

Technical Malfunctions Determination of Vehicle Brake System while Road Accident Analysis

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Issues related to the driver's characterization of condition and technical malfunction of the vehicle braking system before a traffic accident are considered. This Article Purpose is to determine specifics of a technical malfunction of a vehicle braking system before a traffic collision, as well as to consider the interaction of investigative bodies with experts (in particular, in criminal proceedings related to traffic accidents) while establishing reliability of driver statements. Features of appointment of a forensic auto-technical road accident analysis aimed at establishing technical condition of braking system of vehicles, preparation of initial data and research objects are structured. The goals and objectives of the investigation of the technical malfunction of the brake system of the vehicle before the traffic accident are outlined. The procedure for establishing the reliability of drivers' statements about mechanism of development of a traffic accident is specified. Issues related to the study of the vehicle brake system, troubleshooting and their causes are considered. Theoretical provisions and practical recommendations for the application of special knowledge in process of researching the technical condition of the braking system of the vehicle and identifying its malfunctions are formulated. The causal relationship between driver actions and detected malfunctions of the

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vehicle's braking system was clarified. Attention is drawn to possible consequences and features of the further investigation of the traffic accident after determining technical reliability of driver statements.

Keywords: *driver's testimony; technical vehicle condition; vehicle operation; traffic accident; brake system malfunctions.*

Research Problem Formulation

While investigation of traffic collision at the stage of receiving testimony of its participants by the investigator (court), there are cases when drivers state that the cause of traffic collision was a malfunction of brake system of the *vehicle*. Complete or partial failure of the braking system is recorded, as which result the vehicle lane changes in an uncontrolled state. Therefore, during inspection of vehicle at the scene of traffic collision, it is necessary to carefully inspect the elements of the brake system. While inspection of the scene of traffic collision, technical condition of the motor vehicle should be identified and recorded, noting the signs of malfunction of the motor vehicle (unless it is obvious that such malfunction is a consequence in the form of a collision, collision or overturning of the motor vehicle and not the cause of the accident), especially if the driver refers to a refusal brake system before the accident. At the same time, it is not enough just to record

the detected malfunctions in the vehicle inspection report without appointing a further road accident analysis, because then questions about the time of occurrence of the malfunction (long before or immediately before traffic collision) and possibility of its timely detection by the driver (mechanic) remain unanswered, without the answers to which it is impossible determine the fault of the persons involved in the accident.

Analysis of Essential Researches and Publications

The theoretical foundations of the research of issues related to the investigation of road accidents caused by vehicle malfunctions were laid by such domestic scientists as: V. A. Bekasov, H. Ia. Bohrad, B. L. Zotov and H. H. Indychenko¹, A. B. Razumov², Yu. B. Suvorov and H. V. Zhylynskyi³, M. G. Shcherbakovskiyi⁴, as well as foreign professionals D. Collins and D. Morris⁵, R. Bayett and R. Watts⁶, and others.

- 1 Бекасов В. А., Боград Г. Я., Зотов Б. Л., Индиченко Г. Г. Автотехническая экспертиза. Москва, 1967. 254 с.
- 2 Судебно-автотехническая экспертиза (часть III). Основы судебно-экспертного исследования технического состояния транспортных средств / под ред. А. Б. Разумова, сост. Г. В. Жилинский. Киев, 1987. 112 с.
- 3 Суворов Ю. В., Жилинский Г. В. Применение специальных технических познаний при расследовании дорожно-транспортных происшествий. Минск, 1989. 73 с.
- 4 Щербаковский М. Г. Призначення та провадження судових експертиз: процесуальні основи, методичні рекомендації, запитання експерту. Харків, 2011. 400 с.
- 5 Коллинз Д., Моррис Д. Анализ дорожно-транспортных происшествий. Москва, 1971. 128 с.
- 6 Коллинз Д., Моррис Д. Анализ дорожно-транспортных происшествий. Москва, 1983. 288 с.

Article Purpose

While establishing reliability of the driver's testimony, determine specifics of technical malfunction of vehicle brake system before the traffic accident, as well as consider the interaction of investigative bodies with experts (in particular, in criminal proceedings related to traffic accidents).

Main Content Presentation

When a driver fails to stop the car in time, he usually cites brake failure. Unfortunately, it is not always possible to study in detail the chain of events and circumstances that caused the collision, which is caused by the impossibility of stopping in time. The driver is not always able (and sometimes unwilling) to recall important details or logically reproduce the sequence of events. Therefore, in order to identify the circumstances of an accident, it is appropriate to determine the causes of these events, the most common of which include: uneven braking, partial or temporary brake failure, loss of frictional properties, problems with heat distribution, the presence of air in the brake system, expansion of the brake drum, problems with the brake amplifier, partial failure of brake systems with a separate hydraulic drive, etc ⁷.

The brake system is a set of devices designed to create and change artificial movement resistance. When diagnosing the brake system, it is necessary to evaluate its compliance with the design, the requirements of the manufacturing plant,

as well as working capacity and efficiency of the action ⁸.

Having recognized the need to conduct a forensic automotive technical examination, investigator (in accordance with Criminal Procedural Code of Ukraine ⁹) adopts a resolution on this, in which he notes the grounds for the appointment of the examination; the name of the institution where the examination is to be conducted and/or the surname of the expert; materials provided to the expert for research; the raw data on which the research is to be based, as well as the questions to be addressed.

Solving issues in criminal proceedings requires specific expertise in the field of forensic examination (in particular, auto technical one) according to Art. 110 *Procedural decisions*", Art. 242 "Grounds for examination", Art. 243 *Procedure for engaging an expert* of Criminal Procedural Code of Ukraine of Ukraine ¹⁰.

Data on the technical condition of vehicles, namely systems designed to ensure road traffic (condition of relevant parts, units and assemblies) are required for performance of auto technical examinations. The main safety systems of motor vehicles: braking system, steering, external lighting devices and chassis. It is possible to check technical condition of aggregates, assemblies and parts of the vehicle in different ways, the most common of that in expert practice are running and bench tests (diagnostics) and element-by-element research. In some cases, it is necessary to carry out a comprehensive examination to determine the causes of malfunctions of individual parts.

7 Байэтт Р., Уоттс Р. *Op. cit.*

8 Жилинский Г. В., Остапюк О. Я., Лошманов В. П. и др. *Экспресс-диагностика систем автомобилей и автобусов на местах дорожно-транспортных происшествий* / под ред. А. Б. Разумова. Киев, 1980. 56 с.

9 Кримінальний процесуальний кодекс України від 13.04.2012 р. № 4651-VI (зі змін. та допов.). URL: <http://zakon2.rada.gov.ua/laws/show/4651-17> (date accessed: 02.06.2020).

10 Ibid ... URL: <http://zakon2.rada.gov.ua/laws/show/4651-17> (date accessed: 02.06.2020).

Vehicle (as well as a separate unit, unit or part) should be considered technically serviceable if, during its actual inspection, all its functional parameters meet the design and operational characteristics, as well as the requirements of regulatory and technical documentation. However, not every malfunction of a separate unit or part leads to a violation of vehicle performance, therefore, causes traffic collision.

Therefore, taking into account the issues that professionals have to solve while road accident analysis (identification of vehicle malfunctions), the following objects of expert research can be singled out.

Objects of road accident analysis forensic research

1. Vehicles

a) mechanical motor vehicles (i.e. motor vehicles, the which movement occurs thanks to the engine) including tractors, self-propelled machines and mechanisms, as well as trolleybuses and motor vehicles with an electric motor with a power of more than 3 kWh ¹¹:

- motor vehicles (in accordance with Art. 1 of the Law of Ukraine On Motor Vehicle Transport ¹², they are defined as wheeled vehicles (bus, truck and car, trailer, semi-trailer), which are used to transport passengers, goods or perform special work functions);
- motorcycles and mopeds recognized as two-wheeled

mechanical vehicles (apparently, these objects should belong to the objects of road accident analysis, taking into account the number of accidents with their participation);

- rail vehicles (trams and platforms with special equipment moving on tram tracks);

b) bicycles (except wheelchairs) are vehicles, which movement is due to the muscular force of the person who is on ¹³.

2. Parts of vehicles, their structural parts and their elements.
3. Vehicle technical documentation.
4. Circumstances at the scene of traffic collision.
5. Traffic collision procedure.
6. Materials of criminal proceedings (procedural documents (protocols of examinations, interrogations, investigative experiments, conclusions of forensic experts, etc.), schemes of traffic collision, video recordings, photo tables).

Forensic expert, examining the objects placed at his disposal, examines only those characteristics that allow to answer the questions posed. It is the characteristics and signs of a specific object that make it possible to distinguish it from others and identify it. Identification and research of such signs helps to solve diagnostic, classification, situational and identification types of tasks ¹⁴.

After the expert vehicle technician receives resolution on appointment of an examination, forensic expert first

11 Правила дорожнього руху : затв. Постановою КМУ від 10.10.2001 р. № 1306 (зі змін. та допов.). URL: <https://zakon.rada.gov.ua/laws/show/1306-2001-%D0%BF> (date accessed: 02.06.2020).

12 Про автомобільний транспорт : Закон України від 05.04.2001 р. № 2344-III (зі змін. та допов.). URL: <https://zakon.rada.gov.ua/laws/show/2344-14#Text> (date accessed: 02.06.2022).

13 Правила дорожнього руху URL: <https://zakon.rada.gov.ua/laws/show/1306-2001-%D0%BF> (date accessed: 02.06.2020).

14 Лубенцов А. В. Теоретичні та методичні основи судової автотехнічної експертизи : дис. ... канд. юрид. наук. Харків, 2018.

get acquainted with all the provided case materials and objects of research, the scene of the accident, as well as the questions posed by the investigator (court). After studying all the materials of the criminal case, forensic expert should plan the sequence of the research. At the initial stage of research, forensic expert should create a model for the occurrence of an accident, that will then be subjected and reasonable research.

During the preliminary study at the preparatory stage of the road accident analysis, actions of forensic expert can lead to the return of materials to the initiator of the examination for their proper registration. Having studied the case materials, forensic expert determines: integrity of packaging and the availability of research objects, their compliance with the list in the accompanying documents; the state of the objects of research (their integrity, the absence of changes caused by transportation, etc.); sufficiency and quality of the objects of research provided for examination; the need to violate the petition for the provision of additional materials (samples) and access to the objects of research related to forensic examination; necessary research methods and sequence of their application.

Forensic research can be carried out only by a qualified forensic expert, on the other hand, the effectiveness and quality of such a research depends on qualifications of the person who appointed the research, as well as on the use by the expert of advances in science and technology and modern technologies that make it possible to store the objects of examination for additional research.

First, the investigator determines the task of the research by formulating questions to the expert and the need for the latter to leave for the inspection of the objects under research and agrees on the research timing. At this stage, the expert identifies the shortcomings that arose during the appointment of expertise and the removal of the materials and objects submitted for research and should demand their elimination for further research.

Road accident analysis begins with the expert's study of actual data about the accident and its individual moments. According to Clause 11.2 of the Instruction on appointment and conducting forensic examinations and researches, forensic expert is prohibited from independently collecting materials to be examined, as well as selecting raw data, if they are ambiguously reflected in provided materials¹⁵. However, forensic expert has the right to independently use the necessary literature from normative and reference sources regarding the objects provided for research (vehicle), namely: the structure of the structures of certain units and aggregates, their operational parameters and characteristics recommended by the manufacturer. If, during the investigation, the expert comes to the conclusion that the objects provided for investigation, specified in the resolution on the appointment of the expertise (resolution), and the circumstances of the accident from a technical point of view are unreliable, then the expert must notify the investigator (court) who ordered the expertise in writing, and request new materials necessary for conducting the study, or clarify the identified shortcomings.

15 Про затвердження Інструкції про призначення та проведення судових експертиз та експертних досліджень та Науково-методичних рекомендацій з питань підготовки та призначення судових експертиз та експертних досліджень : затв. наказом Мініюсту України від 08.10.1998 р. № 53/5 (зі змін. та допов.). URL: <https://zakon.rada.gov.ua/laws/show/z0705-98> (date accessed: 02.06.2020).

While research, forensic expert can find out new data and circumstances about which the investigator (court) did not raise issues in the decision on the appointment of the examination, but which identification is essential for subsequent conclusion of the case. Therefore, in order to uncover the crime, the investigation may accept these additional circumstances and use them as evidence in the case¹⁶. Timely detection of such circumstances makes it possible to promptly investigate and solve the crime, based on the actual versions.

Studying materials submitted for forensic examination, expert develops a dynamic model of the accident, integral which part is the calculations necessary both to verify technical reliability of the initial data and to directly solve the questions posed to the expert. Usually, engineering calculations provide an opportunity to determine not so much absolutely accurate values of values (for example, the length of the braking distance of the vehicle), but the limit of possible range of values available while accident¹⁷.

Peculiarity of calculation application methods in auto technical examinations to some extent brings them closer to the methods of mathematical modeling: their main purpose is not to determine the exact quantitative values of certain parameters, but to determine the structure of the investigated process, its main characteristics and the limits in which it occurred.¹⁸ *It should be noted that solving questions regarding the mechanism of interaction of vehicles with each other or with elements of the road environment is most often possible only by means of real-time modeling, that is, direct research and comparison of*

tracks on vehicles. Therefore, forensic expert can obtain actual results when the vehicle is in the same condition at the time of its submission for examination as it was immediately after the accident (for this purpose, it should be stored in conditions that exclude the change of existing and the appearance of new traces on).

Having appointed an examination aimed at determining the technical condition of the brake system, it is necessary to provide a vehicle for the research (to solve the tasks of forensic examination, the vehicle inspection protocol and its photos are often not enough). Before the vehicle is presented to forensic expert institution or until the expert arrives at the vehicle storage place, it is necessary to ensure complete preservation of the vehicle. It is forbidden to adjust the brake mechanism, replace components, add brake fluid and carry out any other repair and restoration work. Transportation of vehicles for examination, checking of the technical condition of the brake system is allowed only by fully loading. If it is necessary to determine the cause of depressurization of the brake system, destruction of brake discs or drums, air entering the brake system, etc., then this part or assembly can be sent for research, having previously dismantled it from the vehicle describing it in detail and attaching it to the case with an appropriate decision. At the same time, the appearance and position of the removed part (node) on the vehicle (tractor, motorcycle, etc.) must be described in detail in the vehicle inspection report and photographed. Dismantling conditions must be noted in the physical evidence review protocol, which, together with the detail (node), vehicle review protocol and

16 Про затвердження Інструкції ... URL: <https://zakon.rada.gov.ua/laws/show/z0705-98> (date accessed: 02.06.2020).

17 Кристи Н. М. Методические рекомендации по производству автотехнической экспертизы. Москва, 1971. 112 с.

18 Лубенцов А. В. Оп. cit.

decision on appointment of road accident analysis is sent to forensic expert institution or expert. When sending a destroyed part for examination, it is necessary to provide all its fragments; the fracture surfaces must be isolated from mechanical impact (friction or impacts), moisture, etc.¹⁹

The impact of brake system malfunctions on the occurrence of traffic collision is usually detected in extreme conditions, when the driver of the vehicle is forced to use the maximum functionality of the system to prevent harmful consequences (collision, collision, etc.). In such conditions, the driver applies emergency braking in order to stop the vehicle at a minimum distance. In emergency braking mode (depending on the technical condition of the brake system and the road surface), wheel locking (all, rear or front only, left or right bead or individual wheel) may occur. Driving a vehicle while braking in wheel lock mode in certain road situations can cause traffic collision²⁰.

Even a slight violation of the tightness of the hydraulic system leads to leakage of brake fluid and depressurization of the system. Air in the brake system first gradually increases working stroke and reduces the hard stop of the brake pedal at the end of the stroke, then, as the amount of air in the system increases (this process increases), pedal can completely sink to the floor of the cabin, and braking in this case is possible, only several times pressing the brake pedal. Air entering the brake system increases the brake application time and the length of the braking distance compared to the standard values. As air accumulates, braking performance will decrease because much of the pedal effort will be spent compressing the air and

displacing the brake fluid through the leak, causing the brake system to depressurize. The same situation is observed when air enters the system through the supply tank of the main brake cylinder in conditions of a significant decrease in the brake fluid level. Braking efficiency is significantly reduced if (in addition to such processes) fluid leaks into the working brake cylinders with brake fluid spilling onto the friction linings and barrel.

Braking may not be sufficiently effective if additional supports (jamming of levers, pedals, swelling of cuffs during the use of poor-quality brake fluids or ingress of gasoline, gas, acetone, etc.) have emerged in the drive elements.

Malfunctions of the vacuum brake booster, related to the disruption of its connection system or the destruction of diaphragm, do not directly affect the performance of the brake system, but the driver has to put much more effort to the pedal. However, if the vacuum booster fails suddenly, the driver who is accustomed to operating the booster system is not always able to respond to the maximum deceleration of the braking situation, so the booster failure may indirectly affect the event.

The gradual increase in the gap between the linings and the barrel increases the working stroke of the pedal and reduces the force of pressing the brake linings against the drum, thus reducing the braking torque and the overall braking efficiency. Wear of the linings to the brake pads leads to a significant reduction in the braking torque developed by the brake mechanism due to a reduction in the coefficient of friction. The coefficient of friction also decreases in the pair of the lining – the barrel and in the case of lubrication of the linings.

19 Байэтт Р., Уоттс Р. Оp. cit.

20 Судебно-автотехническая экспертиза

Malfunctions of the hydraulic brake system, such as breakage of flexible hoses or destruction of brake pipes, the escape of pistons with brake cylinder collars outside the working area, significant dusting cause a complete failure of the brake system.

During emergency braking in the road environment, when it is necessary to stop the vehicle at the minimum possible distance, specialists most often record failures of the brake system associated with its lack of efficiency and/or failure.

Uneven braking can lead to loss of transverse stability, that can cause a slip, exit from the roadway, roll over of the vehicle, exit to the lane of oncoming traffic, collision with oncoming vehicle, as well as provocation of other emergency situations²¹.

The vehicle should be considered technically faulty if its technical condition does not meet the requirements of Section 31 "Technical condition of vehicles and their equipment", Clause 31.4.1 "Brake systems" of Traffic codes, as well as if there are other defects in the brake system that make it impossible to protect traffic²².

Driver actions, if he operates a motor vehicle with brake system malfunctions, which he knows about or should have discovered during the operation of the motor vehicle, should be considered as a violation of the Traffic codes. For example, air was detected in the brake system on the vehicle (reducing efficiency of the brake mechanisms). While driving, the driver, having applied the brakes, lost control and drove into the oncoming traffic lane, where the accident occurred. Inspection of the vehicle did not reveal

any damage or depressurization of the brake system, the brake pedal was soft, fell under the influence of the driver on the controls, but braking occurred only from the second or third time it was pressed. In such a traffic situation, the driver was able to detect the improper condition of the brake system, because he must monitor the technical condition of the vehicle: equipment should meet the requirements of standards related to road traffic safety, environmental protection, as well as the requirements of technical operation rules, instructions of manufacturing companies and other regulatory and technical documentation. In addition, while driving, the driver had to pay attention to the road conditions, the condition of the roadway, and the technical condition of the vehicle he was driving if there was air in the working brake system²³. Since in the given traffic situation the driver did not take into account these factors, which led to his loss of control and the departure of the vehicle into the lane of oncoming traffic, as which result of the accident occurred, actions of the driver do not meet the requirements of the mentioned section. 31 "Technical condition of vehicles and their equipment" and clause 31.4.1 "Brake systems" of the Traffic codes, which were (from a technical point of view) causally related to the occurrence of this accident.

However, conclusion that there is no causal relationship between such actions (or inaction) of the driver and event is possible, if forensic expert determines that even in the lack of a technical malfunction of the brake system, driver did not have

21 Судебно-автотехническая экспертиза ...

22 Правила дорожного руху ... URL: <https://zakon.rada.gov.ua/laws/show/1306-2001-%D0%BF> (date accessed: 02.06.2020).

23 Ibid.

the technical ability to prevent an accident in a certain road environment.

There may also be no causal relationship between the actions of the driver operating the vehicle with a technically faulty brake system and the event when the driver had the opportunity to prevent the event and in the presence of a malfunction. In this case, the driver may take other measures to prevent the event from occurring in a timely manner due to the cause of the event ²⁴.

After performed research, forensic expert formulates a conclusion in which he evaluates the results obtained, referring to certain signs (materiality of the complex of signs; stability and individuality of the identified signs that coincide and differ; the significance of the signs for the conclusion about the availability or lack of identity).

The results of road accident analysis should be evaluated by analyzing the expert compliance with the procedural order of obtaining initial data on the vehicle and its investigated details, as well as the scientific validity and reliability of the expert's conclusions. First of all, it is necessary to analyze the reliability and quality of the source data, because in the case of their unreliability (even after applying scientifically based research methods), it is possible to reach wrong conclusions. For this, it is important to determine whether the expert applied the correct values of the design and operational parameters of the vehicle, the quantitative indicators of the actions of the participants of the movement and its conditions (that is, whether they correspond to the current methodological provisions). In order to evaluate the

research of individual parts, assemblies and aggregates, as well as damaged vehicle and other material objects, it is necessary to analyze the circumstances of their detection, fixing, removal and packaging; find out whether proper measures were taken to preserve them, whether they could be replaced or damaged already after the accident. Evaluating the results obtained on the basis of calculations, forensic expert sometimes has to change the primary road accident model or completely abandon it and develop a new one that would be consistent with the results of the conducted research ²⁵.

Conclusions

Possibility of detecting malfunctions of the brake system during the inspection of the technical condition or control of the vehicle is established on the basis of the determined time of the occurrence of the malfunction, the nature of such detection, the location of the damage (hidden or open defect of parts), the data of trace evidence and metallographic research, as well as taking into account the list of inspection operations technical condition of braking system of vehicles, provided for by job instructions for drivers and other persons. It is possible to establish a cause-and-effect relationship with detected malfunctions of the brake system of the vehicle only in the case of applying special knowledge in the field of auto engineering, i.e. only by appointing an road accident analysis that is able to reliably find out whether the driver was able to detect malfunctions of the brake system and whether the detected malfunctions are in causal connection with traffic collision.

²⁴ Иларионов В. А. Судебная автотехническая экспертиза : метод. пособ. Ч. 2. Москва, 1980. 163 с.

²⁵ Лубенцов А. В. *Op. cit.*

Визначення технічної несправності гальмової системи транспортного засобу під час проведення автотехнічної експертизи

Артем Кошкарів

Розглянуто питання, які стосуються характеристики водієм стану та технічної несправності гальмової системи транспортного засобу перед дорожньо-транспортною пригодою. Мета статті — визначити особливості технічної несправності гальмової системи транспортного засобу перед дорожньо-транспортною пригодою, а також розглянути взаємодію слідчих органів з експертними (зокрема, у кримінальних провадженнях, пов'язаних із дорожньо-транспортними пригодами). Структуровано особливості призначення судової автотехнічної експертизи, спрямованої на встановлення технічного стану гальмової системи транспортних засобів, підготовки вихідних даних та об'єктів дослідження. Окреслено цілі й завдання дослідження технічної несправності гальмової системи транспортного засобу перед дорожньо-транспортною пригодою. Зазначено порядок встановлення достовірності показань водіїв про механізм розвитку дорожньо-транспортної пригоди. Розглянуто питання, пов'язані з дослідженням гальмової системи транспортного засобу, усуненням її несправностей і їх причинами. Сформульовано теоретичні положення та практичні рекомендації із застосування спеціальних знань у процесі дослідження технічного стану гальмової системи транспортного засобу й виявлення її несправностей. З'ясовано причинний зв'язок між діями водія та виявленими несправностями гальмової системи транспортного засобу. Звернено увагу на можливі наслідки й особливості подальшого розслідування дорожньо-транспортної пригоди після визначення технічної достовірності показань водіїв.

Ключові слова: технічний стан транспортного засобу; експлуатація транспортного засобу; дорожньо-транспортна пригода; несправності гальмової системи.

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Declaration of Competing Interest

The author declare that he has no conflict of interest.

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