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Fertigungstechnik
Materialforschung

Investigative report:

Comparison of the optical properties between two different lacquer systems and the evaluation of the polishing ability of the coating with different polishing methods.

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Table of Contents	page
1 Task.....	3
2 Selection of tests, laquer systems and substrates.....	3
3 Execution of the tests.....	3
3.1 Application of the lacquer systems.....	3
3.1.1 Construction of the coating system.....	3
3.1.2 Polishing method of Messr. Nobelclean.....	4
3.1.3 Traditional polishing method of Lürssen	5
3.2 Evaluation of the test results.....	5
3.2.1 Determination of the gloss grad.....	5
3.2.2 Determination of the color tone change.....	7
3.2.2 Determination of orangen peel and DOI by Wavescan.....	10
3.2.3 Polishing / Sealing of the surfaces before QUV – weathering.....	12
4 Discussion of the measurement results.....	13
5 Summary.....	13

1 Task

The target of this project was to examine the optical comparison between two lacquer systems selected by the principal before and after artificial weathering and then to evaluate the polishing power with different methods. The coating systems used until now do not offer a sufficient optical impression after a natural weathering. Therefore in general the surface is polished with commercially available products. In the investigations a new kind of polishing method of the company Nobelclean was compared with traditional methods. The lacquer systems were examined in regard to color tone, gloss and waviness before and after a Q.U.V. weathering . After the adequate polishing method the surface was measured once more and then outsourced to the Q.U.V. test again and the optical properties were examined again.

2 Selection of the examination, lacquer systems and substrates

a.) Examination of the surfaces lacquered according to the demands of the principal:

- Gloss grade at 20° geometry with Tri-Gloss of Messr. BykGardner according to DIN EN ISO 2813
- Color tone determination at 45°/D65 geometry with MA 68 II of Messr. X-Rite according to DIN 6174
- Wavescan and structure with Wavescan DOI of Messr. BykGardner

b.) Substrate used

- Aluminium

c.) Lacquer systems selected

- International grounding Epoxy GP Coating, Thinner No. 7
- AWL Grip Epoxy Primer 545 white / grey, Spray Reducer T0006
- AWL Grip TopCoat Carinthia Blue and Darkgreen , Spray Reducer T0003
- Mankiewicz Alexseal Primer 101, Reducer 442 / 101
- Mankiewicz Finish Primer 442, Reducer 442 / 101
- Mankiewicz Alexseal TopCoat 501 Carinta Blue and Darkgreen, TopCoat Reducer

The substrates and lacquer systems were set by the principal.

3 Execution of the test

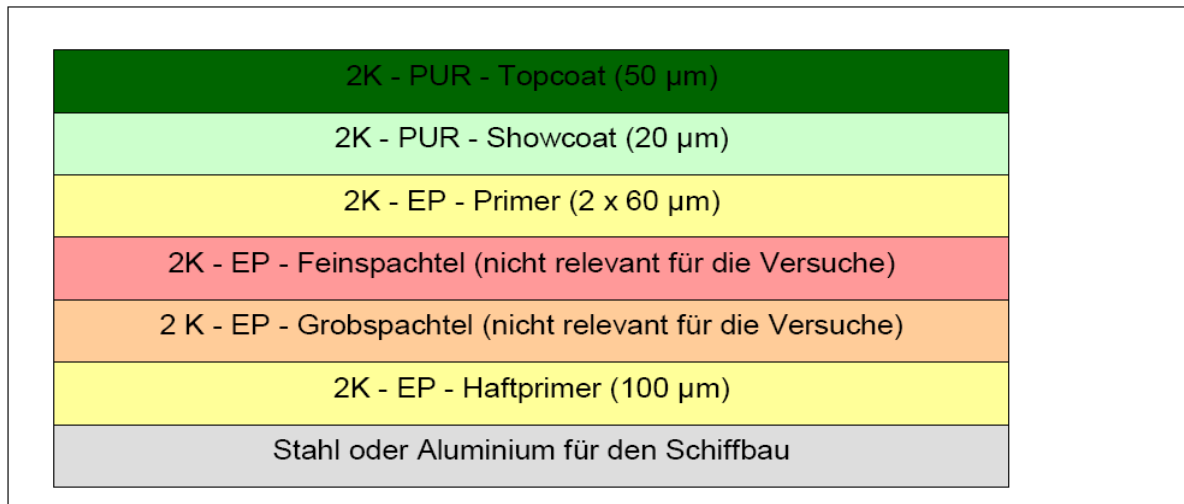
3.1 Application of lacquer systems

The application of the lacquer systems was carried out at the IFAM in an air-conditioned lacquer cabin of Messr. SLF. In this lacquer cabin the temperature and the relative humidity can be regulated individually. During the application a temperature of 22° C and a relative humidity of 55 % were set. There were used lacquer according to the agreement with the principal and varnished according the demands of the lacquer manufacturer.

3.1.1 Structure of the coating system

The graphics below (picture 1) show the coating structure.

Comparison of optical properties of lacquer samples weathered



Picture 2: Total structure of the coating and the layer thickness

3.1.2 Polishing method of Messr. Nobelclean

Following the polishing method of Messr. Nobelclean (picture 2) is explained.

1. Work prodedure:

rough cleaning without water and removal of dust and dirt deposits

2. Work prodedure:

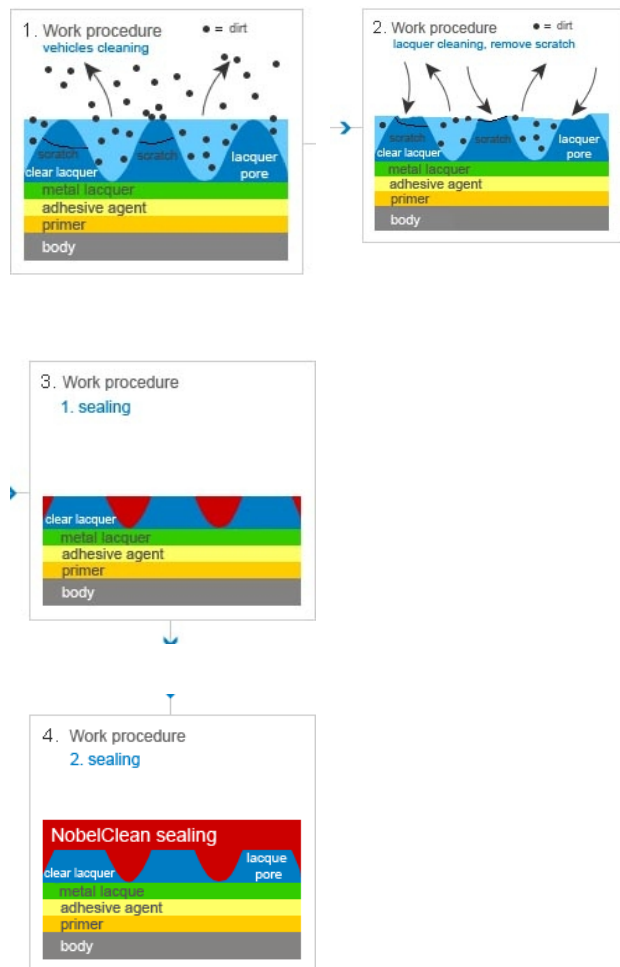
The lacquer is gently cleaned and realised with Nobel Flex and a special cotton plate of dull spots as well as holograms (NC 33 + NC 35). The lacquer is cleaned with Novelorbit and a special bonnet as well as with NC15-20 a second time and is prepared for sealing.

3. Work prodedure:

Application of the 1st sealing NC 50 (acrylpolymer).

4. Work prodedure:

The LACK surface is now consolidated and filled with the product Nobelorbit and a special 100 % layer of developing acryl-sealing NC 50 I plus a High – End Nano-Solution NC 50 II.



Picture 2: Description of the polishing process of Messr. Nobelclean

Comparison of optical properties of lacquer samples weathered

For further details concerning the polishing method of Messr. Nobelclean you can directly ask the manufacturer.

3.1.3 Traditional polishing method of Lürssen

The traditional polishing method of Messr. Lürssen often is not sufficient in order to polish dull surfaces completely or after longer weathering of a ship disturbing holograms appear.

With the traditional polish (3M Finesse It TM, part 09639, batch: CCD1877, shelf life 07 / 2009) the removal and the smoothing of the surface is carried out with extremely soft polishing agents, which are mostly bound in a paste or liquid, sometimes also known as polish. The polishing agents are bound in cloth, felt, rubber, pitch or leather discs and are applied on the surface.

When polishing traditionally, the material is applied with rotating polishing discs of cloth, felt or leather. The polishing agent is applied as emulsion or a so-called solid paste on the disc, the so-called polishing agent.

3.2 Evaluation of the test results

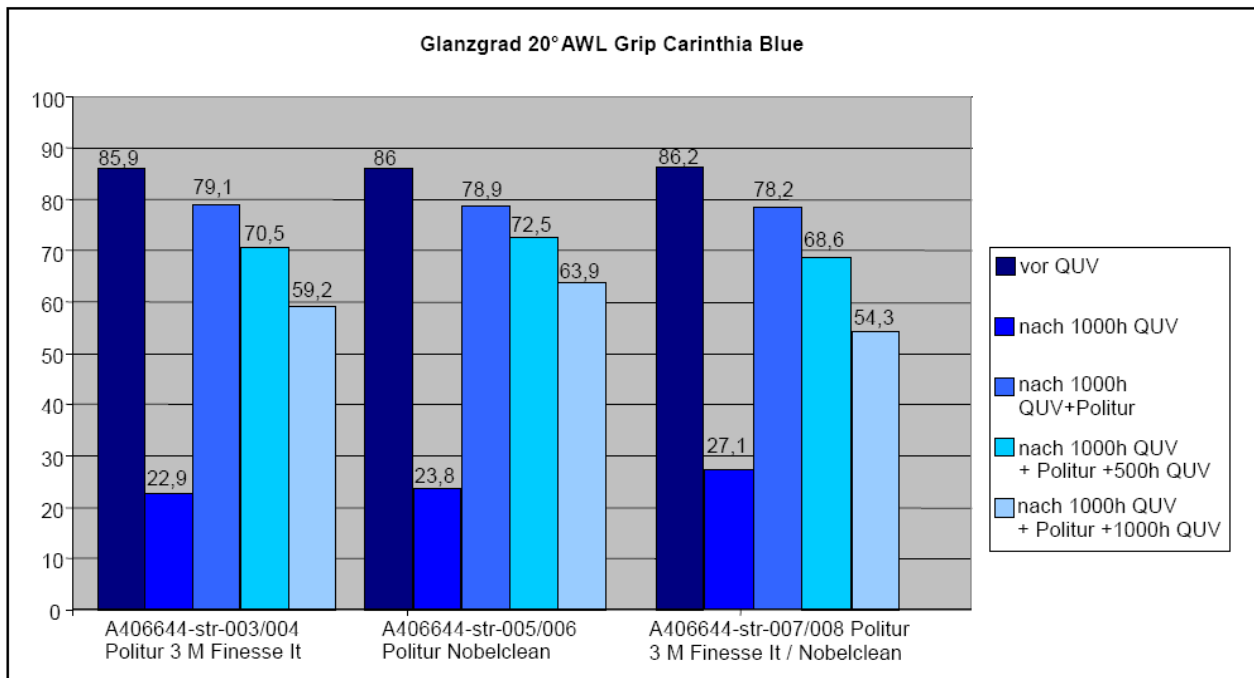
3.2.1 determination of the gloss

the gloss grade was examined:

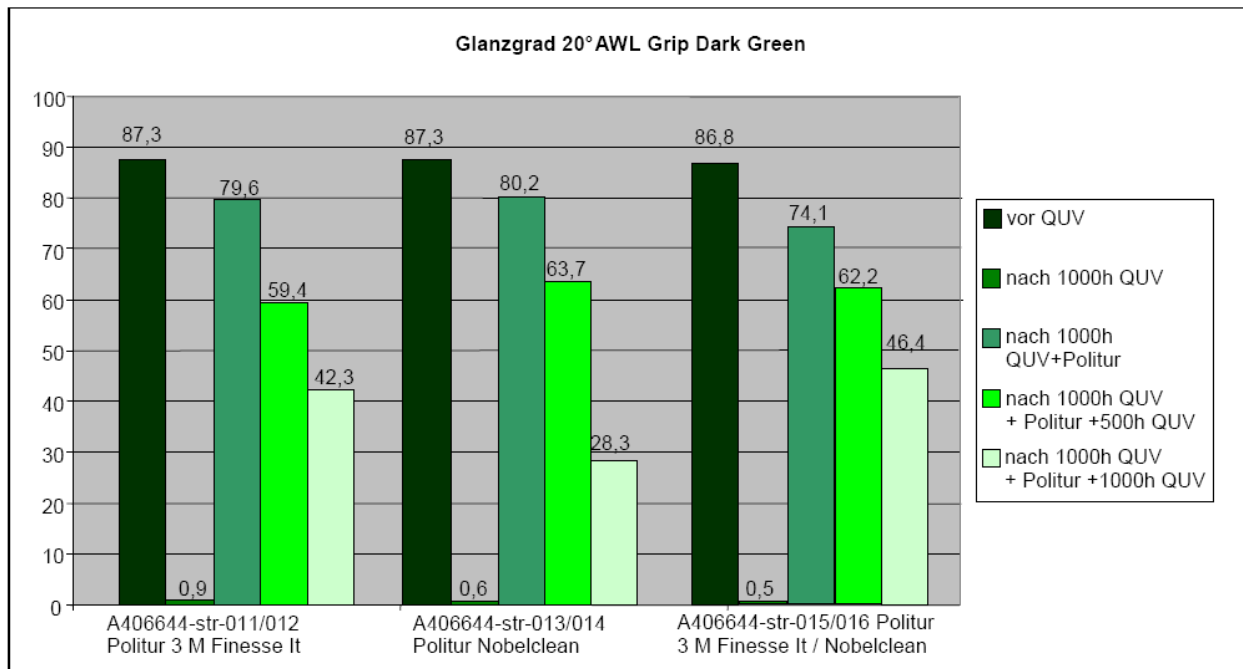
- before QUV load
- after QUV load 1000 h
- after QUV load + different polishing methods
- after QUVI load + different polishing methods + new QUV load 500 h and 1000 h

The test results are shown in the pictures 3 to 7.

Comparison of optical properties of lacquer samples weathered

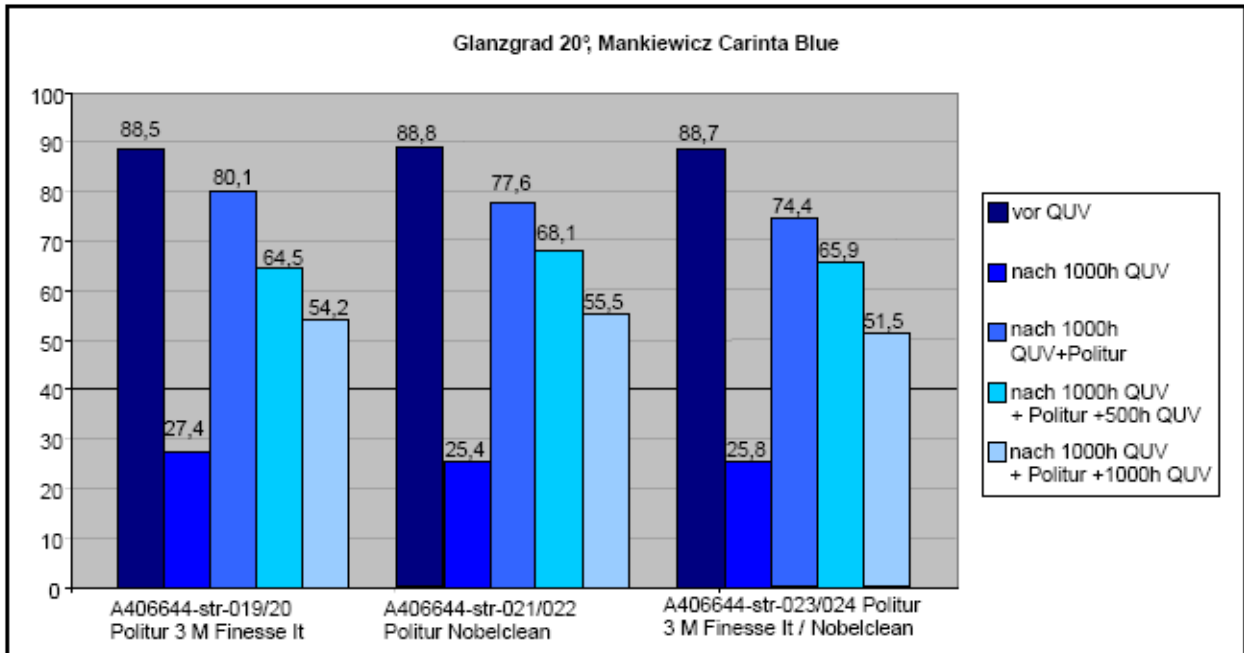


Picture 3: Determination of the gloss grade AWL Grip Carinthia Blue

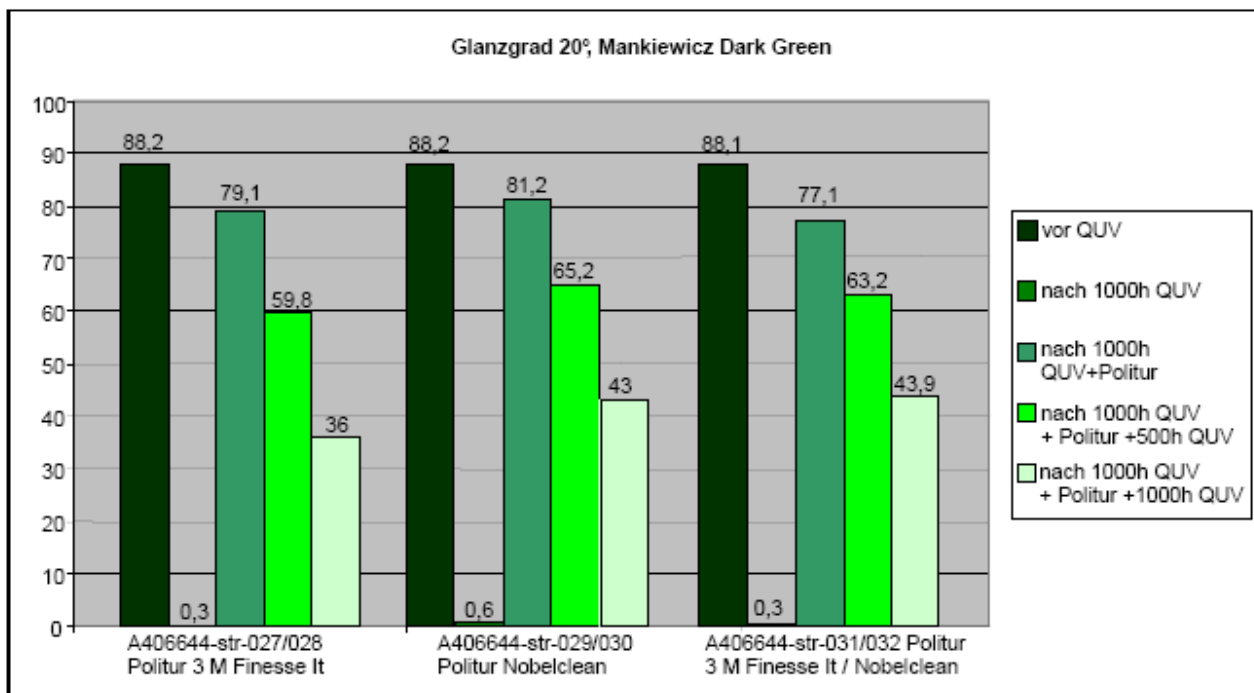


Picture 4: Determination of the gloss grade AWL Grip Dark Green

Comparison of optical properties of lacquer samples weathered



Picture 5: Determination of gloss Mankiewicz Carinta Blue



Picture 6: Determination of gloss Mankiewicz Dark Green

All individual evaluations are mentioned in attachment 1: gloss determination

3.2.2 Determination of the color tone change

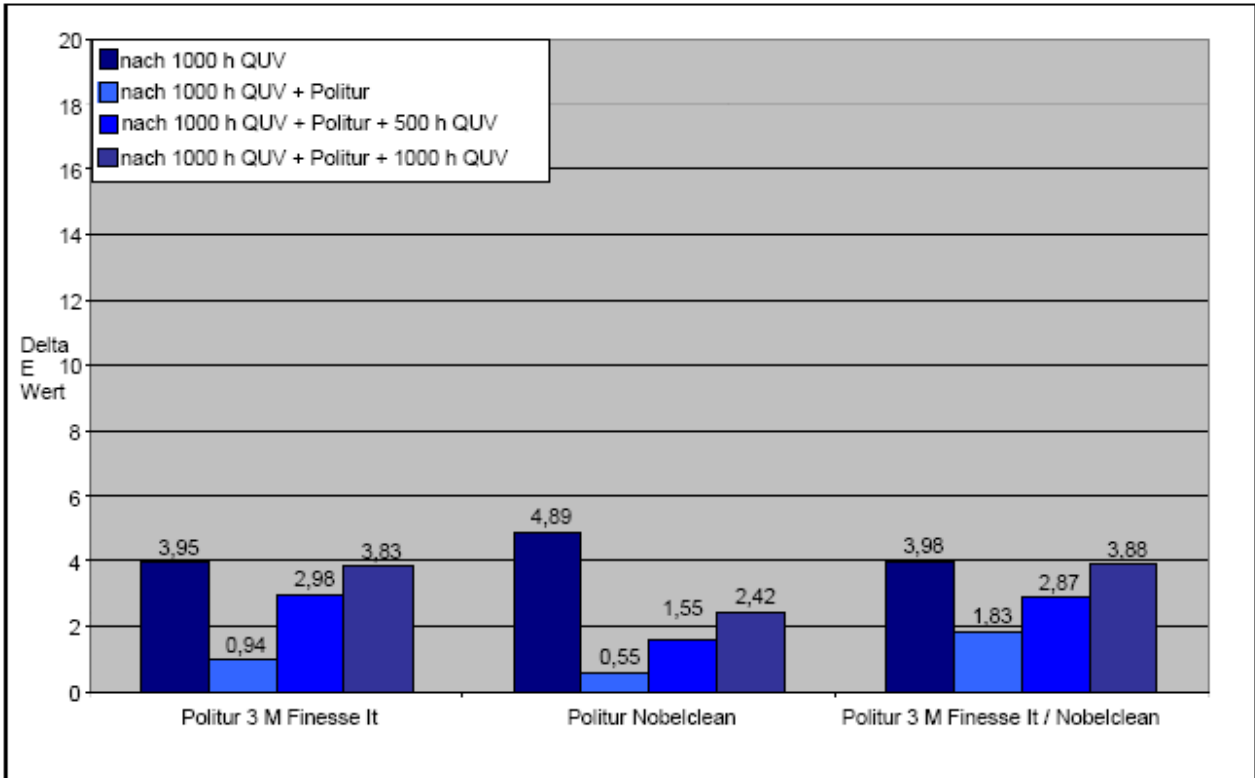
the color tone was examined:

- before QUV load
- after QUV load 1000 h
- after QUV load + different polishing methods

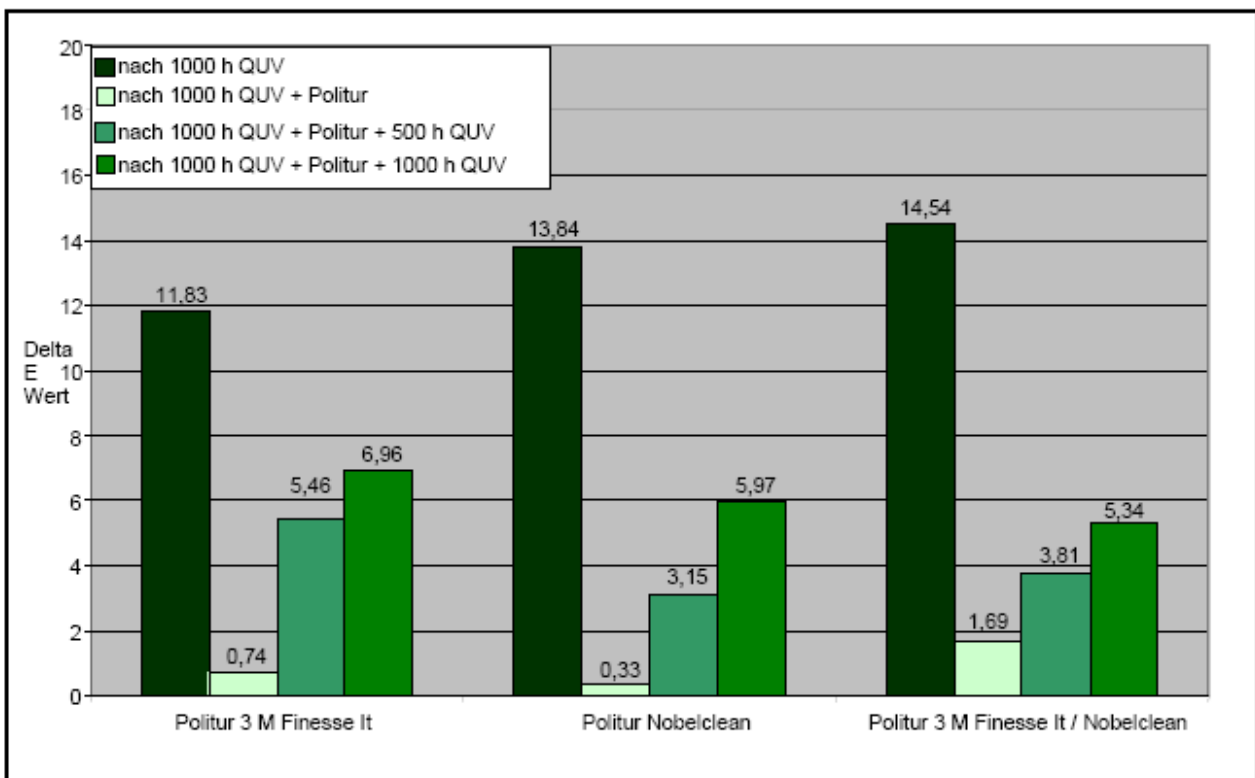
Comparison of optical properties of lacquer samples weathered

- after QUV Belastung + different polishing methodes + a new QUV load 500 h and 1000 h

In the pictures 7 to 10 the color tone changes are graphically shown.

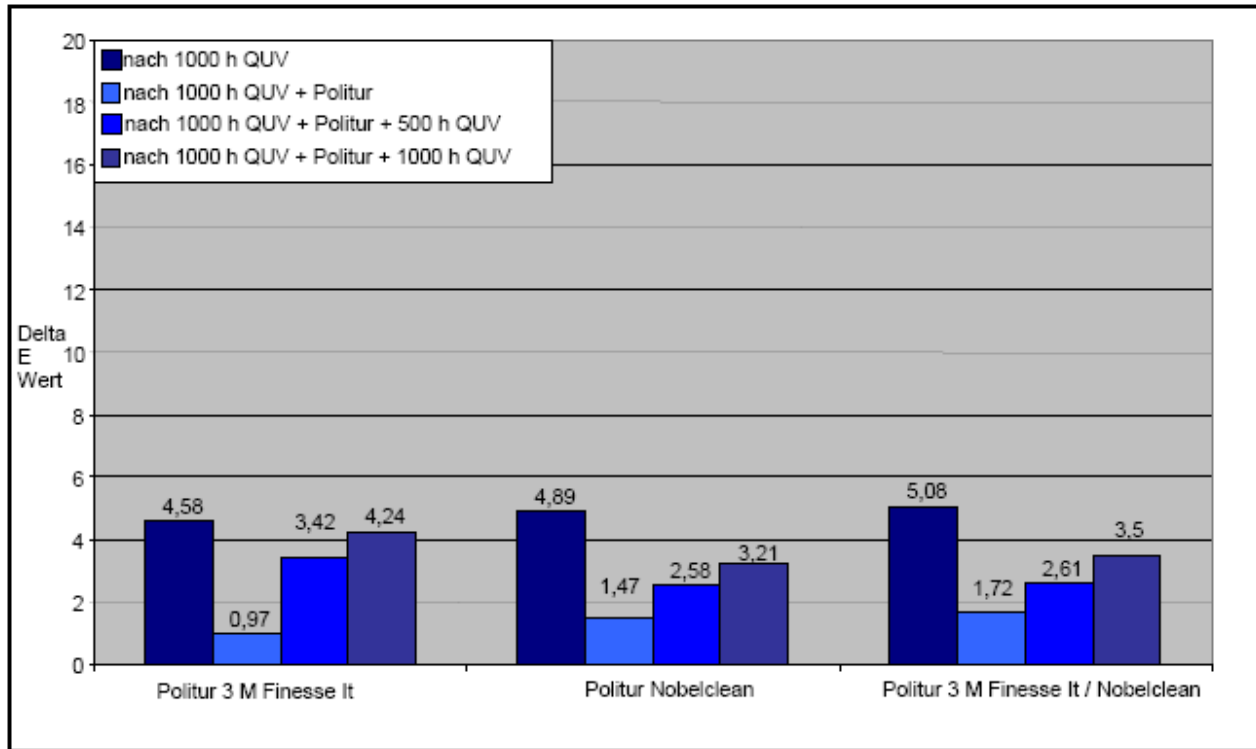


Picture 7: Change of the color tone of AWL Grip Carinthia Blue

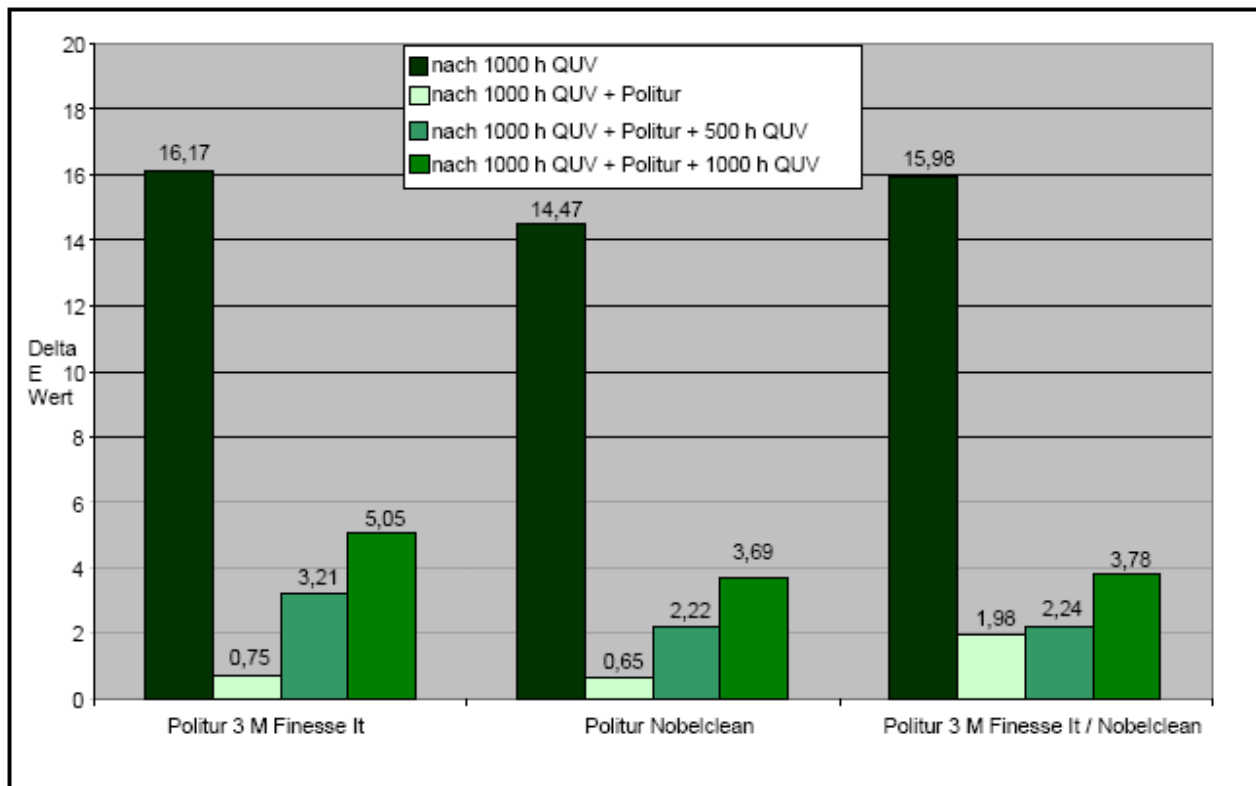


Picture 8: Change of the color tone of AWL Grip Dark Green

Comparison of optical properties of lacquer samples weathered



Picture 9: Change of color tone Manhievicz Carinta Blune



Picture 10: Change of color tone Mankiewicz Dark Green

The individual values or the changes of brightness respectively are shown in the attachment 2 - determination of the color tone

Comparison of optical properties of lacquer samples weathered

3.2.2 Determination of orange peel and DOI by Wavescan

The test results are summarized in table 1 and 2.

Table 1: Determination of the optical values before the outsourcing

Proben-Nr.	System	Farbton	Schicht- dicke	DOI	du	Wa	Wb	Wc	Wd	Glanz 20°
A406644-str-001	AWL Grip	Carinthia Blue	250µm	90,8	3,6	11,3	30,4	13,7	12,2	86,2
A406644-str-002	AWL Grip	Carinthia Blue	250µm	88,3	4,1	16,7	38,9	16,8	14,2	86,3
A406644-str-003	AWL Grip	Carinthia Blue	255µm	91,4	2,8	11,6	29,3	13,8	10,4	86,1
A406644-str-004	AWL Grip	Carinthia Blue	250µm	91,1	2,6	12,9	30,7	14,1	9,3	85,7
A406644-str-005	AWL Grip	Carinthia Blue	260µm	87,8	5,7	18,8	38,9	15,1	9,8	86,1
A406644-str-006	AWL Grip	Carinthia Blue	270µm	89,3	4,4	14,7	35,2	16,6	12,3	85,9
A406644-str-007	AWL Grip	Carinthia Blue	255µm	91,3	2,0	13,0	30,6	12,7	10,7	86,2
A406644-str-008	AWL Grip	Carinthia Blue	260µm	90,5	4,0	13,8	31,0	12,7	8,7	86,1
A406644-str-009	AWL Grip	Dark Green	270µm	86,6	7,9	18,0	40,2	18,8	14,3	86,7
A406644-str-010	AWL Grip	Dark Green	250µm	86,6	8,0	20,3	40,3	20,1	17,2	87,4
A406644-str-011	AWL Grip	Dark Green	270µm	87,3	6,2	17,8	39,9	20,2	15,6	87,5
A406644-str-012	AWL Grip	Dark Green	265µm	87,9	4,6	16,8	39,6	20,5	18,0	87,1
A406644-str-013	AWL Grip	Dark Green	265µm	89,3	5,0	13,0	34,2	17,8	14,6	87,2
A406644-str-014	AWL Grip	Dark Green	265µm	87,1	7,1	16,6	39,2	19,9	17,3	87,4
A406644-str-015	AWL Grip	Dark Green	275µm	90,9	3,6	11,8	29,9	16,8	13,9	87,1
A406644-str-016	AWL Grip	Dark Green	265µm	86	7,9	20,5	42,3	19,5	15,1	86,6
A406644-str-017	Mankiewicz	Carinta Blue	250µm	96,6	1,0	3,0	4,6	3,7	4,0	88,6
A406644-str-018	Mankiewicz	Carinta Blue	250µm	96,7	1,0	2,2	3,8	2,5	2,3	89,2
A406644-str-019	Mankiewicz	Carinta Blue	260µm	96,6	1,0	2,8	4,9	2,4	2,1	88,2
A406644-str-020	Mankiewicz	Carinta Blue	260µm	96,6	1,0	2,6	5,0	3,1	4,0	88,8
A406644-str-021	Mankiewicz	Carinta Blue	265µm	96,6	1,0	2,8	5,1	3,8	4,2	88,9
A406644-str-022	Mankiewicz	Carinta Blue	250µm	96,7	1,0	2,4	4,4	2,9	4,0	88,7
A406644-str-023	Mankiewicz	Carinta Blue	265µm	96,6	1,0	2,7	4,5	2,7	2,3	88,6
A406644-str-024	Mankiewicz	Carinta Blue	250µm	96,6	1,0	2,7	5,6	3,0	3,3	88,8
A406644-str-025	Mankiewicz	Dark Green	285µm	89,5	5,1	17	33,6	23,6	29,7	88,4
A406644-str-026	Mankiewicz	Dark Green	290µm	91,4	2,8	14,2	29,2	20,2	22,5	87,4
A406644-str-027	Mankiewicz	Dark Green	270µm	89,1	5,7	18,3	34,3	23,2	26,7	88,1
A406644-str-028	Mankiewicz	Dark Green	285µm	90,2	4,0	14,9	32,5	20,2	27,0	88,2
A406644-str-029	Mankiewicz	Dark Green	275µm	88,5	6,0	15	35,8	28,8	33,3	88,0
A406644-str-030	Mankiewicz	Dark Green	290µm	90,3	2,7	14	33,5	21,2	26,2	88,3
A406644-str-031	Mankiewicz	Dark Green	280µm	87,1	6,2	17,7	40,4	28	33,0	87,6
A406644-str-032	Mankiewicz	Dark Green	280µm	88,7	5,2	15,5	36,1	25,1	31,1	88,7

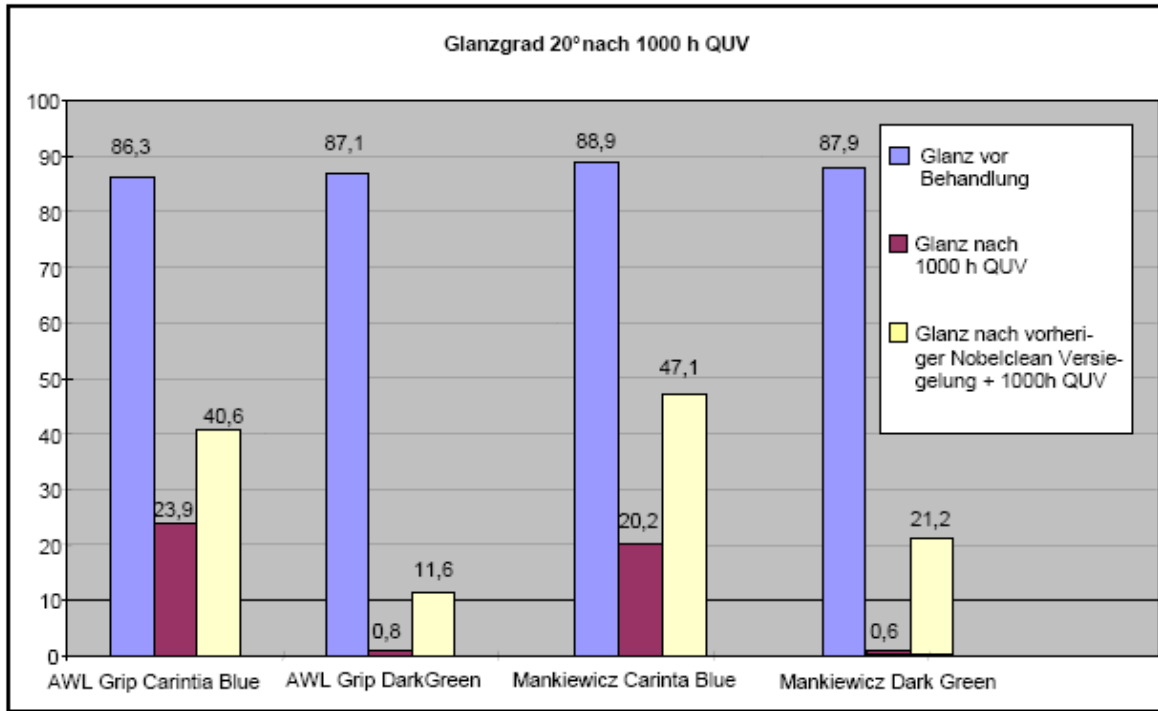
Comparison of optical properties of lacquer samples weathered

Table 2: determination of wave scan after polishing method

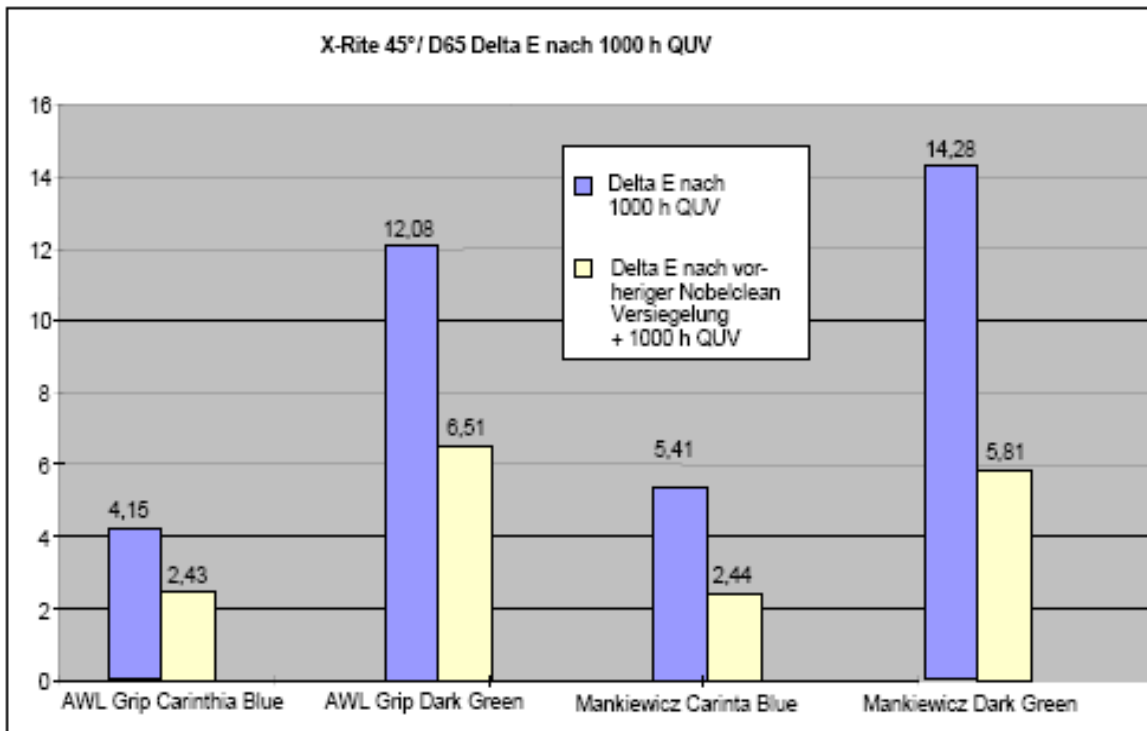
Proben-Nr.	System	Farbton	Schicht- dicke	DOI	du	Wa	Wb	Wc	Wd	Glanz nach 1000 h QUV	ΔE nach 1000h QUV	Politurverfahren
A406644-str-001	AWL Grip	Carinthia Blue	250µm	x	x	x	x	x	x	26,5	3,61	Unpoliert
A406644-str-002	AWL Grip	Carinthia Blue	250µm	x	x	x	x	x	x	21,2	4,69	Unpoliert
A406644-str-003	AWL Grip	Carinthia Blue	255µm	89,7	4,6	9,9	33,2	14,3	10,7	19,3	4,44	3 M Finesse It
A406644-str-004	AWL Grip	Carinthia Blue	250µm	91,2	2,3	9,3	30,8	14,7	11,3	26,5	3,45	3 M Finesse It
A406644-str-005	AWL Grip	Carinthia Blue	260µm	88,5	9,2	11,4	30,7	14,9	9,4	21,6	5,22	Nobelclean
A406644-str-006	AWL Grip	Carinthia Blue	270µm	92,2	3,7	6,1	24,9	11,6	9,2	26,1	4,17	Nobelclean
A406644-str-007	AWL Grip	Carinthia Blue	255µm	91,5	2,3	8,1	29,6	14,8	13,3	27,1	3,92	3M Finesse It + Nobelclean
A406644-str-008	AWL Grip	Carinthia Blue	260µm	91,2	3,8	7,2	28,6	13,4	11,4	27,0	4,03	3M Finesse It + Nobelclean
A406644-str-009	AWL Grip	Dark Green	270µm	x	x	x	x	x	x	0,7	12,12	Unpoliert
A406644-str-010	AWL Grip	Dark Green	250µm	x	x	x	x	x	x	0,8	12,05	Unpoliert
A406644-str-011	AWL Grip	Dark Green	270µm	91,0	4,0	8,7	29,2	14,8	11,9	0,7	12,76	3 M Finesse It
A406644-str-012	AWL Grip	Dark Green	265µm	91,0	3,3	8,7	30,3	13,9	11,1	1,0	10,9	3 M Finesse It
A406644-str-013	AWL Grip	Dark Green	265µm	93,1	4,7	6,8	18,1	9,5	9,0	0,4	14,57	Nobelclean
A406644-str-014	AWL Grip	Dark Green	265µm	92,3	5,7	7,7	20,2	9,8	10,7	0,7	13,11	Nobelclean
A406644-str-015	AWL Grip	Dark Green	275µm	89,0	5,7	11,9	34,4	15,3	11,5	0,3	16,10	3M Finesse It + Nobelclean
A406644-str-016	AWL Grip	Dark Green	265µm	85,5	12,1	13,4	36,6	18,5	16,8	0,7	12,99	3M Finesse It + Nobelclean
A406644-str-017	Mankiewicz	Carinta Blue	250µm	x	x	x	x	x	x	16,6	5,71	Unpoliert
A406644-str-018	Mankiewicz	Carinta Blue	250µm	x	x	x	x	x	x	23,7	5,11	Unpoliert
A406644-str-019	Mankiewicz	Carinta Blue	260µm	95,3	2,3	4,0	9,5	3,8	2,7	27,6	4,46	3 M Finesse It
A406644-str-020	Mankiewicz	Carinta Blue	260µm	94,7	3,2	5,0	10,6	6,2	7,8	27,3	4,71	3 M Finesse It
A406644-str-021	Mankiewicz	Carinta Blue	265µm	94,6	3,5	5,1	10,8	5,0	3,8	21,3	5,41	Nobelclean
A406644-str-022	Mankiewicz	Carinta Blue	250µm	93,6	5,4	5,9	12,5	5,6	5,2	29,5	4,37	Nobelclean
A406644-str-023	Mankiewicz	Carinta Blue	265µm	95,5	1,9	3,0	9,0	3,9	3,9	27,7	5,00	3M Finesse It + Nobelclean
A406644-str-024	Mankiewicz	Carinta Blue	250µm	94,4	4,3	3,9	10,0	4,3	2,7	23,9	5,16	3M Finesse It + Nobelclean
A406644-str-025	Mankiewicz	Dark Green	285µm	x	x	x	x	x	x	1,0	13,63	Unpoliert
A406644-str-026	Mankiewicz	Dark Green	290µm	x	x	x	x	x	x	0,3	14,94	Unpoliert
A406644-str-027	Mankiewicz	Dark Green	270µm	94,3	2,4	4,8	16,8	12,2	19,1	0,3	16,39	3 M Finesse It
A406644-str-028	Mankiewicz	Dark Green	285µm	92,8	4,4	7,0	20,1	13,1	17,0	0,3	15,95	3 M Finesse It
A406644-str-029	Mankiewicz	Dark Green	275µm	92,8	6,7	7,9	13,7	16,2	24,6	0,2	15,43	Nobelclean
A406644-str-030	Mankiewicz	Dark Green	290µm	92,2	6,8	6,9	17,8	9,8	17,4	0,9	13,51	Nobelclean
A406644-str-031	Mankiewicz	Dark Green	280µm	93,4	3,3	6,3	19,3	16,5	25,4	0,4	15,64	3M Finesse It + Nobelclean
A406644-str-032	Mankiewicz	Dark Green	280µm	94,7	2,1	3,9	15,5	16,5	18,1	0,3	16,33	3M Finesse It + Nobelclean

3.2.3 Polishing / sealing of the surfaces before QUV – weathering

The following pictures 12 and 13 show the difference between the outsourced samples not treated and samples sealed before. In these tests the samples were sealed with the Nobelclean method before outsourcing.



Picture 11: Determination of the gloss grade with additional polish sealing



Picture 12: Determination of the gloss grade with additional polish sealing

4 Discussion of the measurement results

Determination of the gloss grade:

After 1000 hours of Q.U.V.- outsourcing the gloss grade of both color tones (Carint(hi)a Blue and Dark Green) extremely decreases. However there could not be observed a difference between the lacquer systems. Due to an additional polishing of the lacquer coating weathered the gloss grade of the original value at the beginning is approximately achieved. The traditional polishing method as well as the polishing technique of Messr. Nobelclean achieve the same good values. A combination of both polishing methods does not improve the gloss grade. After another 1000 hours of Q.U.V. outsourcing of the polished lacquer samples there are however achieved significantly higher gloss grades than after the first Q.U.V. outsourcing. Here the polishing method of Messr Nobelclean does a bit better and the gloss values are a bit higher.

Determination of the color tone:

After the Q.U.V. outsourcing the color tone of both lacquer systems decreases drastically and the ΔE - values (up to a value of >14) are for the green color tone are outside the limiting value of the standard DIN 6174. It can be observed that only the L - values change significantly. There cannot be realized any color tone shift in the color axes a (red - green) and b (yellow - blue) respectively in both lacquer systems. There were not observed any differences in the lacquer systems. The color tone difference and the ΔE - value decreases below 1 by polishing the lacquer coating. The polishing with the products of Messr. Nobelclean is significantly better than the traditional polishing. A combination of both polishing methods does not bring any advantage in this case. After a further artificial weathering of the samples polished a change of the color tone and the ΔE - value can be observed, but the ΔE - values of the Nobelclean samples are significantly better and the limiting values (ΔE - value < 10) can be kept.

Wavescan:

Unfortunately Wavescan measurements were only possible before outsourcing and after polishing. After the Q.U.V. - outsourcing the samples were too dull. A significant difference between the same color tones of both lacquer systems could not be realized, but there are however significant differences between both color tones of the same lacquer system. The „Carint(hi)a Blue“ shows significantly better values than „Dark Green“. After polishing of the lacquer sample weathered the same test values could be achieved as before the outsourcing.

Polishing and sealing of the coating:

A previous sealing of the coating with the products of Messr. Nobelclean shows a significant improvement of the test results after a Q.U.V. outsourcing. The gloss limiting values and the ΔE - values of the surface sealed are significantly better after the Q.U.V outsourcing than without sealing.

Here also no significant difference between both color tones of both lacquer systems has been realized. The color tone „Carint(hi)a Blue“ shows a better performance than the color tone „Dark Green“.

5 Summary

The aim of this project was to compare two coating systems with the variation of the color tone in their optical properties after an artificial weathering (Q.U.V) and to evaluate the color stability. The tests carried out have clearly shown that the color tone Dark Green has always shown worse results concerning the gloss grade and color tone changes in both lacquer systems than the color tone Carint(hi)a Blue. After a Q.U.V. outsourcing the gloss grade has decreased significantly and the color

Comparison of optical properties of lacquer samples weathered

tone change has increased. There could not be realized any other differences between the lacquer systems of AWL Grip and Mankiewicz.

The original gloss value and color tone of the lacquer samples weathered could be achieved by polishing. The polishing tests have showed at the same time that the polishing method of Messr. Nobelclean shows better test results than the traditional polishing method. A combination of the polishing methods is not usefull and no improved coating can be achieved.

A sealing of a coating with the products of Messr. Nobelclean before results in a significantly improved weathering stability in the Q.U.V. test than the traditional polishing. This additional sealing is for the outer coating of ships at Lürssen useful.