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STARTING FIRES IN ELECTRICAL SWITCHBOARDS AND EXTINGUISHING THEM

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Creating a connection between experts from the fire department and those from energy and mechanics, the authors analyse the causes that can generate fires on a first laboratory prototype that will be used in the electrical power supply panels of various electrical equipment, provided with a device to extinguish fires. Moreover, the means and methods of extinguishing these fires in low voltage installations are critically exposed, for the benefit of the public persons that can be exposed to risk. Data from the authors' research as well as their professional experience are used.

Keywords: fire, electrical installations, heating of conductors, extinguishing the fire

1. Introduction

The writing of this article was based on a first laboratory prototype that will be used in the electrical power supply panels of various electrical equipment, provided with a device to extinguish fires that occur in electrical installations with water under pressure or steam. This article bridges the gap between experts from the fire department and those from energy and mechanics departments.

The production and supply of electricity is the vital component of all processes related to human existence and activity. Without electricity, no kind of activity can work, starting with those specific to residential areas and ending with industrial ones. The generation of this source of energy and its direction to consumers, however, also involves dangers regarding the impact on both the environment and the human factor. One of these dangers, of particular importance, is the fires that can occur in the electricity transport and distribution processes, fires that, apart to the damage they cause in the system, result in significant material damage and, unfortunately, sometimes loss of human lives.

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In Romania, according to the latest statistics of the General Inspectorate for Emergency Situations (ISU), take places annually approx. 30,000 interventions to extinguish fires of which 26% are electrical fires [1]. At European level also, statistics suggest that every year more than 5000 people die in fires, and around ten times that number are injured. Of the recorded fires, a quarter is also of an electrical nature [2]. Although fires of an electrical nature represent an important and hidden threat, with enormous damages and very unpleasant consequences, only relatively recently have the causes and ways of extinguishing and prevention begun to be addressed and studied [3, 4]. Recent work has been focused both on the study of the causes that can lead to the occurrence of fires in power or distribution electrical installations, but also on the study of extinguishing possibilities with suitable agents so that material damage is limited to a minimum possible [5, 6]. Also, for the same purpose, design and execution rules are developed to ensure the safety in operation of installations with the risk of electrical fires [7, 8].

The existence of disturbances in electrical networks affects a whole series of consumers, both domestic and industrial, disrupting their proper functioning and, in the most unfavorable cases, leading to their failure and the initiation of a fire [9, 10]. The permanent concern for the removal of the causes that can lead to electrical fires, their early detection and the alarming of human personnel, combined with a prompt intervention of qualified personnel, constitute the prerequisites for limiting the negative effects of electrical fires and the total removal of the loss of human life. The authors aimed to present in this paper the main causes that can lead to the initiation of fires at electrical panels and distribution circuits as well as the means and methods of their elimination.

2. The causes of fires in electrical installations.

Electrical distribution boards are components of electrical installations with the role of ensuring the distribution of electricity either to other boards or to different consumers. They contain wirings that includes connection, protection, control, or manoeuvring elements, and in the case of important switchboards, also measuring, control, signalling, adjustment and possibly automation equipment. In most cases they are enclosed in boxes, cabinets or niches that protect them against unauthorized interventions, weather, or mechanical damage (Fig. 1).

In abnormal conditions, fires can occur in these switchboards that can put the electrical installation out of service by destroying the switchboard or can spread outwards initiating ignition foci in the adjacent space.


Fig. 1 Industrial electric switchboards

The most common causes of fires at electric switchboards are abnormal regimes caused by overcurrent, overvoltage, voltage drop below certain limits or distorted regimes. Aging and puncture of insulations, wear of connection and switching elements but also other causes such as improper handling or maintenance can also cause fires to occur. All these causes determine the initiation of the fire through the appearance of singular or multiple ignition centres, because of the increase of the local temperature above the melting or ignition limit of the insulations or the materials with which the conductor is in contact.

Overcurrent can be of short duration (under 10 – 15 seconds) or long duration (overload). In the case of short-term overcurrent, the intensity values can far exceed the nominal values, because there is not enough time for the temperature to rise to the fire initiation limit. In the case of long-term ones, more moderate exceeding of the nominal values can cause the temperature to increase over time to the limit of ignition of the insulation or the materials with which the conductor is in contact.

Overvoltage represents the frequent exceeding of the rated voltage, which over time has the effect of aging the insulation material, reducing its life, and increasing the probability of the occurrence of fault or short-circuit currents that can cause a fire (Fig. 2).

The decrease in the supply voltage also leads, over time, to undesirable effects because, in the case of certain categories of consumers such as electric motors, it causes the current to increase and the heating of the supply cables, with all the consequences that follow from here.

The distorted regimes are due to the use on an ever-increasing scale in the AC power supply circuits of some non-linear electronic components that generate the propagation of harmonics of high intensity currents in the network. In the case of three-phase circuits, the generated harmonics cause the neutral conductor to be charged with a harmonic current of rank III that can reach up the intensity of the phase current. In these operating conditions, significant overheating of the neutral conductors occurs, creating the danger of damage of the insulations and finally the occurrence of fire conditions.

The aging of the insulations, as a normal phenomenon in operation or because of the aggressive action of the environment (submission to extreme temperatures and humidity or the action of corrosive substances), causes the loss of insulator quality or the appearance of cracks in the material, thus favouring the occurrence of fault currents or breaking through the insulation and causing a short circuit to neighbouring conductors or to ground.

Wear of contact or switching elements is one of the frequent causes of electrical fires. Loosening of fixed contacts (connection points) or repeated actuation of mobile contacts (switches, jumpers and coupling bars) causes sparks and electric arcs that heat, oxidize and melt the contacts, causing a strong increase in contact resistance and local temperature. These phenomena cause the melting and ignition of the insulations as well as the support materials in the immediate vicinity, which can generate strong fires, the melting of the metal of the conductors and the production of short circuits.

Mishandling by maintenance personnel or improper maintenance, can also promote and generate fire conditions. Failure to check and improper fixing of connection points, installation of improperly calibrated fuses, periodic failure to check the contacts of sockets, switches and coupling elements, connecting consumers through improvised installations, connecting consumers with powers higher than the rated load of the switchboard or network, non-compliance with the norms protection against environmental action, are just some of the frequent causes that lead to dangerous overheating that can generate fires.

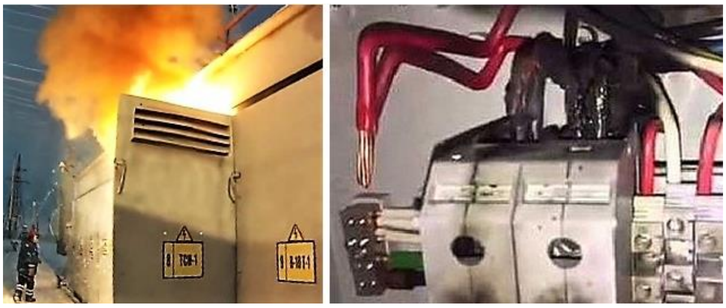

Fig. 2 Fires at electrical boards

3. Heating of electrical conductors.

The heating of electric conductors above the permitted limit and the occurrence of fires is due to several phenomena that occur because of non-compliance with the design, execution, and operation rules of electricity distribution facilities.

The Joule-Lenz effect consists in the dissipation of energy in the conductor and the appearance of a thermal effect resulting in an increase in temperature. In a conductor that has the electrical resistance *R*, through which an effective current I flow, the heat flow equivalent with dissipated power P is generated:

$$P = RI^2 \ \text{[W]} \tag{1}$$

which is transmitted to the outside through the insulation, its temperature t_{iz} depending on the intensity of heat transfer to the surrounding air with t_a temperature:

$$t_{iz} = t_a + \frac{P}{\pi D L \alpha} = t_a + \frac{RI^2}{\pi D L \alpha} \ [°\text{C}] \tag{2}$$

In relation (2) D is the outer diameter of the insulation, L the length of the conductor and α, the convection coefficient of the surrounding air, usually having values of 3...5 W/m^{2}K. Relationship (2) determines for an electric conductor, depending on its section, material, insulation and laying method, the maximum admissible current so that in undisturbed continuous mode, the temperature difference $\Delta t = t_{iz} - t_a$ does not exceed the value for which it can appear the danger of melting or igniting the insulation. Exceeding this limit value obviously leads to the deterioration of the insulation and the appearance of the possibility of a short circuit with the final effect of fire (Fig. 3).

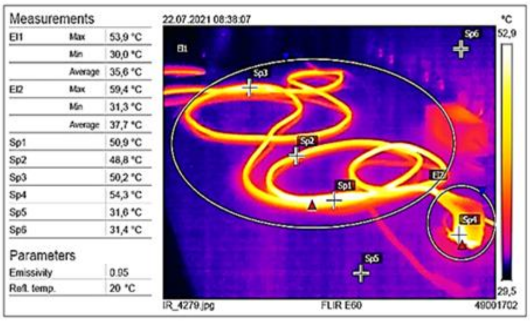

Fig. 3 Conductor heated due to overload.

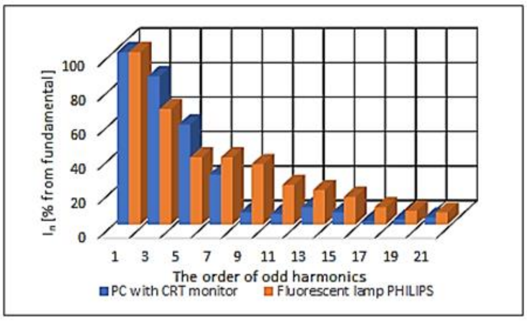

Fig. 4 The intensities of harmonic currents.

Fig. 4 shows the intensity of the harmonic currents for two typical power supply cases: a desktop computer with a CRT monitor and a standard PHILIPS fluorescent lamp, expressed as a percentage of the fundamental harmonic intensity. The intensity of these currents differs depending on the equipment, the important contribution being the odd harmonics of order 3...9 in the neutral conductor. The effective current, which produces dissipation through the Joule-Lenz effect, for a single thread conductor in which such a regime occurs, has the expression:

$$I = \sqrt{\sum_k I_k^2} \ \text{[A]} \tag{3}$$

where I_k is the harmonic current of rank k. For the two cases shown in Fig. 4 the result $I \cong 1.5 I_1$, show that the harmonic regime increases by about 50% the current corresponding to the undisturbed regime. Since P_{JL}, the power dissipated by the Joule-Lenz effect depends on the square of the current intensity, the thermal effect increases by 2.25 times: $P_{JL} = 2.25 P_{JL,1}$, causing the conductor to overheat. In three-phase circuits, the harmonic regime also causes a current to appear in the neutral conductor, which depending on the type of distortions can reach an intensity up to three times the intensity of the phase current ($I_{n\,max}/I_f = 3$). As a result, the electrical power dissipated by the Joule-Lenz effect can increase up to four times, causing the cable to heat up very strongly. The power dissipated over a 1m length of a three-phase cable is expressed as:

$$P_{JL} = \dot{q}_l = 3\rho_c \frac{I_f^2}{A_f}\left(1 + 3k_d \frac{A_f}{A_n}\right) \text{ [W/m]} \tag{4}$$

where ρ_c is the resistivity of the conductor material, A_f and A_n are the cross-sectional areas of the phase and neutral conductors, respectively, and k_d is the distortion factor with values in the range [0...1] [11]. Fig. 5 shows the variation of the temperature of the insulation surface of the three-phase cable ACYBY 3x150SE+70RE depending on the effective intensity of the phase current, for the undisturbed sinusoidal regime (k_d=0) and for harmonic regimes with different values of the distortion factor, depending on the ratio between the current through the neutral conductor (I_n) and the phase current (I_f). For the maximum permissible working temperature of 70 °C, the maximum phase current, in undistorted mode, has the value of 200 A. For strongly distorted harmonic regimes, the maximum operating temperature is reached at half the value of this current and for the maximum current of the undisturbed regime reaching the short circuit [12].

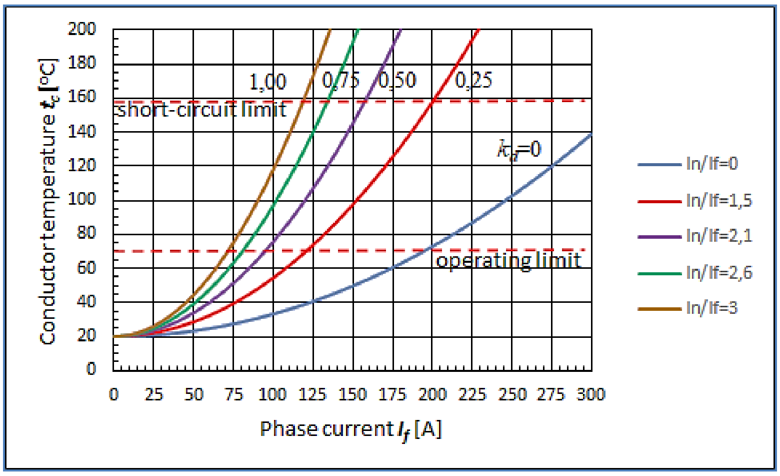

Fig. 5 Heating of the ACYAby 3x150SE+70RE three-phase cable due to the distorted regime [12]

The skin effect appears in the case of distorted regimes at high frequencies, corresponding to higher harmonics. The electric current no longer propagates over the entire section of the conductor but only through a film located on its surface, reducing the cross-sectional area of the cable, and increasing the apparent electrical resistance by up to 60%. This phenomenon results in the increase of the power dissipated by the Joule-Lenz effect and the additional heating of the cable. This effect can be reduced by using multicore conductors.

Loading the cables with high power consumers and non-sinusoidal operation, leads to the strong increase in heat generation by the Joule-Lenz effect and the rapid increase in the temperature of the cable to the short-circuit limit, ultimately starting the fire [13].

4. Heating of electrical contacts.

Electrical contacts are specially constructed parts between which the continuity of a circuit is achieved. As a result, any electrical installation can be seen as a set of conductors and functional elements interconnected by "electrical contact points" [14]. The contact that establishes the continuity of the circuit is made by pressing the contact parts against each other with the help of a force. Electrical contacts can be:

- ***Fixed contacts*** that are made by joining the contact parts with screws or rivets, serving to achieve the continuity of a circuit or for connecting to the terminals of an electrical device;
- ***Removable contacts*** where one element is fixed and the other removable, without load or voltage (electrical sockets, fuses);
- ***Movable switching contacts*** in which at least one contact is fixed and at least one is movable, capable of being moved, for closing, opening, or switching circuits (switches, relays)

Any electrical contact introduces an additional resistance into the circuit, called contact resistance (R_t), expressed by a relationship of the form [14]:

$$R_t = \frac{K}{F^m} \quad [\Omega] \tag{5}$$

in which *K* is a coefficient that depends on the nature of the contact material, the shape and degree of finishing of the contact surfaces and their condition, *F* [N] is pressing force of the contacts and *m* is an exponent that depends on the number of contact points [15].

During operation, electrical contacts are subjected to several stresses, the most important of which is thermal stress because, by heating the contacts, the temperature can rise to the point of melting and igniting the insulation of the conductors, or the support materials. For an electrical contact to work normally, without heating up, it is necessary to press it with sufficient force for its two parts to touch over the entire contact surface. No matter how well it is processed, the touch is not done on the entire apparent surface, but only on a very large number of micro-points, corresponding to the peaks of the asperities. For any type of contact, when it loosens or when the contact breaks, the following phenomena happen in a very short time:

- as the pressure on the contact parts decreases, the real contact surface decreases a lot, by reducing the number of contact points, reaching at a given moment that the entire current in the circuit passes through a single contact point;
- reducing the number of contact bridges leads to the constriction of the current lines and the increase of the current density, the metal being strongly heated, which can reach melting;
- continued loosening or removal of the contact causes the liquid metal bridge to thin and eventually, due to the ever-increasing heating caused by the passage of the current, it vaporizes;
- the existence, in a very small space, of a large amount of metal vapours and strongly heated electrolytes creates the conditions for the appearance of an electric arc between the contacts, the current in the circuit continuing to flow. There is the specific noise (sizzling) and the excessive increase in temperature which, by melting the plastic insulation and support materials, can initiate combustion with the appearance of a flame (Fig. 6).

Fig. 6 Fire caused by imperfect contacts and overload.

5. Starting a fire

The phenomenon of initiating a fire-type event is also known as the burning triangle (Fig. 7), which can be defined by the relationship [16]:

Fig. 7 The burning triangle

$$Initiating\ fire = f(x_1, x_2, x_{31}, x_{32}, x_4) \quad (6)$$

where: x_1 is the means of producing the fire (or parts of its composition), x_2 - the source of the fire, x_{31} - the first material that can ignite, x_{32} - the atmospheric air and x_4 is the circumstance that leads to the occurrence of the fire. The means of producing the fire may or may not contain the seat of the phenomenon or the source of ignition. The source must generate sufficient energy to initiate ignition and be in some distance relation to the first flammable material. For a fire-type event to be generated, the simultaneity in time and space of the variables x_k (t,s) in relation (6) is sufficient. For a certain space, each of these variables appears in a certain time interval Δt_k, the fire being initiated only in the time interval that corresponds to the intersection of the k time intervals (Fig. 8), the minimum time at which the fire is initiated being the lower limit of this interval.

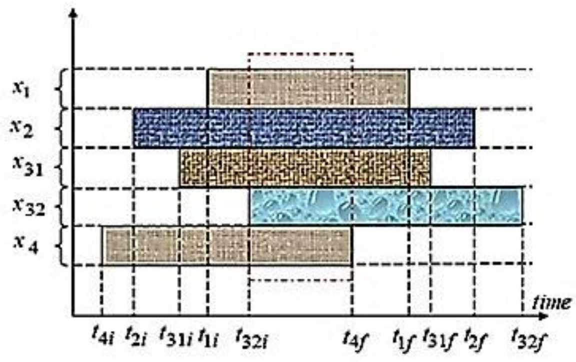

Fig. 8 The time interval in which the fire can occur.

Mathematically, the minimum time at which the fire occurs can be expressed by the relationship:

$$t_{min} = min\left(\bigcap_k \Delta t_k\right) \tag{7}$$

resulting for the situation presented in Fig. 8:

$$\Delta t_{fire} = t_{4f} - t_{32i}; \quad t_{min} = t_{32i} \tag{8}$$

The initiation of fires therefore implies the simultaneous existence in time and space of the variables in equation (6):

x_1 - the mean or the component elements in its structure (devices, apparatuses, tools, etc.), which generate the ignition source because of the performing of some functional activities (energy supply to consumers, circuit coupling, personnel intervention, etc.);

x_2 - the source of ignition (heating of conductors and contacts, piercing of insulation, appearance of electric arc, etc.) which is necessary to exceed the minimum ignition energy of the nearby flammable material (plastic materials, paper, cardboard, etc.);

x_{31} - the flammable material (the first material in the series of combustible materials existing in the space where the fire may occur) that generates the ignition phenomenon (fuel vapours, alcohol, solvents, powders and organic fibres, etc.);

x_{32} - atmospheric air (for the initiation of combustion, it is necessary to contain oxygen between the limits of 16...21%);

x_4 - the circumstances that contribute to the realization of the phenomenon (humidity of the environment, non-compliance with the instructions for use, improvised installations, faulty devices, unauthorized interventions, etc.).

Related to the variables that constitute the equation of the initiation of fires, the control of the risks of initiation of a fire is carried out by applying standards, norms, technical prescriptions, labour protection norms or instructions for use, to one or more of the x_k variables, existing in total several realization modes given by the relation:

$$N = \sum_{n} C_k^n \; ; \quad n \in [1 \ldots k] \qquad (9)$$

where k is the number of independent variables in equation (6), and n is the number of variables on which fire risk control is established [17].

6. Means of extinguishing fires at electrical boards.

The most used media for extinguishing fires in electrical boards are water, foam, powders and inert gases (carbon dioxide, nitrogen, inergen, etc.). The means used to extinguish fires determine the interruption of the burning process due to the effects that these media have on the fire:

-cooling the combustion area (water, foam);

-isolation of the burned area from atmospheric air (water, foam);

-dilution of gases in the combustion area, which can maintain and develop the fire (water, inert gases);

-combustion inhibition (powders);

-the chemical effect on combustion reactions (powders).

Water is the oldest and most used extinguishing agent, being the cheapest, easy to procure and with a considerable cooling capacity. In case of fire, water is used in the form of *compact jet*, *spray jet*, *water mist* or *steam*. The sizes of the water droplets are of great practical importance, because it is necessary that as much water as possible reaches the fire outbreak and remains there until complete evaporation

Foam is the main extinguishing agent for combustible liquids lighter than water, stored in tanks or leaked and accumulated in the layer, in case of damage to warehouses and technological installations.

Dry powders are a particularly effective extinguishing agent. The extinguishing effect of the powders is due either to the components resulting from the thermal decomposition of the powder (water vapor, carbon dioxide and sometimes nitrogen), or to the thermal decomposition as an endothermic reaction (cooling effect), or to the inhibition of the combustion reaction (anticatalytic effect).

Inert gases are a good extinguishing agent because, having a high density, they quickly infiltrate the whole space, replacing the air and depriving the fire source of oxygen.

Carbon dioxide is an extinguishing agent used in many applications. It does not conduct electricity and therefore can be used to extinguish fires in electrical installations.

Nitrogen can be used for the inertization of spaces or technological installations by partially replacing the air in the respective spaces, for diluting combustible-air mixtures, for extinguishing fires in technological installations or closed spaces, for transporting extinguishing powders, or operating the automatic opening of fixed installations extinguishing fires with the help of powders.

Inergen is a mixture of inert gases (52% nitrogen, 40% argon, 8% carbon dioxide) that has the property of reducing the oxygen level in the room so that combustion can no longer be maintained.

FM 200® agent is an HFC freon (R 227ea - heptafluoropropane). Its main extinguishing mechanism consists of heat absorption, with a secondary chemical contribution through thermal decomposition in the flame.

NOVEC® 1230 is a clean fire extinguishing agent, developed as an alternative to replace halons and hydrofluorocarbons (HFC), being chemically a fluoroketone.

7. Methods of extinguishing fires at electrical boards.

Interventions for extinguishing fires at electrical switchboards can be done with fixed means, which are component parts of this equipment, or with mobile means, handled by intervention personnel.

7.1. Fixed means for extinguishing fires.

Fixed water mist extinguishing system is the simplest and cheapest extinguishing system, using a small amount of water.

The fields of use are multiple: warehouses of flammable liquids, electrical transformer stations; gas tanks; cable galleries etc. The mist extinguishing installation is currently associated with a fire detection system that actuates the opening of solenoid valves, as well as with a fire alarm control panel (Fig. 9). The discharge nozzles are fed with water from the distribution network by means of a filter that removes particles with a size greater than 500 microns. They generate a fine, conical and directional sprayed water mist, where the droplet size is of the order of 20 to 200 microns. The special geometry of these nozzles allows their use at low pressure, without requiring a pressurizing agent, which leads to a simplification of the installation compared to high pressure systems and to a lower price. The installation can work in automatic or manual mode [18].

Fig. 9 Fixed water mist extinguishing system in acting and a spray nozzle.

Fixed inert gases extinguisher system. These installations represent the most widespread option in Romania as a fire extinguishing system, due to the ability to minimize damage to goods and people in the protected space. Compared to water, which is an excellent extinguishing agent due to its ability to stop the burning process and absorb the released heat, inert gases installations also ensure the protection of assets, the extinguishing agent leaving no residue and no-reacting with the materials in the protected space. Areas of use: warehouses or premises with valuable products, spaces for storage or use of electrical devices and equipment, halls or factories and car garages [19]. Fig. 10 shows the typical arrangement of an inert gas extinguishing installation.

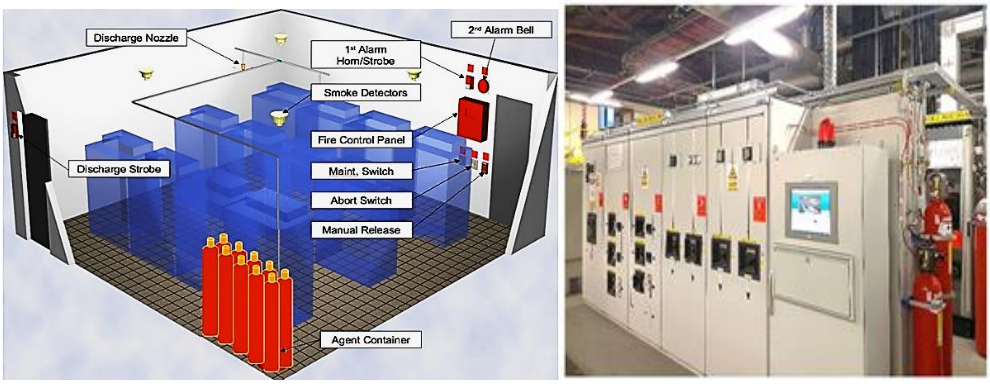

Fig. 10 Inert gases fire extinguisher system

The inert gas extinguishing agent can be carbon dioxide, inergen, heptafluoropropane (FM 200®) or fluoroketone (NOVEC® 1230). The system can protect large premises, such as server rooms, rooms for cabinets and switchboards with electrical equipment or rooms for electrical transformers, but they can also be made as individual units for the protection of dedicated equipment.

Fig. 11 BONPET extinguishing device

The BONPET® device shown in Fig. 11 was also designed for fixed individual fire protection. It is mounted inside the cabinets with electrical equipment that must be protected. The device is actually a glass ampoule filled with a fluoroketone or CFC type liquid. In the event of a fire, if the temperature exceeds 80...90°C, due to expansion, the liquid breaks the ampoule and evaporates quickly, creating a cooling effect and replacing the air. Eliminating the source of oxygen, the fire can be extinguished in a few seconds, and for a volume of the ampoule of about 600 cm^3, the protected volume is 8...10 m^3 [20, 21]

Fig.12 Fixed dry powder extinguish system

Fixed dry powder extinguishing system. Powder extinguishing systems are used for the protection of cabinets with electrical or electronic equipment, with a volume of up to 3 m^3. The system consists of a container, usually round, containing approx. 1...1.5 kg of non-toxic and electrically non-conductive dry powders, placed inside the enclosure that must be protected. In the event of a fire, the released heat causes the container to self-activate after approximately 3...5 seconds, dispersing the powder over a volume of approximately 3 m^3. The powder extinguishes the fire by thermal decomposition accompanied by an endothermic and anticatalytic effect. Fig. 13 shows the protection mode of cabinets with electrical equipment by fixed spherical fire extinguishers [22].

7.2. Mobile means for extinguishing fires.

Mobile means of small capacity. These means of extinguishing fires, placed at hand, can be transported to their place by anyone. They come in a large variety of sizes and capacities and can work with water, powders, foam or inert gases.

Large capacity fire extinguishers, transported on wheels. In the case of intense or extensive fires, small, hand-carried fire extinguishers cannot provide a sufficient amount of extinguishing agent. As a result, the use of large capacity cylinders is required, which cannot be transported manually, and are mounted on carts or trailers

Self-propelled means for extinguishing fires. In the case of large-scale fires, located outdoors or in halls, such as transformer stations, panels and control desks or large cabinets with electrical and electronic equipment, in order to be able to intervene quickly and efficiently, containers containing large quantities of extinguishing agent are mounted on self-propelled chassis (Fig. 13).

Fig. 13 Self-propelled means for extinguishing fires.
a) water mist cannon extinguishing an electric transformer; b) powder or foam truck

The impulse fire fighting system (IFEX). The recently developed pulse extinguishing technology has proven to be particularly effective, extinguishing a fire in a very short time with low consumption of extinguishing agent and minimal material damage. The extinguishing agent is sent at very high speed, in a split second, directly into the focus of the fire. Propulsion of the extinguishing agent is carried out with compressed air, having a pressure of approx. 25 bar. The extinguishing agent is primarily simply water, but the system can use most extinguishing agents, even special agents used to extinguish metal fires. The impulse created by the high discharge speed, over 100 m/s, and the large cooling surface allow effective extinguishing of fires from a safe distance. Liquid fires can be extinguished by using foam with additives; wood fires can be extinguished simply with water; even fires in high-voltage electrical appliances can be extinguished with water alone. In this case, the minimum distance to be kept is only 1 meter [23].

Fig. 14 The IFEX® Impulse fire fighting gun

The IFEX® Impulse fire extinguisher (Fig. 14) is the centrepiece of impulse fire extinguishing technology. It is made of stainless steel and consists of a rear pressure chamber, a quick release valve, a front chamber for water or extinguishing agent and an agent release mechanism. If the valve is open, the compressed air pushes the agent out of the front chamber in a few milliseconds at very high speed, forming a finely dispersed cloud with high impact power. The flame is practically *blown*, being instantly extinguished by both impact and cutting off the oxygen supply [23].

The device can be carried on the back by the operator or mounted on a self-propelled vehicle. For efficiency reasons, the BMI of the fire fighter has to be determined previously [24].

8. Conclusions

Nowadays, electrical fires represent an important part, over 25%, of all fires, causing both loss of human life and significant destruction of material goods. Beside the practical need to save the public persons around, it is an element of novelty the fact that all the research and results in this article have been conducted on a first laboratory prototype that will be used in the electrical power supply panels of various electrical equipment, provided with a device to extinguish fires that occur in electrical installations with water under pressure or steam. It is thus created a connection between experts from the fire department and those from energy and mechanics departments.

At the same time, electrical fires are also a hidden threat; they can break out even when, apparently, things are in order. Consequently, permanent attention is needed to remove their causes, as well as to develop and use effective and fast extinguishing means. The frequent causes of electrical fires are the heating of the conductors and the electric arcs generated by the imperfection of the contacts. Since the heating of the conductors is due to the increase in the intensity of the currents, either due to overloads or due to short circuits caused by their inadequate insulation, it is necessary for the maintenance staff to constantly check the condition of the wiring and the power of the consumers connected to the network. The most important thing, however, is the proper calibration of the electrical circuit protection elements (switches) and the permanent control of their technical state of operation.

Another thing, just as important, is the permanent check of the technical state of operation of electrical contacts, both fixed and mobile, especially sockets and switches, to avoid the formation of electrical discharges that lead to their overheating and ignition.

The essential condition for limiting the consequences of an electrical fire is its detection in the initial phase and rapid intervention to extinguish it. That is why it is necessary to permanently train all people who are or work in rooms where electrical appliances work, so that they can be able to notice any situations in which an electrical fire could occur and act quickly to prevent it.

Extinguishing media must also be on hand, loaded with the appropriate agents and checked for proper operation, to be used until the intervention of qualified personnel. Also very important is the installation of fixed, automatic extinguishing and alarming means in permanently unattended areas, where there is electrical or electronic equipment in operation, under voltage. Electrical switchboards, both for lighting and power installations, as well as transformer stations are often placed in separate, closed rooms to which only authorized personnel have access. It is very important that these rooms have automatic means of detecting and extinguishing fires using agents that do not destroy the installations, such as inert gases, powders or water mist.

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