. For example, the **Deutsches Institut für Bautechnik (DIBT**) employs different tests to examine the corrosion stability of surfaces.

Corrosion tests carried out in the laboratory are combined with open-air weathering in the urban climate of Berlin, Germany as well as on the island of Sylt. In many cases, the salt spray test detailed above is combined—sometimes with

different salt concentrations to those specified in *ISO 9227,* with defined dry phases along with an impact phase of pure water spray.

In the process of carrying out these laboratory corrosion tests, the components that are to be tested are exposed to in-part, extreme temperatures in a range of from -40°C to +80°C.

In addition, a variety of sector-specific climatic extremes tests have also established themselves in the automobile industry market.

These tests are characterized by salt spray stages with stages at higher or lower temperatures, higher and lower levels of humidity as well as alternating rest stages. The variation of salt concentration, humidity and temperature results in the constant changing of the corrosive environment on the part, providing an optimal simulation of realistic environmental conditions.

For example, in the GMW14872 cyclical corrosion test components are sprayed with a solution of 0.90% NaCl, 0.1% CaCl2 and 0.075% sodium bicarbonate multiple times in the course of eight hours and then exposed to temperatures of 25°C to 60°C and humidity of < 30% to 100% in other test stages (duration of test cycle: 24 hours).

And in the alternating climate tests of the Swedish vehicle manufacturer, **Volvo**, components are not sprayed, but sprinkled from above in stages. These tests are known as accelerated corrosion tests (ACT). In the one-week test cycle of the ACT I, test components are sprinkled with a 1% NaCl solution with a pH level of 4.2 for a number of hours and then exposed to temperatures of 35°C to 50°C and humidity of 40% to 95 %.

In the **Ford** L-467 cyclical corrosion test, components are sprinkled with a 0.5% NaCl solution and then they are exposed to temperatures ranging from 25°C to 50°C and humidity of 70% to 95% in other test stages. Here too, a test cycle takes one week.

Specialized Tests in Practice

In addition to tests conducted in the laboratory, in various sectors specialized tests tailored to a range of different requirements are conducted to test the corrosion resistance of part surfaces. For example, car manufacturer, **Audi**, uses the INKA, one of the most rigorous tests, to simulate twelve years of car use under extreme conditions, with the five stages of the test covering 19 weeks. **Mercedes** has a similarly tough testing routine, the so called MEKO Test, while at **BMW**, vehicles are required to prove their corrosion resistance in an extensive Dynamic Corrosion Test (DyCo).

Selecting Corrosion Tests to Suit Individual Requirements

Consequently, this means that corrosion tests permit numerous findings to be obtained for assessing and optimizing the corrosion resistance of steel parts, providing an important basis for the long-term retention of functionality and lifetime. However, it is always important to choose the test that is precisely suited to the specific practical requirements of the respective part.

View of the test chamber for the climatic extremes test at -40°C/+80°C.

Finally, it should also be noted that corrosion tests can only simulate the various daily stresses that parts and components are exposed to, and can never reflect the full complexity of these.

Further information on corrosion tests as well as suitable surface coatings for diverse part requirements and areas of application can be found at the following websites:
www.doerkenusa.com or www.doerken-mks.de **FTI**

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