MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TRANSPORT UNIVERSITY

Department of “Technical Operation of Vehicles and Car Services”

METHODOLOGICAL GUIDELINES

FOR PERFORMING THE LABORATORY WORK

"INSPECTION AND ADJUSTMENT OF EXTERNAL VEHICLE LIGHTING DEVICES"

from the educational discipline "Technical Operation of Vehicles"
for second-level (master's) students of higher education
in the specialty 015 "Vocational Education (by specializations)",
specialization 015.38 "Vocational Education (Transport)",
educational-professional program "Vocational Education (Transport)"

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Approved
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First vice-rector, professor
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KYÏV NTU 2023

Guidelines for performing the laboratory work “Inspection and adjustment of external vehicle lighting devices” from the educational discipline "Technical Operation of Vehicles" for second-level (master's) students of higher education in the specialty 015 "Vocational Education (by specializations)," specialization 015.38 " Vocational Education (Transport)," educational-professional program " Vocational Education (Transport)" / Authors: V.O. Biletskyi, O.M. Ivanushko, O.S. Buhaichuk, V.O. Khavruk - Kyiv: NTU, 2023. - 39 p.

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GENERAL RULES OF LABORATORY WORK SAFETY

1. A student can start performing a laboratory work only after completing the introductory safety briefing with a corresponding entry in the instructions log.

2. The engine can only be started by the instructor or laboratory supervisor. It is prohibited to be near the flexible hose for exhaust gas during the engine startup.

3. During engine operation, the supply-exhaust ventilation should be turned on.

4. Ensure that clothing, especially when using a strobe light, does not come into contact with rotating engine parts.

5. Touching the conductive parts of cables and sensors at their connection points to the engine is prohibited.

6. After completing the work, the instructor should clean up the workspace and hand it over to the laboratory supervisor.

GENERAL RULES FOR PERFORMING LABORATORY WORK

1. Rules for performing laboratory work

During the laboratory work, students are questioned by the instructor in turn regarding the content and theory of the performed work.

The use of laptops, tablets, smartphones connected to the power grid in the classroom is allowed only under the supervision of the instructor. Students are obliged to inform the instructor about any socket malfunctions.

2. Procedure for performing laboratory work

The laboratory work consists of three stages:

2.1. Preparation for work (student's independent work):

- studying the theoretical material based on the educational literature;
- familiarization with the content and procedure of the work;
- preparation for answering the questions provided at the end of the work;

2.2. Recording experimental data of the laboratory work:

- filling out a report with the data;

- checking intermediate results and stages of the laboratory work by the instructor;

2.3. Documenting the work or report and defending the obtained results.

A fully documented laboratory work should include:

- title and purpose of the work;
- titles of sections (stages) of the work, diagrams; diagrams should be labeled and neatly drawn using a ruler and other tools;
- completed tables with experimental data;
- analysis of the obtained results, conclusions.

LABORATORY WORK
INSPECTION AND ADJUSTMENT OF EXTERNAL VEHICLE LIGHTING DEVICES

Aim of the work: to study the methods and acquire practical skills for inspection and adjustment of the headlights during vehicle maintenance.

Tasks:

1. to familiarize with the requirements for external lighting devices and the structure of control devices.
2. to investigate and, if necessary, adjust the alignment of the vehicle's headlights.
3. to investigate the operation of other external vehicle lighting devices.

Devices and equipment:

1. ŠKODA Superb vehicles;
2. headlight tester - BAHCO BLBT100 photometer;
3. torque wrench;
4. manometer;
5. device for measuring tire tread depth;
6. lux meter LX-1010BS(100KLUX);
7. ruler (50 cm) or measuring tape and metal protractor.

1. GENERAL INFORMATION

1.1. External lighting devices

Automobiles are equipped with the following lighting devices:

Front:

- low beam and high beam headlights - designed to illuminate the road at short or long distances while driving;
- position lights - designed to indicate the dimensions of the vehicle under conditions of poor visibility;

- daytime running lights - designed to improve the visibility of the vehicle during daylight hours;

- fog lights - designed to improve the visibility of the vehicle in conditions of poor visibility;

Rear:

- brake lights - designed to warn other road users about the deceleration or complete stoppage of the vehicle;

- reverse lights - designed to warn other road users and illuminate the road when the vehicle is moving in reverse;

- rear fog light - designed to improve the visibility of the vehicle in conditions of poor visibility;

- position lights - designed to indicate the dimensions of the vehicle under conditions of poor visibility;

Side:

- turn signals - designed to warn other road users about upcoming maneuvers;

- hazard warning lights - designed to warn other road users about problems with the vehicle, the driver, or the road.

An additional external lighting device on motor vehicles is the license plate illumination, which must be turned on during nighttime or in conditions of poor visibility.

The term "high beam" refers to the light beam of a headlight or headlight system designed to illuminate the road ahead of the vehicle in the absence of oncoming traffic. The "low beam" is the light beam of a headlight or headlight system that provides illumination of the road ahead of the vehicle when driving in populated areas or when encountering oncoming traffic on highways.

According to the requirements of the international standard UN/ECE R 48, which is in effect in all contracting parties of the "Geneva Agreement of 1958," including Ukraine, all cars and buses must be equipped with two or four high beam headlights. The type of each headlight must be officially approved. Each headlight must bear a marking indicating its compliance with the approved type.

High beam headlights must emit white light.

The dashboard of the vehicle must have a control signal indicating the operation of the high beam headlights (blue or yellow).

The high beam headlights can be turned on simultaneously or in pairs (if there are four of them).

When switching from low beam to high beam, at least one pair of high beam headlights must be turned on. When switching from high beam to low beam, all high beam headlights must be turned off simultaneously.

According to the requirements of the international standard UN/ECE R 48-02, all cars and buses must be equipped with two low-beam headlights. The headlight type must be officially approved. Each headlight must be marked to indicate its compliance with the approved type.

Low-beam headlights must emit white light.

The use of a control signal for the operation of low-beam headlights is not mandatory.

When switching from high-beam to low-beam headlights, all high-beam headlights must be simultaneously turned off. When switching from low-beam to high-beam headlights, the low-beam headlights may remain on.

It is permissible to combine the functions of both low-beam and high-beam headlights in one headlight. The combinations and configurations of high-beam and low-beam headlights are shown in Figure 1.1.

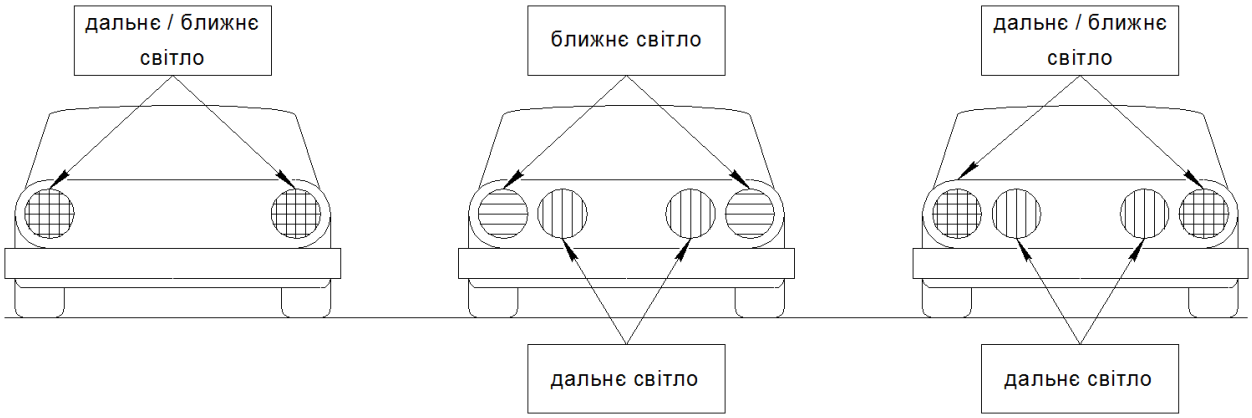


Figure 1.1 - Schemes of installation, combination, and combination of low and high beam headlights:

a) - combination of low and high beam in one headlight; b) - combination of low and high beam headlights; c) - combination of low and high beam in one headlight with its additional combination of high beam headlights.

For low/high beam headlights according to schemes a) and c), lamps with two separate light sources are used for each operating mode.

The distribution of light on the road depends on the design of the optical element and the lamp. Modern cars are equipped with headlights featuring American and European asymmetrical light distribution systems. Asymmetrical light provides better illumination on the side of the road the vehicle is moving towards and reduces the degree of glare for

oncoming drivers. The reduction of glare during oncoming traffic is achieved by using dual-filament lamps in the headlights.

In headlights with the American light distribution system, the filament of the high beam (usually arc-shaped) is located at the focus of the reflector. The filament of the low beam (cylindrical in shape) is slightly shifted upward and to the right relative to it (when looking at the reflector from the light aperture side).

The light beam in the American distribution system for low beam is diffused, without a clear light-dark boundary. Increasing the angle of dispersion of the reflected light beam necessitates secondary light distribution using a diffuser with a complex system of microelements. Reflectors with less depth are used to reduce the light flux of the rays reflected upward and to the right of the optical axis.

Headlights with a European light distribution system create a clearly defined light-shadow boundary for low beams. The filament of the high beam has an arc shape and is located at the focal point of the reflector. The filament of the low beam, which is cylindrical in shape, protrudes forward and is positioned slightly higher and parallel to the optical axis. The rays from the low beam filament that strike the upper half of the reflector's reflective surface are reflected downward, illuminating the road ahead of the vehicle. A light-shadow boundary is created by a screen located below the low beam filament, which blocks the rays from reaching the lower side of the reflector.

Compared to the American system, the European light distribution system illuminates the right side of the road, the roadside, and causes less glare for oncoming drivers. The fluctuation of the light-shadow boundary due to uneven road surfaces quickly fatigues the driver's eyes while driving. The American system with a diffuse beam for low beams is less sensitive to road irregularities. When vehicles with different low beam distribution systems meet, drivers of vehicles with European-style headlights experience more glare. The use of headlights with an American light distribution system is prohibited on the roads of contracting parties to the Geneva Agreement and EU member states.

1.2. Requirements for external lighting devices of wheeled vehicles (WV)

Headlights of WV must meet the following basic requirements:

- provide sufficient illumination of the road and objects on it;
- not blind oncoming drivers.

The requirements for external lighting devices, from the perspective of WV safety, are specified in subsection 6.1 of DSTU 3649:2010, namely:

1) it is not allowed to change the positioning of external lighting devices (ELDs), remove them, install additional ELDs, or change the operating mode of ELDs unless provided for by the design or documents for WV retrofitting;

2) it is not allowed to use damaged and cracked light-reflecting surfaces or diffusers of ELDs, install devices that restrict their visibility, apply coatings to ELDs (tinting, painting, etc.) that reduce light transmission, alter their light intensity, light distribution, or color;

3) on WVs taken out of production or those brought into compliance with the requirements of DSTU 3649:2010 or retrofitted according to approved documents, it is allowed to install ELDs from other MVs in accordance with the requirements of DSTU UN/ECE R 48-02;

4) the indicators for turning on lighting devices must be functional and have symbols provided by the design;

5) the number, color, and presence of ELDs on WVs are determined in accordance with Table B1 (Appendix B);

6) for WVs manufactured before 2003, it is not mandatory to install reverse lights, side turn signals, rear fog lights, additional brake lights, and hazard lights. For trailers attached to cargo and passenger cars manufactured before 2003, it is not mandatory to install front clearance lights. For WVs longer than 6 m and manufactured before 2003, it is not mandatory to install triangular-shaped side reflectors and side marker lights;

7) low beam headlights, high beam headlights, and fog lights must be equipped with light sources and adjusted according to the operational documentation of the WV;

8) the use of headlights intended for use on roads with left-hand traffic on WVs is not allowed;

9) the use of gas discharge light sources on wheeled vehicles (WV) without an automatic headlamp leveling system and headlamp cleaning devices is not allowed;

10) the initial tilt angle of the low beam headlights must correspond to the value specified by the manufacturer of the wheeled vehicle (WV) in the operating instructions or operational documentation, or on the label directly next to the headlights (Fig. 1.2), or on the manufacturer's company plate;

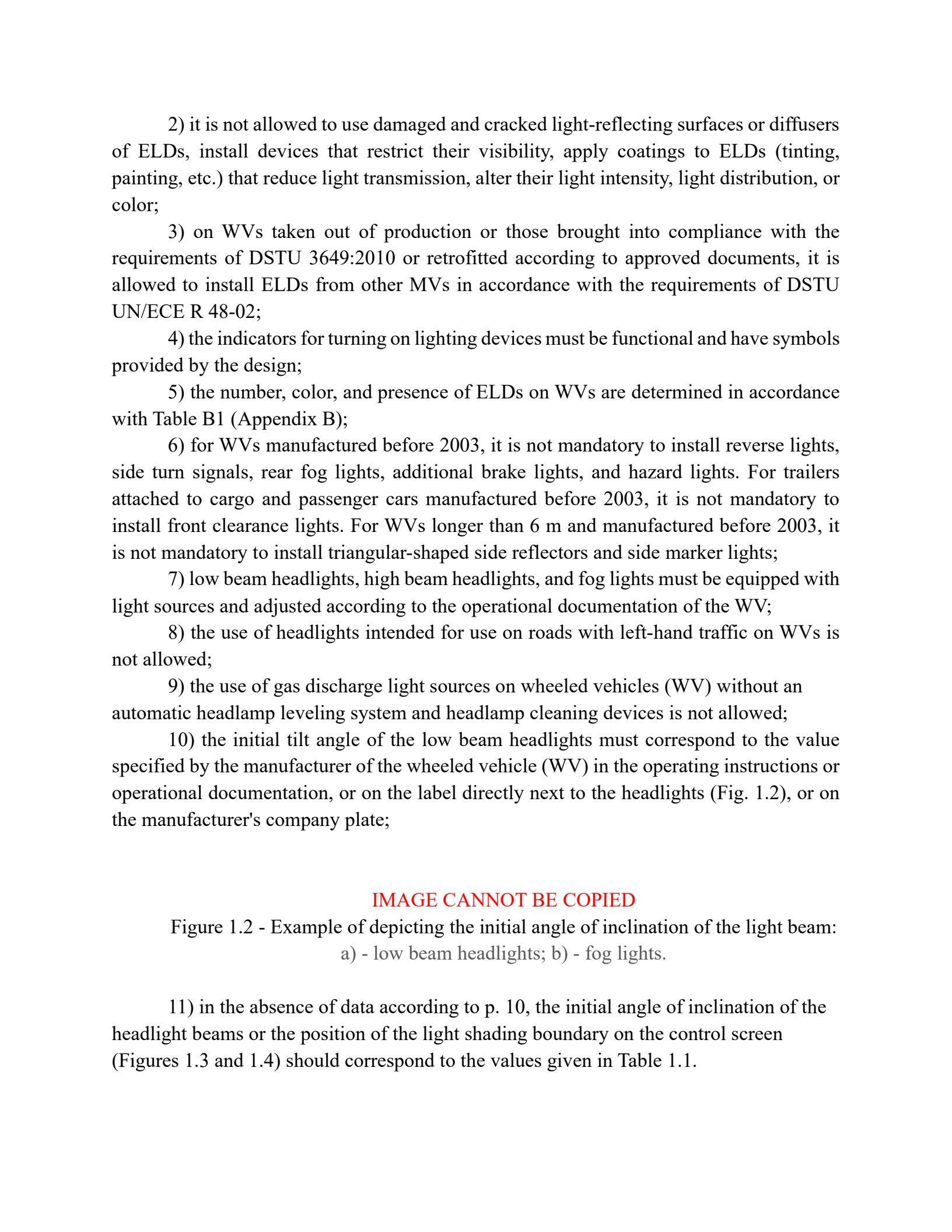


Figure 1.2 - Example of depicting the initial angle of inclination of the light beam: a) - low beam headlights; b) - fog lights.

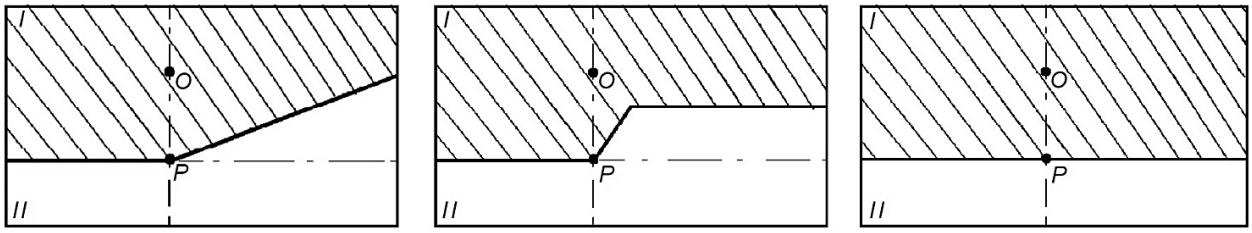
11) in the absence of data according to p. 10, the initial angle of inclination of the headlight beams or the position of the light shading boundary on the control screen (Figures 1.3 and 1.4) should correspond to the values given in Table 1.1.

Table 1.1 - Recommended values of the initial angle of inclination of headlight beams or the position of the light shading boundary on the control screen.

The distance from the lower edge of the visible surface of the headlight to the supporting surface (h), mm	The downward tilt of the low beam headlight in the vertical plane, %	The difference in vertical coordinates of points P and O on the control screen, located 5 m away from the headlight, mm.
h < 800	1,0 - 1,5	50 - 75
800 < h < 1000	1,0 - 2,0	50 - 100
1000 < h < 1200	1,5 - 2,0	75 - 100
h > 1200	2,0 - 2,5	100 - 175

12) the intensity of light for each headlight operating in "low beam" mode should correspond to the values provided in Table 1.2;

13) the brightest part of the headlight beam in "high beam" mode should be concentrated near point O (refer to Figure 1.3);



a) b)

c)

Figure 1.3 - The positioning of points O and P of the light boundary depending on the type of light distribution:

a) - with a slanted right section of the light boundary (in "low beam" mode);

b) - with a broken right section of the light boundary (in "low beam" mode);

c) - for fog lights or lights designed for use during both left-hand and right-hand traffic (in "low beam" mode);

I - area of low illumination; II - area of intense illumination.

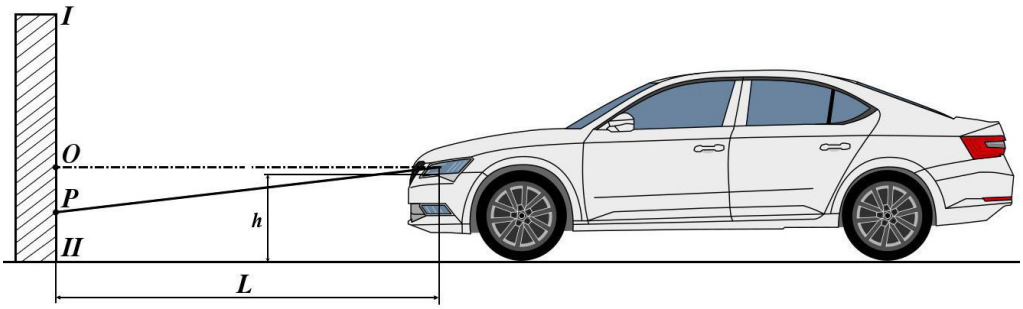


Figure 1.4 - Positioning of the WV during inspection:

O - point of intersection of the headlight's optical axis with the control screen; P - for a headlight operating in "low beam" mode - the point where the light boundary transitions from a horizontal section to a slanted section, for fog lights or lights designed for use during both left-hand and right-hand traffic (in "low beam" mode) - the point located on the horizontal section of the light boundary; L - distance to the control screen; h - distance from the lower edge of the visible surface of the headlight to the supporting surface; I - area of low illumination; II - area of intense illumination.

Table 1.2 - Recommended values of headlight beam intensity operating in "low beam" mode

Headlight beam distribution type	Beam intensity, cd	
	in the direction of the headlight's optical axis, not more than	at the point on the control screen, located 5 m away from the headlight, with a coordinate of - 0.1 m vertically below point P, not less than
C, CR	800	1600
HC, HCR, DC, DCR	950	2200

14) the total beam intensity of all headlights in "high beam" mode should be not less than 20,000 cd and not more than 225,000 cd;

15) the angle of inclination of fog lights or the position of the light shading boundary on the control screen must comply with the requirements stated in Table 1.3;

Table 1.3 - Recommended values of the angle of inclination of fog lights or the position of the light shading boundary on the control screen.

Distance from the lower edge of the visible surface	Downward inclination of the beam of the fog light in the vertical plane, %	The difference in vertical coordinates of points P and O on the control screen,

of the headlight to the supporting surface, mm		located 5 m away from the headlight, mm
250 - 750	2,00	100
More than 750	4,00	200

16) the intensity of light of each fog lamp, measured at point O (Fig. 1.3), must not exceed 625 cd;

17) position lamps, outline lamps, and the auto-train sign must operate in a steady mode. The rear registration plate illumination lamp must be activated simultaneously with the position lamps and provide reliable illumination of the surface of the registration plate;

18) brake signals must activate when the corresponding brake control elements are engaged and operate steadily throughout the entire braking period;

19) the reverse lamp must only be activated when the reverse gear is engaged;

20) turn indicators and side repeaters of the indicators should operate in a flashing mode with the following parameters: - flash frequency - 90 ± 30 flashes per minute; - turn indicators located on the same side of the vehicle must operate in phase;

21) the emergency signaling system must ensure synchronous activation of all turn indicators and side repeaters in a flashing mode;

22) rear fog lamps must be activated when the low-beam, high-beam headlights, or fog lights are turned on and operate steadily;

23) the light intensity of signal lights must correspond to the values given in Table 1.4.

Table 1.4 - Recommended values of signal light intensity.

The name of the signal light	**The light intensity along the optical axis, cd.**	
	Not less than	Not more than
Turn signal:		
- Front	58,0	860
- rear with constant light intensity	32,0	200
- rear with variable light intensity during operation:		
- during the day	82,0	700
- at night	26,0	120
- side repeater	0,4	200
Brake signal:		

- with a constant light intensity - with variable light intensity in operation mode: - during the day - at night	26 83 19	100 520 80
Dimensional: - front - front, built into the headlight - rear (as well as upper)	 2 1 1	 60 100 12
Parking	1	60
Reverse	51	600
Rear fog	48	300
Trailer sign	2	60

Note 1. In the case of a combination of two lights, the value of the maximum light intensity should be increased by 1.4 times.

Note 2. The intensity of ELD, excluding the headlights (low and high beams), shall be controlled as needed (for example, in the absence of an official approval sign, disputes over the power of light sources, or covering of ELD, etc.).

1.3. Need for inspection and adjusting the headlights of a wheeled vehicle

Inspection and adjusting the headlights is done in one of the following cases:

• when replacing the bulbs in the headlight (this applies to both single and dual optics);

- when replacing one or both headlights (this may be caused by a malfunction or the owner's desire to install a more technologically advanced lighting device provided by the vehicle's design);

- if the car owner feels uncomfortable driving with the existing lights and needs to perform adjustments;

- in case, while driving in the dark, oncoming drivers signal (flash with high beams) that they are being blinded;

- during the installation of fog lights (adjustment is performed only for fog lights);

- after performing work related to changes in suspension stiffness;

- when replacing/installing wheels or tires of a different diameter (within the permissible limits set by the vehicle manufacturer);

- during routine maintenance (if necessary) or mandatory technical inspection (after detecting deviations from the norm).

Automotive service experts recommend performing diagnostics, which will indicate the need for headlight adjustment, at least once every six months or every 50,000 km of the vehicle's mileage.

1.4. Requirements for the service area for inspection and adjusting the headlights of WV

The properties and condition of the surface of the premises where the inspection and adjustment of the external lighting devices of the vehicle are carried out are of crucial importance for the accuracy of the work. According to subparagraph 7.1.4 of DSTU 3649:2010, the platform intended for testing must be horizontal, level, with an allowable deviation of ± 3 mm per 1 m in any direction. In addition, there is the ISO 10604 standard, which accurately describes the "test surface" and specifies permissible deviations.

If the standard is not followed, even small deviations significantly affect the distribution of light. For instance, the headlight adjustment device (headlight tester) has a built-in lens that reduces the 10-meter measuring distance to 50 cm (scales the light beam 1:20). Therefore, a mere 5-millimeter measurement error on the tester's control screen results in a 10 cm deviation of the light beam at a 10-meter distance from the vehicle.

Inspection and adjusting of the headlights on wheeled vehicles are not done frequently and are usually sought through the services of a technical maintenance station (TMS). To ensure the proper alignment of the motor vehicle headlights, the TMS service area must meet specific requirements. According to Directive 2014/45/EU on vehicle inspection, which has been in effect in EU member states since 2018, the following requirements are established for the TMS service area regarding headlight verification and adjustment:

- The TMS and headlight alignment equipment must form a single system and constitute a metrological unit.

- The positions for placing the vehicle and the headlight alignment equipment must be clearly marked, for example, through markings on the surface. At least two lines are required to mark the initial and outer edges of the installation zone. It is recommended for the surface to be marked with extra space.

- The surface for the vehicle should have a slope no greater than 1.5% and be oriented in one direction.

- The length of the service area in front of the vehicle, for headlight verification and adjustment, should be at least 4 meters for passenger cars and 8.5 meters for commercial vehicles.

- The service area surface should not have irregularities greater than ± 1 mm per 1 meter.

In Ukraine, TMS for German car brands, including Škoda, which is part of the Volkswagen Group, must also comply with relevant normative requirements.

1.5. Methods for inspection and adjusting the external lighting devices of WV

Vehicles must be equipped with headlights that provide adequate road illumination without blinding oncoming drivers. Directives of the European Union EEC R48, EEC 76/756, EEC 76/761, and the Ukrainian State Standard DSTU 3649:2010 regulate the need to control the horizontal and vertical adjustment of the headlights, the luminous intensity of the high-beam lamps, and the frequency of the turn signal flashers.

According to StVZO (Straßenverkehrs-Zulassungs-Ordnung), the blinding effect of low-beam headlights is considered avoided if the illuminance does not exceed 1 lux at a distance of 25 meters in front of each headlight when the beam is projected onto a surface perpendicular to the road at the height of the headlamp center or above.

In Ukraine, the verification and adjustment of motor vehicle headlights are carried out according to the requirements of DSTU 3649:2010, while authorized car service enterprises follow the directives of the European Union. Leading manufacturers of automotive lighting and electronics, such as Hella KGaA Hueck & Co (Germany), specify compliance with the requirements of ECE R48 and EEC 76/756, 16, which define the basic alignment and dimensions (Appendix B), for adjusting the headlights of vehicles covered by these directives. For vehicle categories not covered by these directives, the requirements of ECE R53 apply. The verification of the light beam angle (e) for a passenger car is performed using shadows on a control screen (Fig. 1.5).

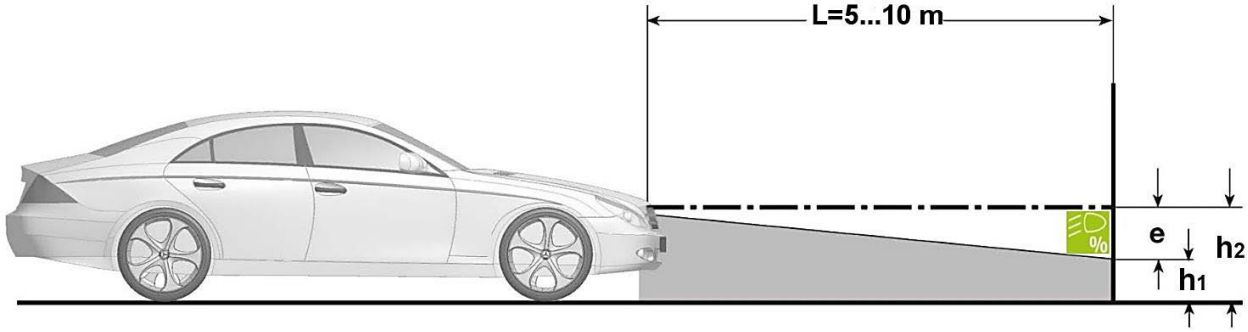


Figure 1.5 - Determining the angle of the near light beam of the headlight

The deviation of the near light beam of the headlight is expressed in percentages and can be calculated using the formula:

$$\frac{(h2 - h1)\ L \times 100}{}, \%$$

where: L - the distance from the screen to the center of the headlight, mm;

h1 - the height of the light line above the reference surface, projected on the wall at a distance of L, mm;

h2 - the height of the center of the headlight above the reference surface, mm.

The distance from the car to the screen is from 5 to 10 meters. The distance should be chosen considering that the higher the dynamic characteristics of the car, the longer the braking distance during emergency braking, and accordingly, the headlights should be properly adjusted to the braking distance.

Since each car has its own dimensions and headlight placement, the layout of the control screen must be individually adapted (see figure 1.6). As a result, to obtain the required beam of light, it is necessary to adjust the adjusting screws located under the car's hood at the rear of the headlight.

If the car has combined high and low beams, only the high beam can be adjusted, while the low beam is adjusted automatically. If the car has a separate system for high and low beams, each beam of light must be adjusted separately. The wall marking will also differ slightly - the low beam is adjusted using the method described above.

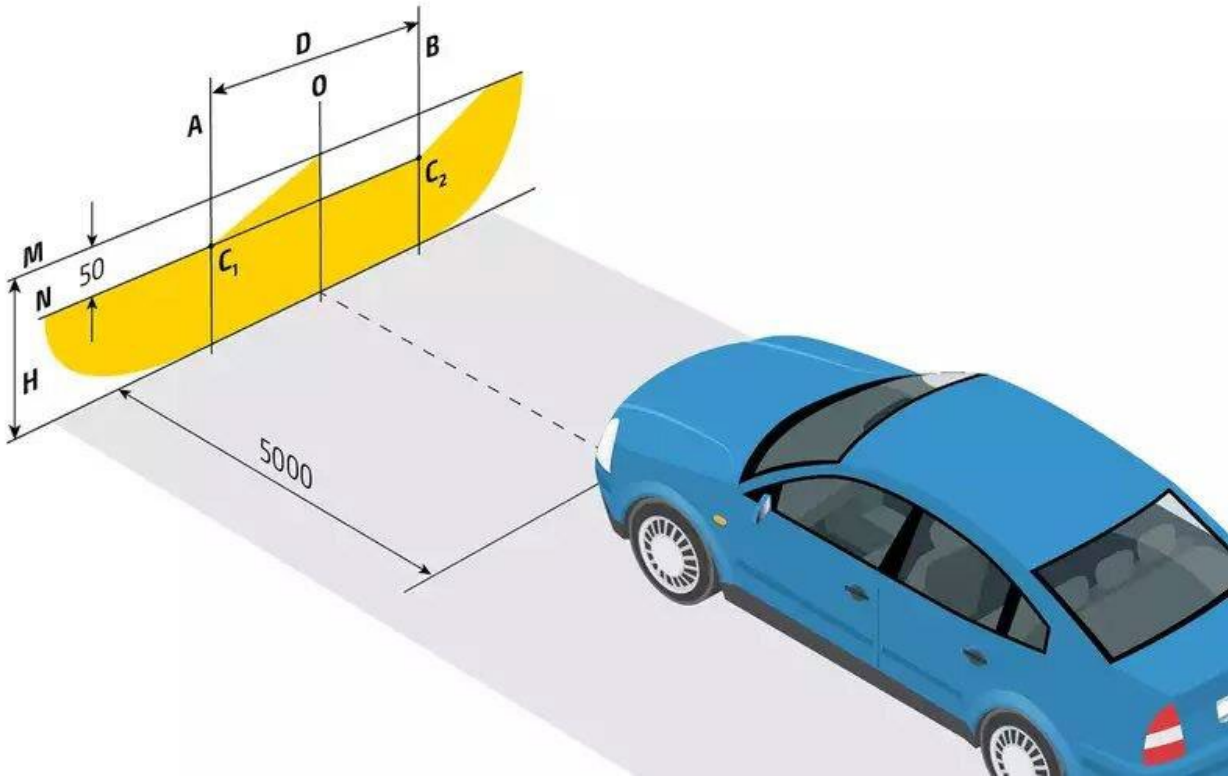


Figure 1.6 - Checking the low beam of the car's headlights on the control screen (example)

The high beam should be positioned so that it precisely aligns with the central marking of the headlights. In this case, it is better to use special equipment, without which achieving perfect adjustment is impossible.

The second method of headlight adjustment involves tuning the entire light complex. A necessary control screen is used, just like in the first case, but with a different marking (Fig. 1.7):

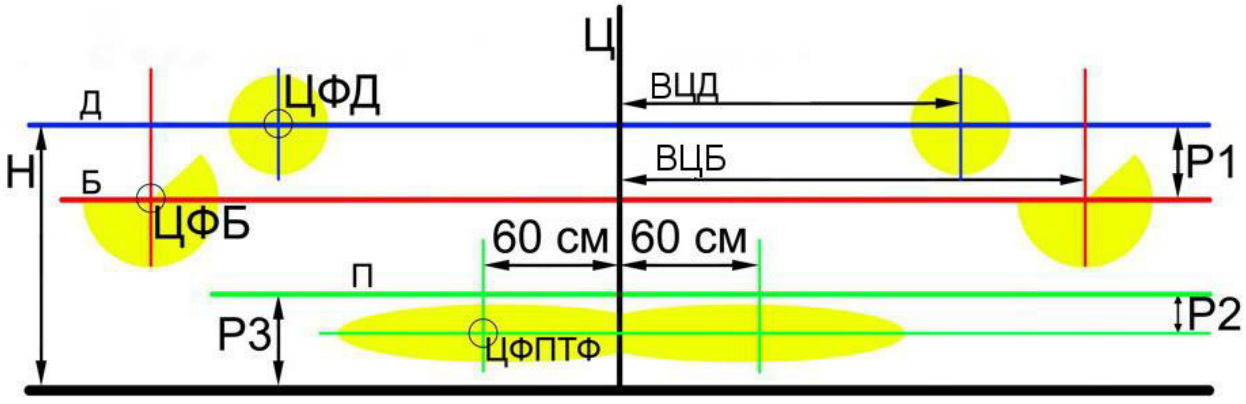


Figure 1.7 – Complex inspection of car headlight alignment on the wall:

Ц - the central axis of the car; Н - height from the ground to the center of the headlight; Д - line of the high beam headlight; Б - line of the low beam headlight; П - line of the fog lights; ВЦД - distance from the center of the car to the center of the high beam headlight; ВЦБ- distance from the center of the car to the center of the low beam headlight; Р1 - 7.62 cm (3"); Р2 - 10 cm; Р3 - distance from the ground to the center of the fog lights; ЦФПТ - center of the fog light beam; ЦФД - center of the high beam headlight; ЦФБ - center of the low beam headlight.

1) in order to apply control points, the car must be parked as close as possible to the screen. Both low and high beams are turned on alternately, and the light beam is traced on the wall to determine the centers of each headlight. Vertical lines are drawn through them;

2) move away from the screen at a distance of 7.5 meters (this method involves precise use of average values);

3) on the screen, identify the positions corresponding to the center of the high beam lamps and connect these two points horizontally;

4) draw another horizontal line below, at a distance of 3 inches (7.62 cm). This will be the upper boundary line of the low beam;

5) draw a vertical line that evenly divides the distance between the centers of the low and high beam headlights in half.

If a headlight level adjuster is available, it should be adjusted according to the obtained load - the position of the car with one driver, without passengers.

Inspection installation and adjustment of anti fog lights (AFL) differ somewhat. Fog lights are used in low visibility conditions and have a distinct light distribution with a low positioning relative to the road surface. The dispersion of fog lights is increased in the horizontal plane and limited in the vertical plane. The scattering effect of the foggy environment on the light beam of fog lights is reduced due to the shorter path length of the light rays. The light beam of the fog light must have a sharp cut-off line in the horizontal plane of the optical axis to avoid illuminating particles of fog and dust located above this plane.

Before proceeding with the adjustment of fog lights, it is necessary to take into account the UN ECE Regulation No. 19, which sets out the following main requirements:

1) the light beam of the AFL must meet the following conditions:

- the light distribution of the beam is directed downwards, and its upper limit should be clearly defined.
- the horizontal dispersion angle should not exceed 70°;

2) the mounting height of fog lights should be no less than 250 mm from the road surface;

3) the maximum distance between the fog light and the external outline of the vehicle should not exceed 400 mm.

Prior to inspection of AFL, it may be necessary to load the vehicle (according to the Škoda Superb car specifications - 75 kg) and fill the fuel tank.

The control screen should display markings with lines, points of intersection, and boundaries of formed geometric figures that indicate the necessary adjustment parameters (Fig. 1.8):

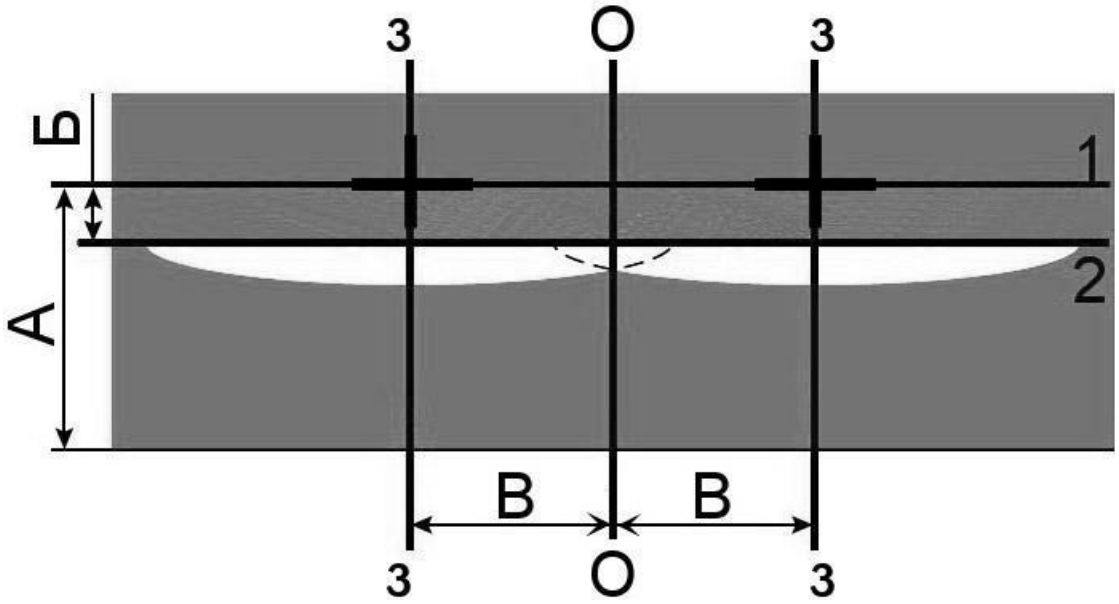


Figure 1.8 - Marking for adjusting fog lights:
O-O - the axial line of the vehicle; z-z - lines passing through the centers of the fog lights

vertical lines:

- O-O - the axial line of the vehicle;
- z-z - lines symmetrical to the O-O line and passing through points corresponding to the centers of the fog lights;
- B - distance from the center line of the light to the vehicle's axial line. Horizontal lines 1 and 2;
- A - distance from the supporting surface to the center of the optical element of the fog light;
- Б - determined according to the data provided in Table 1.5.

Table 1.5 - Distance Б between lines 1 and 2.

Marking the distance on the diagram (Fig.1.6)	**Value, mm**

A	250-500	500-750	750-1000
Б*	100	200	400

*Note: the values are given for the case when the WV is installed 10 m away from the screen.

2) AFL are turned on, when one of the fog lights is covered with a non-transparent screen, and the adjustment of fog lights is done separately;

3) by using the adjusting screws, the positions of which are indicated in the vehicle operation manual, the movement of the light beam is carried out until the center of the light beam is located at the intersection point of lines "z-z" and "2".

The boundary of the light beam formed by the fog light should coincide with line "2". Considering the drawbacks and modern trends in automotive technical service, testing and adjusting the headlights are performed using modern specialized devices called "regloscopes."

Structurally, all regloscopes are similar; they may differ in positioning devices (laser or optical (mirror)), the presence or absence of instruments for measuring illuminance (luxmeter), and the interface of the screen. The general structure of a regloscope, using the BAHCO BLBT1001 model as an example, is shown in Figure 1.9.

Figure 1.9 - General structure of the BAHCO BLBT100 leveling instrument:
1 - base; 2 - wheels (4 pieces); 3 - tilt adjustment screw; 4 - bracket for mounting the rod; 5 - Fresnel lens; 6 - tape for positioning the optical camera; 7 - bracket for mounting the optical camera positioning; 8 - bracket for mounting the positioning laser device; 9 - positioning laser device; 10 - rod; 11 - digital lux meter; 12 - screen; 13 - optical camera; 14 - handle.

The structural features of the BAHCO BLBT1001 leveling instrument allow for checking and adjusting headlights within a measurement height range of 240…1400 mm, making it suitable for all types of motor vehicles. Its precision complies with the requirements of the EU (standard NFR63-801).

The most essential part of the leveling instrument is the optical camera (Figure 1.10), which utilizes a Fresnel lens. When the incoming light flux is perpendicular to the lens surface, the image on the measuring screen remains unchanged within ±30 mm displacement of the headlight's geometric center relative to the lens center in all directions. This significantly speeds up the verification process, as there is no need to precisely align the lens center and the center of the headlight being tested.

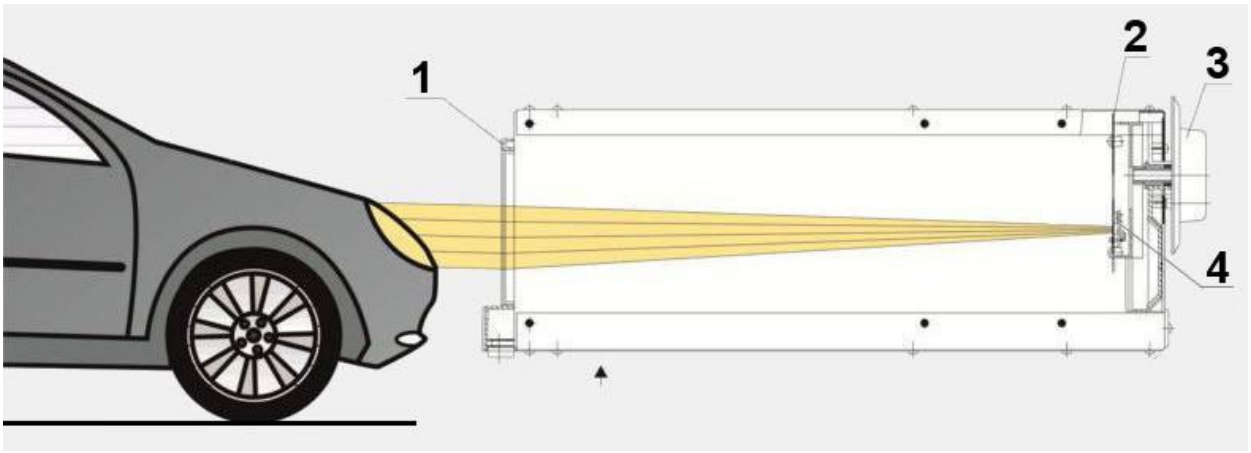


Figure 1.10 - Optic regloscope camera:
1 - Fresnel lens; 2 - screen; 3 - switch with a scale; 4 - photodetector

The procedure for inspection the alignment of headlights using a regloscope involves performing actions similar to those with a control screen, except there is no need to use a distance of 5...10 m. This is the main advantage of using regloscopes.

As for all lighting devices of motor vehicles (KTZ), a check is made for the intensity of light, measured in candelas (cd). In the case of using the photometric instrument called a luxmeter, which determines the illuminance measured in lux (lx), the intensity of light is calculated using the formula:

$$\mathbf{I = E \cdot L2} \quad (1.1)$$

where, I - intensity of light, cd;
E - illuminance, lx;
L - distance of photo measurement, m.

The intensity of light is determined for headlights operating in the "low beam" mode at the control points O and P (see Fig. 1.3 and 1.4), for headlights operating in the "high beam" mode - at the location of the brightest part of the light beam, and for turn indicators, the maximum value should be taken. The obtained values of the light intensity for the lighting devices of motor vehicles should comply with the specified standards as presented in paragraph 1.2 (see tables 1.2 and 1.4, pp. 14).

Additionally, the flashing frequency of the turn indicators is checked using a stopwatch. The flashing frequency of the turn indicators should be determined for not less than 10 flashes.

2. PROCEDURE FOR INSPECTION VEHICLE LIGHTING DEVICES

2.1. Preparing the vehicle for inspection

When preparing the vehicle for inspection and adjusting the headlight beams, the following operations must be performed:

1) position the vehicle on a solid support surface with a deviation of ± 3 mm per 1 m in any direction;

2) visually inspect the condition of the units and elements of the lighting devices for:

- proper functioning of all lighting devices by turning them on;
- the condition of the housing of the lighting devices and headlight reflectors for any chips, scratches, or cloudiness;
- absence of dirt on the glass casings of the lighting devices and headlight reflectors.

If any defects are found, they should be rectified.

3) check the tire type and size. If they do not correspond to the technical conditions (TC) of the manufacturer's plant (for Škoda Superb vehicle, all wheels should have the same size - 205/55R16), the tires should be replaced with the recommended ones;

4) check the tire condition: the tread depth should comply with DSTU 3649:2010 depending on the vehicle category (Fig. 2.1 and Table 2.1), and inspect for the presence/absence of cracks or cuts;

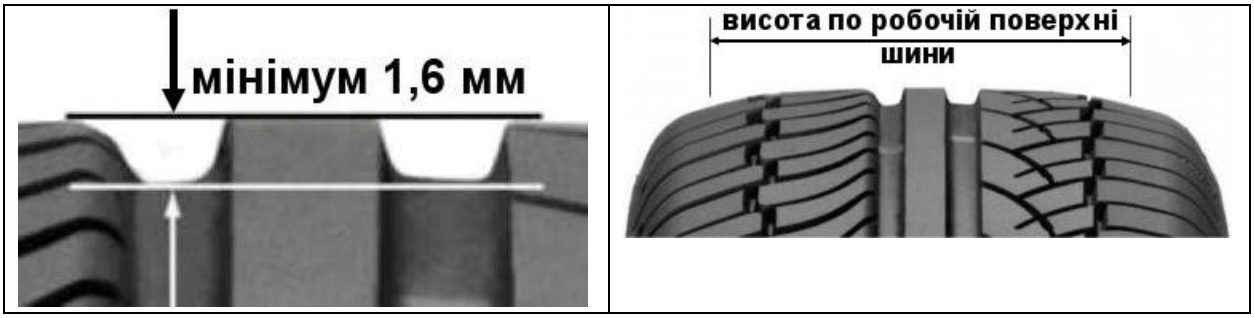


Figure 2.1 - Tire Tread Pattern Height Check

Table 2.1 - Tire Tread Pattern Height (according to DSTU 3649:2010)

The category of WV	Tire Tread Pattern Height, mm not less than
M1, M1G, N1, N1G, O1	1,6
M2, M2G, M3, M3G	2,0
N2, N2G, N3, N3G, O2−O4	1,0

5) check the tire pressure to meet the requirements of the manufacturer's technical conditions (for Škoda Superb: 210 kPa / 2.1 bar for front tires; 200 kPa / 2.0 bar for rear tires). If necessary, adjust the pressure to the specified norm;

6) check the condition of the wheels for any damages, cracks, chips, and ensure all fastening elements are present, intact, and tightened to the required torque (for Škoda Superb - 120 N·m);

7) to perform the inspection according to DSTU 3649:2010, the vehicle must be in an empty weight condition, and the headlight beam leveler (if present) should be set to the initial position (position "0"). For vehicles with hydraulic or pneumatic suspension, the manufacturer's checking conditions should be observed. Record the results of the vehicle preparation and preliminary inspection of the lighting devices in the laboratory report (Table 3.1 and 3.2).

2.2. Preparing and positioning of the BAHCO BLBT1001 headlight tester for inspecting vehicle headlights

Preparation and positioning of the BAHCO BLBT100 headlamp aligner for inspection involve the following steps:

1) set up the headlamp aligner on a solid supporting surface with a maximum incline of 1.5% in one direction in front of the vehicle (see Figure 2.2);

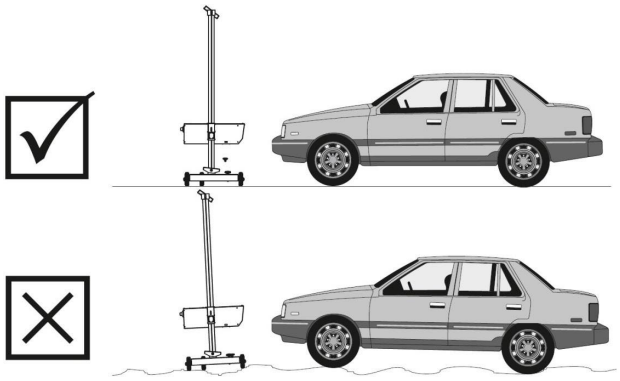


Figure 2.2 - Placement of the car and headlamp aligner on the supporting surface

2) position the optical camera on the headlamp aligner and activate the laser device (see Fig. 2.3);

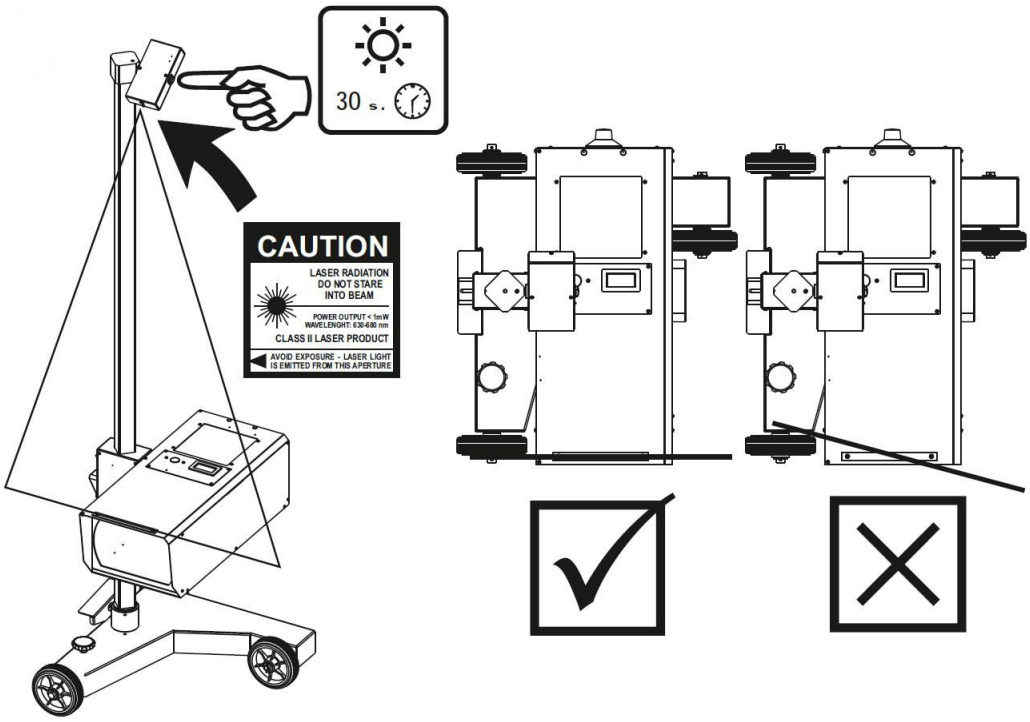


Figure 2.3 - Positioning of the optical camera on the BAHCO BLBT100 headlamp aligner

3) align the headlamp aligner parallel to the supporting surface (Figure 2.4).

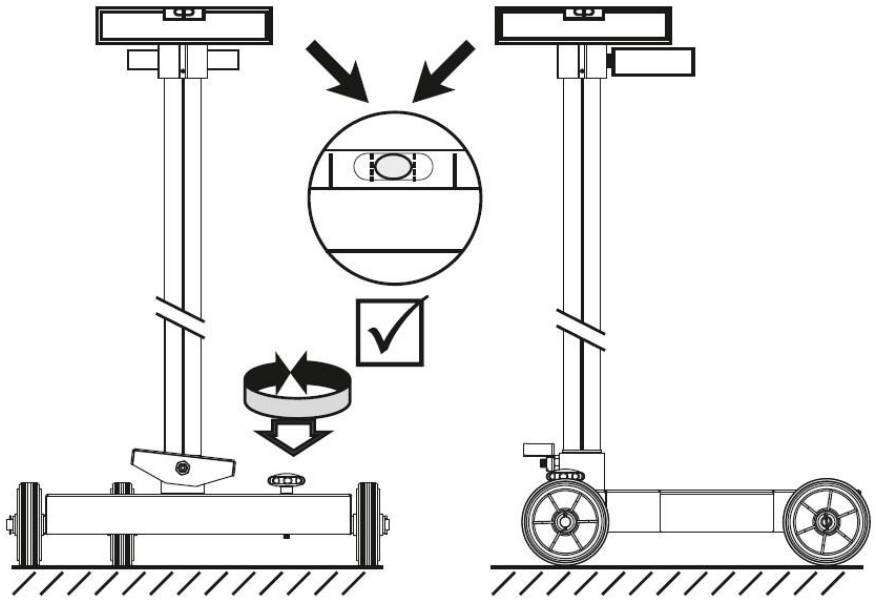


Figure 2.4 - Alignment of the optical camera relative to the supporting surface

4) place the headlamp aligner in front of the vehicle at a distance of 30-50 cm (see Figure 2.5);

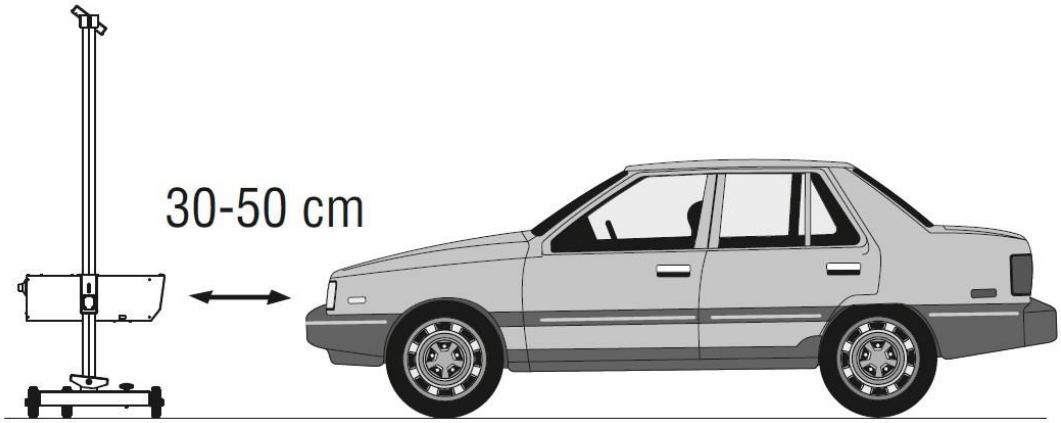


Figure 2.5 - Placement of the headlamp aligner in front of the vehicle

5) position the center of the Fresnel lens opposite the center of the vehicle's headlamp. Adjust the height (h) of the optical camera on the stand to facilitate positioning (markings are provided on the stand, and a laser is integrated into the headlamp aligner's housing). Fix the camera in this position (see Fig. 2.6);

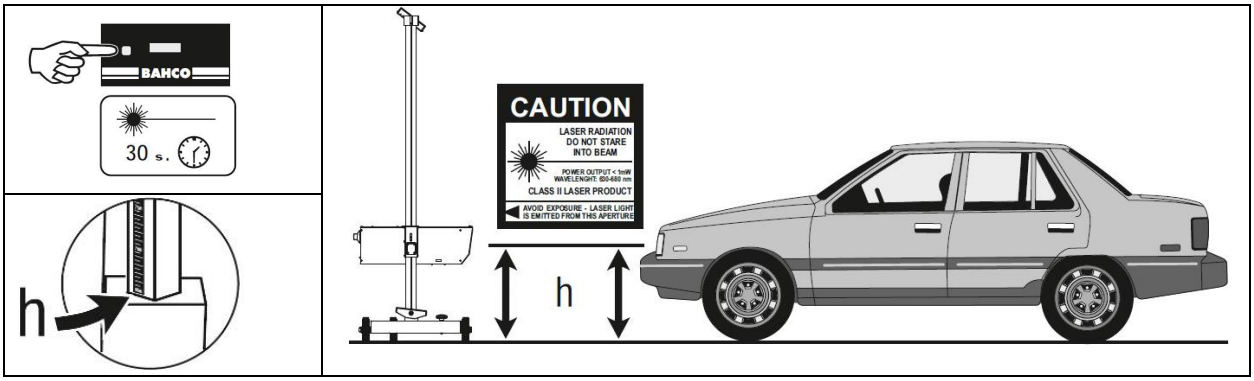


Figure 2.6 - Setting up the headlamp aligner at the height relative to the center of the headlamp

6) align the headlamp aligner parallel to the longitudinal axis of the vehicle. To do this, activate the laser level of the device. Identify two symmetric points on the vehicle's body, preferably on the headlamps, and direct the laser towards them. Position the headlamp aligner in such a way that the two previously selected points are aligned on the line marked by the laser beam (see Figure 2.7).

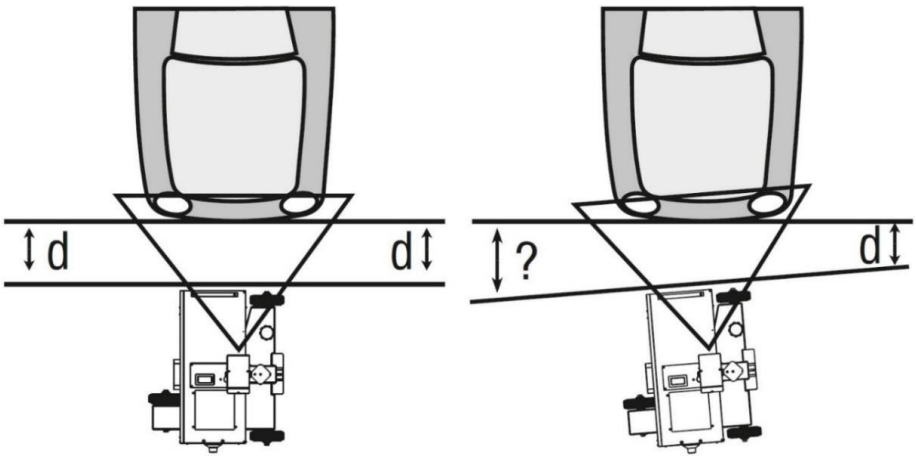


Figure 2.7 - Positioning of the headlamp aligner perpendicular to the longitudinal axis of the vehicle

2.3. Inspection and adjusting low beam headlights

Procedure:

1) on the outer part of the headlight assembly in the car's engine compartment, determine the pre-set angle of inclination (see example in Fig. 2.8).

2) on the backside of the optical camera of the headlight tester, set the pointer of the rotating adjustment disk to the value (Fig. 2.9) corresponding to the angle of light inclination indicated on the headlight assembly (for Škoda Superb car, it is 1.0%).

If the angle of headlight inclination for the specific vehicle is unknown or not indicated, follow the requirements of DSTU 3649:2010 or European directives for measurements (Appendix B).

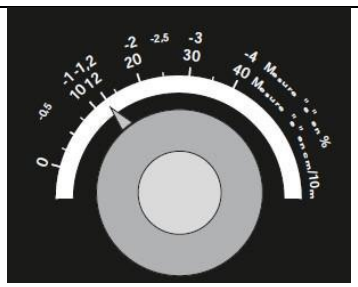


Figure 2.9 - General view of the rotating adjustment disk-regulator

3) start the engine (it should run at idle speed) and turn on the low beam headlights. The correct alignment of headlights with asymmetric low beam is achieved when the light border precisely aligns with the horizontal part of the dashed line 1 (Fig. 2.10).

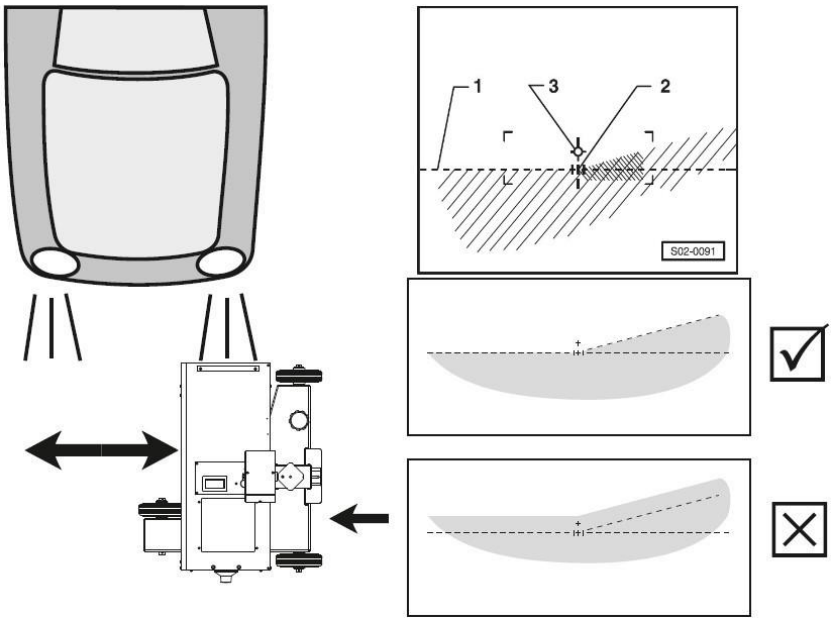


Figure 2.10 - Checking the low beam of the headlights:
1 - light border; 2 and 3 - points P and O, respectively (according to DSTU 3649:2010)

Additionally, the light border should refract in a way that exactly matches the refraction of the dashed line at point 2 (Fig. 2.10). To improve the determination of point 2, turn the headlights off and on several times or close and reopen the headlight being tested.

4. If the position of the light border does not meet the requirements, perform adjustments. For Škoda Superb car, the adjustment elements are shown in Fig. 2.11.

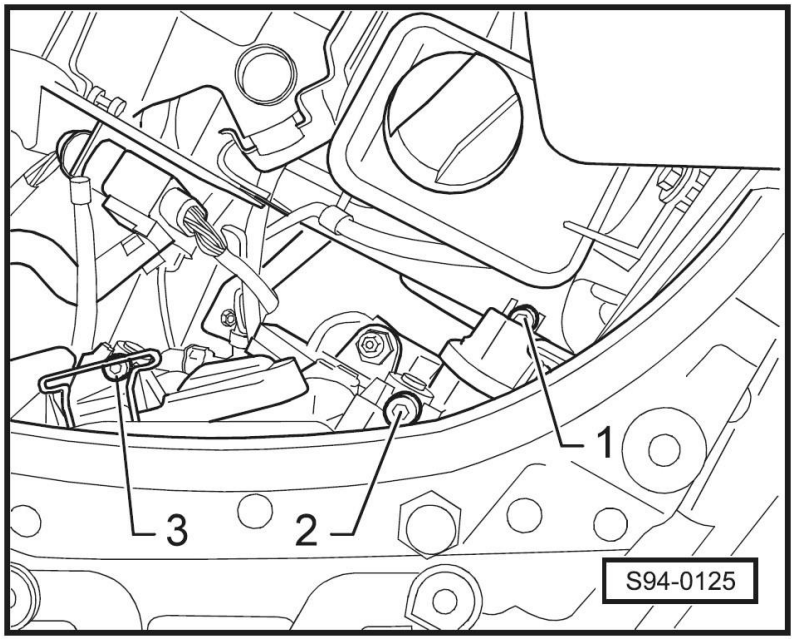


Figure 2.11 - Headlight adjustment elements for the ŠKODA Superb car:
1 - headlight low beam vertical adjustment screw; 2 - headlight low beam horizontal adjustment screw; 3 - fog light adjustment screw (if they are integrated into the same headlight assembly with the low beam)

5) Repeat the headlight alignment check in the "low beam" mode, first turning the lights off and then turning them back on – the light border should be along the contour line 1 with a refraction at point 2 (Fig. 2.10).

As an additional check, for headlights with combined low and high beam, switch the headlights to "high beam" – the center of the light beam (brightest point) of the high beam should be on the mark corresponding to point 3 (Fig. 2.10). Then the headlights are properly adjusted.

Repeat steps 3-5 for the left and right headlights, respectively.

6) Use a lux meter to measure the illuminance value (regloscope BAHCO BLBT100 is equipped with a digital lux meter, Fig. 2.12). Calculate the light intensity for each headlight in the "low beam" mode using formula (1.1) and determine if the measured value corresponds to the specified control value (see table 1.2).

If the measured value exceeds the specified control value, replace the lamp with the recommended one from the manufacturer's specifications and repeat the check.

If the measured value is lower than the specified control value, replace the lamp with a new recommended one and repeat the check. If the measured value is still lower than the specified control value, replace the headlight or its components (diffuser or reflector).

If the difference in light intensity values between the left and right headlights exceeds 20%, the headlight lamps, headlights, or their components need to be replaced. Record the results of the headlight check in the "low beam" mode in Table 3.3 of the laboratory work report.

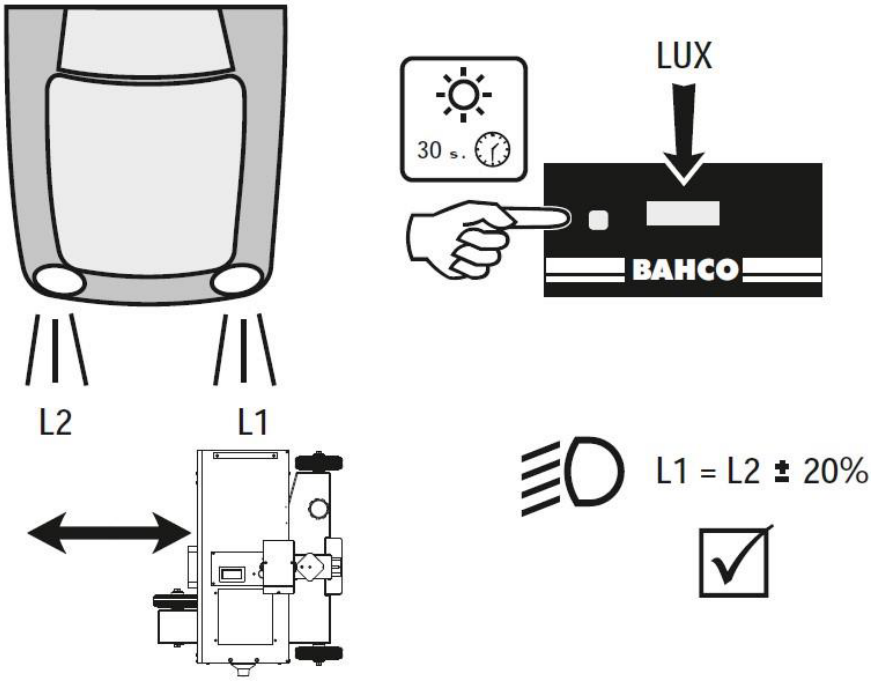


Figure 2.12 - Measurement of the intensity of the low beam of headlights using a digital lux meter on BAHCO BLBT100

2.4. Inspection and adjusting high beam headlights

Procedure:

1) repeat steps 1 and 2 of section 2.3.

2) start the engine (it should run at idle speed) and turn on the high beam headlights. If the center of the high beam light beam is located at point 3 on the measuring screen (Fig. 2.10), then the headlight direction is properly adjusted. Otherwise, it is necessary to readjust the position of the light border.

3) for headlights with common adjustment screws for both low and high beams, recheck and readjust the low beam if necessary (Fig. 2.13);

4) if, on the correctly adjusted inclination of the headlights in the "low beam" mode, the light border of the high beam is positioned too high or too low, then replace the lamp. If the problem persists, replace the headlight assembly components - reflector and/or projector.

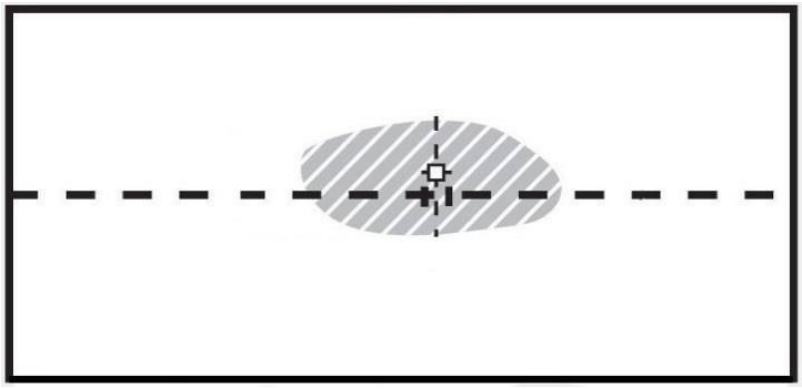


Figure 2.13 - Image of the light border of the headlight in the "high beam" mode

Results of the headlight high beam inspection for the car should be recorded in Table 3.3 of the laboratory report.

2.5. Inspection of other lighting devices

Procedure of actions during the inspection of the light intensity of the lighting devices of the car:

1) start the engine (it should run at idle speed) and turn on the lighting device;

2) turn on the lux meter, set it to measure illuminance within the range of up to 2000 lux, and remove the protective cover from the photometric element (Fig. 2.14);

Figure 2.14 - Luxmeter LX-1010BS(100KLUX):
1 - screen/display; 2 - power on/off button; 3 - range selection button for measurement; 4 - photometric element without a protective cover

3) place a luxmeter in front of the vehicle's light instrument perpendicular to the axis of the light beam. If necessary, use a screen to precisely determine the brightest area of the light beam;

4) using a ruler, measure the distance between the glass casing of the light instrument and the photometric element of the luxmeter;

5) turn on the luxmeter and determine the illuminance after the measured value stabilizes.

Attention! *In case the illuminance value does not stabilize and the lamp flickers, take the arithmetic mean between the minimum and maximum values as the valid measurement.*

In the case of controlling the strength of the turn signal lights based on the measurement results, consider the maximum value.

6) calculate the light intensity using formula (1.1) for the controlled light instrument;

Attention! *The intensity of certain light instruments, except for the low and high beam headlights, should be checked as needed (for example, in the absence of official approval, in case of disputes regarding the light source power or application of coatings on the light instruments).*

7) Use a stopwatch to determine the frequency of the turn signal lights blinking separately from the left and right sides of the vehicle, as well as in the "hazard warning" mode. The measurements are taken for 1 minute, but not less than 10 flashes.

8) Record the results of the inspection of the vehicle's lighting instruments in Table 3.4 of the laboratory report.

3. LABORATORY WORK REPORT
INSPECTION AND ADJUSTMENT OF EXTERNAL VEHICLE LIGHTING DEVICES

1. Type and model of the inspected car_____

2. Identification number (VIN - code):_____

Table 3.1 - Results of the car's tire and wheel inspection

Indicator (norm)/ Wheel	Front left	Front right	Rear left	Rear right
Tire size (_____)				
Air pressure (_____) MPa				
Tread depth (_____) mm				
Torque for screws/nuts, (_____) H·m				

Table 3.2 - Results of the inspection of the car's lighting devices

Name	Description of the external condition of the lighting device	Conclusion / recommendation
Headlight Left		
Optical element		
Housing		
Bulb		
Headlight Right		
Optical element		
Housing		
Bulb		
Headlamp Left		
Optical element		
Housing		
Bulb		
Headlamp Right		
Optical element		
Housing		
Bulb		
Right turn signals		

Optical element		
Housing		
Bulb		
Left turn signals		
Optical element		
Housing		
Bulb		

Table 3.3 - Results of the car's headlight alignment inspection

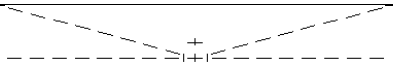
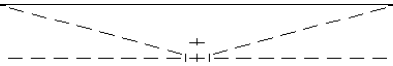
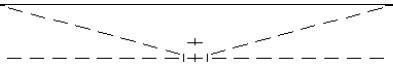
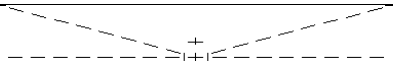
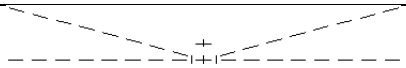
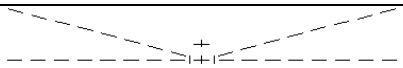
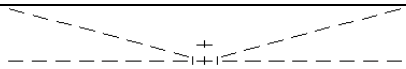
Parameter	Headlight Left	Headlight Right
Headlight beam angle "e", %		
Image on the screen during the low beam headlight adjustment inspection		
Image on the screen after the low beam headlight adjustment inspection		
Image on the screen during the high beam headlight adjustment inspection		
Image on the screen after the high beam headlight adjustment inspection		

Table 3.4 - Results of the inspection of other lighting devices

Name of the signal light	Light intensity along the optical axis, cd Not less than / Not more than		The measured light intensity, cd	Conclusion / recommendation
Turn signal:				
- front	58	860		
- rear (with constant light intensity)	32	200		

- side repeater (if available)	0,4	200		
Brake signal	26	100		
Dimensional:				
- front, built into the headlight	1	100		
- rear	1	12		
Parking	1	60		
Reverse	51	600		
Rear antifog	48	300		
Name of the signal light	**Blinking frequency, min1**		**Measured value, min1**	**Conclusion / recommendation**
Turn signal:	90 ± 30 min-1			
- left				
- right				
- In hazard warning mode				

Conclusions:

_____

_____

_____

_____

_____”__”_____20__

_____ _____

LIST OF USED SOURCES

1. State Standard of Ukraine (DSTU) 3649:2010. Wheeled vehicles. Safety requirements for the technical condition and control methods (BN No. 11-12-2010/436). [Effective from July 1, 2011]. Official edition. Kyiv: State Standard of Ukraine, 2010. 19 p.
2. ISO 10604:1993. Road vehicles – Measurement equipment for orientation of headlamp luminous beams. 7 p.
3. UTAC NFR 63-801. Road vehicles. Garage equipment. Equipment for checking and adjusting lights. 1 – 01/03/1982. 2 p.

Literary Sources:

4. Repair Manual for Superb 2002. Service inspections and maintenance. Headlight aiming check and adjustment. 2001. 02-6. Pp. 3-5.
5. BAHCO BLBT100. SNA Europe SAS (Group Headquarters). France. 12 p.
6. HELLA GUTMANN SEG IV. 8PA 007 732–301...–311. Instruction manual (EN). BD0056V0002RU0315S0. HELLA GUTMANN SOLUTIONS GMBH, 2014. 22 p.
7. Nussbaum Headlight Aiming Device HLT 510, 600, 610V, 620. Operating instructions. 6 p.
Internet Resources:
8. HEADLIGHT ADJUSTMENT. HELLA TECH WORLD – The Workshop's Friend. [Electronic resource] / HELLA // – Access mode: URL: https://www.hella.com/techworld/uk/Technical/Automotive-lighting/Headlight-adjustment-835/ – Access date: November 15, 2022.

Appendix A

Table A1 - Classification of Wheeled Vehicles by categories

Category	Characteristics of WV
M	**Self-propelled WV (automobiles or motor transport vehicles) with no fewer than four wheels, intended for passenger transportation (passenger cars, minibusses, buses, trolleybuses)**
M1	WV intended for passenger transportation and having no more than 8 seats, excluding the driver's seat
M2	WV intended for passenger transportation and having more than 8 seats, excluding the driver's seat, and a maximum weight not exceeding 5 tons
M3	Motor vehicles intended for passenger transportation and having more than 8 seats, excluding the driver's seat, and a maximum weight exceeding 5 tons
N	**Self-propelled WV (automobiles or motor transport vehicles) with no fewer than four wheels, intended for the transportation of goods (cargo vehicles, trucks - semi-trailers or ballast tractors)**
N1	WV intended for the transportation of goods, which maximum weight does not exceed 3.5 tons
N2	WV intended for the transportation of goods, which maximum weight exceeds 3.5 tons but does not exceed 12 tons
N3	Motor vehicles intended for the transportation of goods, which maximum weight exceeds 12 tons
O	Non-self-propelled WV- trailers (as well as semi-trailers)
O1	Trailers with a maximum weight not exceeding 0.75 tons

O2	Trailers with a maximum weight that exceeds 0.75 tons but does not exceed 3.5 tons
O3	Trailers with a maximum weight that exceeds 3.5 tons but does not exceed 10 tons
O4	Trailers with a maximum weight exceeding 10 tons

Note 1: To designate WV, the designation "O" is used in combination with the categories "M" or "M". For example, a WV in category N1 is denoted as "M1O".

Note 2: For a more comprehensive classification of WV, please refer to the "Consolidated Resolution on the Construction of WV".

Appendix B

Table B1 - Quantity, colour, and availability of ELD on the WV

ELD Name		ELD Colour	ELD Quantity	The need for installing ELD (depending on the category (type) of WV)
1		2	3	4
High-beam headlight		white	2 or 4	Mandatory on all cars and buses. Prohibited on trailers
Low-beam headlight		white	2	
Front fog light		white or yellow	2	Optional on all cars and buses. Prohibited on trailers
Reverse light		white	1,2 or 4	Mandatory for categories M, N1, O2, O3, O4. Optional for category O1.
Turn signal (indicator)	front	autoyellow	2	Mandatory on all cars and buses. Prohibited on trailers
	side	autoyellow	1 from both sides	

	rear	autoyellow	2 or 4	Mandatory for all categories
Brake signal (brake light)	main	red	2 or 4	Mandatory for all categories
	additional	red	1	Mandatory for category M1. Optional for other categories
License plate illumination lamp		white	Not less than 1	Mandatory for all categories
Front dimensional light		white	2	Mandatory on all cars and buses. Mandatory on trailers with a width greater than 1.6 meters. Optional on trailers with a width less than 1.6 meters
Rear dimensional light		red	2 or 4	Mandatory for all categories
Rear fog light		red	1 or 2	Mandatory for all categories
Position light	front	white	2	Mandatory on WV with an overall width exceeding 2.1 meters. Optional on WV with an overall width ranging from 1.8 meters to 2.1 meters
	rear	red	2	
Rear reflector	no triangular-shaped	red	2	Mandatory on all cars and buses. Optional on trailers if they are grouped

				with other rear position lights
	triangular-shaped	red	2	Mandatory on trailers. Prohibited on cars and buses
Front no triangular-shaped reflector		white	2 or 4	Mandatory on trailers. Mandatory on WV equipped with all front headlights with hiding reflectors. Optional on other WV
Side no triangular-shaped reflector		autoyellow	Quantity depends on length	Mandatory on cars and buses with a length exceeding 6 meters. Mandatory on all trailers. Optional on cars and buses with a length not exceeding 6 meters
Side dimensional light		autoyellow	Quantity depends on length	Mandatory on all WV with a length exceeding 6 meters. Optional for other WV

1) One mandatory and one optional rear fog light for WV of category M1 and all other WV with a length not exceeding 6 meters. Two mandatory and two optional rear fog lights for all WV with a length exceeding 6 meters, except for WV of category M1.

2) Two mandatory and two optional rear fog lights for WV of categories M2, M3, N2, N3.

3) Two mandatory and, in the absence of an additional braking signal, two optional rear fog lights for WV of categories M2, M3, N2, N3, O2, O3, O4.

4) Two mandatory and, in the absence of clearance lamps, two optional rear fog lights for WV of categories M2, M3, N2, N3, O2, O3, O4.

5) Two mandatory and two optional rear fog lights, provided they do not reduce the effectiveness of the mandatory rear fog lights.
6) The extreme rear fog light may be red if it is grouped, combined, or incorporated with any other red rear position light.
7) At least one rear fog light must be installed in the middle third of the WV , while the extreme front rear fog light must be positioned no more than 3 meters from the front edge of theWV; in the case of trailers, this distance includes the length of the drawbar. The distance between two adjacent rear fog lights must not exceed 4 meters. The distance between the extreme rear fog light and the rear edge of the WV must not exceed 1 meter.
Note: If optional rear fog lights are installed, the requirements of DSTU UN/ECE Regulation No. 48-02 must be followed.

Appendix C

Table C1 - Values of the light extinction boundary inclination of WV headlights (according to the requirements of EU directives EEC R48, EEC 76/756, EEC 76/761)

№	Type of vehicle	The established angle of light beam inclination of the headlamps 'e'.		Errors			
		Low beam and high beam headlights	Fog lights	Up	Down	Left	Right
1	2	3	4	5	6	7	8
1. Automobiles, multi-track vehicles, except for agricultural and forestry vehicles. Tractors and working machines or similar transport vehicles							
1.1	EEC (EU)/EAEU as the basis for conducting the test						
1.1.1	Cars with lighting according to Directive 76/756/EEC or approved under ECE R48		2,0%	0,2	0,8	0,5	0,5

1.2	Technical requirements for the operation of trackless transport (StVZO) as the basis for testing	The set angle indicated on the vehicle					
1.2.1	Cars with the initial approval for operation from 01.01.1990. Headlights not higher than 1200 mm above the road level						
1.2.2	Cars with the initial approval for operation until 31.12.1989. Headlights not higher than 1400 mm above the road level1). Also, cars with the first approval for operation from 01.01.1990. Headlights higher than 1200 mm but not higher than 1400 mm above the road level1)	1,2%	2,0%	0,5%	0,5	0,5	0,5
a)	Cars (including station wagons)	1,2%	2,0%	0,5%	0,5	0,5	0,5
b)	Vehicles with adjustable suspension level or automatic compensation of the light beam tilt	1,0%	2,0%	0,5%	0,5	0,5	0,5
c)	Cargo trucks with a front loading platform	1,0%	2,0%	0,5%	0,5	0,5	0,5
d)	Cargo trucks with a rear loading platform, with the exception of	3,0%	4,0%	1,0%	0,5	0,5	0,5

	vehicles according to 1.2.2 b)						
e)	Tractor units (prime movers), with the exception of vehicles according to 1.2.2 b)	3,0%	4,0%	1,0%	0,5	0,5	0,5
f)	Buses, with the exception of vehicles according to 1.2.2 b)	3,0%	4,0%	1,0%	0,5	0,5	0,5
1.2.3	Vehicles with headlights H ≤ 1400 mm1)	H/3	(H/3+ 7)	1,0%	0,5	0,5	0,5
2. Single-track and similar vehicles							
2.1	93/92/EU as the basis for testing						
a)	2-wheeled low-displacement motorcycles	No requirements					
b)	3-wheeled low-displacement motorcycles and 4-wheeled passenger cars						
c)	Low-displacement motorcycles without/with a sidecar	from 0,5 to 2,5%	2,0%	0,5	0,5	0,5	0,5
d)	Three-wheeled low-displacement motorcycles						
2.2	ECE - R 53 as the basis for testing	The set angle indicated on the vehicle	2,0%	0,5	0,5	0,5	0,5
2.3	Technical requirements for the operation of railless transport (StVZO) as the basis for testing	1,0%	2,0%	0,5	0,5	0,5	0,5
3. Agricultural or forestry tractors and working machines or similar vehicles							

3.1	EEC (EU)/EAEU as the basis for testing						
a)	Headlight height: 500 mm < h ≤ 1200 mm	from 0,5 to 4,0%	2,0%	1,0%	0,5	0,5	0,5
b)	Headlight height: 1200 mm < h ≤ 1500 mm	from 0,5 to 6,0%	2,0%	1,0%	0,5	0,5	0,5
c)	Additional headlights (on tractors equipped with front superstructures): H ≤ 2800 mm	H/3	2,0%	1,0%	0,5	0,5	0,5
3.2	Technical requirements for the operation of railless transport (StVZO) as the basis for testing						
a)	Single-axle tractors or working machines with headlights of permanent low-beam, on which the required angle of light beam inclination is indicated	2 × N	2,0%	1,0%	0,5	0,5	0,5
b)	Multi-axle tractors or working machines	1,0%	2,0%	0,5%	0,5	0,5	0,5

1) Up to the highest point of the illuminated surface.

2) The characteristics of these devices must comply with the manufacturer's instructions.