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Fire Incident Caused from Electrical Installations: Case Study – Fire as Result of Short Circuit

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ABSTRACT

Electrical installations, which are very essential for modern living, can also pose significant fire risks when improperly designed, installed, or maintained. This paper explores the various causes of fires originating from electrical systems, including faulty wiring, overloads, and equipment failures. The discussion extends to prevention strategies and mitigation measures, emphasizing the importance of regular maintenance, adherence to safety standards, and the use of advanced technologies in detecting and preventing electrical fires. At the end of the paper, a case study is presented, where improperly designed electrical installation causes fire at commercial building.

Key Words: Electrical, Wiring, Fires, Protocols, Maintenance

INTRODUCTION

Determining the cause of the fire is a combined expert examination conducted by examining the victim facility by an expert examination primarily determines whether it was a fire caused by a technical failure or irregularity or it is about an intentionally caused fire – arson.

The fire expert procedure, if it is about electricity as a possible cause, is carried out inspection and testing of electrical installations and electrical devices, by determining the place of origin and types of failure on part of the electrical installation or on electrical device, and determining the connection between failure and cause of fire. The procedure is carried out seeing the scene of the event and expert examination of the material expert opinion of the exempted at the scene of the fire.

CAUSES OF FIRE, OCCURENCE AND DETECTION

In continuation of this paper will be given explanations about how a fire occurs, the way of its detection and what are the reasons for its outbreak.

Otherwise, the burning process itself is a complicated chemical-physical process. It is a process in which the fuel violently combines with pure oxygen or oxygen from the air as an oxidant (in an amount that supports combustion) under the influence of a heat source. The process is followed by the development of abundant heat in the form of flame or embers.

The first step in investigating the possible causes of a fire by the persons in charge of this operation is to collect information from eyewitnesses and injured persons about the following circumstances

- ✓ what the mentioned persons noticed in relation to the fire,
- ✓ was there a smell of burning insulation of electrical conductors,
- ✓ whether a spark or electric arc was observed in a part of the electrical installation or one of the electrical consumers,
- ✓ whether smoke is observed on any part of the electrical installation or on
- ✓ to one of the electrical consumers,
- ✓ whether a voltage drop was observed immediately before or during the fire.

It is also necessary to investigate whether before the fire broke out in a part of electrical installations or installed consumers there were any defects or disturbances such as problems with the electrical protection system, overheating or burning of electrical installations, then other defects in consumers and from what nature were the defects that occurred, etc.

During the burning process, the fuel combines with oxygen from the air and violently oxidizes in the presence of heat and light.

During the heating of fuel materials, primary products of combustion are released, i.e. flammable gases which, in contact with the flame, oxidize into secondary or reaction products which are usually no longer combustible.

The phenomenon of "fire development" and the stages of fire development are described differently in different literatures in the field of burning and extinguishing theory.

Otherwise, for every fire that occurs in a certain location, the following actions are taken by a specialized team responsible for such problems to accurately detect the causes.

They are as below:

1. On-site inspection during the fire;
2. On-site inspection after extinguishing the fire.

While the fire lasts, the following steps are analyzed below:

1. Registration of external manifestations caused by the fire;
2. Weather conditions and atmospheric conditions;
3. Color of the flame, smoke and amount of smoke;
4. The smell, the sounds, and recording with a video camera.

After extinguishing the fire, the following steps are also taken:

1. Overview of the damaged objects, objects and their surroundings;
2. Determining the border on the spot;
3. Fixing traces;
4. Internal and external inspection of the facilities;
5. Harmonization of specific traces of the external and internal parts of the objects;
6. Detailed examination of the specific traces in the area where the fire started and determination of the center of the initial fire, i.e. the center of the fire;
7. Re-examination of the damaged building and its surroundings, near and far.

It is also necessary to investigate whether before the fire broke out in part of the electrical installations or installed consumers there were any defects or disturbances such as problems with the electrical protection system, overheating or burning of electrical installations, then other defects in the consumers and from what nature were the defects that occurred, etc.

Otherwise, electric current can cause a fire in several ways:

- ✓ heating of electrical conductors and devices through which electric current passes,
- ✓ short circuit,
- ✓ spark and electric arc,
- ✓ overheating of electro thermal devices,
- ✓ electric arc between uninsulated conductors,
- ✓ large transient resistances.

The high temperatures that are reached during current load in electrical installations also cause a carbonization process in the insulation itself, which acquires semiconducting properties, enabling the occurrence of an electric arc.

According to the Joule-Lenz law, the amount of heat Q [J] that the electric current develops in the conductor is proportional to the square of the current I [A], the resistance of the conductors R [Ω] and the time of current flow T [s]

$$Q(t) = I^2RT$$

A short circuit is the most common cause of fire when it comes to electrical installations - that is, a primary short circuit. If the short circuit is not immediately terminated, the installations will be destroyed and fire conditions will be created. A short circuit occurs as a result of:

- ✓ mechanical damage,
- ✓ dilapidated installation,
- ✓ systematic overload,
- ✓ Presence of moisture.

A short circuit is a phenomenon in electrical networks in which interconnections occur through low resistance at any point of various connections on an electrical circuit.

The total resistance of the electric circuit at the moment of short circuit decreases sharply, which leads to a significant increase in the current compared to the normal current.

The characteristic traces of a short circuit are melted conductors and other parts of the installation and devices as a result of an electric arc, the temperature of which can be from 1500 to 4000 ° C.

It very often happened that the short circuit was taken as the cause of the fire as soon as the place of the breakthrough was found, without a detailed analysis of that part of the conductor, but there are frequent cases when the discovered short circuit occurred as a result of fires-secondary short circuit, while the cause of the fire is something else.

The other potential common causes of fire are as below:

- ✓ **Damaged wiring** – Electrical wires can become worn, frayed, or loose over time. When this happens, the wirings can overheat and slowly burn over a prolonged period.
- ✓ **Malfunctioning appliances** – Fires can result from faulty or poorly maintained electrical appliances and equipment. Examples include cords, kitchen appliances, heating and air conditioning units, and other devices that draw significant amounts of power.
- ✓ **Overloaded circuits** – Plugging too many devices into a single circuit can overload it. Exceeding the circuit's capacity can generate high amounts of heat and ignite nearby combustible materials.
- ✓ **Poorly installed extension cords and power strips** – Replacing permanent wiring with improperly installed extension cords or connecting multiple appliances to a single power strip can cause a circuit overload and create a fire hazard.
- ✓ **Faulty outlets and switches** – Loose connections, damaged components, frayed cords, and incorrect wiring can result in overheats and trigger fires.
- ✓ **Defective lighting fixtures** – Faulty bulbs, lamps, and other lighting fixtures can emit excess heat, which can induce fires. In addition to this, using bulbs that go beyond the recommended wattage increases this risk.
- ✓ **Proximity to heat sources** – Fires are likely to occur if faulty wires or electrical tools are situated near combustible materials.
- ✓ **Malfunctioning electrical systems** – Electrical systems can experience short circuits, electrical arcs, and other faults, which can subsequently lead to fires.

SIGNS OF FIRE

Electrical fires pose serious hazards, but their impacts can be minimized if we understand their significant signs. This knowledge allows us to respond quickly and keep everyone safe in the event of a fire.

It's important to stay vigilant and take immediate action if you notice any of the following indication signs:

- ✓ **Burning odor** – A distinct smell of melting plastic, rubber, or wiring is a common sign of an electrical fire. If you find an unusual or persistent burning smell without any apparent source, it could be a hint of an electrical issue.
- ✓ **Smoke** – The presence of smoke, whether visible or faint, is a clear warning alarm for fires. If you see it coming from electrical appliances, outlets, or wiring, it's crucial to act immediately to prevent the fire from spreading.
- ✓ **Sparks** – Aside from the smoke, visible sparks from outlets, switches, or appliances could signal an impending electrical fire. Be sure to keep an eye out for these sparks, whether they appear intermittently or continuously.
- ✓ **Discolored outlets** – Scorch marks or discoloration may suggest that outlets or switches are overheating and, consequently, can lead to potential fire damage. If you spot these marks, it's best to report them for immediate action.
- ✓ **Hot switch plates** – If the switch plates or outlets feel hot to the touch, it could signify an electrical problem, as heat buildup can be a precursor to an electrical fire.
- ✓ **Flickering lights** – Frequent flickering of lights, along with a burning smell, could point out an electrical fire hazard. This can arise from loose connections, faulty wiring, or overloaded circuits.
- ✓ **Tripped circuit breakers** – Circuit breakers and fuses are bound to trip or blow up with too much current flowing. If this happens frequently without getting repaired, it can lead to electrical fires.

CASE STUDY: FIRE IN COMMERCIAL BUILDING

On xx/xx/xxxx, according to Inspection Notice No. 604-2017, at around 02:30 a.m., a fire broke out in the roof structure of a building owned by X.Y located in XX which three shops are located on the ground floor, separated by partition walls from each other and separate entrance doors.

The fire started in the roof structure in the part above the shoe store "Pro Shot", and the joint roof of the shoe store and the clothing store was set on fire.

Part of the shoes that were on the upper shelves and part of the clothes of the boutique that were also on the upper shelves were burned, while the rest of the shoes and clothes were completely damaged by smoke and when extinguishing the fire with water. A small part of the wooden structure of the bookstore was affected by the fire, and during the extinguishing of the fire, some of the materials that were arranged on the upper part of the shelves were damaged by water.

According to the Minutes for the inspection of the secured place of the event, the metal cabinet is located in the part of the bookstore where one three-phase electronic meter, two control single-phase electric meters that serve to measure the consumption of electricity in the clothing and footwear store, are installed, below them there were three blade fuses, and above the meter you can see three main fusible fuses each for one phase and six other fusible fuses, three of which are for the electrical installation for the shoe store and three for the clothing store. Both clothing and footwear stores have a panel with automatic fuses and FI assemblies.

The connection of the burned building to the LV (low voltage) network of Operator is carried out through an aerial four-core aluminum cable XOO-A, 4 x 16 mm2, which leads from the wooden pole of the LV network to a metal pipe (console) placed above the roof of the clothing store, passes through the roof and through the partition wall of the bookstore and is connected through protective fuses to the electronic three-phase meter.

The part of the supply four-core cable that passes through the roof has melted to the point of drops, a fact that indicates that the conductor on that part suffered extreme high temperatures, causing it to break.

According to the analysis carried out by Department for Criminalistics-Technical Investigations and Expertise's at the Ministry of Internal Affairs of pieces of connected aluminum cable XOO-A, 4 x 16 mm2, burnt conductors and fuses from the burned building, it was ascertained as below:

-The piece of the XOO-A power connection cable with a section of 4 x16 mm2 placed in the protective installation hose from the distribution network pole to the tension console from the building in the area of the entrance to the attic structure due to fire actions was broken by melting the cores.

In the piece of the XOO-A electrical connection cable with a section of 4 x16 mm2, there is damage in the part that is from the attic space, while the rest of the part whose ends are connected to the blade fuses is preserved and undamaged.

-The melted remains of the XOO-A power connection cable with a cross-section of 4 x 16 mm2 in the space of the roof construction are with the usual melting of aluminum conductors due to the relatively low melting point of Al around 660 °C.

Also, in the further part of the analysis made by officials, it was established that all the fuses installed in the three burnt shops were in proper condition.

The above statements indicate that the electrical installation in the burned buildings was correctly dimensioned and was not the cause of the fire, in other words the internal connection that includes lines, equipment and devices from the end of the external connection to the connected object for which the user is responsible for maintenance was in good condition in terms of electrical regulatory configuration.

The electric power connection cable XOO-A with a cross-section of 4 x16 mm2 is used for overhead electric networks for the distribution of electricity, for making house connections, for public lighting, for industrial energy distribution, etc.

Otherwise, it consists of four aluminum conductors with a cross-section of 4 x16 mm2, which serve as phase conductors, all of which are mutually insulated.

Taking into account the fact that the melting point of aluminum is 660 °C, one comes to the conclusion that such high temperatures can only develop with short circuits between the phase conductors and they have melted.

Most likely, due to wear and tear of the power conductor, the short circuit between the phase conductors occurred, while the sparks created in spherical shapes as a result of that process, created conditions for the fire to break out in the roof structure of the burned buildings.

Figure 1. A burnt conductor as a result of a short circuit

Figure 2. Damaged roof where is found source of fire

CONCLUSION

Fires caused by electrical installations represent a significant safety concern that requires comprehensive strategies for prevention and mitigation. By adhering to safety standards, conducting regular maintenance, and utilizing advanced protective technologies, the risk of electrical fires can be greatly reduced. Continued efforts in education, research, and policy development are essential to safeguard lives and properties from the devastating effects of electrical fires.

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