Headlight lens reparation

Oslo RCAR 2010

Introduction

According to statistics of Generali Group, in 2009 the headlight was the part that was most often replaced. This is due to the fact that after an accident or a vandalic act which damages the lens of the headlight, the headlight must be replaced.

The transparent caps of the front lights are made of polycarbonat, which is painted with a layer of protective paint either by a standard painting procedure or by insertion of a transparent film during the manufacturing phase, before molding the plastic material.

In this study we will demonstrate that in case of superficial damage, scratches or UV-ray yellowing of the headlight lens, it is possible to restore the lights through a standard painting cycle.

The major headlight producers in the world

The business line Automotive Lighting (AL) was set up in 1999 starting from a 50/50 joint-venture which brought to the merging of the sector divisions of the company Robert Bosch GmbH with the ones of the company Magneti Marelli Spa. After the incorporation of Seima Group (leader in the production of back lights) in 2001, the Automotive Lighting division also took over the control on the stockholding of the Robert Bosch company in 2003 and it became its only owner.

Valeo began its manufacturing activity in Saint Ouen, in France, producing gaskets for brakes and clutch. Today it is a private industrial group totally focused on the planning, production and sale of components and integrated systems for cars and trucks and it is a world leader in automotive components.

Hella KGaA Hueck & Co: This German company was established in 1899 and its first factory was built in Lippstadt in 1911. It is a car component supplier and it develops and produces electronic and lighting systems for car industry.

Ichikoh Industries Ltd. Ichikoh Industries is an important Japanese company for the production of car lights and rear-view mirrors. The company is based in Tokio and it has developed the first rear optical group in Japan: that is the first electric rear-view mirror in the world and the state of the art HID front lights (HID – High Intensity Discharge).

The manufacturing process (Supplied by Automotive Lighting)

F) Other parts

A) Body

B) Body subgroup

C) Reflector

D) Lens

E) Frame

G) Light assembling and test

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AUTOMOTIVE LIGHTING

A) Body

Process: thermoplastic injection molding

Materials: talc-filled polypropylene (PP-TD40) or glass fibre-filled polypropylene (PP-GF30) are normally used.

B) Body subgroup

Process: assembling process of parts on the body such as motor bikes, fixing items, ventilation, cables etc.

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C) Reflector

- Process:
  - Thermosetting injection molding
    - ➢Molding
    - ➢ Robot + hand trimming
  - Basis painting: this is done to even out the surface of the molded piece
    - ➢ Washing (or brushing)
    - ➢ Painting (flow coating or spray)
    - ➢ UV Curing
  - PVD Metalization (sputtering metalization is also used): this is done in order to lay a thin layer of aluminium to enhance the reflection power of the item
    - ➢ Ionization: this is done in order to clean the item
    - ➢ Aluminizing: laying of aluminium in high vacuum with process
    - ➢ Protection: this is done in order to lay a layer of silicone monomer to prevent the corrosion of aluminium.
    - Materials. Base material: thermosetting material, unsaturated polyester resins BMC (Bulk Moulding Compound) with glass fibres and mineral charge.

Riflettore sbavato

Riflettore metallizzato

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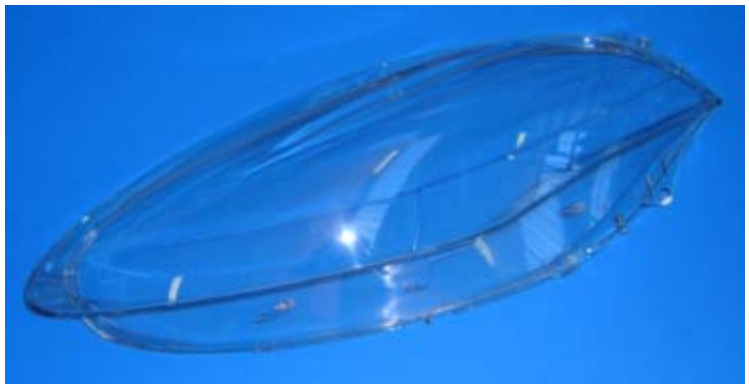
D) Lens

- Process:
  - Thermoplastic injection molding
  - Flow coating or UV curing (or thermic) spray painting (hardcoating). His is donein order to enhance the scratch resistance of the polycarbonat and to protect it from chemical agents and from UV rays.
- Materials. Base material: thermoplastic polycarbonat (PC)



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E) Frame

- Process:
  - Thermoplastic injection molder
  - PVD metalization (sputtering metalization is also used): This is done in order to lay a thin layer of aluminium to enhance the reflection power of the item
    - ➢ Ionization: this is done in order to clean the item
    - ➢ Aluminizing: laying of aluminium in high vacuum with process
    - ➢ Protection: this is done in order to lay a layer of silicone monomer to prevent the corrosion of aluminium.
- Materials: thermoplastic polyamide (PA) or polybutylene terephthalate (PBT) or polycarbonat (PC)

Cornice (Bezel)

Bell of sputter coating

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G) Headlight assembling and testing

Assembling → Lens sticking → Pneumatic seal test → Photometric test → Final examination

The raw material for the lenses

Polycarbonat is a generic polyester (polymer) of the carbonic acid, identified with the abbreviation PC.
Polycarbonats are characterized by mineral acid resistance, aliphatic hydrocarbon resistance, petrol resistance, oil resistance, water below 70˚C resistance and alcohol (except methylic alcohol) resistance.
They can be processed by extrusion or molding.
Polycarbonat is characterized by high toughness, but it is a notching sensor, as a notch reduces its fatigue strength.
Its transparency and its colourlessness allow an 89% light permeability in the visible spectrum. To prevent yellowing caused by UV rays, stabilizers such as benzothriazoles are used or protections are applied to the surface which is exposed to the weather (this technique is used for the treatment of the transparent surfaces of the headlights).
The transparency of polycarbonate and its excellent mechanical properties make it the natural replacing material of glass, unlike which it is cold-bendable.

Regulations

The norms for the homologation of the headlights are listed in the rule N. 112 of the UN Economic Board for Europe (UN/ECE), published in the official journal of the European Union Gazzetta Ufficiale on16/12/2005.
Testing procedures, manufacturing norms and functional specifications are established.

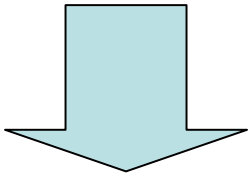
We kept to such specifications, also to verify the reliability of the reparations we had carried out.

Homologation tests on lenses

1. Limited photometry
    - Temperature change
    - Transmission size
    - Diffusion size
- Weather
- Chemical agents
- Detergents
- Hydrocarbons
- Deterioration
- Adherence

Reparations

Is it possible to paint the transparent cap of the headlights?



Yes, in the following cases :

- Vandalic act
- Scratch or scrape (caused by an accident)
- Detachment of the original painting
- Opacity caused by UV rays (yellowing of the lens surface)

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You can see the video on the same web page

Operation tests

4 pairs of new headlights have been used. Each pair was composed of one painted headlight and one original headlight.
The headlights have been mounted on a special structure, which has been located outdoor. Each pair has been supplied with 13,5V voltage by means of a stabilized power supply for 1.278 hours. The lights have been cyclically turned out and on in order to simulate their use on a car in about 3,5 years of regular employment, according to studies done by ACI and by the Ministry of Infrastructures and Transports.

Results of operation tests

At the end of the test, we have measured the brightness of the light beam of each headlight, both with dirty and with clean surface, and this has been compared with the result obtained from the measurement made before the beginning of the test.

The variations of brightness for dirty is not significant (average difference 28lux)

Variation of brightness following to painting

In order to verify the variations of brightness produced following to the laying of the superficial paint layer, the lighting produced by the new headlight has been compared with the lighting of the painted headlight, and the average lighting variation has been measured on 21 points for each headlight using a panel placed at a distance of 10 metres from the headlight.

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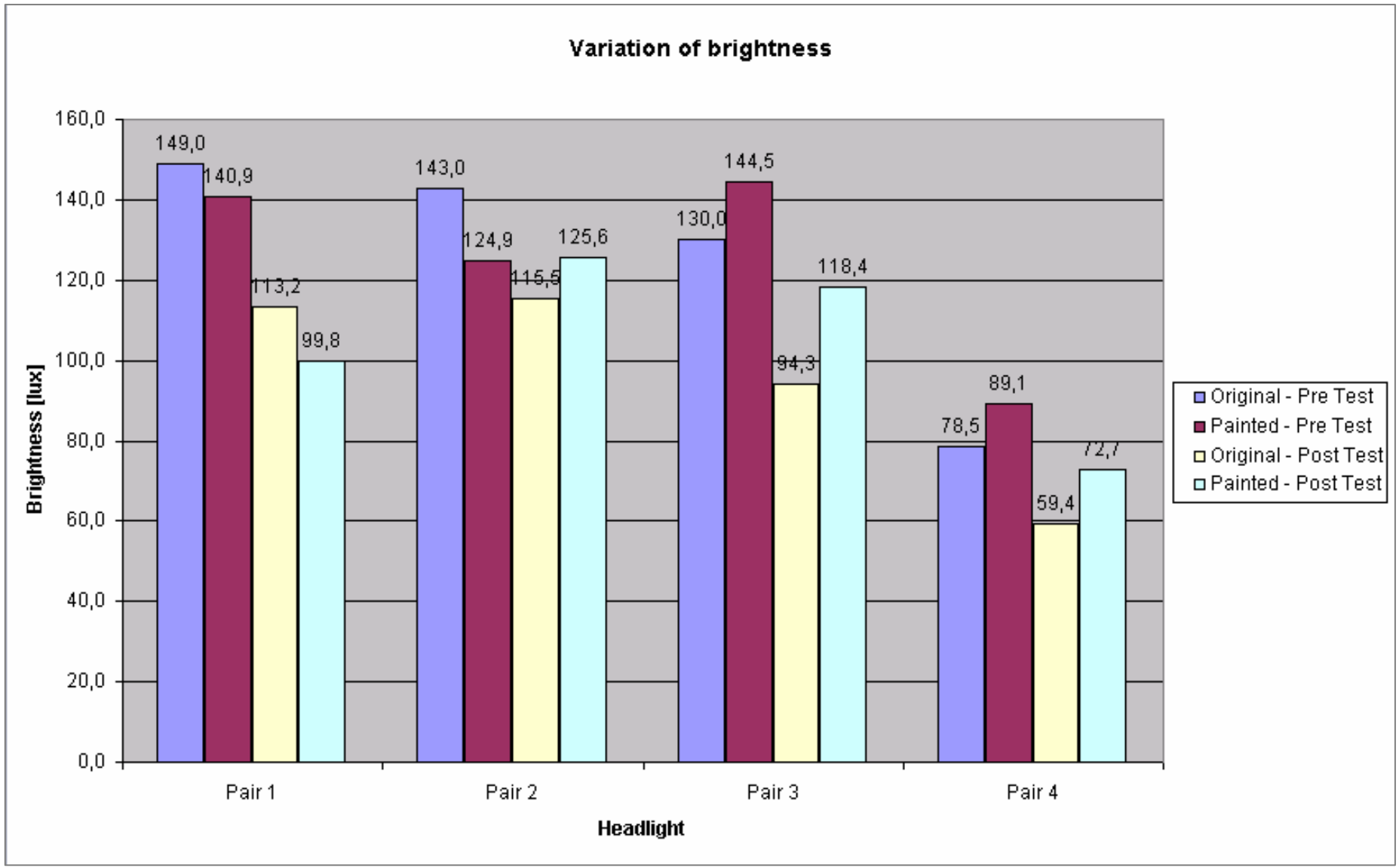

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Aging tests and mechanical tests

Preparation of the specimens

11 identical specimens have been cut from a matrix, and as many new headlights have been used.

The specimen have been numbered from 1 to 11: a two-component paint has been laid on the ones numbered from 1 to 5; a one-component paint has been laid on the ones numbered from 6 to 10; no paint has been laid on number 11 (master).

Aging tests

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The specimens obtained have been tested in the laboratories of the University of Genua, where they had to undergo the following tests:

- exposition in climatic chamber;
- exposition at sun light;
- chemical agents attacks;
- detergents and hydrocarbons attacks;

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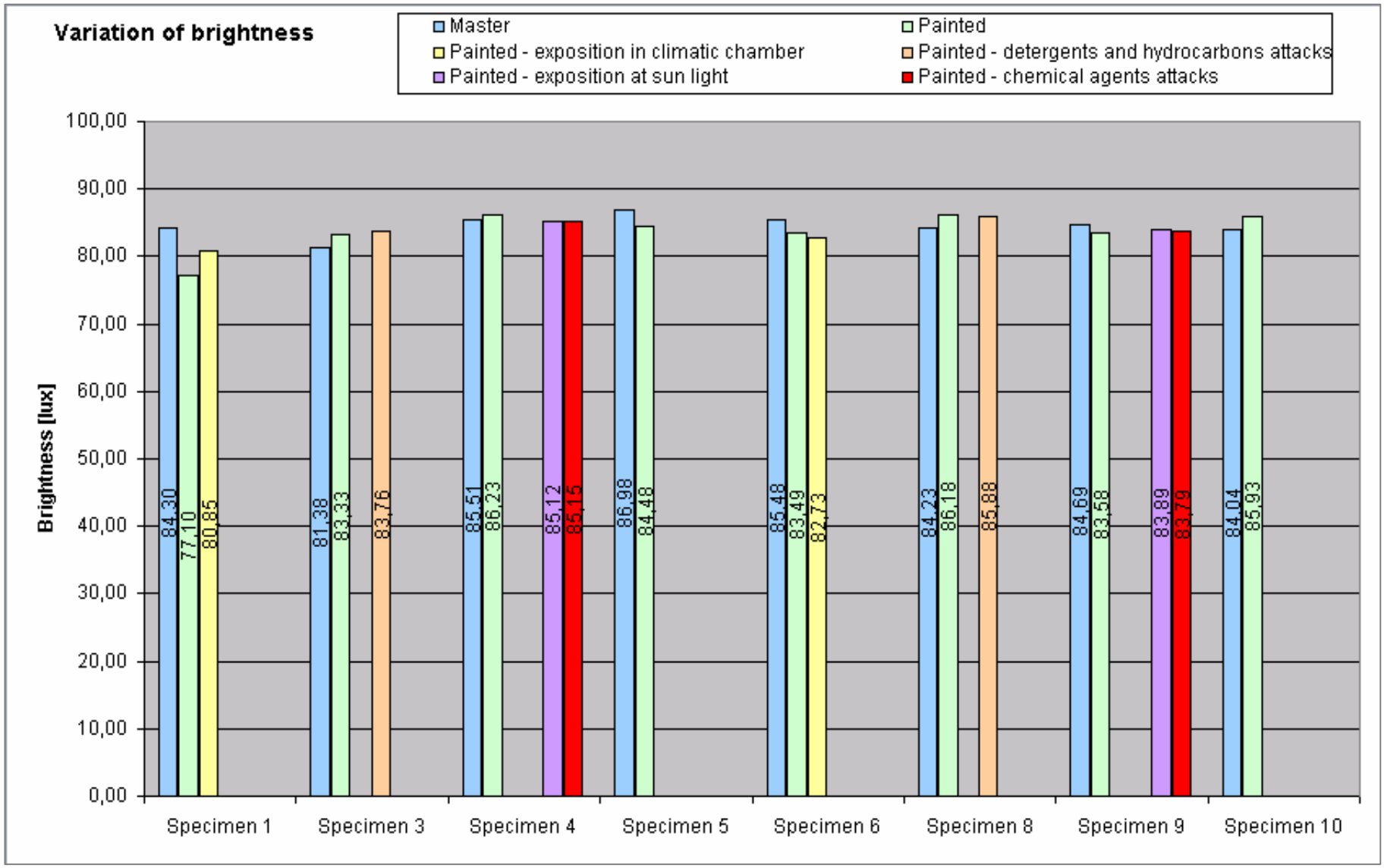

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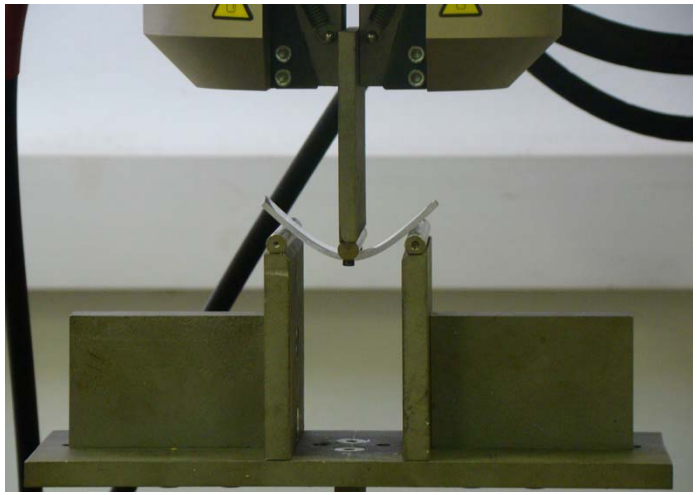
Mechanical tests

A further aspect has been verified for both items taken into consideration, that is the capability to maintain the mechanical features of polycarbonat unchanged, so that the mechanical features of the lenses are maintained.
This has been verified through a three-point bending test according to UNI EN ISO 178. The crack point of the original polycarbonat (the one without painting) has been measured and compared with the crack point of the samples which had undergone the painting process with transparent paint. This procedure has been carried out in order to verify whether the paint has an aggressive action on the polycarbonat used to manufacture the lenses.



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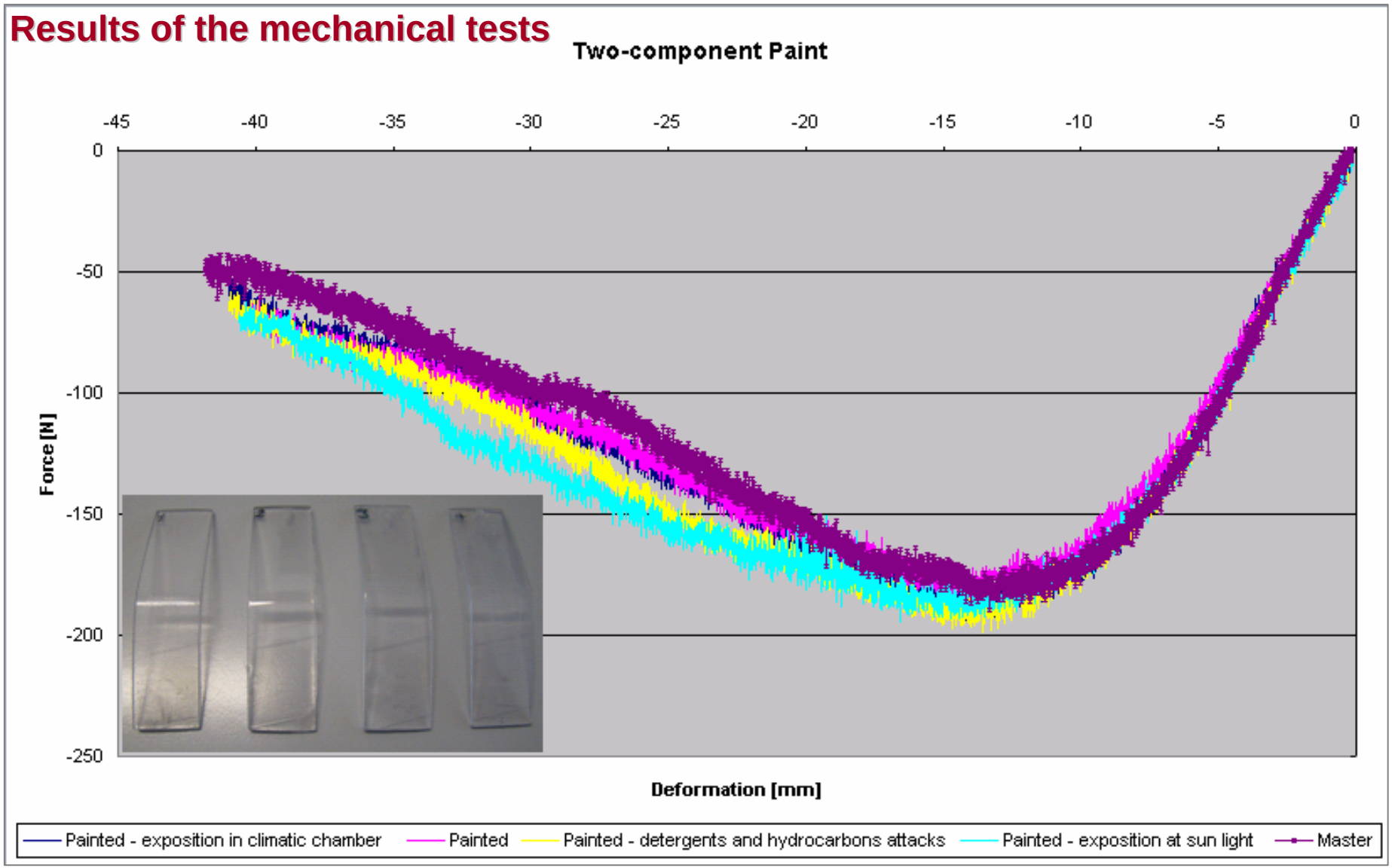
Results of the mechanical tests



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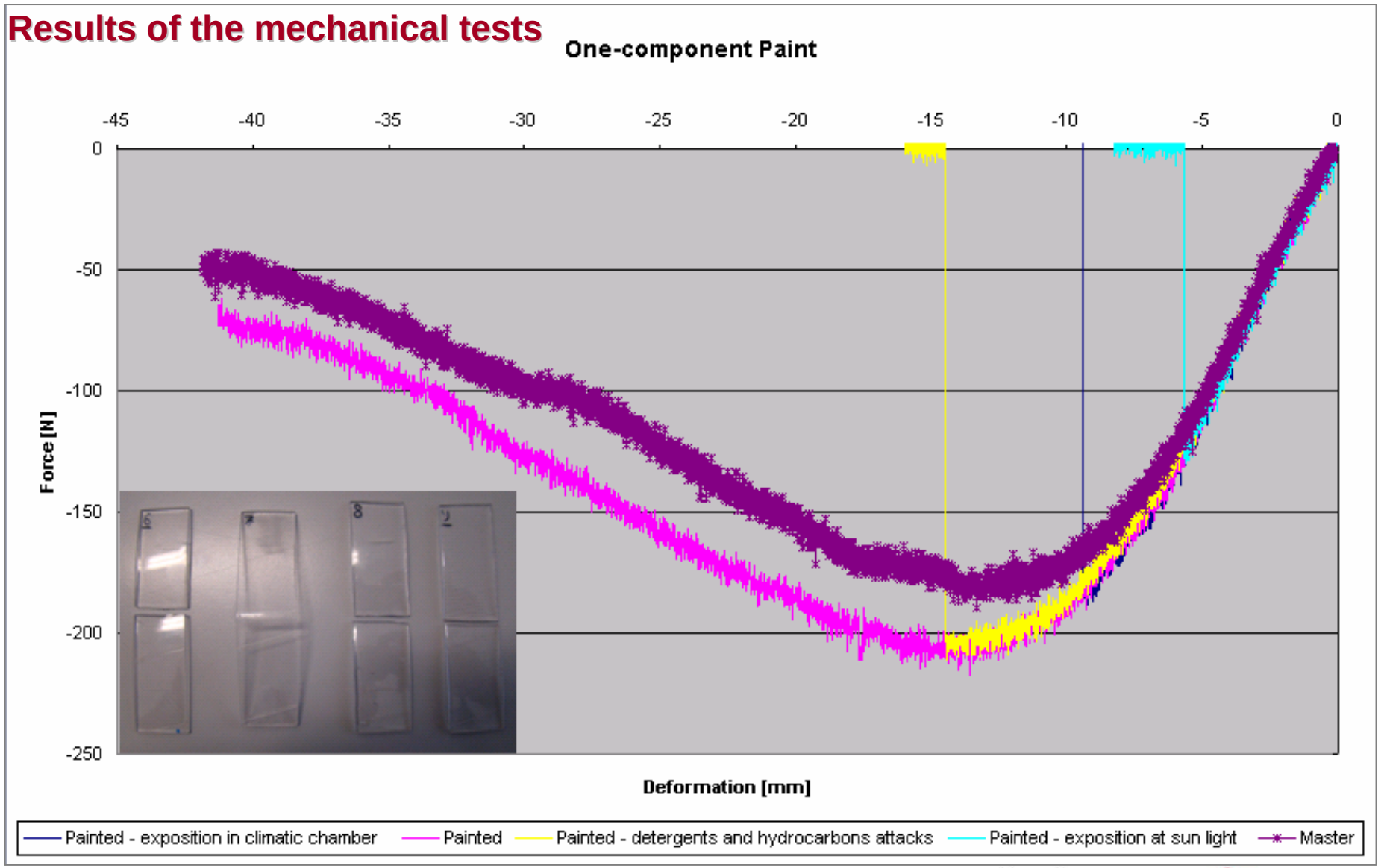
Headlight cover repair

Results of the mechanical tests



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Pull off test

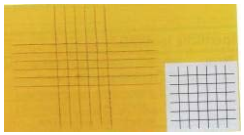
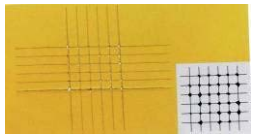
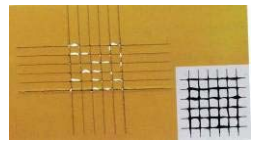
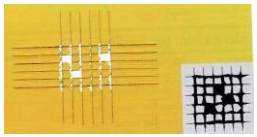
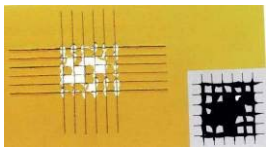
• The test has been carried out in compliance with the norms : UNI EN ISO 16276-1; UNI EN ISO 4624, to assess the adhesion level of paint to the support;
• This test consists in sticking an alumium dolly on a painted support, to carry out a traction test

Specimen (Paint Type)	Treatment	σ [MPa]	F [N]
1 (two-comp.)	Exposition in climatic chamber	0,46	144,5
2 (two-comp.)	Nothing	0,93	292,16
3 (two-comp.)	Detergents and hydrocarbons attacks	0,91	285,88
4 (two-comp.)	Exposition at sun light and chemical agents attacks	0,49	153,93
6 (one-comp. UV)	Exposition in climatic chamber	0,93	292,16
7 (one-comp. UV)	Nothing	0,96	301,59
8 (one-comp. UV)	Detergents and hydrocarbons attacks	0,89	279,6
9 (one-comp. UV)	Exposition at sun light and chemical agents attacks	0,81	254,46
11 (master)	Nothing	3,77	1184,4

Adhesion tests

Adhesion tests have been carried out on pairs of identical headlights (left): one headlight was new and one was painted. The test has been carried out in compliance with the norms ISO 2409 or ASTM D 3359 and has been classified in the following table.

The test has been carried out the day after the painting (first test) and then after 4 days (second test) and then after 7 days (third test).

Value	Features	Example
ISO: 0	Perfect adhesion;	
ISO: 1	Detachment of small parts of paint in the corners of the checkering;	
ISO: 2	From the detachment of the paint along the edges to 2 small checkers;	
ISO: 3	from 3 to 7 small checkers;	
ISO: 4	from 8 to 15 small checkers;	
ISO: 5	over 16 small checkers	

Results of adhesion tests

Model of the headlight			TWO-COMPONENT product			ONE-COMPONENT product		
			1st test	2nd test	3rd test	1st test	2nd test	3rd test
Toyota	Yaris	Dx	0	0	0	0	0	0
Toyota	Yaris	Dx	0	0	0	0	0	0
Toyota	Yaris	Sx	0	0	0	0	0	0
Ford	Focus	Dx	2	5	4	0	0	0
Seat	Ibiza	Sx	0	0	0	0	0	0
Ford	Mondeo	Dx	0	5	0	0	0	0
Mercedes	Classe A	Sx	0	0	0	0	0	0
Fiat	Punto	Sx	0	5	5	0	0	0
Fiat	Punto	Sx	2	0	0	0	0	0
Renault	Modus	Dx	0	5	5	0	0	0
Average			**0,4**	**2**	**1,4**	**0**	**0**	**0**
			1,3			**0**		

The two-component product presents more critical points as regards the adhesion to the support

Reparation costs

In both cases the headlight is repaired in about 30 minutes, but the two-component product needs 15 minutes more for drying under IR lamp, while the one-component product needs only 2 minutes.

As to the costs of the products, the situation is as follows:

Two-component product

- about 12 € each headlight + masking materials
- about 0,250 kwh electric power for 15 minutes drying time for each headlight, amounting at about 0,028 €

One-component product

- about 5 € each headlight + masking materials
- 1000 € initial investment, as it is necessary to buy a UV lamp, which is not very common in Italian body shops, unlike the IR lamp
- about 0,0132 kwh electric power for 2 minutes drying time for each headlight, amounting at about 0,0015 €

Conclusions

The results obtained using the two products to repair the lenses of the headlights are excellent as regards the quality of the reparation, the duration in time and the conservation of lighting features.

No significant lighting loss has been verified after the tests, above all if we compare them with the variations of the surrounding light and with the effects of dirt. Furthermore, no structural alteration of polycarbonat have been found and the appearance is aesthetically excellent.

The only aspect to be studied in deep, on which the producer is already carrying out laboratory tests, is the adhesion of the two-component product, whose outcomes in the checkering test are not always satisfying, according to the features of the polycarbonat on which it is laid.

We hence consider the use of these products as a valid and saving alternative to the replacement of the whole optical group of the vehicle in case of superficial damage on the lens or in case of yellowing.

Difficulties in marketing

This methodology may present some critical points, as the body makers would lose the financial income coming from the sale of a new headlight.