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FIRE INVESTIGATION

Abstract: The Higher Education Technical School of Professional Studies in Novi Sad is a higher education institution that celebrates its 60th anniversary this year. We educate our students at four departments: mechanics, protection, graphics and electrical engineering. In the current third cycle of accreditation of study programs for the period 2017-2023 we have accredited 10 three-year study programs at the basic studies and 7 one-year specialist study programs. Amendments to the Law on Higher Education [1], allowed professional master studies, accordingly, and in the framework of ERASMUS + project K-FORCE, in 2018 we accredited the two-year master study program Protection Engineering. The aim was to enable this study program to provide the vertical continuation of the education to our graduated students of the basic study programs: Protection against catastrophic events and fires, Safety at work and Environmental protection, as well as other interested candidates. Within the mentioned master program, there is a course Investigation of causes, phases and consequences of a fire, and within this lecture the goal is to present in general the material that is being studied in this subject.

Key words: combustion, fire, arson, fire investigation

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1. COMBUSTION

Materials in terms of combustibility (flammability) are divided into: combustible (flammable) and nonflammable (quartz, glass). Combustible materials can be easily flammable (paper) and harder to ignite (wool, hair, PVC). Hardly flammable materials burn while the ignition source affects them, and when it is removed, the burning stops [2].

Combustion is an exothermic chemical reaction between the combustible materials and the oxidizer in which a noticeable (significant) amount of heat is released, and often light as well. Combustible materials in gas, liquid and solid aggregate state can combust, if there are oxidizer (oxygen, fluorine, chlorine, ...) and heat present, the so-called fire triangle. The methods of ignition of substances are: piloted ignition by action of flame or spark and nonpiloted ignition (thermal ignition, autoignition), ignition by rising the temperature due to the inflow of large amounts of energy or enthalpy [3].

Gas combusts in a mixture with an oxidizer when its concentration in that mixture is between the lean and upper flammability limits (explosiveness). If the gas mixture contains exactly as much flammable gas and oxidizer as needed for complete combustion, it is called a stoichiometric mixture. Accordingly, no reactant is present in the surplus. An explosion represents a rapid release of energy and the increase of the pressure when the premixed flame expands indoors. Deflagration is the combustion of gas or explosive material at a speed lower than the speed of sound (340 m/s). It is caused by the heat transfer. The fires are mostly deflagrations. Detonation represents the combustion of gas or explosive material at speeds higher than the speed of sound (340 m/s), resulting in a shock wave that spreads in front of the flame, causing the compression of the gas it encounters, heating it and igniting it. The probability of detonation of some gas is higher in oxygen than in air [3].

The burning of liquid is actually the burning of its vapor, so the essential characteristic of the flammable liquid that determines its susceptibility to ignition, is the ease with which the liquid molecules evaporate to form a gaseous mixture with air, which lies within the limits of flammability. Therefore, the ability to ignite some liquid is related to the temperature at which the liquid is located. The lowest temperature of the liquid in which vapors are generated in sufficient quantity to ignite in the presence of an external source of ignition is called the flash point of the liquid. The concentration of the vapors above the liquid surface then corresponds to the lean flammability limit. At the flash point of the liquid fuel, when the vapors above the surface of the liquid are combusted, no further combustion of the liquid fuel has to be continued. The fire point of the flammable liquid is its important characteristic, and it is defined as the temperature of the liquid at which the sufficient amount of vapor is formed above its surface to continue the process of combustion of the liquid after the ignition started. With easily evaporative liquids, the flash point and fire point coincide, while for less evaporative liquids that are harder to ignite, the fire point is increased by 10 to 20 K. Division of liquids based on their flash point: Class I (< 38°C), Class II (≥ 38°C < 60°C) and Class III (≥ 60°C) [3].

Mechanisms of solid materials combustion: direct combustion - carbon and solid chemical elements (mainly metals) with high melting points and boiling points, such as Si, Ti, B, Zr, are combusted in this way, because they hardly evaporate, their hard surface is being combusted; combustion with a change in the aggregate state, the material first melts, and the resulting gas vapors are getting combusted (wax, paraffin, grease); combustion with the decomposition (pyrolysis) [3].

The decomposition process for solid fuels is called pyrolysis. If oxygen is not present, the process is called anaerobic pyrolysis. More often, the pyrolysis occurs in the air, when it is called oxidation pyrolysis. Anaerobic pyrolysis is endothermic. Oxidative pyrolysis is usually endothermic or thermally neutral. Pyrolysis usually stops when the heat source is removed or extinguished. Solid material pyrolysis requires heating of the material to a temperature at which chemical bonds begin breaking, including phase transformations, releasing of volatile compounds and molecular fragments. Combustion of solids in principle takes place in two phases. In the first phase, the combustion of gaseous products of decomposition of solid matter occurs, in the second phase the solid residue is combusted. The first phase is usually followed by flame, the size of which depends on the speed of the formation of gaseous products. The second stage of combustion is usually not accompanied by flame, or the flame is very small [3].

There are two ways of burning solid substances: flaming combustion and nonflaming combustion (smoldering or glowing combustion). Smoldering combustion occurs with porous materials in which the interior of the pores exothermally reacts with oxygen, and the released heat is not carried away with sufficient speed to the environment, but it additionally heats the material. For most organic solids, the ignition temperature is 270-400°C and self-ignition temperature around 600°C [3].

After the solid gets inflamed, when the flame begins to expand on its surface, two ways of further behavior are possible. One type of material, like wood and certain plastic materials, burn with forming on top of its surface a growing charred layer (charring combustibles). The second class of materials, which includes a large number of common plastic masses such as polyethylene, polystyrene and acrylic, burns without forming charred layer or forms it in a thin layer that makes the burning surface black, but never builds thicker charred layer (noncharring combustibles) [3].

Some flammable substances that are in the air in the form of dust can explosively combust under certain conditions. The dispersion systems of solid particles, according to the place of formation, are divided into natural dusts (not prone to explosion) and technical dusts (cement, plaster, flour). The ignition temperature of the cloud of dust assumes the lowest temperature of a single heated area at which the mixture of dust with air is ignited. The smoldering temperature of the deposited powder (dust) is the lowest temperature on the surface of the heated substrate which causes the ignition of 5 mm thick layer of deposited powder (dust) [4,5].

Mechanisms of heat transfer. Heat can only be transferred if there is a temperature difference and is transmitted in a direction in which the temperature drops. There are three basic ways of heat transfer: conduction, flow (convection, mixing), radiation. In the case of heat transfer by conduction and convection, the exchanged heat is directly proportional to the difference in bodies temperature, while heat transfer by radiation is proportional to the fourth degree of the absolute temperature of the warmer body, thus becoming the dominant mode of heat transfer at high temperatures [3].

2. FIRES

Fire is an uncontrolled, unwanted and destructive combustion [3,5]. The cause of fire is the way of the forming of the heat which caused the fire. Causes of fire can be: direct contact with flame or glowing material, electrical current (overheating of electrical conductors, short circuit, large transient resistance, sparking and electric arc, electric-thermal devices), static electricity (oil, rubber, paper, textile industries), natural causes of fire (atmospheric electricity discharge, earthquake, thermal effects of the sun), mechanical causes of fire (friction, pressure, shock), self-ignition (oils, coal, materials of plant origin - cereals, straw, hay), exothermic materials (thermal instability, self-polymerization, intra and intermolecular oxidation-reduction) [3,6].

When determining the cause of the fire and the way it is propagated at the scene, it is necessary to examine all the traces and examine the circumstances under which the fire occurred to determine the place where the fire first appeared. This place is commonly referred to as the center of the fire, which means that the fire first appeared in that place, ie in that place the burning process of the material began and the fire spread to the environment. The area by which the fire spread is called a fire scene [6]. Very often in statistical data, literature and official reports, statements are made that the cause of the fire is a children's play, a faulty installation, a construction defect, etc., which is wrong because it does not indicate the manner of heat generation. Namely, only the fire risks are stated, but not the cause of the energy occurrence which caused the fire [7].

External fire manifestations indicate the quality and quantity of the burning material, as well as the phase in which the fire is. Here, especially important are: color and flame size; quantity, density and color of the smoke; smells before fire, during fire and during the investigation; quantity and appearance of particles of the char; sounds (breaking, cracking, explosion) [6].

According to the area in which they occur, fires can be outdoor and indoor, as well as on the means of transport. The characteristic of wildfires is large spatial coverage, spreading speed, possibility of sudden change of direction, the ability to "skip" obstacles such as roads, rivers, fire protection belts. In addition to forest fire, wildfire sub-determinations are also: brush fire (a fire which "cleans-brushes" the vegetation off the terrain), a bush fire (the fire of bushes, shrubs, macchias), desert fire (the fire of the desert regions), grass fire, (fire of the grass terrains), hill fire (fire of hilly terrains), peat fire (fire of peat), vegetation fire (fire of vegetation), veldfire (fire of South African meadows). These also include the fires of cereal fields and stubbles [8,9].

In the enclosure of residential, commercial, public, industrial and other facilities there are different types of materials, each of which is behaving differently in fire, however, all these fires go through the same stages of development: burning, spreading, flashover (fire jump), blasting phase, fire diminishing. The availability of oxygen determines whether the fire will develop in this way, and to what extent, or will it extinguish by itself [2,3]. The average time from ignition to flashover in residential buildings in 1950 was 25 minutes, but today it is only 3 minutes [10].

The fires of means of transport include fires on means of transport for passenger and freight traffic (road vehicles, trains, planes, ships), as well as fires in construction, agricultural and machinery in other branches of industry. The largest number of fires occurs on road vehicles, and in this category mostly on passenger cars [6,11].

3. MATERIALS BEHAVIOUR IN FIRE

Based on the appearance of certain materials after the flame and high temperature cease to make effect, we can conclude what kind of processes took place during the fire, detect the phases of the fire, where from the fire was transmitted, and thus reach the place where the combustion began. Additionally, it is necessary to take into account the conditions for air supply, draught or artificial ventilation [6].

Wood belongs to a group of solid combustible materials. The degree of flammability of wood depends on the type of wood, the processing of the surface, the size of the pieces, the humidity. It is ignited at 250-300°C. On the wood surface, during burning, a charred layer that has thermal-insulating properties is formed and for some time it slows the burning down. This layer is similar to the crocodile skin, so it is called by this name. The prolonged action of the fire makes the cracks on the wood deeper, and the pieces of "crocodile skin" superficially more tiny and distinctive where the fire lasted longer, ie closer to the center of the fire [6].

Ordinary glass belongs to nonflammable materials. In the event of a fire, glass usually cracks quickly due to thermal shock and can not be considered as a fire-resistant material. With the use of borosilicate and multilayer glass with high temperature resistant intermediate layers, the behavior of glass in the fire is significantly changed, so the glass has become one of the materials that can be used as a fire barrier [6,7].

Brick (terracotta) is still widely used in the construction of buildings. It is obtained from clay which is processed by special procedures, and then by using the machines it is formatted and baked in ovens at a temperature of about 900°C. Temperatures that usually occur in fires, brick can withstand because its melting point is about 1200°C and therefore there are no major damages and deformations in the fire. The bricks are connected and coated with mortar used for masonry, which, as a rule, should have poorer mechanical characteristics than ceramic products. So, mortar will allow a certain (limited) expansion of individual ceramic elements during heating, thus delaying the moment of partial or complete cracking of the ceramic blocks, and lateral wall distortion [6].

Stone is the oldest natural construction material. The natural stone used in the construction can be: sedimentary rock (limestones, dolomites, sandstones), metamorphic rock (marble), magmatic rock (granite). Granite cracks occur already at a temperature of 500-600°C, and at a temperature of 800°C, the elements for which the granite is used are ruined. Limestone begins to crack at about 600°C, and at a higher temperature it breaks down [6].

Concrete is a mixture of cement and aggregates (sand, gravel, ...) with water. Above 500°C, ordinary concrete begins to peel off as a result of a change in structure. In the case of reinforced concrete at temperatures of 400-600°C, the changes reach a critical size and constructions collapse [6]. The color of the concrete indicates the temperature it was exposed to during the fire, and the load capacity of the concrete structures should be tested before returning them to use [7,12].

Lime mortar which is obtained through a mixture of slaked lime, sand and water, is considered to be an effective fire protection agent. Due to water releasing at elevated temperatures (about 530°C), there is destruction, resulting in the smaller or larger pieces of mortar peeling off, thus leaving the walls bare and exposed to direct fire effects. By tracing these traces, the direction of the spread of fire can be determined [6].

Steel is very unreliable from the aspect of fire protection, if it is not protected. Unprotected and fully loaded steel elements remain stable on fire for 15 to 30 minutes. In the event of an increase in temperature, especially in fire conditions, the mechanical properties of the steel are significantly changed, which can cause the wear of the steel structure to be depleted at a temperature of about 600°C. On the surface of the steel objects present in the fire, a color appears indicating the temperature they were exposed to [6,7].

Plastics (synthetic polymeric materials) belongs to a group of modern construction materials. In addition to a series of good properties, their biggest drawback is that in the event of a fire, they intensively burn with the production of very dangerous combustion products [6,7].

In the Republic of Serbia, construction products and components are classified according to the standard SRPS EN 13501-1: 2019 [13].

4. FIRE TRACES

Traces of combustion at the door always indicate in which room the fire was active. The side of the door which is more burned indicates the direction of movement and the center of the fire, provided that the external factors did not affect the spread of the fire. When there are no traces of fire effect at the joint between the window wings and the window frame, this indicates that the window, or door, were closed, otherwise with the open position the traces of the fire activity are clearly visible. During the fire, the glass parts of the door and windows are cracking or melting. The glass parts are inserted into the grooves and when the cracking or melting occurs, these grooves remain filled with parts of the glass, which is not the case in deliberate breaking, because the person who deliberately sets the fire provides himself a passage and most often moves the parts of the glass from the frame in order not to get hurt. Then the fire leaves traces on the parts of the groove in the form of a soot or char. Bearing in mind that the melting temperature of the glass is about 770°C, a broken and melted glass is always found at the place of the fire. With glass breaking due to impact, there appear fissures that are much longer and more distinctive than those resulting from the heat, a star-like fracture. Also, the layers of soot on the glass may indicate whether the glass was broken before the fire or due to the fire. During the thunder strike, round openings can be found on the glass. The position of the latch of the lock at the moment of the ignition and duration of the fire should always be checked. If the latch is clean (not sooted), the doors were locked before and during the fire [6].

Paper can intensively burn, which depends largely on the shape of the packaging. In the case of a paper of stacked sheets such as books, archives, rolls of paper, the direction of fire spreading is noticeable, because surface damage occurs due to the lack of oxygen in the combustion of cellulosic substance. Here, the traces of burning will be deeper and more pronounced on the side that was first affected by the fire. In the case of paper waste, that is paper in a loose state, then the combustion process is carried out intensively to full combustion, so arson should be suspected [6].

Metal structures have a great application in construction, and are also used as partitioning elements, roof or support structures, for the construction of columns, slabs, in some cases, complete supporting structures are made of them. On the basis of the degree of load and deformation on metal structures, it is possible to determine with certainty the exact place of the outbreak of the fire, that is the room in which it was created. The greatest deformations on the metal elements occur due to the action of heat in places near the center of the fire, or at the very site of the origin of the fire [6].

Traces in the vicinity of the fire site. In the vicinity of the fire site, a large number of traces that are directly or indirectly related to the cause of the fire can be found, such as foot marks, tire marks, objects from the facility, parts of the facility, parts of the devices and installation, various containers in which flammable liquids for acceleration of the fire were kept and other things as well. Traces surrounding the location of the fire can appear there also intentionally in order to mislead the person identifying the cause of the fire [6].

Traces of fire from the outside of the building. One of the most important traces on the outside is the existence or absence of a stack of soot above the holes (windows, doors), the so-called flue gases halo. Flue gases halos are formed only if the combustion process takes place in an enclosed room, which assumes a room with a impermeable ceiling. By the combustion of combustible substance, the combustion products that over time create some overpressure in the room are released. Being warmer, the combustion products fill the upper parts of the room and due to the overpressure, they tend to exit, so they encounter the first cracks above the windows and doors where they then come out. On the outer walls of the object, which are colder, the condensation of damp combustion products takes place and consequently the soot deposits are formed. The formation of flue gases halo will not occur if the fire first outbreaks in the attic space of the building, and then is transferred to the inside of the building, because in this case, after the demolition of the ceiling construction and the transfer of fire into the interior of the room, flue gases as warmer freely flow through the demolished ceiling construction. If in a building there are flue gases halos above a number of windows and doors, this indicates that the fire was transferred from the room to the room through the openings by which they were connected, in which case the fire broke out in the room above which the flue gases halos are most intense, or if in the same room there is a greater number of openings, then the place of fire is in the vicinity of the opening where there are the most intense haloes. It must be considered here which material was burning because the intensity of the flue gases halos can be misleading if the burning material was releasing a large amount of flue gases such as rubber or plastic, as well as weather conditions (wind speed and direction) [6].

Traces on the inside of the building. After the cessation of the fire, it is concluded what processes were taking place in it, which is concluded by the appearance of certain materials. Based on the appearance of the material, the phases of the fire are determined, as well as the direction of the fire (its transfer), the place of the start of the combustion, ie the center of the fire. The place of the outbreak of the fire is determined by the degree of damage of the material that was in the fire, by comparing the damaged material with the material which the fire did not affect, based on which it is determined where the fire started and what was the direction of its operation. After comparing the material and parts of the building affected by the fire, other factors that influence the combustion flow, which include the supply of air, the composition of the combustion products, the thermal value of the surrounding material, the fire load, are assessed [6].

5. ARSONS

If it is found that there are highly flammable substances in the hot spot, this can serve as a strong indication, and perhaps also as a proof that the fire had been deliberately set. The suspicion is even greater if these substances are not normally located in such facilities. Fires caused by the candle as a source of ignition leave traces of paraffin, stearin, wax, wick and other materials from which candles are made. On both the suspected person and his/her clothes the traces of easily flammable liquids, that is, paraffin, stearin and wax can be found, as well as general traces indicating their presence at the place of fire (earth, dust) [6,14].

Arsons are intentional or criminal fires that are caused by conscious or deliberate human activity, from various initiatives, to different objects and in different ways. Motives are usually: revenge (hurt pride, jealousy, envy), self-interest (payment of insurance), vanity, concealment of crimes (murder, theft) [6,14]. Arsons are often performed by persons in an alcoholic state, as well as by persons on the social and economic margin of society [6,15].

Criminalistic division of the causes of fire: natural (lightning, earthquake, solar energy), accidental - unintentionally caused by human guilt (children's play, cigarette but, failure to comply with fire protection measures, construction deficiencies - poor performance of electrical and gas installations, flue ducts), arsons (intentional or criminal fires) [6].

In order to determine the cause of the fire, sometimes the reconstruction of the event has to be made. Reconstruction of the event occurs in cases where the investigation has not been thoroughly carried out and is performed in order to re-investigate all the circumstances under which the fire occurred. Examination of certain circumstances is called an investigative experiment. It should be particularly emphasized that the same conditions must be achieved during the investigative experiment, that is, the same materials, the same temperature, humidity, working conditions, radiation, etc. should be used, which is quite difficult. If the conditions are not identical then the reconstruction of the event will not be successful. Reconstruction of the event can be done only in objects that the fire did not completely destroy [6].

Fire and arson are mentioned in the Criminal Code of the Republic of Serbia in the following articles: 204 (severe theft during fire), 278 (causing general danger by fire for humans and property by acting or ignoring protection measures), 285 (who does not report a fire or does not take remedial measures), 286 (who acts in an unauthorized manner with flammable and explosive material), 313 (jeopardizing of the constitutional order and state security through arson), 326 (non-participation in the elimination of general danger), 344a (bringing pyrotechnics, flammable, explosive materials to sports events and public gatherings), 351 (abuse of the aid sign and danger sign), 391 (causing fire out of terrorist initiatives), 414 (theft of arms and a part of a combat agent) [16].

6. METHODS OF ANALYSIS IN THE EXPERT INVESTIGATION OF FIRE

In criminological-technical expert investigation the physicochemical methods that very accurately and precisely provide data on both the qualitative and the quantitative content of the individual elements of a trace sample are applied. The qualitative composition of the substance, in the chemical sense, can be inorganic and organic. In the first case, the basic feature represents its microelement composition, and in the other the content of characteristic groups (functional groups) [17].

Spectroscopic (spectrometric) methods are based on the capacity of atoms and molecules to emit radiation of a certain wavelength when they are brought into an excited state or absorb radiation of a certain wavelength when this radiation is passed through a sample of a material. Depending on the origin of the radiation being examined (emitted, absorbed or reflected), the following is distinguished: emission, absorption and spectrum of reflected radiation (reflection spectra). Each type of atom emits only the predefined wavelengths of electromagnetic waves. Each atom can absorb only electromagnetic radiation of the wavelength that it is capable of emitting. Regarding the reflected-radiation spectrum, it should be kept in mind that the substance reflects those waves that it does not permeate and does not absorb. A set of waves of different wavelengths that a sample emits, absorbs or reflects, as well as its graphic scheme, is called a spectrum. Each spectrum of electromagnetic radiation carries information on the chemical composition of the substance that emits it, absorbs it or reflects it [17].

Atomic emission spectrometry. After the excitation of the specimen, the atoms present give characteristic spectra in the visible part of the electromagnetic spectrum, including the near UV zone, on the basis of which the atoms present are identified, ie the elemental composition of the sample is obtained. Laser microspectral analysis works on the same principle, but on smaller samples. The analyzed fragment of the object is observed under an optical microscope, with the magnification of 500×, and then the atomization of the sample is carried out by the laser beam, followed by the excitation, and the result is the emission spectrum of the present atoms. Due to the destruction only of the point on the surface of the sample, this method is considered practically non-destructive [17].

Atomic absorption spectrometry is used for the quantitative analysis of the target chemical element of metal in the sample (mercury, arsenic, lead), based on the absorption of the characteristic wavelength of light [17].

Infrared spectrometry is based on the absorption of infrared radiation by the characteristic functional groups in the molecule, due to the vibrational movement of the present chemical bonds. Infrared spectrometry is used in criminalistic technique to identify various substances of organic origin such as: drugs, explosives, petrol, petroleum and other fuels, grease, adhesives, various poisons, insecticides, paints, varnishes [17,18].

X-ray fluorescence analysis is based on the ability of the atom to absorb X-ray radiation which results in electrons being excited from the inner part of the electron shell. In doing so, the transition to the basic energy state is characterized by the emission of the radiation of approximately same energy as in the incoming (primary) radiation that caused the excitation. Namely, it is about the X-ray fluorescence, whose wave length is characteristic of the atom that emits them. Based on the emitted spectra of X-ray fluorescence, a unambiguous element identification can be performed. X-ray fluorescence analysis is used in the criminalistic technique for the analysis of pure metals, alloys, various mineral substances, powder materials, molten materials, liquids, various substances of organic origin [17].

X-ray diffraction analysis. The arrangement of atoms in the crystalline substance forms the flat surfaces of different positions and mutual distance. If a beam of X-rays is directed to these crystals, then they will reflect from these flat surfaces in different directions. There is a bending of light - diffraction. On this occasion there occurs the appearance of interference, that is, concurrence (mutual amplification and attenuation) of X-rays when passing through crystalline flat surfaces, which practically means that a part of the incoming radiation is dispersed to a plurality of interdependently separated rays. Each crystalline substance has its own specific arrangement and intensity of the traces of diffraction, which means that, based on the appearance of the diffraction image, each crystalline substance can be identified individually. Unlike spectral methods, with the help of which the identification of the individual elements from the composition of the material traces is performed, by the method of the X-ray diffraction analysis the identification of chemical compounds is done. It is used as a supplement to spectral analysis, especially when it is necessary to determine the composition of the most complex chemical compounds. It is used to distinguish the primary from the secondary short circuit [6,17,18].

Neutron activation analysis is based on artificial radioactivity, ie a phenomenon that occurs when an element is bombarded with alpha particles, beta particles or neutrons. In this situation, neutrons easily penetrate into a nucleus of atoms causing the instability of the decaying nucleus, thereby making it artificially radioactive (the excited state of the atomic nucleus). Each radioactive element has a certain time to disintegrate, the so-called "half-life", which represents a characteristic size for each element in nature. It is this size that has been used in criminalistic technique for determining the elemental composition of micro traces. This is one of the most sensitive and most reliable instrumental analytical methods for determining the qualitative and quantitative elemental composition of a substance with minimal damage to the sample, but it is quite expensive. In criminalistic laboratories of highly developed countries, it is widely used for determining the distance of shooting, identifying the human hair, as well as for determining the presence of an element in samples of different traces [17].

Gas chromatography represents a method of separating and detecting of volatile organic compounds and some inorganic gases out of the mixture. The ingredients of the mixture are forced to move, whereby, on the basis of chemical similarity, they are distributed between the two environments (phases) out of which one is mobile and the other is immobile. The mobile phase is an inert gas moving through a glass or steel tube (column), in which there is a stationary phase, which can be liquid or solid. Because of the different affinity towards the substrate, the sample components move at different speeds, coming up one after another until the exit from the column. At the exit from the column there is a detector that detects the components according to the sequence of their exiting and it is registered through the recorder (this record is called a chromatogram). Depending on the concentration of the particular ingredient, the higher or lower, or narrower or broader peak will be drawn on the chromatogram. Each peak on the chromatogram corresponds to a particular compound from the test mixture which takes some time to pass through the chromatographic device (so-called retention time, ie the time of retention of the compound in the column). On the basis of the retention time, it is not possible to perform unambiguous individual identification of chemical compounds, since the retention times of different compounds may be similar or coincide. Today, this problem is overcome by connecting a gas chromatograph to a mass spectrometer, whereby further analysis of a compound from a mixture is carried out using the mass spectrometry method. In the criminal investigation, materials of different origin can be analyzed using the gas chromatography method, and this method is most often used for toxicological analyzes of various drugs, narcotics, pesticides and other poisons, as well as for determining the composition of traces of fires, explosives, fats, oils [17,18,19].

Mass spectrometry represents a physicochemical method used in criminalistic laboratories for the identification of organic substances based on the mass spectrum, which is characteristic and specific for this compound. The sample is bombarded with a beam of charged particles (electrons, ions) that cause ionization of the molecules by transforming it into ion. A portion of these molecular ions, due to high energy, is further decomposed (fragmentation) into characteristic ions of smaller molecular weights. All the obtained fragment ions from the test sample are classified in the analyzer according to their mass, ie according to the mass and charge ratio of ions. Thus separated, they come to the detectors where they are register in the form of a mass spectrum, which is characteristic of the test sample. The entire system connects to a modern computer system in the memory of which the database with mass spectra of various organic compounds is contained, so that the data obtained for the tested compound is computerized and compared with the database, which results in the identification of an unknown substance in a very short time. In the field of criminalistic-technical investigation, the mass spectrometry method has wide application in the testing of drugs, poisons of organic origin, synthetic materials, fibers, explosives, highly flammable liquids [17,18].

It is a very delicate process to identify dead bodies which are mostly, or completely, carbonized. High temperatures destroy most of the identification features of the human body, so at present the method of analysis of the DNA (deoxyribonucleic acid) residues of bones, teeth, hairs and similar cellular material is applied [14].

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8. TEST FOR STUDENTS

1. Combustion reaction is? a) exothermic b) endothermic

2. If a liquid has different flash and fire point, which one is lower?
   a) flash point b) fire point

3. Pyrolysis is? a) exothermic b) endothermic

4. Three mechanisms of heat transfer are:

   ____

   ____

5. What is the cause of fire?

   ____

   ____

6. What is the center of the fire?

   ____

   ____

7. Arsons are? a) intentional fires b) unintentional fires

8. List some motives for arsons?

   ____

   ____

9. Which physicochemical method of analysis is most often used to identify flammable liquids at the fire scene?

   ____

   ____

10. Which method of analysis is most often applied for identification of dead bodies at the fire scene at present?

    ____

    ____