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ANALYSIS OF WAYS OF DE-ENERGIZATION OF RESIDENTIAL BUILDINGS WITH AIR POWER NETWORK INPUT

Abstract – The article analyzes the ways and means of de-energization of residential buildings. Methods of performing inlet of electrical power networks in residential buildings are analyzed. The paper studies the special features of emergency de-energization in the case of fire in the residential sector by cutting the current-carrying wire and cables. Conditions of use of the hand-operated mechanical and non mechanical tool that is used by fire and rescue departments for emergency de-energization are indicated, the advantages and disadvantages are pointed out. Conclusions regarding the effectiveness of the use of insulated tools for cutting stranded wires are drawn and potential ways for future research are specified. For emergency de-energization of residential buildings in case of fire dielectric tools are used. Regardless of the type the existing tools can be used for cutting wire separately in compliance with safety code. The presence of a metal tip in cutting tool during cutting of multiple-core wires and wires under voltage leads to electrical power network emergency state. In order to optimize the process of emergency de-energization of residential buildings is advisable to use the tools with extension bars as it is safer and helps minimize the number of rescuers involved into the work of the de-energization. So a promising area for future research is developing of tools for emergency de-energization of residential buildings in case of fire input to which is made by multiple-core wire or cable.

Keywords: de-energization, cutting tool.

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АНАЛІЗ СПОСОБІВ ЗНЕСТРУМЛЕННЯ ЖИТЛОВИХ БУДІВЕЛЬ ІЗ ПОВІТРЯНИМ ВВОДОМ ЕЛЕКТРИЧНОЇ МЕРЕЖІ

У статті здійснений аналіз способів і засобів знеструмлення житлових будівель. Проаналізовані способи виконання вводів електричних мереж у житлових будівлях. Розглянуті особливості аварійного знеструмлення при пожежі в житловому секторі шляхом перерізання струмоведучих жил проводів та кабелів. Висвітлено умови застосування ручного механізованого та немеханізованого інструменту, який використовується пожежно-рятувальними підрозділами для аварійного знеструмлення, вказано на переваги та недоліки. Зроблені висновки щодо ефективності використання діелектричного інструменту для перерізання багатожильних проводів та вказано на перспективні шляхи подальшого дослідження. Для аварійного знеструмлення житлових будівель при пожежі використовують діелектричний інструмент. Не залежно від виду існуючі інструменти можуть бути використані для пожежного різання проводів з дотриманням вимог безпеки праці. Наявність металевого леза в ріжучому інструменті при перерізанні багатожильних кабелів та проводів під напругою призводить до аварійного режиму роботи електромережі. З метою оптимізації процесу аварійного знеструмлення житлових будівель доцільно використовувати інструменти з подовжувальними штангами, тому що це безпечніше та сприяє мінімізації кількості залучених рятувальників до проведення робіт із знеструмлення. Таким чином перспективним питанням для подальших досліджень є розробка інструментальних засобів аварійного знеструмлення житлових будівель при пожежі, ввід до яких виконаний багатожильним проводом чи кабелем.

Ключові слова: знеструмлення, ріжучий інструмент.

Challenge problem. Fire fighting operations by conductive substances at any object begin after its de-energization. In order to minimize the time in the residential sector, de-energizing is performed by cutting electrical power network inlet of the house near power line pole. For this type of work a special dielectric tool is used [1]. The main disadvantages of the dielectric tool is the ability of the de-energization of the electrical power network with phase voltage till 220 V and the need for cutting each strand separately from each other, which is not possible when insulated wires and cables are used.

Actuality of emergency de-energization of residential buildings is confirmed by analysis of the fire statistics. If 90% of fires are fought with water, so the time of fire localization depends on from time of de-energization that in turn influences the material damage. Figure 1 shows the involvement of damage caused by fire depending on the time of the fire growth.

Analysis of recent achievements and publications

Our analysis of the existing tools and methods of emergency de-energization of residential buildings shows that for the purpose of cutting wires and cables rescuers use manual and mechanical tools with metal blades. The use of such a tool is possible in case when connection of a residential building is made by single-core wires but during cutting of multiple-core wire electrical power network emergency state is occurred.

Emergency de-energization during fire fighting is used by experts in Europe, CIS, USA and others. Hungarian researcher Joseph Toby pays a significant attention to the issue of cutting stranded insulated cables. He investigated the possibility of cutting the cables under 400 V, 6 kV and 15 kV by special hydraulic shears with a long hose (at least 8m) and a hydraulic pump. The researcher identified a safe distance for cutting live wires and proved that the use of a cutting tool can only be a last resort, because there is high probability of an accident as a result of short-circuit [2].

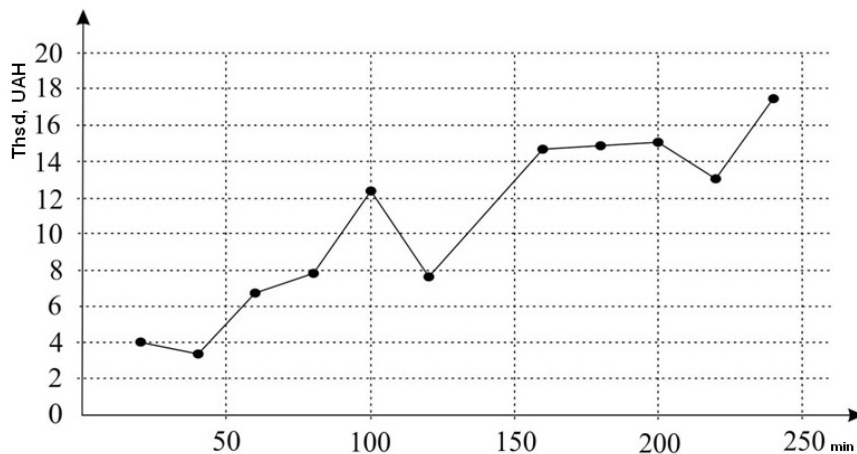


Figure 1. Averages of losses from fires in Cherkassy oblast depending on the time of the fire growth (from the moment of localization) in 2014

Proceeding from the above, we can conclude that the subject of the emergency de-energization of residential buildings, entering of which is made by multiple-core cable, requires further research towards the safety of rescuers and minimization of accidents in electrical power networks.

Problem definition and its solution

The main objective of the research is to analyze existing methods and means of de-energizing of residential buildings by cutting the conductors. To achieve this goal it is necessary to solve the following problems:

- To analyze techniques of electrical power network inlets in residential buildings;
- To analyze the methods of emergency de-energization of residential buildings in case of fire;
- To systematize the existing tools and methods for cutting wires and cables.

Results of the research will give the opportunity to mark off the ways to optimize the operational activities of the rescue fire units in the liquidation of fire in a residential building that is under voltage.

The presentment of the main research material with full justification of scientific results

Techniques of electrical power network inlets in private households

Up to date, two techniques of inlets in a private house are used: underground and aerial. Underground technique is that the column support runs downhill and cables are laid in the tube.

By aerial technique uses ropes on which cables are suspended or self-supporting insulated and uninsulated wires, within that the height from the ground shall not be less than 6 m above pass ways, not less 3.5 m above walkways and the attachment point on the house no low 2, 75 m.

- By 2011, for the installation of an overhead line inlet a wire without insulation of AC brand [3] was used. According to [3] nowadays wires of SSIW brands are used (Figure 2), which can be twin wire or four-wire. For underground inlet armoured and unarmoured cables are used.

- Inlet of power supply input of private households is engaged from 0.4 kV overhead lines of local networks.

- Earthing of the neutral wire definitely must be done, which according to [3] can have two implementation options:

- Earthed at regular distances (100 ... 200 m) neutral of the network serves as the neutral conductor circuit and zero protective conductor simultaneously – TN-C system;

- For the grounding of the equipment separate conductor is laid, which serves as the only protective conductor – TN-S system [3].

The second option is a must for residential, administration and amenity facilities, high occupancy buildings and similar which are building. In this case, in rooms with single-phase network, internal network is performed three wired – phase, neutral and protective conductors. At construction sites with three-phase consumers internal network is made by five-conductor line – 3 phase, 1 neutral and 1 protective (Figure 3).

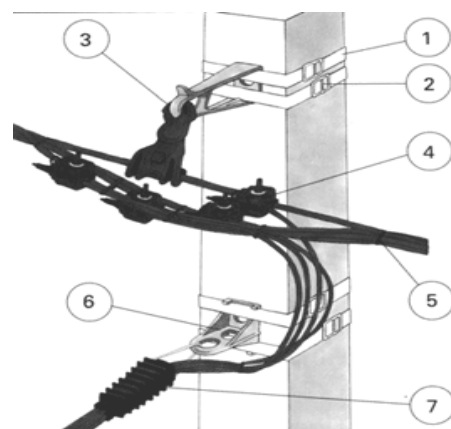


Figure 2. Branching to the consumer power line performed by the wire of SSIW brand, where: 1 - stainless steel strip 2 - strip connection, 3 - intermediate clamp with bracket, 4 - piercing clamp, 5 - cable tie, 6 - anchor pole bracket, 7 - anchor clamp

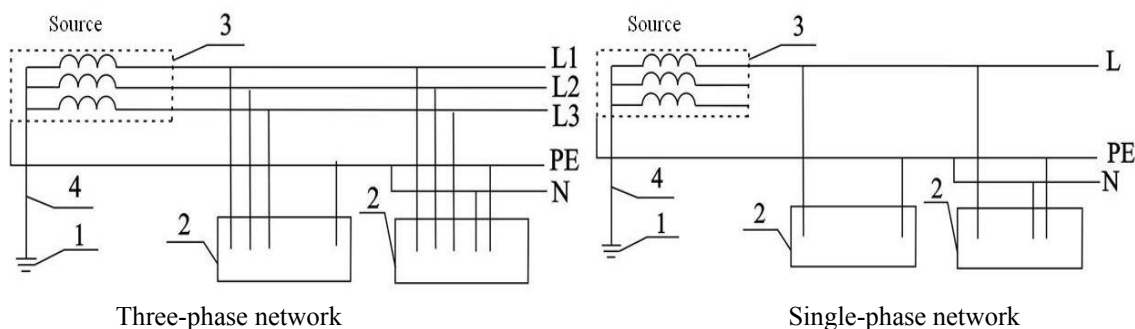


Figure 3. Scheme of system grounding in three-phase and single-phase alternating-current electric installation with voltage up to 1kV, where: L1, L2, L3 - linear (phase) conductors; 1 – ground-wire of power supply; 2 – exposed conductive parts; 3 – ground-wire of exposed conductive parts; 4 – protective grounding conductor (grounding of the system is marked by thick lines); N - neutral conductor electrically connected to the neutral point of the power supply; L - linear (phase) conductor, PE - protective conductor

Independent from the considered options in the building when applying separate protective conductor, the last is branched from neutral of network at the inlet panel of the building till disconnect contacts, and to ensure its integrity and reliability in the network of this conductor should not be any disconnects, fuses and so on. So three-phase inlet is made by four-wire circuit and single-phase inlet is made by two-wire circuit till the input protection switching device. In both cases, protective wire PE can be added to.

Analysis of the special aspects of functioning of the three-phase electrical power networks shows that during the cutting wires separately there is a threat of three-phase or twice-phase formation range without phase-neutral wire. A feature of this mode is that in asymmetrical load in phases with a smaller load voltage rises sharply, while in the phases with harder load voltage sharply reduces (Figure 4). Such mode will lead to failure of electronic equipment and electric motors of refrigerators, washing machines, ventilation systems. In the absence of fault of protection devices this equipment can become a new source of inflammation.

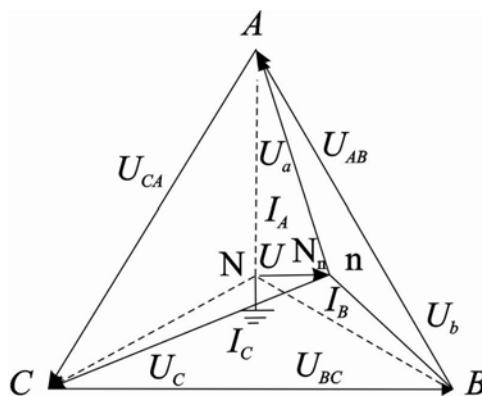


Figure 4. Vector diagram of currents and voltages when connecting symmetric load without neutral wire

Methods of de-energization of private households

One of the stages of operational actions of fire and rescue departments is to establish the place and method of power cut-off. There are two ways of the electrical network cut-off: a mechanical de-energization or emergency power cut-off. Emergency de-energization of the electrical network by cutting cores is performed if the electrical network is damaged and there is a risk of electric shock of rescuers that involved in fire-fighting, there is a risk of the beginning of new bodies of fire in case of getting water on them or there are conditions that hinder fire fighting operations and dismantling structures.

It is regulated by requirements [1] that the electrical networks and facilities under phase voltages above 220 should be disconnected by representatives of power engineering. Disconnect of electrical equipment with voltage phase in network above 220 personnel can be made by fire-rescue unit at the direction of fire ground commander or chief of operational activities [4].

During de-energization the rescuer should be guided by the requirements of security, namely: to work in dielectric protective equipment; to cut feeder outer cables only near insulators from the side of power consumption with the expectation that the wires which falling or sagging, are not left energized and to cut each wire (conductor) separately from the others; if the wires are hung on poles or on the racks, the rescuer need to climb the extension ladder installed around the column; to put a mat on the ladder rung, to stand on it and to consolidate himself by safety hook at ladder rung (working with a metal ladder between the safety hook and ladder rungs there is should be insulation lining) cutting should be started with the bottom wires in order for wires under voltage remain fixed on insulators and could no unite with each other or with other items, for such work should be involved at least two people of operative calculation.

Tools for cutting wires

Cutting wires is carried out using a special tool which according to the principle of work is divided into three main types: mechanical, hydraulic and electric. To facilitate the efforts constructions with hinge elements are used, in scissors with extension rod force to the cutting head is transmitted by the strand (the rope) or rod. The common element of all types of cutting tool is a cutting metal tip.

Instrument manufacturers do not allow simultaneous cutting of several leading conductors under voltage, as a result of short circuit tool cutting head breaks down. The exception is the tool "Hydraulic safe cable cutting machine Tehnorez™" which has a special grounding rod and knives are made from stainless steel with thickness of 14 mm, which even after a short-circuit remain working. Rescuer safety when working with a hydraulic machine is achieved by the machine's equipping by remote control of the cutting head at a safe distance and use of hydraulic high pressure hose. The main disadvantages of this tool are the impossibility of remote work at height and the limit of the distance to the cutting place which is caused by length of the hose.

To make an emergency de-energization at a distance models of tools with extension bar are used. Tool REP-2 is made for cutting separately overhead power lines and internal wiring under voltage up to 1000 V. Unlike to ordinary scissors for cutting electrical wires this tool can cut overhead power transmission lines under voltage directly at a height of 6.1 meters from the ground without fire ladders that allows doing de-energization by a single worker.

Conclusions

The analysis of methods of performing inlet of electrical power networks in residential buildings points to the existence of underground and air input. The air input until 2000 was made by wires of AC brand, and from 2011 - self-supporting wires of SIP brand.

For emergency de-energization of residential buildings in case of fire dielectric tools are used. Regardless of the type the existing tools can be used for cutting wire separately in compliance with safety code. The presence of a metal tip in cutting tool during cutting of multiple-core wires and wires under voltage leads to electrical power network emergency state.

In order to optimize the process of emergency de-energization of residential buildings is advisable to use the tools with extension bars. In comparison with the dielectric scissors the tool with extension bars is safer and helps minimize the number of rescuers involved into the work of the de-energization.

Prospects for further research. So a promising area for future research is developing of tools for emergency de-energization of residential buildings in case of fire input to which is made by multiple-core wire or cable. The development of such tools should ensure the implementation of a number of basic requirements, including: efficiency of the action as to de-energization of residential building, rescuers safety during its use, and also to exclude the possibility of electrical power network emergency state.

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