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ISSN 0543-5846
METABK 62(2) 251-254 (2023)
UDC – UDK 620.193:620.197/621-4:668.395.004.12:531.117=111

COMPARISON OF ADHESION PROPERTIES OF THE PRIMERS FOR WIDE CONSUMPTION

Received – Primljeno: 2022-10-21
Accepted – Prihvaćeno: 2022-12-20
Original Scientific Paper – Izvorni znanstveni rad

This research focused on comparison of adhesion properties of three different primers for wide consumption. Tested primers differed in their price range, and the conducted experiment aimed to determine whether more expensive primers were providing better adhesion between the substrate material and the coating. The primers were applied on specimens in two layers, each being 30 μm thick (total dry film thickness was 60 μm), as well as in one layer being 45 μm thick. After drying, specimens were exposed to indoor and outdoor atmospheric conditions. Adhesion properties were tested by the cross-cut test, and analysis of obtained results proved that the primers' price range cannot be considered as an indicator of the primers' quality with respect to their adhesion properties.

Key words: corrosion, surface protection, primer thickness, cross-cut test, adhesion properties

INTRODUCTION

Corrosion causes damages on the material through harmful action of atmospheric conditions. It represents a major problem in steel constructions, from their storage to maintenance of finished products under certain operating conditions [1]. This fact is supported by the information that costs related to corrosion damage amount to 2,5 billion USD [2]. In order to reduce such negative effects of corrosion, it is necessary to invest into surface protection technologies. Besides influencing indoor and outdoor factors that cause corrosion, it is also possible to create a protective barrier between the supstrate material and a potentially aggressive environment. Since 3/4 of metal structures are protected by organic primers [3], the above-mentioned surface protection technology is investigated in this research. According to their purpose, there are primary coats, intermediate coats, and top coats, of which primers have to deliver good adhesion [4, 5]. This research studies adhesion properties of such coats. By applying the cross-cut test, i.e. by cutting a right-angle lattice pattern into the coating in order to test adhesion properties, this research tests three different primers for wide consumption. Those primers are not developed for a specific industry, but primers for widespread use. Within this experiment, the primer A belonged to the lowest price range, the primer B to the medium price range, while the most expensive primer was marked with C. Primers were applied in two layers of different dry film thicknesses, which were then exposed to two different environments, all with the aim of determining if the quality of primers' adhesion properties.

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EXPERIMENTAL PART

Specimens of 150 x 100 x 3 mm in size are presented in the Figure 1. Chemical composition of the supstrate material used for preparation of specimens is overviewed in the Table 1.

Figure 1 Specimen

Table 1 **Chemical composition of the supstrate material / mas. % [6]**

C	Si	P	S	N
0,17	+	0,05	0,05	≤ 0,007

Prepared specimens were treated with abrasive jet in accordance with the HRN EN ISO 12944-4 standard to meet the required quality of Sa 2,5 as determined by the HRN ISO EN 8501-1 standard. Roughness of specimens was measured with the Elcometer 224 device. Each

specimen was measured for ten times in order to obtain the mean value, which had to range from 40 to 70 µm. Before applying the primer to the supstrate material, it was necessary to check the environment conditions, as they need to comply with determined values (substrate material temperature (*T*s) minimum 3 °C higher than the dew point temperature, air temperature (*T*a) minimum 5 °C, maximum relative humidity 85 %). In this experiment, environment conditions were determined by the Elcometer 319 Model S&T device, and the obtained values were as follows: relative humidity (*RH*) 52,2 %, supstrate material temperature (*T*s) 25,8 °C, air temperature (*T*a) 26,5 °C, dew point temperature (*T*d) 15,9 °C, difference between the substrate material and the dew point temperatures (*ΔT*) 9,9 °C. Since all measured values were within determined limits, the experiment proceeded with the primers' application on the prepared specimens. As mentioned above, in this experiment three primers were marked with the letters A, B and C to denote their different price ranges. The primer A was the cheapest, while the primer C was the most expensive. Primers were applied either in one 45 µm-thick layer or in two layers, each being 30 µm thick, thus making total dry film thickness of 60 µm. Although manufacturers recommend that all tested primers be applied in a dry film thickness of 60 µm, real application is often different. All tested primers are commonly used in households, for some crafts or hobbies, so it is expected that they will be usually applied in just one coat, the thickness of which shall not meet recommended values. For this reason, this experiment was performed also on specimens coated with primers of 45 µm dry film thickness in order to determine adhesion properties for such an alternative. The Figure 2 shows measuring of the 60 µm-dry film thickness, while the Figure 3 shows measuring of the coat with a target value of 45 µm.

Each specimen with two layers of primer was measured ten times to determine its formed dry film thickness, the least value of which was 53,8 µm, while the greatest value was 61,1 µm. The mean value (arithmetic mean of ten repeated measurements) was 58,42 µm, which fits into tolerable limits. The value of 58,7 shown on Figure 2 refers to the last measurement.

Figure 2 Measuring of the dry film thickness formed by the primer with the dry film thickness of 60 µm

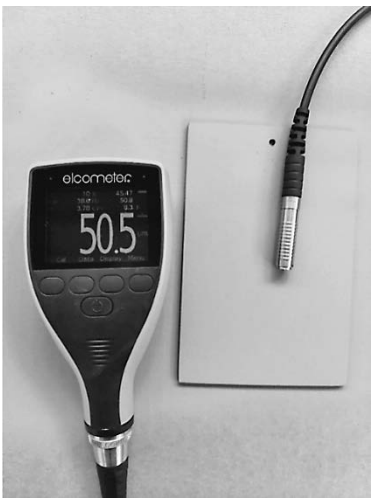

Figure 3 Measuring of the dry film thickness formed by the primer with the dry film thickness of 45 µm

Specimens with one layer of primer with the dry film thickness of 45 µm were measured ten times to determine the formed dry film thickness, the least value of which was 38,8 µm, while the greatest value was 50,8 µm. The mean value (arithmetic mean of ten repeated measurements) was 45,47 µm, which was within acceptable limits. The measured value of 50,5 µm presented in the Figure 3 refers to the last measurement. The Table 2 presents the experiment plan, i.e. labels of the specimens with corresponding values of the formed dry film thickness, as well as the designated testing environment to which specimens will be exposed.

Table 2 **Experiment plan**

Specimen	Dry film thickness	Testing environment
A1-1	60 µm (2 x 30 µm)	Indoor atmospheric condition
B1-1		
C1-1		
A1-2		Outdoor atmospheric condition
B1-2		
C1-2		
A2-1	45 µm	Indoor atmospheric condition
B2-1		
C2-1		
A2-2		Outdoor atmospheric condition
B2-2		
C2-2		

After being exposed to designated atmospheric conditions, coated specimens were visually inspected to find out that none of the specimens developed bubbles, there were no signs of corrosion or any other damages. After visual inspection, specimens were tested for the adhesion properties of the applied primer by the cross-cut test, i.e. the method of cutting a right-angle lattice pattern into the coating. The method is performed according to the HRN EN ISO 2409 standard, and the testing is done by the Elcometer 107 device. It is important

to select a cutter with a metal blade that is appropriate for specific dry film thickness. According to the standard, specimens coated with primer up to 60 μm thick are incised with a cutter of 6 x 1 mm-incision spacing, while specimens coated with 60-120 μm thick layer of primer are incised with a cutter of 6 x 2 mm incision spacing. A cutter is pressed against the specimen and pulled all the way down to the substrate material to create incisions of 20 mm in length. Then a next cut is incised by 90° rotation, so that horizontal and vertical lines form a lattice. After incision, the surface is brushed to remove the particles. Penetration of cuts into the coating is visually inspected. Adhesive tape is applied on the specimen lattice pattern, which has to be removed within 5 minutes at an angle of 60° from the surface. The final step in performance of the cross-cut test is visual inspection of the lattice pattern by using a magnifying glass. Below there are figures presenting specimens after being subjected to the cross-cut test. Figures from 4 to 9 present specimens coated with primer and exposed to indoor atmospheric conditions.

Assessment of the performed tests is done in accordance with the HRN EN ISO 2409 standard and the obtained results are overviewed in the Table 3.

Table 3 **Assessment of specimens exposed to indoor atmospheric conditions**

Specimen	Assessment
A1-1	Gt 0
B1-1	Gt 1
C1-1	Gt 0
A2-1	Gt 0
B2-1	Gt 0
C2-1	Gt 0

Figures 10 to 15 present specimens exposed to outdoor atmospheric conditions and tested with the cross-cut method.

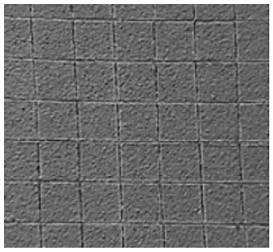

Figure 4 Specimen A1-1

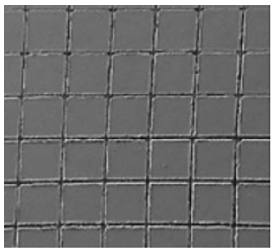

Figure 5 Specimen B1-1

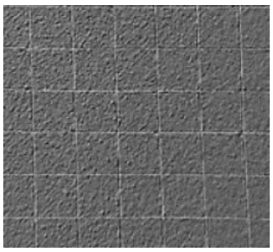

Figure 10 Specimen A1-2

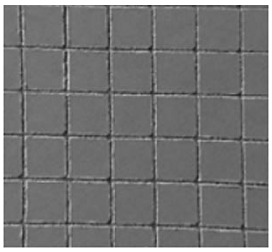

Figure 11 Specimen B1-2

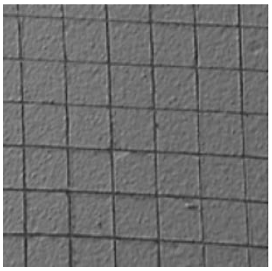

Figure 6 Specimen C1-1

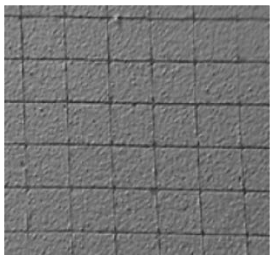

Figure 12 Specimen C1-2

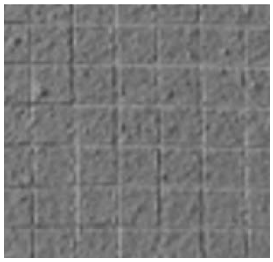

Figure 7 Specimen A2-1

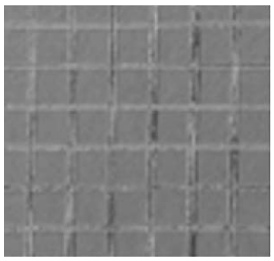

Figure 8 Specimen B2-1

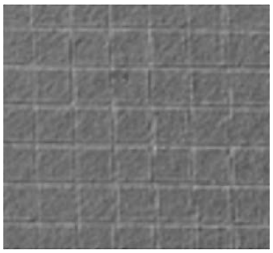

Figure 13 Specimen A2-2

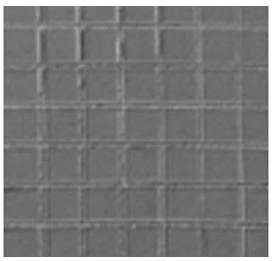

Figure 14 Specimen B2-2

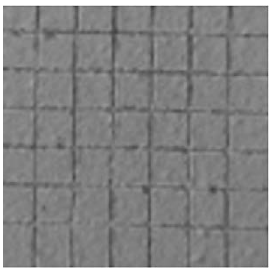

Figure 9 Specimen C2-1

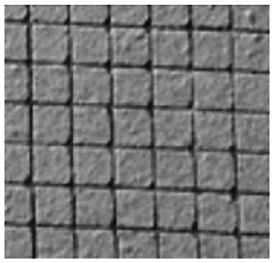

Figure 15 specimen C2-2

Table 4 **Assessment of specimens exposed to outdoor atmospheric conditions**

Specimen	Assessment
A1-2	Gt 0
B1-2	Gt 1
C1-2	Gt 0
A2-2	Gt 0
B2-2	Gt 0
C2-2	Gt 1

Results for previously presented test specimens are overviewed in the Table 4.

According to the HRN EN ISO 2409 standard, the grade Gt 0 marks completely smooth lattice edges with none of the squares in the lattice detached, while the grade Gt 1 means that small flakes of coating detached at intersections, but no more than 5 % of the surface got affected [7].

CONCLUSION

Results obtained by the cross-cut test, as well as assessment of tested specimens proved no major differences in adhesion properties of examined primers, meaning that there are no significant differences in adhesion of tested primers to the substrate material. Regardless of the price range, primers for wide consumption have similar adhesion properties. The same trend occurred for coatings of 60 μm dry film thickness, as well as for coatings of 45 μm dry film thickness. Almost the same adhesion properties were confirmed for all tested primers, regardless of the type of atmospheric conditions they were exposed to. Tested specimens subjected to the cross-cut test did not exhibit deviations along the edges of the incised lattice or in detached squares. In cases of detachment, such coating removal was below the limit of 5 %.

REFERENCES

[1] L. F. Montoya, D. Contreras, A. F. Jaramillo, C. Carrasco, K. Fernández, B. Schwederski, D. Rojas, M. F. Melendrez: Study of anticorrosive coatings based on high and low molecular weight polyphenols extracted from the Pine radiata bark, Progress in Organic Coatings 127 (2019), 100-109

[2] NACE International: International Measures of Prevention, Application, and Economics of Corrosion Technologies Study, Texas, USA, 2016, pp. 1-72

[3] I. Juraga, V. Alar, I. Stojanović: Korozija i zaštita premazima, Fakultet strojarstva i brodogradnje, Zagreb, 2014, pp. 3

[4] T. Mariappan, A. Kamble, S. M. Naik: An investigation of primer adhesion and topcoat compatibility on the waterborne intumescent coating to structural steel, Progress in Organic Coatings 131 (2019), 371-377

[5] W. C. Puspitasari, F. Ahmad, S. Ullah, P. Hussain, P. S. M. Megat-Yusoff, P. J. Masset: The study of adhesion between steel substrate, primer, and char of intumescent fire retardant coating 127 (2019), 181-193

[6] M. Novosel, D. Krumes, I. Kladarić: Željezni materijali, Konstrukcijski čelici (II. dopunjeno izdanje), Strojarski fakultet u Slavonskom Brodu, Slavonski Brod, 2013, pp. 15

[7] HRN EN ISO 2409:2020, Boje i lakovi – Ispitivanje zarezivanjem mrežice (ISO 2409:2020; EN ISO 2409:2020), Zagreb, Hrvatski zavod za norme, 2020, pp. 1-18

Note: Responsible person for English translation: Martina Šuto.