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The Proposal of Methodology to Investigate the Passenger Cars Fires

The paper deals with investigating the fires of passenger cars. In general, in the last decade, the main causes of these fires were arson. Based on the developed proposal of methodology for investigation the cause of car fires, the entire process is described together with the individual steps necessary to identify the causes of fire initiation, while the appropriate conclusions are drawn.

Keywords: fire, fire investigation, methodology, passenger car

Introduction

The Slovak Republic ranks high in the production of passenger cars in Central Europe. It is mainly due to the existence of three automotive companies: Volkswagen Slovakia, PSA–Peugeot Citroën and Kia Motors Slovakia. Generally, the boom of cars is connected to the increased risk of passenger car fires, as it is recorded in the statistics of light passenger car fires and their share of total fires in the Slovak Republic, which has had an increasing tendency for the last 15 years. Currently, the intentionally set passenger car fires is one of the main causes of car fires in a global perspective. These fires are particularly difficult to investigate and identify the cause of their initiation. In terms of fire investigation, it is still necessary to improve the particular methodologies of fire investigation that are applied at different stages of the investigation by the fire investigators of the Fire and Rescue Service (FRS). The methodologies for investigation passenger car fires are especially complex, because often the whole car burns down totally, especially in case of intentional fires.

Problem

The methodology of car fire investigation is a complex system, which is applied according to the type of car, fuel, and particularly the materials used in the manufacture of the car. The materials used in the manufacture of older cars clearly show a much faster progress of car fire initiation. Currently, in car manufacturing the use of flame retardant coated materials has increased, therefore the rate of the fire propagation of newer cars is lower. Many

experts dealing with intentionally set fires agree with the notion that most of the intentionally set car fires were initiated by a flammable liquid. With petrol as a fire accelerator, we meet often. [1] In intentionally set fires, the arsonists use the commercially available flammable liquids. Besides gasoline, they use acetone, synthetic diluent, Molotov Cocktails, kerosene, petrol, technical gasoline, methanol, toluene and their mixtures. [2] Several scientific works deal with car fires and the use of burning accelerators by documenting the fire place, measuring the temperature of a fully developed car fire [3] [4], finding electric shortcut as a fire reason; they also subsequently model them using software, and express the need for training in this area. [5] [6]

The passenger cars contain an extensive scale of combustible materials and ignition sources. Due to the increase in severity of the damage, there is sometimes difficult to tell apart the sources of ignition from the first firing material (cause), heat sources that were not the cause of a fire and secondary materials (consequence). Modern passenger cars contain many electrical sources in the dashboard, doors, seats, ceiling of the passenger compartment and floor. Engine compartment and the passenger compartment are separated by a vertical steel panel. The panel is perforated with holes for the passage of cables and other components, thereby in the passenger compartment there are more ignition sources and the possibility for the fire to spread is higher. In a fully developed car fire it is difficult to say whether the fire has spread from the engine into the cabin, or vice versa. [7]

In the process of investigating the fire, first it is determined the place of the fire, and then its cause. [8] Often, the fire place is determined with precision, but the cause remains unknown. The investigation of the exact causes of fires is influenced by many negative factors, e.g. high temperature (in a car fire the temperature reaches c.a. 1000 °C) that destroys and distorts all evidence and traces. [9] The temperature progress in car fires (Figure 1) is described in a work, where the author speaks about temperatures above 1000 °C. [10] A researcher, who dealt with the thermal decomposition of tires, described the temperature progress but only a temperature up to 550 °C was recorded. [11] Of course, the evidence is usually destroyed not only by the action of high temperatures, but also during rescue work, extinguishing the fire with water flow respectively. [12]



Figure 1. Temperatures recorded in car fires

To localize the place of fire and determine its cause, they frequently use the patterns of traces after the fire on the bodywork of the car, or on the frames of the car, as well as in the interior of the car. Similarly to fires of building constructions, the same general procedures are used in case of car fires. Whenever possible, the car should be investigated at the scene. [13]

As the fire is reported, the sooner the fire investigator arrives at the place of fire, the better he will ensure taking important evidence that could be destroyed in the fire-fighting operation. [14]

Investigation of cars after a fire is a complex and multifaceted activity. As in the case of fires of building constructions, the first step is to determine the place of fire. Most vehicles have three major spaces: engine compartment, passenger compartment or the car interior and cargo space, the boot respectively. Exterior investigation may reveal important traces after the fire. Location (exact place) of fire and the way of reaction, e.g. windscreen, may assist in finding the area of a fire initiation. The fire in the passenger compartment typically causes damage to the top of the windshield and leaves radial traces of burning on the ceiling of the car cabin. [13]

Objective

The objective of the paper is to propose a methodology of car fire investigation, applicable in practice by the fire investigators of the Fire and Rescue Service (FRS) in Slovakia.

Methodology

The proposal of methodology to investigate the causes of car fires stems from the legal regulations and practical experience of fire investigators, operating at different levels in FRS in Slovakia, based on the specification of certain tasks and description of fire investigation procedures as a complex of activities carried out, required to produce a comprehensive conclusion on setting the cause of the car fire. [15]

Results and Discussion

The proposal of the methodology of fire investigation can be easily described and displayed by the diagram below (Figure 2).

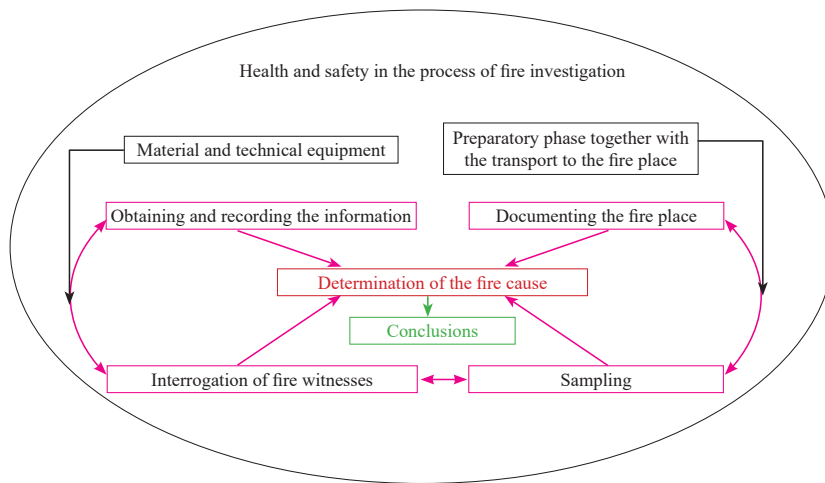


Figure 2. Diagram of the proposed methodology of car fire investigation

Based on the information available, and because the process of car fire investigation is too complex, the description of the methodology should be divided into various sub-parts linked to each other directly, i.e.:

- Material and technical equipment
- Preparatory phase together with the transport to the place of fire
- Health and safety in the process of fire investigation
- Obtaining and recording the information
- Documenting the fire place
- Interrogation of fire witnesses
- Sampling
- Determination of the fire cause
- Conclusions

Material and technical equipment

Fire investigation, in addition to the knowledge on this field, requires the tools with which the various operations are carried out. Such tools are the material and technical equipment of the fire investigator. To correctly determine the cause of fire is essential to have the following material and technical equipment:

- professional camera with tripod,
- camera,

- laptop with internet connection,
- dictaphone,
- tools for work and sampling,
- Personal Protective Equipment.

Preparatory phase together with the transport to the place of fire

The preparation of the fire investigator should be based on implementing the measures that are used in the operational-capability of resources and material and technical equipment which he uses in the process of investigation. The preparation of material and technical equipment is also included.

After the announcement of a car fire to the coordination centre of the Integrated Rescue System (IRS), the rapid departure of the fire brigade is very important. In the current legislation, the time for the fire brigade to depart from the fire station is set to maximum of one minute. Nonetheless, the car fire has a fast progress. The rapid extinction of a fire and the salvage of the car values are affected by two factors. The first one is the early announcement of a fire in the initial fire phase and the second one is the rapid intervention of the fire brigade. To avoid the loss of any significant evidence, the fire investigator should, where it is possible, come to the fire place as soon as possible, together with the fire brigade respectively. In order to get to the fire place he should use the assigned service car, in rare cases he could use a private car.

After the arrival at the fire place he should observe the fire progress, important facts and behaviour of the fire witnesses. It is essential to carry out the necessary operations at the time when the unit fights the fire. After the intervention, using different methods, the fire investigator searches for forensic sources, where the fire was initiated respectively, while it is important to document all the steps.

Health and safety in the process of fire investigation

The fire investigator must pay special attention to his health and safety in the process of investigation of the fire causes. The procedure of a comprehensive examination of the car includes various safety hazards. An important factor in protecting the lives and health of the fire investigator is the personal protective equipment and safe work procedures. Since the fire investigator may be located at the fire place simultaneously with the intervening fire brigade, he must be equipped with personal protective equipment (PPE) just like the fire-fighter, who carries out the fire-fighting activities. The fire investigator should be provided with these basic PPE:

- fire-fighting clothes,
- fire-fighting boots,
- protective helmets,
- gloves,
- rubber, resistant to chemicals, gloves,
- protective working shoes,
- hearing protectors – headphones
- coats against rain and moisture,
- vests – with reflective stripes,
- goggles, face shields,
- anti-vibration glasses,
- rubber boots (Order no. 32/2016).

Regarding the safe working practices in car fire investigations, it is very important to follow the fundamental principles of health and safety at work. Before the fire investigator starts to investigate the car from the bottom, he must verify whether it is adequately secured against movement to avoid injury. It is necessary to combine the use of hydraulic lifts, jacks or other devices used to keep the weight of the car with the locking means of appropriate equipment to prevent sudden movement of the car or its fall on the fire investigator. Potential serious risks to the safety of the fire investigator are the inactivated airbags (supplementary restraint systems). Sodium acid, the propellant for the airbags in older cars is also dangerous and getting in contact with it or its inhalation may represent a potential health hazard for the fire investigator.



Figure 3. A passenger car in fire and after it [Pantya P., 2015]

The fire investigator must be able to identify the systems present, know the operational status of these systems and, where it is necessary, to know how these systems can be turned off before investigating the car to prevent their accidental opening. Inspection of the burned-down car can bring many other situations that endanger the fire investigator. This includes e.g. leakage of fuel or residuals of fuel in the tank (which is a fire risk), leaking grease (the fire investigator can slip and fall), the risk of electric shock (e.g. from

the battery, high-voltage systems in hybrid cars respectively), broken glass (it can cause injury), etc. [13]

Obtaining and recording the information

To obtain and record information directly at the fire place, it is essential that the fire investigator collects and registers information necessary for the purposes of further examination and determination of the cause of the car fire. We can divide them into three groups: basic information, information on the car and information on the fire.

- *Basic information*
 - Municipality
 - Address (location) of fire incident (e.g. highway, road, side road, forest road, garage, workshop, garden, parking and other)
 - Date of observing the fire
 - Date of announcing the fire
 - Time of observing the fire
 - Time of announcing the fire
 - Ownership (private, official, undetected)
 - Owner (name and surname, date of birth, residence)
 - Direct damage
 - Salvaged values
 - Injuries
 - Killed
 - Number of fire damage (other) cars
 - Passengers closed in the cabin
 - Technical intervention of fire brigades
 - Car equipped with portable fire extinguishers
 - Use of a fire extinguisher
 - Car insurance (mandatory, accidental)
 - Insurance company
 - In the case of an accident, the data on other participants of the accident.
- *Information on the car*
 - Producer
 - Model, type
 - Registration number of the manufacturer
 - Year of manufacture
 - Validity of the technical and emission control
 - Bodywork (hatchback, combi, pick-up, cabriolet, coupe, others)

- Number of doors
- Colour
- Evident damage to the car – not caused by the fire (broken window, levered parts of the bodywork, wrapped rag to a wheel of the car, etc.)
- Motor fuels (petrol, diesel, LPG, CNG, el. energy, other)
- Fuel system (carburettor, injection, turbo-blower, compressor, other)
- Setting on motion switch position at the time of the fire (switched-on, switched-off)
- Fuel tank (metal, plastic, other)
- Fuel pipeline (metal, plastic, rubber, other)
- Transported materials – Cargo
- Additionally mounted equipment.

To obtain the information on the car would help to have a database of cars with a detailed technical description directly from the individual manufacturers. The reason is simple. Many times, during a fire, it is not possible to identify the particular components of the car. That database would assist in identifying and storing the equipment, which may cause fire (alternator, batteries, starter, safety box, cigarette lighter, etc.). The database also should include a detailed description of the car and its equipment (heated seats, electrically adjustable seats, electrical opening of windows, lights, electric side mirror adjustment, type of setting on motion switch, etc.).

- *Information on the fire*

- The space that began to burn at first (engine, dashboard, the passenger compartment, cargo compartment, brakes, wheels, unknown, other),
- The part that began to burn at first (starter, alternator, carburettor, fuel distribution, fuel pump, heating, air conditioning, electrical installation of the car, ignition switch, appliances, apparatus, etc.),
- Type of fire (activity), under which it occurred (accident, collision, maintenance, repair, intent, during driving, in setting in motion, parked in the garage, parked in the parking lot),
- Source of ignition – initiator (electrical short circuit, high contact resistance, overloaded wiring, heat from parts of the car, the temperature of the tools, cigarette lighter, cigarette, another car, not detected, other),
- Substance (material), which determined the development of the fire (fuel, upholstery, luggage, unidentified, other).

Documenting the fire place

A part of the static inspection of the fire place is its documentation. Proper documenting, photographing and video recording is a key element in the process of investigation. The fire investigator, on situational drawing of the fire place must mark the reference points and their distance to the car. The drawing shall be sufficiently detailed to be able to accurately mark the location of the car, prior to the time of its departure. It is necessary to take a photograph of the entire crime scene, so that the surrounding buildings, road construction, vegetation, or other cars and tire imprints, or traces of shoes could be seen and observed. They must also document any damage caused by the fire on any of these objects or spilled fuel and other matters, which are apparent in the visual inspection of the crime scene and can serve to further analysis of the spread of fire. The car is required to be photographed in a proper and consistent manner. Photographs should be taken on all sides, including the top and bottom. It is necessary to capture the damaged and undamaged sides, including damage to the interior and exterior of the car, all evidence of the direction of fire spread, either from the outside of the car or the inside (engine space, passenger compartment, boot, cargo space, etc.). It is also necessary to photograph the storage space for cargo and transported materials. The crime scene must be also documented after the removal of the car, focusing especially on burned areas on the ground or on the road, as well as the position of glass and other debris. Photographs must be supplemented by drawings and notes. [13]

Interrogation of fire witnesses

A key element in the process of investigating the causes of car fires is the interrogation of witnesses. Interrogation of witnesses should be led by the fire investigator with the help of police officers. Proper statements of witnesses will help to confirm or deny possible (verified) causes of the fire. The most important question at the interrogation should be: where or in which part of the car a witness observed the fire. According to witness statements and observed traces, the fire investigator, applying the exclusion method is able to determine the cause of the fire. Interviews with persons who witnessed the early stages of the fire development can help the fire investigator to narrow the space of the origin of the fire and that one must subsequently be subjected to more detailed examination.

Sampling

If it is not possible to directly determine the cause of a fire, it is necessary to apply sampling. If there is suspicion of the use of flammable liquids, the procedure is as follows. A police dog, trained to search for fire accelerators, is sent to the fire place. If the fire accelerator was applied, the dog marks the place of application with a high probability. Thus, the identified place is ensured by the fire investigator, who takes the samples for laboratory testing next. Before sampling, it is important to photographically document the actual condition and the place which is part of the expertise examination. Flammable liquids are collected in airtight containers because they are usually volatile. We consider adequate packaging the glass bottles with threaded or airtight bags. High temperatures during the fire may cause evaporation and the burn-down of the flammable liquids, it is therefore difficult to take a sample of them in liquid form. Then, it is necessary to take such porous material (wood, textiles, soil, debris, etc.), in which the flammable liquid is likely to soak up. The materials are collected and hermetically sealed in the polyamide bags specified to be used for samples.

In taking and packaging samples for laboratory examination, it is important to ensure that they will not be tampered by secondary damage. It should retain their original condition and material composition. It is also important to take from the fire place the samples which were not contaminated with fire accelerator for comparison with the contaminated ones. The taken sample must be sent or personally delivered to an accredited laboratory for detailed examination.

Determination of the fire cause

Determination of forensic focus and determination of the cause of the fire is the main task of the fire investigation. We consider the completely burned down part, or the part that is most damaged by fire, respectively the forensic focus of the fire.

Determining the cause of the fire is based on the knowledge acquired during the fire place inspection and documents received at the time of preparing the report (survey) about the cause of the fire. He applies the information on the presence of persons and the operations taken immediately before fire ignition in the place, near the place of fire ignition respectively. To correctly determine the cause of the fire, it is necessary, from the beginning, to work with multiple possible versions about the cause of the car fire.

From a legal point of view, in the final evaluation and determination of the cause of the car fire it is necessary to indicate the most likely determined cause.

Summary

The task of the fire investigator is to determine the cause of the fire as closely as possible. In case it would be found that the car was intentionally set on fire, the police force takes over this incident and addresses it as a crime.

The fire investigator, be it a technical malfunction, or intentional setting on fire of the car, records the information on the fire in a computer program for the purpose of archiving and statistical evaluation.

Conclusions

In general, fire investigation is a very complex process. However, car fires are much more complicated, because of the smallness of the space, the many ignition sources and volume of materials with different fire characteristics that affect the entire process of the burning of a car. Based on the elaborated proposal of methodology for investigation of passenger car fires, it is possible to observe the entire process of the fire investigation, starting with the collection of basic data, through realisation of required operations to be done at the fire place, to sampling and specification of the most likely fire cause and ending in conclusion of the investigated fire by the fire investigator. And the education of fire investigators, not only on the field of automotive techniques and technology, largely depends on the number of successfully concluded car fires.

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Javaslat a személygépkocsi tüzek tűzvizsgálati módszertanára

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A cikk a személygépkocsitűzek tűzvizsgálatára irányul. Általában az utolsó évtizedben a személygépkocsitűzek esetében megjelent a szándékos tűzokozás égésgyorsító anyagokkal. A javasolt tűzvizsgálati módszertan alapján ismertetjük a vizsgálati eljárás teljes folyamatát azokkal az egyedi lépésekkel, amelyekkel felderíthető a tűz keletkezési oka és arról következtetések vonhatóak le.

Kulcsszavak: tűz, tűzvizsgálat, módszertan, személygépkocsi