



Beratung - Schadensfallaufklärung - Qualitätssicherung - Forschung - Prüfung

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Test report

PB500/02/07

Customer: Emil Frei GmbH & Co.
 Am Bahnhof 6
 78199 Bräunlingen

Order: Testing of powder-coated steel specimens in accordance with the
 Draft Standard DIN EN ISO 12944-6:2006, corrosivity category C 5-I,
 high durability

Date of order: 2006-09-04
 Laboratory number of order: 194/06/6568
 Period of testing: 2006-09-07 to 2007-01-02

Number of pages: 5

Tested system: Priming coat: PE 1204A
 Top coat: PF 1004A

Person responsible for testing: sgd. Dipl.-Ing. (FH) P. Lebelt

Head of testing department/
 Head of testing laboratory: sgd. Dr. A. Rudolf

Head of testing department: sgd. Dr. J. Gehrke

Dresden, 2007-02-07

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|--------------------------------|------------------------|-------------------------|
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| Date: 2007-02-07 | Date: 2007-02-07 | Date: 2007-02-07 |

Translation according to original test report PB500/02/07

Dresden, 14.06.2011

Head of testing department


 Dr. Andrea Rudolf

1 Test specimens

The customer has provided 10 powder-coated steel sheets, measuring 150 mm x 100 mm x 2 mm, to be tested regarding corrosion protection in accordance with the Draft Standard DIN EN ISO 12944-6:2006. 9 test sheets have been used for stress applications and 1 test sheet as reference specimen. The powder-coating system with the system number 23 has been applied to a blast-cleaned surface and consists of:

Priming coat: PE 1204A

Top coat: PF 1004A

The preparation of the test sheets and the measuring of the film thicknesses have been done by the customer. Examinations for the identification of the coating materials, deviating from the Draft Standard DIN EN ISO 12944-6:2006, have not been conducted.

2 Test conditions

The stress application or the duration of the stress application has been selected in accordance with Draft Standard DIN EN ISO 12944-6:2006. The corrosivity category C5-I with the durability high has been taken as the basis. Three test sheets have been exposed to each of the following stresses in accordance with test system 1:

- 1) 720 hours of continuous condensation in accordance with DIN EN ISO 6270-1
- 2) 720 hours of humid atmospheres containing sulfur dioxide in accordance with DIN EN ISO 3231-1,0S
- 3) 2160 hours of stress caused by neutral salt spray (fog) in accordance with DIN EN ISO 7253 (new version: DIN EN ISO 9227-10:2006)

By agreement with the customer the test method for chemical resistance in accordance with DIN EN ISO 2812-1 has been replaced by the method in accordance with DIN EN ISO 3231-1,0S. The edges of the test sheets have been protected from corrosion by means of additional coating (edge protection).

In case of 3 selected test sheets the total film thickness of the powder-coating system has been determined by the IKS Dresden GmbH in accordance with DIN EN ISO 2808 and has been expressed in the summary of results. Measuring values obtained by the customer, which have been taken into the test report, are marked with an asterisk.

Prior to the stress caused by neutral salt spray (fog) a centred, horizontal scratch has been introduced to the coating down to the substrate of the specimens. In deviation from the Draft Standard DIN EN

ISO 12944-6:2006 the defects have been introduced by a scratching tool, type Sikkens. The width of the scratch has been 0,5 mm. No artificial defects have been introduced to the remaining specimens.

3 Evaluation

The adhesive strength of the powder-coating system prior to the artificial stress application has been obtained by means of the cross-cut test in accordance with DIN EN ISO 2409.

Every stress application has been followed by a visual evaluation of the test sheets in accordance with DIN EN ISO 4628, Part 2 to 5. In accordance with DIN EN ISO 4628 Part 8 the corrosion and delamination at the scratch have been evaluated after the stress caused by the neutral salt spray (fog). Irregularities, which are not to be evaluated in accordance with DIN EN ISO 4628, have not been noticed.

Furthermore, the adhesive strength has been tested by means of the cross-cut test in accordance with DIN EN ISO 2409 prior to and after the removal of the tape after the end of the respective stress application after conditioning of the specimens in an indoor environment for 24 hours.

Immediately after the end of the stress application in accordance with DIN EN ISO 7253 the infiltrated coating has been removed starting from the scratch using a scalpel. The width of the area infiltrated by rust has been measured at 12 measuring points at distances of 5 mm and arithmetically averaged. The corrosion M from the scratch has been calculated using the following equation:

$$M = (C-W)/2$$

C: Width of the area infiltrated by rust (arithmetic mean value)

W: Original scratch width/mm

4 Summary of results

The results are summarised in the following table 1.

Table 1: Powder-coating system: Priming coat PE 1204A
Top coat PF 1004A

| Assessment prior to stress application | | | | |
|---|----------------------------------|--|--|----------------------|
| | | Test panel 2 | | |
| DIN EN ISO 2808 | Film thickness/ μm | 169,9 ^{max. 202 μm *} min. 145 μm | | |
| DIN EN ISO 2409 | Cross-cut | 0 | | |
| Assessment after stress application | | | | |
| Test 1: DIN EN ISO 6270-1 - Continuous condensation | | | | |
| Duration 720 h | | Test panel 3 | Test panel 4 | Test panel 5 |
| DIN EN ISO 2808 | Film thickness/ μm | 171,9 ^{max. 184 μm *} min. 160 μm | 171,8 ^{max. 187 μm *} min. 156 μm | 187 \pm 13 |
| DIN EN ISO 2409 | Cross-cut | 0 | 0 | 0 |
| DIN EN ISO 4628-2 | Degree of blistering | 0 (S0) | 0 (S0) | 0 (S0) |
| DIN EN ISO 4628-3 | Degree of rusting Ri | Ri 0 | Ri 0 | Ri 0 |
| DIN EN ISO 4628-4 | Degree of cracking | 0 (S0) | 0 (S0) | 0 (S0) |
| DIN EN ISO 4628-5 | Degree of flaking | 0 (S0) | 0 (S0) | 0 (S0) |
| Test 2: DIN EN ISO 7253 - Stress caused by neutral salt spray (fog) | | | | |
| Duration 2160 h | | Test panel 11 | Test panel 12 | Test panel 14 |
| DIN EN ISO 2808 | Film thickness [μm] | 177,0 ^{max. 201 μm *} min. 160 μm | 176,4 ^{max. 201 μm *} min. 162 μm | 187 \pm 23 |
| DIN EN ISO 2409 | Cross-cut | 0 | 0 | 0 |
| DIN EN ISO 4628-8 | Corrosion at the scratch [mm] | 0,8 \pm 0,7 | 1,3 \pm 0,8 | 0,7 \pm 0,4 |
| DIN EN ISO 4628-8 | Delamination at the scratch [mm] | 5,0 \pm 0,8 | 4,1 \pm 0,7 | 4,7 \pm 0,7 |
| DIN EN ISO 4628-2 | Degree of blistering | 0 (S0) | 0 (S0) | 0 (S0) |
| DIN EN ISO 4628-3 | Degree of rusting Ri | Ri 0 | Ri 0 | Ri 0 |
| DIN EN ISO 4628-4 | Degree of cracking | 0 (S0) | 0 (S0) | 0 (S0) |
| DIN EN ISO 4628-5 | Degree of flaking | 0 (S0) | 0 (S0) | 0 (S0) |
| Test 3: DIN EN ISO 3231-1,0S - Humid atmospheres containing sulfur dioxide | | | | |
| Duration 30 cycles 720 h | | Test panel 6 | Test panel 7 | Test panel 9 |
| DIN EN ISO 2808 | Film thickness/ μm | 172,3 ^{max. 182 μm *} min. 162 μm | 170,5 ^{max. 180 μm *} min. 158 μm | 192 \pm 15 |
| DIN EN ISO 2409 | Cross-cut | 0 | 0 | 0 |
| DIN EN ISO 4628-2 | Degree of blistering | 0 (S0) | 0 (S0) | 0 (S0) |
| DIN EN ISO 4628-3 | Degree of rusting Ri | Ri 0 | Ri 0 | Ri 0 |
| DIN EN ISO 4628-4 | Degree of cracking | 0 (S0) | 0 (S0) | 0 (S0) |
| DIN EN ISO 4628-5 | Degree of flaking | 0 (S0) | 0 (S0) | 0 (S0) |

*Measuring values have been obtained and reported by the customer.

5 Assessment of test results

The powder coatings can only be evaluated and assessed following the Draft Standard DIN EN ISO 12944-6:2006, since powder coatings are not taken into account in the standard. In order to pass the test the powder-coating system shall meet the conditions in accordance with table 2 after all stress applications. In doing so, only one out of 3 specimens may deviate from the requirements.

Table 2: Conditions for a passed test in accordance with Draft Standard
DIN EN ISO 12944-6:2006

| Test method | Requirements |
|--|--------------------------------|
| Cross-cut in accordance with DIN EN ISO 2409 prior to stress application (film thickness < 250µm) | Characteristic value 0 to 1 |
| Degree of blistering in accordance with DIN EN ISO 4628-2 | 0 (S0) |
| Degree of rusting in accordance with DIN EN ISO 4628-3 | Ri 0 |
| Degree of cracking in accordance with DIN EN ISO 4628-4 | 0 (S0) |
| Degree of flaking in accordance with DIN EN ISO 4628-5 | 0 (S0) |
| Corrosion at the scratch DIN EN ISO 7253 (new version DIN EN ISO 9227) | M ≤ 2 mm |
| Cross-cut in accordance with DIN EN ISO 2409 after stress application (film thickness < 250µm) | Characteristic value 0 to 1 |

**The tested powder-coating system passed the test in accordance with Draft Standard
DIN EN ISO 12944-6:2006, corrosivity category C 5-I, high durability.**

The tests have been conducted under laboratory conditions with utmost care. Liability for the effectiveness of the tested coating material/coating system in practice in reference to this test result shall not be – also in terms of a third party – assumed.