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Accelerated testing of waterborne coatings

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Abstract

According to environmental regulations, many of the traditionally used organic solventborne coatings should be replaced by low-toxicity and environmentally friendly alternatives (e.g. by waterborne paints).

We report here effects of weathering on waterborne coatings. Three styrene–acrylate waterborne paint systems containing various types of inorganic pigments were studied on steel substrate; salt spray, humidity chamber and field exposure tests were carried out on them. The accelerated laboratory tests were performed both on coatings after 2 weeks of coating preparation ("fresh" coating) and on naturally aged ones, i.e. after field exposures of various durations ranging from 3 months to 2.5 years. We found that—for a certain time—the longer the exposure period, the better are the results of salt spray and humidity chamber tests. Additional experiments were carried out on samples with different pretreatments: in some cases the results of the accelerated tests after cyclic dry–wet or heat pretreatments are better than that of "fresh" coatings.

Keywords: Salt spray test; Humidity test; Dry–wet cyclic pretreatment; Heat pretreatment

1. Introduction

Choosing a coating system to protect a metal construction against corrosion is important to harmonize the required durability of the construction and the expected lifetime of the coating, and naturally it is necessary to take economical and technical aspects into consideration.

Reliable lifetime prediction of the coatings is an essential—although difficult—task. We may expect adequate performance estimates if the coating is tested in the same—or similar—environment as that of the actual application [1]; however, such a natural exposure test requires too long time. For reducing test time, accelerated natural exposures and laboratory tests have been developed. These methods have been discussed in many works, among them in ref. [1] by Applemann. Accelerated outdoor tests have additional disadvantages over the non-accelerated ones: these are of poor reproducibility because of uncertainties of weather (note that the "non-accelerated" outdoor tests are much less sensitive to weather changes, since the time scale of the test is larger than that of the weather changes). The advantages and drawbacks of various exposure tests (natural and accelerated natural) have been discussed by Johnson and McIntyre [2].

Although accelerated laboratory tests are, in general, the fastest and their conditions are reproducible, reliability of their results is sometimes inadequate. Unfortunately, during the accelerated tests not only the relevant corrosion processes are speeded up but other, unwanted processes are initiated as well [3–5]. According to the generally adopted view, an accelerated test is reliable and acceptable if, for a series of coatings, it yields the same ranking as that obtained by the natural exposure test. By the results of these tests and the field experiments, it is possible to predict the lifetime of a coating. Carlozzo and co-workers were seeking correlation between six accelerated test methods and nine geographically different exposure sites applying nine different coating systems [6,7].

Many groups follow corrosion protection properties by electrochemical methods like impedance spectroscopy [3,8–13] or noise analysis [14–16].

The salt spray chamber and humidity chamber tests are widely used accelerated laboratory procedures for predicting

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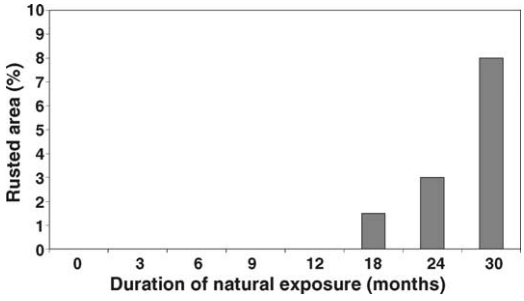

Fig. 1. Percentage of rusted area on the base metal as a function of natural exposure duration for samples covered with coating no. 2.

corrosion performance of coatings [1] although these methods have often been criticized [1,3,4,17], especially in relation to waterborne paints [18], but good correlations were found between the results of salt spray and natural marine environment exposure tests [7,19]. Different procedures were developed modifying and varying these methods and there are researchers who suggest pretreatments before tests too, for example Wienbeck [20]. Other authors applied tests involving UV exposure and/or some type of heat treatments [13,17,21].

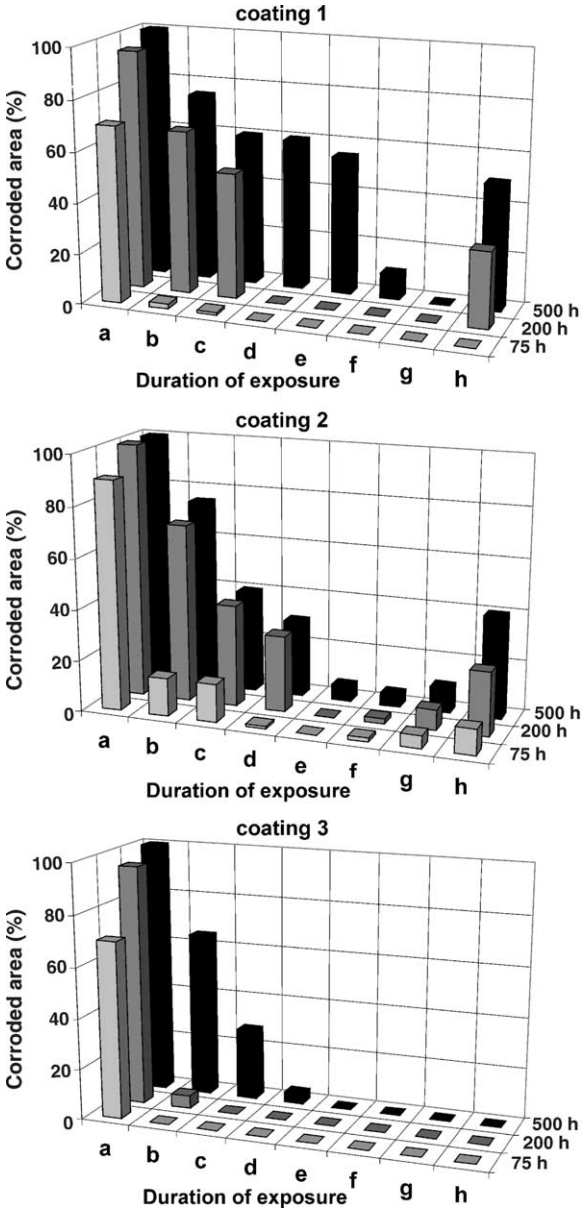

Fig. 2. Dependence of corroded area on natural exposure and on the salt spray chamber durations. Natural exposure durations are given as: (a) 2 weeks at room temperature and (b–h) 3, 6, 9, 12, 18, 24, 30 months of natural exposure, respectively.

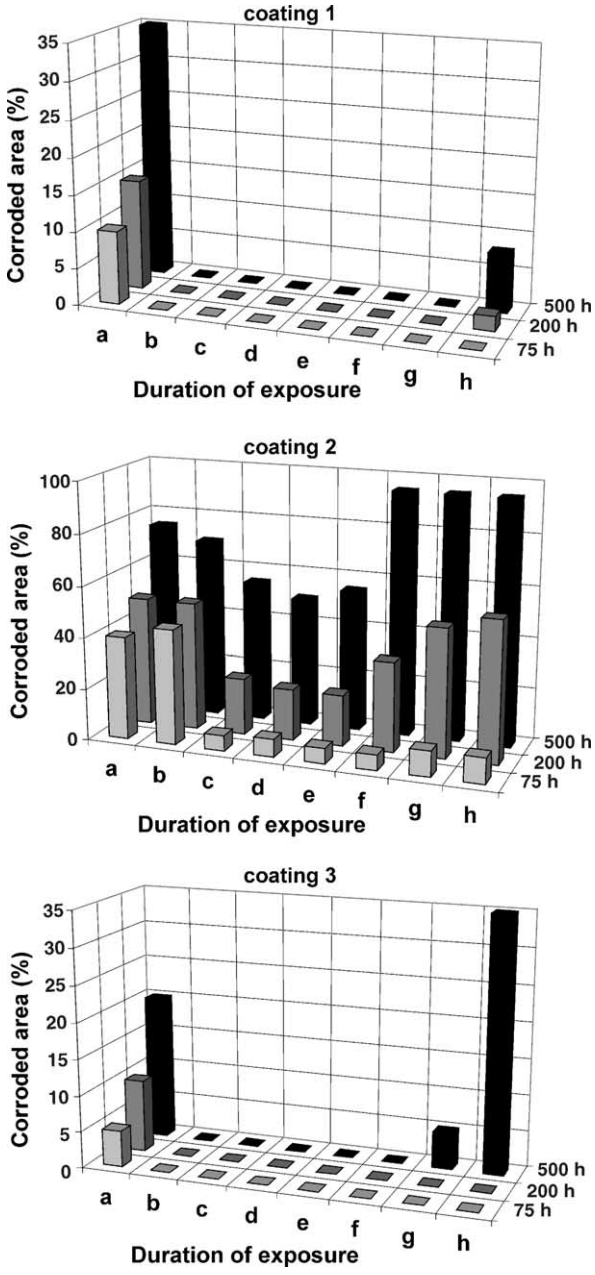

Fig. 3. Dependence of corroded area on the natural exposure and on the humidity chamber durations. Natural exposure durations are given as: (a) 2 weeks at room temperature and (b–h) 3, 6, 9, 12, 18, 24, 30 months of natural exposure, respectively.