

# VISIBILITY AND SAFETY OF VEHICLE TRAFFIC IN THE DARK (CURRENT REALITY, FUTURE PROJECTIONS)

*Bakutin Yevhen*

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**Annotation.** In the problem of traffic safety, a special place is occupied by the issues of visibility of the road situation. The driver of a car has to solve with constant tension perhaps the most difficult visual tasks that a modern person faces in various situations of everyday, technology-rich life. On roads with an ever-increasing traffic intensity, severe lighting conditions are observed at night, and the eyes have to work in a narrow working area of the field of vision (the brightness of the luminous surface of the headlights of oncoming cars). Visual work at night is very difficult, since with a decrease in the brightness of the background, visual functions are reduced. A person as a biological object is poorly adapted for visual work at night. Statistics from countries around the world indicate that the probability of a traffic accident at night is 5-8 times greater than during the day. In Ukraine, approximately 40% of accidents occur in the dark. Visibility conditions and traffic safety on night roads are determined by the “light climate” provided by automobile lighting devices – headlights.

**Key words:** visibility of road conditions, driver, visual work at night, visibility conditions, dark time of day, blinding.

## 1. Introduction.

Analysis of foreign statistical data on accidents shows that even satisfactory road conditions and a well-established service system do not solve the problem of night safety with an increase in the level of motorization.

The main factors that reduce the visibility of the road and the reliability of information about the road situation when illuminating with headlights are the presence of sources of glare, low level of brightness of the road-background, limitation of the angle of scattering of the headlights of the driver's field of vision, large unevenness of brightness in the field of vision and limited time of observation of road objects. In modern road conditions and transport situations, effective automotive lighting of the headlight (low beam) must meet the requirements: to illuminate the road and obstacles without creating increased glare and discomfort for drivers of oncoming vehicles.

An important factor determining the visibility conditions, and therefore the safety of traffic with automotive lighting is the brightness contrast between the object of observation and the background (road surface). Visibility when illuminating with headlights depends on the average brightness of the road surface, the brightness of objects being observed, the blinding effect of headlights of oncoming vehicles, the uniformity of brightness distribution and a number of other factors.

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## 2. The aim of the work.

Measures to improve traffic safety during dark hours are considered.

## 3. Review and discussion.

According to art. 3 of the Constitution of Ukraine defines that a person, his life and health, honor and dignity, inviolability and security are recognized as the highest social value in Ukraine [1]. However, today Ukraine has a catastrophic situation in the field of ensuring the safety of citizens, which is caused by the intensive growth of the number of sources of increased danger, in particular vehicles, and the demands on the people who drive them, and the unprecedented powers and speeds are accompanied by the intensification of human mental activity. All this, with limited psychophysical capabilities of a person, leads to an increase in the probability of committing motor vehicle offenses.

According to official statistics published by the Department of Patrol Police in Ukraine for the period from 2020 to 2021, there were a total of 168,107 traffic accidents (traffic accidents). 3,541 people died in 2020, 3,238 people in 2021, 31,974 people were injured in 2020; in 2021 – 29,738 people. In 2020, there were 26,140 people killed and/or injured in traffic accidents. At night from 22:00 to 06:00 – 4,739 people; in the evening from 18.00 to 22.00 – 6722 people. For 2021, respectively – 24,521 people, night time from 22:00 to 06:00 – 4,519 people; evening time from 18.00 to 22.00 – 6105 people [2].

The figures are significantly ahead of the similar indicators of most countries of the world and are one of the most acute socio-economic problems and are characterized by an extremely high level of risk of traffic accidents and the severity of their consequences.

One of the causes of road accidents is determined by the decrease in the ability of the driver to see the road situation (as an example due to the blinding of the driver by oncoming headlights of vehicles), which causes an increase in traffic accidents at night. Such a situation indicates the need for radical changes and decisions on road safety by state bodies and road users themselves.

In connection with the tense situation on the country's highways, in October 2020, the Cabinet of Ministers of Ukraine approved the "Strategy for increasing the level of road safety in Ukraine for the period until 2024" dated October 21, 2020 №. 1360. The main goal of this program is to reduce the level of accidents and the severity of the consequences of road accidents, to improve the system of state management of road safety [3].

Data from the National Safety Council (NSC) also confirm that during the spring and summer months, the highest number of traffic accidents with fatal consequences occurred at 8:00 p.m. and 11:59 p.m. Non-fatal crashes peak in the early summer, from noon to 3:59 p.m. From November to March, the peak of fatal crashes occurred at 4:00 p.m. until 7:59 p.m. [4].

In addition, the National Highway Traffic Safety Administration (NHTSA) [5] reported an alarming increase in the number of fatal nighttime crashes in 2021. That year, crashes increased by 11 percent between 6:00 p.m. and 5:59 a.m. These statistics highlight the increasing dangers of driving at night, likely due to reduced visibility.

The British IAM Roadsmart RAC Club conducted a benchmarking survey at the end of 2023 that surveyed 2,000 drivers. The result was that 89% thought most car headlights on UK roads were too bright; most drivers (91%) reported being dazzled by them. Additionally, 85% of those affected by glare said they believed the problem was getting worse. The RAC has been conducting research on this topic in the UK since 2018 [p. 4; 6].

Vision plays a major role in the driver's work. To drive a car, he must see vehicles, pedestrians, road signs and signals on the road. Very often, the driver has to visually assess the position of the car on the road, the direction and speed of movement, the position and distance to objects. The organ of vision is the eye, which makes it possible to distinguish objects, their color and properties, to



determine the distance to them. A necessary prerequisite for the visual perception of an object is its selection from the background. Such selection becomes difficult in low light, the same color of objects and the background, blinding the eyes with bright light or when entering a dark passage from a lighted street. However, in order to recognize an object, it is necessary not only to distinguish it from the background, but also to perceive its shape. And it depends on the visual acuity. Visual adaptation is the ability of the eye to adapt to changes in illumination.

With a sharp transition from darkness to light or vice versa, temporary blindness occurs, the duration of which is from a few seconds to 2-4 minutes. During this time, the unguided car actually travels a considerable distance (at 30 km/h, the car travels 8.33 m in 1 second). Sensation is a reflection in the human consciousness of objects and phenomena of the material world, which arises as a result of their action on the sense organs, distinguishing visual, auditory, olfactory, skin, motor, vibrational and other sensations [7].

However, it is known that the recovery of the driver's eyes after glare can take up to 9 seconds (source: Royal Society for the Prevention of Accidents, UK). That time covers a considerable distance without being able to see properly. At 30 km/h it is already 75 meters, at 50 km/h 125 meters and at 100 km/h even 250 meters [p. 4; 6].

RAC report of survey on glare on road traffic: When it comes to the effects of glare on drivers, two-in-three (67%) who suffer say they have to slow down considerably until they can see clearly again, while a similar proportion (64%) believe some headlights are so bright they risk causing accidents. In fact, five per cent of these drivers state they have nearly been involved in a collision themselves [p. 9; 6].

The comprehensive survey of motorists was conducted up to the end of 2023 to determine the extent to which they are affected by glare from light sources on vehicles and what restrictions they experience when driving. To summarise, the representative survey conducted by a market research institute came to the following conclusions for Belgium, Germany, Austria and Switzerland: 71 % find the glare intolerable or annoying 32 % almost always or regularly feel dazzled 51 % of respondents pinch their eyes shut or even close them briefly · 58 % have problems perceiving objects in the vicinity of the dazzling light source\* · 30 % stated that they continued to see an image of the light source for a limited time after passing it (afterimage), or even felt pain 75% of those surveyed consider it necessary to review and update the regulations on reducing glare from vehicle lighting. The survey thus gives the mobility clubs a clear mandate to take action to protect consumers and introduce measures that ultimately lead to less glare in road traffic [p. 4; 6].

A rapid change in light levels causes so much irritation of the retina that temporary blindness occurs. Blinding can occur when the driver is illuminated by the headlights of oncoming cars, the light of street lamps, the glare of reflected light, etc. The time of blindness varies widely and, depending on the subjective qualities of the person and the level of irritation of the retina, can last from several seconds to several minutes.

Unfortunately, some drivers of their own accord replace classic vehicle headlights with others (halogen, xenon, LED, etc.) that definitely improve the driver's visibility, but such headlights can dazzle oncoming drivers, creating an emergency situation on the road. This especially applies to the installation of the above-mentioned lamps in headlights not adapted by the manufacturer. It should be noted that the largest sector of the country's motor vehicle fleet is the private property of individuals, therefore the state of accidents on individual vehicles determines the overall situation regarding accidents in the state.

In almost all cases, when vehicles drive off in the dark, regardless of whether there was blinding in this case or not, drivers are constantly in emergency situations, and in some fraction of a second, there is always an invisible zone behind the cars when they drive off. When moving vehicles at night, it is necessary to assess whether the distance visible in front of the car is sufficient for it to stop at a given speed. Only such actions of the driver make it possible to ensure the safety of traffic at night [p 28,8].

In their daily activities, employees of the National Police of Ukraine prevent and counter a significant number of offenses, one of which is non-compliance by drivers of vehicles with requirements, when

“the technical condition of vehicles and their equipment must meet the requirements of standards related to road safety and environmental protection, as well as rules of technical operation, instructions of manufacturing enterprises and other regulatory and technical documentation” (Decree of the Cabinet of Ministers of Ukraine “On Traffic Rules”, 2001).

According to the Law of Ukraine “On the National Police”, chapter IV provides for the powers of the police, namely, article 23 provides for control over compliance with the Traffic Rules by its participants and the legality of the operation of vehicles on the street and road network [9].

In Ukraine, according to the “Traffic Rules”, if the design of the car does not provide for xenon, halogen, etc. lamps, it is forbidden to change their type independently. Thus, drivers who independently installed those not provided for by the manufacturer in violation of the requirements of the technical documentation can be prosecuted. Yes, according to art. 122 of the Code of Ukraine on Administrative Offenses for the use of headlights in violation of the requirements of the relevant standards entails administrative responsibility [10].

There is no doubt that an employee of the National Police of Ukraine cannot determine by eye (i.e., organoleptic control) the excess of the permissible level of light intensity of the vehicle’s headlights, without measuring the level of light intensity of the vehicle’s headlights with a technical device - “light meter, lux meter, etc.” Of decisive importance in the aspect of the process of forming the evidence base and in the subsequent decision-making in such cases of administrative offenses is the correct recording of the data of the results of the measurement of the light intensity level of the car headlights during the use of technical devices by the patrol police of Ukraine.

For a more detailed explanation of the term blinding and the dark time of day, let’s turn to the Resolution of the Cabinet of Ministers of Ukraine, where section 1, item 1.10 “On road traffic” defines blinding, that is, it is the physiological state of the driver due to the effect of light on his vision, when the driver objectively, it is not possible to detect obstacles or recognize the boundaries of road elements at a minimum distance, and the dark time of the day is the part of the day from sunset to sunrise. In conditions of insufficient visibility on mechanical vehicles, the main beam of the headlights or additional fog lights can be turned on, provided that this will not dazzle other drivers [11].

Chapter 19 “On Road Traffic” provides for the driver’s use of external lighting devices, namely, paragraph 19.1 in the dark and in conditions of insufficient visibility, regardless of the degree of road illumination, as well as in tunnels on a moving vehicle, lighting devices must be turned on on all mechanical vehicles - low beam (high beam) headlights. In the case of deterioration of visibility in the direction of traffic caused by the headlights of oncoming vehicles, the driver must reduce the speed to such that it would not exceed the safe conditions of the actual visibility of the road in the direction of traffic, and in case of blinding - stop without changing the traffic lane and turn on emergency light signaling. Restoring movement is allowed only after the negative effects of blinding have passed.

P. 31.1. “On road traffic” stipulates that the technical condition of vehicles and their equipment must meet the requirements of standards related to road traffic safety, as well as technical operation rules, instructions of manufacturing enterprises and other regulatory and technical documentation.  
P. 31.3. The operation of vehicles is prohibited when the external lighting devices, namely: the number, type, color, placement and mode of operation of the external lighting devices do not meet the requirements of the vehicle design or the headlight adjustment is violated.

According to the National Standard of Ukraine (DSTU) 3649:2010, namely section 6 provides requirements for the safe technical condition of a wheeled vehicle, namely clause 6.1 specifies the requirements for external light devices “it is not allowed to change the location of light devices, to dismantle them, to install additional light devices devices, as well as change the mode of operation, if this is not provided for by the design or documents regarding the approval of the conversion of the wheeled vehicle.” [12].

According to the Requirements for checking the design and technical condition of a wheeled vehicle (KTZ), “it is not allowed to use light sources not provided by the manufacturer of the wheeled vehicle.”

The total luminous intensity of all headlights in the “main beam” mode must be not less than 20,000 cd and not more than 430,000 cd (11) (candela (cd) is a unit of light intensity) [13].

First of all, it should be noted that after the elimination of the mandatory technical inspection of vehicles, by the Decree of the Cabinet of Ministers of Ukraine (Decree of the Cabinet of Ministers of Ukraine “On approval of the Procedure for conducting mandatory technical control and scope of inspection of the technical condition of vehicles, technical description and sample protocol of inspection of the technical condition vehicle”, 2012), control over this issue was completely lost. Although there is a check of the measurement of angles of inclination of beams, light distribution, light intensity of headlights at the stations of technical control of vehicles, but the list of vehicles to be checked is very small and does not, in principle, cover those passenger cars and motorcycles operated by their owners with replaced headlight bulbs.

To date, there is no, at least in free access, any legal act that would determine the list of technical means that employees of the National Police of Ukraine are authorized to use to measure beam angles, light distribution, light intensity of headlights on the street and road network of populated areas and the sequence of checking the level of light intensity of the vehicle’s headlights.

From the point of view of road safety, it is most important to eliminate and be able to evaluate physiological glare, since its consequence is a reduction in the detection distance and distinction of the road and objects on it.

Less studied in motor transport is psychological glare - discomfort. In the classification of glare phenomena, visual discomfort is defined as a feeling of inconvenience or tension. In uncomfortable lighting conditions, drivers quickly get tired, their visual performance decreases. To analyze the physical parameters that determine discomfort, as well as to make an approximate comparative assessment of the level of discomfort caused by headlights when oncoming vehicles pass.

Discomfort increases with the increase in the brightness of the headlight surface and their angles of size. Preference should be given to headlights with less blinding brightness, since an increase in brightness has a greater effect on increasing discomfort.

To improve the level of traffic safety on night roads, it is necessary not only to have good headlights, but also to know how to use them and look at the road correctly. Drivers must be taught to drive safely at night.

An important factor characterizing the conditions of vision and the lighting system is the visibility range (distinction distance) of a pedestrian or an obstacle of small angular dimensions, simulating the unevenness of the road. Visibility range is the main criterion that directly characterizes the lighting system from the point of view of traffic safety.

Ultimately, the efficiency of lighting devices is determined by the maximum safe speed of the car in the dark.

It is necessary to evaluate car headlights taking into account the change in the driver’s visual functions during night work, which leads to physical and emotional overstrain.

In the practice of automotive lighting engineering, there is a need for a simple device that would directly measure the degree of visibility of an object, similar to how a lux meter measures the degree of its illumination. It is advisable to use it to evaluate the blinding glare (glare) of lighting devices. The presence of blinding light sources from the headlights of oncoming traffic reduces the visual performance of the driver. Evaluation of the driver’s glare when illuminating by headlights is still relevant and requires its own solution.

The psychological impact of an oncoming car is determined by the brightness of the headlights and their angular dimensions. At a sufficiently large distance from the headlights of an oncoming car, psychological glare is “acceptable”, but starting from a certain distance, the sensation of the glare of the headlights can become “unpleasant” or even “unpleasant and painful”.

As a result of the reforms carried out, the employees of the National Police of Ukraine began to actively use technical means when establishing the guilt of a person for committing an administrative offense in the field of road traffic safety, and their use became a significant, progressive step forward, which is aimed at improving the quality of security and order, establishing justice in the state.

In the future, the use by the National Police of Ukraine of technical devices for measuring and regulating the light intensity of vehicle headlights will be aimed at preventing and countering offenses primarily related to driving a converted vehicle (if the vehicle design does not include halogen, xenon, LED lamps which it is forbidden to independently change their type), as well as the reduction of accidents on the street – road network at night.

The device will allow you to evaluate the glare created by headlights, as well as evaluate the quality of lighting in various areas and points of the road by the value of the threshold contrast. The psychological impact of an oncoming car is determined by the brightness of the headlights and their angular dimensions. At a sufficiently large distance from the headlights of an oncoming car, psychological glare is “acceptable”, but starting from a certain distance, the sensation of the glare of the headlights can become “unpleasant” or even “unpleasant and painful”.

#### **4. Conclusions.**

The conducted research allows us to draw the following conclusions:

1. Administrative and legal regulation of the use of technical devices by employees of the National Police of Ukraine to control on the patrol route the observance of the Traffic Rules by its participants and the legality of the operation of vehicles on the street and road network (the sequence of checking the measurement of the angle of inclination of the beams, the light intensity of the headlights, etc.) , can be determined exclusively by the laws of Ukraine.
2. Using technical devices (light meter, etc.), patrol police officers will be able to measure the light intensity of headlights on the street and road network of populated areas and the sequence of checking the level of light intensity of vehicle headlights in order to effectively control the technical condition of vehicles, the established rules, regulations and standards, to ensure road traffic safety, as well as for effective and constant monitoring of compliance with the requirements of legislative and other normative legal acts, regarding the protection of drivers from being dazzled.
3. Only those lamps specified by the manufacturer can be installed in the car’s headlights. If the design of the car does not provide for other lamps, then it is forbidden to change the type of lamps yourself. Operation of the car in such a case is prohibited, and drivers who independently installed the lamps in violation of the requirements of the technical documentation must be prosecuted in accordance with the current national legislation of Ukraine.

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**Yevhen Bakutin,**

*Candidate of Law*

*Senior teacher of the Department of Tactical Training*

*National Academy of Internal Affairs*

*E-mail: bakutin\_e@ukr.net*

*ORCID: 0009-0000-4480-7584*