THIN COATINGS APPLIED ON MATERIALS METALLURGICAL PERFORMANCE FOR SHORT - TERM ANTICORROSIVE PROTECTION

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Abstract

This contribution focuses on the short-term corrosion protection production materials. Conservative ability of coatings applied on materials metallurgical performance for short - term anticorrosive protection study is a current topic. Experimental section deals with testing of coating system on the substrate. The choice of the protective coating system depends primarily on the expected or planned service life of corrosion protection provided by barrier method restrictive access to water and corrosive components from the environment to the substrate material. The coating system was paint by nano inhibitor water-soluble acrylic based which has been based on sample STANDARD from low carbon steel. STANDARD samples were supplied with a defined surface treatment and roughness used for laboratory tests and to develop of coating systems. The coating system was applied by pneumatic spraying. The purpose of mechanical surface treatment is mainly to get rid of the surface material impurities. The relief of the substrate surface, cleanliness of the substrate surface before coating application and the appropriate technique of coating application on the substrate are important factors influencing the quality and service life of coatings. Applied coating system was exposed to artificial salt spray atmosphere and a corrosive solution which is used for testing by the so-called accelerated immersion test. Following was the evaluation of degradation and adhesion of the tested coating system. The results of the experimental part showed that the coating showed high ability of adhesion to the base material. Also corrosion test in corrosion chamber and immersion test showed very interesting results.

Keywords: Coating system, surface treatment, coating technology, nanocoatings

1. INTRODUCTION

Surface treatment material is an integral part of today's world. Constantly increasing requirements for treatment surface of the base material require new types of paint systems and modern technologies for their applications. Corrosion shall be subject almost all materials, such as metals and their alloys, as well as inorganic and organic materials. Corrosion protection of steel products places greater emphasis on the thickness of the protective layer of paint. The basic mechanism of coating is protected by a barrier between the metal and the corrosive environment. A barrier reduces the access of aggressive constituents from the environment (air, water, etc.) to the base material. In terms of time, there is short-term and long-term corrosion protection. The aim of short-term protection is give customer the product without damage (corrosion) with the desired appearance and properties.

2. SPECIFICATION OF EXPERIMENTAL MATERIALS

For experimental work were used samples STANDARD, which were made from low carbon steel (producer LABIMEX CZ Ltd. company), dimensions 102 x 152 x 0.8 mm. The surface was cleaned and degreased. These samples are applied nano-inhibitor water based acrylic paint.

Table 1 The chemical composition of the sample STANDARD

Chemical composition				
Element	**C**	**Mn**	**P**	**S**
Contents [%]	max. 0.13	0.25-0.60	0.04	0.05

Nano-inhibitor waterbased acrylic paint was applied by pneumatic spray. The average dry film thickness of the coating was 135.04 micron.

3. EXPERIMENTAL MEASUREMENTS

The experimental works were focused on laboratory testing of coating systems applied on steel sheet with the evaluation their corrosion resistance and mechanical properties testing.

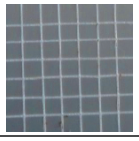
Experimental measurements:

1) Cross-cut adhesion test according to EN ISO 16276-2
2) Corrosion tests in artificial atmospheres - Salt spray tests according to EN ISO 9227
3) Immersion test according to ČSN 673087

3.1. Cross-cut adhesion test according to EN ISO 16276-2

Evaluation of adhesion was done with a cross-cut test according to EN ISO 16276-2, which refers to EN ISO 2409. Cuts into the coat were made by the cutting tool and by the template. Film thickness determines the spacing of each cut and size squares. Special adhesive tape is affixed on the cuts and after the measurement it removes paint squares with a bad adhesion. Result of the test is reported as a numerical rating corresponding to the observed damage (see **Table 2**).

Table 2 Cross-cut adhesion test - results

SAMPLE	PHOTO	CLASSIFICATION
Nano-inhibitors, water-based paint based on acrylic		0

The measurement result is the arithmetic mean of the total three measurements per sample. The result is a very good adhesion to the substrate. The cut edges are smooth and no square is damaged.

3.2. X-cut test according to EN ISO 16276-2

The cutting tool is created cut in the paint in the shape of the letter X. The length of each cut has to be 40 mm. Angle between cuts is in the range from 30 ° to 45 °. Length of adhesive tape is 75 mm, which is fixedly pressed against the cuts and within 5 minutes of torn away. The result is processed as numeric rating corresponding to the observed damage (see **Table 3**).

Table 3 X-cut test - results

SAMPLE	PHOTO	CLASSIFICATION
Nano-inhibitors, water-based paint based on acrylic		0

The results of the cross-section are very good. There was no flaking of paint.

3.3. Corrosion tests in artificial atmospheres - salt spray test according to EN ISO 9227

The corrosion test was carried out in a salt corrosion chambers LIEBISCH S400 M-TR. Before loading the samples in the corrosion chamber was taping the edges with tape. This operation prevents the creation of the primary corrosion. For the test were prepared two samples, one of them has been created a vertical cut with a length of 70 mm. Depth of cut has to be up to the base substrate. The investigated samples were documented in each cycle. The test period was determined on 72 hours, which corresponds to testing for a short term protection of materials against corrosion. The results for each measurement interval are shown in **Table 4 and 5**.

Table 4 Results of corrosion tests (samples without cut)

The application of the coating system by pneumatic spraying (without cut)			
Sample	**Exposure in a corrosion chamber [hours]**	**The degree of blistering**	**Degree of rusting**
Nano-inhibitors, water-based paint based on acrylic	**0**	0(S0)	Ri0(S0)
	72	1(S2)	Ri0(S0)

On the samples were classified degree of blistering 1 (S2), which corresponds to the size of the defect just visible to the unaided eye or with correction. The samples also showed no degree of corrosion.

Table 5 Results of corrosion tests (samples with cut)

The application of the coating system by pneumatic spraying (with cut)				
Sample	**Exposure in a corrosion chamber [hours]**	**The degree of blistering**	**Degree of rusting**	**Delamination/ corrosion**
Nano-inhibitors, water-based paint based on acrylic	**0**	0(S0)	Ri0(S0)	0/0
	72	1(S3)	Ri1(S1)	2/3

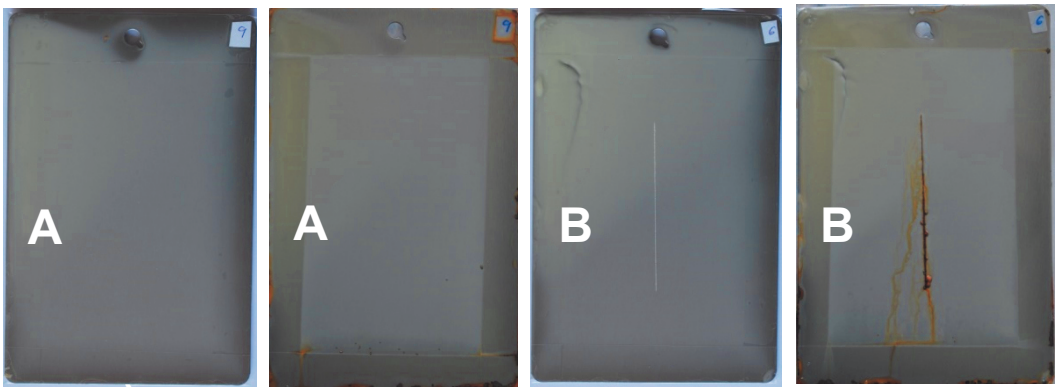


Fig 1 Photos of degradation of coatings: A) samples without cutting, B) samples with cut, a) before loading into the chamber corrosion, b) after 72 hours of exposure in the corrosion chamber

On the samples were classified degree of blistering 1 (S3) corresponding to the size of the defect distinctly visible to the unaided eye or with a correction of visual defects (0.5 mm). The samples also showed a degree of perforation Ri1 (S1) corresponding to the defect only visible at a magnification of up to ten times. Delamination was evaluated at level 2, or small.

3.4. Immersion test according to to ČSN 673087

The standard shall apply testing the ability to protect the substrate against undercutting at the site of damage in a defined environment. The procedure is used for coatings on steel and the process is based on the exposing test specimens acidified sodium chloride solution with the addition of hydrogen peroxide. After completion of each cycle the samples were rinsed with distilled water and left out of the device. This was followed by hanging samples in air for 8 hours. After the last cycle, the samples were removed and rinsed three times with distilled water. The samples were then placed in a thermostat with a temperature of 40 ± 1 °C. The final step is cooled at room temperature of 23 ± 2 °C.

The evaluation in each interval is shown in **Table 6 and 7**

Table 6 Results of individual intervals are given in **Table 6 and 7**

The application of the coating system - pneumatic spraying (samples without cut)			
Sample	**Exposure**	**The degree of blistering**	**Degree of rusting**
Nano-inhibitors, water-based paint based on acrylic	**Before loading into the solution**	0(S0)	Ri0(S0)
	After the 3rd cycle	4(S5)	Ri5(S5)

The samples were classified by the degree of blistering 5 (S3), which describes the size of the defect clearly visible to the unaided eye or with a correction (0.5 mm). The samples also showed a degree of rusting Ri5 (S5), which is described by the size of defects greater than 5 mm.

Table 7 The results of immersion test (samples with cut)

The application of the coating system - pneumatic spraying (samples with cut)				
Sample	**Exposure**	**The degree of blistering**	**Degree of rusting**	**Delamination/ corrosion**
Nano-inhibitors, water-based paint based on acrylic	**Before loading into the solution**	0(S0)	Ri0(S0)	0/0
	After the 3rd cycle	2(S3)	Ri1(S1)	2/1

The samples were classified by the degree of blistering 2 (S3), the size of the defect is clearly visible to the unaided eye or with a correction (0.5 mm). The samples also showed a degree of perforation Ri1 (S1) corresponding to the defect only visible at a magnification up to ten times. Delamination was evaluated at level 2 - small.

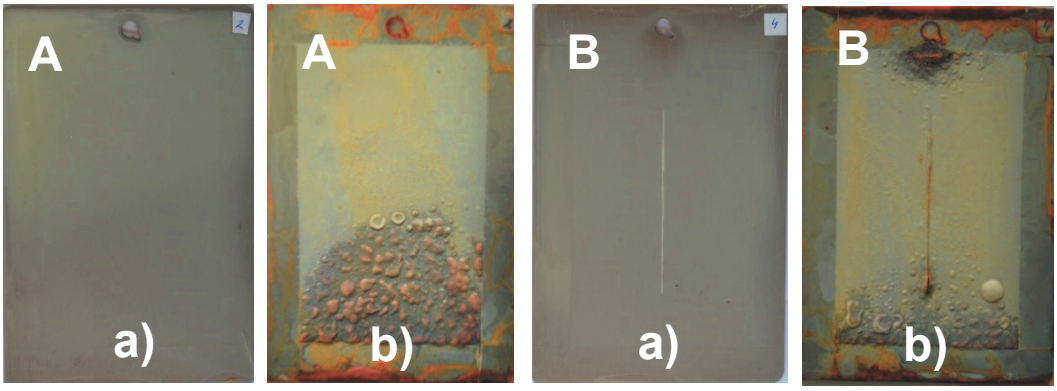


Fig. 2 Photos of degradation of coatings: A) samples without cutting, B) samples with cut, a) before loading to the solution, b) after the third cycle of immersion test

CONCLUSION

Corrosion protection is deals not only with long-term protection of material, but also short-term. Requirements placed on short-term protection of material are very specific and require individual study. It is necessary to find solutions that meet the requirements of the technology (application conditions, transparent coating), corrosion resistance requirements, environmental requirements and not least economic requirements. The research was focused on the short-term protection of steel materials by using transparent water-based coating containing nanoparticles of corrosion inhibitors. The results of the experiments show above standard results for the short-term corrosion protection of material (about 1 year) in environments with very high corrosivity of environment.

ACKNOWLEDGEMENTS

The research work has been solved with the support of the Ministry of Education, Youth and Sports of the Czech Republic under the Research and Development for Innovation program, name of project: Pre-Seed Activity VSB***-TUO II - Materials, number of project: CZ.1.05/3.1.00/14.0320.***

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