

# Analysis of methods of assessing the quality of protective paint car coatings

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**Abstract.** At present, modern ways to protect a varnish coating of cars have become widespread among motorists. Small particles of dirt, dust, winter reagents, minuses of car wash systems, a large number of stones on the road do not have the best effect on car cover. All operational impacts destroy the protective paintwork, after which the steel car body is no longer able to resist the effects of the environment. The body begins to rust and deteriorate. The car eventually loses its appearance, ceases to shine, becomes opaque. Reduction of adverse operational impacts on the paint coating of the car is achieved by modern methods of protection. A wide distribution in the market of automobile cosmetics was produced by protective polishes based on wax or synthetic constituents. It is connected with their small cost and ease of application. The flagship on auto market for the protection of car paint coating is armor plate. This is a protective transparent film with a thickness of approximately 100 microns, providing the maximum degree of protection. Thus, with the help of modern means of protecting paint coating, one can minimize the negative impact of the environment and prolong youth to a car.

## 1 Introduction

A large number of modern paint coatings used in the automotive industry must ensure reliable protection of the body from external factors. However, when operating cars under high-speed conditions, often the strength of the coatings themselves is not enough. The reasons for their violation are [1-3]: the temperature factor, mechanical effects caused by the ingress of stones, branches and other solid objects. In this regard, various protective measures have been developed to extend the life of paint coatings and, accordingly, to protect body parts from contact with the environment. The application of such funds is possible at specialized car repair centers, the type and method of application depends on the level of professionalism of the technical personnel and the financial capabilities of the car owner (some protective equipment has a large cost commensurate with the price of a small car).

Evaluation of the quality of various protective coatings of cars [4-5] formed the basis of the studies presented in this paper. The urgency of the problem to be solved lies in the choice of the optimal protective agent, as well as in the application of various methods that allow assessing the quality of the protective agent.

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For the experiment, the body element, the trunk lid of the 2105 series is chosen. The reasons for choosing this element are the small radii of curvature, due to which the process of preparation and application of protective equipment is facilitated, sufficient area for separation into several investigated areas with different types of coatings applied.

In the process of preparing the experiment, the body element was primed, then it was covered with a layer of black paint. As the final layer was used a varnish coating. The varnish was chosen the softest, acrylic based, domestic production. The reason for choosing the color of the coating is its sensitivity to various types of damage: the blackest body elements show the most damage during operation.

## 2 Materials and methods

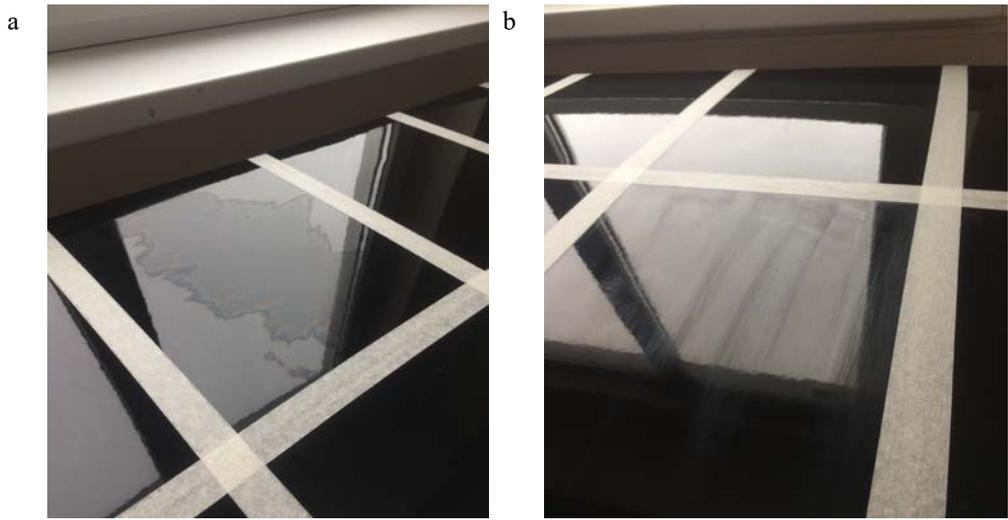
To carry out the experiment, the surface of the paint coating is polished with fine abrasive agents followed by degreasing. After the preparatory operations, the body element was divided into sections (Figure 1).



**Fig. 1.** Vehicle body element prepared for experiments

The first pair of sections was left with the original coating, the second pair was covered with liquid protective wax by the well-known Turtle Wax company, the third pair (Figure 2) was coated with a protective coating of low quartz particles by Ultra Technologies under name Fast Quartz, the fourth pair was coated with so-called "Liquid glass" by Willson, the fifth pair of sections was coated with a protective coating by Ultra Technologies under name Ceramic Coat, and a high-quality protective film based on polyurethane by the well-known company Hexis (Figure 3). This film has reducing properties when heated.

Carrying out of the further researches of the put on protective means are divided into two stages. The first stage of the research was based on the Wolf Wilborn test [6-7]. The use of this test makes possible to demonstrate clearly the differences of various protective devices after mechanical influences.



**Fig. 2.** Protective layer of Fast Quartz: a – on the upper section; b – on the lower section

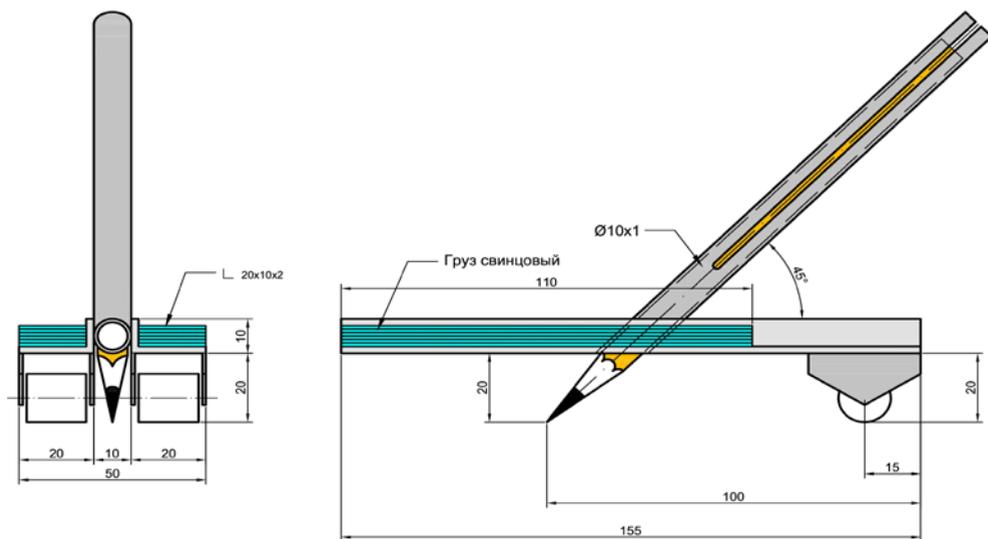


**Fig. 3.** Protective film based on polyurethane by Hexis

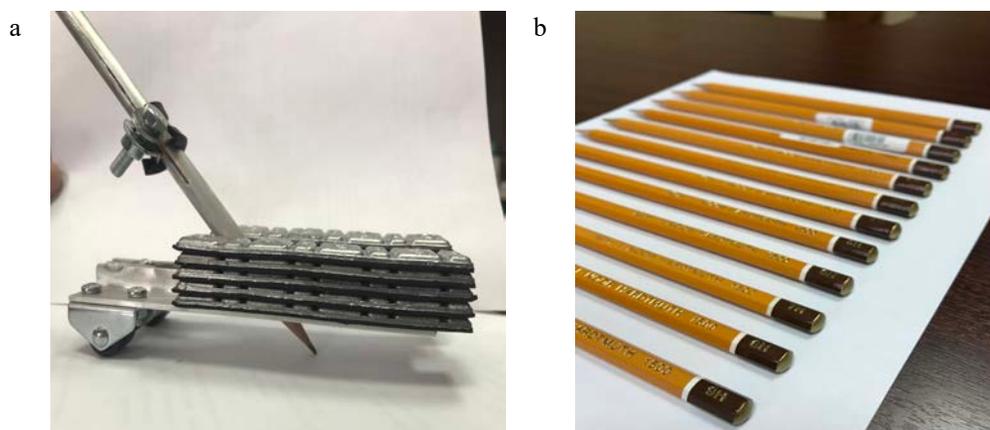
The test is regulated by the standards ISO 15184, ASTM D3363, JIS K-5600, ECCA-T4-1, BS 3900-E19, SNV 37113, SIS184187, NEN 5350, MIL C 27 227, JIS K-5400. The test procedure is as follows. On the surface of the paint coating is a pencil at an angle of 45 degrees with a pressing force of 7 Newton (about 700 grams), after installation moves the pencil to the side of its tilt. The test is carried out using pencils of different hardness, after which the degree of damage to the surface of the paint coating is assessed.

To carry out the Wolf Wilborn test directly, an experimental setup was made (Figure 4 and Figure 5). The design of the test setup is made of an aluminum tube with a diameter of 10 mm. with a wall thickness of 1mm, and an aluminum corner measuring 20x10x2. Between the two parallel and symmetrically located corners at an angle of 45 degrees, the tube is fixed, in turn, to each of the corners from one edge are fixed wheels, and a pencil is installed in the tube. Load design was carried out using lead weights.

The test was performed using KOH-I-NOOR HARDTMUTH pencils, the hardness values of the pencils were 2B-9H.



**Fig. 4.** Diagram of the experimental setup for the Wolf Wilborn test



**Fig. 5.** Installation for the Wolf Wilborn test: a – general view of the installation; b – used pencils with different hardness

Figure 6 shows the photographs of each of the sections examined after the Wolf Wilborn test. As a result of the test, it is seen that the hardness (degree of protection) in all test samples is different. It should be noted that when performing a test on a surface that is not protected by modern means, a strictly linear relationship between the degree of damage and the hardness of the pencil is noticed. Based on this, it was decided to compare the degree of damage in the test samples with the degree of damage to the unprotected surface.

For clarity, the results of the experiment are indicated in tabular form (Table 1). The digits in the table indicate: 0 – no damage, 7 – maximum damage.

Based on the results of the studies, a graph of the hardness (pencil) and the degree of damage was plotted (Figure 7).

The graph shows that on the untreated surface the relationship between the hardness of the pencil and the lesions is strictly linear with large surface damage. On the surface protected by the wax composition Turtle Wax, not bad protection to hardness of the pencil 2H is observed, after which the protection schedule has the same linear dependence as in the case with the untreated surface. During the test, the protective compositions of Fast

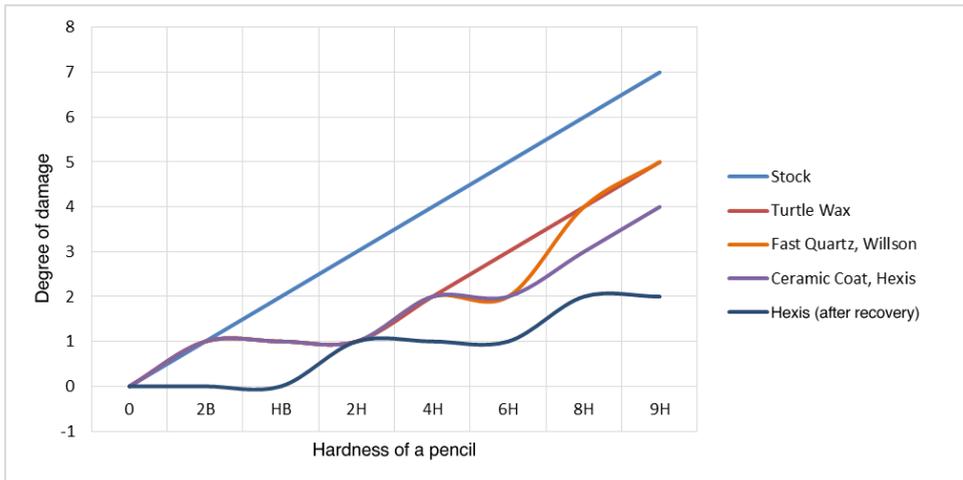
Quartz and Willson showed similar protective properties up to a pencil hardness of 6N. The maximum protection was shown by the protective composition Ceramic Pro and polyurethane film Hexis, they confidently resisted not only damage from the pencil hardness of 6N, but also other harder pencils. Due to the reducing properties on heating, the polyurethane film was less damaged as a result.



**Fig. 6.** Wolf Wilborn test results: a – Hexis; b – Ceramic Coat; c – Willson; d – Fast Quartz; e – Turtle Wax; f – Without protection

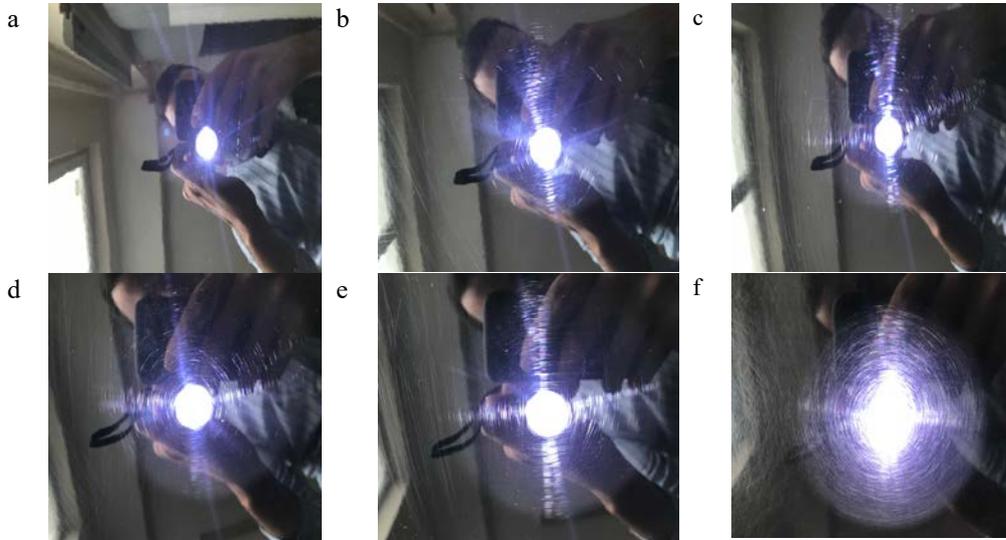
**Table 1.** Damage values depending on the type of coating

Hardness of a pencil	Without protection	Turtle Wax	Fast Quartz	Willson	Ceramic Coat	Hexis	Hexis (after recovery)
2H	1	1	1	1	1	1	0
HB	2	1	1	1	1	1	0
2H	3	1	1	1	1	1	1
4H	4	2	2	2	2	2	1
6H	5	3	2	2	2	2	1
8H	6	4	4	4	3	3	2
9H	7	5	5	5	4	4	2



**Fig. 7.** Graph of hardness (pencil) and degree of damage

The second stage of the research is based on visual perception of the quality of the coating after mechanical treatment with a brush with a rigid plastic pile. The basis of this study lies in the scratching effect of the tested surfaces [8-9]. Damage assessment is performed visually using a direct light source. The results of this test (Figure 8) completely coincided with the results of Wolf Wilborn's test, with the exception of the surface that was protected by a polyurethane film, the plastic fleece had no effect on this surface, in contrast to the hard pencils used in the Wolf Wilborn test.



**Fig. 8.** Visual test results: a – Hexis; b – Ceramic Coat; c – Willson; d – Fast Quartz; e – Turtle Wax; f – Without protection

One of the important moments of using protective means of paint coatings is the cost of materials and the cost of preparatory work. Table. 2 presents the approximate comprehensive cost of works for the protection of a medium-sized passenger car is given for each of the coatings under consideration.

**Table 2.** Estimated comprehensive cost of works to protect a medium-sized car

	<b>Turtle Wax</b>	<b>Fast Quartz</b>	<b>Willson</b>	<b>Ceramic Coat</b>	<b>Hexis</b>
<b>Cost, (rub)</b>	500	500	10 000	25 000	100 000

### 3 Results and discution

As a result of the conducted researches, various approaches for the evaluation of the quality of protective coatings for cars' varnishes are considered. Dependencies of the properties of protection of paint coatings after various mechanical influences have been established. Such products as Ceramic Coat and Hexis have the best level of protection, however, due to their high cost, they can have very limited application. Protective coatings Turtle Wax, Fast Quartz, Willson showed the worst resistance against mechanical influences, however, if compared to areas of paint without protection, they definitely perform protective properties.

In the near future, it is forecasted to reduce the cost of complex body protection of the car, so that modern means of protection will be more widely distributed among not only the premium class cars, but also the middle class.

### References

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