http://www.moderntechno.de/index.php/meit/article/view/meit26-02-034
DOI: 10.30890/2567-5273.2023-26-02-034

УДК 658.328.3(075)

ASSESSMENT OF THE TECHNICAL CONDITION OF THE ELECTRICAL SYSTEMS IN HISTORICAL BUILDINGS

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Abstract. *The analysis of the emergency operation of electrical systems in buildings of historical urban development, in which the saturation of premises with technical life support systems has greatly increased, as a result of which the load of electrical systems and the release of thermal energy in areas with high transient resistances, has increased. The proposed method makes it possible to determine an emergency electrical systems with a high transient resistance, which converts part of the electrical energy into heat, which leads to the ignition of electrical cables. It is based on comparing the magnitude of the voltage that is supplied to the input of the electrical systems under study, with the magnitude of the voltage at the output of this electrical systems at the terminals of the consumer's electrical appliance. This makes it possible to timely identify a possible electrical source of ignition, electrical systems with high transient resistances sections, repair it in a timely manner or replace it with a new one, which will reduce the risk of a fire due to the thermal effect of electrical energy.*

Key words*: fire safety, electrical source of ignition, electrical systems, assessment of the technical condition of the electrical systems, high transient resistance*

Introduction. In modern conditions, among the problems of state construction, the issue of ensuring people's safety against threats of a social, natural, and man-made nature is of particular importance. One of the components of public safety is fire safety, which involves the protection of life, property and society from fires.

In connection with the significant increase in the electrical capacities of the equipment used in educational and administrative institutions located in multi-story buildings of historical urban development, the state of their fire safety has recently become a particularly relevant and acute problem [1].

In hidden electrical systems of domestic electricity supply, the electric current flows through a large number of connections with high transient resistances (HTR), which are often performed by the prohibited method of "twisting", which increases the probability of catching fire of the insulation of the conductors in the connection city. The thermal effect of the electric current on the insulation of the wires in the sections with HTR sharply reduces its mechanical and dielectric properties. When the electric current flows through the damaged section of the power grid from the HTR, due to the high resistance of the current at the connections, the voltage drops, the power loss increases, and heat energy is released, which leads to overheating of the power grid conductors. If the heated sections of the conductors come into contact with combustible materials, ignition or ignition of the insulation of the wires occurs.

Main text. Until recently, the current regulatory and technical documents did not consider the issue of monitoring the state of electrical systems with a voltage of up to 1000V during operation, and, in particular, the determination of emergency hidden indoor electrical systems with areas of HTR exceeding permissible values. A method based on comparing the amount of power spent on providing the consumer P_{in} with the power used by the electrical consumer P_{out} is proposed to determine the HTR in hidden low-voltage electrical systems (below 1000 V).

Part of the input spent power P_{in} is distributed between the power consumed by the consumer's electrical systems (P_{out}), and the lost power in the electrical systems conductors (P_c), which is converted into thermal energy and spent on their heating, and the power of individual sections of conductors with high transient resistances (P_{HTR}). The amount of useful power used by the consumer (P_{out}) can be determined by formula (1):

$$P_{out} = P_{in} - \left(P_c + P_{HTR}\right). \quad (1)$$

The input power is determined by the formula (2)

$$P_{in} = U_{in} \times I\,, \quad (2)$$

where: U_{in} is the input voltage of the electrical systems**,**

I is the current strength of the electrical systems.

The output power is determined by formula (3)

$$P_{out} = U_{out} \times I\,, \quad (3)$$

where U_{out} is the output voltage of the power grid at the consumer's load.

In case of an emergency operation mode of the power grid, namely: excessive loss of power in electrical conductors P_c and connections with existing sections of HTR P_{HTR}, unacceptable overheating of conductors occurs; melting of the insulating sheath of the cable; there is a short circuit and an overload of the electrical systems and, as a result, a fire. The loss of power in the electrical systems leads to a decrease in the amount of used power P_{out} in comparison with the amount of spent power P_{in}. Based on the above, as a criterion for assessing the fire safety of the electrical systems, we will introduce the fire safety coefficient of the electrical systems K, which shows the share of input power that is wasted on heating the electrical systems:

$$K = P_{in} / P_{out}\,. \quad (4)$$

Substituting formulas (2) and (3) into formula (4), we get the expression for determining the value of the fire safety factor K as the ratio of the input voltage U_{in} to the output U_{out}, formula (5):

$$K = P_{in} / P_{out} = U_{in} \times I / U_{out} \times I = U_{in} / U_{out}\,. \quad (5)$$

According to (5), for an ideal electrical systems conductor, the output voltage U_{out} should be equal to the input U_{in}, and the value of $K = 1$. An increase in the value of K indicates an increase in power losses in the electrical systems due to an increase in the resistance of the electrical systems as a result of the presence of sections with HTR, a decrease in the transverse cross-section of conductors, and other reasons.

According to regulatory documents [2, 3], the value of the transient resistance of the bus section at the point of the contact connection should not exceed the resistance value of the bus section of the non-contact connection of the same length by more than 1.2 times.

Experimental studies were conducted to confirm the possibility of using the proposed method of determining the electrical systems with existing sections of the HTR. The electrical schematic diagram for the experimental study of an electric circuit with HTR sections is shown in Fig. 1.

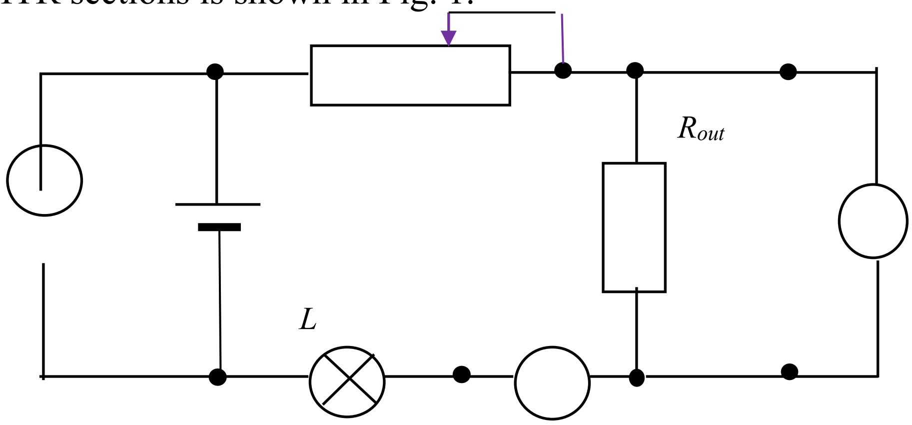

Fig. 1. Electrical schematic diagram for experimental determination of the parameters of an electric circuit with sections of HTR.

U_{in} – reference power source; L – an electric light bulb for simulating the resistance of the conductor R_c; R_{HTR} potentiometer – simulates the resistance of the area with HTR; resistor R_{out} – simulates the load of the consumer; V_1, V_2 – voltmeters, A - ammeter.

Elements connected in series form a closed electric circuit. Voltmeter V2, connected in parallel to the load resistor of the electrical circuit to measure the value of the output voltage of the electrical circuit $U_{out} = U_{Rout}$.

The photo diagrams of the connections of the elements of the experimental setup for evaluating the HTR are presented in fig. 2.

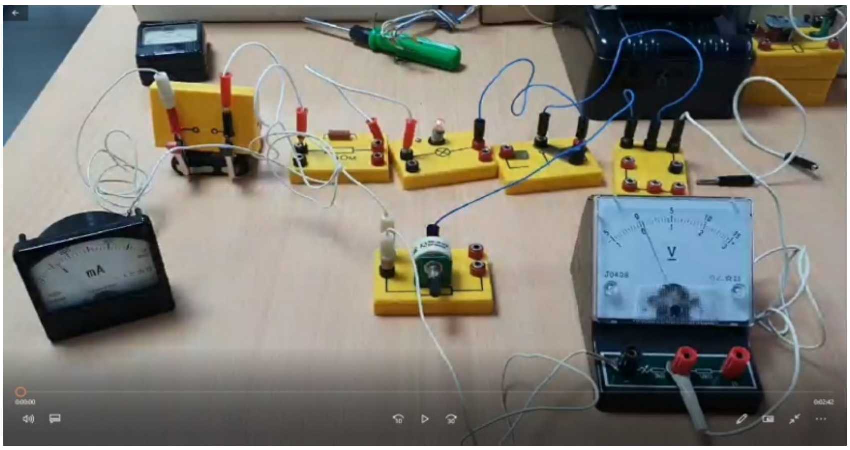

Fig. 2. Photo of the experimental installation for determining the emergency state of the hidden electrical circuit.

The following are used for measurement: 1. – milliammeter (A) measuring range 1 – 600 mA for measuring the electrical current of the electrical circuit; 2 – power source (E) electric battery with a voltage of U_{in} = 5 V; 3 – potentiometer (R_{HTR}), simulates the resistance of the section of the electrical circuit with HTR; 4 – an electric light bulb (L), at a voltage of 3.5 V, which simulates the resistance of the conductor Rпр and visually demonstrates the change in the current strength of the electrical circuit I; 5 – electric switch (K1) for switching the electric circuit; 6 – multiplier of electrical conductors; 7 – voltmeter V_2 for measuring voltage U_{out} on resistor R_{out}, measurement range (1-3 V).

Research Results From a dry-charged battery (voltage source U_{in}), which simulates a stabilized power supply, a constant voltage U_{in} =2.5 V is supplied to the input of the electrical circuit (contacts 1, 2). The strength of the electric current (I) flowing through the electric circuit is measured by an ammeter A. The voltage U_{out} (contacts 3, 4) on the reference resistor (R_{out}) is measured by a voltmeter V_2 on a scale of 5 V.

$$K = U_{in} / U_{out} .$$

A potentiometer was used to change the resistance value (R_{HTR}) of the circuit section with HTR. When the value of the resistance R_{HTR} increases, the value of the voltage U_{out} on the resistor R_{out} decreases. Voltage U_{out} on the reference resistor (R_{out}). measured by a voltmeter V_2. After receiving the data, the coefficient values were calculated.

The measurement results are shown in table. 1.

Table 1. Results of experimental measurements of fire hazard coefficients of the electrical circuit

№ п/п	1	2	3	4	5	6	9	10
I, electric current, A	0.125	0.124	0.110	0.10	0.09	0.08	0.065	0.06
U_{in}, input voltage, V,	2,5	2,5	2,5	2,5	2.5	2,5	2,5	2,5
U_{out}, output voltage, V,	0.025	0.375	0.625	1.25	2.133	2.10	2.25	2.5
$K = U_{in}/ U_{out}$	100.8	6.667	4.00	2.0	1.198	1.19	1.11	1.00
The presence of unacceptably high transient resistances	**Yes**	**Yes**	**Yes**	**Yes**	**No, *limit***	**No**	**No**	**No**

Conclusions The main causes of fires are violations of fire safety rules during the installation of electrical systems (28%) and operation of electrical installations (35.7%). A significant number of fires, especially in historic buildings, occur due to the emergency mode of operation of electrical systems and equipment, namely: the presence of sections of the electrical systems with large transient resistances.

The proposed method of determining emergency power grids from HTR that consume excess electricity power, based on the calculation of the ratio of the voltage applied to the input of the power grid under investigation to the voltage value on the electrical device connected to the systems, makes it possible to prevent the occurrence of fires in indoor electrical systems in advance and reduce the risk of fires due to thermal action of electric energy, primarily in the buildings of the historical development.

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Аннотация. *Проведен анализ аварийной работы электросетей в зданиях исторической застройки городов, в которых очень увеличилась насыщенность помещений техническими системами жизнеобеспечения, в результате чего увеличилась нагрузка электрических сетей и выделение тепловой энергии в участках с большими переходными сопротивлениями (БПС). Предложенный метод позволяет определить аварийную электросеть с большим переходным сопротивлением, которое преобразуют часть электрической энергии в тепловую, что приводит к возгоранию электрических кабелей. Он основан на сравнении величины напряжения, которое подается на вход исследуемой электросети, с величиной напряжения на выходе данной электросети на клеммах электроприбора потребителя. Это дает возможность своевременно выявить возможный электрический источник возгорания, электросеть с участками БПС, своевременно ее отремонтировать или провести замену на новую, что уменьшит риск возникновения пожара по причине теплового действия электрической энергии.*

Ключевые слова: *пожарная безопасность, электрический источник воспламенения, электросеть, оценка технического состояния электросети, большие переходные сопротивления.*

Статья отправлена: 13.04.2023 г.