Report
Scratch resistance, chemical resistance and weathering resistance of a coating system of Optimum Car Care B.V.

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Report number:	89204199.1
Project number:	89203345/89204199
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Date:	November 7th, 2013
Number of pages:	10 (including appendices)
Number of appendices:	4 (4 pages)

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1 Introduction

This report describes the determination of the scratch resistance, the resistance to some chemicals and resistance to weathering of a coating of Optimal Car Care B.V.
TÜV Rheinland Nederland B.V. (TÜV Rheinland) offered the tests by means of offer forms 37145 and 37321, dated respectively February 1st and February 27th 2013, which were signed and agreed upon by Optimum Car Care B.V.
Optimal Car Care B.V submitted coated panels of approximately 10 x 15 cm to TÜV Rheinland for the scratch resistance tests and the chemical resistance test These samples consist of a thin metal substrate coated with a white primer, a black midcoat and a clear topcoat.
The panels have been registered under sample number 13.0069/1.
Later, Optimum Car Care B.V. sent an aluminium panel of approximately 15 x 30 cm to TÜV Rheinland for the execution of the weathering tests. According to Optimum Carr Care, the coating consists of a white primer, a blue midcoat and a clear topcoat. This panel has been registered under sample number 13.0069/2.

2 Investigations

2.1 Scratch resistance of the black coating system

The scratch resistance was determined according to ISO 1518 using a Gardner scratch resistance tester. This method is executed as follows:
A mechanically driven scriber, with a hemispherical point of 1 mm in diameter, is pulled over the coated surface of the test panels while the load is increased until the point of the scriber is scratching through the coating onto the substrate. The minimum load (in Newton), at which the coating is about to be cut through, is a measure for the scratch resistance.
In addition, the loads for reaching the intermediate layers were determined as well.
The clear top coat is hard to discriminate as a separate layer when scratched through. Therefore, the moment the shiny upper layer is scratched through is regarded as the moment the clearcoat is scratched through.

The test results are summarized in table 1.

Table 1, Results of the scratch resistance tests.

Test	First visible scratch	Scratch through clear top coat	Scratch through black midcoat	Scratch through white primer
	Load (N)			
1	8	18	35	58
2	5	22	37	48
3	7	17	38	55
Average of series	7	19	37	54

2.2 Resistance to chemicals of the black coating system

For the determination of the chemical resistance the effects of the following three chemicals were assessed:

1. Concentrated hydrochloric acid (37%);
2. Concentrated phosphoric acid (85%);
3. Ethanol (96%).

The tests have been performed according to ISO 2812, part 1 - method 3. In this method, a small amount of the chemicals is placed on surface of the test sample. The chemicals are covered with a watch glass to prevent evaporation.

The effects of the chemicals on the tested surface is evaluated after three chosen time intervals.
In this investigation the tested surface has been evaluated after 5 minutes, 1 hour and 24 hours.
For each evaluation a new test sample has been used. The photos in the appendixes A, B and C illustrate the findings.

The results of the evaluations are summarized in table 2.

Table 2, Results of the chemical resistance tests.

Chemical:	Results after		
	5 minutes	1 hour	24 hours
Concentrated hydrochloric acid (37%)	Some whitening of the surface	Stronger whitening	Whitening
Concentrated phosphoric acid (85%)	Intact	Slight discoloration and change in gloss	Severely damaged
Ethanol (96%)	Slightly increased gloss	Some wrinkling and swelling. After drying, the wrinkling and swelling become less pronounced, but remain clearly visible	Some wrinkling and swelling. After drying, the wrinkling and swelling become less pronounced, but remain clearly visible

2.3 Resistance to weathering of the blue coating system

The sample has been artificially aged for 1,000 hours (6 weeks) in a so called Ci 4000 Atlas Weather-Ometer according to ISO 4892 (part 1 and 2). In this device, the ageing as it occurs outdoors is simulated and accelerated.
After 500 and 1,000 hours of artificial ageing the following properties have been measured:
- Gloss (in gloss units) according to ISO 2813, using a Byk-Gardner, Micro-Tri-Gloss;
- Colour according to ISO 7724 (CIE Lab) using a Minolta spectrophotometer, type CM-2600d;
- Scratch resistance of the top layer according to ISO 1518 using a Gardner scratch resistance tester.

The gloss has been measured at angles of 20, 60 and 85 degrees.
From the Lab-values (including specular component) the discolouration has been calculated (expressed as the ΔE value)

After weathering, it is not possible to properly discriminate the presence of a substantial clear top coat. The scratch resistance was assessed in an identical way as described in paragraph 2.1

The results of the three evaluations are summarized in tables 3, 4 and 5.

Table 3, Results of the artificial aging test.

Time of exposure in hours	Results						
	Gloss (Average of ten measurements)			Colour (Average of three measurements)			
	20°	60°	85°	L	a	b	ΔE
0	73	87	100	25.237	-0.207	-4.233	n.a.
500	71 (-3%)	87	100	25.302	-0.173	-4.248	0.07
1,000	69 (-5%)	86 (-1%)	100	25.373	-0.133	-4.260	0.16

n.a.: not applicable

Table 4, Results of the scratch resistance tests after 500 hours of exposure.

Test	First visible scratch	Scratch through clear top coat	Scratch through blue midcoat
	Load (N)		
1	5	12	22
2	5	20	37
3	5	25	37
Average of series	5	19	32

Table 4, Results of the scratch resistance tests after 1000 hours of exposure.

Test	First visible scratch	Scratch through clear top coat	Scratch through blue midcoat
	Load (N)		
1	5	15	22
2	5	8	19
3	5	12	18
Average of series	5	12	20

3 Conclusions

The scratch resistance according to ISO 1518 of the top layer on the black coloured test samples is approximately 19 N, the scratch resistance of the whole coating system is approximately 54 N.
The results of the chemical resistance tests show that the coating system has a limited resistance against the tested aggressive substances.

In the weathering test, the dark blue sample shows only a small loss of gloss and a very small discolouration (ΔE < 0,25 means that the discolouration is almost invisible).
The scratch resistance however does show quite some changes. It is not clear whether this is a result of the weathering of the clear top layer or of the underlying dark blue layer. It is also likely that the coating might not have been fully cured at the beginning of the test and became harder and more brittle during the test (usually however, more cure means a higher resistance to scratching). Another possibility is that the thickness of the clearcoat shows some variations, thus explaining the deviations.

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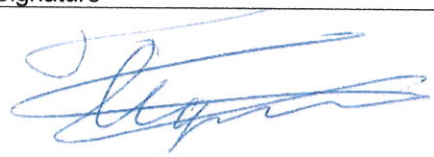
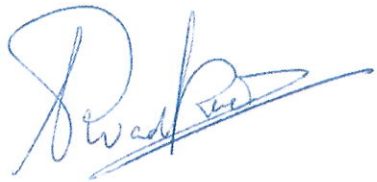
4 Signatures

Author	Signature
Mr A.M. Agterberg, B.Sc. Specialist Coatings	
Peer review	Signature
Mr R. van der Kaaden, B.Sc. Specialist Coatings	

(This is the end of this report),

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Appendix A, Photos after 5 minutes of exposure to chemicals.

Photo 1, After 5 min. of exposure to hydrochloric acid.

Photo 2, After 5 min. of exposure to phosphoric acid.

Photo 3, After 5 minutes of exposure to ethanol.

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Appendix B, Photos after 1 hour of exposure to chemicals.

Photo 1, After 1 hour of exposure to hydrochloric acid.

Photo 2, After 1 hour of exposure to phosphoric acid.

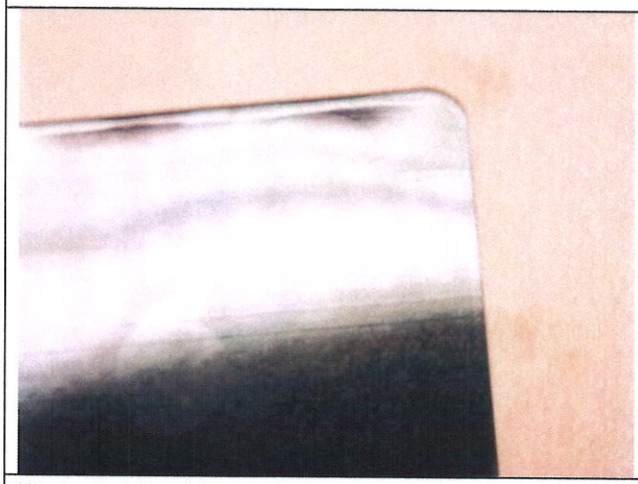

Photo 3, After 1 hour of exposure to ethanol.

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Appendix C, Photos after 24 hours of exposure to chemicals.

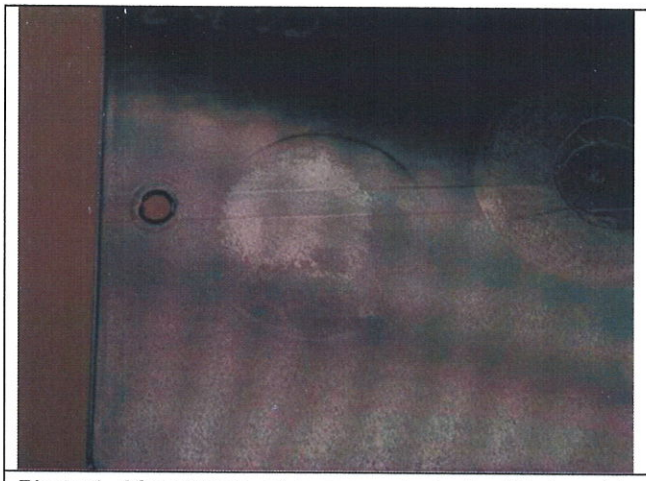

Photo 1, After 24 hrs. of exposure to hydrochloric acid.

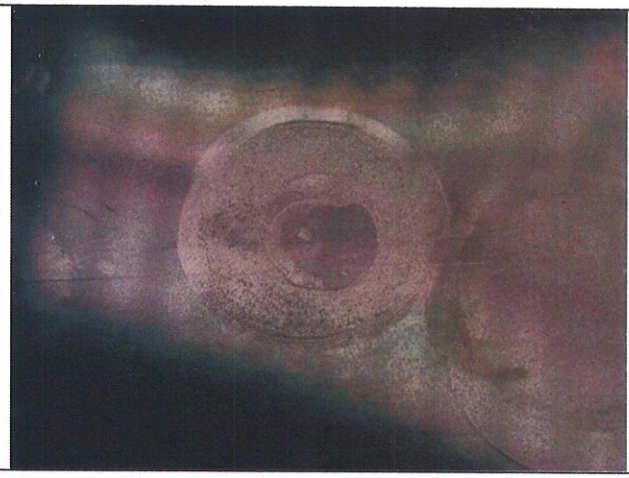

Photo 2, After 24 hrs. of exposure to phosphoric acid.

Photo 3, After 24 hrs. of exposure to ethanol.

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Appendix D, Photos prior to and after artificial weathering

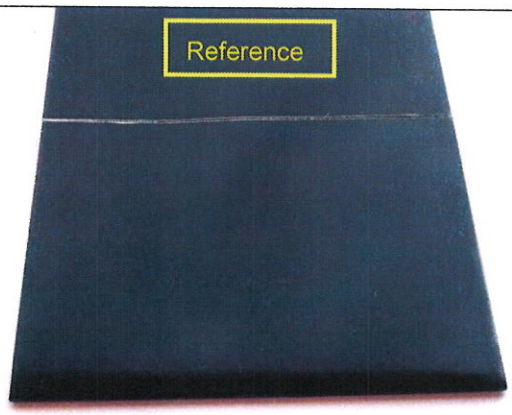

Photo 1, After 0 hrs. of artificial weathering.

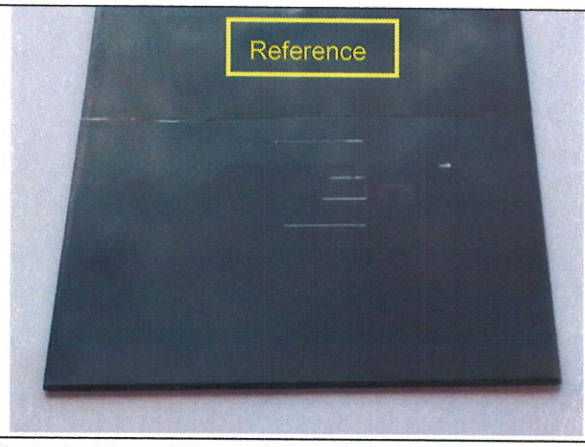

Photo 2, After 500 hrs. of artificial weathering.

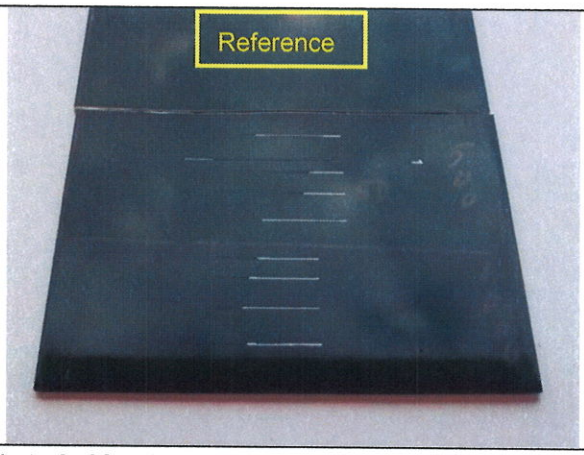

Photo 3, After 1,000 hrs. of artificial weathering.