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UNIFIED MEASUREMENT METHODOLOGY FOR HEADLIGHT BEAMS INCLINATION BY USING DIFFERENT TYPE OF TESTERS

Georgi Mladenov
gmladenov@tu-sofia.bg

Technical university of Sofia, Sofia 1000,8 Kl. Ohridski Ave,
Faculty of transport, Department „Engines, Automotive engineering and Transport"
BULGARIA

Key words: *dipped-beam headlight, initial inclination of the headlight beam, headlight beam measuring and leveling device, headlamp mounting height*

Abstract: *This paper presents a developed methodology for determining the direction of the dipped-beam headlamps using different specialized devices, which will allow for unambiguous results, regardless of the measuring devices used and factory labels of the headlamps. Using the developed measurement methodology, it is possible to measure the direction of the dipped-beam headlamps of vehicles produced before and after the entry into force of the European Directives for the type-approval of headlamps used in vehicles. Despite the use of different types of measuring instruments, unmatched results are obtained, which is achieved thanks to the measurement methodology. Furthermore, the reference limits required for measuring and regulating the dipped-beam headlamps of vehicles produced prior to the entry into force of the EC type-approval directives are set. This will allow proper control of the direction of the headlamps, which will improve traffic safety.*

1. INTRODUCTION

While driving the vehicles, the majority of the information (95-99%) the driver receives visually [1]. During the dark hours of the day, when the natural light is low, driving is possible only with the use of artificial lighting - in general, their own headlight beams.

The lighting system is designed to provide maximum visibility for the roadway and the objects on it, and for all traffic modes, the distance illuminated by the headlight beams must be greater than or equal to the braking distance for the particular road conditions [1].

There are two requirements to the lighting system and in particular to the headlight beams:

- The headlight beams must illuminate the roadway as far as possible;
- Not to dazzle the drivers of oncoming traffic.

These two contradictory requirements cannot be satisfied with one type of light, which is why the lighting system operates in two modes, called the dipped (low) beam and the main (high) beam headlights.

2. MATERIALS AND METHODS

Automotive front lighting solutions have been focusing on how to achieve optimal illumination of the road space in front of the driver. The objective is to illuminate the road and its surroundings as much as possible so that the driver is able to identify obstacles and pedestrians on the roadway. Conversely, they should protect preceding or oncoming drivers from excessive glare.

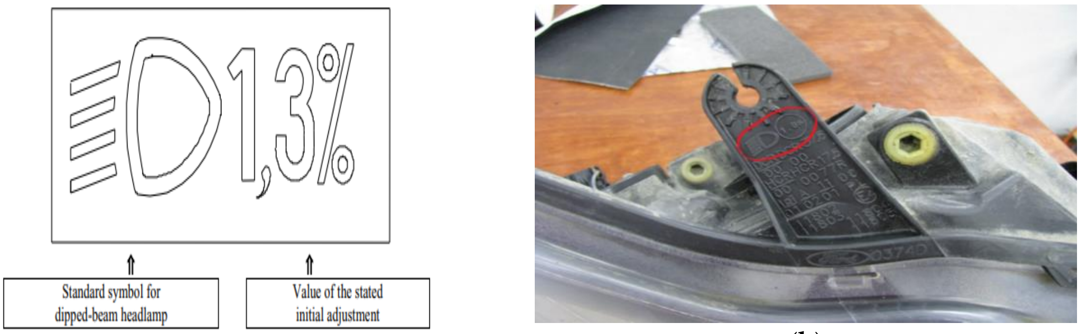
Low beams, also known as dipped beam or passing beam, provide an asymmetrical illumination pattern that ensures sufficient lateral and forward illumination while minimizing glare towards oncoming cars and other road users. “Passing-beam (dipped-beam) headlamp" means the lamp used to illuminate the road ahead of the vehicle without causing undue dazzle or discomfort to oncoming drivers and other road-users.

The aim of the study is to demonstrate methodology for determining the direction of the dipped-beam headlamps using different specialized devices, which will allow for unambiguous results, regardless of the measuring devices used and factory labels of the headlamps.

3. FORMULATION OF THE PROBLEM

According to Commission Directive 91/663/EEC [2] and Regulation No 48 of the Economic Commission for Europe of the United Nations [3] the initial downward inclination of the cut-off of the dipped-beam to be set in the unladed vehicle state with one person in the driver's seat shall be specified within an accuracy of 0.1 per cent by the manufacturer and indicated in a clearly legible and indelible manner on each vehicle close to either headlamp or the manufacturer's plate by the symbol shown on figure 1 (a) .

On figure 1 (b) is shown the indication of the downward inclination of the dipped-beam headlamps cut-which is put into operation. The value of this indicated downward inclination shall be defined in accordance the height of the headlamp for the dipped-beam which is defined Regulation No 48 of the Economic Commission for Europe of the United Nations [3].



(a) (b)

Figure 1. (a) Indication of the initial downward inclination; (b) Dipped-beam headlamps with Indication of the initial downward inclination.

There are no requirements for marking the initial inclination of the headlamps prior to the entry into force of the directives. Such a headlamp is shown in figure 2.

Figure 2. Dipped-beam headlamps without Indication of the initial downward inclination

The lack of marking for the initial inclination of the dipped beam results in the impossibility of setting limits to compare the results of the headlamp measurement.

The basic element of passing beam headlights is the “cut-off line”. It was intended in European beam pattern as tool for correct adjustment of passing beam according far road illumination and protection oncoming drive eyes from excessive glare. Cut-off line was established on the one hand as a natural part separating bright and dark area in the conventional low beam, on the other it was assigned essential function the visual aiming of headlights. It is used as well in test houses practices as in vehicles factories and by service maintenance or periodical technical inspection.

The geometric position of the headlamp beam relative to the longitudinal axis of the vehicle, also known as headlight adjustment, is especially important from the point of view of traffic safety. The adjustment of the headlamps is determined by two angles α in a vertical plane and β - in a horizontal plane.

The angle α is determined by the height HΦ on which the headlamp is located and the illuminated distance Sosv according to the requirements of the normative documents.

The light distribution of the dipped-beam headlamps is precisely regulated by normalizing the illumination at a certain number of characteristic points on a vertical screen, placed in front of the headlamp. The screen shown in figure 3 is a perspective view of a straight horizontal road section [4].

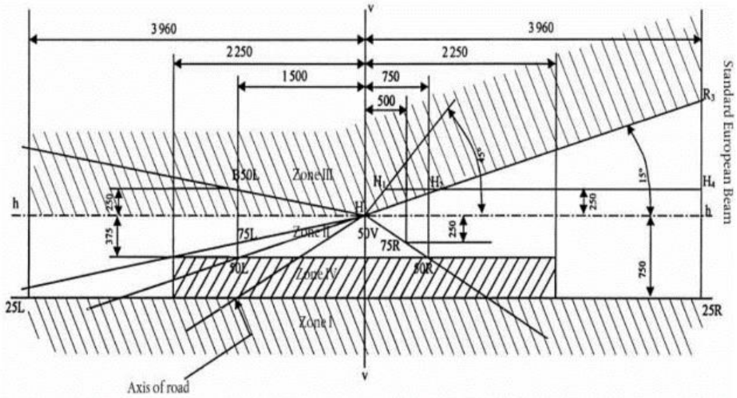
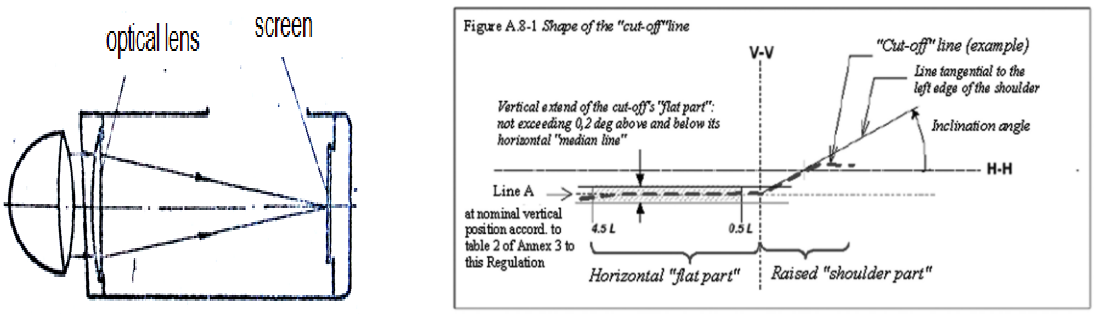


Figure 3. Photometric measuring screen for normalizing the light distribution of car headlights

Practically the only and most widely used technical equipment of controlling the lighting are the optical instruments for checking and adjusting the headlights. In general, the construction of these devices consists of an optical chamber comprising a collecting lens, a screen, a mechanical stand and a vehicle guidance system. The principle scheme of such a device is shown in figure 4 (a).

The principle on which the measurement of the geometric position of the headlamps is based is that, by means of the counter-positioning in front of the headlamp and correspondingly oriented with respect to the longitudinal axis of the vehicle, the optical system of the device simulates a screen perpendicular to the vehicle at a distance of 10 m. Visually, on the device screen, the position of the light spot created by the headlamp is controlled in relation to the preset reference lines shown in figure 4 (b) [5].



(a) (b)

Figure 4. (a) Principle scheme of optical instruments for checking and adjusting headlamps; (b) Description of what is contained in the second panel.

4. DESCRIPTION OF THE EXPERIMENTAL LAYOUT

The position of the reference lines is determined by the values of angle α and angle β, taking into account the height at which the headlamp Hf is located and the distance it illuminates Slight.

In figure 5 is shown an example of determining the position of the reference line in a vertical plane by the distance h for two different heights of the headlamp in the dipped-beam mode [6]. The distance h is determined by the geometric relationship as shown:

$$h=(S_{scr}/S_{light}).H_f, \quad (1)$$

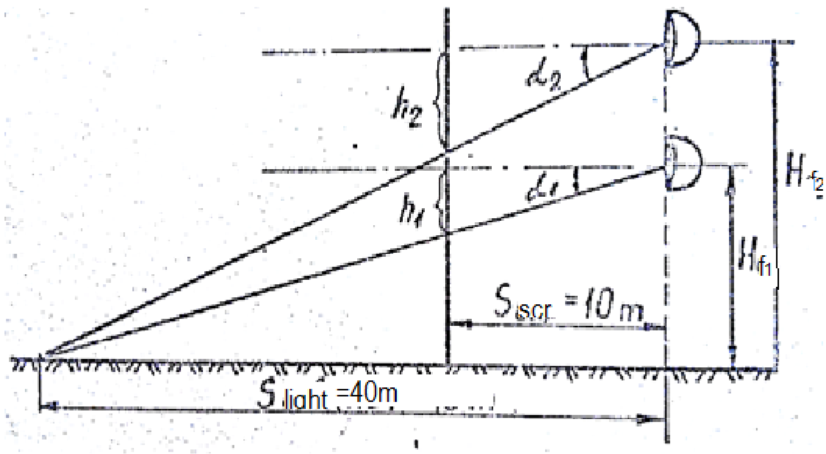


Figure 5. Determination of the position of the reference line when adjusting headlamps of different heights.

For headlamp inspection and adjustment devices, the position of the reference line in a vertical plane is set by varying the position of the screen relative to the optical axis of the lens or on the screen itself, several reference lines are plotted and the light-dark border must fall between them from the height of the lighthouse. According to equation (1) the distance h depends on the height of the headlamp Hf and the distance it illuminates Slight. There is no requirement in the regulations for the distance to be illuminated by the dipped-beam headlamps.

In [2] and [3] Dipped-beam inclination may be defined as the angle, expressed in milliradians, between the direction of the beam towards a characteristic point on the horizontal part of the cut-off in the luminous distribution of the headlamp and the horizontal plane, Or by the tangent of that angle, expressed in percentage inclination, since the angles are small (for these small angles, 1 per cent is equal to 10 mrad). If the inclination is expressed in percentage inclination, it can be calculated by means of the following formula:

$$((h_1-h_2)/L).100, \quad (2)$$

Where the parameters used are shown in figure 6.

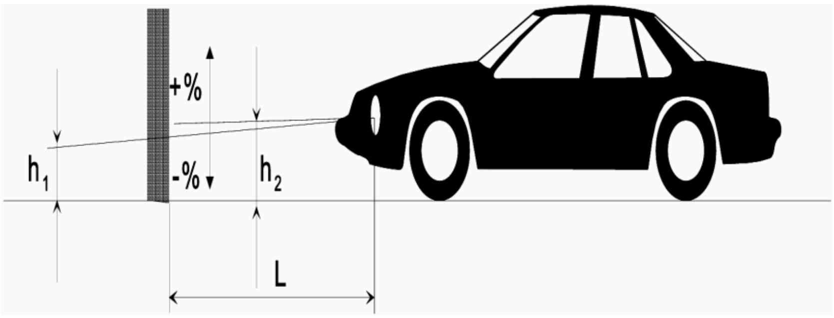


Figure 6. Dipped-beam downward inclination of a vehicle.

5. RESULTS AND DISCUSSION

On inspection and adjustment devices, the position of the reference line in a vertical plane is set by changing the position of the screen relative to the lens optical axis [6]. Depending on the units of change of the position of the screen, the optical instruments are in cm / 10m or in %. Apart from these two types of devices, there are also devices with a fixed screen. There are three reference lines on this instrument on the screen and the light spot is to be within the range of the reference lines depending on the height of the headlamp. The screen of this appliance is shown in figure 7.

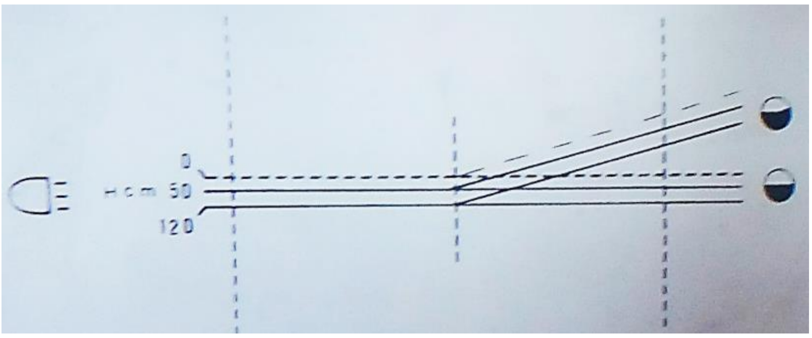


Figure 7. Dipped-beam downward inclination of a vehicle.

There are several types of device orientation systems for the vehicle: mechanical, optical, light and mirror.

The presence of vehicles with headlamps with and without an indication of the initial inclination and three different types of measurement equipment requires the establishment of a methodology which allows for the achievement of unambiguous results when checking the direction of the passing lamps of both types of headlamp irrespective of the type of optical devices.

For the determination of the inclination of the dipped-beam headlamps, a uniform methodology has been developed to ensure unambiguous results in the use of different headlamp inspection devices with and without an indication of the initial inclination of the dipped-beam headlamps.

For the correct results, the following conditions for conducting the measurement must be met:

• The ground on which measurements are made shall be as flat and horizontal as possible, so that the reproducibility of measurements of dipped-beam inclination can be assured with an accuracy of 0.5 mrad (±0.05 per cent inclination)

- Tyres shall be inflated to the full-load pressure specified by the vehicle manufacturer. The tires of the vehicle must be of the same type, model and size, with the same tread pattern on one axle and possibly dry and clean
- The vehicle shall be fully replenished (fuel, water, oil) and equipped with all the accessories and tools specified by the manufacturer
- The check must be carried out in the unloaded condition of the vehicle. The vehicle shall have the parking brake released
- The vehicle must be shaken before each measurement. Before the measurements are made, wait until the vehicle returns to rest
- In the case where a headlamp levelling device are adjusted manually the latter shall be adjusted to the unladed state
- The steering wheels of the vehicle must be in a straight line position

Depending on the optical instrument used to check the direction of the headlamps, it is possible to carry out three types of measurement.

5.1. Measurement with an optical device in which the screen positioning scale is in percent.

It shall be checked for the presence of a mark on the hull of the headlamp according to figure 1 (a).

5.1.1. Inspection of a headlamp marked with the initial inclination of the dipped-beam headlamp in percentage (%).

The screen of the appliance is placed in a position corresponding to the markings in percent for the initial inclination. When the border of the light-dark dot falls on the reference line, which is delineated on the surface of the screen, the headlamp is technically suitable.

5.1.2. Inspection of a headlamp without indication of the initial downward inclination in percentage (%).

The height of the headlamp must be measured. Depending on the measured height (H_f), two measurements must be made with the minimum and maximum values of the screen positioning percentage in accordance with table 1. When the border of the light-dark spot falls between the two positions of the reference line on the screen of the instrument, the headlamp is technically suitable.

Table 1. Limits for the position of the screen depending on the height of the dipped-beam headlamp

Measured headlamp height H_f in meters	**Scale values for screen positioning in percent**	
	Minimum	**Maximum**
$H_f < 0,80$	1,0 %	1,5 %
$0,80 \leq H_f \leq 0,90$	1,0 %	2,0 %
$H_f > 0,90$	1,5 %	2,0 %

5.2. Measurement with an optical device in which the screen positioning scale is in cm/10m.

When using this device, it is also necessary to check for the presence of a mark on the hull of the headlamp for initial downward inclination according to figure 1 (a).

5.2.1. Inspection of a headlamp marked with the initial inclination of the dipped-beam headlamp in percentage (%).

The screen of the appliance is placed in a position corresponding to the markings in percent for the initial inclination multiplied by 10. When the border of the light-dark dot falls on the reference line, which is delineated on the surface of the screen, the headlamp is technically suitable.

5.2.2. Inspection of a headlamp without indication of the initial downward inclination in percentage (%).

The height of the headlamp must be measured. Depending on the measured height (Hf), two measurements must be made with the minimum and maximum values of the screen positioning in cm / 10m in accordance with Table 2. When the border of the light-dark spot falls between the two positions of the reference line on the screen of the instrument, the headlamp is technically suitable.

Table 2. Limits for the position of the screen depending on the height of the dipped-beam headlamp**.**

Measured headlamp height H_f in meters	**Scale values for screen positioning in cm/10m**	
	Minimum	**Maximum**
$H_f < 0,80$	10 cm/10m	15 cm/10m
$0,80 \leq H_f \leq 0,90$	10 cm/10m	20 cm/10m
$H_f > 0,90$	15 cm/10m	20 cm/10m

5.3. Measurement with an optical device with a fixed screen.

The device is used to check the headlamp with or without indication of the initial downward inclination. Measurement shall be carried out on three reference lines, depending on the height of the headlamp from 0 cm to 50 cm and 50 cm to 120 cm, or with graphical images of light, lightweight and commercial vehicles.

For the verification of the developed methodology, a check of the passing lights of a Škoda Fabia car was performed by using three optical devices for checking and adjusting the headlamps.

Figure 8 (a) shows measurement of the direction of the headlamps with a device KS-20, in which the scale of the position of the screen is in units of cm / 10m and has a mechanical orientation system.

The second measurement was carried out with an device in which the screen change scale is in percentage (%) and has a mirror system for orientation. The device, which brand is Tecnolux, screen setup, and the position of the light-dark spot on the screen are shown in figure 8 (b).

(a) (b)

Figure 8. (a) Measurement the direction of the headlamps by device with adjustable screen which scale is in cm/10m; (b) Measurement the direction of the headlamps by device with adjustable screen which scale is in %.

The third measurement uses a Technotest optical device, which has a fixed screen and a mechanical orientation system. The position of the light-dark border on the screen as well as the orientation of the device to the vehicle are shown in figure 9.

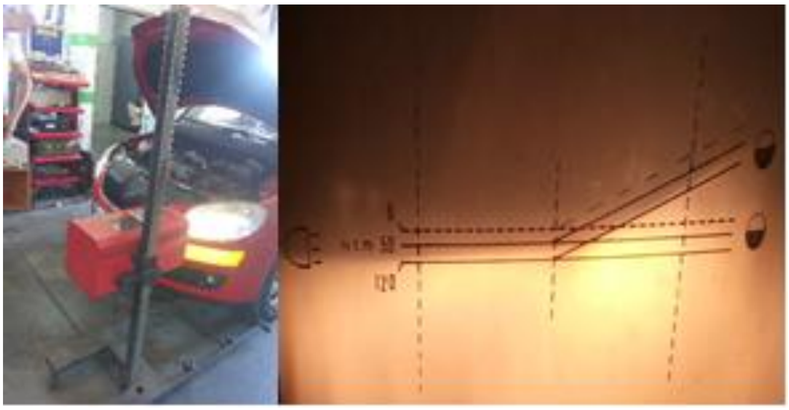


Figure 9. Measurement the direction of the headlamps by device with fixed screen.

In the three separate inspections, identical results were found for the position of the border of the light-dark spot created on the screen. For the first two measurements by devices with movable screen, it was adjusted according to the procedure described, and in the measurement the border falls exactly on the reference line on the screen of the instrument. When measured with the fixed-screen device, the boundary falls between the reference lines corresponding to a headlamp height of 50 and 120 cm Hf and taking into account that the height of the checked headlamp is Hf = 67 cm, the result obtained can be considered to be correct adjusting the direction of the headlamps.

6. CONCLUSIONS

The following conclusions can be drawn from this:

A uniform methodology has been developed to measure the direction of the headlamps with different types of optical instruments, depending on the measurement units of the positioning of the measuring screen.

The method allows measuring the direction of headlamps with or without indication of the initial downward inclination.

The established uniform positions of the light-dark boundary on the screens of three types of optical instruments prove the adequacy of the developed methodology and the possibility of using it in checking the technical condition of the motor vehicles.

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REFERENCES
[1] Трайков Б., Киров Ч., Електрообзавеждане и електроника на автомобила, С., „Техника“, 2007.
[2] 91/663/EEC: Commission Directive of 10 December 1991 adapting to technical progress Council Directive 76/756/EEC relating to the installation of lighting and light-signaling devices on motor vehicles and their trailers.
[3] Regulation No 48 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of vehicles with regard to the installation of lighting and light-signaling devices.
[4] Regulation No 31 of the Economic Commission for Europe of the United Nations (UN/ECE) —Uniform provisions concerning the approval of power-driven vehicle's sealed-beam headlamps (SB) emitting a European asymmetrical passing beam or a driving beam or both.
[5] Regulation No 123 of the Economic Commission for Europe of the United Nations (UN/ECE) —Uniform provisions concerning the approval of adaptive front-lighting systems (AFS) for motor vehicles.
[6] Трайков Б., Симеонов Е., Ръководство за лабораторни упражнения по надеждност, диагностика и поддържане на автотранспортните средства, С., ВМЕИ, 1989.

УНИФИЦИРАНА МЕТОДОЛОГИЯ ЗА ИЗМЕРВАНЕ НА НАСОЧВАНЕТО НА ПРЕДНИТЕ СВЕТЛИНИ ЧРЕЗ ИЗПОЛЗВАНЕ НА РАЗЛИЧЕН ТИП ТЕСТЕРИ

Георги Младенов
gmladenov@tu-sofia.bg

Технически университет – София
София, бул. „Климент Охридски“ 8
БЪЛГАРИЯ

Ключови думи: *фарове за къси светлини, първоначален наклон на лъча на фаровете, устройство за измерване и регулиране на лъча на фаровете, височина на монтиране на предния фар*

Резюме: *Настоящата статия представя разработена методология за определяне на посоката на фаровете за къси светлини с помощта на различни специализирани устройства, което ще даде възможност за гарантиране на резултатите, независимо от използваните измервателни уреди и фабричните марки на фаровете. Използвайки разработената методология за измерване, е възможно да се измери посоката на фаровете за къси светлини на превозни средства, произведени преди и след влизането в сила на европейските директиви за типовото одобрение на предните фарове, използвани в превозните средства. Въпреки използването на различни видове средства за измерване се получават сравними резултати, което се постига благодарение на методологията за измерване. Освен това са определени референтните граници, необходими за измерване и регулиране на фаровете за къси светлини на превозни средства, произведени преди влизането в сила на директивите на ЕО за типово одобрение. Това ще позволи правилен контрол на посоката на предните фарове, което ще подобри безопасността на движението.*